BOOK OF PROCEEDINGS

9th International Soil Science Congress on
"The Soul of Soil And Civilization"

Soil Science Society of Turkey Cooperation with
Federation of Eurasian Soil Science Societies

14 - 16 October, 2014 Side, Antalya / Turkey

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PREFACE I

9th International Soil Science Congress on "The Soul of Soil and Civilization" was held by the Soil Science Society of Turkey (SSST) collaborating with the Federation of Eurasian Soil Science Societies (FESSS) in Side, Antalya, Turkey, October 14-16, 2014. The opening ceremony with more than 500 participants from 61 different countries was in the Sueno Hotel Beach Side in Antalya, Turkey.

"New Status of Paleopedology in Geo-biosciences" by Dr. Alexander O. Makeev and "Soils Sustaining Life" by Dr. Ahmet R.Mermut were presented as keynote speeches at the opening of the congress.

During the congress, 117 oral and 397 poster presentations were held in four different rooms at Seuno Hotel for the following topics in soil science;

I. Soil Biology and Biochemistry
II. Soil Physics & Mechanics
III. Soil Chemistry
IV. Soil Erosion & Conservation
V. Soil Fertility
VI. Soil Pollution & Remediation
VII. Soil Hydrology
VIII. Soil Management & Reclamation
IX. Soil Health & Quality
X. Soil Genesis, Classification & Mapping
XI. Soil Mineralogy & Micromorphology
XII. Geostatistics, Remote Sensing & GIS
XIII. Plant Nutrition & Fertilization


There was an opening cocktail at the end of the first day in Sueno Hotel. It was a nice time for participants to meet and know each other and start new friendships.




The best poster presentations were awarded in the plaque ceremony at the end of the congress.


The standing for the poster competition are
The first place, "*Effects of poultry litter biochar on soil enzyme activities and tomato, pepper and lettuce plants growth*" by **M.Onur Akça**, Turkey; **The second place**, "*Changes of anatomical structures in roots as a response to cadmium accumulation in barley and lettuce plants*" by **Vila Alle**, Latvia; **The third place**, "*Biological activity of soils in sporadic permafrost zone of Western Siberia*" by **Anna Bobrik**, Russia.
Chairmanship of the federation was held by the Soil Science Society of Turkey (SSST) between 2012 and 2015. It was delivered by Dr.Ayten Namlı president of SSST to Dr. Evgeny Shein vice president of the Soil Science Society of Russia.
Appreciation certificates were presented to the section chairs for valuable contributions in the oral presentations.

A photo of all participants together after the closing ceremony of the congress.

Turkish night was in the Sueno Hotel at the last day of the congress.






This proceeding book contains 190 presented papers in the congress. Some presented papers published or will publish Eurasian Journal of Soil Science, Soil-Water Journal, Kazakh Journal of Soil Science and The Journal of Ege University Agricultural Faculty. We hope that this book will be helpful to researchers, students and others interested in soil science and natural resources around the World. We trust that this proceedings will be useful as a source for the state of knowledge and practice of soil science. Finally, we sincerely thank all invited speakers, scientific committee, members, chairmans of scientific sections, authors and participants.

Dr.Rıdvan KIZILKAYA, President of the Congress

Dr.Coşkun GÜLSER, Secretary of the Congress

PREFACE II

Civilization is often influenced by the soil quality and the kinds and quality of plants and animals grown on them. As one of the most important natural resources, soils have almost leaded great civilizations. While soil destruction or mismanagement was associated with the downfall of some civilizations, good soils had helped to build them.

The Soil Science Society of Turkey (SSST) was founded by the leadership of Prof.Dr. Kerim Ömer Çağlar in 1964. The objectives of the SSST are to bring people together to share and support their knowledge, experiences in the soil science. The SSST as a member of the International Union of Soil Science has more than 850 members and organized 21 scientific meetings, national and international levels biennially. The International Symposium series was started with the first meeting "M. Şefik Yeşilsoy Interational Symposium on Arid Region Soil" organized by SSST in 1998. Since then, the SSST has been struggling with national and worldwide problems faced by the producers and researchers through 6 international scientific meetings organized in every two years. The goal of these symposiums stimulates international scientific interactions in soil science. 9th International Soil Science Congress on “The Soul of Soil and Civilization” in Antalya-Turkey, October 14-16, 2014. SSST Board believes that the oral and poster presentations, discussions and recommendations given during this congress will support valuable information to soil scientists for their future activities. We would like to give special thanks to Organizing and Scientific committee for their excellent efforts to develop this Congress and Sueno Hotel, for hosting the Congress and for the immense facilities they have.

As President of of Soil Science Societies (SSST), I am delighted to invite you to Istanbul to participate in the 5th EUROSOIL International Congress that will be held between 17 July and 22 July 2016. We are looking forward to recive participants from all over the world in Istanbul and to help us making all together the congress an unforgettable scientific event and feel the fascinating atmosphere of this world metropolis.

Dr.Ayten Namlı

President, Soil Science Society of Turkey

President, Federation of Eurasian Soil Science Societies

Up to now, all these international meetings organized by SSST are given with date and locations as follows;

8th International Soil Science Congress on “Land Degradation and Challenges in Sustainable Soil Management”

May 15 – 17, 2012
Çeşme, İzmir, Turkey

7th International Soil Science Congress on "Management of Natural Resources to Sustain Soil Health and Quality"

May 26 – 28, 2010
Samsun, Turkey

6th International Meeting on "Soil Fertility and Agroclimatology"

29 October-1 November, 2008
Kuşadası, Aydın, Turkey

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5th International Soil Meeting (ISM) on "Soil Sustaining Life on Earth, Managing Soil and Technology"

May 22-26, 2006
Şanlıurfa, Turkey

4th International Soil Congress (ISC) on "Natural Research Management for Sustainable Devolopment"

June 7-10, 2004
Erzurum, Turkey

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The effects of different organic and inorganic materials on growth of maize plant (*Zea mays L*) under greenhouse conditions

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Abstract

It is well known that the intensive use of chemicals in agricultural production systems causes important environmen problems in both soil quality and human health. Therefore, use of organic fertilizer is so popular and compared to chemi fertilizers for sustainable agriculture. The aim of this study was to investigate the effects of compost and different inorga materials such as ground glauconite, pyrite, rock phosphate and their combinations on growth of maize plant under bo mycorrhizal and nonmycorrhizal conditions. The treatments were control, compost, rock phosphate, glauconite, pyri compost+rock phosphate, compost+glauconite, compost+pyrite, compost+rock phosphate+glauconite, compost+ro phosphate+pyrite, compost+rock phosphate+ glauconite+pyrite. The experiment was carried out under greenhou conditions at University of Çukurova, Faculty of Agriculture, Department of Soil Science and Plant Nutrition. The experime was carried out in the low fertile and with high $CaCO_3$ content Karaburun soil series. In the experiment, shoot dry matt plant diameter, plant length, root dry matter, root length and root infection was determined. The results shown that t application of compost+rock phosphate increased shoot dry matter, plant diameter and plant length compared to oth treatments of maize plant under mycorrhizal conditions. In addition, root dry matter and root length was increased w application of compost+glauconite traetment under nonmycorrhizal conditions. These experiments also shown that generally the mycorrhizal application made a difference between treatments.

Keywords: Organic and inorganic materials, mycorrhizae, maize

Introduction

Thousands of years of evolution in agriculture have shifted with the development of technology and industry, especially in the second half of the twentieth century. The objective of agriculture in 1960-1970s along with rapid population increase was shaped with policies called the green revolution. Yield increase has been the primary objective to feed the increasing population. Irrigation, the use of synthetic chemical pesticides and mineral fertilizers has increased with superior and high-yielding varieties. Negative effects created by these inputs first appeared in developed countries, where these pesticides were intensively used, as a result of which alternative techniques that were developed in the early twentieth century began to be analyzed (Çiçekli and Anaç, 2004). Accordingly, a new production style began to appear as an alternative to conventional

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agriculture. In this system, which developed as in the majority of developed countries as "organic agriculture", gives priority to the use of natural sources in agricultural production to the extent possible (Ortaş and Akpınar, 2006).

While some researchers argue that green revolution methods consisting of diversity of high-yielding plants and animals, mechanized agriculture, synthetic fertilizers and chemical substances are necessary to feed the increasing population (Borlaug, 2000; FAO, 2004), some others argue that these methods decrease biodiversity, increase pesticide resistance, cause greenhouse gases, pollute surface and ground water and increase soil erosion (National Research Council, 1989; Relyea, 2005) and that more sustainable methods should be used for food production in the long term (Tilman et al., 2002; Millennium Ecosystem Assessment, 2005). Intensive agriculture have increased the effectiveness and efficiency of agricultural systems in the past, however, it also had negative effects on the environment (Matson et al., 1997). These problems lead to the idea of conservation of nonrenewable natural resources such as agricultural soils and groundwater and laid the basis for modern agricultural policies (EC, 1999).

There is a growing interest on the use of organic fertilizers around the world due to low soil fertility caused by constant use of chemical fertilizers and potential polluting effects of chemicals on the environment (Das et al., 1991). Combined use of organic and inorganic fertilizers make a greater contribution to the improvement of physical and chemical properties of soil and to increase of soil organic matter; it also improves soil volumetric weight, porosity, soil temperature, field capacity and other soil properties. Therefore, combined used of organic and inorganic fertilizers is effective to improve crop quality, plant development and yield (Zhao and Zhou, 2011). Some other researchers state that combined use of organic and inorganic fertilizers have long term effects on soil fertility and crop yield (Lin and Lin 1985; Xie et al.,, 1987; Chen et al., 1993; Liu et al., 1996).

The use and evaluation of natural fertilizer sources, which are effective in intake of plant nutrient elements by the plants, as fertilizer sources are limited and expensive (Ortaş, 1997) seems possible both for sustainable agricultural production and a clean environment.

Material and Methods

Material

The study was carried out in greenhouses of University of Çukurova, Faculty of Agriculture, Department of Soil Science and Plant Nutrition (Adana-Turkey). Karaburun (Typic Xerorthent) soil in University of Çukurova, Faculty of Agriculture Research and Application Farm land was used for the study. The soil was collected from a depth of 0-20 cm. Some physical and chemical analyses of soils were conducted in University of Çukurova Faculty of Soil Science and Plant Nutrition laboratories according to Güzel et al. (1990). Some physical and chemical properties of soil are presented in Table 1. Maize (*Zea mays L*) which is widely grown in Çukurova region, was used as test plant. G. caledonium (1000 spore/pot) was used as mycorrhiza. Ground glauconite, pyrite, rock phosphate and compost (obtained from research field of Soil Science and Plant Nutrition Department in University of Çukurova, Faculty of Agriculture Research and Application Farm by bulk method with an organic matter content of 17.5%) were used as fertilizer source.

Table 1. Some physical and chemical analysis results of test field soil before planting.

Texture	P_2O_5	K_2O	Organic Matter (%)	pH	$CaCO_3$ (%)	Salt (%)	Fe	Zn	Cu
	(kg ha^{-1})						(mg kg^{-1})		
CL	18.7	620.0	1.3	7.63	17.5	0.025	6.02	0.21	0.53

Methods

The research was designed in three replications under mycorrhizal and nonmycorrhizal conditions in plastic pots with a soil capacity of 5 kg. Test variants were as follows: **0)** Control, **1)** 200 g compost/pot, **2)** 160 g rock phosphate/pot, **3)** 125 g glauconite/pot, **4)** 10 g pyrite/pot, **5)** 200 g compost/pot + 160 g rock phosphate/pot, **6)** 200 g compost/pot + 125 g glauconite /pot, **7)** 200 g compost/pot + 10 g pyrite/pot, **8)** 200 g compost/pot + 160 g rock phosphate /pot + 125 g glauconite/pot, **9)** 200 g compost/pot + 160 g rock phosphate /pot +10 g pyrite /pot, **10)** 200 g compost/pot + 160 g rock phosphate /pot + 125 g glauconite /pot + 10 g pyrite /pot.

As basic fertilization, 3 g N (0.6 g N to 1 kg soil) in urea form was applied to each pot at the stage of plantation and 1 g N (0.2 g N to 1 kg soil) was applied when the plants developed 4 leaves.

Sterilization of Growth Environment

The soil was sterilized in autoclave at 120 ^{0}C and under 2 atmospheric pressure for 2 hours to eliminate harmful pathogens and organisms in the soil and to determine the effectiveness of mycorrhiza spores that will be inoculated.

Determination of mycorrhiza infections

Cleansing and staining procedures of plant roots obtained from the test were conducted according to Koske and Gemma (1989). Stained plant roots were cut in 1 cm length and 10 roots were placed on each microscope slide. The roots were analyzed under microscope with an amplification of 40-100 (Giovanetti and Mossea, 1980).

Statistical Analyses

SAS (Statistical Analysis System) statistical package program was used to evaluate the results of the study. Analysis of variance and Tukey tests were performed.

Results and Discussion

Shoot dry weight, plant diameter, plant length, root dry weight, root length and root infection values of maize plant were determined in the study. These values are presented in Table 1 and Table 2. Findings of the study revealed that the application of compost+rock phosphate under mycorrhizal conditions gave the highest shoot dry eight of maize plant (34.7 g/pot). On the other hand, in nonmycorrhizal conditions, compost+glauconite application gave the highest shoot dry weight (33.6 g/pot). Evaluation of average values showed that mycorrhiza application gave increased shoot dry weight of maize plant at a higher level (28.6 g/pot). Similar to our study, Ülgen and Aksu (1969) and Yurtsever et al. (1967) carried out researches on acidic soils of Trabzon and Rize regions of Turkey and reported that maize yield increase with fine grinded rock phosphate application. Wang et al. (2001) reported that organic and inorganic fertilizers not only increase N that is useful in soil and can be taken by the plants, but also increase maize yield. An evaluation of data in terms of plant diameter of maize plant similarly showed that compost+rock phosphate application gain prominence in mycorrhizal environment with a plant diameter of 6.1 mm. This was followed by compost application with a plant diameter of 6.0 mm, however there was no statistically significant difference. An evaluation of general average values showed that mycorrhizal infection had a higher effect on plant diameter than nonmycorrhizal environment. Ortas and Ustuner (2014) reported that mycorrhizal plants grow faster and look healthier than nonmycorrhizal plants in low-fertile soils. An evaluation of plant length data of maize plant revealed that compost+rock phosphate+glauconite application had the highest effect on plant length in nonmycorrhizal environment (119.9 cm); while compost+rock phosphate application had the highest effect on plant length in mycorrhizal environment (119.4 cm) (Table 1). It is understood from Table 1 that, compost and rock phosphate applications in general significantly affected shoot dry weight, plant diameter and plant length of especially maize plant infected with mycorrhiza when compared to the control. In a study carried out in India, Singh and Reddy (2011) reported that inoculation of *P. oxalicum* fungus together with rock phosphate under field conditions increased plant length and biomass of maize plant when compared to the control.

An evaluation of Table 2 in terms of root dry weight, root length and root infection of maize plant revealed that compost and compost+glauconite application, with no statistical difference, increased root dry matter weight of plant the most when compared to the control (1.6 g) with a dry weight of 10.5 g. On the other hand, an evaluation of general averages showed that mycorrhiza inoculation had a higher effect on root dry weight (6.4 g). Data on root length showed that compost+rock phosphate+glauconite+pyrite application significantly increased root length of maize plant when compared to the control (1280.1 mm). This application was followed by compost+glauconite application in nonmycorrhizal environment with a root length of 1276.2 mm. Dev (1998) compared different ratios of pyrite and rock phosphate application in three different plant environments with triple-superphosphate and other sulfur sources and reported that combined use of pyrite and rock phosphate can be practically recommended.

Table 1. The effects of different organic and inorganic materials on root dry weight, root length and root infection of maize plant

	Shoot Dry Weight (g)			Plant Diameter (mm)			Plant Length (cm)		
Applications	-M	+M	Average	-M	+M	Average	-M	+M	Average
0	14.1 ±2.3 c	28.2 ±4.1 c-e	21.1 CD	3.9 ±0.5 cd	4.8 ±0.7 bc	4.33 CD	93.5 ±10.2 c	114.0 ± 5.5 a	103.7 AB
1	25.1 ±7.0 b	32.5 ±3.2 a-c	28.7 AB	5.2 ±0.4 ab	6.0 ±0.5 a	5.63 A	102.4± 9.2 bc	110.0 ±9.4 a	106.2 A
2	5.1 ±2.2 d	24.0 ±1.8 ef	14.5 E	2.5 ±0.7 e	4.9 ±0.4 bc	3.70 D	65.5 ±7.3 d	112.3 ±14.1 a	88.9 C
3	8.3 ±1.4 cd	22.7 ±3.4 f	15.5 DE	3.4 ±0.2 de	4.1 ±0.6 c	3.78 D	72.7 ±2.5 d	109.9 ±10.0 a	91.3 BC
4	6.2 ±4.1 d	25.5 ±2.7 d-f	15.8 DE	3.0 ±1.1 de	4.8 ±0.6 bc	3.89 D	65.8 ±12.6 d	108.9 ±11.8 a	87.4 C
5	27.1 ±4.8 ab	34.7 ±3.4 a	30.9 AB	4.7 ±0.5 a-c	6.1 ±0.4 a	5.43 AB	108.8 ±7.3 a-c	119.4 ±5.8 a	114.1 A
6	33.6 ±1.9 a	33.5 ±2.0 ab	33.5 A	4.9 ±0.8 ab	5.3 ±0.7 ab	5.13 AB	106.7± 6.3 a-c	116.2 ±3.2 a	111.4 A
7	28.7 ±1.7 ab	30.0 ±3.0 a-d	29.3 AB	5.1 ±0.4 ab	5.4 ±0.3 ab	5.23 AB	110.0 ±5.0 a-c	112.5 ± 4.7 a	111.2 A
8	25.3 ±3.1 b	26.6 ±0.7 d-f	25.9 BC	4.5 ±0.3 bc	5.3 ±0.5 ab	4.90 BC	119.9 ± 9.6 a	110.2 ±5.3 a	115.0 A
9	26.3 ±4.1 b	27.5 ±3.0 d-f	26.8 BC	4.5 ±0.3 bc	5.5 ±0.4 ab	4.99 A-C	105.1± 6.2 a-c	110.9 ±5.4 a	108.0 A
10	29.0 ±4.4 ab	29.7 ±0.8 b-d	29.3 AB	5.5 ±0.4 a	5.6 ±0.3 ab	5.53 AB	110.1 ±18.4 ab	117.1± 10.2 a	113.6 A
Average	20.8 B	28.6 A		4.30 B	5.25 A		96.40 B	112.85 A	

P<0.05

Table 2. The effects of different organic and inorganic materials on shoot dry weight, plant diameter and plant length of maize plant

	Root Dry Weight (g)			Root Length (mm)			Root Infection (%)		
Applications	-M	+M	Average	-M	+M	Average	-M	+M	Average
0	1.6 ±0.2 e	6.4 ±1.4 cd	3.96 BC	897.9 ±97.1 a-c	1008.7 ±300.0 ab	953.3 AB	10 ±1.0 ab	87 ±0.6 ab	48 AB
1	10.5 ±0.9 a	8.5 ±1.1 ab	9.49 A	1113.8 ±497.1 a	913.6 ±382.4 ab	1013.7 AB	17 ±0.6 a	90 ± 1.0 a	53 A
2	0.4 ±0.1 e	3.5 ±0.5 ef	1.98 C	560.4 ±57.2 bc	780.8 ±320.1 ab	670.6 BC	7 ±0.6 ab	80 ±1.0 a-c	43 AB
3	0.9 ±0.1 e	3.2 ±0.4 f	2.06 C	533.2 ±82.9 c	683.3 ±330.3 b	608.2 C	0 ±0.0 b	90 ±1.0 a	45 AB
4	1.0 ±0.5 e	4.7 ±1.9 e-f	2.84 C	572.5 ±239.8 bc	798.6 ±194.7 ab	685.5 BC	17 ±0.6 a	77 ±0.6 a-c	47 AB
5	8.5 ±0.9 bc	9.4 ±1.1 a	8.95 A	1185.6 ±295.1 a	1255.0 ± 152.1 a	1120.3 A	10 ±1.0 ab	63 ±2.1 bc	37 B
6	10.5 ±1.4 a	7.6 ±1.1 a-c	9.07 A	1276.2 ±468.3 a	832.4 ±314.3 ab	1054.3 A	17 ±0.6 a	60 ±2.0 c	38 B
7	9.1 ±2.9 a- c	6.6 ±1.5 b-d	7.86 A	1034.1 ±360.4 ab	830.0 ±134.0 ab	932.1 A-C	7 ±0.6 ab	63 ±2.3 bc	35 B
8	5.7 ±1.3 d	5.3 ±0.4 de	5.50 B	968.1 ±189.0 a-c	810.1 ±356.3 ab	889.1 A-C	7 ±0.6 ab	73 ±1.5 a-c	40 AB
9	7.7 ±1.2 c	7.8 ±0.9 a-c	7.76 A	1108.0 ±223.6 a	1122.1 ±514.5 ab	1115.1 A	13 ±0.6 a	83 ±1.5 a-c	48 AB
10	9.0 ±0.6 a-c	7.5 ±1.4 a-c	8.28 A	1130.8 ±323.0 a	1280.1 ±291.9 a	1205.5 A	10 ±1.0 ab	87 ±1.5 ab	48 AB
Average	5.9 A	6.4 A		943.68 A	937.70 A		10.4 B	77.5 A	

In a similar study it was found that the use of pyrite can be an important agricultural strategy to increase the effectiveness of P, Fe and Zn in luminous soil to improve agricultural areas (Addy et al., 1987; Jeffrey, 1987). Root infection, on the other hand, was found to be at the highest level in compost and glauconite application in plants that were infected with mycorrhiza (90%). While average infection level was 77.5% in maize plants that were infected with mycorrhiza, it was 10.4%in plants that were not infected with mycorrhiza.

Conclusion

A general evaluation of our findings showed that organic and inorganic materials such as rock phosphate, glauconite and compost significantly contributed to plant yield and plant growth when they are used alone or in combination. Furthermore, we found that organic and inorganic materials have a higher effect on plant growth and plant yield when they are applied with fungus like mycorrhiza.

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References

Addy, S., K., Sing, A., Sing, R., Awasthi C.,P., 1987. Effect of pyrite and fertilizer on rice protein quality. International Rice Research Newsletter V.12 (3) P: 44-45.

Borlaug, N.E., 2000. Ending world hunger: the promise of biotechnology and the threat of antiscience zealotry. Plant Physiology 124:487–490.

Chen, L.Z., Zhang, M.S.Z., Cao, W.D., Wang, J.Y., Guo, Y.I., 1993. Studies on Growing Crops Used for Both Green Manure and Forage and Their Comprehensive Benefits. Soil and Fertilizers, Beijing, No.4, 147.

Çiçekli, M., Anaç, D., 2004. Organik Tarımda Toprak Verimliliği, Yönetmelikler ve Yeni Yaklaşımlar.

Das, M., Singh, B.P., Ram, M., Prasad, R.N., 1991. Response of Maize (*Zea mays*) to Phosphorus-enriched Manure Grown in P-deficient AIE Isols on Terraced Land in Meghalaya. Indian J. Agric. Sci, 61: 383-388.

Dev, G., 1998. Use of phosphate rock in food grain production under irrigated and rainfed conditions in India. Nutrient Management for Sustainable Crop Production in Asia, 149-358.

EC, 1999. Council regulation (EC) No. 1257/1999 of 17 May 1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF) and amending and repealing certain Regulations. Official Journal of the European Communities L160, 80–102.

Food and Agriculture Organization of the United Nations., 2004. The state of food and agriculture. 2003–2004. Agriculture Series No. 35. Food and Agriculture Organization of the United Nations, Rome.

Güzel, N., Gülüt, K.Y., Ortaş, İ. ve İbrikçi, H. 1990. Toprak verimlilik analiz yöntemleri laboratuar el kitabı. Ç.Ü. Ziraat Fakültesi Yayınları. NO:117. Adana.

Koske, R.E., Gemma, J. N., 1989. A modified procedure for staining roots to detect VAM. Mycological Research 92, 486-505.

Lin, B., Lin, J.X., 1985. A Located Experiment on the Combined Application of Organic Manure and Chemical Fertilizer. Chinese J. Soil Fert., 5: 22-27.

Liu, X.L., Gol, Z., Liu, C.S., 1996. Effects of Combined Application of Organic Manure and Fertilizer on Crop Yield and Soil Fertility in a Located Experiment. ACTA Pedologia Sinica, 33: 138-147.

Matson, P.A., Parton, W.J., Power, A.G., Swift, M.J., 1997. Agricultural intensification and ecosystem properties. Science 277, 504–509.

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: Synthesis. Island Press. Washington. DC.

National Research Council., 1989. Alternative Agriculture.National Academy Press. Washington. DC.

Ortas, I., Akpinar, C., 2006. Response of kidney bean to arbuscular mycorrhizal inoculation and mycorrhizal dependency in P and Zn deficient soils. Acta Agriculturae Scandinavica, Section B - Plant Soil Science. 56; 101–109.

Ortas, I., Ustuner, O., 2014. Determination of different growth media and various mycorrhizae species on citrus growth and nutrient uptake. Scientia Horticulturae 166, 84–90.

Ortaş, İ., 1997. Mikoriza nedir?. TUBİTAK Dergisi. Şubat 1997, Sayı 351. Ankara.

Relyea, R.A., 2005. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities.Ecological Applications 15:618–627.

Singh, H., Reddy, M.S., 2011. Effect of inoculation with phosphate solubilizing fungus on growth and nutrient uptake of wheat and maize plants fertilized with rock phosphate in alkaline soils. European Journal of Soil Biology, 47, 30-34.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor R., Polasky, S., 2002. Agricultural sustainability and intensive production practices. Nature 418:671–677.

Ülgen, N., Aksu, S., 1969. Kaya fosfatı ile süperfosfatın karşılaştırmalı verim araştırmaları. Toprak ve Gübre Araştırma Enstitüsü Raporları Serisi. No: 6, 218-222.

Wang, X.B., Cia, D.X., Hand,g, J.Z.Z., 2001. Land Application of Organic and Inorganic Fertilizer for Corn in Dry Land Forming in a Region of North China. In: Sustaining Global Farm. 10th International Soil Conversation Organization, Meeting held May 24-29, pp:419-422.

Xie, C.T., Yan, H.J., Xu, J.X., 1987. The Effect of Organic Manure on Improvement of Alkali-saline Soil. Chinese J. Soil Sci., 18: 97-99.

Yurtsever, N., Yürür, B., Tezer, G. 1967. Kaya fosfatlarının gübre değeri araştırmaları. Toprak ve Gübre Araştırma Enstitüsü Araştırma Raporları No: 5 380-385.

Zhao, J., Zhou, L., 2011. Combined Application of Organic and Inorganic Fertilizers on Black Soil Fertility and Maize Yield. Journal of Northeast Agricultural University (English Edition). Vol. 18, No. 2, 24-29.

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Fertility of irrigated dark chestnut soils in long-term application of mineral fertilizers in the South East of Kazakhstan

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Abstract

One of the key factors in conservation of soil fertility and increase of crop productivity is rational and efficient use of fertilizers, taking into account the biological needs of the plants and availability of soil mineral elements. World experience of production and application of mineral fertilizers in different regions of the globe shows that fertilizer ensures the conservation of soil fertility, increase of crop productivity and harvesting of 50% additional yield. In this regard, relevant research area is the improvement of existing methods and techniques to increase soil fertility in cropping. Our soil observations were carried out on irrigated dark chestnut soils of the south-east of Kazakhstan, on which more than 60 years vegetable crops are grown in conditions of the intensive vegetable crop rotation. The purpose of research – is scientific assurance of conservation and reproduction of soil fertility and development of methods of rational use of natural resources. The obtained results of conducted soil studies have shown that dark chestnut soils in southeast of Kazakhstan have undergone significant changes during the long period of use in irrigated land cultivation. Parameters of soil fertility (agrochemical, agro physical, biological properties) are largely determined by types crop rotation and systems of fertilizer application. In general, the studies were conducted of the patterns of changes in soil nutrient status - intensive vegetable crop rotation in long-term use of fertilizers, income of mineral nutrients of crops in vegetable crop rotation and their removal depending on the duration of application of fertilizers on irrigated dark chestnut soils of the south- east of Kazakhstan.

Keywords: soil, soil fertility, mineral fertilizers, nutrient stocks, removal of nutrients

Introduction

Long-term use of agricultural land in Kazakhstan resulted in the decline of soil fertility, which currently requires urgent development of activities on contributing to its recovery. Regulation of soil fertility is linked with deep comprehensive study of their properties under the influence of various factors, in particular, weather conditions, agro-technical practices of cultivation, irrigation, use of fertilizers, crop rotations and other activities.

Material and Methods

Research works were carried out in accordance with the following classical methods adopted in soil science and agricultural chemistry, crop production (vegetable growing): In spring, summer and autumn for determining soil condition of the studied fields, samples on depth of 0-20; 20-40; 40-60 cm were selected in

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dynamics. Soil samples were collected by method of continuous columns on soil horizons, including plowing and sub-plowing horizons. Following chemical analyzes have been done: granulometric composition by pipette method with pretreatment by sodium pyrophosphate (Grabarov's modification), humus - by Tyurin, total nitrogen – by Kjeldahl, hydrolysable nitrogen - by Tyurin-Kononova, gross phosphorus - by Ginzburg and Shcheglova, mobile phosphorus - by Machigin in Grabarov modification with subsequent determination on spectrophotometer, gross forms of potassium according to Smith, mobile forms of potassium on Machigin in Grabarov's modification with subsequent determination on flame photometer FLAPHO 4 (1981), pH – by potentiometric (ionomer laboratory I-160 MI) CO_2 – by calciometer.

Results and Discussion

The issue of ensuring high and stable level of fertility and bio-productivity of primary source of agricultural production - soil, by its importance and relevance is a priority and requires a systematic application of scientifically justified use of agrochemicals. Application of fertilizers is one of the main means of intensification of agricultural production and allows not only increase yields of crops every year, but also to increase soil fertility. The latter is particularly important, as soil fertility in Kazakhstan has significantly decreased due to reduced doses of fertilizers since the 90s of the last century. In this regard, the study of plant nutrition and interaction between plant, soil and fertilizer will help to solve many practical objectives of fertilizer application. Our soil observations were carried out on irrigated dark chestnut soils of the south-east of Kazakhstan, on which vegetable crops are grown in conditions of intensive vegetable crop rotation more than 60 years.

Soil and soil-forming rock

Dark chestnut soils in central part of the Trans-Ili Alatau are spread in the sub-mount and pre-mount plains of mountain range, where they are formed mainly on strong loess-like loams. Dark chestnut soils are characterized with average humus concentration (3-5%) and nitrogen (0.2-0.3%) in the upper horizon, with a wide ratio of organic carbon and nitrogen (C: N = 10-12). In depth these indicators are gradually reducing. In the group composition of humus in foothill dark chestnut soils, prevail humic acid, correlation between humic and fulvic acids is higher than 1, and in the depth is leveled. Total amount of absorbed bases of the upper horizons is not high - 20-30 m-eq per 100 g soil. Absorbing complex is basically saturated with calcium (75-85%). On mechanical composition the soils are mainly medium-and heavy loam. Virgin dark chestnut soils are mainly located in the sites with obvious hilly-ridged, ridge- slope terrain forms, sometimes with very steep slopes, therefore they are not used in land cultivation. These soils on loess are the main bulk of lands used for land cultivation, and in irrigation they may be used for cultivation of various crops. Soil-forming processes depend on granulometric, macro-and micro aggregate soil composition. Structure, permeability, capillarity, absorption capacity, soil resistance to tillage, soil ability for self-cleaning in pollution - all these soil properties depend on its granulometric composition and first of all, determine the level of soil fertility. On granulometric composition, according to Kaczynski classification, the investigated irrigated dark chestnut soils on the experimental plot, are medium-and heavy loam (Table 1).

Results of soil studies on investigating nutrient status change patterns in crop rotations in long-term use of fertilizers, intake of mineral nutrients of vegetable crop rotation are given below (Table 2). According to agrochemical characteristics of irrigated dark chestnut soils, it was recorded that on virgin soils, humus composition ranges within 3.04% decreasing in depth to 1.52%. Studied dark chestnut soils in the experimental site contain humus almost 1.5 times less than virgin soil. Maximum humus composition is recorded in the upper layers of soil profile. More uniform distribution of humus in the profile on experimental plots, can probably caused by irrigation and soil-forming processes on the sites previously planned for irrigation farming. According to agrochemical characteristics an insignificant difference in composition of mobile forms of nutrients is observed in the upper layers of natural background: hydrolyzable nitrogen58.8, phosphorus 69, potassium exchange 310, in experimental field respectively 44.8, 22 and 340 mg/kg. According to mobile phosphorus composition, explored soils refer to highly secured soils. In addition to increased phosphorus, and potassium accumulation observed in experimental fields. High level of exchangeable potassium in the soil of experimental field is due to a high concentration of gross potassium in soil, and under intensive farming they transfer into available forms. Application of potash fertilizers also replenishes the amount of exchangeable potassium in soil.

Table 1. Granulometric composition of irrigated dark-chestnut soils

№ п/п	Depth of taking samples, cm	Abs. Dry part, %	Fraction composition in % in absolutely dry soil						
			Fraction sizes in mm						
			Sand		Dust			Silt	Physical clay <0,01
			1,0-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	
Virgin									
1	0-20 см	2,0	-	5,7	58,1	8,3	19,0	8,9	36,2
2	20-40 см	2,0	-	2,1	59,6	12,5	17,7	8,7	38,9
3	40-60 см	1,8	-	1,6	58,6	10,5	17,3	12,00	39,8
Natural background-control									
4	0-20 см	2,7	2,1	20,5	30,4	23,8	2,0	20,9	46,9
5	20-40 см	2,5	0,3	17,2	33,6	16,8	10,2	21,7	48,8
6	40-60 см	2,3	0,0	13,5	33,2	20,5	12,7	20,0	53,2
Experimental field (natural background $+N_{90}P_{120}K_{90}$)									
7	0-20 см	1,6	-	16,1	44,2	17,7	8,3	13,7	39,7
8	20-40 см	1,8	-	8,6	47,4	16,3	15,0	12,7	44,0
9	40-60 см	1,4	-	12,6	44,6	12,9	15,3	14,6	42,8

Table 2. Agrochemical characteristics of irrigated dark-chestnut soil

Depth, cm	Humus, %	Gross forms			Mobile forms			Co^2, %	pH
		N	P_2O_5	K_2o	N	P_2O_5	K_2o		
Virgin									
0-20 см	3,04	0,22	0,20	2,85	42	10	376	0,25	7,1
20-40 см	2,11	0,17	0,16	3,0	39	6	252	1,25	7,5
40-60 см	1,52	0,13	0,21	2,85	40	7	393	4,44	8,0
Natural background-control									
0-20 см	1,89	0,126	0,22	1,5	58,8	69	310	4,33	8,39
20-40 см	1,62	0,098	0,21	1,81	50,4	60	300	6,39	8,44
40-60 см	0,76	0,084	0,21	1,5	39,2	63	290	10,6	8,49
Experimental field (natural background $+N_{90}P_{120}K_{90}$)									
0-20 см	2,27	0,14	0,198	2,19	44,8	22	340	2,6	8,26
20-40 см	1,55	0,098	0,16	1,87	36,4	19	190	6,33	8,32
40-60 см	0,52	0,07	0,1	2,05	28	10	120	4,23	8,48

Soil humus is basic and most important part of organic matter. Published data on the effects of mineral (nitrogen) fertilizers on intensity of humus transformation processes are contradictory. So the work of many scientists (Smirnov and Muravin ,1977, Sokolov et al., 1983) show that application of fertilizers enhances mineralization of soil organic matter, while other evidence suggests that under the influence of nitrogen fertilizers the intensity of humus transformation processes decreases (Demkina, 1991). At the same time there is evidence (Evdokimov et al., 1991) that application of nitrogen fertilizer results in the decrease of the efficiency of use of carbon substrate and increase of respiration of soil microorganisms. Avdeev and Boyko T.A. (1991) believe that nitrogen fertilizers stimulate humus mineralization.

The role of mineral fertilizers in increasing humus concentration in soil until recent period, was considered from positive side. However, in recent years there is a re-evaluation of their value. More often experts have expressed doubts about the possibility of increasing the concentration of organic matter due to application of mineral fertilizers. Moreover, they can cause depletion of soil humus.

For comparative characteristics (Table 3) of the effect of the long-term use of fertilizers in different years of research we have presented data on the following criteria: total humus, gross forms of nitrogen, phosphorus and potassium.

Table 3. Impact of long-term application of mineral fertilizers on changing of main soil fertility indices

Years of research	pH	Humus	Gross forms, %		
		%	N	P_2O_5	K_2O
Virgin (1961-1963)	7,9	3,09	0,22	0,20	2,85
Experimental field (1981-1985)	8,1	3,0	0,16	0,25	2,94
Experimental field (2001 -2005)	8,3	2,0	0,13	0,20	2,25
Experimental field (2012-2014)	8,2	1,89	0,13	0,22	1,53

According to research data we can say that humus concentration in the period of researches 1981- 2014 decreased to 61.2%. According to other indicators, a similar decrease is observed. However, researcher Saparov from Kazakhstan [2004] noted the increase of mobile forms of nutrients. This is due to long-term use of mineral fertilizers on experimental plots, which increases the amount of easy hydrolysable nitrogen and phosphorus compounds accessible for the plants and enriches in water-soluble, hydrophilic organic substances, mobile humus fractions, increases humus activity. However, there are a number of studies conducted in Russia and in foreign countries, which show that long term use of fertilizers into soil is not safe, due to the concentration of certain amounts of heavy metal impurities. These findings are confirmed by the research data obtained by us in 2012-2014, in which the excess of MPC on lead, nickel (maximum permissible concentration) on experimental plots has been observed, which requires constant monitoring of the level of intake, maintenance and removal of heavy metals. Thus, the analysis of the mentioned data indicates a multilateral impact of mineral fertilizers on soil properties. So, the basis of land cultivation is the fertility of arable soils, its preservation and reproduction. In the process of agricultural use of irrigated dark chestnut soils in the foothills of Ile Alatau, there is observed a progressive decline of humus reserves, deterioration of its qualitative composition, transformation of nutrient elements into inaccessible form, which results in reduction of the sustainability and decrease of productivity of agroecosystems. In this regard, it is needed to search for new approaches and solutions related to the study of the possibility of preservation and reproduction of soil fertility by involving renewable natural resources, symbiotically fixed atmospheric nitrogen, green manure, by-products. It is needed to understand in different way the role of crop rotations and crops in formation of soil fertility and environment formation and the ability to maximize the accumulation of biogenic resources and facilitate their transformation in such direction which will provide optimal productivity and sustainability of agro-ecosystems.

Conclusion

In studying the effect of long-term use of fertilizers on soil fertility it was observed the decrease of the levels of total humus to 61.2%, however concentration of mobile forms of nitrogen, phosphorus and potassium increase due to fertilizer application. We have also fixed the excess of MPC of lead and nickel in general by 20-30%. Based on these results we can conclude that long-term use of fertilizers in the comparative analyses of virgin land and experimental plots in irrigated dark chestnut soils results in a progressive decline of total humus, transformation of nutrients into inaccessible forms, which results in weakening of sustainability and reduction of productivity of ecosystems.

References

1. Smirnov P.M., Muravin E.A., 1977. Agrochemistry, Moscow, pp. 240.
2. Sokolov O.A., Semenov V.M., Silkina N.P., 1983. Behavior of nitrogen in the outbreak in localization of nitrogen fertilizers. Soil science 12. 25-35.
3. Demkina T.S., 1991. Dynamics of microbiological parameters of mineralization of soil organic matter. Agrochemicals 8. pp. 65-73.
4. Evdokimov I.V., Blagodatsky S.A., Larionov A.A. and others, 1991. Turnover rate of soil microbial biomass depending on the dose of nitrogen fertilizer. Agrochemicals 12. pp. 49-56.
5. Avdeev T.N., Boyko T.A., 1991. Role of fertilizers in changing of the composition and humus balance of alluvial soils used in intensive vegetable growing. Scientific bases of optimization reproduction of fertility of alluvial soil s in black soil zone of the RSFSR. Scientific papers of Soil Institute V.V. Dokuchaev. Moscow. 68-80
6. Saparov G.A., 2004. Optimizing of fertility in foothill dark chestnut soils in Trans Ili Alatau in vegetable crop rotations. Dissert. for PhD degree. Almaty, pp.123.

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Pyrogenesis and automorphic soil formation in continental taiga of Northeast Asia

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Abstract

Until recently, the understanding of pedogenesis of mountain-taiga soils in the continental Northeast Asia, which is based on permanent transformation of parent rock into zonal soil, was accepted without consideration of active influence of pyrogenesis. Thus, the whole complex of soil processes and events caused by wildfires was not considered. In general, we agree with concepts that consider fire as primarily anthropogenic factor, which is closely related to human activity. During thousands of years wildfires accompanied soil formation in the continental part of Northeast Asia and exerted decisive influence on the processes of soil formation. The influence of pyrogenesis becomes apparent during the period when zonal vegetation is eradicated and successional stages of regeneration are formed through temporary forms of phytocoenoses. It leads to interruption of pedogenesis which is continued on a new cover of diluvium deposits, washed off from a watershed surface and covering partially or completely cut surface of humus horizons of primary soils. Thus, in the absence of covering glaciation, automorphic soils with polycyclic profile are formed, which are composed of two or sometimes three degraded humus horizons with plenty of embedded charcoal. This indicates that soils pass 2-3 stages of zonal pedogenesis during the period of their development, which typically lasts for 2-2.5 thousand years. The scale, high frequency and versatile effects of pyrogenesis allow us to consider it as a subfactor of soil formation especially in humic continental regions of the permafrost zone.

Keywords: pyrogenesis, cryogenic soils, permafrost.

Introduction

Many studies have addressed the question of pyrogenic activity in soils (Arefieva, 1963; Khrenova, 1963; Firsova, 1969; Grishin, 1973; Sapozhnikov, 1973, Popova, 1977, 1986; Johnson, 1990 and others). Taking together the results of these studies, performed on forest soils of non-permafrost regions, one can conclude that following changes typically occur in this type of soils:

- increased mineralization of organic matter in forest floor and decreased acidity of soils due to accumulation of soluble compounds of alkaline-earth metals on soil surface and in its lower horizons;
- uneven accumulation of flammable matter in forest, as well as uneven fires lead to formation of synusial or parcel structure of soil cover, which retain differences in physical and chemical properties, nutritive status and dynamics of biological activity for 4 years. The highest amount of ash accumulates on soil surface after the burn of fallen trees, when redox potential shifts to oxidative, and pH becomes slightly alkaline.
- changing in hydrothermal and nutritive regime of soils, i.e. increasing of content of mobile compounds of

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N, P and K;
- changing in biological and enzymatic activity of soils, i.e. increasing of respiration levels, microbiological content as well as increasing catalase and urease activity after fires of weak and average intensity that do not cause drastic loss of organic matter in the upper layers of soil. In contrast, the decrease in biological activity is observed after severe ground fires, when organic matter of soils burns out;
- formation of specific bumpy microrelief caused by post-fire windfalls that leads to heterogeneity in physical and chemical properties of hills and depressions.

The indicated changes that occur during the post-fire period are also typical for forest soils of the permafrost area, however, here they are largely depend on the relief because of the permafrost, which has a great impact on soil climate and its hydrological characteristics.

Many authors indicate that the destruction of vegetation cover increases soil temperature and therefore results in melting down of the permafrost that leads to increased moistening of the burnt-out sites (Savvinov, 1976; Pozdnyakov, 1986; Tarabukina and Savvinov, 1990; Timofeev et al., 1994; Evdokimenko, 1996; Quirk and Sykes, 1971; Rouse and Mills, 1977). The moistening is mostly contributed by melting of the segregation ice trapped in the upper soil horizons, located above the permafrost. During the first years after fire, such changes may lead to swamping of the territory or even to the formation of collapsed lake ecosystem, which further evolves into "alas" (thermokarst lake).

Thus, there are many studies describing pyrogenic activities in forests and related post-fire changes in soil properties. However, in these studies only selected properties (features) of certain types of soil have been examined. Moreover, these tests covered post-fire changes in vegetation during only the first years of a single seral period, which usually lasts for 50-80 years. Also, the assessment of the effect of pyrogenic factor on soil cover and its properties was primarily made considering its anthropogenic origin.

Material and Methods

Our studies have been carried out in the territory of Southern Yakutia spanning within the coordinates 120°-132°E and 56°-60° N (Figure 1). Southern Yakutia is characterized by cold and humid climate, prevailing taiga vegetation, mountainous terrain with mountains of low and average height and discontinuous distribution of permafrost. These peculiarities favor eluvial processes in soils throughout the region and formation of podzolic soils.

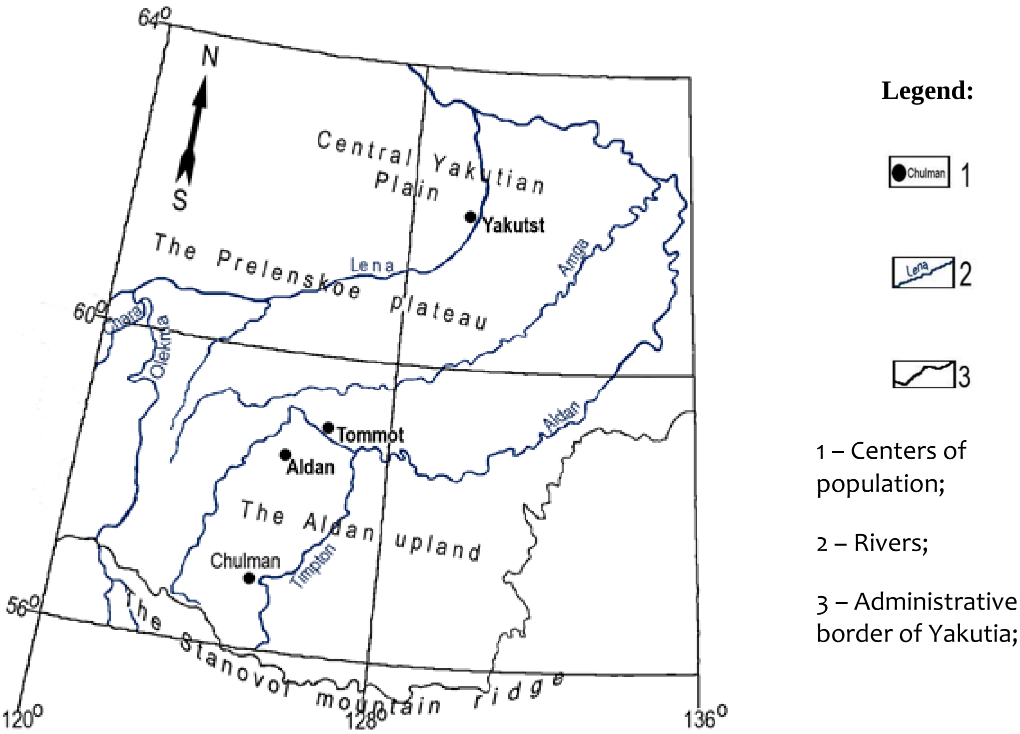


Figure 1. The map of the studied territory

In regard to geographical zoning of soils of Russia (Dobrovolsky and Urusevskaya, 2004), the major part of the studied territory belongs to Prialdan Mountain Province of East-Siberian taiga region which is characterized by the dominance of podzolic brown and frozen mountain taiga soils.
Considering the huge effect of wild fires on content, properties and regime of automorphic soils of permafrost regions, we have suggested the term "Pyrogenesis", which describes the processes and activities that occur in natural landscape in response to wildfire (Chevychelov, 2002).
In this study we have used many different methods commonly utilized in this kind of studies including: comparative geographical, profile-genetic and comparative analytical studies of geographical distribution, content and properties of zonal soils. We also used specific methods, such as micromorphologic and radiocarbon analyses (Rode, 1971; Dobrovolsky, 1983; Rozanov, 1983; Chichagova, 1985). The evolution of soils was studied in relation to other components of the biogeocenosis.

Results and Discussion

According to Sherbakov, 1975; Melehov, 1981; Spurr and Barnes, 1984; Pozdnyakov, 1986; Valendik, 1996; Matveev, 2006 and other authors, a wildfire is viewed as a regular natural ecological factor. We define pyrogenesis as a global subfactor that accompany soil formation in continental taiga territory during thousands of years of earth history.
In conditions of humid and acutely continental climate of southern Yakutia one can observe the unevenness in watering during seasonal and perennial cycles that result in establishing of fire hazardous environment in forest phytocenoses. The periods with high risk of fires occur every 15-20 years, while two consecutive years with high chance fires alternate every 33 years. The years with minimal watering occur once in a century.
In climatic seasonal cycle of the territory the driest period coincide with the period of frequent thunderstorms (Figure 2) as a result, thunderstorms without precipitations frequently occur during this period. The south of Yakutia is characterized by frequent thunderstorms (15-18 days per year), which are the major cause of wildfires in the territory (75% of wildfires are caused by dry thunderstorms).

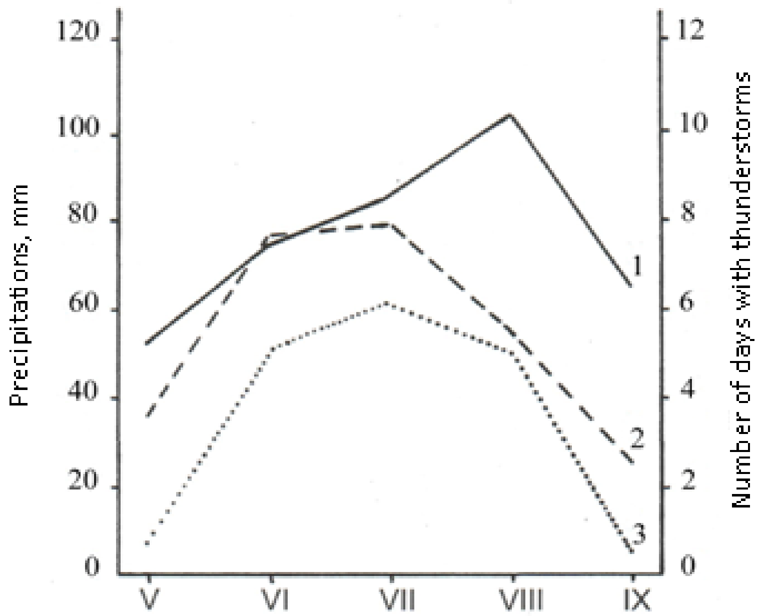


Figure 2. Seasonal variation of: precipitation levels (1), saturation deficiency (2) and the frequency of thunderstorms (3) in southern Yakutia according to Aldan weather station.

The biological turnover in forests of southern Yakutia is very slow, and characterized by low and average productivity that lead to accumulation of significant amount of flammable material, such as thick layer of plant litter, dead standing and fallen trees.
Mosses and, to a greater extent, lichens make up the major part of flammable materials in soil cover. Moreover, they dry very fast and can become flammable on 2^{nd} -3^{rd} day after a rainfall. According to the

classification suggested by N.P. Kurbatsky in 1970, lichens and plant litter are classified as fire conductors of the 1st type, and they make up 37-62% of total flammable material in soil (Table 1).
The abundance of tectonic clefts in the bedrock as well as the presence of the network of cryogenic clefts in drainage surfaces and slopes of rocky eluvium soil, favors collapsed and ultracollapsed filtration of soil. Moreover, plant liter and other organic layers of soil typically do not become completely saturated with atmospheric water due to short period of contact, and rapidly dry after precipitations, reaching its flammable state very fast.

Table 1. Stock and content of fire conductors in forests of Southern Yakutia (under line-tones per hectare, below line – %)

Type of forest	Lichens	Mosses	Twigs	Plant litter	Total
Pine forest with cowberry and lichen, 150 years	6,52 44	1,54 10	1,16 8	5,70 38	14,92 100
Larch forest with cowberry and lichen, 140 years	9,68 35	-	3,16 12	14,50 53	27,34 100
Pine-larch mixed forest with cowberry and lichen, 165 years	1,62 13	0,46 4	2,54 20	7,80 63	12,42 100
Larch-spruce mixed forest with cowberry and moss, 120 years	2,02 5	10,68 25	4,16 10	25,34 60	42,20 100

The average annual number of wildfires in southern Yakutia is around 200, however this number can be two or three times higher in some years. The analysis of the burnt-out areas and age structure of the forests suggests that the territory experience wildfires at least once in 120 years. However, woods growing in dry habitats experience fire more frequently (every 10-15 years). The territories with average humidity burn 2-3 times during one generation of trees, i.e. every 60-70 years, while forests growing in the areas with high humidity experience fires once in 100-150 years.
The morphological analysis of random samples of automorphic soil taken from the studied territory (Table 2), have shown that in 70-80% cases they have pyrogenic features such as embedded charcoal in humus and lower horizons of soil. Considering landscape and climatic features of southern Yakutia the studied territory should be classified as a territory of active pyrogenesis.

Table 2. The Occurrence of pyrogenic features of soils of southern Yakutia (according to descriptions of Tyulina, 1962)

Phytocenosis	Number of studied soils	Including soils with pyrogenic features	
Flood-plain forest	5	2	40 %
Mountain larch forest	5	4	80 %
Pine forest	12	10	83 %
Ayian spruce forest	3	3	100 %
Erman's birch forest	2	2	100 %
Total	27	21	78 %

Due to the active influence of pyrogenesis in the territory of southern Yakutia, the upper layers of soil continuously experience the influence of subsoil during the evolution. This influence does not stop even during formation of differentiated, in terms of content and properties, automorphic soils.
Such influence lies in continuous embedding of new portions of pedogenic rocks into the active zone where soil formation processes take place, which ultimately lead to the maximum intra- and interzonal lithogenic divergence of pedogenesis within the studied territory.
New soil horizons are laid down within the old ones, and after the change in humus formation processes the polygenicity of soil formation is observed (Sokolov, 1993). As a result, complex profiles of zonal soils are formed. The latter is observed in their morphological structure, properties and composition (Table 3, 4). Bellow we describe two soil sections located in the territory of Southern Yakutia.

The section was made in the valley of the Uchur River in Aldan-Uchur ridge, on the southeastern slope of the watershed with 10° steepness, at the absolute height of 700 m, in birch-alder-cedar mixed forest with sedge and cowberry.

Table 3. Gross composition of soils of Southern Yakutia, % per calcined sample

Horizon	Depth, cm	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	$\frac{SiO_2}{R_2O_3}$
Brown soil, section 16-89 TU							
A	2-9	68,08	17,70	8,29	2,89	2,96	5,1
B	15-25	61,79	19,73	7,60	2,63	2,52	4,3
[A]	30-40	61,33	17,77	9,96	2,35	2,87	4,4
[B]	45-55	63,41	17,03	8,37	2,28	2,89	4,8
[A]	51-57	56,78	20,74	12,33	1,98	2,75	3,4
CD	60-70	60,13	18,83	10,30	1,71	2,86	4,2
D	granite	63,79	16,26	6,68	4,22	3,03	5,3
Muck-calcareous soil, section 23-89A							
Ah	4-8	65,01	11,81	10,33	7,80	2,45	6,4
B	8-14	67,90	4,86	5,78	19,02	0,74	12,6
Cca	14-24	13,44	1,11	1,16	65,51	18,15	11,0
[ACca]	26-36	36,21	5,44	3,13	38,29	11,91	8,6
[A]	36-39	66,04	6,10	4,59	13,95	0,67	12,2
[Bca]	39-43	37,10	4,73	2,00	47,29	6,08	10,3
Cca	59-69	13,82	1,06	1,03	62,16	21,33	11,6
D	limestone	11,29	0,87	0,87	69,62	16,69	12,7

Horizon A0, 0-2 cm. Dark-brown, loose and wet forest litter, generally composed of weakly and averagely decomposed plant and leaf litter, has a gradual transition.

A, 2-9 cm. Grayish-dark-brown, unstructured, light-loamy, slightly wet with inclusion of large black charcoal from the surface, the transition is distinct.

Among micro-aggregates of fine earth there are some brown particles of weathered crystal rock of different hardness which consists of pulverescent and sand grains and clay. The clay material is fine-dispersed, presumably composed of hydromica and associated with iron hydroxides and humus. The larger particles contain microzones of carbonized brownish-black humus. The particles of fine earth are pierced through with fungal hyphae, sometimes they include small ball-shaped feces of soil fauna and fungal bodies. It is also rich in different plant residues of different stage of decomposition: fresh, decolorized and decomposed with layers of carbonized humus. Skeleton grains are mostly composed of shredded crystal rocks, including quartz, feldspars, weathered mica and other minerals. And among new formations Fe-Mn micro-concretions are observed.

B, 9-29 cm. Cinnamon-brown, crumbly- pulverescent, medium-sized loam, slightly wet with spots of grey humus, penetrated with roots of herbaceous plants, has vertical fissures along roots and individual large tree roots.

This layer is microaggregated, with a predominance of fine-dispersed clay-iron-humus microaggregates, with occurrence of fine earth particles of 0.3-0.5 mm in size. The grains of the skeleton are weathered, among minerals, quartz and feldspar prevail. Plant residues also occur, however in significantly lesser amount than in the upper horizon. There are also fungal hyphae and Fe-Mn-micro-concretions.

[A], 29-43 cm. The color is heterogeneous, cinnamon-brown with grey interlayers and large spots of humus, with inclusions of black charcoal, it is unstructured, slightly wet and loamy, with distinct transition.

Its microaggregates are of different composition and color, among them the most distinctive are light-yellow clay-iron, brown iron-humus-clay, black clay-humus and black with brown tint-iron-clay-humus. The aggregates have more plant residues as compared to those of overlying B horizon, which are usually carbonized, however one may find some fresh ones of different stage of decomposition. The layer is also rich in detrital minerals as well as feldspars, which are highly weathered. Among new formations Fe-Mn micro-concretions are found.

[B], 43-51 cm. Cinnamon-light brown, unstructured, sabulous, slightly wet with inclusions of black charcoal and granite gruss. The transition is visible.

The horizon is slightly microaggregated and represents anisomerous weakly weathered sandy loam. Clay material covers detrital mineral grains, replacing feldspars. Individual small particles of charcoal are present, skeleton grains are represented by fragments of quartz-feldspar rock with occasional Fe-Mn-micro-concretions. According to peculiarities of microstructure and mineral composition this horizon represents clay-anisomerous sand, which is a product of redeposited eluvial residual soil, slightly affected by soil formation.

[A], 51-57 cm. Dark-grey, unstructured, sabulous, slightly wet, with inclusions of black charcoal and granite gruss, transition is vivid.

Microaggregated, highly humic, contains brownish and pale yellow particles. The aggregates are of different size and color: black clay-humic, brown iron-clay, beige-brown iron-humic-clay. Plant residues are mostly carbonized, although there are fresh thin rootlets and fungal hyphae along aggregates and micro-concretions. The fragmental mineral grains are strongly weathered. The surface of rock debris, quartz grains and feldspars is heavily corroded, with fissures filled with iron-clay material. The occurrence of Fe-Mn- micro-concretions is higher than in all overlying horizons.

CD, 57-72 cm. Brownish-cinamonic, unstructured, loamy, weakly moistened, with inclusion of crushed rock and granite-gneisses blocks on the lower border of the layer.

It is mostly represented by brown-pale pulverescent microaggregates of iron-humic-clay composition, with mixture of fragmented quartz-feldspar grains. Plant material is mostly represented by charry residues and rare fresh inclusions. Skeleton grains are generally consist of fragments of weathered quartz-feldspar rocks with the abundance of Fe-Mn micro-concretions. By microstructural characteristics and composition this horizon resembles the overlying horizon B.

Soil: Brown soil.

In general, the studied soil was developed on unstable slope with deluvium deposits. The post-fire intensification of trans-accumulative slope processes is defined by the amount of inwashed carbonized wood residues. According to microstructural pattern, humus horizons of the third and second soil layers are younger (less mature) as compared to underlying humus horizon A, where increased content of exogenous organic material is observed.

The major morphological characteristics of this soil:

1. The composition of skeleton grains of the primary minerals in all layers of the examined profile is homogeneous and represented by quartz-feldspar with different degree of weathering throughout the profile. Thus, this soil is formed on homogenous autochthonic deposits.
2. The horizons A and BC of the lower soil profile (layer) are more weathered according to the description of their skeleton composition as compared to overlying mineral horizons.
3. Moreover, these horizons are more mature, which is based upon the structure of grains of the primary minerals and on the maximum content of new formations (Fe-Mn-micro-concretions).

Considering this, one may conclude that this soil profile represents unconcordant vertical bedding of soil mass due to the effect of removal-redeposition of soil-eluvium during the post-fire phases of soil development, when partial destruction and burial of more weathered and mature soil horizons by less weathered fine earth, took place. Consequently newer (less mature) part of soil profile was formed during to the next phase of soil formation.

Soil section 23-89A is located 25 km from the city of Aldan, along the Amur-Yakutia highway, and stands 200 meters to the side of it. It is located in the upper part of the gentle slope between the Orto-Saloy River and the Amurskiy Creek, on the elevation of approximately 1050 m above sea level. Surrounding vegetation is represented by Siberian dwarf pine and Siberian fir forest with mixture of grasses and mosses.

A0, 0-4 cm. Dark brown, loose and wet forest litter, generally composed of weakly and averagely decomposed plant and leaf litter, has a gradual transition.

Ah, 4-8 cm. Dark grey, organic-mineral, has no define structure due to the abundance of small roots and plant residues. The layer is pierced through with dense web of plant roots, the transition is vivid.

B, 8-14 cm. Brownish light grey in color, loose and cloddy, loamy sand. Its grey tongues with inclusions of humus penetrate into the next layer, the transition is distinctive.

Cca, 14-24 cm. Whitish with small ocherous spots of iron, unstructured and sabulous. React with HCl with strong bubble formation. The transition to the next layer is vivid by color and granulometric composition.

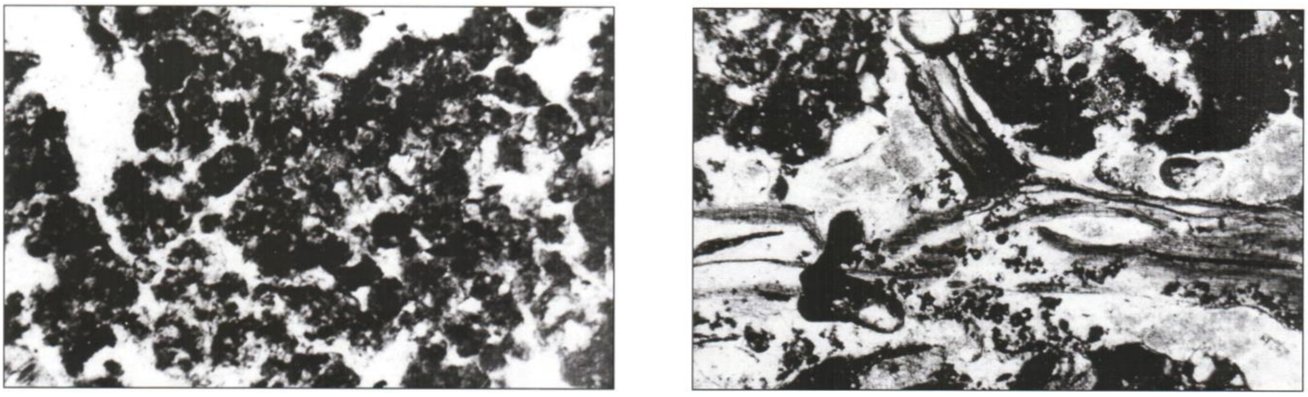
[ACca], 24-36 cm. Light brown, loose and cloddy, sabulous with small grey spots of humus and inclusions of black charcoals. React with HCl with average bubble formation, the transition is vivid.
[A], 36-39 cm. Dark grey, unstructured and sabulous with inclusions of black charcoals, the transition is vivid.
[Bca], 39-43 cm. Light brown, loose and cloddy, sabulous. React with HCl with average bubble formation. Layer transition is distinctive.
Cca, 43-92 cm. Light grey, consist of strongly weathered limestone with sabulous filling of the same composition as of the previous horizon. The amount of broken stone significantly increase towards the bottom. Actively react with HCl.
Soil type: Muck-calcareous soil.

Table 4. Chemical properties and physicochemical characteristics of soils of Southern Yakutia

Horizon	Depth,	pH		Humus,	Nitrogen,	Fractions, %		Carbonate
	cm	H_2O	KCl	%	%	< 0,01 mm	< 0,001 mm	CO_2, %
Brown soil, section 16-89 TU								
A	2-9	5,1	4,1	17,3	0,54	27,4	13,6	-***
B	15-25	5,4	4,2	7,5	0,28	34,0	16,9	-
[A]	30-40	5,2	4,1	14,7*	0,40	28,6	13,8	-
[B]	41-49	5,6	4,2	3,7	0,10	15,3	9,3	-
[A]	49-55	5,2	4,3	32,2*	0,90	20,7	10,3	-
CD	60-70	5,7	4,3	8,7	0,29	33,9	17,3	-
Muck-calcareous soil, section 23-89A								
Ah	4-8	6,7	6,2	45,8**	0,81	-	-	3,2
B	8-14	7,4	7,0	4,3	0,50	12,2	1,2	0,4
Cca	14-24	7,8	7,2	traces	0,01	4,1	0,2	48,1
[ACca]	26-36	7,8	7,0	1,7	0,06	17,9	0,4	16,2
[A]	36-39	7,8	7,2	6,9*	0,18	18,2	0,9	3,8
[Bca]	39-43	7,9	7,1	0,9	0,04	12,4	0,8	17,4
Cca	59-69	8,8	8,3	traces	0,01	4,2	0,4	43,3

*Buried organic material. **Loss amount during calcinations. *** Not detected.

There are two distinct forms of diagnostics of pyrogenesis in soil: the explicit and hidden. With the explicit diagnostics, soils with one, two, and sometimes three buried degraded post-fire humus horizons with embedded black charcoals are revealed in soil cover and in trans-accumulative facies of the territory.
The examined pedones (Tables 3, 4) are attributed to the automorphic types of pedogenesis developing on autochthonic deposits. This is confirmed first of all by the similarity of molecular ratios SiO_2:R_2O_3 that was observed in soil profiles and pedogenic rock, as well as in the adjacent horizons along with similar content of silicon, aluminium and iron oxides in the mineral horizons (B,BC). The apparent stratified structure of profiles of the examined soils, the presence of buried post-fire humus horizons (Table 4), and other soil indices, including humus content, buried organic material, gross N and stratification of their granulometric composition are also indicatives of this type of pedogenesis.
In eluvial and trans-eluvial facies of the landscapes within the studied area there are soils with normal (also known as monocyclic) type of profile structure, in which the effects of pyrogenesis are detected in hidden form, i.e. as some micro-morphological peculiarities of soil horizons B (BC) (Figure 3).



a b

Figure 3. Microphotographs of sections of typical pale-brown soil :
a) humus-clay microaggregates in horizon BC, x 112 b) large plant residue with excrements of soil fauna in horizon BC,x28

This fact indicates that they passed the stage of humus horizon development earlier, or that the humus profile of primary soil was partially washed away. The micromorphological peculiarities of these horizons include: a) well-defined microaggregation, i.e. sponge-like microstructure; b) occurrence of iron-humus-clay microaggregates and inclusions of decomposed organic material in clay plasma; c) presence of thin biogenic pores (root canals); d) increased leachability (weathering) and better distribution of skeleton grains as compared to overlying horizons.

Radiocarbon age of the lower humus horizon of the studied brown soil was estimated as 2075±160 years. Within this period, the soil has passed through three cycles of zonal soil formation with an average frequency of 600 years (Table 5).

The comparison of radiocarbon data obtained from samples of buried post-fire humus of the brown soil with that of sod-podzolic soils with double humus horizon, which were taken from Russian Plain and western Siberia, and formed during xeromorphic phase of Middle Holocene, showed that brown soil is less mature. This proves, that pyrogenesis is a frequent and regular natural subfactor of soil formation.

Table 5. Radiocarbon age of humus horizons of brown soil (section 16-89TU)

Horizon	Depth, cm	Age, years	Sample ID	Dated material
A	2-9	840±260	COAH-3098	I+II Fr.GK
[A]	30-40	1470±145	COAH-3099	-"-
[A]	51-57	2075±160	COAH-3100	-"-

Until recently, these types of soils have been listed neither in Russian soil classification database (2004 edition) nor in the world reference base for soil resources (WRB). Thus, we have preliminary attributed soils with similar profile to the group of pyrogenic soils.

Conclusion

Until recently, the understanding of soil formation processes in mountain-taiga of continental Northeast Asia was based on the notion of continuous development of soil-forming rock into zonal soil. However, this notion did not consider the active effect of pyrogenesis, which is the combination of processes and effects occurring in natural landscapes under the influence of fire.

We believe that the major influence of pyrogenesis consist in destroying zonal vegetation and initiating the succession stages of its restoration, through the temporal forms of phytocenoses, influencing biological cycle (its capacity and chemism) in soil-phytocenosis system that differs from its initial state.

Also, there is a pause in the process of soil formation that continues later on in the new cover of "fresh" deposits, washed off from the surface of watersheds and covering partially or completely peeled off humus or it's underneath horizons of primary soils. Thus, in the absence of covering glaciation, here, the automorphic soils with polycyclic profiles are formed. These soils enclose two, or sometimes three, degraded humus horizons with abundant embedding of black charcoals. This indicates that within the period of its development, usually 2-2.5 thousand years, the soil passes 2-3 stages of zonal soil formation. In soils with monocyclic profile the effect of pyrogenesis is detected in hidden form, as a sponge-like microstructure and formation of humus-clay micro-aggregates in clay plasma of soil horizons.

Because of this, during the short period of zonal soil formation cycle (500-700 years) the initial soil eluvium usually does not acquire the shape of zonal podzolic soils, formed on mature sialytic residual soil. In this case the formation of podzolic soil usually stops at the stage of non-podzolized detrital fersiallithic soil eluvium (sub brown soils), separated in time by individual characteristics of natural landscapes.

Thus, in our opinion, all automorphic soils of continental Northeast Asia, and especially those on the permafrost area experience the influence of pyrogenesis. The scale, high frequency and versatile effects of pyrogenesis allow us to consider it as a subfactor of soil formation in continental taiga, which combine different types of soil formations.

References

Arefieva, Z., 1963. The effect of fire on certain biochemical processes in forest soils. Soils and hydrological regime of Ural forests. Proceedings of Sverdlovsk Biological Institute 36, 29-38.

Chevychelov, A., 2002. Pyrogenesis and post-pyrogenic transformations of properties and composition of permafrost soils. Siberian Ecological Journal. 3, 273-277.

Chichagova, O., 1985. Radiocarbon dating of humus soils. Nauka, Moscow.

Classification and identification of soils of Russia. 2004. Oykumena, Smolensk.

Dobrovolsky, G., Dobrovolsky, V., Romashkevich, A., Gerasimova, M., Tursina, T., 1983. Soil micromorphology. MSU publishing, Moscow.

Dobrovolsky, V., Urusevskaya, I., 2004. Geography of soils. MSU, Kolos Publishing, Moscow.

Evdokimenko, M., 1996. Post-fire dynamics of microclimate and hydrothermic regime of permafrost soils in larch forests of Stanovoi Ridge. Siberian Ecological Journal. 1, 73-81.

Firsova, V., 1969. Forest soils in Sverdlovsk region and their change under the influence of forestry activities, Proceedings of Sverdlovsk Institute of Animal and Plant Ecology 63, 152.

Grishin, I., 1973. The effect of wildfires on soil properties of Priamurie oak forests. Geographical issues of Russian Far East 2, 62-175.

Johnson, D., 1990. Biomantle evolution and the redistribution of earth materials and artifacts. Soil Sci. 2, 84-102.

Khrenova, G., 1963. The effect of fire on microflora of forest soils in Pripyshmin pine forests of Zauralie. Soils and hydrological regime of Ural forests. Proceedings of Sverdlovsk Biological Institute 36, 57-66.

Kurbatsky, N., 1970. A study of quantity and properties of combustible materials in forest. Issues of forest pyrology. Krasnoyarsk, 5-59.

Matveev, P., 2006. The effect of wildfires on larch biogeocenoses in the permafrost area. Siberian Technical University press, Krasnoyarsk.

Melekhov, I., 1981. Fire effect on forests. Leningrad, Nauka.

Popova, E., 1977. The effect of fires on microrelief formation and properties of forest soils. The forests of Middle Priangarie. Nauka, Novosibirsk, 53-67.

Popova, E., 1986. The effect of fires on the pattern of soil cover in pine forests. Soils of pine forests in Siberia. Krasnoyarsk, 63-70.

Pozdnyakov, L., 1986. Forest management in permafrost area. Nauka, Novosibirsk.

Quirk, W., Sykes, D., 1971. White spruce stingers in a firepatterned landscape in inner Alaska. Proc.Symp. “Fire in the northern environment”. Portland, Oregon, 179-197.

Rode, A., 1971. System of research method in soil science. Nauka, Novosibirsk, 92.

Rouse, W., Mills, P., 1977. A classification of fire effects on the microclimate of forest and tundra ecosystems (final report). Environmental Studies. Department of Indian and Northern Affairs. Ottava. 2, 21.

Rozanov, B., 1983. Soil Morphology. MSU publishing, Moscow.

Sapozhnikov, A., 1973. The role of pyrogenic processes in formation of forest biogeocenoses. The results of forest management and biogeocenological studies, 32-34.

Savvinov, D., 1976. Hydrothermic regime in permafrost zone. Nauka, Novosibirsk.

Sherbakov, I., 1975. Forests of northeastern USSR. Nauka, Novosibirsk.

Sokolov, I., 1993. Theoretical issues of genetic soil science. Nauka, Novosibirsk.

Spurr, C., Barnes, B., 1984. Forest ecology. Forest Industry, Moscow.

Tarabukina, V., Savvinov, D., 1990. The influence of fire on permafrost soils. Nauka, Novosibirsk.

Timofeev, P., Isaev, A., Sherbakov, I., Shurduk, I., Volotovsky, K., Boychenko, A., Medvedeva, N., Mikhalyova, L., Sitnikov, N., 1994. Middle taiga forests of Yakutia. Ya. SC. SB RAS, Yakutsk.

Tyulina, L., 1962. Forest vegetation of Middle and Lower parts of the Uchur basin. Acad. of Sci. USSR, Moscow, Leningrad.

Valendic, E., 1996. Ecological aspects of forest fires in Siberia. Sib. Ecol. Journal. 1, 1-8.

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The study of nitrate contamination in spinach vegetation farms in Iran

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Abstract

In the recent years, in order to enhance agriculture products, the producers, in Iran, have tended to use increasingly chemical fertilizers, in particular, nitrogen rather than taking advantage of state of the art knowledge. The purpose of present study is to examine the nitrate amount in the two highly use plants, i.e. spinach at the vegetable farms of Dezful city. The sampling of the farms at third zone of Dezful was conducted randomly through three consecutive pickings from first, middle and last rows during morning. The samples was dried in an oven at 70°C and powdered by a mill. Next, a spectrophotometer device read their nitrates. In order to compare the mean and standard deviation, the nitrate concentration in the tested samples in the three zones was studied by employing Duncan test at 5% level using spss 18. The results showed that the highest nitrate amounts in the tested samples of the three farms were 2128 mg/kg of fresh weight in the Spinach. Thus, there was no significant difference. The amount of 51.85 % of the Spinach were exceeded the standard limit. (1000 mg/kg of fresh weight).

Keywords: Vegetation farms, spinach, nitrate contamination.

Introduction

In recent years, agricultural products producers in country have increased excessive using of chemical fertilizers including azotic fertilizers per acre instead of reaping benefits of new agriculture knowledge for more production. Imagination of increasing performance caused by more increasing use of water and chemical fertilizers in some areas of the country has caused excessive use of water and fertilizers sources, so that continuing this manner in addition to financial damage and intensifying imbalance of nutritious elements in soil, created serious dangers relative to water and soil pollution. In recent years more attention has paid to nitrate absorption by plants in various countries. Also, some of countries have determined permitted range for nitrate concentration in edible plants especially vegetables. Performed researches in Iran about this topic is very few and owing to being high of using vegetables in our country, this matter should be take in to account more (Sobhan ardakani et al., 2005).

Vegetables are important ingredients of a good and healthy diet and obtained results of past researches confirm that using healthy and hygienic Vegetables can prevent heart disease and some kinds of cancers especially cancers of digestive system (Salehipur bavarsad et al., 2011). Amount and the way of distributing nitrate in Vegetables are very important. It affects their health and quality (Tuzel et al., 2001). Suggested amount of using greens and fruits by world health organization is 400 g per day (Hord et al., 2009). Meanwhile excessive use of nitrogen fertilizers, which has a direct connection with absorption and

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accumulating nitrate in plants, is of great interest (Kazemi posht masari et al., 2010). Major form of absorbing nitrogen by plants is in the form of nitrate (Baibordi et al., 2004). Nitrate is one of the most important nitrogen sources for plants use, which is naturally available in soil, water, plants, shallow water, hayloft, agricultural products, weed, and animal tissue and could be added to the soil through using dung or chemical fertilizer. In general, nitrate is one of the common produced compounds through direct use or oxidation of Azote chemical fertilizers and by available microorganisms in the soil, which has a high absorption by plants. When the concentration of nitrate in soil is high, plants can absorb it more than their metabolic needs and gather it in cytoplasm and special vacuoles of cell especially at night. Being high of nitrate in usable organs of vegetables and fodder and in drinking water can cause kinds of poisonings in domesticated animals, and anemia (methmoglobinemia) in infants and create a carcinogenic substance named Nitrosamine in adults.

Spinach with scientific name *Spinacea Oleracea L.* is one of the important vegetable of *beet* family. Spinach is native of central regions of Asia and probably Iran (Kallo and Bergh, 1993; Kawazu Okimura et al., 2003) which have been planted for more than 2000 years (Salunkhe and Kadam, 1998; Daneshvar, 2000; Rubatzky and Yamaguchi, 1997).

Spinach is one of the most important leafy vegetables which has a high nutritional value and its subtle leaves and stems are used freshly (Salunkhe et al., 1991). So that among 42 kinds of fruits and vegetables Spinach from perspective of relative amount of 10 types of vitamins and minerals is in the second grade of importance (Salunkhe et al., 1991) Spinach is a rich resource of minerals and vitamins especially vitamin C (Kawazu Okimura et al., 2003). Spinach is full of Calcium and Ferro, which its Calcium is in the form of Escalated Calcium that is not accessible (Salunkhe and Kadam, 1998). Spinach seed has sedative properties and has an important role in decreasing fever and decreasing inflammation of intestine and gastritis. Seed of this plant is antifebrile because of having high amount of muslin. There are compounds in Spinach which are antibacterial. This plant contains compounds called folic acid that is very useful for curing anemia (Singh et al., 1997)

Material and Methods

From studied farms a random sample of primary cultured was picked to form a composite sample and also from the middle row and from the last row of the agricultural land, which totally 3 samples were taken from every land. In this research, for the preparation of desired sample, edible parts of Spinach organs were sampled. Sampling was done at 5 o'clock in the morning, and then the samples were transferred to laboratory. After transferring samples to the laboratory they were washed with distilled water and after chopping they were air-dried for 48 hours and with measuring wet weight of samples (First sample vessel was weighted and then the vessel was weighted along with the sample), they were dried at temperature 70 °C, and after weighting dry weight, they were powdered using an electric mill. A spectrophotometer was used for measuring nitrate.

Preparing nitrosulfusalicylic complex and reading it using a spectrophotometer:

Important properties of this method are: simplicity, low equipment and other existing ion's don't interference with plant tissues, high speed and wide domain of measurement. Salicylic acid in close proximity to nitrate produces nitro salicylic acid, the color of this combination is yellow- lemon- colored. Intensity of yellow-lemon- colored depends on the amount of nitrate in the plant tissue. This color has maximum absorption at wavelength of 410 nm. In general, this method is more used for measuring nitrate in samples with high concentration (about 3%).

First, 0.1 g of dried Avon and powdered is weighted and 10 ml distilled water is added to it, and after closing the containers, they will be kept at temperature 45 °C for an hour, then samples will be centrifuged at speed of 1000 rpm (or instead active coal and wattman defecator paper can be used to filtrate the extracts).

0.2 ml was taken from obtained extract through this method and 0.8 ml sulphosalicylic acid 5% was added to that. After cooling, 19 ml normal soda 2 was added to this mixture and severity of produced color at wavelength 410 nm was observed by spectrophotometer. It is obvious that for observing extracted samples, first, a standard concentration of 5-300 mg/l nitrate azote must be prepared using dry Potassium nitrate salt and unknown samples could be observed with respect to that. The results of decomposing samples with use of software SPSS18 and comparing averages with use of Duncan test and amount of nitrate by T test with allowed amounts were compared and analyzed. Also, diagrams are drawn by software Excel.

Results and Discussion

With respect to table 2, it has observed that in all three studied farms of Dezful average amount of nitrate is more than allowed that this probability is at level of 0.01. Comparing averages of three farms based on Duncan test showed that there's no meaningful difference between three farms from perspective of amount of nitrate in dried matter. Difference between amount of nitrate in dry matter and wet matter of this product could be observed from table 1. Table 1 shows that there is a high difference between fresh Spinach and dry Spinach product. So it's better to use fresh Spinach.

Table 1. Comparison of average concentration of nitrate in dry matter and wet matter and allowed amount of nitrate concentration in Spinach

Vegetable	Average concentration of nitrate in dry matter (mg kg^{-1})	Average concentration of nitrate in wet matter (mg kg^{-1})	Allowed amount of nitrate concentration
Spinach	11746	1080	300

Table 2. Comparison between measured concentration of nitrate and allowed amount of nitrate in Spinach

Studied area	Number of Spinach samples	Range of measured amounts (mg kg^{-1})	Average nitrate concentration in dry matter of Spinach (mg kg^{-1})	Average nitrate concentration in wet matter of Spinach (mg kg^{-1})	Comparing average amount with allowed amount of 300
1	9	5580-28027	11428.78	850	**
2	9	4548-16014	10255.56	1102.56	**
3	9	6656-34392	13553.44	1289.22	**

** Indicates statistically significant difference in probability level of 1% in Duncan test.

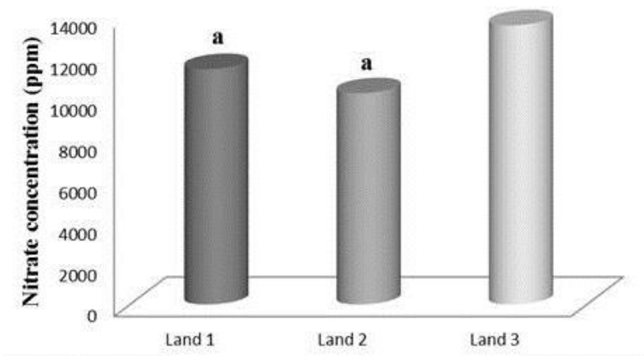

Figure 1. Comparison of average of nitrate in dry matter of Spinach between three farms.

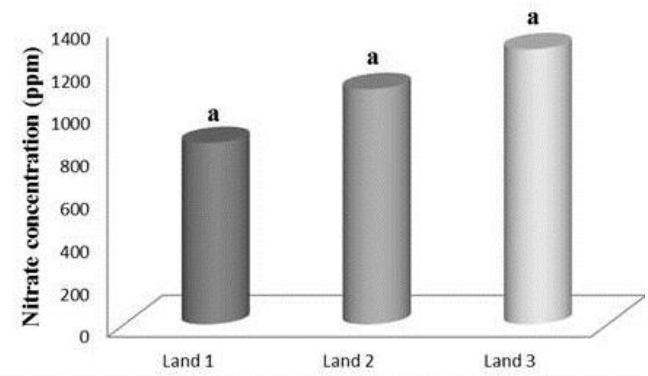

Figure 2. Comparison of average of nitrate in wet matter of Spinach between three farms.

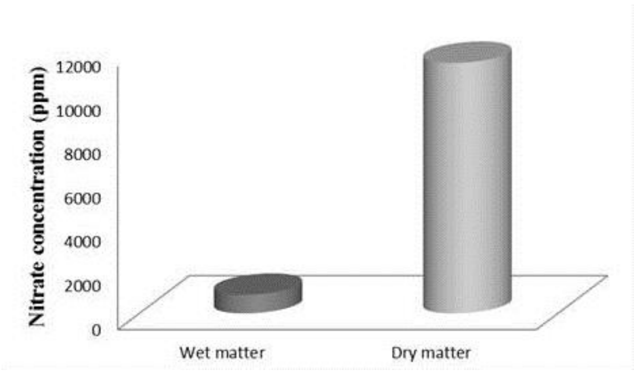

Figure 3. Comparison of average of nitrate in dry and wet matter of Spinach in farm 1.

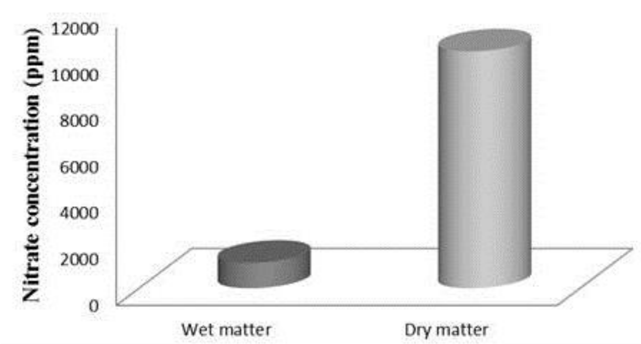

Figure 4. Comparison of average of nitrate in dry and wet matter of Spinach in farm 2.

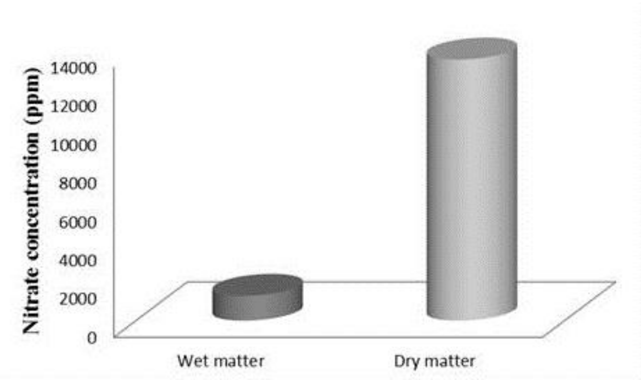

Figure 5. Comparison of average of nitrate in dry and wet matter of Spinach in farm 3.

Conclusion

The average amount of nitrate in all three farms of Spinach is more than allowed amount (300 mg/kg fresh weight), and amount of nitrate in 100% of Spinach samples is more than standard amount. With respect to standard amount of nitrate in vegetables, allowed amount per kg of body weight, is determined lower than 3.65 mg per day (Jafari et al., 2000). If a person with weight of 70 kg used Spinach in his/her diet in Dezful, he/she shouldn't use more than 236.5 g in a day with respect to average amount of nitrate in all three farms (1080 mg/kg fresh weight), cause with using this amount needed amount of nitrate is prepared in the body and using more than this amount can cause adverse effects and disorders in the body. Sampling is done at 8 am or at the time of sunrise in other resources. However, in these research samplings was done at 5 am and coincide with cropping vegetables by farmer and sending it to fruits and vegetables grounds. One of reasons of changings of nitrate with light is dependency of redactaz nitrate enzyme on light spectrum changes (Mohr et al., 1992). Although, there is no light limitation in our country, with changing wavelength of light we can investigate its effects on nitrate metabolism. The effect of light on decreasing nitrate concentration is reported by various researchers (Mortesen and Stromme, 1987; Mohr et al., 1992). It seems that intensity of the light has an important effect on decreasing amount of nitrate. Therefore, farmers shouldn't harvest vegetables before sunrise. One of the reasons of increasing excessive amount of nitrate in these farms is harvesting vegetables some hours before sunrise. It's suggested to harvest vegetables in the afternoon so that this action could be effective in decreasing nitrate in vegetables. Therefore, efforts must be done to decrease amount of nitrate in vegetables especially for those who use vegetables very much in their diet.

References

Salehipoor Bavarsad, M., Ghorbani, M., Afyuni, M., & Kheirabadi, H. 2011. The Concentration of Lead, Nickel and Zinc in Some Vegetables of Isfahan Province. The Twelfth Congress of Iran Soil Science, Tabrzi, September 3rd to 5th.

Kazemi Poshtmesari, H., Kazemi, S., & Afshari, A. 2010. The Investigation of the effect of Consolidated Management of Nitrogen fertilizer, Bio-fertilizer and Manure on Nitrate Accumulation and Nutritious Elements in Lettuce Biomass in Mazandaran Province, the First National Conference on Agriculture and Sustainable Development, Opportunities and Challenges, Islamic Azad University, Shiraz Braqnch, March 10th and 11th, 194-207.

Baibordi, A., Tabatabaei, J., & Malakooti, M. 2004. Optimal Use of Fertilizers as an Effective Step in Increasing the Performance, Improving the Quality and Reducing Pollution in Vegetable Products and Improving the Health in Society, Publication of Applied Agricultural Sciences, 338 pp.

Sobhan Ardakani, S., Shayesteh, K., Afyuni, M. & Mahbubi Sofiani, N. 2005. Nitrate Concentration in Some of the Plant Products in Isfahan, Journal of Ecology, 37, 69-76.

Daneshvar, H., 2000. Vegetable Growth, Shahid Chamran University of Ahvaz Publications, 190, 461 pp.

Tuzel, I.H., Tuze, Y., Gul, A., Meric, M.K., Yavu, O., Eltez, R.Z., 2001. Comparison of open and closed systems on yield, water and nutrient consumption and their environmental impact. International; Society for Horticultural Science. 554:221-228.

Jafari, R.A., Farzan, A., Aziz zadeh. 2000. [The amount of nitrate and nitrite in some vegetables produced in Esfahan city (Persian)]. Research in Medical Sciences.; 123-6.

Hord, N.G., Tang, Y., Bryan, N., Jul, S. 2009. Food sources of nitrates and nitrites. The physiologic context for potential health benefits. AM Journal clin Nutr. 90(1) pp. 1-10.

Kallo, G., Bergh, B.O., 1993. Genetic Improvement of Vegetable Crop. Percamon Press. 833 pp.

Kawazu Okimura, Y.M., Ishii, T., Yui, S., 2003. Varietals and seasonal difference in oxalate content of spinach. Scientia Horticulturae 97:203-210.

Salunkhe, D.K., Kadam, S.S., 1998. Handbook of Vegetable Science and Technology: Production, Composition, Storage and Processing. Marcel Dekker, INC, 721 PP.

Rubatzky, V.E., Yamaguchi, M., 1997. World Vegetables, Principles, Production and Nutritive Values. Chapman and Hall. 843 PP.

Salunkhe, D.K., Bilon, H.R., Reddy, N.R., 1991. Storage, Processing and Nutritional Quality of Fruits Vegetables. Vol 1. CRC Press, Boca Raton. 285 PP.

Singh, V., Pande, P.C., Jain, D. K., 1997. A Text Book of Botany, Angiosperms. Rastogi Publications, India.

Mohr, H., A. Neininger, B. Seith. 1992. Control of nitrate reductase and nitrite reductase gene expression by light, nitrate and plasidic factor. Bota Acta, 105: 81-89.

Mortesen, L.M., E. Stromme, 1987. Effects of light quality on some greenhouse crops. Scientia Horti., 33:27- 36.

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Studying the nitrate contamination in Parsley farms in Iran

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Abstract

The accumulation of nitrate in the agriculture products, especially vegetables, water and foods is one of those factors that exposes the people health and hygiene in particular the neonates to the risk. The purpose of present study is to examine the nitrate amount in the highly use plants, i.e. parsley at the vegetable farms of Dezful city. The sampling of the farms at third zone of Dezful was conducted randomly through three consecutive pickings from first, middle and last rows during morning. The samples was dried in an oven at 70°C and powdered by a mill. Next, a spectrophotometer device read their nitrates. In order to compare the mean and standard deviation, the nitrate concentration in the tested samples in the three zones was studied by employing Duncan test at 5% level using SPSS 18 package. The results showed that the highest nitrate amounts in the tested samples of the three farms were 10295 mg/kg of fresh weight in the parsley. Thus, there was no significant difference. All the parsley samples were beyond standard limit (500 mg/kg of fresh weight).

Keywords: Nitrate, spectrophotometer, Parsley, Dezful.

Introduction

Today reaching to a stable agriculture is of interest for all policy-makers, programmers, and researchers and correct and suitable use of agricultural characteristics specially all types of fertilizers is one of the most important ways in the direction of policies of stable agriculture development. In fact, stable agriculture is producing enough foodstuffs with high quality accompanied with protecting environment health (Malakuti et al., 2004). With respect to increasing population growth in Iran, demand for foodstuffs is more increasing. So that it is common in most places to use chemical and organic fertilizers to produce more product in unite of area. Using too much of chemical substances causes many problems economically and environmentally (Malakuti, 1999). Today relationship of plant feeding management with environmental solution is an important aspect in suggesting every fertilizer. New fertilizer suggestions should optimize performance and quality of plant and minimize the possibility of environmental effects caused by excessive fertilizing (Sadeghipur marvi, 2011).

Protecting human's health has a close relationship with consumer foodstuffs. Existing any pollution in foodstuffs can endanger people's health. Vegetables are important ingredients of a good and healthy diet and obtained results of past researches confirm that using healthy and hygienic Vegetables can prevent heart disease and some kinds of cancers especially cancers of digestive system (Salehipur bavarsad et al., 2011). Amount and the way of distributing nitrate in Vegetables is very important. Because it effects their health and quality (Tuzel et al., 2001). Suggested amount of using greens and fruits by world health organization is 400 g

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per day (Hord et al., 2009). Meanwhile excessive use of nitrogen fertilizers, which has a direct connection with absorption and accumulating nitrate in plants, is of great interest (Kazemi posht masari et al., 2010). Major form of absorbing nitrogen by plants is in the form of nitrate (Baibordi et al., 2004). Nitrate is one of the most important nitrogen sources for plants use that is naturally available in soil, water, plants, shallow water, hayloft, agricultural products, weed, and animal tissue and could be added to the soil through using dung or chemical fertilizer. Applying chemical fertilizers adds to amount of nitrate in soil and through nitrate-making processes because producing natural nitrate in soil.

In general, nitrate is one of the common produced compounds through direct use or oxidation of Azote chemical fertilizers and by available microorganisms in the soil, which has a high absorption by plants. When the concentration of nitrate in soil is high, plants can absorb it more than their metabolic needs and gather it in cytoplasm and special vacuoles of cell especially at night. Being high of nitrate in usable organs of vegetables and fodder and in drinking water can cause kinds of poisonings in domesticated animals, and anemia (methmoglobinemia) in infants and create a carcinogenic substance named Nitrosamine in adults.

Parsley with scientific name *Petroselinum Sativum* belongs to *Umblifereae*. Parsley is a potherb biannual or perennial plant that blossoms at second year, and its growth period is short. Height of this plant is 70 cm. its leaves are dark green colored and have lozenge and triangular cuts with some divisions. Flowers of Parsley are small, greenish and umbel form. Its fruit is small with height of 2 mm and diameter of 1 mm and has a sweet smell. Parsley contains assailable mineral salts that are Calcium, Phosphor, Ferro, Sodium, Potassium and is full of vitamin A. It also has a considerable amount of vitamins B and C. Benefits of Parsley: anti-flatulency, appetizer and excretes renal calculus.

Material and Methods

From studied farms a random sample of primary cultured was picked to form a composite sample and also from the middle row and from the last row of the agricultural land, which totally three samples were taken from every land.

In this research, for the preparation of desired sample, edible parts of parsley organs were sampled. Sampling was done at 5 o'clock in the morning, and then the samples were transferred to laboratory. After transferring samples to the laboratory they were washed with distilled water and after chopping they were air-dried for 48 hours and with measuring wet weight of samples (First sample vessel was weighted and then the vessel was weighted along with the sample), they were dried at temperature 70 °C, and after weighting dry weight, they were powdered using an electric mill. A spectrophotometer was used for measuring nitrate.

Preparing nitrosulfusalicylic complex and reading it using a spectrophotometer:
Important properties of this method are simplicity, low equipment and other existing ions do not interference with plant tissues, high speed and wide domain of measurement. Salicylic acid in close proximity to nitrate produces nitro salicylic acid, the color of this combination is yellow- lemon- colored. Intensity of yellow-lemon- colored depends on the amount of nitrate in the plant tissue. This color has maximum absorption at wavelength of 410 nm. In general, this method is more used for measuring nitrate in samples with high concentration (about 3%).

First, 0.1 g of dried Avon and powdered is weighted and 10 ml distilled water is added to it, and after closing the containers, they will be kept at temperature 45 °C for an hour, then samples will be centrifuged at speed of 1000 rpm (or instead active coal and wattman defecator paper can be used to filtrate the extracts).

0.2 ml was taken from obtained extract through this method and 0.8 ml sulphosalicylic acid 5% was added to that. After cooling, 19 ml normal soda 2 was added to this mixture and severity of produced color at wavelength 410 nm was observed by spectrophotometer. It is obvious that for observing extracted samples, first, a standard concentration of 5-300 mg/l nitrate azote must be prepared using dry Potassium nitrate salt (KNO_3) and unknown samples could be observed with respect to that.

The results of decomposing samples with use of software SPSS18 and comparing averages with use of Duncan test and amount of nitrate by T test with allowed amounts were compared and analyzed. Also, diagrams are drawn by software Excel.

Results and Discussion

With respect to table 2 it's observed that average of nitrate concentration in all three studied farms of Dezful is more than allowed amount which this probability is at level 0.01. Furthermore, comparing averages of three farms based on Duncan test showed that there is not a meaningful difference between farms 2 and 3 from perspective of the amount of nitrate in dry matter (DM). However, these two farms have a meaningful difference with farm 1. Table 1 shows the difference of nitrate in dry matter and wet matter of this product, and could be observed that there is a high difference between dry and wet product of Parsley from perspective of the amount of nitrate. Therefore, it is better to use fresh Parsley.

Table 1. Comparison of average concentration of nitrate in dry matter and wet matter and allowed amount of nitrate concentration in Parsley

Vegetable	Average concentration of nitrate in dry matter (mg kg^{-1})	Average concentration of nitrate in wet matter (mg kg^{-1})	Allowed amount of nitrate concentration
Parsley	37817	4795	500

Table 2. Comparison between measured concentration of nitrate and allowed amount of nitrate in Spinach

Studied area	Number of Parsley samples	Range of measured amounts (mg kg^{-1})	Average nitrate concentration in dry matter of Spinach (mg kg^{-1})	Average nitrate concentration in wet matter of Spinach (mg kg^{-1})	Comparing average amount with allowed amount of 300
1	9	33591-73000	48372.78	5726	**
2	9	12997-68215	32170.56	4642.44	**
3	9	9281-53477	32907.89	4017.11	**

** Indicates statistically significant difference in probability level of 1% in Duncan test.

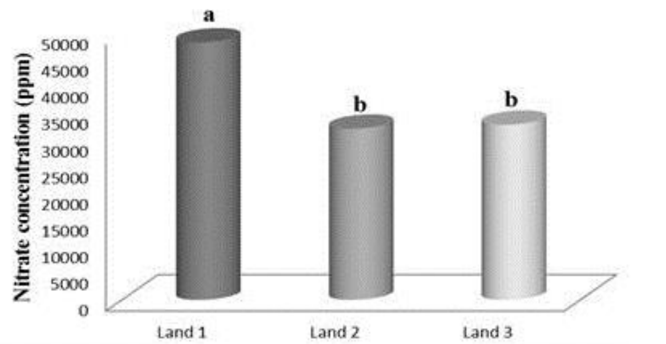

Figure 1. Comparison of average of nitrate in dry matter of Parsley between three farms.

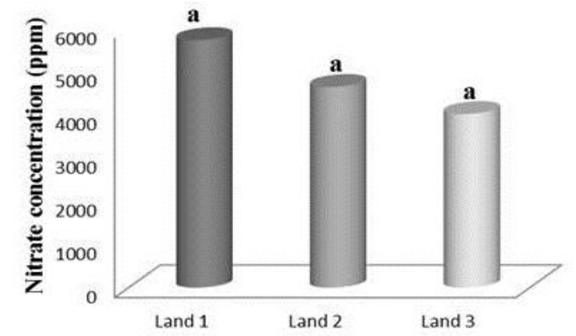

Figure 2. Comparison of average of nitrate in wet matter of Parsley between three farms.

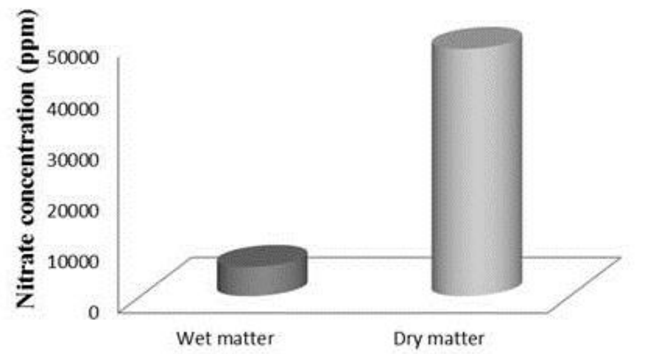

Figure 3. Comparison of average of nitrate in dry and wet matter of Parsley in farm 1.

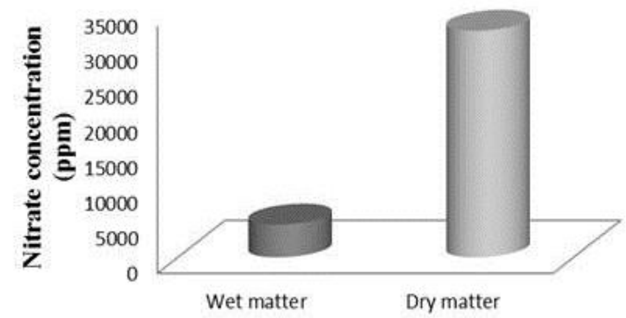

Figure 4. Comparison of average of nitrate in dry and wet matter of Parsley in farm 2.

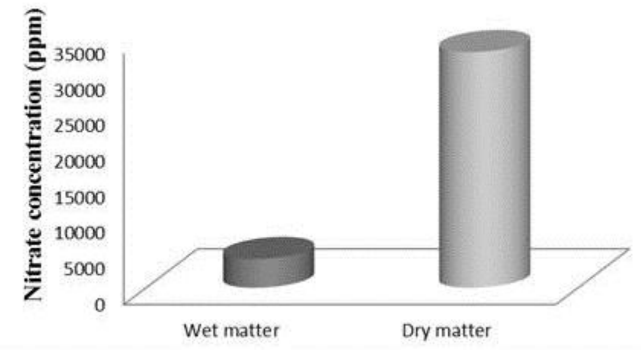

Figure 5. Comparison of average of nitrate in dry and wet matter of Parsley in farm 3.

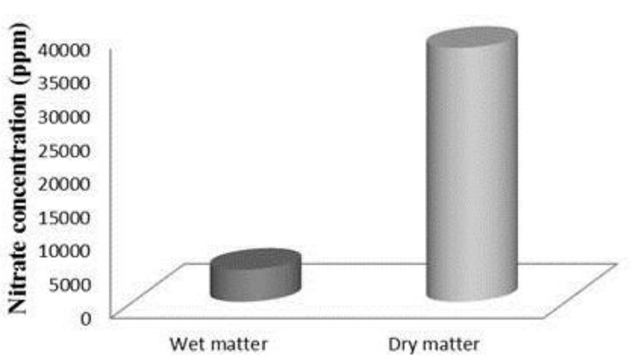

Figure 6. Comparison of average of nitrate in dry and wet matter of Parsley in all three farms.

Conclusion

The average amount of nitrate in all three farms of Parsley is more than allowed amount (500 mg/kg fresh weight), and amount of nitrate in 100% of Parsley samples is more than standard amount. With respect to standard amount of nitrate in vegetables, allowed amount per kg of body weight, is determined lower than 3.65 mg per day (Jafari et al., 2000). If a person with weight of 70 kg used Parsley in his/her diet in Dezful, he/she shouldn't use more than 53 g in a day with respect to average amount of nitrate in all three farms (4795 mg/kg fresh weight), cause with using this amount needed amount of nitrate is prepared in the body and using more than this amount can cause adverse effects and disorders in the body. Sampling was done at 8 am or at the time of sunrise in other resources. Nevertheless, in this research sampling was done at 5 am and coincides with cropping vegetables by farmer and sending it to fruits and vegetables grounds. One of reasons of changings of nitrate with light is dependency of redactaz nitrate enzyme on light spectrum changes (Mohr et al., 1992). Although, there is no light limitation in our country, with changing wavelength of light we can investigate its effects on nitrate metabolism. The effect of light on decreasing nitrate concentration is reported by various researchers (Mortesen and Stromme, 1987; Mohr et al., 1992). It seems that intensity of the light has an important effect on decreasing amount of nitrate. Therefore, farmers should not harvest vegetables before sunrise. One of the reasons of increasing excessive amount of nitrate in these farms is harvesting vegetables some hours before sunrise. It is suggested to harvest vegetables in the afternoon so that this action could be effective in decreasing nitrate in vegetables. Therefore, efforts must be done to decrease amount of nitrate in vegetables especially for those who use vegetables very much in their diet.

References

Malekooti, M. J., Baibordi, A., & Tabatabaei, J. 2004. Optimal Use of Fertilizers as an Effective Step in Increasing the Performance, Improving the Quality and Reducing Pollution in Vegetable Products and Improving the Health in Society, Publication of Agricultural Sciences and Applications.

Salehipoor Bavarsad, M., Ghorbani, M., Afyuni, M., & Kheirabadi, H. 2011. The Concentration of Lead, Nickel and Zinc in Some Vegetables of Isfahan Province. The Twelfth Congress of Iran Soil Science, Tabrzi, September 3rd to 5th.

Malekooti, M. J. 1999. Sustainable Agriculture and Increasing the Performance by Optimizing the Use of Fertilizers in Iran, Agricultural Education Publications, 279 pp.

Kazemi Poshtmesari, H., Kazemi, S., & Afshari, A. 2010. The Investigation of the effect of Consolidated Management of Nitrogen fertilizer, Bio-fertilizer and Manure on Nitrate Accumulation and Nutritious Elements in Lettuce Biomass in Mazandaran Province, the First National Conference on Agriculture and Sustainable Development, Opportunities and Challenges, Islamic Azad University, Shiraz Braqnch, March 10th and 11th, 194-207.

Baibordi, A., Tabatabaei, J., & Malakooti, M. 2004. Optimal Use of Fertilizers as an Effective Step in Increasing the Performance, Improving the Quality and Reducing Pollution in Vegetable Products and Improving the Health in Society, Publication of Applied Agricultural Sciences, 338 pp.

Sadeghipoor Marvi, M. 2011. Investigating the Effect of Various Amounts of Nitrogen and Phosphorus on the Performance and Accumulation of Nitrate in Spinach, the Twelfth Congress of Iran Soil Science, Tabriz, and September 3rd to 5th.

Tuzel, I.H., Tuze, Y., Gul, A., Meric, M.K., Yavu, O., Eltez, R.Z., 2001. Comparison of open and closed systems on yield, water and nutrient consumption and their environmental impact. International; Society for Horticultural Science. 554:221-228.

Hord, N.G., Tang, Y., Bryan, N., Jul, S., 2009. Food sources of nitrates and nitrites. The physiologic context for potential health benefits. AM Journal clin Nutr. 90(1) pp. 1-10.

Jafari, R.A., Farzan, A., Aziz zadeh. [The amount of nitrate and nitrite in some vegetables produced in Esfahan city (Persian)]. Research in Medical Sciences. 2000; 123-6.

Mohr, H., A. Neininger, B. Seith. 1992. Control of nitrate reductase and nitrite reductase gene expression by light, nitrate and plasidic factor. Bota Acta, 105: 81-89.

Mortesen, L.M., E. Stromme, 1987. Effects of light quality on some greenhouse crops. Scientia Horti., 33:27- 36.

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Scrutinizing of quality indicators of industrial waste gas compressor station Bengestan for irrigation of green spaces

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Abstract

In recent years, in Iran, due to scarcity of water, need for new water resources as well as modification of environmental complications, a particular attention has been paid to reuse of water resources. This study was conducted in the gas compressor station of Ahwaz region-1(Bengestan) at the Karoon Company and the water, oil basin as well as the region's soil were sampled and moved to the laboratory for analyzing the water and soil qualities. The water of mixed basins was analyzed of viewpoint EC،TDS،TSS ،pH. Next, the water quality was analyzed in several levels and in various dilutions. The analyses performed on the basins include measurement of total suspended solute solids, total dissolved solutes, electrical conductivity, and soil reaction. The results showed that out of mixed samples, the one tested with treatment of 75% water irrigation and 25% of separation basin water is more suitable than other samples for irrigating the green space of the region. In this region, the sample related to Bengestan enhanced gas station has TSS=3.093 mg/lit. TDS=980 mg/lit and.The results from this study indicated that the use of unconventional water for environmental purposes needs specialized management, which is not transferred the environmental hazards into soil, plants and groundwater and underground water resources while exploiting of it optimally.

Keywords: Separation water, water and oil basin, Bengestan

Introduction

Iran is one of the arid and semi-arid countries in the world with an average rainfall of 250 mm per year. Continuation of the current trend of increased consumption of drinking water and wastewater generation in drinking water, and agricultural and industrial sectors caused limited accessing to freshwater resources, imperiling next generation life and qualitative developments in open water. One of the main points in using wastewater in green space and agriculture is considering wastewater quality used and standards established in this regard, and can be said that the utilization of wastewater may have detrimental effects on human health, soil quality, health and environment. In the Mediterranean, the treated wastewater is considered as an important source of irrigation in agriculture (Jafari, 2002). Iran has seriously experienced water crisis in recent years due to locating in arid region. Increased water consumption due to the expansion of community reduced water resources and consequently using wastewater was increased. In many parts of the world, water is used for various purposes. Waste water which was considered as a source of contamination at a time now is considered as a new source of water supply in the world. Limited water resources, climate fluctuations,

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uneven distribution of water in the country, increasing population, contamination of groundwater and surface water and thereby reaching to a level of water stress led water managers and planners seek the use of non-conventional water resources to achieve sustainable development (Rhoades *et al.,* 1992). The present study was conducted to achieve the mentioned goals and also use separated water from oil and water basins of GAS Compressor Station, as an alternative water source, for irrigating green space. The main objective of this project was investigating the suitability of separated water for green space around the processing facility and providing appropriate solutions to improve quality up to the standard level (Petygrove and Asano, 1990). It is noteworthy that finding and planting a kind of shrubs which are resistant to such water is a positive movement to solve the problem of contaminated water in the facility and use the productive resources efficiently due to environmental requirements and with the aim of avoiding the transfer of water out of the facility as well as the efficient use of such water.

Material and Methods

Ahvaz Bangestan oil field: This reservoir with a combination of Ilam and Sarvak production zones contained approximately 31 billion barrels of oil in the first location and its exploitation begun since 1971. After the imposed war, high volume of well drilling activities focused in this reservoir due to its role in the collection of reservoirs in National Iranian South Oil Company, since 1979 up to now, the total supplementary wells achieved to 125 by drilling 96 new wells and the total production was increased to approximately 160,000 barrels per day. The reservoir oil (API = 25.5) required resistant plants against hydrogen sulfide due to having about 3% volume of S2H gas. After studying the status of oil -water basins at gas compressor stations, water sampling was performed and the samples were transferred to the laboratory for analysis of water quality parameters. Separated basins were completely analyzed, the analysis included TSS, TDS, EC, and pH. Basin dimensions were approximately five to ten meters with the depth of about six meters, which was located in Karoon Company Bangestan Gas Compressor Station. The fluid was drinking water used for washing the station and machinery which was contaminated with oil. The main contamination of water was related to the oil on the water, and the salinity was too low because the water was supplied from Karoon River and had no relation with the zone. The water should be analyzed at four different levels due to the basins water quality: a mixture of 25 % basin water and 75 % well water (drinking water), a mixture of 50 % basin water and 50 % well water, a mixture of 75 % basin water and 25 % well water, 100 % use of the basin water, control: 100% use of well water (Riad, 2001).

Results and Discussion

Water pH indicates the amount of acid or alkaline in water. Appropriate pH range of irrigation water is actually 6.5-8.4, which the plant has good growth in this interval. Generally, lime can be used to improve the low pH or water and soil acidity and sulfur, gypsum or other acidic materials can be used to improve the high pH or too much alkalinity. Figure 1 showed that pH levels were greater than 4 in all samples and pH levels of all separated samples (75 % -25 %, 50 % -50 %, 25 % -75 %) were between 4 and 5. The pH levels of separated samples were low for irrigation and there was acidity problem that should be improved before irrigation. Lime is commonly used to improve the low pH or water and soil acidity. As it was observed in figure 2, all samples EC was more than 2500 µmhos/cm and the samples with 75% irrigation water and 25% basin water had lower EC than other separated samples regarding separated samples (75 % -25 %, 50 % -50 %, 25 % -75 %). But generally, all samples had limitations for irrigation and located on C4 Class based on Wilcox Table and were not suitable for irrigation. As it was observed in figure 3, all samples TDS was more than 500 mg/l and the samples with 75% irrigation water and 25% basin water had lower TDS than other separated samples regarding separated samples (75 % -25 %, 50 % -50 %, 25 % -75 %). Nevertheless, generally, all samples had limitations for irrigation. As it was observed in figure 4, all samples TSS was more than 0.0055 and the sample with 25% irrigation water and 75% basin water had lower TSS than other separated samples regarding separated samples (75 % -25 %, 50 % -50 %, 25 % -75 %). However, generally, not all samples had limitations for irrigation due to having TSS less than 40 mg L^{-1}. Environmental monitoring is one of the most essential components of utilizing wastewater and returned water projects. There are significant health and environmental effects as well as possible discontinuity of the project usefulness and impact without designing and implementing evaluation program and consistent and effective monitoring.

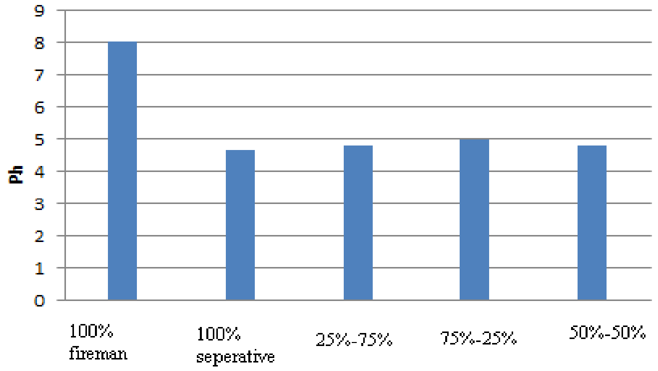

Figure 1. Comparing chart of different ratio of separated water pH in Bangestan area

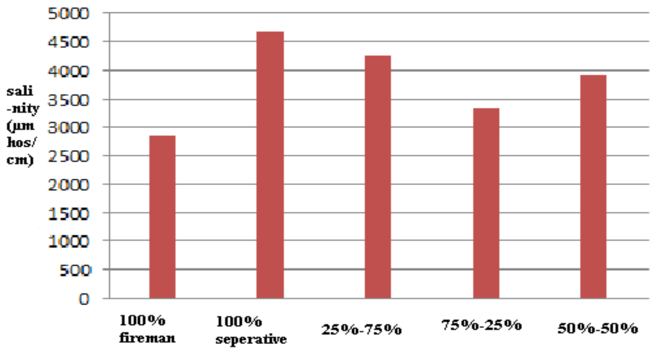

Figure 2. Comparing chart of different ratio of separated water EC in Bangestan area

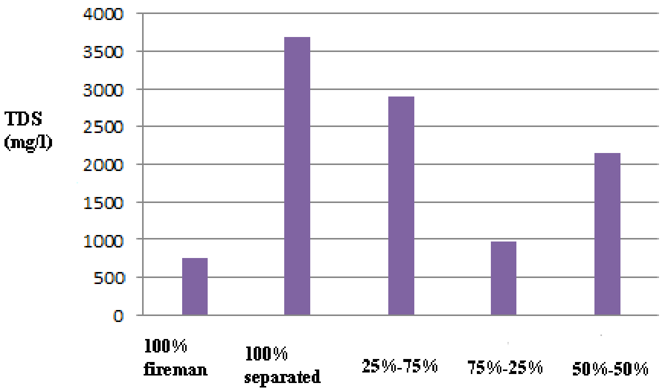

Figure 3. Comparing chart of different ratio of separated water TDS in Bangestan area

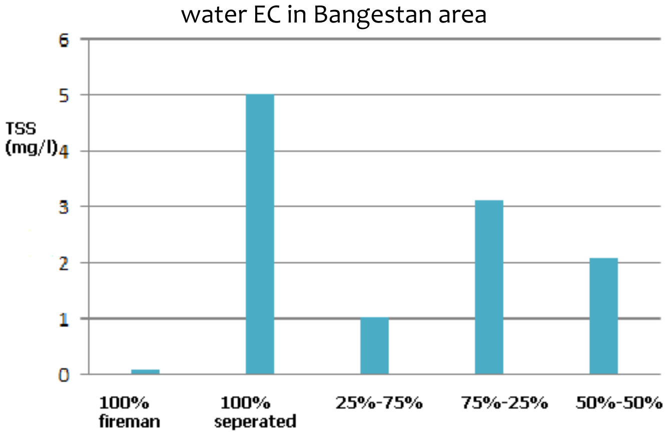

Figure 4. Comparing chart of different ratio of separated water TSS in Bangestan area

Conclusion

Environmental monitoring program included evaluating efficiency of wastewater treatment plants to improve effluent quality, quantity of wastewater generated, evaluating the quality of wastewater, returned consumed water, and adjusting it with the considered standard, water supply line to the place of consumption, quality and quantity of products, and other activities in design to achieve the objectives of the project. In general, objectives of the monitoring plan are as follows: Evaluating project components to achieve optimum yield. Amending various sections and components of the system to reduce the potential health and environmental effects. Controlling the effectiveness of programs and proposed actions to eliminate or minimize health and environmental effects and consequences. Changing system components to increase the efficiency and yield of the system components and sustainable use of these resources. In general, in a comprehensive and engineering design, reuse of wastewater considering wastewater treatment to the extent to achieve quality criteria recommended by monitoring operations program, is mostly focused on treatment stages; however, ongoing evaluating and monitoring treatment stages and design components including soil, crops, groundwater and surface water resources workers health are essential due to probable problems in the treatment stages or potential deficiencies in the management.

References

Jafari M. 2002. Saline Soils in Natural Resources, Tehran University Press.

Petygrove S, Asano T. 1990. Irrigation with Reclaimed Municipal Wastewater. a guidance production. FAO. Irrigation and Drainage Paper No. 48

Rhoades JD, Kandiah A, Mashali AM.1992. The Use of Saline Waters for Crop. Resources Research Foundation.

Riad M. 2001. Wastewater Irrigation for Forest Plantation. Advisory panel project on.

Roberto M., 2004,"Industrial Water Quality Requirements Reclaimed Water", AWWA.

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Change of the morphogenetic peculiarities of plain alluvial-meadow-forest soils under an anthropogenic influence in the dry subtropics river valleys of Azerbaijan

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Abstract

The alluvial-meadow-forest soils (Mollic Fluvisoils) in Azerbaijan spread in the debris cone mountainous rivers of the Great Caucasus and in the largest flood-lands part of the Kura river in Transcaucasia. These soils are shaped under high bonitet and liane plain forests (Populitum ribosum, Quersetum carpinetum, Ulmus foliacca, Solix australior, Carpi-netum corylosum and etc.). The formerly existed vast areas of these forests have been cut and drawn into cultivating of cereals, vegetables, water-melon, fruits etc. As a result of the irrigation with the long silty river waters, intensive culti-vation under hydrothermic regime, an application of organic-mineral fertilizers and other the morphogenetic structure and physical-chemical characters of the alluvial-meadow-forest soils (Irrigari Mollic Fluvisoils) subjected to serious changes. As a result of the presented anthropogenic influences 45-50sm of thickness of aqroirrigated cultured new soil layer has been shaped in the soil profile. A turbidity degree of the river waters which influences on formation of soil profile and cultural soil forming process, dependent deposits and their qualitative structure, a quantity of alluvial humus (1,2-2,0%), total nitrogen (0,025-0,047%), $CaCO_3$ (3,5-5,1%), granulometric structure (<0,01mm= 62-66%), pH (7,8-8,1) seasonal regime observations. A character of the arid subtropics soil forming process of the irrigative and under forest soils has been defined on the basis of the total chemical analysis of soil and fraction composition of humus.

Key words: morphogenetic diagnostics, anthropogenic, irrigation, dry subtropics, plain forest

Introduction

An importance of the river valleys for the agricultural development of the ancient East has been certain for a long time. The first information about early agriculture is concerned the places with the favorable regime humidity and high natural potential fertility of the soils which are flood-alluvial (Bernal, 1956).

The morphogenetic diagnostics and meliorative characters, of the irrigative soils that spread widely in the river valleys of the subtropics and semidesert zones in Middle Asia and Azerbaijan possessing an ancient farming culture have been comprehn sively learnt by V.R.Volobuyev (1976), V.A.Khovda (1973), M.A.Orlov (1966), N.Q. Minashina (1974), M.P.Babayev (1984) and others.

A history of the anthropogenic influence on irrigative agriculture and soil cover is very ancient because Azerbaijan dry subtropics plain-forestry zone possesses a good relief condition, bioclimatic features and river

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net. Exposing of the soil cover to initial serious changes in the research object with attraction of the destructed forests to the dwelling points and the attraction of soils to the agriculture.

At present as a result of the continues processes the plain-forest soil cover expose to the serious changes, and this reflected in natural landscape loss and change of morphogenetic parameters of the soil resources.

The natural alluvial-meadow-forestry soils (Mollic Fluvosoils) spreaded in the Khuba-Khach-maz massif were comprehensively learnt by Smirnov-Loginov (1934), V.V.Akimtsev (1957), H.A.Aliyev (1964) on the basis of the initial regional-geographical researches. The information shortage is available over change of these soils cultivated in connection with the development and enlarging of the irrigative agriculture under an antropogen influence in the plain-forestry zone of the river valley. Over determination of the changes occurring in morphogenetic diagnostics of natural-under forestry and irrigative alluvial meadow-forestry soils the comparative regional- geographical and stationary researches were carried out by V.H.Hasanov and B.N.Ismayilov (1989, 2004, 2009, 2011, 2013) last years. The morphogenetic diagnostics of the natural-under-forestry and Irrigari Mollic Fluvisoils were defined on the basis of the complex researches.

Materials and Methods

The flood of the Kura large artery of the east Caucasus, and also the Khuba-Khachmaz lowland being formed from the enlacing cone of the mountain rivers on the north-eastern slope in the Great Caucasus is an object of the researches. The region belongs to the arid subtropics bioclimatical zone which is characterized by moderate hot dry climate. The air average yearly temperature changes in limits of +12,1-13,2 C^0, but an average yearly quantity of precipitations forms 280-350 mm, a quantity of the average yearly evaporation vibrates in limits of 850-1000 mm, but a coefficient of humidity forms 0,3-0,5. Field surveys were conducted on the basis comparative-geographical method. Soil samples were collected from the genetic horizons of the soil pits (1,5-2,0m) located in forest and irrigated land forms. Muddiness and sediment suspension of irrigation water were determined with bottle-sampler.

The following order of analyses of soil and sediment suspension of irrigation water samples were carried out: granulometric composition-N.A.Kachinsky; total nitrogen and humus content -I.V. Tyurin; absorbing cations Ca and Mg-D.V. Ivanova; pH (water)-potentiometer; content of CO_2 carbonates; total composition of soils by a method of E.A. Arinushkin's leadership: fraction composition of humus – by I.V. Tyurin, in modification by V.V.Ponamarev and T.A. Plotnikov, nitrate nitrogen with phenoldisulfonic acid method by Grandwal and Lyaju, ammonia-nitrogen with neslevization, available phosphates by Machigine, exchangeable potassion by Protasov. The statistical analysis of the diagnostic parameters on genetic horizons was conducted via E.V.Dmitriev's method.

Results and Discussion

Mollic Fluvosoils are widely spreaded in the flood rivers of Kur and Khuba-Khachmaz lowland, However these soils are weakly studied in morphogenetic, classificated and nomenclature connec-tion. The first information about these soils in Khuba-Khachmaz lowland in limits of deltas in the Samur river can be found in V.V.Dokuchayev's works [6] in 1899. According to his data the soils "in general forestry character, and besides under layer of the forestry dry leaves in 2-3 peaks of the ordinary thickness follows bright-grey horizon of 46 cm of thickness, gradually passing to bluish dark clay.

The Primary studies of these soils in Khuba-Khachmaz plain were conducted by V.P.Cmirnov-Loginov (1934) and V.V. Akimtsev (1957) and named as the "Tugay soils". Nevertheless, due to his large-sealed detailed researches H.A.Aliyev (1964) against to the contrary to be called "Tugay soils" proposed to be called "alluvial-meadow-forest" soil. Mollic Fluvosoils occur vastly in the flood plain zone of the Kura river and Khuba-Khachmaz lowland in the alluvial debris cone of mo-untain rivers of the north-eastern part of the Greater Caucasus within Azerbaijan with high site quality of forest (Papuletum rublosum, Alnetum corylotum, Quercetum carpinetum, Cnercetum carinetium, Soliks aystralis etc.)

The alluvial activitry, of the rivers and there fore the influence of ground and sthream water on soil forming process and the generation of forest cover are evaluated as a forcible argument by the authors.

Parent material consists of basically various sandy-gravels and clay–loamy alluvial, alluvial-proluvial sediments by origin. Depending on microrelief condition and climate character of the season the ground water (1,0-3,5q/l), level occurs at the depth of 1,5-4,0m. The facts above mentioned have been approved on the basis of

our long term compo-rative-geoqraphical fieldsoil and chamber-laboratorial researches and it is determined that there are sometimes two (AU^hg=0,8-2.0m) in the genetic profile of the schistous Mollic Fluvosoils spreaded in the river flood-plains of the republic (Hasanov V.H., 1999, 2004).
The soil mark of the informative base as a main document for soil cartography is used "World reference Base" (World Referense,1998) "Classification of Russia soils"(Shishov L.,Tonkonogov V., Lebedeva I., Gerasimova M. 2004). The analogical abovementioned subdivision of natural and irrigated alluvial-meadow soils is also compiled in the fundamental researches (Babayev M., Jafarova Ch., Hasanov V., 2006)

The natural Mollic Fluvosoils possess normal developed profile, little thick neat-like-grainy structural under forest litter (AO=1,5-2,0cm), dark-grey coloured, biological accumulative humus layer (AUz+A/B) ais settled on soil surface. The medium and deep layers (Bg-B/Cg-Cg) are gleyificated to a different degree in a form of bluish and ochre-brown rust spots. Soil forming carbonatic alluvial deposits are distinguished by their different granulometric structure.

One of the typical properties of the genetic profile of the alluvial-meadow-forest soil is the coplex particle size distribution. In subsurface horizon (Bgca) the amount of silt and glay particles decreases considerable (<0,01 mm=49±7,8%;<0,001mm=17,0±4,2%). Physical clay (<0,01mm) content in the accumulative horizon (AUz) reashes 55 ± 4,7%. Simul-taneously, silt fraktion (<0,001mm) content reaches a value of 20 ± 3,4 %, however its low content in the deep horizons (B/Cgca) is charakteristic (<0,01 mm=20 ± 3,7; <0,001mm = 11 ± 4,9 %). Moreover, the burried humus rick horizon (AU^hg) is characterized by the severe content of the physical and silt fraktions with the valuos of 42,3 ± 3,2 %; 16 ± 2,5% respectively, on the contrary in the deeper horizons (Cgca) physical clay and silt content reaches values of 15 ± 3,4%; 7,0 ± 2,2 % respectively. Such a complicated particle size distribution in the profile of the described soils is explained with the flood regime and is regarded as a diagnostic value (table 1).

The average organic matter content in the humus-rich horizon (AUz= 19 ±1,5cm) reaches a value of 5,4 ± 0.8 % , however its content drops sharply of in the deep horizon (Bgca-B/Cgca) with a value of 0.7-1,0 ± 0,2 %. But, burried humus-rich horizon (AU^hg) contains organic matter content (2.3± 0.3%) 3-4 times more than the topsoil and deep horizon. According to the organic matter content soil profile contains a bit of total nitrogen and its content reaches a value of 0.17%±0.1 with the large C:N ratio (10±0.9) that confirms the low nitrogen ensure of the alluvial-meadow-forest soils (table1).

The profile of the described soils is characterized by the high calcareousness (CaCO3= 10±0.9 %) with equally distribution through the profile. Mollic Fluvosoils are highly saturated with the basis. Total absorbed basis vary sharply depending on the organic matter content and particle size distribution. So, in the surface horizon (AUz) total absorbed basis reaches a value of 32 ± 3.2 mg.ekv/100g, however deep horizons that are not rich in organic matter with light granulometric composition, with a value of 14 ± 1.6mg.ekv/100gr. Ca cations prevail in the saturated basis with the Ca:Mg ratio ranging between 1.8-3.0. The described soils are alcali in reaction, pH in water solution varies between 6.7-8.0. During the recent 70-80 years human economic activity has caused the defo-restation and cutting in the Kura river flood-lands and Quba-Khachmas lowland, consequ-ently the vast areas are used for planting cereals, vegetables, fruits, water-melons in irrigative con-dition. According to the neo Azerbaijan soil classification natural Mollic Fluvosoils profile is cha-racterized by the flowing genetic horizons system: AO-AUzca-A/Bca-Bgca-B/Cgca-AU^hgca-Cgca.

As a result of the intensification of the man's economic activate the forests are cut off in the Kura river flood-land and Khuba-Khachmaz massif and large areas are used under irrigative grain, vegetable-orchard, fodder plants and perennial fruit gardens in those places. For a long time an anthropogenic effect has been reflected in change of the morphogenetic structure and phisico-chemical features in the soils under forest. These soils held their abovementioned natural zonality features and agroirrigative cultured new soil layer as formed in a thickness of 45-50cm as a result of constant irrigation with turbid river waters, intensive cultivation, application of the organic-mineral fertilizers and other agrotechnic measures. Dusty-clody-like structural dark-grey color is charac-teristic for a tillage layer (AU'a=28±2,0cm) of Irrigari Mollic Fluvisoils. Hardening of the under-tillage layer (AU"a=23±1,8cm) (dense 1,32 q/cm^3), weak gleyification of the medium and deep la-yers (Bg-B/Cg-Cg) and other morphological signs are characteristic. The following genetic horizons system is characteristic for a profile of the soils: AU'aca-AU"aca-Bgca-B/Cgca- AU^hgca -Cgca.

Table 1. Diaqnostic parameters in the Mollic Fluvosoils

Character and signs	Natural Mollic Fluvosoils			Irrigari Mollic Fluvisoils		
	Genetic horizos	**Mean value (M)**	**SD (±)**	**Genetic horizos**	**Mean value (M)**	**SD (±)**
Thickness, cm	Ao	Forest floor	Forest floor			
	AU'	19,41	1,54	AU'aca	28,36	2,04
	A/Bca	16,72	1,53	AU"aca	23,17	1,86
	Bgca	32,35	4,41	Bgca	30,23	3,15
	B/Cgca	21,94	4,85	B/Cgca	24,74	3,56
	AU^{h}_{g}ca	27,0	3,97	AU^{h}_{g}ca	33,00	4,37
	Cgca	30,29	2,96	Cgca	28,58	2,19
Structure	AUz	Small-nut		AU'a	Silt-grumble	
	A/B	Small-grumble		AU"at	Gloomy-grumble	
	Bg	Grumble-nut		Bt	Small-columnar	
Density g/sm^3	AUz	0,25	1,15	AU'a	1,15	1,20
	A/B	1,12	1,20	AU"at	1,23	1,32
	Bg	1,22	1,25	Bt	1,15	1,45
Humus, %	AUz	5,42	0,83	AU'a	3,05	0,65
	A/B	2,88	0,52	AU"a	2,24	0,47
	Bg	1,02	0,21	Bg	1,34	0,34
	B/C	0,84	0,18	B/C	1,00	0,37
	AU^{h}_{g}	2,34	0,31	AU^{h}_{g}	1,9	0,52
	Cg	0,46	0,14	B/Cg	1,00	0,18
Nitrogen, %	AUz	0,31	0,04	AU'a	0,22	0,03
	A/B	0,13	0,03	AU"a	0,14	0,02
	Bg	0,08	0,01	Bg	0,08	0,01
C:N	AUz	10,61	1,08	AU'a	7,92	0,94
	A/B	9,34	0,98	AU"a	8,18	0,72
	Bg	8,56	0,29	Bg	7,90	0,31
$CaCO_3$, %	AUz	10,48	2,03	AU'a	13,05	3,05
	A/B	11,94	2,33	AU"a	15,19	2,97
	Bg	11,30	3,14	Bg	15,35	3,18
	B/Cg	11,44	2,24	B/Cg	13,58	2,73
	AU^{h}_{g}	8,58	2,01	AU^{h}_{g}	9,72	2,21
	Cg	11,21	1,75	Cg	12,06	2,02
Absorbtion capacity, mg-ekv.	AUz	32,31	3,27	AU'a	26,06	2,91
	A/B	28,67	3,70	AU"a	24,76	2,56
	Bg	21,48	3,72	Bg	22,29	1,75
pH in water solution	AUz	7,53	0,29	AU'a	8,02	0,36
	A/B	7,68	0,30	AU"a	8,10	0,29
	Bg	7,86	0,27	Bg	8,24	0,21
	AU^{h}_{g}	7,10	0,19	AU^{h}_{g}	7,75	0,18
	Cg	8,03	0,25	Cg	8,32	0,27
Silt fraction < 0,001 mm, %	AUz	20,35	3,39	AU'a	25,44	2,86
	A/B	18,70	4,61	AU"a	28,76	3,01
	Bg	17,68	4,22	Bg	29,78	3,18
	B/Cg	14,21	4,94	B/Cg	13,32	2,73
	AU^{h}_{g}	16,20	2,57	AU^{h}_{g}	20,60	1,54
	Cg	7,60	2,23	Cg	18,19	2,17
Physical clay < 0,01 mm, %	AUz	55,17	4,73	AU'a	60,76	3,98
	A/B	50,13	7,56	AU"a	64,88	4,75
	Bg	48,79	7,98	Bg	65,10	5,16
	B/Cg	40,26	8,73	B/Cg	57,08	4,83
	AU^{h}_{g}	42,27	1,9	AU^{h}_{g}	56,70	3,2
	Cg	15,35	3,46	Cg	36,44	2,95

Hardening of the granulometric structure under an influence of the irrigation of cultivated Irrigari Mollic Fluvisoils with the silty river waters for a long time is clearly seen. A quantity of physical clay (<0,01mm) on the tillage layer (AU'a) rises to 61±3,9% and 65±7,4% on the under tillage layer (AU"a). A quantity of the silt particals (<0,001mm) changes by 25±2,8% and 29±3,0%.

Despite reduction of the humus quantity on the tillage layer in the irrigative Mollic Fluvisoils (AU'a=3,1±0,3%), its movement to the under tillage (AU"a=2,3±0,5%) and deep layers (Bg+B/Cg=1,0-1,3%) was determined. A quantity of total nitrogen was 0,22% and a ratio of C:N formed 7,9-8,2 on the tillage layer. Under an influence of irrigation leaching of carbonates in the soil profile from upper layers ($CaCO_3$=13±3,1%) to medium and deep layers (Bg-B/Cg) $CaCO_3$= 15±3,2% was defined. Carbonates are arrested attention in medium layers as a micelle form on morphogical side. Comparatively decrease (AU'a=26±2,9mg-ekv) of absorption capacity of the irrigative soils is observed in comparison with natural-soils under forest. Ca cation dominates in absor-ption capacity, Ca:Mg changes by 2,0-3,5, pH increases in the irrigative soils (8,0±0,4) very much.

The depending deposits of the river waters fundamentally exert an influence on cultural soil forming process and formation of irrigative soil profile. The depending deposits which the flowing mountainous rivers bring from mountain-meadow and mountain-forest zone have good agronomic features in the research object. A quantity of the depending deposits (turbit) in the river waters changes by 8,9-13,3 g/l, they possess a clayey granulometric structure (<0,01mm=62,4-76,8%; <0,001mm=15,8-22,1%), and are ensured with enough humus (1,1-1,6%). Dominating of limestone products in the mountain rocks renders its effect on carbonatic depending deposits ($CaCO_3$=3,5-5,4%).As a result irrigation soil physical properties deteoriorate, such as structure (AU"+A/B= 20-25cm), getting strong of the subarable horizon (dencity value 1.35-1.52), organic matter reduction (up to 3.0%), leaching clay particles (<0.01mm=63.2 %; <0.001 mm=32.4%). It was determined from the research consequences that depending deposits brought by the river waters were ensured with the nutrient, especially with P_2O_5 well. Here easily assimilating nitrogen combinations (N-NH_3=8,9-28,6 mg/kg; N-NO_3= 3,0-6,1 mg/kg) and exchangeable K_2O (239-412 mg/kg) quantity is enough high (table 2-3).

Table 2. Physical-chemical composition of irrigation sediments

Sample location	Mineralization of stream water, g/l	Humus, %	Total nitrogen, %,	$CaCO_3$, %	pH in water solution	Particle size distribution, % mm	
						<0,001	<0,01
Kura river	3,52	1,35	0,071	3,48	7,6	20,72	68,36
Samur river	5,24	1,57	0,092	4,53	7,9	15,84	62,42
Khusarchay river	4,67	1,64	0,085	5,42	7,8	22,06	76,08
Qudyalchay river	5,08	1,13	0,078	3,76	8,0	18,80	67,54
Samur-Absheron channel	3,29	1,08	0,071	4,19	7,0	21,82	64,04

Table 3. Nutrients of irrigation sediments (mg/kg)

Sample location	N-NH_3	N-NO_3	P_2O5 mobile	K_2O exchangeable
Kura river	6,28	3,08	16,78	239
Samur river	13,27	6,05	28,56	407
Khusarchay river	11,51	5,27	22,18	376
Qudyalchay river	8,85	4,42	26,74	418
Samu-Absheron channel	10,76	6,10	19,92	277

The analytical material (table 4) shows that the first fraction of humin acids significantly (18,4-25,17 %), acids (12,7-15,8 %) dominates in the fraction-grouping composition of humus. Highly low content of the third fraction pays attention to both humin (2,8-4,1 %) and especially fulvo acids (1,4-3,1 %). The humin acids of the investigated soils are distinguished by a great mobility. Beside above mentioned, a composition of humin acid fraction increases towards the low layers. A sum of humin acids fraction on the upper horizons form 33,2-35,1 %, but it rises till 42,7 % on the low horizons. Under such mobility of humin mobility of humin acids the low content of fraction, extracted from decalsificating soil of onesided cultivation of 0,1 NaOH is connected with its high calcareous. A relation of $C_{h.a}$.: $C_{f.a.}$ more than unit in alluvial-meadow-foresry soils, they from 1,36-1,60 in mountain AU analyzed samples. A high mobility of humin acids of the investigated soils is also confirmed by a low humin content (25,4-35,1 %) and weakly development and youth of accumulative humus mountain AUz and all the genetic profile in the natural Mollic Fluvisoils.

Table 4. Fraction content of humus in the Mollic Fluvisoils

No. profile	Genetik layer's and depth.,sm	Carbon of humus in soil – C, %												Cha.:Cf.a
		C, %	Bitum	Decal-senat	Humin acids				Fulfo acids				Humin	
					Fraction's									
					1	2	3	Total	1	2	3	Total		
Natural Mollic Fluvisoils														
775	AUzca 2-18	3,12	2,56	5,76	22,19	9,24	3,64	35,07	13,83	8,79	3,15	25,89	30,12	1,36
	A/Bca 18-35	1,72	1,95	6,03	25,12	13,65	4,13	42,70	15,89	9,53	2,90	28,11	33,27	1,52
215	AUzca 2-15	1,86	3,25	6,43	18,37	11.84	3,08	33,29	12,19	7,92	2,07	22,68	25,36	1,47
	B/Cca 15-30	1,03	4,76	7,35	23,15	12,94	2,76	38,75	14,24	9,54	1,43	24,23	28,43	1,60
Irrigari Mollic Fluvisoils														
16	AU'a 0-30	1,71	1,76	3,58	14,24	11,38	3,24	28,86	10,68	9,34	3,22	23,24	23,36	1,24
	AU" a 30-55	1,30	1,28	3,17	16,86	14,21	3,78	34,95	13,43	11,75	3,28	28,46	26,12	1,22
20	AU'a 0-25	1,80	1,83	3,17	13,87	10,95	2,58	27,40	11,08	10,18	3,42	25,68	21,96	1/07
	AU" a 25-48	1,36	1,56	2,46	14,58	11,74	3,96	30,28	12,60	11,56	2,13	26,29	23,72	1,13

Decrease of humus quantity on the tillage layer (AU'a=0-30cm) of the Irrigari Mollic Fluvi-soils rendered its effect on change of its fraction structure. As is obvious from comparative ana-lyse of the analyses results that reduction of humin (13,8-16,9%) and fulvo (10,7-12,6%) acids is arrested attention in humus structure. This is connected with the highest carbonaceous of the irrigative soils ($CaCO_3$ =13,1-15,2%). Reduction of mobility in humus fraction structure of the irrigative soils is observed with the narrowing of Ch.a.:Cf.a. (1,07-1,24) was observed (table 4).

The given gross chemical analyses of the nmatural Mollic Fluvisoils show a high content of CaO (4,7-8,9 %) and MgO (3,5-4,7 %), that is connected with the enough high calcareous and arid bioclimatical conditions of soil formation. A distribution of silicon oxide and sesguioxides in the soils profile, mainly, has been conditioned by lythology of alluvial floats abd their humusness. So in the clayey humous-accumulative (AU =25-30cm) and buried humus horizons ($AU^h{}_g$=70-100cm) a content of R_2O_3 forms 23,4-25,7%, on the low loamy-horizons (Cg=90-120cm) its quantity falls till 18,6-22,3%. A contrary character processes silicon oxide content distribution: from surface to low horizon where a quantity of SiO_2 increases from 54,2-57,3 % to 58,5-59,7 %. In this connection the molecular correlation SiO_2:R_2O_3 is narrower for horizons of AUz-$AU^h{}_g$ (4,2-4,3) than for the rocks (4,7-4,8).

We must note that a strong change isn't observed in total chemical structure of irrigative and natural soils under forest. SiO_2 decrease and R_2O_3 increase are observed in the cultivated tillage and under tillage layers (AU'a+AU"a=45-50cm) of the irrigative soils. It is observed by much narrowing of the ratio of SiO_2:R_2O_3 (3,5-4,1) (table 5).

Table 5. Common chemical content of the Mollic Fluvisoils

Number profile	Genetik layer's and depth.,sm	Incandes cencen loss	Incandes of weight, %									$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$
			SiO_2	Al_2O_3	Fe_2O_3	P_2O_5	CO	MO	K_2O	Na_2O	SO_3			
Natural Mollic Fluvisoils														
775	AUzca 2-18	11,1	58,3	17,6	8,1	0,14	4,7	4,7	2,0	2,2	2,2	6,0	15,4	4,2
	A/Bca18-35	8,3	58,2	16,4	7,2	0,06	7,8	3,7	2,0	2,7	0,9	6,5	17,7	4,3
	B/Cgca 83-112	9,5	54,5	15,3	6,7	0,04	8,6	3,3	2,2	3,1	0,9	6,1	21,6	4,7
	Cgca 145-180	7,0	57,8	16,3	6,3	0,04	8,9	3,7	1,6	3,3	0,5	6,0	24,1	4,8
Irrigari Mollic Fluvisoils														
16	AU'aca 0-30	8,5	53,5	18,5	7,6	0,29	4,8	4,9	2,2	0,8	0,6	5,1	18,8	4,1
	AU"aca 30-55	7,6	54,1	20,3	9,1	0,22	5,4	4,6	2,5	0,6	0,5	4,5	15,8	3,5
	Bgca 55-80	6,3	53,2	19,1	10,2	0,17	5,0	4,2	2,0	0,8	0,7	4,7	13,9	3,5
	Cgca 115-150	5,9	55,1	17,6	8,6	0,15	6,8	5,1	1,8	0,7	0,9	5,3	17,0	4,1
20	AU'aca 0-25	7,9	55,4	17,4	8,4	0,15	4,2	4,1	1,6	0,9	0,7	5,4	17,4	4,0
	AU"aca 25-48	8,1	53,9	18,5	8,1	0,11	6,1	5,0	1,2	0,6	0,5	4,9	17,6	4,1
	Bgca 48-85	6,2	50,8	15,5	7,3	0,08	8,5	6,2	2,3	0,9	0,7	5,6	18,8	3,9

Conclusion

- The natural Mollic Fluvisoils possess normal developed profile, little thick neat-like-grainy structural under forest litter (AO=1,5-2,0cm), dark-grey coloured, biological accumulative humus layer (AUz+A/B) ais settled on soil surface. The medium and deep layers (Bg-B/Cg-Cg) are gleyificated to a different degree in a form of bluish and ochre-brown rust spots. Soil forming carbonatic alluvial deposits are distinguished by their different granulometric structure.
- As a result of the presented anthropogenic influences 45-50cm of thickness of agroirrigated cultured new soil layer has been shaped in the Irrigari Mollic Fluvisoils profile. Being disturbed the sowing layer structure of the irrigative soils (AUa'iz=22-25sm) getting dustry-clodiesh character, hardening of under-sowing layer (AUa"iz=18-20sm) (density-1.35-1.42q/cm3), growing heavier of granulo-metric structure (<0.01mm= 60-65%), relatively reducing of humus (3.1±0,65%) and motion into the deep horizons, being fulvatic-humatic structure (Ch.a:Cf.a.= 0.9-1.2), distribution of carbonates equally over a profile (CaCO3 = 6.8-8.0%), weak alkaline environment (pH=7.2-8.0) and other morphogenetic indices.
- It was determined from the research consequences that depending deposits brought by the river waters were ensured with the nutrient, especially with P_2O_5 well. Here easily assimilating nitrogen combinations ($N\text{-}NH_3$=8,9-28,6 mg/kg; $N\text{-}NO_3$= 3,0-6,1 mg/kg) and exchangeable K_2O (239-412 mg/kg) quantity is enough high.

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References

Akimtsev V.V., 1957, Tuqay soils // Soils of Caspian lowlands in Caucasus. Rostov. N/D, pp 128-145

Aliyev H.A., 1964, Forest and part forest step soils of the North-Eastern part of the Greater Caucasus. //Az. SSR Science Academy Publishing House, Baku, 264 p.

Babayev M.P., 1984, Irrigated soils and their fertility features of Kura-Araks plain. Baku, Elm, 174 p.

4.Babayev M.P., Jafarova Ch.M., Hasanov V.H., 2006, Temporary Classification of Soils of Azerbaijan // Eurasian soil Science, N 11, pp. 1176-1182

Bernal Dj., 1956, Science and History of the Community // "Inostranaia Literatura", Moscow, 367 p.

Dockuchaev V.V., 1949, Report of soil assessment in Caucasus especially, vertically and horizontally soil zones. (1898) (Collection of Articles), M-L, Production of Acad. Of Sciences of SSSR, vol.6, 506 p.

Hasanov V.H., 1999, Dynamics of soil forming process in flood-lands of Kura-Araks lowland.// Collction of Articles of Institute of Soil Science and Aqrochemstry vol. XV. Baku, Elm, pp 69-85

Hasanov V.H., 2004, Evolution and classification of alluvial-hidromorphic soils in Azerbaijan.// Collection of articles of Soil science and Aqrochemistry, vol. XVI. Baku, Elm, pp. 156-179

Hasanov V.H., 2004, The Soils of Flood and Lowland Forests of Azerbaijan.// In Morphogenetic Profiles of Soils of Azerbaijan "Elm" Baku, pp. 112-132.

Hasanov V.H., Aslanova R.H., Ismayilov B.N., 2009, Chancing morphogenetic index of "Fluvisoils" in flood zone of Kura river under anthropogenic influence // "A role of the antropogenous factor in transformation modern ecogeographical conditions of Azerbaijan" Materials of Baku State University, vol. II, pp. 339-344

Hasanov V.H., 2011, Anthropogenic impact of the change of soil-ecological conditions and properties of alluvial meadow-forest soils of the floodplain of the river Kura // AU-Russian scientific conference materials "Soil change patterns in anthropogenic influences and regulations of the status and functiong of soil cover" Moscow, pp. 176-181

Hasanov V.H., Ismayilov B.N., 2013, Morphogenetical diagnostics of alluvial-meadow-forest soils dry subtropics in the flood-lands of Azerbaijan, // ISSN: 2146-7072 Soil-Water journal, Vol. 2, N 2 (1) pp. 1167-1176.

Ismayilov B.N., 2009, The influence of irrigation over alluvial-meadow-forestry soil dynamics in Khuba-Khachmaz massive. // Collection of articles of Soil Science and Aqrochemistry, Vol. XVIII, Baku, pp.101-110

14. Khovda V.A.,1973, Principles of Soil study. Book 1 and 2, Moscow, Nauka, 467 p.

15. Minashina N.Q.,1974, Irrigated soils of semideserts and their remediation. M. Kholos, 365 p.

16. Orlov M.A.,1966, New terminology of cultivated soils of valleys in Middle Asia. Annals of Tashkent University. vol. 283. pp. 69-78.

17. Smirnov-Loginov V.P.,1934, About Problems of the soils called "Tuqay soils" //Articles of Az.Fan SSR. Vol. 2. Baku, pp. 45-67.

18. Shishov L.L., Tonkonogov V.D., Lebedeva I.I., Gerasimova M.I., 2004, Classification and Diaqnosis of the Soils of Russia // "Oykumena", Smolensk, 342 p.

19. Volobuyev V.R., Buyanovskiy Q.A., Isgenderov I. Sh., 1976, Chagrins of soils by long-term irrigation in Kura-Araks plain. Coffect. Of articles of (Soil Scientists) Congress Yugoslavia, Saraevo, pp.257-263.

20. World Reference Base for Soil Resources, 1998, Rome, 91 p.

21. World Reference Base for soil Resources. Draft, 1994, Rome, 161 p.

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Soil erosion risk assessment with ICONA model in Madendere watershed

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Abstract

Soil erosion is one of the most important environmental problems in most area of World. The aim of this research is to determine soil erosion risk assessment with ICONA model in Madendere watershed of Kocaeli, Kartepe district. The soil erosion risk assessment stages of this model occurred seven steps. Main parameters of these steps are slope, geology, land use, land cover information. A potential erosion risk map (step 3) was obtained from the slope(step 1) and lithofacies layers (step 2) generated using a digital elevation model (DEM) and digital geological and soil maps. As a result of this process, the distribution of the erosion risk classes was 7.58% (low), 4.96% (moderate), 3.75% (medium), 26.19% (high), and 57.53% (extreme). Land use (step 4) and land cover (step 5) layers derived from GEOEYE 2013 image data classification were combined to produce the soil protection map (step 6). The soil protecting map clearly showed that 58.35% of the study area was classified as very low and 38.20% of the study area was classified as very high. In addition to settlement is the remaining of area 3.45%. Soil erodibility and soil protection layers were combined to form the ICONA soil erosion status map in the final step (step 7). This final map showed that 50.07% of the study area had high and very high was sensitive. The rest of study area 49.93% had lower (settlement, very low, low and appreciable) erosion condition. This study also showed that GIS and RS techniques play an important role in determine of soil erosion risk studies.

Keywords: ICONA, Madendere watershed, Soil erosion risk, Geographic information system.

Introduction

Soil is the habitat of many organisms.Soil problems are important environmental problems(Entezari et al., 2013). Foremost among soil problems is erosion. Erosion is animportant natural process, consisting by geological time but it is increased year by year by human activities in many areas of the world. For preventing erosion necessary measures should be taken from political, economic, cultural and technical respect.

Soil erosion is one of the most important land degradation factors that play a role in sustainable land production. In the same time, soil erosion is occurred threat to the preservation of soil and water resources(Bayramin et al., 2003, Millward and Mersey, 1999).Soil erosion is a physical process, but its underlying causes are firmly rooted in the socio-economic, political and cultural environment in which land users operate (Stocking and Murnaghan, 2001). Therefore, the degree of soil erosion in a particular climatic

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zone with particular soils, land-use and socio-economic conditions, will always results from a combination of the above factors (De Graff, 1993).Among the main reasons of soil erosion are usually growing population, improper land using,destruction of the forests for fire wood or deforestation and so on(Reusing et al, 2000).

Turkey is a mountainous and hilly country. The average altitude is approximately 1250 m above sea level, and 59.0% of the total land has more than 12% slope. Because of the topographic conditions, soil erosion is the biggest problem in Turkey; some 72.6% of the land is exposed to severe and very severe soil erosion problems (Doğan, 1998). 59% of agricultural areas, 54% of forest areas and 64% of pasture lands have active erosion in Turkey.Turkey are fairly sensitive to erosion, due to in the geographical location, climate, topography, geological formation and soil conditions (Erosion activity plan, 2013).The European Union member states have totally 25 million ha of erosion vulnerable areas; unfortunately this rate reaches 61.9 million ha in Turkey (TFCSE, 2001).

In order to determine soil erosion risk assessments in the world, number models have been used such as chemicals, runoff and erosion from agricultural management systems (CREAMS), coordination of information on the environment (CORINE), landerodibility assessment methodology (LEAM), modular soil erosion system (MOSES), ephemeral gully erosion model (EGEM), erosion-productivity impact calculator (EPIC), european soil erosion model (EUROSEM), revised universal soil loss equation (RUSLE), soil and water assessment tool (SWAT), universal soil loss equation (USLE), universal soil loss equation 2D (USLE-2D), universal soil loss equation modification (USLE-M) and water erosion prediction Project (WEPP) (URL-1).One of these models is ICONA model to predict soil erosion. This model has been used by EU countries and by some Mediterranean states (e.g., Turkey, Tunisia, Syria and Egypt) for the assessment and mapping of soil erosion risk. This model techniquehas been very important role to predict erosion of the soils.

In order to determine soil erosion risk assessments in the world,numerous models have been used.One of these models is ICONA model to predict soil erosion. This model has been used by EU countries and by some Mediterranean states (e.g., Turkey, Tunisia, Syria and Egypt) for the assessment and mapping of soil erosion risk.This model techniquehas been very important role to predict erosion of the soils.

To determination of soil erosion risk using real measurement values in large scale is become difficult of perform due to cost, labour and time. Therefore this model has very important role to make management plan for sustain able land use management. The purpose of this study is to evaluate and determine the erosion risk of Madendere Watershed using the ICONA model.

Material and Methods

Field Description of the Study Area

The study area located in Madendere Watershed of Kocaeli-Kartepe district is coordinated at 4515500-4518000 N and 262400-264800 E (UTM-m) and the total area is approximately 5.5 km^2(Figure 1). Mean sea level altitude of the watershed is 415 m. Average annual precipitation and temperatures of the study area are730.4 mm and 11.3 °C, respectively (Table 1). Land use and vegetation of the study area are generally, covered by forest, arable land and pasture.

Table 1. Meteorological data of the study area

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
T °C	0.0	2.0	5.8	11.0	15.5	19.5	22.0	21.5	18.0	12.2	6.5	1.9	11.3
P(mm)	92.8	82	78.9	76.3	57.7	40.3	14.6	15.1	26.6	54.7	85.4	106	730.4

T: Temperature P: Precipitation

A range of soil types are present because of the significant differences in climate, geomorphology, vegetation, complicated geo-hydrologic conditions, parent materials, and cultivation. According to Soil Taxonomy (1999), Soil types of the study area Entisol, Inceptisol and Alfisol based on soil order level by taking into consideration of pedological development.The underlying bedrocks within the study area consist of primarily are slightly to medium compacted sedimentary rocks, soft or low resistant or deeply weathered rocks such as marl, clay slats and loos, non cohesive sediments or soils.

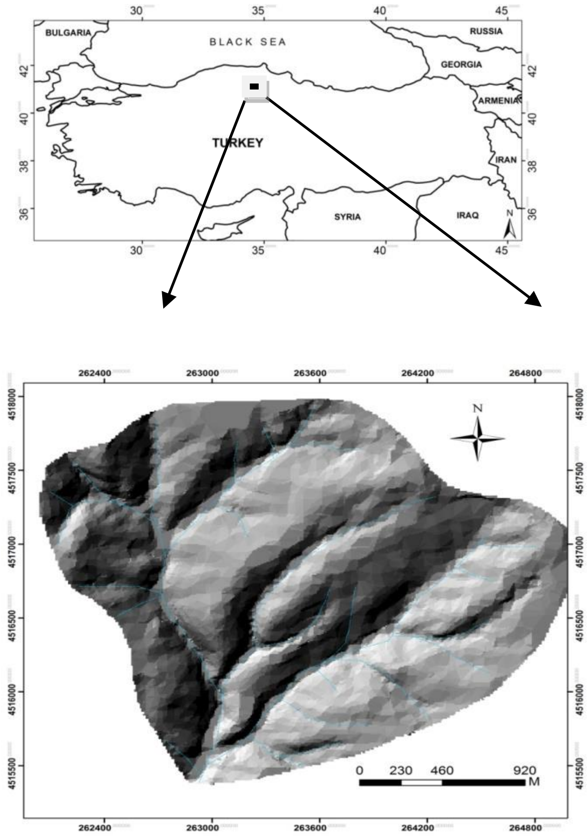


Figure 1. Location map of the study area.

Methods

ICONA model mainly compose seven steps. DEM from topographic map scaled at 1:25.000,Geoeye satellite image dated in 2013 and digital geological and soil data were used to estimate actual erosion risk in the ICONA model. Firstly, the slope layer was generated from DEM data and classified into five groups, and by analyzing the digital geological map, geological formations and soil map were classified into five groups according to their resistance to weathering in order to prepare the lithofacies layer. The slope layer and the lithofacies layer were then overlaid to produce a soil erodibility map. Ground truth information in study area was collected in the field with global positioning system (GPS), Geoeye satellite image was classified using to determine different land use categories in the study area. Five different land uses determined to in study area, and this land use types with vegetation cover overlapped to produce soil protection layer. In the final phase of the study, soil erodibility and soil protection layers were combined to generate the ICONA soil erosion status map (Figure 2).

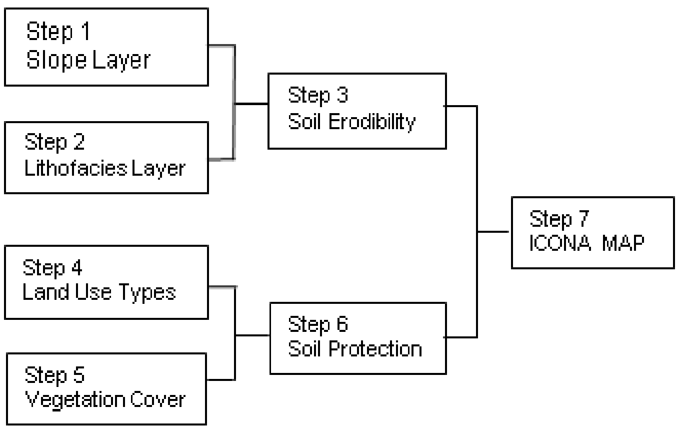


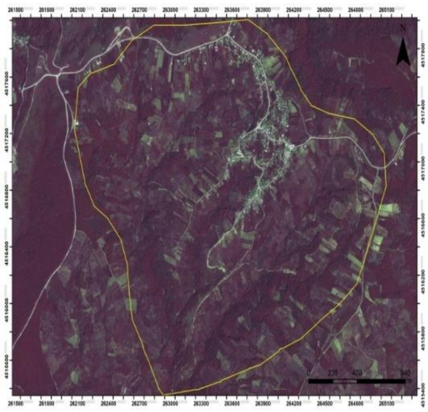
Figure 2. Flow diagram of the study

Results and Discussion

To determine land use and land cover of the study area, Geoeye satellite image that has 0.5 m x 0.5 m spatial resolution and dated 2013 were used. According to remote sensing analysis, primary land uses are forest, cultivated land, pasture, orchard and settlement (Figure 3). Forest is the highest land coverin the study area and has about 38.38% of the total area, followed by orchard (34.93 %), pasture (13.67 %), cultivated land (9.55 %) and settlement (3.47 %). Distribution of the land use types of the study area is presented in Table 2.

Table 2. Distribution of the land use types of the study area.

Vegetation cover	Area (ha)	Area (%)
Settlement	19.06	3.47
Cultivated land	52.5	9.55
Pasture	75.2	13.67
Orchard	192.13	34.93
Forest	211.11	38.38
TOTAL	550	100



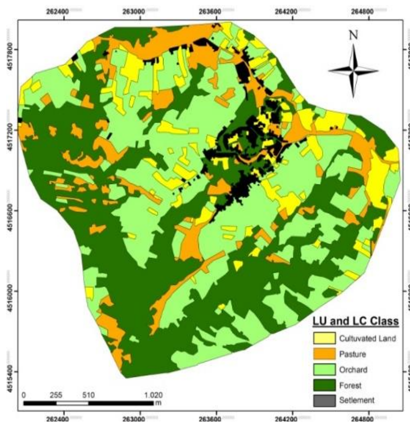


Figure 3. Geoeye image and land use Land Cover maps of the study area

Slope is undoubtedly cirucial factor influencing overland flow generation and soil erosion(İmamoğlu et al., 2014). Because lands with low slope has less than erosion risk from lands with high slopespeed of overland flow.For this study, the slopemap was drawn by digitization of 1/25.000 scale topographicmap within GIS software and categorized into five sub-slopegroups.Slope groups belong to study area are presented in Figure 4. Values of this slope groups also are shown in Table 3. This group are classified as %0-3, %3-12, % 12-20, % 20-35 and % 35+. It can be seen that about 65 % of study area has more than 35% slope, also about 15 % area has less than 12% slope and big part of the study area has high potential soil erosion risk.

Table 3. Slope group of study area.

Slope Classes		Area (ha)	Area (%)
Flat and nearly flat	0-3 %	42.43	7.71
Medium	3-12 %	37.85	6.88
Steep	12-20 %	112.65	20.48
Very Steep	20-35 %	220.87	40.16
Extreme	> 35 %	136.19	24.76
TOTAL		550.00	100.00

Slope and lithofacies maps were combined to generate erodobility map. Erodobility classes of study area are presented in Figure 5. The proportional distribution of this erodobility classes are shown in Table 4.While about 84 % of study area has high and extreme erodobility risk, about 12 % of study area has a moderate and low soil erodobility.

Vegetation cover is also the most crucial element in erosion model, since it is the only factor that can readily be altered, and provides effective soil control (Milliward and Mersey, 1989).Intensity of vegetation cover is affecting significantly erosion rates. Usually, the erosion risk decreases as plant intensity rises. Soil Protection map was formed by overlaying land use types and vegetation cover layers. Soil protection map of study area is presented in Figure 6.According to this map, about 38 % of the study area has very high protection and about 58 % of area has very low erosion risk and less than is required protection precaution. Besides about 4 % of area is settlement. Distribution of the vegetation cover classes of the study area is showed in Table 5.

Table 4. The proportional distribution of erodobility map in study area

Level of Erodobility	Area (ha)	Area (%)
Low	40.70	7.40
Moderate	26.61	4.84
Medium	20.14	3.66
High	153.73	27.95
Extreme	308.83	56.15
TOTAL	550.00	100.00

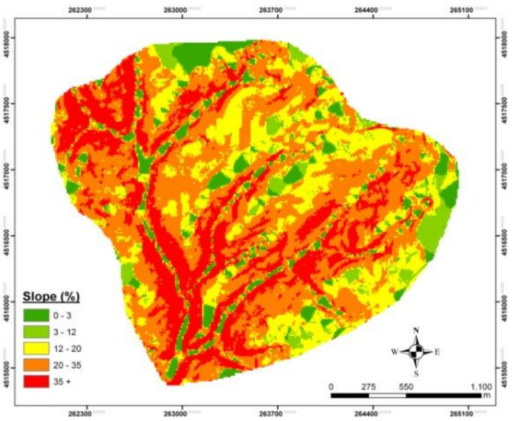


Figure 4. Slope map of study area

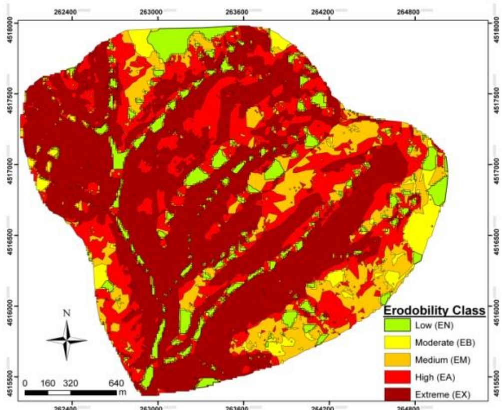


Figure 5.Erodobility map of study area

Table 5. Distribution of the vegetation cover classes of the study area.

	Coverage	
Vegetation cover	(ha)	%
Settlement	19.07	3.47
Very high	211.11	38.38
Very low	319.82	58.15
TOTAL	550.00	100.00

Finally, the ICONA erosion classes were determined by analyzing soil protection and soil erodobility layers. ICONA erosion risk map of study area are presented in Figure 7.Distribution of the ICONA soil erosion risk classes also are given in Table 6. According to ICONA, while about 44% of study area has low and very low erosion risk, about 50% of study area has high and very high erosion risk. It can be seen in chart that whereas areas with low erosion risk are covered by forest, areas with high erosion risk arepasture, orchard and cultivated land. In order to decrease erosion risk, it should be taken variable precaution cultural.

Conclusion

Land use, vegetation cover, parent material, topographic conditions, rainfall and soil properties are the major factors that affect soil erosion (Bayramin et al., 2003).This studycarried out in Madendere Watershed showsthat lands belong to pasture and orchard have under high and very high erosion risk. On the other hand, forest lands are more resistant from cultivated land, pasture and orchard. For this reason, in orchard and pasture lands are should more precaution for reduce to erosion risk in this watershed.In addition, in this study, vegetation cover show that play in role important for decrease of erosion risk. Uncovered lands are exposed further erosion. Therefore, these areas need good management method for effective erosion control. The control of soil erosion processes associated with besides appropriate land use and appropriate management planning, also vegetation cover.

Table 6. Distribution of the ICONA soil erosion risk classes

Level of Erodibility	Area (ha)	Area (%)
Settlement	18.61	3.38
Very low	56.07	10.19
Low	184.25	33.50
Appreciable	15.71	2.86
High	51.15	9.30
Very high	224.21	40.77
TOTAL	550.00	100.00

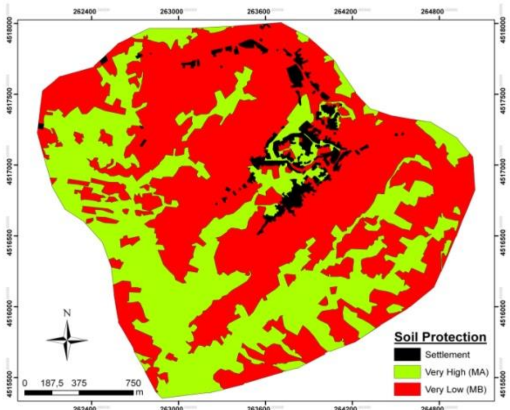


Figure 6. Soil protection map of study area.

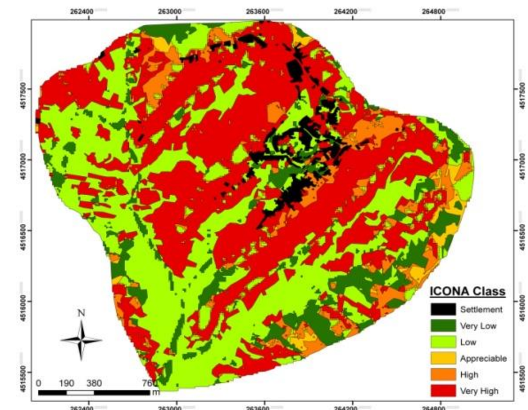


Figure 7. ICONA erosion risk map of the study area

The ICONA erosion model is very useful for determine the erosion risks of lands. Because the conventional methods require high labour cost and time to collect data. İn large areas areguite difficulties in measuring soil erosion with traditional methods. Therefore, Bayramin et al. (2003) show that these problems can be overcome by using predictive models and new techniques.GIS and RS techniques are very effective and useful to assess erosion riskin this research.

References

Bayramin, I., O. Dengiz, O. Baskan and M. Parlak, 2003. Soil erosion assessment with Icona Model case study: Beypazari Area. Volume: 27, Number: 2, 105-116. TUBITAK.

De Graaf, Jan. 1993. Soil conservation and Sustainable Land Use. An Economic Approach. Royal Tropical Institute, the Netherlands.

Doğan, O. 1998. Sustainable policies for soil resource management in Turkey. GDRS, No: 212, Research Institute-Ankara,

Entezari, M., Honarmandnezhad, S., Shahzeidi, S.S and Nematolahi, F, 2013. Use of Modified CORINE Methodology for Comparison, Potential Soil Erosion and Actual Soil Erosion in the Basin Watershed-Jahrom, Fars, Iran. Journal of Basic and Applied Scientific Research. 3(3)183-188.

İmamoglu, A., D. Turan. İ., Dengiz. O., Saygın. F., 2014. Soil Erosion Risk Evaluation: Application of Corine Methodology at Engiz Watershed, Samsun. CAES Volume 2: 15-21

Millward, A.A and J.E. Mersey. 1989. Adapting the RUSLE to model soil erosion potential in mountainous Tropical Watershed. Catena, 28: 109-129.

Millward, A.A. and J.E. Mersey. 1999. Adapting the RUSLE to model soil erosion potential in a mountainous tropical watershed. Catena, 38: 109-129.

Ministry of forest and water, 2013. Erosion activity plan. No:12. Ankara.

Reusing, M., T. Schneider and U. Ammer. 2000. Modelling soil loss rates in the Ethiopian Highlands by integration of high resolution MOMS-02/D2-stereo-data in a GIS. Journal of Remote Sensing, 21: 1885-1896.

Soil Survey Staff. 1999. Soil Taxonomy. A Basic of Soil Classification for Making and Interpreting Soil Survey. USDA Handbook No: 436, Washington DC.

Stocking, M., and N. Murnaghan. 2001. Hand book for the Field Assessment of Land Degradation. London: Earthscan Publication, UK.

TFCSE, The Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats, *http://www.tema.org.tr,* visited on November 27th, 2001.

URL-1, http://soilerosion.net/doc/models_menu.html.

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Effect of the phosphopotassic fertilization on wheat culture irrigated with saline water

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Abstract

To improve the state and plant resistance to salinity which is our objective in this study, we worked on the fertilization in salted medium. The experiment comprises two doses of phosphorus P1, P2 and four doses of potassium K0, K1, K2, K3 while using two levels of water salinity S1 and S2. The experiment is carried out in pots of vegetation with a durum wheat culture. The experimental device applied is ¨split-plot comprising 16 treatments and 3 repetitions. Our results show that salinity has a significant effect on the reduction of growth and yield of plant; however the fertilizer has contributed to the improvement of the aptitudes of the plant in salted medium. The phosphoric fertilization played a very important role, the highest dose P2 gave the good results of growth, yield of grain, yield of straw and the weight of 1000 grains. However the potash contribution has a less clear effect, but it is noted that the weak and medium dose K1 and K2 are the best on some parameters under the conditions of our experiment. Concerning the content of the grains of phosphorus, we noticed that the highest contents are recorded in the most saline treatments. Besides the treatments having received the dose P2 present sodium contents of the grains weaker than those having received the dose P1 what shows the importance of phosphorus under these conditions. It seems that the fertilization in saline condition ensures a favorable nutritional medium against to the aggressiveness of salinity.

Keywords: salinity, phosphorus, potassium, wheat

Introduction

The fertilization plays a very significant role in soil fertility and crop production increasing. However, in the salted mediums it is the subject of various views of scientists. The researches conducted in this field have different and sometimes contradictory results (Feigin, 1985). Certain are for the fertilization because it increases the fertility of the soil and create a favorable medium of nutrition for corps opposite to the aggressive effect of salinity. On the other hand others authors are opposed for reason of the additional salts brought by fertilizers. Indeed, if the fertilization is excessive or fertilizer is localized by high concentration in a small volume of the soil this increases the osmotic effect which affects the plant (Aragues, 1983). But, it seems that the reasoned contribution of manures can give good results like was announced by several research carried out in this field (Bertrand, 1981; Saurat, 1989; Shaher and Fadel, 1996; Osman et al., 1997; Nagaz et al., 2000; Almutawa and El Katony, 2001; Flora et al., 2003; Znati, 2009). According to Jurinak and Wagenet (1981) in (Aragues, 1983), in the majority of the cases, a moderate level of salinity of the soil can be compensated by the increase in the fertilization. Therefore to improve the state and plant resistance to

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salinity which is our objective in this study, we opted to work on fertilization in saline medium by the contribution of different doses of essential nutrients for plant namely the phosphorus and potassium using two levels water salinity, The experiment was conducted in pots of vegetation with a durum wheat crop and took place at the Department of Agronomy at the University of Biskra in Algeria.

Material and Methods

Material

Soil: The soil used in the experiment is that of the experimental field of agronomy department which characterized by a clay loam texture. The other characteristics are summarized in Table 1.

Table 1. Characteristics of the soil

Bulk density	1,4
EC 1/5 (dS/m)	4.58
pH	8.5
Total limestone (%)	37.96
Available phosphorus (ppm)	245.64
Available potassium (meq/l)	11.43
Organic matter (%)	0.67
Soil solution: (meq/l)	
Potassium K^+	0.86
Calcium Ca^{++}	21.20
Magnesium Mg^{++}	7.80
Sodium Na^+	20.97
Sulphates $SO4^{--}$	17.75
Chloride Cl^-	29.08
Bicarbonates $HCO3^-$	1.50

Water of irrigation: Two quality of water are used in this experiment, one is brought of a well of EC = 8 dS/m, the other is the water of agronomy department of EC=5.5 dS/m. The characteristics of water used are in table 2.

Table 2. Chemical quality of irrigation water

Water Quality	CEdS/m	pH	K^+ (meq/l)	Na^{++} (meq/l)	Ca^{++} (meq/l)	Mg^{++} (meq/l)	Cl^- (meq/l)	SO_4^{--} (meq/l)	HCO_3^- (meq/l)	CO_3^{--} (meq/l)
S1	5.5	7.49	0,28	38,69	8.2	6.6	33,24	10,49	5,7	0,8
S2	8	7.61	1,03	55,50	17.2	7.8	44,11	33,15	3,0	1,0

Fertilizers: fertilizers used are:

- Potassium fertilizer: potassium sulphate containing 50% K_2O.
- Phosphoric fertilizer: the triple super phosphate containing 46% P_2O_5

Plant: The plant used in this experiment is a durum wheat variety called Vitron. This is an early variety with short straw,

Pots: The pots used are in plastic perforated in bottom, their height is 22cm, and their sections higher and lower are 30 and 18cm of diameter respectively.

Methods

Experimental design

The experiment comprises 16 treatments and 3 repetitions. The treatments are combinations of the levels of the 03 studied factors: potassium fertilizer: K0, K1, K2, K3, phosphoric fertilizer: P1, P2 and salinity of irrigation water: S1 and S2.

The doses of potassium fertilizer are: K0= 0 units /ha, K1=50 u/ha, K2=100 u/ha, K3=150 u/ha.
The phosphoric fertilizer doses are: P1 = 50 u / ha, P2 = 100 u / ha.

The levels of water salinity are: S1 = 5.5 dS/m, S2 = 8 dS/m.
Thus the treatments are:

S1K0P1	S1K1P1	S1K2P1	S1K3P1	S1K0P2	S1K1P2	S1K2P2	S1K3P2
S2K0P1	S2K1P1	S2K2P1	S2K3P1	S2K0P2	S2K1P2	S2K2P2	S2K3P2

Experimental device

The experimental device applied is the split-plot with three floors with 16 treatments and 3 replicates.

Installation and conduct of the experiment

Preparation of soil: the soil is removed from the experimental field of agronomy department to about 25cm, dried and sieved to 2 mm.

Mineral manure: the basic mineral manure applied is manure of potassium fertilizer in the form of potassium sulphate and phosphorus fertilizer in the form of TSP (triple superphosphate) according to treatments. The nitrogen was brought with split in cover with an amount of 120 u/ha in the form of urea 46%.

Filling of the pots: we put in each pot 8.5kg soil well mixed with the basic mineral manure indicated above according to treatments.

Studied Parameters and analyzes

Plant: three measurements of height of plants stems were taken periodically during the growing season, grain yield and straw and weight of 1000 grains as well as the grain content of phosphorus, potassium and sodium.
Soil: three taking away of soil were carried out also periodically during the cycle of wheat to determine the EC and pH, as well as the cations and anions at the end of the cycle.

Drainage water: drainage water was also collected twice during the crop cycle for the analysis of their EC.

Results and Discussion

Effects of salinity and fertilization on plant

Evolution of plant growth (plant height) :According to growth results, we note that salinity has a marked effect on reducing plant growth (Bizid et al, 1988; Ben Naceur 2001; Hu et al, 2008; Montanri et al, 2008; Kadri et al, 2009), this is clear on the control treatments without fertilizer S1K0P0 and S2K0P0 whose heights are 34.7 and 23.5cm respectively and also on the treatment S2 compared to S1 (Figure 1).

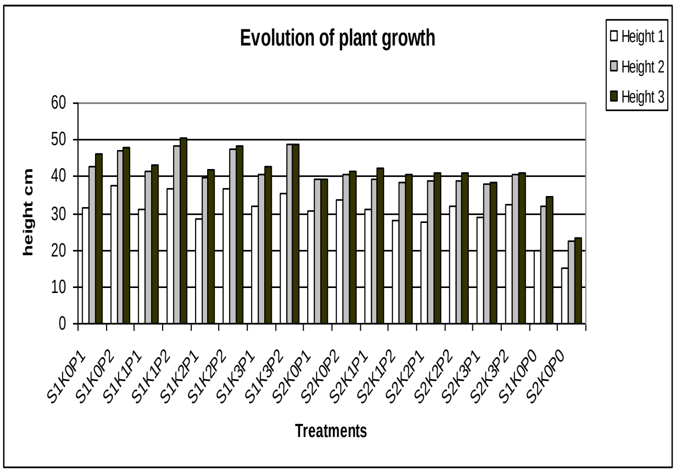

Figure 1. Evolution of plants growth

On the other hand, it may indicate a positive effect of fertilization on plant growth compared to control treatments had not received fertilizer. Plant growth is generally rapid between the first and second measurement period, but then became slower at the end of cycle. The height of the higher stems is 48 to 50cm recorded in the treatments irrigated by the least salted water S1 namely: S1K1P2, S1K2P2 and S1K3P2 (Figure 1). Analysis of variance shows that there is a total significant effect of phosphorus. The P2 treatments set up the first group and the P1 treatments set up the second group it means that the dose of phosphorus P2 has a more favorable effect than P1. Also the interaction shows that there is a significant effect between S1- P2 and S1- P1.

The grain yield: The fertilizer has contributed to increased yields in saline conditions compared to control without fertilizer whose yields are almost null (S1N0P0K0: 0.01 g / pot, S2N0P0K0: 0 g / pot). The Treatments irrigated with S1 generally have the highest yields compared to those irrigated by S2. We note that the treatments that received the dose P2 have higher yields than those who received the dose P1, this is clearer especially for treatments S1 (Figure 2). Analysis of variance shows that the SP interaction is significant between S1- P2 and S1- -P1, and also between S2-P2 and S2-P1 in favour of P2. It seems that the contribution of phosphorus improves nutrition and tolerance of plants in a salted environment (Shaher and Fadel, 1996).

However, a low to medium dose of potash seems sufficient under the conditions of our experiment especially with regard to the plant species according to our results.

The straw yield : Straw yields are generally similar between identical treatments of S1 and S2 with a marked superiority of P2 treatments especially for the treatments S1. It seems that the effect of salinity is less marked at the production of straw compared to the grains. But P2 dose is still the best compared to P1 whatever at the height level or grain yield and straw (Figure 3). According to Balbaa (1979), the taking away of phosphorus by the plants is influenced negatively by salinity. Indeed, Cl inhibits the absorption of the P_2O_5 and the increase of the content of this last has a significant effect in salted medium (Shaher and Fadel, 1996). This is confirmed by a significant overall effect of P2 compared to P1. The analysis of variance showed here a significant overall effect of potassium where K1 represents the best dose of potassium relative to other doses.

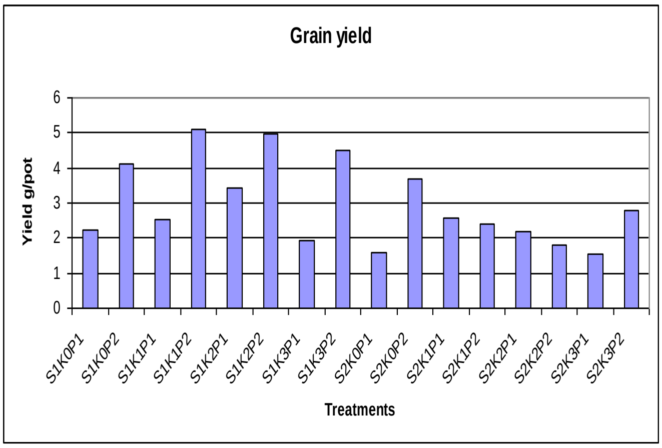

Figure 2. Grains yields

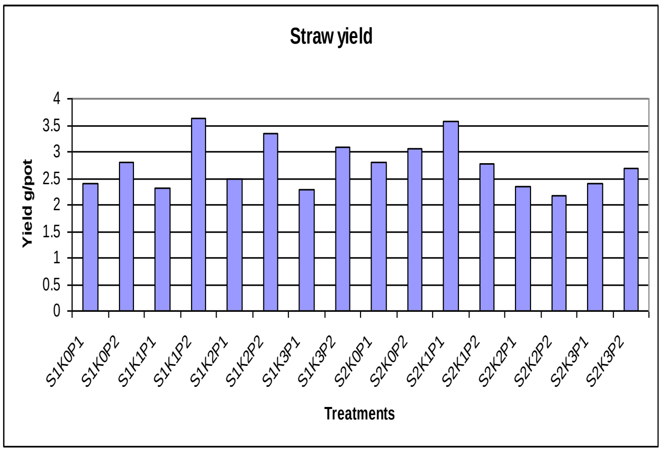

Figure 3. Straw yields

The weight of 1000 grains: The obtained results show that the weight of 1000 grains of the S1 treatments is generally higher than the treatments S2 (Figure 4), which indicates that the increase in salinity has a negative effect on the weight of 1000 grains, which is also confirmed by the analysis of the variance which shows a total significant effect of S1 compared to S2. On the other hand all the treatments that received P2 have higher weight of 1000 grains than those received P1 what confirms the positive effect of phosphorus on the weight of 1000 grains (Batten, 1987 in Brahımı, 1991). The total effect of P2 is always significant compared to P1, as well as the total effect of K is significant where K2 and K1 present the best averages.

The phosphorus content of grains: Generally the content of phosphorus in the grains is higher in the S2 treatments than the treatments S1 (Figure 5). It seems that the plant uses more phosphorus when it is available to balance the negative effect of the other anions especially the chlorides which are very abundant in a very salted medium, which indicates that the phosphoric fertilization has a positive influence under the saline conditions.

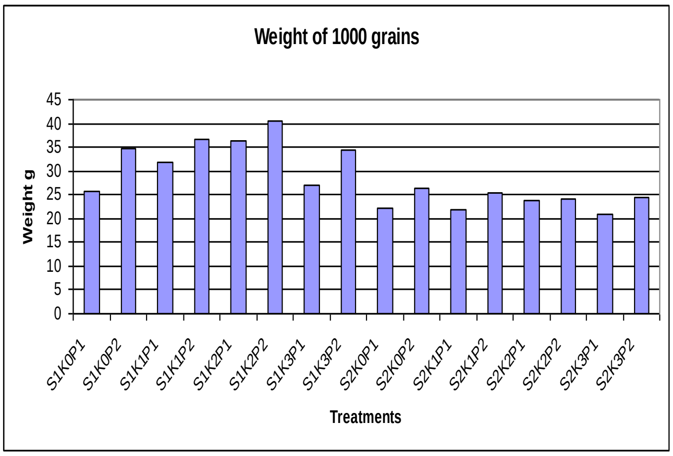

Figure 4. weight of 1000 grains

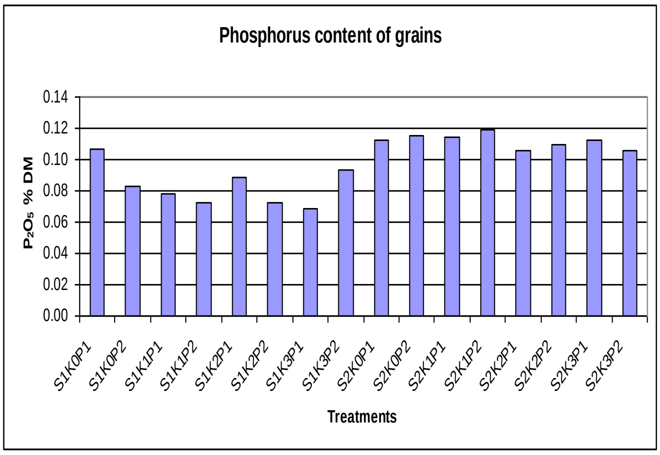

Figure 5. Phosphorus content of grains

The potassium content of grains: The results show that the concentration of K in the grains is very close between S1 and S2 treatments (Figure 6), which seems to us that the effect of potassium in our experiment is not very clear like phosphorus, this is probably due to the requirement of the species and the content of soil in potassium. The wheat crop is not very demanding of potash (Comıfer, 2009).

The sodium content of grains: The obtained results show clearly the effect of salinity on Na content of grains. Indeed, the percentage of Na in the grain of the S2 treatment is higher than that of the S1 treatments (Figure 7) due to the high content of Na in the irrigation water S2. The growth reduction due to salinity is accompanied by an increase in accumulation in the plant of Na (Grenway 1963; Munns et al, 1982 in Soltanı, 1990). An important remark is observed in the treatments that received the dose P2 which present lower levels of Na compared to those who received the dose P1, which also shows the importance of the contribution of phosphoric fertilization in these conditions.

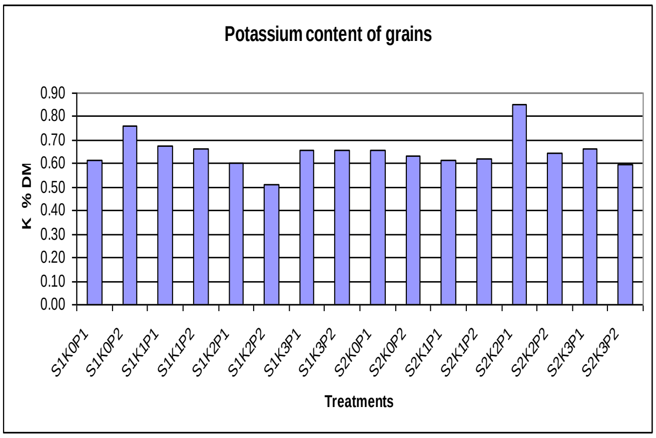

Figure 6. Potassium content of grains

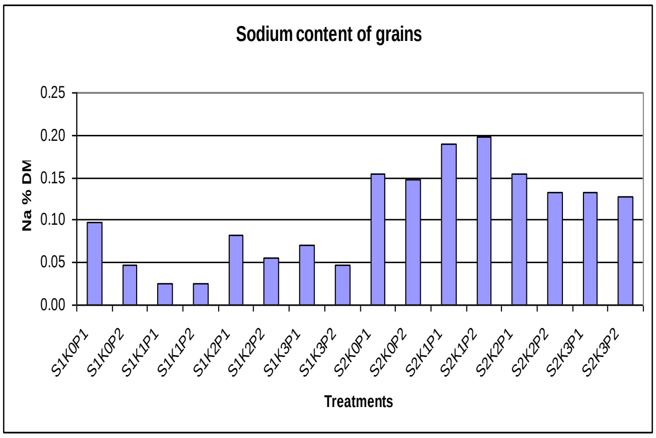

Figure 7. Sodium content of grains

Effects of salinity and fertilization on soil

Evolution of soil EC: Generally the electrical conductivity of the solution of soil is higher in the S2 treatments compared to S1 (Figure 8), this is due to the difference in salinity between irrigation water applied. According to the results obtained, the electrical conductivity of the soil is decreased at the end of the cycle of the plant; this reduction is explained by the significant application of leaching. This last seems more effective on the level of the treatments irrigated by the least salted water S1 than those irrigated by the most salted water S2 during the cycle of the culture.

Evolution of soluble salts

Sodium: As in the case of the grains of the plants, the contents of the soil of soluble Na in the S2 treatments are higherthan those in the treatments S1 (Figure 9) due to the higher concentration of the irrigation water S2 in this element.

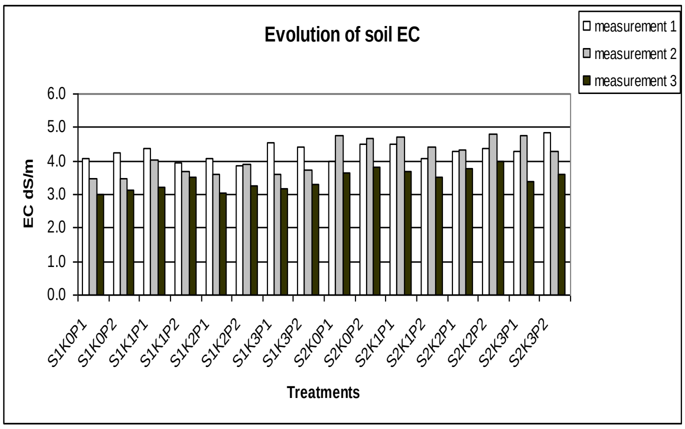

Figure 8. Evolution of soil EC

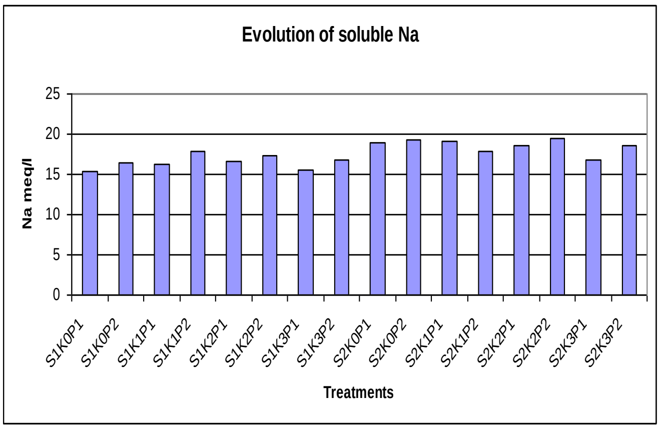

Figure 9. Soluble sodium content of the soil

Potassium: Generally, the contents of soluble K in the soil are close between the identical treatments S1 and S2. They increase relatively with the increase of the potassium doses (Figure 10).

Calcium and magnesium: Generally the soil contents of soluble Ca are close between the various treatments S1 and S2 (Figure 11), this is due probably on the studied soil which is calcareous, on the other hand, for Mg, we notices a relative superiority of the S2 treatments compared to S1 (Figure 12).

Chloride : The Cl content of the soil in the treatment S2 is higher than in the S1 treatment (Figure 13) due to the higher concentration of the irrigation water S2 in this element. The Cl content generally varies with the variation of EC of the soil and also with soluble Na content (Cruesı 1970; Halıtım 1988).

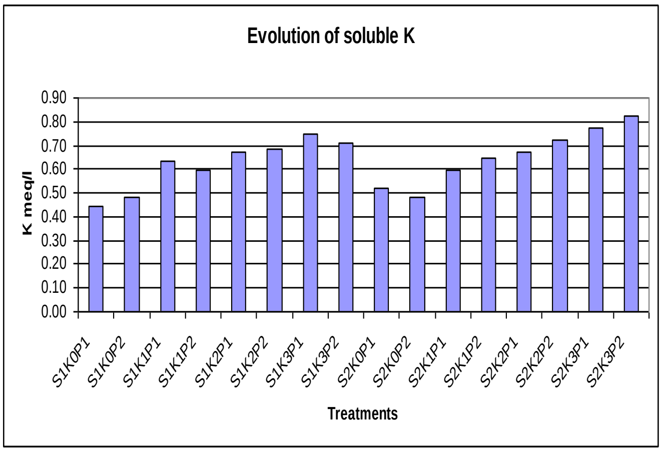

Figure 10. Soluble potassium content of the soil

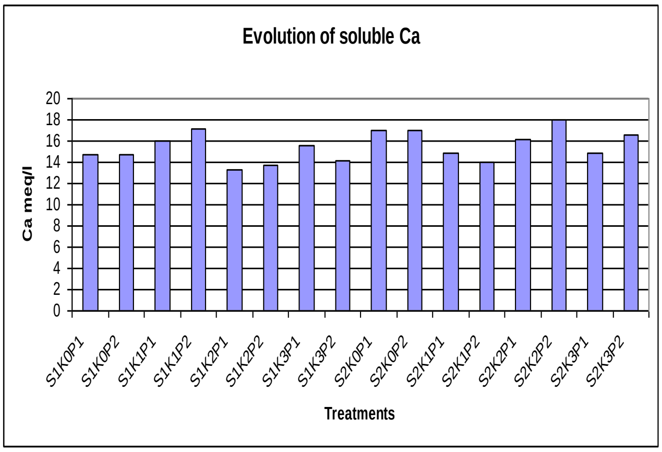

Figure 11. Soluble calcium content of the soil

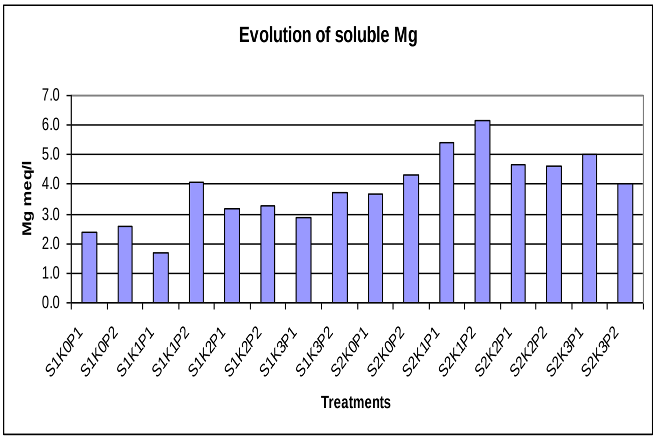

Figure 12. Soluble magnesium content of the soil

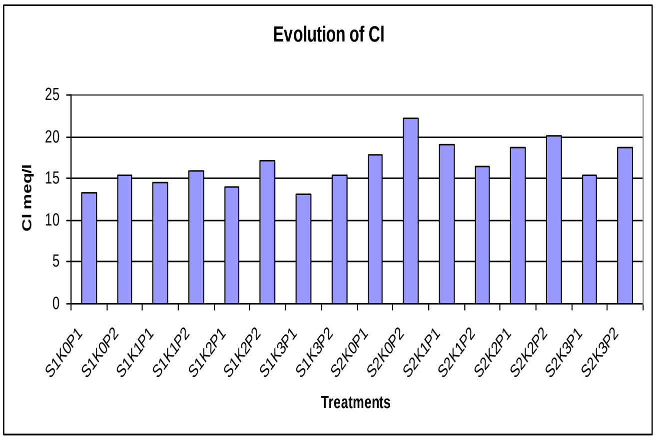

Figure 13. Cl content of the soil

Sulphate and bicarbonates: The contents of the soil of SO_4 are very close between the various treatments around 15 meq/l (Figure 14) however, the contents of the soil of HCO_3 are weak, less than 2 meq / l (Figure 15).

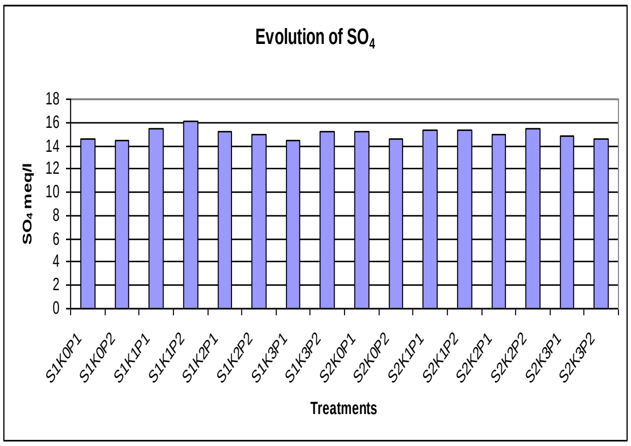

Figure 14. SO_4 content of the soil

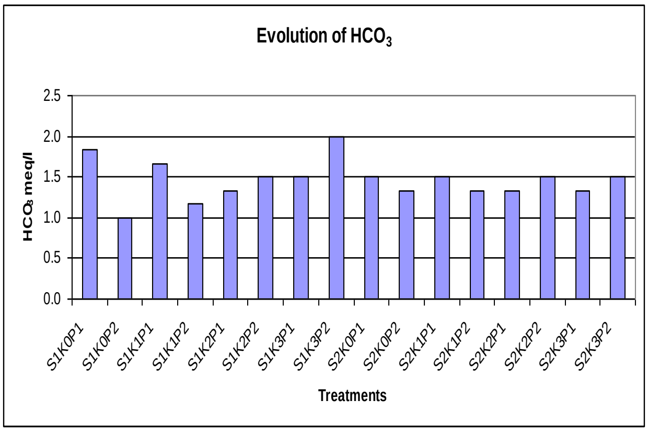

Figure 15. HCO_3 content of the soil

Soil available phosphorus content: Generally, the contents of the soil of available phosphorus are close between them, with a relative superiority of the treatments having received P2 than those having received P1 (Figure 16).It seems that the effect of phosphorus is more evident on the plant than on the soil.

Soil available potassium content: The results show that the K available contents are higher than those of K soluble because of the richness of soil in clay. The contents are generally close between the treatments (Figure 17).

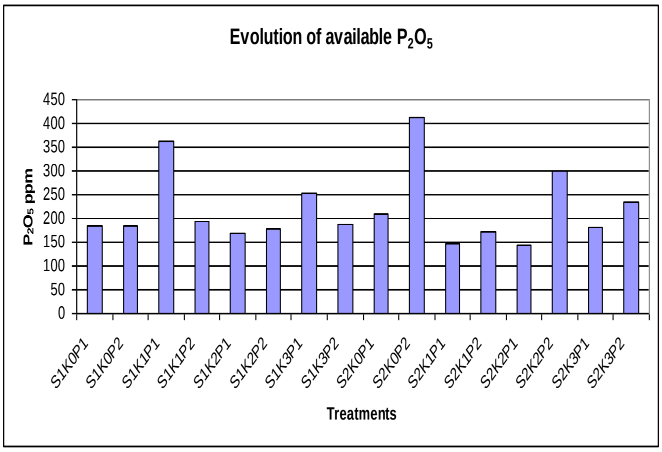

Figure 16. Available phosphorus content of the soil

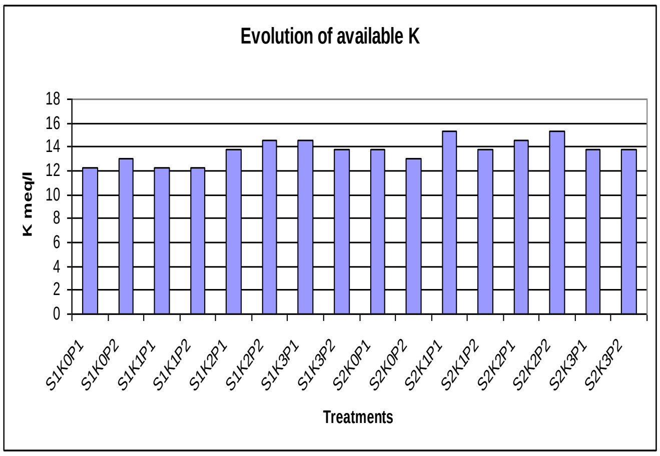

Figure 17. Available potassium content of the soil

Evolution of EC of drainage water : The results show that the electrical conductivity of drainage water of the S2 treatments are higher than those of the S1treatments (Figure 18), this is a consequence of a higher salinityof the soil resulting from the accumulation of salts brought by the salted irrigation water S2 (Yurtseven et al., 2003). The evolution of the EC of drainage water shows a general reduction following a important application of leaching.

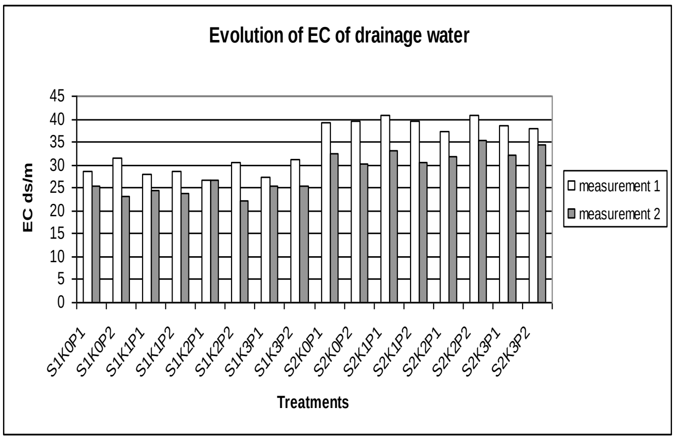

Figure 18. Evolution of EC of drainage water

Conclusion

Salinity has a significant effect on reducing the growth and yield of the plant; however fertilization contributed to improving the aptitudes of the culture in a salted medium. The phosphoric fertilization played a very important role, the highest dose P2 gave the good results of growth, grain yield, straw yield and weight of 1000 grains. However the contribution of potash has a less clear effect, but we note that the low and medium dose K1 and K2 are the best on some parameters in the conditions of our experiment. For the content of phosphorus in grains, it was noted that the highest levels are recorded in the most saline treatments, as well as the treatments having received the dose P2 have sodium content of grains smaller than those having received the dose P1 which shows the importance of phosphorus in these conditions. It seems that the fertilization in saline condition ensures a favorable nutritional environment against aggressive salinity. Also, it remains the most effective way to obtain acceptable yields especially in Saharan soil generally poor in nutrients elements (Halılat, 2004).

References

Al Mutawa, M.M, El Katony, T.M., 2001 Salt tolerance of two wheat genotypes in response to the forms of nitrogen. Agronomy 21, 259-266.

Aragues R., 1983 The quality and availability of water used in irrigation systems. In. Nutrient Balances and the need for fertilizers in semi arid and arid regions. Proceedings IPI. Morocco, 315 – 323.

Balba A.M., 1979 The effect of salinity on soil fertility and fertilizer efficiency in soils. In soils in Mediterranean type climates and their yield potential. Proceedings IPI. Spain, 125-129.

Bennaceur M, Rahmoune C, Sdiri H., Meddhi ML., Selmi M., 2001 Effet du stress salin sur la germination, la croissance et la production en grains de quelques variétés maghrébines de blé. Sècheresse 12, 3, 167 – 174.

Bertrand R., 1981 Sols salsodiques et cultures irriguées avec des eaux salines. Ed. GERDAT – IRAT, 44P.

Bizid E, Zid E, Grignon C., 1988 Tolérance à NaCl et sélectivité K^+/Na^+ chez les triticales. Agronomie 81, 23-27.

Brahimi T., 1991 Contribution à l'étude de l'utilisation des phosphates naturels dans la fertilisation phosphatée d'un sol saharien. Mémoire ingénieur, ITAS Ouargla.

Comifer., 2009 Fertilisation P K : Grille de calcul de dose. Groupe P K Mg, 2P.

Cruesi, 1970 Recherches et formation en matière d'irrigation avec des eaux salées UNESCO. 243P.

Feıgın A., 1985 Fertilization management of crops irrigated with saline water. Plant and soil 89, 285 – 299.

Flores P, Navarro J.M, Carvajal M., 2003 Tomato yield and quality as affected by nitrogen source and salinity. Agronomy 23, 249-256.

Halilat M.T., 2004 Effet de la fertilisation potassique et azotée sur blé en zone saharienne. IIP regional workshop on potassium and fertigation development in West Asia and North Africa. Rabat, Morocco.

Halitim A., 1988 Sols des régions arides d'Algérie. OPU. Alger, 384P.

Hu Y, Burucs Z, Schmıdhalter U., 2008 Effect of foliar fertilization application on the growth and mineral nutrient content of maize seedlings under drought and salinity. Soil sciences and plant nutrition 54, 133-141.

Kadri K, Maalam S, Cheikh M.H, Benabdallah A, Rahmoune S., 2009 Effet du stress salin sur la germination, la croissance et la production en grains de quelques accessions tunisiennes d'orge. Science et technologie C 29, 72-79.

Montanari M, Degl'innocenti E, Maggini R, Pacifici S, 2008 Effect of nitrate fertilization and saline stress on the contents of active constituents Echinacea angus tifolia. Food chemistry 107, 1461-1466.

Nagaz K., Benmechlıa N., Hamdy A., 2000 Irrigation water quality and nitrogen for yield and water use efficiency of barley in the arid climate of southern Tunisia. In Plant nutrient management under pressurized irrigation systems in the Mediterranean region. Proceeding IMPHOS. AMMAN, 344-352.

Osman A.A, Alnabulsı Y.A, Helalıa A.M., 1997 Effects of water quality and frequency of irrigation growth and yield of barley. Agricultural water management 34, 17-24.

Saurat A., 1989 Potash fertilization in Arab countries. Potash review 3, 1-10.

Shaher M., Fadel K, 1996 Efficiency of use of the nitrogen and phosphorus fertilizers on the development and the yield of wheat irrigated by saline water. In use of saline water in agriculture. ACSAD, 28P.

Soltani A, Hajji M, Grignon C., 1990 Recherche de facteurs limitant la nutrition minérale de l'orge en milieu salé. Agronomie 10, 857-866.

Yurtseven E, Kesmez G.D, Unlukara A., 2003 The effects of potassium on salinity tolerance fruit quality and water consumption for tomato under saline conditions. Proceeding of an international workshop: sustainable strategies for irrigation, 192-203.

Znatı A.A., the good management of nutrient elements use decreases the negative effects of salinity on the plant. Arabic Fertilizers, 36, 37-54.

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Effect of nitrogen fertilization date, dose and soil properties on nitrate and ammonium distribution pattern in a soil profile

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Abstract

In the present study, leaching and distribution pattern of nitrate and ammonium were examined in the soil profiles of an olive plantation where long term nitrogen fertilization was practiced in enhanced doses. In this regard, 6 different levels of nitrogen (0-400-800-1200-1600-2000 g N/tree) in the form ammonium sulfate was incorporated under the canopy starting from the year 1994 to 1999. The soil of the experiment had a high infiltration capacity because of vertic properties of clay loam texture. In order to study the nitrate and ammonium status of the soil, 24 profiles were dug during (1997) and after (2001) the experiment. Results showed that significant amounts of nitrate can leach if excess nitrogen used. Nitrate, if compared with the study years decreased after the termination of the experiment; however, it was still over the threshold values. It can be concluded that excess nitrogen fertilization can threaten and further contaminate the underground waters.

Keywords: Nitrate, Ammonium, Olive, Leaching, Nitrogen Fertilization

Introduction

According to the FAO, nitrogen fertilizers need of the world is estimated as 117 million tones for the year 2016 (Anonymous, 2012). This value proves the importance of N fertilization only by itself. Incorrect fertilizations may cause N losses. Cameron and Haynes (1986) reported that N losses by leaching can be effected by season, climate, soil properties, management, irrigation and application of solid wastes; also they reported that losses by this way as 2-100 kg/ha/year. Viets and Hageman (1971) examined the factors effecting accumulation of nitrate in soil, plant and water. In the study they prepared by the help of more studies, they examplified about nitrate accumulation in soil, nitrate movement and distribution through soil profile, nitrate contents of drainage water, nitrate concentration in arid and wet area soils. According to Frissel (1978), 10-50% of nitrogen added into soil is lost in the form of NO_3which is a result of nitrification.

Residual N which stays in soil after plant use, can be adsorbed by soil components or can be a part of organic matter; it can be lost in gasaous form or can be effected by denitrification. Also, it may be moved under root zone by leaching (Wang and Alva, 1986). Pratt et al. (1972) informed that if the application dose of N is not above the plants requirement, there can not be any $NO_3$for denitrification.

N losses by leaching do not only decrease the available N content; it also causes agricultural and environmental problems. Even in good agricultural practises conditions, N uptake of annual plants stays

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below 50%(Baligar and Bennett, 1986; Gillian et al., 1985). It is reported that efficiency of N use can be effected by plant type. In this context, this efficiency rate can be 40-50% in graminae and 20-40% in fruit trees(Dou et al.,1997).

Leaching losses in the form of nitrate are more common in sandy soils under high rainfall regimes. In rainy seasons when rainfall values extent the evaporation values, leaching losses in the form of nitrate occure. N losses by leaching depend onsoil properties and N concentration of soil profile. In soils which have high infiltration rate, high porosity and permeability, rapid and high leaching losses can be expected(Razzaque and Hanafi, 2004). Leaching situation of N in diffrent climate, soil type and cropping pattern was determined(Avnimelech and Raveh, 1976; Baker and Johnson, 1981; Kissel et al., 1974). Işıldar and Karakaplan (1991), studied the N distribution through soil profile and leaching conditions due to increasing use of N fertilizers in Misli Plain, Niğde. For this purpose, they have applied 0-50-100-150-200 kg/da ammonium sulfate fertilizers on potato plant in two different area. They have done NH_4-N and NO_3-N analyses of soils which were taken from opened soil profiles (0-120 cm) in the beginning of vegetation and harvest. Harvest foundings that show increased NO_3-N content in 60-120 cm layer of the soil profile were connected to leaching losses of N.

Razzaque and Hanafi (2004), established an experiment with the peat soils in laboratory conditions to determine the leaching losses of N. Soils were taken from two different gardens which were used for pineapple cultivation for 21 and 42 years. In this regard, 60 kg/da N in the form of urea were applied to columns which were fulled with soils and leaching process was carried out for 28 days. In the end of the research, it is determined that 53-66% of the applied N was lost by leaching.

Gaines and Gaines (1994), applied the following procedure to determine the effect of soil texture on NO_3leaching. They fulled the 2×3 inch soil columns with sand, peat-sand (85:15), sandy loam and sandy clay loam; they also saturated the columns with 240 ppm NO_3-N solution by dipping the columns in it; after this, they leached the columns ten times by 50 ml water. Results of the research proved that soil texture effects nitrate retention; the lowest nitrate retention (119 ppm) was achieved in sandy soil and the highest retention (173 ppm) in sandy clay loam soil.

Krichmann and Begström (2001) in their study which was prepared by the help of more studies, examined the reducing or increasing conditions of nitrate leaching under the conditions of organic agriculture practises. Researchers informed that organic and conventional agriculture were showed differences with regards to cropping pattern and nitrogen input; in organic agriculture with lower N input, average N leaching was lower to a certain extent. Also, researchers reported that there were no significant foundings proving the possibility of reducing nitrate leaching by organic agricultural practises with as the same aim of yield as in conventional agriculture; they informed that reducement of nitrate leaching can be a part of proper and preventive precautions in these conditions.

Schuman et al. (1975) in their research which they have done between the years 1969-1974 investigated the effects of 168 and 448 kg/ha/year N applications on nitrate movements in two different basin in Iowa State of USA. As a result, in one of the basins, NO_3 movement were determined as 6,1 m with 448 kg N application, and due to this movement 720 kg/ha accumulated under root zone; with recommended N dose of this basin (168 kg/ha) there were no accumulation or movement of NO_3-N under root zone.

Izsaki and Ivany (2005) investigated the leaching situation of NO_3-N between the years 1989-2000 by using different doses of NPK as 0-80-160-240 kg/ha and taking soil samples from 0-300 cm depth, in 4th, 8th and 11th year of this 11 year experiment. Consequently, they reported a negative statement of N as a result of 80 kg N application; in 8th and 11th years of the experiment with the use of 160 kg/da N, they reported a balanced statement of N; by using 240 kg/ha dose of N, they determined a raising statement of N. They also informed that leaching becomes more important after 8th year with the dose of 160 kg/ha N and the highest N accumulated zone was 140-180 cm depth.

Infiltration rate of soil has an important role in nitrogen leaching process. Infiltration is defined as the process by which water on the ground surface enters the soil. Infiltration is faster in dry soils. However when soil humidity raises, this rate starts to decrease until infiltration rate stands on a constant value. This constant situation of soil profile means that infiltration is limited by percolation capacity(Aydın,1989).

Researches that investigated the nutrition conditions of Aegean Region olives, determined that N contents of the olive leaves are under the reference values. By considering the low olive yield of our country and with the case of insufficient N nutrition of olive trees, an experiment was carried out with 6 different N doses changing among 0-2000 g/tree/year, between the years 1993-1998. In this study, the experimentation of higher doses of N than optimum value, brought the necessity of examining the movement and accumulation of N through soil profile and the possibility of contamination of underground water. For this purpose, NO_3-N and NH_4-N distributions were investigated through pedons in fertilization period (1997) and after fertilization period(2001). Besides, with the aim of preparing data for the nitrate contamination rate of groundwater and underground waters, data sets were attempted to established by determining the infiltration rate of experimental soil.

Material and Methods

The study was carried out in Kemalpaşa-İzmir, Turkey. Experiment was conducted in randomized blocks experimental design with 5 repetition and 2 trees per repetition. 25-30 years old Memecik type of olive trees were fertilized with 6 different doses of N (0-400-800-1200-1600-2000 g N/tree/year)(N_0-N_1-N_2-N_3-N_4-N_5) for 5 years. $(NH_4)_2SO_4$ form of N was used for fertilization. Also, all trees including the control were fertilized with 400 g P_2O_5 /tree/year in the form of TSP and 500 g K_2O/tree/year in the form of K_2SO_4 . Fertilization was carried out at the end of the February or beginning of the March by incorporating fertilizers under the canopy that prepared by ploughing lines on four sides of it.

In this study, soil samples were taken from 24 profile (0-180 cm) opened by excavator for each subject belonging 2nd and 4th randomized blocks, including 1st at 14 September 1997 and 2nd at 2 November 2001.

Moist samples taken from profile were brought to laboratory and sifted through 5 mm mesh for NH_4 and NO_3 analyses. After1.0 N $CaCl_2.2H_2O$+1.0 N NaCl extraction, NH_4 and NO_3 analyses of samples were donespectrophotometrically. Humidity determination of samples was carried out at the same time and results were calculated by referencing dry soils(Kandeler and Gerber, 1998; Scharpf and Wehrmann, 1976).

After NH_4 and NO_3 analyses, soil samples were air dried in laboratory conditions and sifted through 2 mm mesh. Particle size distribution of experimental soil was determined by the Bouyoucos hydrometer method (Bouyoucos 1962); bulk density (Black, 1965); particle density, total porosity and humidity, water filled pores, air filled pores, field capacity, wilting point (U.S. Salinity Lab. Staff, 1954); total water-soluble salts by measuring electrical resistance in water-saturated soils (U.S. Soil Survey Staff, 1951); pH, by pH-meter with glass electrode in water-saturated soil (Jackson, 1967); $CaCO_3$, by using Scheibler Calcimeter (Schlichting ve Blume, 1996); organic matter, by determining the organic-C percent of wet decomposited samples and multiplying these values by the factor 1.724 (Rauterberg ve Kremkus, 1951); cation exchange capacity, by measuring Na^+flame photometrically after saturation of samples with NaOAc and extraction by NH_4OAc (Jackson,1967). Infiltration tests of experimental field was carried out with double cylinder infiltrometer(Bouwer, 1986). Obtained data were used for calculation of cumulative water depth (D) and infiltration rate (I). Statistical evaluation was done by Tukey multiple comparisons test.

Results and Discussion

Soil Properties of Experimental Field

Organic matter contents of these Vertic Xerofluvent soils were found low. It was also observed that bulk density values of soils raised with increasing soil depth (Table 1).

As a result of average values of infiltration tests, infiltration rate equation and cumulative water depth equation were determined as $I=41.585t^{-0.3091}$and $D=0.6927t^{0.,6911}$, respectively.

Infiltration rate value was calculated as 11.73 cm/h by using infiltration rate equation. Classifications of soils by infiltration rate acccording to Konhke (1968) were given in Table 2.

Table 1. Some properties of experimental soil (pedon 8).

Soil depth (cm)	Particle size distrubution (%)			Texture	db g/cm³	dp g/cm³	Field capacity %	Wilting point %
	Sand	Silt	Clay					
Ap (0-18)	40	30	30	Clay loam	1.40	2.56	24.80	15.61
C_1 (18-59)	40	28	32	Clay loam	1.58	2.54	23.87	16.75
C_2 (59-84)	42	24	34	Clay loam	1.58	2.60	26.89	19.18
C_3 (84-117)	42	24	34	Clay loam	1.72	2.58	27.52	19.91
C_4 (117-148)	46	18	36	Sandy clay	1.75	2.63	28.20	17.85
C_5 (148-180)	50	24	26	Sandy clay loam	1.77	2.60	20.72	14.24
C_6 (180 +)	70	12	18	Sandy loam	1.81	2.61	18.13	12.57

db: bulk density dp: particle density

Soil depth (cm)	pH	$CaCO_3$ %	Soluble salt %	Org. Mat. %	CEC Cmol/kg
Ap (0-18)	7.60	7.15	0.083	0.722	28.24
C_1 (18-59)	7.65	7.17	0.056	0.616	28.24
C_2 (59-84)	7.60	5.13	0.065	0.439	28.73
C_3 (84-117)	7.61	5.22	0.065	0.422	28.73
C_4 (117-148)	7.69	12.86	0.062	0.155	29.65
C_5 (148-180)	7.72	16.53	0.058	0.052	22.79
C_6 (180 +)	7.74	18.66	0.046	0.026	18.82

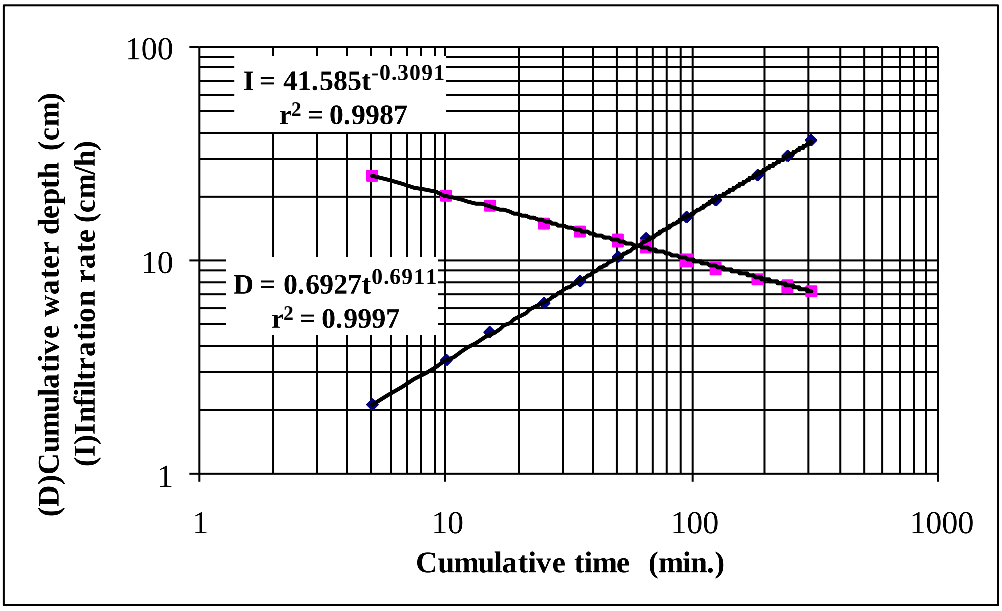

Figure 1. Infiltration rate and cumulative water depth equations and lines that calculated with regards to the average results of infiltration tests.

Table.2. Classification of soils infiltration values (Kohnke, 1968).

Infiltration class	I=Infiltrasyon rate (cm/h)
Very slow	<0.1
Slow	0.1-0.5
Rather slow	0.5-2.0
Moderate	2.0-6.3
Rather fast	6.3-12.7
Fast	12.7-25.4
Very fast	25.4<

In a research that carried out in Gediz Delta, infiltration rates of delta soil were determined as between 1.33-24.71 cm/h. According to these values, it was found that infiltration rates of delta area change between rather slow and fast. Based on these results, it was informed that all plant nutrients, heavy and trace metals which are able to reach soils by any applications (fertilizers, insectisides, wastes, irrigation water etc.) can infiltrate underground waters and lagoons and contaminate them (Delibacak and Okur, 2000).

One of the most important reasons for deterioration of natural balance and habitats is the fertilizer overuse. Leaching and contamination of these fertilizers to ground and underground waters is also depend on infiltration rate of soils. Determination of infiltration rate equations relative to research area soils can help to assess leaching rate of NO_3 ions. Besides, equations of infiltration rate and cumulative water depth can help to irrigation process and determination of required water content for soil reclamation. Infiltration rates of experimental soils were assessed as rather fast. Accordingly, the possibility of nitrate leaching and contamination to ground and underground waters gains importance by using high doses of nitrogen fertilizers.

Effects of Nitrogen Fertilizers on Soil NO_3-N and NH_4-N Contents

Examination of NO_3-N and NH_4-N movements and accumulations in soil shows that the concentrations of both forms increase linearly by enhancing doses of fertilizers (Table3-5).

Table3.NO_3-N content of soil with regards to application dose and sampling time.

	All		1997			2001		
N_0	5.404	e	6.711	e	A	4.038	c	A
N_1	9.480	e	11.082	e	A	7.878	c	A
N_2	34.211	d	56.146	d	A	12.277	bc	B**
N_3	60.594	c	108.750	c	A	12.437	bc	B**
N_4	75.947	b	132.500	b	A	19.393	b	B**
N_5	175.069	a	312.979	a	A	37.159	a	B**
		**		**			**	

* Tukey P≤0.05,** Tukey P≤0.01
Significant differences between treatments indicatedby different letters. Upper letter in row, lower letter in column.

Table4.NH_4-N content of soil with regards to application dose and sampling time

	All		1997			2001		
N_0	6.904	e	7.033	d	A	6.775	c	A
N_1	21.136	d	22.725	c	A	19.548	b	A
N_2	27.071	c	27.983	c	A	26.158	a	A
N_3	30.698	bc	34.250	b	A	27.146	a	B**
N_4	34.712	ab	37.225	b	A	32.199	a	A
N_5	38.489	a	47.900	a	A	29.078	a	B**
		**		**			**	

* Tukey P≤0.05,** Tukey P≤0.01
Significant differences between treatments indicatedby different letters. Upper letter in row, lower letter in column.

Table5.Total N content of soil with regards to application dose and sampling time.

	All		1997			2001		
N_0	12.308	f	13.804	f	A	10.813	e	A
N_1	30.616	e	33.807	e	A	27.425	d	A
N_2	61.282	d	84.129	d	A	38.435	cd	B**
N_3	91.292	c	143.000	c	A	39.583	c	B**
N_4	110.659	b	169.725	b	A	51.593	b	B**
N_5	213.558	a	360.879	a	A	66.238	a	B**
		**		**			**	

* Tukey P≤0.05,** Tukey P≤0.01
Significant differences between treatments indicatedby different letters. Upper letter in row, lower letter in column.

This difference is particularly big with regards to nitrate. In this context, toxicity symptoms of olive trees that were fertilized by N_4 (1600 g/tree) and N_5 (2000 g/tree) doses can be an effect of excessive N accumulation in soil. Haynes (1986) informed that he has observed NH_4 toxicity symptoms by slot fertilization of ammonia and ammonium fertilizers to a limited area of soil. In other research, it is stated that 600-800 g N/tree fertilizer applied on 15-50 years old olive trees in Spain which is a Mediterranean country as Turkey (IFA, 1992).

Occuring toxicity symptoms on trees, nitrate accumulation and risk of contaminaton to underground waters signs the importance of dose choosing. Results which were obtained from domestic and foreign studies shows parallelism with the results obtained from control and low dose (N_0 and N_1) of N applications (Kovancı,1969; Viets and Hageman,1971; Usta, 1983; Sağlam, 1976; Alvarez et al., 2001). NO_3-N and total N contents of soils show statistically (time) significant differences with regards to sampling time (Table 3-5). However, these differences are not significant for NH_4-N (Table 4).

Total N Distribution Pattern of Soil Profile

Regardless of sampling times, total N values were found higher at upper layers for N_0 and N_1applications while these values were found higher at lower layers for other N applications (Table 6.).

Table 6. Total-N (NO_3-N + NH_4-N) contents of soil with regards to application dose and sampling depth.

	N_0		N_1		N_2		N_3		N_4		N_5	
1 (0-18)	**21.700**	a	41.063	a	49.763	cd	67.253	c	85.718	c	143.318	d
2 (18-59)	19.300	ab	35.578	a	51.625	cd	70.087	c	84.723	cd	146.275	d
3 (59-84)	12.713	abc	**45.350**	a	64.860	bc	59.218	c	68.098	d	256.725	c
4 (84-117)	8.863	abc	30.890	ab	73.100	ab	91.915	b	117.555	b	**325.303**	a
5 (117-148)	6.250	bc	17.565	bc	**84.413**	a	**187.950**	a	**217.223**	a	295.417	b
6 (148-180)	5.025	c	13.250	c	43.933	d	71.328	c	90.638	c	114.313	E
		*		**		**		**		**		**

* Tukey P≤0.05,** Tukey P≤0.01
Significant differences between treatments indicatedby different letters.

Infiltration rate, porosity, soil type, clay and organic matter content of the research area were found capable to effect distribution of NO_3-N and NH_4-N through soil profile. Although clay contents of upper layers are high, due to high infiltration rate caused by vertic properties of soil and low to moderate organic matter content; NO_3-N values have reached very high levels at 4th and 5th layers in 1997 particularly (Fig.2).

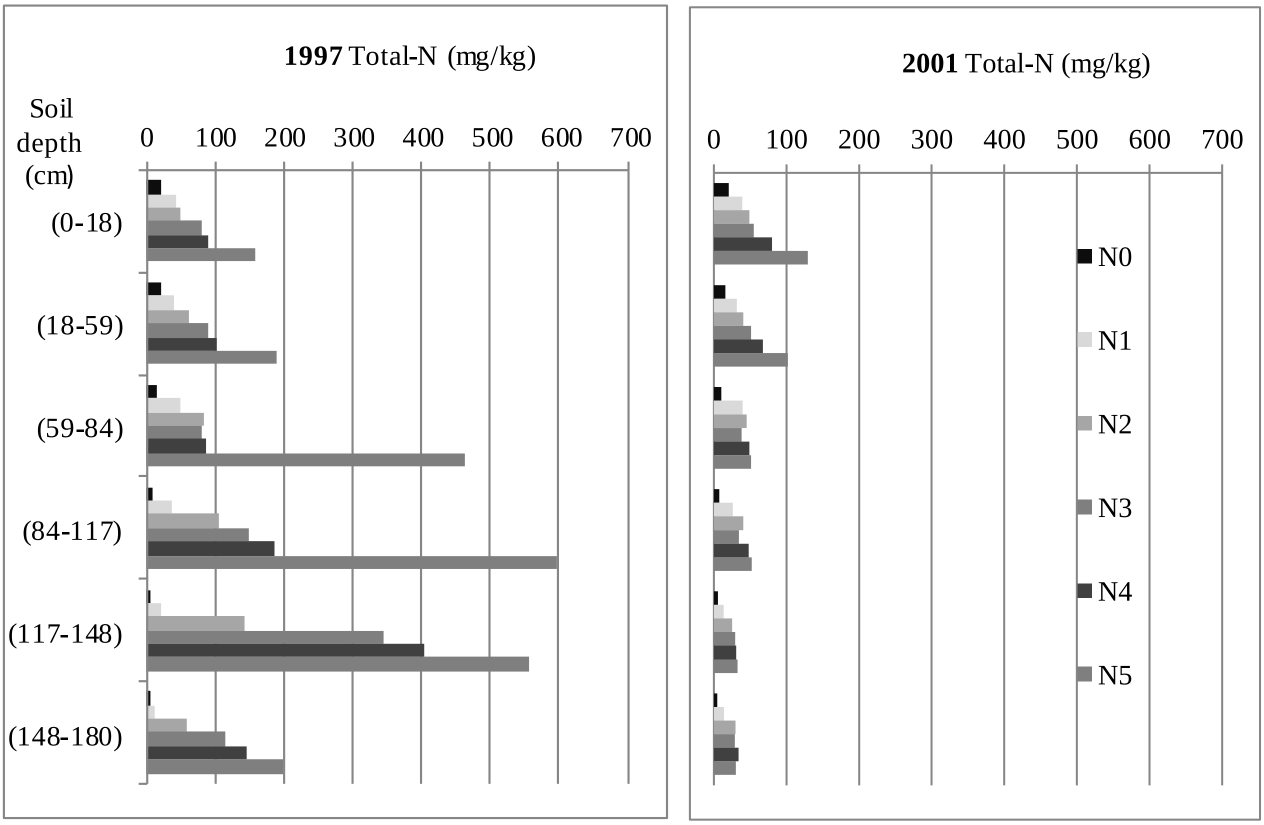

Figure 2. Total-N (NO_3-N + NH_4-N) content of soil with regards to application dose and sampling depth in 1997 and 2001.

Conclusion

Results obtained from the study can be summarized as follows:

- High dose applications of N fertilizers for a long time can lead a significant amount of NO_3-N accumulation through soil profile.
- NO_3-N concentration and accumulation through profile varies significantly with regards to fertilization time. A significant amount of NO_3-N can stay at soil profile even after a few years from fertilization.
- Olive trees showed toxicity symptoms and dryings by the application of high dose N fertilizer.
- As a result of high dose application of N, NO_3-N accumulation through profile constitutes a great risk for underground waters; the substantial decrement of NO_3-N contents at lower layers of soil profile (180 cm) invigorate this possibility.

References

Alvarez, C.R., Alvarez, R., Steinbach, H.S., 2001. Prediction of Available nitrogen content in soil profile depth using available nitrogen concentration in surface layer. Commun. in Soil Sci. and Plant Anal. 32 (5&6): 759-769.

Anonymous, 2012. Current world fertilizer trends and outlook to 2016. Food and Agriculture Organization of the United Nations, Rome.

Avnimelech, Y., Raveh, J.,1976. Nitrate leakage from soils differing in texture and nitrogen load. J.Environ. Quality 1:79-82.

Aydın, M., 1989. Toprak-Su Koruma. Çukurova Üniversitesi Ziraat Fakültesi Yardımcı Ders Kitabı No:17, Adana.

Baker, J.C., Johnson, H.P., 1981. Nitrate-nitrogen in tile drainage as affected by drainage. J.Environ.Quality. 4:519-522.

Baligar, V.C., Bennett, O.L., 1986. NPK fertilizer efficiency: A situation analysis for tropics. Fet. Res. 10:147-164.

Black, C.A., 1965. Methods of soil analysis. Part I. American Soc. of Agronomy. No. 9.

Bouwer, H., 1986. Intake rate: Cylinder infiltrometer. In: A. Klute (Ed.): Methots of Soil Analysis, Part I. Agronomy Monograph series No. 9 (2nd edition), ASA and SSSA, Madison, Wisconsin, p. 825-844.

Bouyoucos, G.J., 1962. Hydrometer Method Improved for Making Particle Size Analysis of Soil. Agronomy Journal, Vol. 54, No:5.

Bremner, J.M., 1965. Total Nitrogen. Edit. C. Black. Methods of Soil Analysis. Part 2. Amer. Soc. of Agr. Inc., Publisher, Madison, Wisconsin, USA. P: 1149-1178.

Cameron, K.C., Haynes, R.J., 1986. Retention and movement of nitrogen in soils.In:Mineral Nitrogen in the Plant-Soil System (Ed:R.J. Haynes).Academic Pres,167-241.

Delibacak, S., Okur, B., 2000. Gediz Deltasında Yayılım Gösteren Toprakların İnfiltrasyon Hızları ve Ağır Metal İçerikleri. Ege Üni. Ziraat Fak. Dergisi Cilt: 37, No. 1, s. 9-16, Bornova.

Dou, H., Alva, A.K., Khakural, B.R., 1997. Nitrogen mineralization from citrus tree residues under different production conditions.Soil Sci. Soc. Amer. J. 61:1226-1232.

Frissel, M.J., 1978. Cycling of Mineral Nutrients in Agricultural Ecosystems. Elsevier, Amsterdam.

Gaines, T.P., Gaines, S.T., 1994. Soil texture effect on nitrate leaching in soil percolates. Commun. in Soil Sci. And Plant Anal. 25 (13& 14):2561-2570.

Gillian, J.W., Logan, T.J., Broadbent, F.E., 1985. Fertilizer use in relation to the environment. In: Fertilizer technology and Use (Ed:O.P. Engelstad). Soil. Sci. Soc. Amer. Madison,Wisconsin,USA.561-588.

Haynes, R.J. 1986. Nitrification. In:Mineral Nitrogen in the Plant-Soil System (Ed:R.J. Haynes).Academic Pres,Inc.p.127-165.

IFA, 1992.World Fertilizer use Manual.Inter. Fert. Ind. Assoc.,Paris. p 229-233.

Işıldar, A.A., Karakaplan, S., 1991. Niğde-Misli Ovası Topraklarında Azot Hareketi.Doğa-Tr.J. of Agriculture and Forestry.15:318-327.

Izsaki, Z., Ivany I., 2005. Effect of mineral fertilization on NO3-N leaching on clay soil. Commun. in Soil Sci. and Plant Anal. 36:383-391.

Jakson, M.L., 1967. Soil Chemical Analysis. Prentice Hall of India Private Limited. New Delhi.

Kandeler, E., Gerber, H., 1988. Short-term assay of soil urease activity using colorimetric determination of ammonium. Biol. Fertil. Soils. 6:68-72.

Kirchmann, H., Bergström, L., 2001. Do organic farming practices reduce nitrate leaching ?.Commun. in Soil Sci. and Plant Anal. 32 (7& 8): 997-1028.

Kissel, D.E.,Ritchie, J.T., Burnett, E., 1974. Nitrate and chloride leaching in swelling clay soil.J.Environ. Quality 4:401-405.

Kohnke, H.,1968. Soil Physics. Mc Graw-Hill Book Corp., New York,USA.

Kovancı, İ., 1969. İzmir Bölgesi Tarla Topraklarında Nitrifikasyon Durumu ve Bunun Bazı Toprak Özellikleri ile Olan İlişkisi Üzerinde Araştırmalar. E.Ü. Ziraat Fak. Toprak Bölümü, İzmir.(Doçentlik Tezi).

Pratt, P.F., Jones, W.W., Hunsaker, V.E., 1972. Nitrate in deep soil profiles in relation to fertilizer rates and leaching volume. J. Environ. Qual. 1(1):97-102.

Rauterberg, E., F. Kremkus, 1951. Bestimmung von Gesamt Humus und alkalischen Humusstoffen in Boden, Z. für Pflanzenernaehrung, Düngung und Bodenkunde, Verlag Chemie, Gmbh, Weinheim.

Razzaque, A.H.M., Hanafi, M.M.,2004. Leaching of Nitrogen in Peat Soils.Commun. in Soil.Sci. and Plant Anal. 35(13&14):1793-1799.

Sağlam, M.T., 1976. Erzurum, Hasankale ve Erzincan Ovası topraklarında amonyum fiksasyonu,amonyum fiksasyonu ile potasyum arasındaki bazı ilişkiler, mineralize olan nitrojen ve nitrojen kayıpları üzerinde bir araştırma. A.Ü. Yayın No:467, Ziraat Fak. Yayın No:220,Erzurum.

Scharpf, H.C., Wehrmann, J., 1976. Die bedeutung des mineralstickstoffvorrates des bodens zu vegetationsbeginn für die bemessung der N-düngung zu winterweizen.Landw. Forsch. 32:100-114.

Schlichting, E., H.P. Blume., 1966. Bodenkundliches Praktikum. Verlag Paul Parley, Hamburg und Berlin.

Schuman, G.E., McCalla, T.M., Saxton, K.E., Knox, H.T., 1975. Nitrate movement and its distribution in the soil profile of differentially fertilized corn watersheds. Soil Sci. Soc. Amer. Proc. 39:1192-1197.

U.S. Salinity Lab. Staff., 1954. Diagnosis and improvement of saline and alkali soils. U.S. Goverment Handbook No:60 Washington, USA.

Usta, S.,1983. Ankara Yöresi Buğday/Nadas Ekim Nöbeti Uygulanan ve Ahır Gübresi Verilen Tarla Toprağında Azot Formlarının Tüm Ekim Nöbeti Periyodu Boyunca Dağılımları Üzerinde Bir Araştırma. A.Ü. Ziraat Fak. Toprak Bölümü, Ankara. (Doktora Tezi).

Viets, F.G., and Hageman, R.H., 1971. Factors Afecting the Accumulation of Nitrate in Soil,Water and Plants. US Dept. of Agr.Handbook No:413,Washıngton.

Wang, F.L., Alva, A.K., 1986. Leaching of nitrogen from slow-release urea in sandy soils. Soil.Sci.Soc.Amer.Jour. 60:1454-1458.

Soil quality assessment using linear and non-linear scoring functions

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Abstract

Assessing the quality of soils of GAP region with high agricultural potential for the country and development of soil quality indexes unique to the region are crucial in assuring the suitable use of agricultural areas and sustainability of soil productivity. Since irrigation started in the agricultural soils of the Harran Plain, they have been used intensively, and they have been increasingly degraded due to unsustainable management methods and cropping designs, which resulted in the loss of the production potential. After GAP development project, the land use of the region changed, and increases in crop productivity have been observed through the use of different crop varieties and chemical inputs (fertilizers and pesticides). However these increases have not lasted long and farmers have started to have difficulty in maintaining the same yield, because soil quality losses decrease the use efficiency of crop inputs. *Soil analyses carried out with the support of agricultural ministry do not solve present problems and support sustainable agriculture.* Instead, developing and adaptation of soil quality indexes which will make interpretation of quantitative results easy and allow comparison of different management methods among farmers would be more useful.In order to have a sustainable agriculture in the Harran plain and the other areas which are to be opened to irrigation, there is an urgent need for monitoring the soil quality with minimum data set that are easy and cheap to obtain and are effective in resolving the problems related to agriculture and environment and also explaining the problems which agriculture sector face and developing the soil quality indexes. The goal of this study was to investigate the potential of assessing and monitoring the qualities of soils in the research area with linear and non-linear scoring functions. For this purpose, the soils of the Harran Plain under different soil management applications (manure application, different crop rotation) were sampled, over 200 soil samples were collected and over 30 soil parameters including various soil physical, chemical and biological characteristics were determined both in laboratory and field. Soil quality indexes were obtained from selected variables using both linear and non-linear scoring functions. overall the qualities of soils were found low. Average soil quality indexes obtained by linear and non-linear scoring function were 32/100 and 48/100, respectively. This study presents the primary findings of soil quality initiative research conducted in the Harran Plain, Southeastern Turkey.

Keywords: Soil quality index, Harran plain, soil management, scoring functions

Introduction

In order to meet food and fiber need of increasing population country's soils are intensivelly used causing a degradion and loss of production potential. In the Harran Plain, irrigation started in 1995, which changed land use patterns and caused dramatic increases in crop productivity. It was partly due to the use of chemical inputs such as fertilizers and pesticides. At the same time intense and unsuitable soil management (i.e.

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intensive tillage, inefficient flood irrigation, intense use of chemicals such as fertilizer and pesticides, monoculture and inadequate organic input) practices caused a degredation in soil quality. In turn, soil degradation and inefficient use of chemicals negatively impact the environment through losses to water resources and the atmosphere (e.g., greenhouse gases, nitrate contamination and erosion) (Bilgili et al. 2014).

Soil quality (health) assessment offers a new approach to farming through the integration of physical, chemical and biological aspects of soil for improved crop productivity and environmental and economic sustainability (Idowu et al. 2007) (Figure 1).

Soil quality (health) is the ability of soils to perform their functions well (Karlen et al. 1994). It is related to dynamic structure of soils which are impacted by human activities and different management applications. There is a strong relation between soil quality (health) and sustaniability of soil resources and it is directly related with crop production potential.

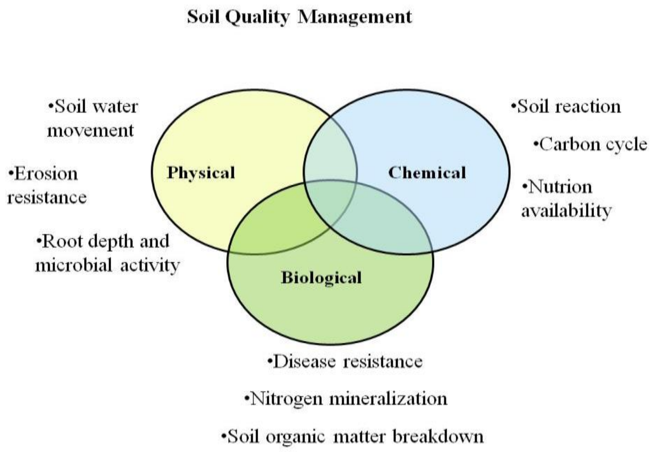

Figure 1. Concept of soil quality and associated processes

As a results of decreases in soil quality, surface water can be contaminated, crops can not benefit from precipitation sufficiently and soils are carried away with erosion (Doran et al. 1996). There are two rules related to soil quality; 1) soils have both genetical characteristics determined with soil formation factors and also dynamic characteristics impacted from human activities and management practices 2) assessment of soil qualities should reflect soil biological, chemical and physical properties and also the interaction among them (Karlen ve ark. 2003). Evalution of soil qualities is mandatory fo sustainable agriculture, it gives early signs of information about the mistakes in soil and water resources and helps us in determining the problematic areas (McGrath and Zhang, 2003).Assessment of soil quality can be carried out for three purposes 1) comparison of the differences occuring different soil management systems 2) changes in soil quality and trends happening in the same location or 3) comparison of problematic and non problematic areas in a location (Seybold et al. 2001).

Soil quality can not be measured directly, but it can be measured through measuring and relating the soil physical, chemical and biological properties that are sensitive to agricultural management practices and are neccesary for crop growth (Doran ve Parkin, 1996). Since 1960's for the assessment of soil quality various methods such as soil quality cards, pedotransfer functions, soil quality indexes and multiple parameter indicator krigings have been used; among them soil quality indexes are most commonly and easily used ones (Andrews et al. 2002). It was emphisized that soil quality indexes are useful tools in the assessment of the sustainability of soil and plant management practices (Karlen et al. 2003). Andrews and Carroll (2001), soil quality indexes are useful for the evaluation of sustaniability of soil and plant management. When soils are not understood sufficiently and not managed properly they can loose their important functions. The parameters which will be used in assessing of soil qualities should be standardized, scientifically appropriate, can represent biological, physical and chemical functions of soils and be sensitive to the changes in agricultural applications. In addition the parameters which will be used should be measured easily, cheap and they can be interpreted and growers should easily reach to them (Doran et al. 1996).

Obtaining soil quality indexes and chosing of appropriate and neccesary soil quality indicators (parameters) requires the consideration of not only soil function and crop productivity and also management targets specific to the area that growers should focus on, these functions are complex and variable. One soil in terms of one function can be evaluated as sufficient in quality but on the other hand it may not be sufficient in terms of another function. Therefore there are quite a lot of potential soil quality parameters and so there is a need for a research in chosing the appropriate one (Nortcliff, 2002).

For determination of soil quality, organic carbon, total nitrogen and phosphorous, exchangeable cations (Ca, Mg, Na, K), cation exchange capacity (CEC), pH, plant available K and P, DTPA extractable micro nutrients (Cu, Fe, Mn,Zn), sulphur, boron, silisium, EC and SAR, plant available NH_4 and NO_3, soil penetration resistance, agregate stability (resistive agregate ratio), hyraulic conductivity, infiltration, plant available water content, bulk density, water content at field capacity, microbial biomass and mineralizable nitrogen have been used (Andrews et al. 2002; Sharma et al. 2005; Lee et al. 2006). The goal of this study was to evaluate the qualities of soils in the Harran plain using both linear and non-linear scoring functions and assess the factors constraning soil productivity.

Material and Methods

The study area is located in the Harran plain, Southeastern Turkey. The study area has semi-arid climate conditions with an average temperature, precipitation and evaporation of 17.2 °C, 365.2 mm and 1848 mm, respectivelly. Main crop management of the study area is mainly cotton and wheat - corn cultivation. From five different soil series more than 200 disturbed and undisturbed soils samples have been collected at 0-30 cm depth. Sampling was performed randomly during October and November 2012 when crops were closer to harvesting time period and the fields are at field capacity moisture condition. Soils of the study area are high in pH, $CaCO_3$ content and cation exchange capacity. Soils are mosty clayey in texture and dominant clay mineral is smectite. Undisturbed soil samples were used for bulk density and saturated hydraulic conductivity measurements which were performed using constant head method applied on saturated samples with capilarity. Disturbed samples transported into the laboratory were air dried and sieved from 2 mm for soil chemical analyses. For soil biological analyses the samples were stored in the refrigirator at 4 °C. More than 30 soil quality parameters were determined and summary of the analyses are shown in Table 1.

Soil Quality Index

Linear Scoring Function

Before soil parameters were transformed using any linear or non -linear scoring function, they were grouped as "more is better" and " less is better "variables. The former one included variables such as; soil organic matter, soil biological properties, plant available phosphorous, available water content whereas the latter group included variables such as bulk density, pH, EC, soluble Na etc. (Table 1). Soil texture data (per cent clay, silt and sand contents) were not included within the data set used for the calculation of soil quality indexes since those variables are not impacted by any soil management practices.

For linear scoring transformation, firstly, values of each soil variables belonging to "more is better" group were ranked from high to low and then all values were divided by the highest value so that score of the soil with the highest value received the biggest score, which is 1. In

the case of variables within group " less is better ", they were ranked from low to high and the lowest value were divided by all values so that in this case the soil with the lowest value received the biggest score, which is 1. This was repeated for each soil quality variable in the two groups ("more is better" and "less is better"), separately. At the end, for each soil sample, linear scores calculated for each variables were averaged to obtain final score of each soil sample (Andrews et al. 2002).

Non- Linear Scoring Function

For Non-Linear Score transformation Normal Cumulative Distribution Function have been used. The cumulative normal distribution function, CND(m,s), is the integral of equation 1 and it gives the probability (between 0 and 1) that a member of the distribution is ≤ x (Andrews et al. 2002; Moebius-Clune et al. 2011).

$$f(x) = \frac{1}{\delta\sqrt{2\pi}} e^{-\frac{(X-\mu)^2}{2\sigma^2}}, -\infty < x < \infty \qquad \text{(equation 1)}$$

CND(m,s) was developed for scoring of the variables by using mean (m), standard deviation; (s) and normalizing to a scoring ranging from 0 to 1. In order to get the cumulative normal probabilities and score all measured values, the NORMDIST function in Excel (Microsoft Office, 2007) was used. Examples for Scoring curves obtained using non-linear scoring function for some selected variables in both groups are shown in Figure 2.

Table 1. Soil quality Indicators and their function in soil

Soil Quality Parameter	Soil Function	Function Type	Method
Soil Organic matter (%)	Water and Nutrient retention	More is better	Wet Oxidation (Walkley and Black, 1934
Available Phosphorous (mg kg-1)	Plant P uptake	More is better	Sodium Bicarbonate Tecnique (Olsen, 1954)
$CaCO_3$ (%)	Plant Nutrient Uptake	Less is better	Calcimeter method (Kacar, 1994)
Cation Exchange Capacity (me 100 g-1)	Plant Nutrient Uptake		
Exchangeable Cations (me 100 g-1) (Ca, Mg, Na,K)	Plant Nutrient Uptake Salinity	More is better	NH_4OAc extraction technique (Kacar, 1994)
Available Water Content (AWC, g g-1)	Plant Water Uptake Drought resistance	More is better	Pressure plates (Klute, 1986)
Soil Micro Nutrients (mg kg-1) (Fe, Cu, Zn, Mn)	Plant Nutrient Uptake Soil productivity	More is better	DTPA extraction (Lindsay and Norvell, 1978)
Agregate Stability (WSA %)	Erosion, Runoff Infiltration, Crusting	More is better	Wet sieving (Wuddivira and Camps-Roach,2007)
pH	Soil reaction, salinity	Less is better	Soil saturation paste (Rhoades et al. 1999)
EC (dS m-1)	Soil salinity	Less is better	Soil saturation paste (Rhoades et al. 1999)
Soluble cations (Ca,Mg, Na, K) (ppm)	Soil salinity	More is better	Soil saturation paste (Rhoades et al. 1999)
Hydraulic conductivity (cm s-1)	Permeability Soil compaction	More is better	Constant head technique (Klute and Dirksen, 1986)
Bulk density (g cm-3)	Soil compaction	Less is better	Undisturbed soil sample (Bluke and Hartge, 1986)
Microbial biomass (mg)	Soil productivity Mineralization	More is better	Incubation technique (Anderson ve Domsch, 1978)
Soil enzyme activities (catalase, urease, dehidrogenase)	Soil Biological activity	More is better	Incubation technique (Liu et al. 2008)
Number of soil microorganisms cfu/g (bacteria, fungi,actinomycetes)	Soil Biological activity	More is better	Dilution technique (Garzia et al. 1994)

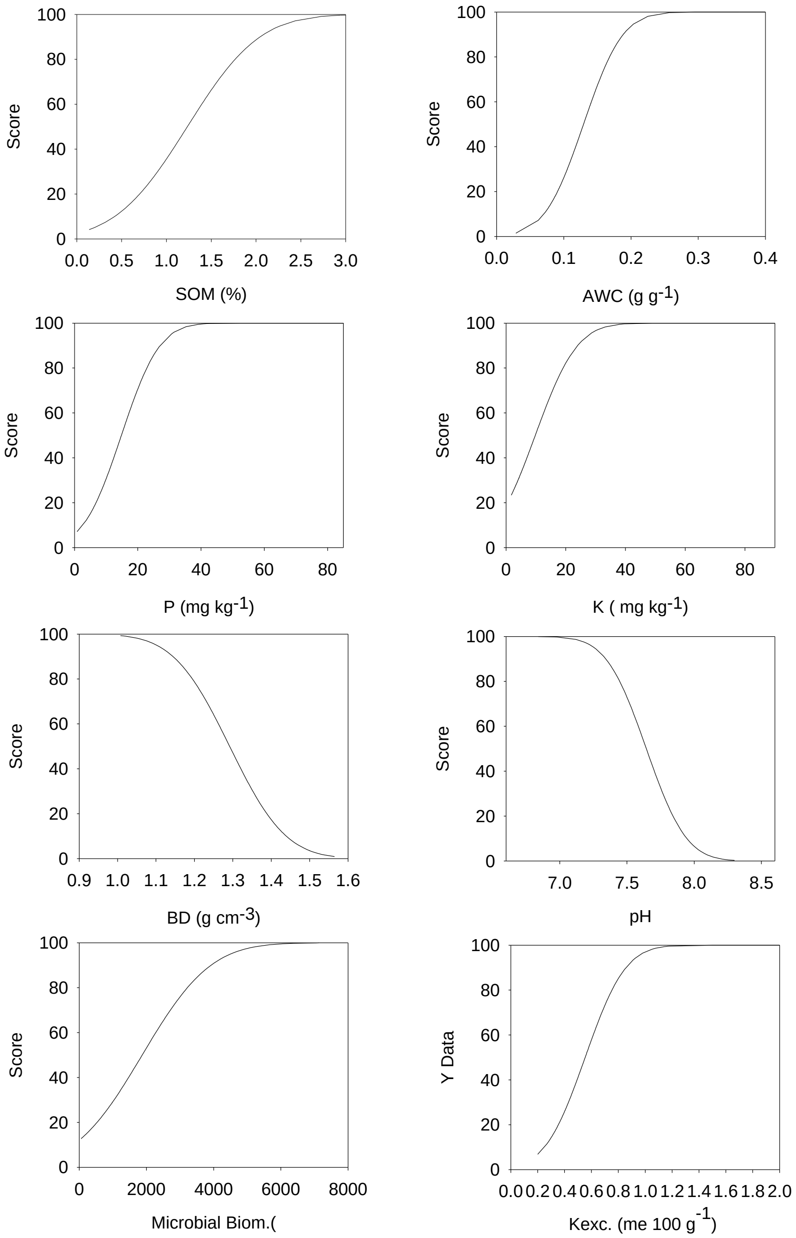

Figure 2. Examples of non-linear scoring for some selected variables

Results and Discussion

The distributions of soil physical, chemical and biological quality parameters within the study area are shown in Figure 3. Accordingly soil quality variables generally showed a skewed distribution having a very high variation across the study area. The results for the variables measured more and less were within the range of values reported by earlier studies performed in the study area (Ersahin, 1991; Kızılkaya et al. 2007; Sayğan, 2007; Bilgili, 2011).

Soil quality indexes obtained by the combination of these aforementioned soil physical, chemical and biological properties were determined using both linear and non-linear scoring functions. The distrubitons of soil quality index (SQI) values obtained using both approaches are given in Table 2. SQI values determined using linear scoring function ranged from 32/100 to 44/100 and while the values obtained using non-linear scoring function ranged from 48 to 71. The values obtained for linear scoring function were lower than the ones obtained using non-linear scoring function (Table 2). It was stated that the non-linear function can better represent the effects of different management systems (Andrews et al.2002). Figure 4 shows the relationship between the values obtained using linear scoring function transformation and non-linear scoring transformation. There was a good correlation (r=0.64) between two.

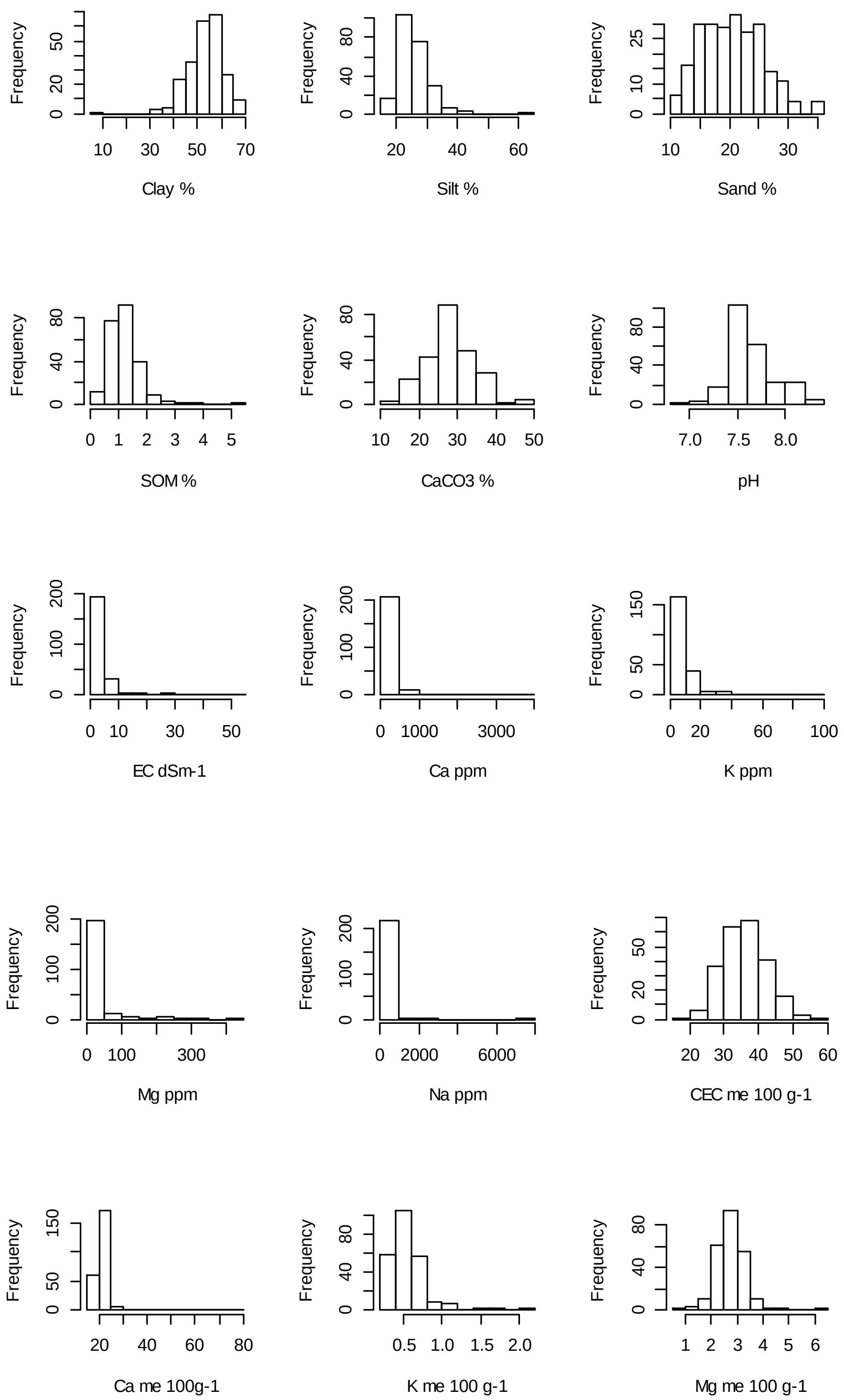

Figure 3. The distribution of soil quality parameters across the study area (The Harran Plain)

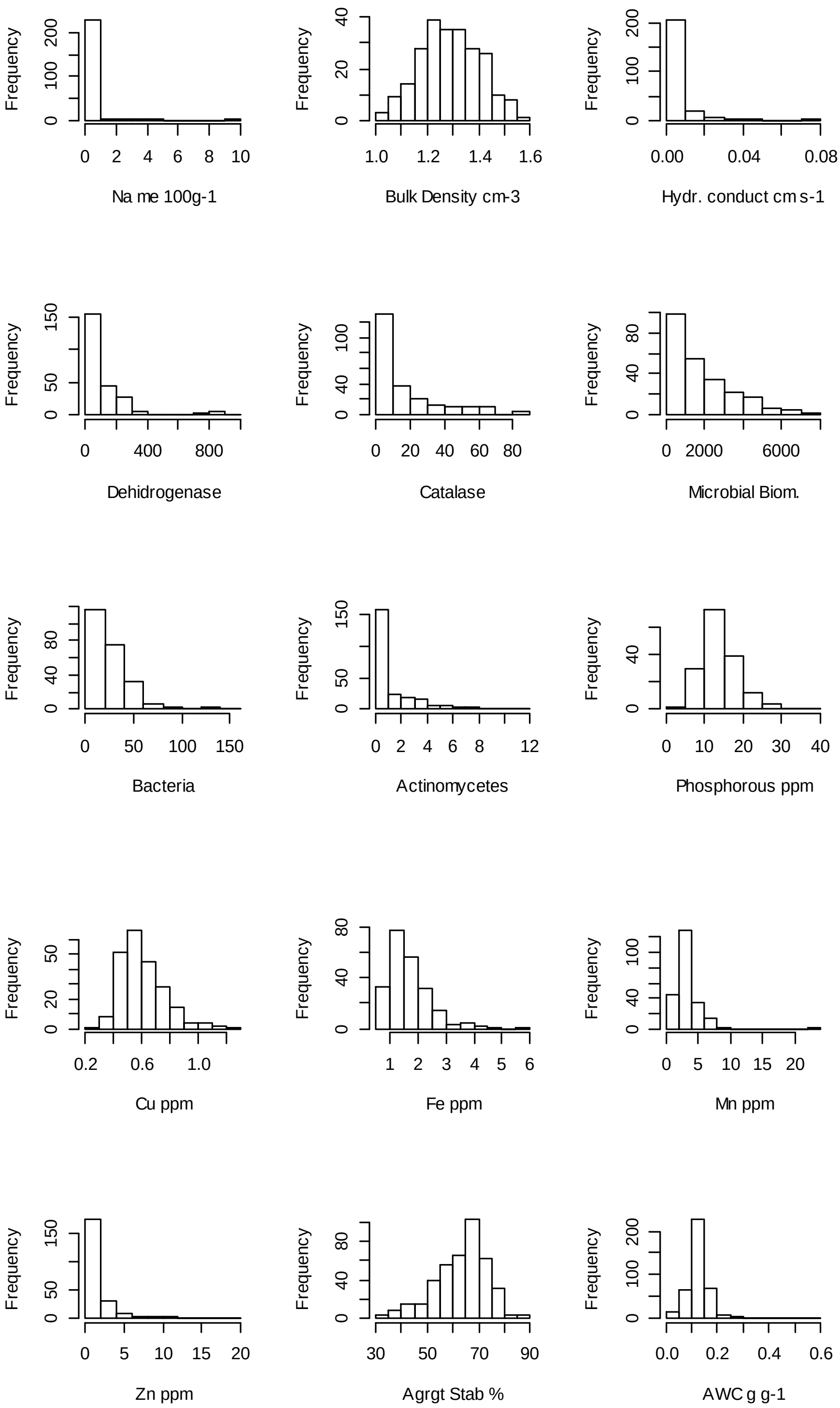

Figure 3. Cont.

Table 2 . Soil Quality Indexes obtained using Linear and Non-Linear Scoring Function

	Min	Mean	Max	Stdev	CV§
Linear scoring	32.1	24.2	44.4	3.5	10.9
Non-Linear scoring	48	30.3	71.2	6.7	13.9

§ Coefficient of Variation

Scores (S) for each indicator range from 0 to 100 and they can be grouped as very low (less than 40 %), low (40- 55 %) indicating soil constraints, intermediate range (55-75 %), high (70-85 %) indicating optimal soil functioning and very high (greater than 85 %). Accordingly the soil qualities of the study area obtained using both linear and non-linear scoring function were low. Lower soil quality is the indication of degradation and inappropriate use of soil and water resources.

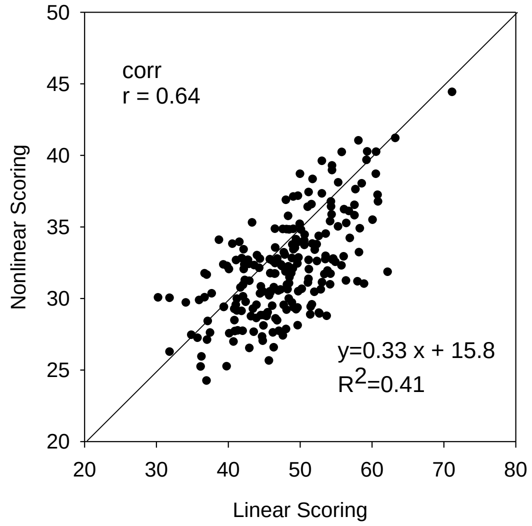

Figure 4. The relationship between the soil quality indexes obtained using linear scoring and non-linear scoring functions

Conclusion

This study presented primary findings of ongoing soil quality initiative research project conducted in the Harran Plain, Southeastern Turkey. Overall soil quality variables had a broad range. Soil quality indexes were obtained by combining all physical, chemical and biological quality parameters. Overall the soil quality indexes obtained using both linear and non-linear scoring functions were found low. That was mostly because of intensive tillage, monoculture cropping and almost no addition of organic inputs into soils in the study area investigated.

Acknowledgements

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References

Andrews, S.S., Karlen, D.L., Mitchell, J.P., 2002. A comparison of soil quality indexing methods for vegetable production systems in Northern California, Agriculture, Ecosystems and Environment , 90, 25–45.

Andrews, S.S., Carroll, C.R.,2001. Designing a decision tool for sustainable agroecosystem management: soil quality assessment of a poultry litter management case study. Ecol. Appl., 11, 1573-1585.

Bilgili, A.V., Aydemir, S., Sönmez, O., Kaya, C., Aydoğdu, M.,2010. Tarımsal desteklemede toprak kalitesi ve önemi. Eylül-Ekim 2010 Sayı:195 Sayfa:40-44.

Bilgili, A.V., Çullu, M.A., Akça, E., 2014. Post Irrigation Changes In the Harran Plain. In: Çullu, M.A., Aydoğdu,M., Bilgili, A.V., Akça, E., Nagano, T., Hamasaki, H., Kubota, J. (Eds.), Water Management Stakeholders Workshop. p. 61-65. 3-4 March/2014. Şanlıurfa.

Doran, J.W., Parkin, T.B., 1996. Quantitative indicators of soil quality: A minimum data set, Doran, J.W and Jones, A.J., (Eds.). Methods for assessing soil quality, Madison, WI. p.25-37.

Doran, J.W., Sarrantonio, M., Liebig, M.A.,1996. Soil health and sustainabilty. Advances in agronomy, ed: Sparks,D.L., vol:56, Academic press, CA, pp:1-54.

Erşahin, S., Yeşilsoy, M.Ş., 1993. The relationships between infiltration rates and some physical and chemical properties of six widely distributed and important soil series selected in Harran Plain. Turkish Journal of Agriculture and Forestry. 17, 863-873.

Idowu, O.J., van Es, H.M., Abawi, G.S., Wolfe, D.W., Ball, J.I., Gugino, B.K., Moebius, B.N., Schindelbeck, R.R., Bilgili., A.V., 2007. Farmer-Oriented Assessment of Soil Quality using Field, Laboratory, and VNIR Spectroscopy Methods. Plant and Soil 307:243-253.

Karlen, D.L., Wollenhaupt, N.C., Erbach, D.C., Berry, E.C., Swan, J.B., Each, N.S., Jordahl, J.L., Long-term tillage effects on soil quality. Soil Till. Res, 32, 313–327, (1994).

Karlen, D.L., Ditzler, C.A., Andrews,S.S, 2003. Soil Quality: Why and How ?, Geoderma, 114, 145-156, (2003).

Karlen, D.L.,Mausbach, J.W., Doran, J.W., Cline, R.G., Harris,R.F., Schuman, G.E., 2007.Soil quality: A concept, definition, and framework for evaluation. Soil Sci. Soc. Am.J., 61, 4-10.

Lee, C-H, Mao-Yi, W, Asio, V. B., Chen, Z-S., 2006. Using A soil quality index to assess the effects of applying swine manure compost on soil quality under a crop rotation systems in Taiwan, Soil Science, 171, 210-222.

Mcgrath, D., Zhang, C.S., 2003. Spatial distribution of soil organic carbon concentrations in grassland of Ireland. Appl. Geochem., 18, 1629-1639.

Moebius-Clune, B.N., H.M. van Es, van Es, H.M., Idowu, O.J., Schindelbeck, R.R., Kimetu, J.M., Ngoze, S., Lehmann, J., Kinyangi, J.M., 2011. Long-term Soil Quality Degradation along a Cultivation Chronosequence in Western Kenya. Agriculture Ecosystems and Environment, 141, 86-99.

Nortcliff, S., 2002. Standardization of soil quality attributes. Agric. Ecosyst. Environ., 88,161-168.

Sayğan, E.P., 2007. Harran Ovasındaki Bazı Toprak Serilerinin Fosfor Fraksiyonları, (Yüksek Lisans Tezi), Harran Universitesi Fen Bilimleri Enstitüsü.

Seybold, C.A., Dick, R.P., Pierce, F.J., 2001. USDA soil quality test kit: Approaches for comparative assessments. Soil Survey Horiz, 42, 43-52.

Sharma, K.L., Mandal, U.K, Srinivas, K., 2005. Long-term soil management effects on crop yields and soil quality in a dryland Alfisol. Soil & Tillage Research, 83, 246–259.

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Wildfire effects on soil microbial biomass and soil respiration

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Abstract

Soil CO_2 efflux, which includes respiration from roots (autotrophic) and soil organisms (heterotrophic), is a key source of CO_2 from terrestrial ecosystems and plays an important role in regulating carbon pools and global carbon cycling. Soil respiration is a major flux of CO_2 to the atmosphere and in arid and semi-arid ecosystems it has been less intensively investigated than in other ecosystems. Soil microbial biomass carbon and soil respiration are often applied for understanding effects of environmental factors on soil organisms, monitoring carbon cycles. An improved understanding of microbial activity impact on relations between soil C and nutrient cycling is needed to predict ecosystem responses to the disturbances. It is known that fire changes soil properties, depending on fire severity and soil type and fire is the one of the disturbances acting on forest soil carbon emission. Additionally fire has some impacts on soil that influence nutrient availability for plants. This study is deal with modifications observed in some physical, chemical and biological soil parameters after a low severity wildfire in a semi-arid Oak-Juniper mixed forest in Eskişehir, Turkey. Soil samples were taken from ash layer and 0-5 cm depths after removal of ash. The samples were analysed to determine a series of soil physical (soil texture and bulk density), chemical (electrical conductivity, pH, organic matter, total nitrogen, available phosphorus content and Ca^{2+}, Mg^{2+}, K^{+}, Mn^{2+}, Zn^{2+}, Fe^{2+},Cu, and Na^{+} concentrations) and biological characteristics (Cmic, CO_2 evaluation). ANOVA tests were applied to test the effect of fire and species on ash and soil samples. The results indicated that soil microbial biomass carbon (Cmic) was significantly affected by the fire. Cmic was significantly different in terms of species and it was higher in Juniper soils. The layers (unburnt soil, burnt soil and ash) were in different groups for Cmic, CO_2 evaluation, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Mn^{2+}, Zn^{2+}, Fe^{2+} concentrations and they were higher in ash. Fire enhanced available nutrients in ash and its leachates to soil which are important for plant regeneration. Ash layer's higher carbon contents may have a higher resistance to biological degradition than the unburnt soil floor, which may have important implications for the evaluation of CO_2 and C budgets.

Keywords: Wildfire, microbial biomass carbon, carbon dioxide evaluation, ash, available nutrients.

Introduction

Wildfire has been the dominant disturbance in coastal Mediterranean forests. With increasing climate change fires may have become an important threat in semi arid forests due to regeneration problems in these forests. In fact an increase in crown fires is starting to be observed in montane areas (Pausas et al., 2008).

Carbon (C) is a major chemical element playing an important part in earth's biogeochemical cycle. Terrestrial ecosystems store vast amounts of carbon and its interaction with the atmosphere has significant influence on global climate (Bonan, 2008). International negotiations to limit greenhouse gases require an understanding of the current and potential future role of forest C emissions and sequestration in both managed and unmanaged forests. (Pan et al., 2011). Carbon in forest ecosystems is located in four distinct pools that are

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different in their behaviour and functions, and interact during stand development when C is being allocated form one pool to another (Pregitzer and Euskirchen, 2004). Carbon from the atmosphere enters ecosystems through photosynthesis and is sequestered into live vegetation pool. When a plant dies C moves to the dead biomass pool, with fractions to the forest floor pool. Dead biomass (including belowground) and forest floor pool C slowly become incorporated into the mineral soil organic C pool. Throughout this process, C is also released to atmosphere via autotrophic and heterotrophic respiration (Seedre, 2013).

Soil CO_2 efflux is an important component of C cycle in terrestrial ecosystems (Hui and Luo, 2004). Soil carbon respired by terrestrial ecosystems contributes 68 - 100 Pg C yr^- to the atmosphere, only slightly less than the estimeted global terrestrial gross primary productivity of 100 - 120 Pg C yr^- (Rustad et al., 2000). As atmospheric CO_2 concentration and global temperature continuously increase, more carbon will be respired from the soils (Schimel et al., 1994, Schlesinger and Andrews, 2000). Soil CO_2 production results from respiration of living roots and microbial decomposition of litter and soil organic matter. Microbial respiration is a key mechanism that regulates net ecosystem function (the rate of carbon sequestration) (Pregitzer and Euskirchen, 2004). The soil microbial biomass is frequently used as an early indicator of changes in soil chemical and physical properties resulting from soil management and environmental stresses in agricultural ecosystems (Brookes, 1995, Jordan et al., 1995). The charcoal from burning can support microbial communities, which are small in size but have a higher specific growth rate than those of the humus (Pietikainen and Kiikkila, 2000).

The plant species burned by the fire, the combustion temperature and the time of exposure to elevated temperatures influence the physical and chemical characteristics of ash and its leachates (Pereira et al., 2013). Ash has an important role in the recovery of burned areas, because it contains a large reservoir of the available nutrients for plant growth (Ùbeda et al. 2009, Pereira et al., 2011, Pereira et al., 2012). In addition, the ash layer has an influence on soil erosion vulnerability and water retention (Khanna and Raison 1986, Pereira et al. 2012,). Ash cover after the fire provides protection against rainsplash impact, retains water, reduces erosion and run-off (Cerdà and Doerr, 2008).

Variable in microbial activity creates uncertainity in our current understanding of soil C cycling, and improved understanding of microbial activity impact on relations between soil C and nutrient cycling is needed to predict ecosystem responses to the disturbances (Chapin et al., 2009, Allison et al., 2010, Hartman et al., 2013). In this connection fire effect on Cmic, CO_2 evaluation, and available nutrients in ash and soil was researched in this study.

Material and Methods

The study area was located on oak-juniper (*Quercus cerris-Juniperus oxycedrus*) mixed forest in Eskişehir, Turkey (39° 32' 17'' N, 30° 34' 21'' E, 1250m asl.). A low severity wildfire burned the area in August, 2013. Total precipitaiton is 450 mm and annual mean temperature is 11°C in the study area.

3 months later after the wildfire, soil samples were taken from 0-5 cm depths after removal of ash under each of the species in control and burned areas and ash samples were taken randomly from burned area. All the samples were stored at 4° C until the analyses.

Soil pH was determined in a 1:5 (v/v) soil/water solution (TS 8332 ISO 10390). Soil electrical conductivity (EC) was determined in a 1:5 (m/v) soil/water solution. Coarse, fine, and total sand, silt, and clay contents were determined by the Bouyoucos hydrometer method (Kroetsch and Wang, 2008). Total organic carbon (Corg) content was measured by Walkley-Black (TS 8336) and, organic matter by multiplying Corg with 1.72. Total carbonate ($CaCO_3$) was determined by volumetric method (TS 8335 ISO 10693). Available phosphorus (P_2O_5) was determined according to the method of Bray-Kurtz (TS 8338), and available K was determined by flamephotometer in NH_4OAc extract according to method described by Turkish Standard of TS 8341. Ca, Mg, Fe, Mn were also extracted with NH_4OAc and determined by atomic absorption spectrometer (Kacar, 2009). The available micronutrients of Cu and Zn were determined by the extraction with 0.05 N HCl + 0.02 N H_2SO_4 and analyzed by atomic absorption spectrophotometer (Kacar, 2009). Total N (TN) content was determined by Kjeldahl digestion by the Kjeltec Auto 1030 Analyzer (Tecotor, 1987), and water content was determined gravimetrically after the soil was oven-dried for 24 h at 105°C (TS ISO 11465).

Soil microbial biomass carbon was determined with fumigation chloroform method (Vance et al., 1987). TOC-L analyzer Shimadzu was used to measure the content of organic C in the extracts. Soil microbial respiration was determined by substrate-induced method (Höper, 2006).

All statistical analyses were conducted with SPSS for windows (SPSS 17.0). ANOVA tests was carried out to identify differences between burnt and unburnt soils. For determining significant differences between ash layer, burnt and unburnt soils, post-hoc Tukey's-b test was applied. Significant differences were considered at a $P<0.05$.

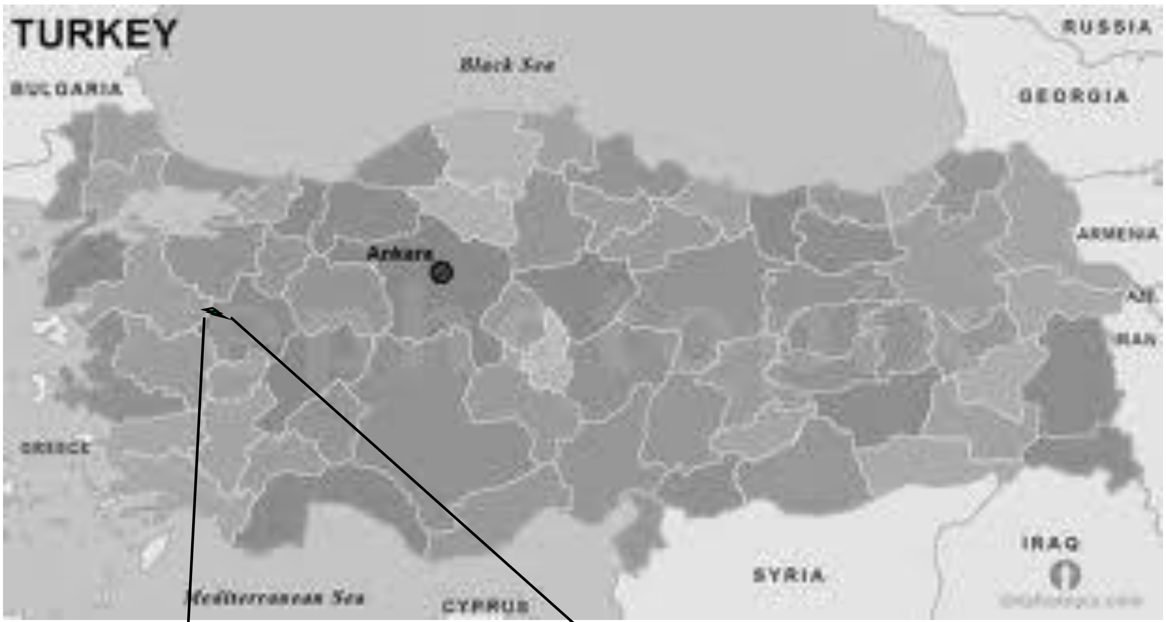

Figure 1 The location of the study area

Figure 2. Burnt area

Figure 3. Control (Unburnt) area

Results and Discussion

Fire affected some soil properties like bulk density (BD), organic matter (OM), Cmic and Cmic:Corg ratio significantly. Bulk density, Cmic and Cmic:Corg were decreased while OM was increased with burning. Cmic and CO_2 efflux were affected by species and they were significantly higher in soils under Juniper trees. This result may be due to differences in chemical composition of forest floor of tree species.

Bulk density increases as a result of the collapse of the organo-mineral aggregates (Giovannini et al., 1988) and the sealing due to the clogging of soil pores by the ash or the freed clay minerals (Durgin and Vogelsang, 1984) after the fire. On the other hand BD tends to decrease as soil OM concentration increases (Curtis and Post, 1964, Périé and Ouimet, 2008). In this study higher soil OM amounts was resulted in lower BD in the burnt areas (Table 1).

Table 1. Changes in soil properties of unburnt and burnt areas mean ±sd (standart deviation)

Soil properties	Oak				Juniperus			
	Unburnt (control)		Burnt		Unburnt (control)		Burnt	
BD g/cm^3	1,12	±0,25	0,84	±0,02	1,24	±0,00	0,97	±0,14
Sand %	48,96	±2,47	45,15	±4,38	55,46	±0,00	44,13	±7,87
Silt %	25,52	±1,23	26,64	±1,46	20,24	±0,00	26,36	±4,50
Clay %	25,52	±1,23	28,21	±4,68	24,29	±0,00	29,52	±3,79
pH 1/2,5	6,57	±0,33	6,33	±0,92	6,55	±0,07	7,33	±0,68
EC 10^3 25°C mS/cm	0,11	±0,04	0,17	±0,03	0,06	±0,01	0,33	±0,28
$CaCO_3$ %	0,04	±0,00	0,08	±0,06	0,04	±0,00	0,23	±0,24
OM %	4,90	±1,73	7,17	±0,62	3,67	±0,01	6,75	±2,24
TN %	0,29	±0,11	0,38	±0,07	0,21	±0,00	0,37	±0,11
C:N	9,89	±0,39	11,13	±1,39	10,15	±0,02	10,53	±1,32
P mg kg^{-1}	27,69	±4,24	46,55	±15,23	16,78	±0,00	103,42	±80,45
Cmic µg C g^{-1}	3932,0	±9,33	560,7	±383	7247,9	±861	3236,3	±2250
CO_2 efflux µgCO_2-C g^{-1}	1,56	±0,51	3,20	±0,45	1,32	±0,51	3,20	±0,45
qCO_2	0,0004	±0,0001	0,0081	±0,0052	0,0002	±0,0001	0,0016	±0,0014
Cmic:Corg	10,77	±3,81	6,93	±0,62	13,49	±0,03	8,09	±3,15

The recovery of soil organic matter in the burnt areas starts with the natural or artificial reintroduction of vegetation and generally is fast, thanks to the high net primary productivity of secondary ecological successions (Certini, 2005). Soil organic carbon increase after the fire may stem from the incorporation in mineral soil unburnt residues, the transformation of fresh organic materials to more recalcitrant forms, and the increase of N-fixer species in the burnt areas (Johnson and Curtis, 2001). Increase in organic matter in burnt area may result from forming of charcoal due to incomplate combustion of organic matter.

The immediate effect of fire on soil microorganisms is a reduction of their biomass although adverse effects on soil biota can be due to some organic pollutants produced by the combustion processes (Certini, 2005). Although the charcoal layer induces changes in the microbial community of the humus, it does not reduce the amount of humus microbes and the charcoal from burning can support microbial communities, which are small in size but have a higher specific growth rate than those of the humus. (Pietikainen et al., 2000). Microbial biomass C increase, consequently, higher Cmic:Corg ratio may depend on high levels of organic soil component in ash. Santín et al. (2015) rewieved that the transformation by fire of part of the forest floor into ash, which includes both pyrogenic carbon and mineral components, led to an enrichment of the carbon content, a higher C/N ratio and an increase of the thermal recalcitrance of this organic soil component. The authors pointed out that the enhanced recalcitrance of the pyrogenic C is likely to increase the residence time of the soil C pool, these transformations may have important implications for the C fluxes and budgets.

In this study significant increases in amounts of Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Mn^{2+}, Zn^{2+}, and Fe^{2+} concentrations in burnt soil and ash samples were observed (Table 2). Fire has a mineralization effect on organic matter, increasing the amount of carbonates, oxides, hydroxides and base cations available for leaching (Ulery et al., 1993, Soto and Diaz-Fierros, 1993, Pereira et al., 2013). Enhanced nutrients in ash leaching to soil changed the chemistry of soil.

Fire-induced changes to cycles of soil nutrients other than N and P generally are slighter and more ephemeral. The availability of these nutrients generally is increased by the combustion of soil organic matter and the increase is strictly dependent upon type of nutrient, burnt tree species, soil properties, and pathway of leaching processes (Kutiel and Shaviv, 1992). A month after a wildfire, available Ca, Mg, and K in the soil of a *Q. rubra–Populus grandidentata* forest were significantly higher than pre-fire levels, but after further 3 months the increases were almost gone (Adams and Boyle, 1980). More persistent (some years) fire-induced enhancement of the availability of these three bases were reported by Simard et al. (2001) under *Picea mariana*.

Table 2. Biochemical properties in unburnt-burnt soils and ash layers

Soil properties	soil layers		
	unburnt (0-5 cm)	burnt (0-5 cm)	ash
Cmic µg C g^{-1}	5802,85[b]	2123,87[b]	16376,93[a]
CO_2 efflux µgCO_2-C g^{-1}	1,44[c]	3,20[b]	7,37[a]
N %	0,25[b]	0,38[b]	0,74[a]
P mg kg^{-1}	22,23[a]	74,98[a]	58,37[a]
K mg kg^{-1}	200,48[b]	189,42[b]	752,76[a]
Ca mg kg^{-1}	1867,00[c]	3593,38[b]	6546,75[a]
Mg mg kg^{-1}	254,91[c]	301,41[b]	355,00[a]
Mn mg kg^{-1}	2,15[b]	4,62[ab]	8,52[a]
Zn mg kg^{-1}	0,06[b]	0,13[ab]	0,20[a]
Fe mg kg^{-1}	0,93[b]	1,06[b]	1,42[a]
Cu mg kg^{-1}	0,24[a]	0,61[a]	0,36[a]
Na mg kg^{-1}	12,13[b]	17,00[ab]	28,80[a]

Different letters on values show different groups based on a Tukey's-b test ($P<0.05$).

The behaviour of micronutrients, such as Fe, Mn, Cu, and Zn with respect to fire is not well known because specific studies are lacking. However, under *Pinus pinaster*, it is founded that both total content and easily reducible (extractable by NH_4- acetate + hydroquinone) forms of Mn increase significantly following fire, thanks to Mn supplied by the ash in the form of amorphous and crystalline oxides, while the exchangeable Mn does not show any variation (Gonzalez Parra et al., 1996). Fe, Cu, and Zn may behave similarly to Mn and move downwards very little (Certini, 2005). Heating may have effects on nutrient availability indirectly, by modifying the soil microbial community. In a coniferous forest dominated by *Pseudotsuga menziesii*, Perry et al. (1984) checked the deleterious effect of slash burning on hydroxymate siderophores, high affinity Fe^{3+} chelators released in soil by various microorganisms including mycorrhizal fungi. Siderophores facilitate Fe uptake to both microbial flora and higher plants. The seedlings of Pseudotsuga suffered iron deficiency only in burnt areas; evidently, a reduction of siderophore-producing organisms occurred here, because pasteurisation induced similar Fe limitation in unburnt soils (Certini, 2005). In this study available micronutrients increase may due to increase of microorganisms which released siderophores to soil considering the increase of microbial biomass. Siderophores can chelate metals other than iron include Al, Cu, Zn, and Mn.

Conclusion

Fire changed the soil properties with enhancing available nutrients in ash and its leachates to soil which are important for plant regeneration. On the other hand ash layer's higher carbon contents, explained with increase of pyrogenic C increase by Santin et al. (2015), may have a higher resistance to biological degradition than the unburnt soil floor, which may have important implications for the evaluation of CO_2 and C budgets.

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References

Adams, P.W. and Boyle, J.R. 1980. Effects of fire on soil nutrients in clearcut and whole-tree harvest sites in Central Michigan. Soil Science Society of America Journal, 44, 847-850.

Allison, S.D., Wallenstein, M.D., Bradford, M.A., 2010. Soil-carbon response to warming dependent on microbial physiology. Nature Geoscience 3, 336–340.

Bonan, G.B., 2008 Forests and climate change: Forcings, feedbacks, and the climate benefits of forests. Science, 320, 1444–1449.

Bouyoucus, G.J., 1962. Hydrometer method for making particle size analysis of soil. Agronomy Journal 54,464-465.

Brookes, P.C., 1995. The use of microbial parameters in monitoring soil pollution by heavy metals. Biol. Fert. Soils, 19, 269–279.

Cerdà A, Doerr SH. 2008. The effect of ash and needle cover on surface runoff and erosion in the immediate post-fire period. Catena 74, 256–263.

Certini G., 2005. Effects of fire on properties of forest soils: a review. Oecologia 143, 1–10.

Chapin, F.S., McFarland, J., McGuire, A.D., Euskirchen, E.S., Ruess, R.W., and Kielland, K., 2009. The changing global carbon cycle: linking plant–soil carbon dynamics to global consequences. Journal of ecology, 97 (5), 840-850.

Curtis, R. O. and Post, B. W. 1964. Estimating bulk density from organic matter content in some Vermont forest soils. Soil Sci. Soc. Am. Proc. 28, 285-286.

Durgin, P.B., Vogelsang, P.J., 1984. Dispersion of kaolinite by water extracts of Douglas-fir ash. Can J Soil Sci 64:439–443.

Giovannini, G., Lucchesi, S., and Giachetti, M., 1988. Effects of heating on some physical and chemical parameters related to soil aggregation and erodibility. Soil Sci 146:255–261.

Hartman, W.H., and Richardson, C.J., 2013. Differential nutrient limitation of soil microbial biomass and metabolic quotients (qCO_2): Is there a biological stoichiometry of soil microbes? plos one. www.plosone.org.

Höper, H. 2006. Substrate-induced respiration, In:Microbiological Methods for Assessing Soil Quality. Bloem, J., Hopkins, D. W., Benedetti, A. (eds), CABI, Wallingford, 84–92.

Hui, D. and Luo, Y., 2004. Evaluation of soil CO2 production and transport in Duke Forest uisng a process-based modelling approach. Global Biochemical Cycles. 18, 4.

Jackson ML. 1969. Soil chemical analysis: Advanced course. 2nd ed. published by the author, Univ. of Wisconsin, Madison, USA.

Johnson DW, Curtis PS (2001) Effects of forest management on soil C and N storage: meta analysis. For Ecol Manage, 140, 227–238.

Jordan, D., Kremer, R.J., Bergfield, W.A., Kim K.Y., Cacnio V.N., 1995. Evaluation of microbial methods as potential indicators of soil quality in historical agricultural fields. Biological Fertility of Soils. 19, 297–302.

Kacar, B. 2009. Toprak Analizleri, Nobel Yayın dağıtım, Nobel Yayın No: 1387, Genişletilmiş 2. Basım, 467 s, Ankara.

Khanna, P.K. and Raison, R.J. 1986. Effect of fire intensity on solution chemistry of surface soilunder a Eucalyptus pauciflora forest. Australian Journal of Soil Research, 24, 423–434.

Kroetsch, D., Wang, C., 2008. Particle Size Distribution, in section VI Soil Physical Analysis, Section Ed. By Angers D.A., Larney, F.J., In: Soil Sampling and Methods of Analysis 2. Edition, Ed. By Carter, M.R., Gregorich, E.G., Boca Raton, 1224 p, 713-725.

Kutiel, P. and Shaviv, A. 1992. Effects of soil type, plant composition and leaching on soil Nutrients following a simulated forest fire. Forest Ecology and Management, 53,329- 343.

Pan, Y.D., Birdsey, R.A., Fang, J.Y., Houghton, R., Kauppi, P.E., Kurz, W.A., Phillips, O.L., Shvidenko, A., Lewis, S.L., Canadell, J.G., Ciais, P., Jackson, R.B., Pacala, S.W., McGuire, A.D., Piao, S.L., Rautiainen, A., Sitch, S., Hayes, D., 2011. A Large and Persistent Carbon Sink in the World's Forests. Science 333, 988–993.

Pausas, J.G., Lllovet, J., Rodrigo, A. and Vallejo, R., 2008. Are wildfires a disaster in the Mediterranian Basin?-A Review. International Journal of Wildland Fire, 17, 713-723.

Périé, C., and Ouimet, R., 2008. Organic carbon, organic matter and bulk density relationships in boreal forest soils. Canadian Journal of Soil Science, 88 (3), 315-325.

Pereira P, Úbeda X, Martin D. 2011. Heavy metals released from leaf litter exposed to different fire temperatures. A laboratory experiment. Darnus Vystymosi Strategia ir Pratica 1, 137–154.

Pereira P, Cepanko V, Vaitkute D, Pundyte N, Pranskevicius M, Zuokaite E, Úbeda X, Mataix-Solera J, Cerdà A. 2012. Grassland fire effects on ash properties and vegetation restoration in Lithuania (North-Eastern Europe). Flamma 3, 3–8.

Pereira P., Úbeda X., Martin D., Mataix-Jolera J., Cerdà A., and Burguet M., 2013. Wildfire effects on extractable elements in ash from a Pinus pinaster forest in Portugal. Hydrological Processes. wileyonlinelibrary.com.

Perry, D.A., Rose, S., Pilz, D., Schoenberger, M.M., 1984. Reduction of natural ferric iron chelators in disturbed forest soils. Soil Sci Soc Am J 48,379–382.

Pietikainen, J., Kiikkila O., and Fritze, H., 2000. Charcoal as a habitat for microbes and its effect on the microbial community of the underlying humus. OIKOS, 89, 231–242.

Pregitzer, K.S., Euskirchen, E.S., 2004. Carbon cycling and storage in world forests: biome patterns related to forest age. Global Change Biology 10, 2052–2077.

Rustad, L.E., Huntington T.G., and Boone R.D., 2000. Controls on soil respiration: Implication for climate change. Biogeochemistry, 48, 1–6.

Santín C., Merino A., Doerr S.H., 2015. Chemical transformation of the forest floor during a boreal forest fire. FLAMMA, 6 (1), 39-41. In press.

Schimel, D. S., Braswell, B. H., Holland, B.A., McKeown, R., Ojima, D. S., Painter, T. H., Parton, W. J., and Townsend, A. R., 1994. Climatic, edaphic, and biotic controls over the storage and turnover of carbon in soils, Global Biogeochem. Cycles, 8, 279–293.

Schlesinger, W.H., and Andrews J.A., 2000. Soil respiration and the global carbon cycle, Biogeochemistry, 48, 7–20.

Seedre, M., 2013. Disturbance effects on boreal forest ecosystem carbon dynamics. PhD thesis. Instutiue of Forestry and rural Engineering, Estonian University of life Sciences. ISBN 978-9949-536-01-6 (pdf).

Soto B, Diaz-Fierros F. 1993. Interactions between ash leachates and soil. International Journal of Wildland Fire 3, 207–216.

Tecator, 1987. Application Note, AN 30/87.

TS 8335 ISO 10693. Soil Quality- Determination of Carbonate Content- Volumetric Method (In Turkish).

TS 8336. Soils - Determination of Organic Matter (In Turkish).

TS 8338. Soils - Determination of Phosphorus-Modified by Bray and Kurtz Method No 1. (In Turkish).

TS 8341. Soils - Determination of Potassium. Ammonium Acetate Method (In Turkish).

TS ISO 10390. Soil Quality - Determination of pH (In Turkish).

TS ISO 11265. Soil Quality - Determination of Electrical Conductivity (In Turkish).

TS ISO 11465. Soil Quality- Determination of Dry matter and water Content by Gravimetric Method (In Turkish).

Ùbeda, X., Pereira, P., Outeiro, L., Martin, D., 2009. Effects of fire temperature on the physical and chemical characteristics of the ash from two plots of cork oak (Quercus suber). Land Degradation and Development 20, 589–608.

Ulery, A.L., Graham, R.C., Amrhein, C. 1993. Wood ash composition and soil pH following intense burning. Soil Science 156, 358–364.

Vance, E.D., Brookes, P.C. and Jenkinson, D.S. 1987. An extraction method for measuring soil microbial biomass. Soil Biology and Biochemistry, 19, 703-707.

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Domestic sewage and its availability of some heavy metals in soil depths

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Abstract

This study was conducted with the objective of reviewing the impact of the application of raw and treated sewage on the trend of changes of iron in different soil depths. An experiment was performed three times to this end in the form of a CRD (Completely Randomized Design) with three treatments including tap water, treated sewage, and raw sewage. Soil sampling was done as composites at the soil depths of 0-30 and 30-60 cm. The available iron was determined in soil by DTPA method. The data experimented was analyzed at two probability levels of 1 and 5 percent by SPSS statistical software to determine the level of significance, and the Duncan test was used to compare the averages. The results from the statistical analysis showed that the use of raw and treated domestic sewage has stimulated an increasing trend in available iron concentration.

Keywords: Available iron concentration, Domestic sewage, Soil depths, Completely Randomized Design

Introduction

The developments of the cities and wrong consumption patterns have caused an increase in the domestic sewage (Gholami et al. 2011). Environmental pollution has unpleasant changes on physical, chemical and biological characters of main sources such as water, air and soil, which has dangerous effect in health and survival of human and other living organs or limit their activities (Gholami et al. 2012). Given the use of more than 90 percent of water in agriculture, the necessity of irrigation water conservation prompted the experts to promote the use pressurized irrigation methods widely. Concentration of population and industrial centers in different areas causes production of a high amount of sewage effluent, which will bring many environmental problems around the areas with the current trend of sewage disposal. In this relation, the best way of sewage wastewater disposal is its application in agriculture after conventional treatment processes. The optimal use of municipal sewage in plant nutrition can help largely prevent undesirable environmental impacts due to its discharge (Ebrahimizadeh, 2007). Irrigation and artificial recharging of aquifers are among the most important methods of sewage disposal in soil and the further use of sewage. The use of wastewater for irrigation not only lets soil properties benefit from its positive impacts, but also it makes wastewater as a water resource. During non-farming season also, through sewage disposal on soil, soil can treat sewage more and make the increase in water conservation in aquifers with non-potable agricultural use possible.

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Materials and Methods

The study area

The study was conducted to investigate the application of raw and treated sewage on the trend of the changes of available iron on a farm located in Khuzestan province. The average annual rainfall was 244 millimeters and the temperature average was 22 degrees centigrade.

Statistical design

As the research was carried out in a greenhouse, it was with three replications in a completely randomized design which, including invoices consisted of 18 pilot plants altogether. For performing an experiment for each treatment, a P.V.C tube with 100 centimeters height and 15 centimeters diameter, altogether 9 P.V.C tubes were considered in each run. To prevent the preferable penetration, the inner surface of the tubes was impregnated with paraffin oil. The end part of the tubes was blocked by a non-metal mesh and then the tubes were filled with soil. From Karun River and the raw and treated sewage in the same area, the water required was temporarily saved. Moreover, irrigation with water treatments was done on the base of 70 percent of the moisture limit of the field capacity once a week for 3 months. Prior to irrigation, which was manually done, its amount was calculated by measuring the percentage of the soil weight moisture through monitoring methods.

Soil sampling and analysis

First, soil samples were prepared from the depths of 0-30 and 30-60 cm of the soil surface by a ruler and after the design implementation, each sample was put in a plastic sac and sent to the central laboratory of Science and Research Branch, Islamic Azad University, Khuzestan, Ahvaz, Iran. After drying at 105 degrees centigrade in an oven, all soil samples were passed through a 2 millimeter sieve in the laboratory and prepared to determine of available iron concentration.

Determine of available iron concentration

The iron absorbency of the soil was measured by extracting using DTPA (0.005 M) which was read by the atomic absorbency device known as Perkin - Elmer type model 3030 in specific waves (Panahpour et al. 2011).

Results and Discussion

Statistical computations and analysis

The data achieved from the study was saved in Excel software database. After that, drawing the diagrams and the initial review and study of the data were done. The data experimented was analyzed at two probability levels of 1 and 5 percent by SPSS statistical software to determine the level of significance, and the Duncan test was used to compare the averages. The final interpretation and conclusion were on the base of the data at the end.

The properties of the soil under study

The results related to the chemical properties of the soil experimented were presented in Table 1 before the use of the study treatments. Accordingly, silt loam soil texture was without salt, containing 0.57 % organic carbon.

Table 1. The chemical properties of the soil experimented

Clay, %	Sand, %	Silt, %	Cd, $mg.kg^{-1}$	Cl, $mg\ l^{-1}$	K, $mg.kg^{-1}$	P, $mg.\ kg^{-1}$	OC, %	pH	EC, dsm^{-1}	depth
46	8	46	1.63	18.8	244	6.9	0.57	7.58	3.85	0-30

The chemical properties of the tap water and raw and treated sewage used

Some chemical properties like salinity, pH, the concentration of some of main and low-consumed nutrients and also heavy metals of tap water and treated sewage were measured and the results were displayed in Table 2. The standards suggested by The World Food Organization were used to evaluate the quality of the tap water and treated sewage used for irrigation. On the base of these standards of the quality of the treated sewage, the electrical conductivity is a little exceeded. This can be followed by salinity stress and poisoning of the plants sensitive to salinity. But the sewage pH was within the allowable range. The concentration of chloride ion, micronutrients and heavy metals also was detected more than the standard limit in the sewage.

Therefore, due to the application of sewage, probably, the concentration of these elements in soil ought to be considered in the long term. Additionally, according to the mentioned standard in the tap water, except for manganese, the concentration of micronutrients (heavy metals) was detected more than the standard boundary. The comparison of the analyses results of the treated and raw sewage, and the tap water showed that the concentration of the nutrients and heavy metals in the treated and raw sewage is more than that in the tap water.

Table 2. The chemical properties of the tap water, treated and raw sewage used

Cu, mg/l	Zn, mg/l	Mn, mg/l	Fe, mg/l	Cd, mg/l	Cl, mg/l	pH	EC dsm-1	
17.9	56.8	0.34	30	4.72	27.5	7.7	3.99	raw sewage
12.6	49.3	0.21	20	1.01	-	-	-	tap water
19.4	56.5	0.62	35	4.91	30.3	8.2	4.5	treated sewage

Statistical description of the data measured:

To determine the level of significance of the impact of the raw and treated sewage on properties under study, variance analysis was used on the base of mean squares and the results were presented in Table 3.

Table 3. The variance analysis of iron in the soil

Fe	Random freedom	Source
7.015ns*	5	treatment
0.016	12	Error
7.033	17	total

*there is not a significant difference

Based on the Table results, there is not a significant difference between iron at the levels of 5 and 1 percent.

Investigation of different parameters changes under experimental treatments

Average comparison of the properties under study was done at the levels of %5 and %1 through Duncan test and the results achieved were displayed in a figure 1.

Experimental treatments include:
S1I1: The tap water at the depth of 0-30
S2I1: The tap water at the depth of 30-60
S1I2: The treated sewage at the depth of 0-30
S2I2: The treated sewage at the depth of 30-60
S1I3: The raw sewage at the depth of 0-30
S2I3: The raw sewage at the depth of 30-60

The trend of changes of iron under the impact of the experimental treatments

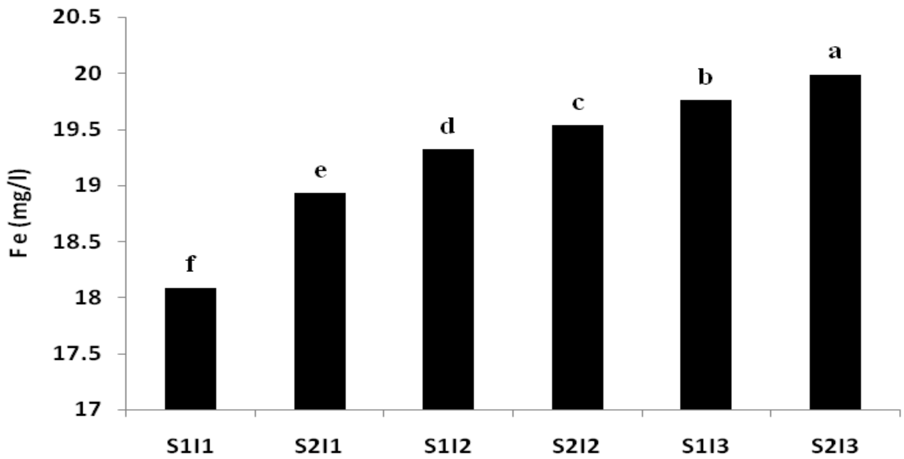

Figure 1. The comparison of different treatments average on the amount of Fe
(Similar letters indicate lack of significance among the treatments considered)

The above diagram shows the trend of iron changes in the treatments used in the study. Due to averages comparison, it was specified that irrigation with treated and raw wastewater had increased iron amount in different treatments at a constant depth of 0-30. Statistically speaking, at the probability levels of 5 and 1 percent, among different treatments, there is a significant difference, whose reason is a higher amount of iron in the treated and raw wastewater than that in the initial soil and the tap water. Iron-rich wastewater irrigation increased absorbable iron in soil (figure E; $p<0.05$). Our findings are consistent with those of Feizi (2001) where he indicated that wastewater irrigation has a significant effect on accumulation of certain elements in soil and plants over eight years; he also measured higher values of iron and magnesium in maize crop irrigated using wastewater (Omidbakhsh et al. 2012).

Conclusion

By using domestic sewage, the concentration of available iron in soil would increase. As the time goes by, the density of the absorbable iron increased accidentally. Generally, the high evaporation and other environmental conditions in the region under the study, the salt concentration and other elements at the height of 0-30 cm and 30-60 cm were the main reasons for this to happen (Gholami et al. 2011). Due to the acceptable density of iron within the soil as a result of the employed treatment, the researcher arrives at this conclusion that using the alternation treatment was the best beneficial one. Due to water shortage in the country and the necessity of using non-conventional water, it is suggested to carry out similar research in other parts of the country for more understanding and the optimal use of non-conventional waters such as effluents. In the present state of water resources, using wastewater is absolutely inevitable. On the other hand, the increase in the volume of wastewater is a problem, which caused treatment plants not to have the necessary capacity for treating total wastewaters. Thus, it is required to use low quality wastewaters also through practicing new management.

References

Ebrahimizadeh, M.A. 2007. The Impact of Effluent and Tap Water on the Productivity of Water and Fertilizer, Corn Growth and Soil Properties with the Least environmental impacts through Three Irrigation Methods (Drip Tape, Subsurface, and Furrows). Master's thesis, Shiraz University.

Feizi, M. 2001. Effect of treated wastewater on accumulation of heavy metals in plant and soil. In: Ragab R, Pearce G, Changkim J, Nairizi S, Hamdy A (Eds.). ICID International Workshop on Wastewater Reuse and Management. Seoul, Korea, pp: 137-146.

Gholami, A. Ahmadi Sh. and Panahpour E. 2011. The Effect of Using Compost Leachate on Soil Reaction and Soil Cadmium Absorption. Advances in Environmental Biology, 5(10): 3102-3109.

Gholami, A. Davami, A.H. Panahpour E. and Amini H. 2012. Evaluation of "Conocarpus erectus" Plant as Biomonitoring of Soil and Air Pollution in Ahwaz Region. Advances in Environmental Biology, 6(5): 1735-1739.

Omidbakhsh, M. Jafarnejadi, A. Gholami, A. and Mosavifazl S.M. 2012. Study of Effect of Refined Waste Water Application on Trend of Changes in Certain Soil Chemical Properties in Khouzestan, Iran. Advances in Environmental Biology, 6(4): 1552-1557.

Panahpour, E. Gholami A. and Rezaei Mirghaed H. 2011. The Effect of Using Compost Leachate on Absorption of Soil Iron. Advances in Environmental Biology, 5(8): 2390-2395.

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Ecological monitoring of soils in industrial areas in Bulgaria

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Abstract

The Ecological status of the Bulgarian soils according to content of toxic substances (Pb, Cu, Zn, Co, Ni, Cr, Cd, As, Hg) is analyzed in the context of the framework of the National Monitoring network. The distance between points in this network in too large (16 x 16 km) so it's not found local pollution in industrial areas. That's why the individual scientific studies by monitoring networks with points at a short distance, showed that the polluted soils in Bulgaria with content of heavy metals and metalloids above the maximum allowable concentrations are 43 660 ha, this represents 0.7% of the agricultural areas of the country. Of these soils 7 985 ha are polluted, the pollution is associated with increased concentrations of lead, cadmium, copper, zinc, reaching up to 5 times the maximum allowable concentrations. The present study shows information about heavy metal pollution of soils in two anthropogenic polluted regions - municipality Kuklen and the municipality Chelopech and Chavdar. In the area of the municipality Kuklen is located the Non- ferrous metal plant, and in the municipalities of Chelopech and Chavdar the gold and copper extraction plant company operating. The summarized data for soil diversity, according to limit concentrations of harmful substances and updated maps both monitored regions enable for the development of plans to implement the ameliorative activities for improvement soil quality.

Keywords: heavy metal, pollution, monitoring, limit concentration

Introduction

Heavy metal pollution is a big problem for industrialized countries. Basic pollutants of soil, plant and water are Cd, Zn, Pb, As, etc. As a result of the activities of many industrial factories around 360,000 acres in Bulgaria soils contain Cd, Zn, As, Cu above the maximum permissible concentration (5,2). The objects of interest from an environmental perspective are soils polluted with heavy metal. They are the result of genetic formation of the soil cover, and the anthropogenic impact. Usually by method of distribution and types of pollution are divided to local and diffuse contamination. Diffuse pollution is a presence of a substance or agent in the soil as a result of human activity and emission from mobile sources, from sources of a larger area or from many sources. Diffuse pollution is caused by diffuse sources and appears before their emission, transformation and dilution reflect the transfer in soil. Generally it is associated with atmospheric deposition, certain farming practices and inadequate treatment and recycling of waste. Atmospheric deposition of anthropogenic pollutants (including nutrients and acid deposition) are due to emissions from industry, transport, farming and agriculture. The local pollution is occurring in intensive industrial activities, inadequate treatment of waste, mining, military activities or incidents that allow significant release of pollutants. If the natural soil functions of buffering, filtering and transformation are exceeded, is observed significant environmental and health

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problems leading to water pollution, heavy or chronic toxicity, uptake of pollutants by plants, flatulence (EEA).

The aim of this study is to propose an approach for monitoring of soils with increased levels of heavy metals, due to pedogenic or technogenic pollution.

Material and Methods

Objects of study:

1.Municipality Kuklen and Non- ferrous metal plant - Plovdiv

The most studied regions of heavy metal pollution is the territory in which it is built and operated for over 40 years Non - ferrous metal plant (KCM). The area affected by the impact of KCM falls mainly on the land of municipality Kuklen.

To assess the actual changes in soil quality were selected points of the proposed monitoring network in 1993 with 1x1 km grid (a joint project between the Institute of Soil Science "N. Pouskarov" and the Institute of Soil Science, Bonn, Germany). In period 1996-2011 selected points of the monitoring network were jointly controlled by KCM (license laboratory) and ISS "N. Poushkarov".

2.The municipality Chelopech and Chavdar and Chelopech Mining area

In the area of Sredna Gora (Balkan region) for many years have operated some of the largest mining and processing enterprises (Elatsite Med - mine and copper plant, Chelopech Mine - gold factory, Assarel Medet mining industry and Copper-plant Kumerio-Med).

A lot of information received from researches in the area of Mining Company "Chelopech", Chelopech indicates the high potential negative impacts due of increased geological background and extraction activities of the different plants.

Municipality Kuklen

The municipality Chavdar and Chelopech

Fig. 1. Location of surveyed stations of the monitoring network (by Google-Earth)

Scheme of network for environmental monitoring with 0.4 km grid covering the agricultural lands of villages Chelopech and Chavdar was developed. A soil map with geographic coordinates was made (Fig. 1). In preparation of soil maps are used data from large-scale soil investigations of ISS "N.Poushkarov". The heavy metal content is determined according to the requirements of Order 3/2008 by *aqua regia* digestion.

Results and Discussion

Both objects are made date maps of soil diversity. They are geographically oriented, and will be used to develop plans for sustainable land management (Fig. 2 and Fig. 3).

1.Municipality Kuklen and Non- ferrous metal plant (KCM)- Plovdiv

Planned studies were conducted in five selected points of created monitoring networks. For the area of KCM they are the following:

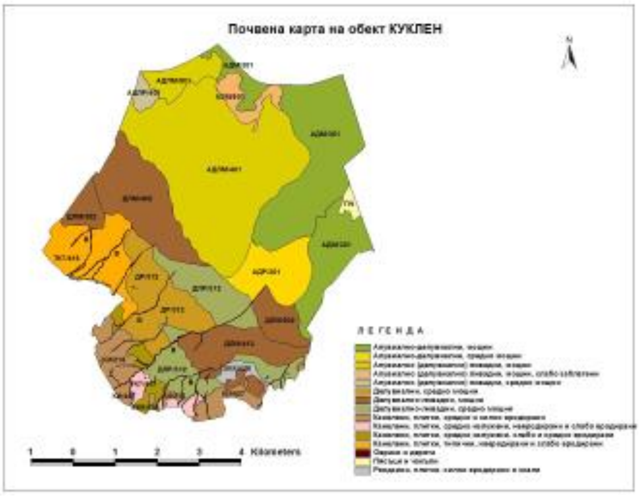

Fig. 2. Soil Map of the municipality Kuklen

Point 1 is located in Alluvial (deluvial) – meadow soils, powerful, medium sandy loam *(8)* and Eutric Fluvisols according to WRB *(3)*.

Point 2 is located in Deluvial-meadow, powerful soils, light loam *(8)* and Eutric Fluvisols according to WRB *(3)*.

Point 3 is located in Alluvial (deluvial)-meadow soils, powerful, slightly sandy loam *(8)* and Eutric Fluvisols according to WRB *(3)*.

Point 4 is located in Alluvial (deluvial)-meadow soils, medium strong, slightly sandy loam *(8)* and Eutric Fluvisols according to WRB *(3)*.

Point 5 is located in Alluvial (deluvial)-meadow soils, powerful, slightly sandy loam *(8)* and Eutric Fluvisols according to WRB *(3)*.

The comparison of the values of the lead, zinc and cadmium with the requirements of Order 3/2008 showed significantly increased concentrations in agricultural lands (Table 1).

Table 1. Concentrations of pollutants, mg/kg

Point	Pb	Zn	Cd	pH
1	2 145	2 525	49.0	7,3
2	675	1 125	16.0	7,6
3	1 070	1 300	28.0	7,6
4	10 000	6 300	202	7,5
5	103	195	3.00	7,7
MPC	120	400	3,0	

According to pH the soils are neutral, slightly alkaline and alkaline. The obtained results showed that the values of lead, zinc and cadmium expressed very high values, respectively 10000, 6300 and 202 mg. kg^{-1} soil, which is 625, 16 and 33 times surpassing MPC. The high levels of pollutants soil affect not only soil fertility and its phytotoxicity, but declined also crop production in the region and made it unsuitable for human and animals consumption.

2. The municipality Chavdar, Chelopech and Chelopech-Mining area

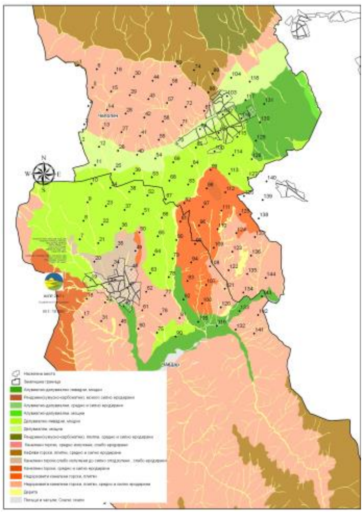

Fig. 3. Soil Map of research area

Point 1 is located in Deluvial-meadow soils, powerful, light-sandy clay *(8)*.

Point 2 is located in the recultivated area.

Point 3 is located in Alluvial (deluvial) -meadow soils, heavy sandy loam *(8)*.

Point 4 is located in Deluvial-meadow soils, powerful, medium sandy loam *(8)*.

Point 5 is located in the highly leached to slightly podzolized cinnamon forest soils, slightly eroded *(8)*.

Main problem of pollution in municipality of Chelopech is high soil acidity. Soil reaction ranged from 4.3 - very acidic to 5.9 - moderately acid. It is well known that the mobility of the metal increases with lower values of the soil solution (6).

In the studied soils high concentration of copper was determined. They surpass maximum limits concentration regulated in the Order 3/2008 (Table 2).

Table 2. Copper concentration (mg/kg)

Point	Cu	pH	MPC
1	544	4,3	80
2	210	4,9	80
3	64,5	5,9	80
4	120	5,9	80
5	139	5,0	80

The data obtained for the content of copper in the five points ranged from 544 to 120 $mg.kg^{-1}$ soil. Copper values are 6.8 times surpassing MPC. A high concentration of copper becomes a toxic threat to plant agro-systems and the environment as a result of the strong dependence on soil reaction. In small quantities of copper is required for normal growth of plants. In acidic soils can accumulate toxic levels of copper to plants, resulting in contamination of soil with copper compounds. Copper compounds once fallen in acidic soils with a reduced humus retain its solubility, which makes the copper easy mobile and absorbable (4,7).

In the first steps of soil monitoring we summarized data for soil diversity, according to limit concentrations of harmful substances and updated maps both monitored regions enable for the development of plans to implement the ameliorative activities for improvement soil quality.

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References

1. Nikova, I., 2009. Physico-chemical evaluation and amelioration of acidic soils. Doctorate thesis, NCAS, ISS "N. Poushkarov", 160.
2. Dinev, N., Nikova, I., Sechkova R., Banov, M., 2008. Remediation strategies for acid and contaminated soils. International conference, „Responses of Plants to Environmental Stresses", 12-18 May 2008, Elena, BAS, General and applied physiology, Vol. XXXIV, №3-4, 397-404
3. IUSS Working Group WRB., 2007. World Reference Base for Soil Resources 2006, first update 2007. World Soil Resources Reports. № 103. FAO, Rome.
4. Benkova, M., 2005. Colloid-chemical interactions at organo-mineral melioration of soils polluted with heavy metal. Doctorate thesis, NCAS, ISS "N. Poushkarov", 140.
5. Atanasov, I., Tchuldjian, H., Bojinova, P., 1993. Assessment of the soil contamination in the frame of land reform in Bulgaria. Symposium mit osteuropaischen staaten: Undersuch-undersmethoden, BewertungsmaBstabe and Staatliche regelungen fur den Bodenschutz, Schmalenberg, 1-4 Desember, 63-68
6. Ganev, S., 1990. Modern soil chemistry, Publishing House "Science and Art", Sofia.
7. Tchuldjian, H., 1978. Chemical states of the copper in the soil and their toxicity for the plants in the processes of industrial pollution. Doctorate thesis, Sofia, 156.
8. Koynov, V., Trashliev, H., Ninov, N., Yolevski, M., Boyadziev, T., 1964. Classification and systematics of soil in Bulgaria. BAS, Sofia.

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Assessment of gasgeochemical state of soils, grounds and surface atmosphere during land use engineering for construction

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Abstract

During town-building reserved areas with unfavourable properties particularly river valleys and overflow land are frequently used. During the land use engineering soils are being covered with man-made technogenic grounds. Grounds can contain construction garbage and household organic residues. Increased methane concentration in soils and grounds causes risk of fire and explosion situation. At the same time sanitary-hygienic danger of atmospheric pollution occurs. The high methane and carbon dioxide content in the atmosphere is dangerous for human health. Also these gases' emission causes increase greenhouse gases' content in the atmosphere and influences on the global climate changes. Assessment of gas geochemical state of soils, grounds and surface atmosphere before construction start and technogenic grounds after land use engineering. Objects of research are the alluvial soils and technogenic grounds in the widest part of Moskva river's valley. The registered low rates of methanogenesis before construction start are 0.02-0.03 $ng.g^{-1}.h^{-1}$ in automorphic and sedihydromorphic soils, 0.13 $ng.g^{-1}.h^{-1}$ in hydromorphic soils. Methanogenesis is provided for corresponding oxidation (on the average from 4-6 $ng.g^{-1}.h^{-1}$ to 19 $ng.g^{-1}.h^{-1}$). Methane concentration in atmosphere varies from 0.4 to 3.0 ppm. Carbon dioxide concentration in soils is 375.0 ppm, gas emission is 16.4 $mg.m^{-2}.h^{-1}$, concentration in surface atmosphere is less than 157.3 ppm. After land use engineering processes bacterial methanogenesis and oxidation increased. Unfavourable physical and mechanical properties, processes of organic remains' decomposition in technogenic grounds caused increase of methanogenesis rates optionally to 0.62 $mg.m^{-2}.h^{-1}$. In this case high rates of methanogenesis aren't provided for corresponding oxidation in technogenic grounds so it causes methane accumulation in ground stratums on the average from 5.4 ppm to 2872 and 3080 ppm. These are potential dangerous concentrations as per fire and explosion hazard criterions (according to Russian standart). Methane concentration in surface atmosphere increases on the average to 2.6 ppm. Methane accumulation in the atmosphere to 35 and 65 ppm is above points with potential dangerous methane concentration in grounds, it approaches to liminal concentration of sanitary-hygienic criterions. As a result of methane oxidation processes and decaying organic remains carbon dioxide is produced and accumulated in soils and grounds on the average to 3000 ppm. Its concentration in atmosphere is 1.7 times smaller (1681 ppm), this is 0.4 max. permissible concentration (MPC). It's fact that 0.2 MPC (800 ppm) carbon dioxide concentration causes unfavourable human and animal health conditions. In natural soils high rate of methanogenesis is provided for corresponding bacterial oxidation, it prevents methane accumulation in soils and the atmosphere. In technogenic grounds high rate of methanogenesis isn't provided for corresponding methane oxidation, and it causes accumulation methane in soils, grounds and the atmosphere.

Keywords: greenhouse gases, methanogenesis, methane oxidation

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Introduction

The intensive urbanization involves reclamation of reserve territories, often adverse environmentally. More often territories with a high level of ground water are used for inhabited construction. The overflow land and river valleys concern to them. The land use engineering is carried on waterlogged overflow land according to Town-Planning Code of the Russian Federation. Territories were being covered with piled-up transportic grounds (Rulebook Urban Development, 2011). Often grounds contain construction waste, presented by mineral and organic components. Transportic technogenic grounds and underlying natural peat-like layers are able to generate biogas, which consists of methane and carbon dioxide. The heightened methane concentration in soils and grounds causes risk of fire and explosion situation. At the same time sanitary-hygienic danger of atmospheric pollution occurs. The high methane and carbon dioxide content in the atmosphere is dangerous for human health. Also these gases' emission causes increase greenhouse gases' content in the atmosphere and influences on the global climate changes. All aforesaid is responsible for the actuality of this research.

Material and Methods

The object of this research is located in Moscow region in the overflow land of Moscow River. The territory was used in agriculture before 2003. Since 2004 the land use engineering has been begun according to the rules of Town-Planning Code. Territory was being covered with piled-up transportic grounds.

The four key area was put for research. The soil survey and gasgeochemical survey conducted. The morphological descriptions of soil profiles conducted in the field condition. We selected 145 samples of soils and grounds. There were selected 182 air samples for determine concentration of methane and carbon dioxide in soils and grounds. 202 air samples were selected for definition these gases's concentration in surface atmosphere and 2m height.

Blast-hole gasgeochemical survey. The airproof tubes were installed to the 60cm depth into the soil. In an hour the samples of soil's air were selected in the glass flasks with NaCl brine. Then concentration of methane and carbon dioxide was determined by the gas chromatograph.

Research of methane and carbon dioxide emission from soil into the atmosphere was conducted by the static chamber method. The low hollow metal bottomless cylindrical container (volume of 1100 cm3) were used as chambers. They were crashed into the soil's surface to the 5cm depth. The air samples of surface atmosphere were selected immediately and in an hour. The first sample characterized the concentration of gases in the atmospheric air, the second sample indicate processes of the emission or absorption of gases from soils. The emission (absorption) of gases was calculated using the formula:

$$q\ (mg \bullet m^{-2} \bullet h^{-1}) = \Delta Ch / \Delta t,$$

where ΔC - change in concentration of gases in the chamber (mg • m-3) during the exposure time (Δt, 1:00), h - height of the camera (0.1 m).

The research of the potential activity of methane bacterial oxidation was carried out according to the method by Zvyagintsev (Zvyagintsev, 1991). The samples of soil in the flasks were incubated above water of room temperature during 4 days for better moisturization and extraction of microorganisms from latent state. Then the flaks were closed, after which methane approximately 100% concentration was introduced in the amount of 0,2 cm^3. In the 0,5 cm^3 air sample from flask determined initial (C_0) and then every other day – the residual concentration in the gas chromatograph. Simultaneously the abiotic absorption of methane was evaluated. For this the experiment was repeated but before the addition of methane in the gas phase of fask acetylene (3cm^3), as an inhibidor of methane oxidation process, was injected. The measurement of residual methane was also performed for 4 days. The rates of methane oxidation and abiotic absorption were calculated by the formula:

$$V\ (ng / g\ per\ hour) = (dC \bullet K \bullet Vgf) / (MP \bullet t),$$

where dC - concentration difference in the first and the last measurement, ppm; K-conversion factor mg/m3 (0,657 at 20 ° C); Vgf - volume of gas phase cm^3; MP - soil sample weight, g; t - time hour. The rate of methane oxidation was calculated as dC = dC without acetylene - dC with acetylene.

The research of granulometric texture, the content of organic carbon, pH, the specific surface was carried by the standard methods (Vadyunina and Korchagina, 1986).

Results and Discussion

Assessment of gasgeochemocal state of soils and their ecological functions was conducted on natural Gleysols, Fluvisols and Albeluvisols, either on Technosols Transportic and Regosols, formed corresponding before and after land use engineering. Gleysols and Fluvisols were formed in conditions of the central and lower overflow on alluvial sediments of Moscow River. Albeluvisols were formed on old alluvial sediments. Technosols and Regosols were formed on technogenic grounds. The depth of technogenic grounds varies from 1,0 to 7,3m. In most cases there is a buried clayed layer with inclusion of organic and sometimes interbedded with peat on the territory of low overflow. Groundwater was found at the 2-4m depth. Capillary fringe groundwater tapers from the 1,2m depth. Flooding of the territory is fixed.

As a result of land use engineering there was a change of soil in researched area. Technosols and Regosols with unfavorable physical properties were formed in the thickness of technogenic sediments on buried natural alluvial soils with good morphological and physico-chemical properties. Technosols have loamy, sometimes sandy granulometric texture, contain construction and household garbage (25-30%). Construction waste is represented by rubble, asphalt crumbs, broken brick, concrete rubble, shards of glass, plastic, metal and wood.

Natural soils have a cloddy crumb structure that is favorable for life of soil fauna and microorganisms. Organic carbon content in soil thickness (10-50cm) of automorphic Albelyuvisols and Flyuvisols is 0,7-0,9%. In hydromorphic Gleysols concentration of organic carbon is 1.5%. In the upper horizon and Albelyuvisols (0-10cm) the content of organic carbon is 1,76% (Table 1).

Technosols are generally have blocky structure, predominantly loamy, sometimes sandy granulometric texture. Compared to natural soils increase of physical clay content (from 13,9 to 20,9% in Albelyuvisolys in Technosols), and specific surface area of particles (from 84,7 to 178,4 mg • m^{-2} in Flyuvisols in Technosols) is marked. Fragments and thick bands of lowland peat unevenly distributed in the soil profile. The content of organic carbon in the column (10-50cm) is from 0,9 to 1,8%.

Table.1 Chemical and physical properties of natural and undeveloped soils and anthropogenic soils

	Fluvisols	Gleysols	Albeluvisols	Regosols	Tecnosols Spolic	Tecnosols	Tecnosols Humic
Physical clay, %	15,8±1,2	19,5±1,5	13,9±0,0	15,9±0,9	16,9±0,5	15,3±0,0	20,9±0,0
Silt,%	6,6±0,7	7,7±1,3	6,8±0,0	6,2±0,5	6,2±0,5	7,2±0,0	5,5±0,0
Specific surface area,mg • m^{-2}	84,7±8,3	105,1±11,7	92,1±0,0	90,2±10,4	137,8±15,7	178,4±0,0	110,1±0,0
Sorption ng • g^{-1} per hour	19,7±2,4	27,1±3,3	7,8±0,0	18,1±3,3	16,4±2,0	22,0±0,0	18,3±0,0
pH	7,7±0,1	7,6±0,1	6,6±0,0	7,8±0,2	6,8±0,4	7,3±0,0	7,2±0,0
Organic carbon,% (0-10cm)	-	-	1,76±0,0	0,8±0,0	-	-	-
Organic carbon,% (20-50cm)	0,9±0,1	1,5±0,2	0,7±0,0	1,7±0,3	1,8±0,3	0,9±0,0	0,9±0,0

Albeluvisols and Fluvisols, formed in automorphic conditions, are characterized by low rates of methanogenesis: 0,02-0,03 ng • g^{-1} per hour. Hydromorphic conditions and increased organic matter content in Gleysols cause a high rate of methanogenesis (0,13 ng • g^{-1} per hour). In natural soils, high rate of bacterial formation of methane is offset by a corresponding bacterial oxidation (4,6-6, ng • g^{-1} per hour, Gleysols 19,7 ng • g^{-1} per hour), not allowing a large accumulation of methane in the soil column (Table 2).

The unfavorable physical and mechanical properties, as well as the availability of natural and anthropogenic organic residues in piled-up grounds and processes of its decomposition led to an increase of the methanogenesis rates up to 0,62 ng • g^{-1} per hour (in Regosols). In technogenic grounds high rates of methanogenesis are not compensated by corresponding oxidation (0,0-1,8 ng • g^{-1} per hour), that leads to the accumulation of methane in the soil to abnormal or potentially dangerous quantities (and 3080,0 2871,5 ppm). The location in hydromorphic conditions and large amount of organic matter contributes to the creation of anaerobic conditions and increases speed of methanogenesis, but prevents bacterial methane oxidation processes (Table 2).

Table 2. Rates of methanogenesis, methane oxidation and methane content in the soil and atmosphere and emission rate.

	Methanogenesis, ng • g^{-1} • h^{-1}	Methane oxidation, ng • g^{-1} • h^{-1}	CH_4 in soil, ppm	CH_4 emissions, mg • m^{-2} • h^{-1}	CH_4 in the atmosphere, ppm	CH_4 at the 2m height, ppm
Gleysols	0,13±0,06	19,7±7,3	10,3	0,1	3	2,6
Albeluvisol	0,03±0,01	4,6±1,9	2,6	0,0	2,3	2,5
Fluvisols	0,02±0,00	6,4±4,8	0,3±0,1	0,0	0,4±0,2	-
Tecnosols Spolic	0,07	0,0	2871,5	-2,9	64,9	2,6
Tecnosols Humic Gleyic	0,04	1,8	593,6	0	2,3	2,5
Tecnosols Humin (automorphic)	0,04	0,0	3080,0	0,06	34,5	2,7
Regosols (automorphic)	0,03	66,7	208	-0,01	2,4	2,2
Tecnosols (automorphic)	0,1±0,02	7,3±4,9	297,9±33,1	0,24±0,0	2,7±0,1	2,6±0,04
Regosols (hydromorphic)	0,62	34,7	2,6±0,1	-0,001	2,4±0,1	2,4±0,04
Tecnosols Humic (hydromorphic)	0,01	15,7	9,8	0,0	2,7	3
Tecnosols (hydromorphic)	0,01±0,0	13,3±6,2	3,6±0,6	0,01	3,7±0,6	2,6±0,1

In the low concentrations of methane in Technosols and Regosols, the methane emission into the atmosphere is small (up to 0,1 mg • m^{-2} • h^{-1}) or completely absent (Table 2). Above the points with anomalously high concentrations of methane in Technosols (3080,0 and 2871,5 ppm) its accumulation in the atmosphere occurs and reaches 34,5 and 64,9 ppm, respectively, which is 0,5-0,9 Tentative Safe Exposure Level (TSEL). The average methane concentration in the surface layer of the atmosphere over this territory is 2,6 ppm (Table 2)

As a result of processes of methane oxidation and decomposition of ground's organic matter the formation of carbon dioxide and its accumulation in the soil and ground occur. In late-autumn period in Fflyuvisols before land use engineering CO_2 content in the soil was low and amounted to 375,0 ppm, emissions into the atmosphere gas was 16,4 mg/m2 per hour, CO_2 content in the surface atmosphere was near 157,3 ppm (Table 3). Carbon dioxide content in the soil air of Albeluvisols and Gleysols during the summer was up to 2547,0 ppm and 2959,0 ppm, respectively). Perhaps this is caused by recreational load in the researched area.

Table 3. Carbon dioxide content in soils, atmosphere and emission rate

	CO_2 in the soil, ppm	CO_2 emissions, mg • m^{-2} • h^{-1}	CO_2 in the atmosphere, ppm	CO_2 at the 2m height, ppm
Fluvisols	375,0±52,4	16,4±10,1	157,3±40,0	-
Gleysols	2959,0±0,0	152,0±0,0	1712,0±0,0	1825,0±0,0
Albeluvisol	2547,0±0,0	265,1±0,0	1632,0±0,0	1476,0±0,0
Urbic Tecnosols Spolic Gleyic	9123,0±0,0	127,7±0,0	1746,0±0,0	1580,0±0,0
Urbic Tecnosols (automorphic)	2503,1±393,4	35,6±18,3	1592,7±56,7	1734,6±155,5
Urbic Tecnosols Humic	2366,9±388,1	104,4±54,2	1654,9±50,1	1846,3±85,3
Regosols	2237,3±140,5	154,2±48,5	1602,6±42,9	1554,7±50,7

After filling the territory with piled-up grounds increased content of carbon dioxide in soil and ground (an average of 2237-9123,0 ppm) is observed. This is due to increased methane oxidation processes and oxidation of organic matter of piled-up grounds for aerobic conditions. Emission of CO2 in the atmosphere increased with its accumulation in soils and grounds. In places with abundant grass and woody vegetation in automorphic Albelyuvisols and hydromorphic Gleysols rate of carbon dioxide emission was respectively 265,1 and 152,0 mg • m^{-2} per hour, Regosols - 154,2 ± 48,5 mg • m^{-2} per hour. This can be explained by processes of respiration of roots and microorganisms. In technogenic grounds without vegetation emission's rate is lower (above 41,6 ± 15,2 and 79,8 ± 39,7 mg • m^{-2} per hour respectively). In the surface layer of atmosphere carbon dioxide content decreased by 1.7 times compared with the thickness of the soil and averaged 1681,4 ppm (Fig. 1). Carbon dioxide emissions from soils and grounds make the definite contribution to the total fluid content in the atmosphere But it should be understood that the concentration of carbon dioxide in the atmosphere is integral and characterizes the contributions of other sources with possible large intensity.

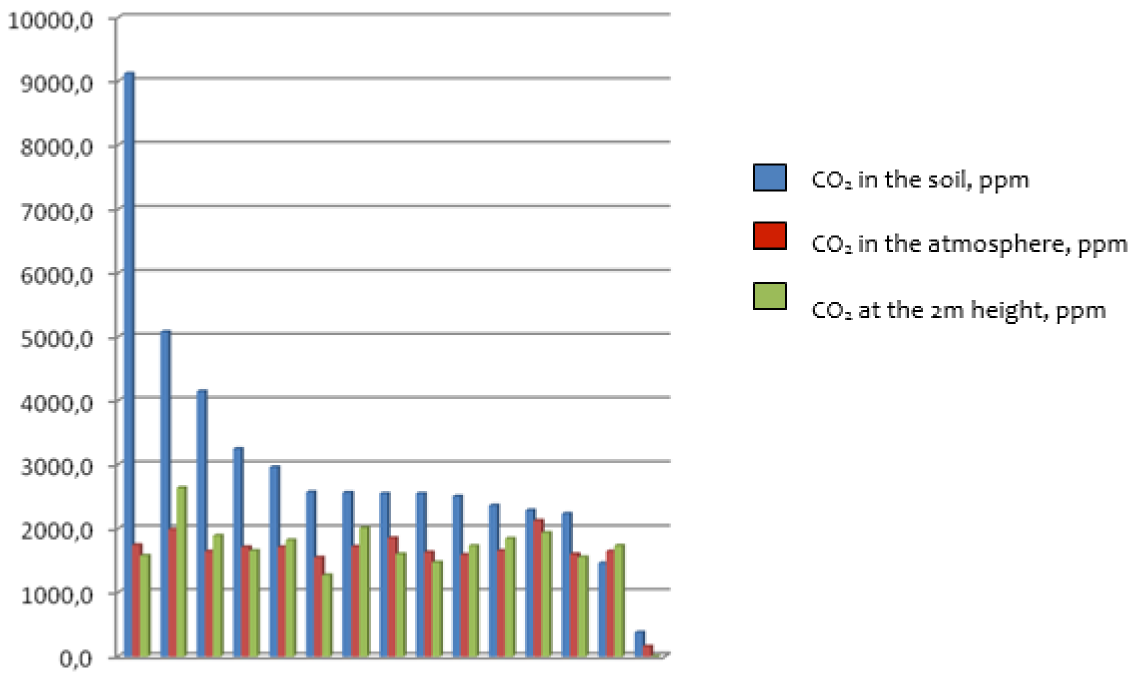

Figure 1. CO_2 content in soils and atmosphere

By the criteria of risk of fire and explosion situation the methane concentration in natural soils and Regosols was at a normal level. The methane content in the atmospheric surface layer does not reach critical values. However, in the concentrations of methane in the soil near 2872 and 3080 ppm increasing of emissions and gas accumulation in the atmosphere (up to 35 and 65 ppm, respectively) is observed. This content of methane in the air is 0,5-0,9 TSEL (GBV 2.1.6.696-98).

The sanitary-hygienic criteria of CO2 in the atmospheric surface layer is equal to 1681,4 ppm (this is 0,4 MPC hygienic regulations) (GN 2.2.686-98). Unfavorable for the life of people and animals the carbon dioxide concentration in the surface atmosphere is 800 ppm (0,2 MPC) (Robertson, 2008).

Conclusions

1. As a result of land use engineering for construction natural hydromorphic soils were covered with organogenic and mineral grounds, which served as the parent rocks for Technosols and Regosols.
2. Availability of peat-humus fragments, organic waste disposal, high density, low specific surface area of piled-up grounds under flooding conditions contribute to the creation of anaerobic conditions, which causes intensive processes of methanogenesis.
3. In natural soils high rate of bacterial methane formation is compensated by respective bacterial oxidation, preventing the accumulation of methane in the soil and atmosphere. In technogenic grounds the ecological functions of soil are not realized - high intensity of methanogenesis is not provided by methane oxidation that leads to the accumulation of methane in the soil, ground and atmosphere.
4. According to the criteria of risk of fire and explosion situation methane content in natural soils and Regosols is at a normal level. In Technosols methane concentration reaches potentially dangerous and abnormal values. There is an increasing of methane concentrations in the atmosphere to 0,5-0,9 TEL inder its potential dangerous concentrations in soil.
5. The processes of methane oxidation and oxidation of organic substances in piled-up grounds under aerobical conditions result in accumulation of carbon dioxide in the soil in an average of 3000 ppm. Gas emissions from soils and soil make the definite contribution to the total fluid content in the atmosphere

References

Vadyunina AF Korchagina ZA Methods of study of the physical properties of soils. - M. Agropromizdat, 1986. – 146p.

GBV 2.1.6.696-98 Exposure Limits (WEL) of pollutants in the air of residential areas. Hygienic standards

GBV 2.2.5.686-98 Maximum allowable concentration (MAC) of harmful substances in the air of the working area. Hygienic standards

GN 2.2.5.1313-03 State sanitary-epidemiological rules and regulations. Chemical factors of the industrial environment.

GOST 25100-95 Grounds. Classification

Methods of Soil Microbiology and Biochemistry: Textbooks / Ed. DG Zvyagintsev. - Moscow: MGU, 1991. – 304p.

Correlative base World soil resources: a framework for international classification and correlation of soil. Moscow: KMK. 2007. 278p.

Robertson DS Ecological Bulletin Russia: "The negative impact of rising levels of carbon dioxide in the atmosphere on the human body" / / Moscow: Moscow - 9/2008. P.23-25

Rulebook. Urbanism. Planning and construction of urban and rural settlements, 2011

Terpelets VI, VN Slyusarev Teaching manual for the study of agro and agro-chemical methods of soil investigation. - Krasnodar Univ FSEIHPE KubGAU 2010. – 65p.

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Improving nutrient elements uptake in lettuce under Light Emitting Diode irradiation

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Abstract

The development of human population relies on vegetative parts of plant species for nutrition and other human activities. Light Emitting Diodes (LEDs) as high intensity source of visible radiation could be used for growing selected horticultural and agronomic plants under controlled environments where plants take benefits from the LED lighting such as dwarfness and increased productivity and quality. The devices fabricated in this study were installed in four incubators each containing 100% red LEDs, 100% blue LEDs, 70% red-30% blue LEDs and 100% white LEDs. In each cabinet, 120 LEDs were set on a 24" * 24" sheet of aluminum platform and the solid-state design was affixed to a ceramic and steel support to facilitate efficient heat transfer to the mounting substrate. Lettuce plants (Lactuca sativa L. Cv. Grizzly) transplanted at four leaves stage in plastic pots (10*10 cm) containing cocopeat-soil (50:50) were randomly arranged in three replications in each cabinet. Greenhouse grown plants were also used for comparison. Pots were irrigated once per day with tap water. Application of blue LED light on lettuce plants for two months increased leaf water content and led to elevated concentrations of Mn, Zn, Fe, Ca and nitrogen compared to field conditions. However; the highest wet and dry weight of lettuce and Mg content was achieved in plants grown under red-blue (70% red-30% blue) LEDs. It seems that application of LED lamps on seedling plants could increase productivity and stimulate their uptake of nutrient elements. LED lighting may provide a novel tool for agricultural research and production due to its positive influence on plant morphology and composition for improving economic yield and nutrient quality of edible vegetables.

Keywords: Lettuce, Light Emitting Diode, nutrient elements, growth chamber, greenhouse

Introduction

Light emitting diode (LED) is a unique type of diode consisting of a chip of semiconductor material doped with impurities to create a p–n junction leading to monochrome light emission across the entire visible spectrum when electron current passed through the semiconductor diode. They have been rapidly evolved from low-intensity signal indicators into powerful light sources from street lighting to lighting greenhouses and for urban agriculture which is now a growing industry with high-tech greenhouses equipped with LED lights (Yeh and Chung, 2009). Compared to traditional and artificial light sources for photosynthetic organisms, LEDs have a very significantly longer life span, ease of light intensity control and higher PAR efficiency ideal for irradiation of plants to revolutionize production in controlled growth environments (Darko et al., 2014)

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Recently, there is growing concern on efficient energy usage, environmental impact of agricultural inputs and food safety in production systems (Pinho et al., 2012). In reducing energy usage for crop production, LEDs are not only efficient form of lighting because of their low energy consumption but also have low heat generation meaning less energy used for cooling plant grow structures such as glasshouses, greenhouses, and plant factories (Watanabe, 2009; Goto, 2012). The monochrome nature of LEDs provides the crops with specific and high quality wavelengths of light which translate to less energy being used for growing the crop. Moreover, the increased use of LEDs in environmentally controlled and closed-type plant production systems allows crop production to be continued throughout the year, regardless of external weather conditions (Schuerger et al., 1997; Darko et al., 2014). Therefore, it is predicted that LED lights are developed further and become a light source with considerable potential for high-power lighting for agricultural productions.

With the advent of LEDs, increasing research for commercial plant production utilizing LEDs has occurred. Studies have looked at different colors of LEDs, different colors of fluorescent lights, and various combinations of these two on crop production. Some of crops which have been already cultured under LED light radiation are lettuce (Yanagi, and Takita, 1996; Martineau et al., 2012), pepper (Brown at al., 1995), wheat (Goins et al.,1997), spinach (Yanagi and Okam-oto, 1997;), and banana (Duong at al., 2002). More recently, vegetables like mint and basil and pot flowers including petunia, primula, marigold and stock were grown under LED irradiation with high marketability characteristics when they were compared with greenhouse or field grown counterparts (Colquhoun et al., 2013; Sabzalian et al., 2014).

In lettuce, high power LED lighting systems have been shown to accelerate the growth rate of plants compared to plants grown under normal solar irradiance or under greenhouse hydroponic culture (Chin et al., 2012; Martineau et al., 2012). Johkan et al. (2010) also found that in red leaf lettuce, red LEDs increased leaf area up to 33% compared to fluorescent light. Generally blue and red LEDs are typically used for plant growth because chlorophyll a and chlorophyll b efficiently absorb wavelengths in the blue and red ranges. The experiments have confirmed that both blue and red LEDs have a positive effect on lettuce growth and the accumulation of antioxidant phenolic compounds.

According to the studies, red light irradiation without blue light was effective at stimulating the biomass accumulation of lettuce plants; however, red light alone induced abnormal leaf shape and had a negative effect on polyphenolics and antioxidant levels. There is a lot of variation among genotypes of lettuce cultivated around the word which their responses to LED lighting are not necessarily similar. It is also unknown how LEDs may affect the nutrient element acquisitions by lettuce in the edible and non-edible parts. The objective of this study was therefore to determine the effects of different LED light sources on growth, quality and mineral elements concentrations of lettuce Cv. Grizzly in a pot experiment.

Material and Methods

Plant material

Lettuce seeds (Variety, Grizzly) were placed in each hole of 2.5 cm × 3.8 cm horticultural cubes containing cocopeat. The horticultural cubes were moistened with tap water and placed in plastic trays with clear covers. The trays were put on a laboratory bench under ambient light conditions and room temperature. When the seedlings had one set of fully expanded leaves, they were transferred to 1.9-liter containers containing a soil-cocopeat mixture (50%:50%). Pots were placed in four LED incubators and in the greenhouse with three replications. Growth temperature was set at 25±2°C similar to outside average daily temperature. Pots were irrigated once per day with tap water (hardness 13, pH 7.5) and with nutritive solution (1 g/L) containing the main nutritive elements (K, Mg, Ca, N, P, S) once a week. Lettuce plants were grown for 2 months in the lab under different light treatments including blue LEDs, red LEDs, red+blue LEDs and white LEDs and greenhouse lights. After this period, fresh and dry weights of shoots and roots were measured as plant biomass.

LED incubator and light control system

Four sets of the Control Unit (CU) were independently designed to support 120 LED lights in four growth cabinets. LED arrays (OSRAM, Germany), emitting white (AL–R10001NW, 380–760 nm), red (AL–R1001NR, 650–665 nm), blue (AL–R1001NB, 460–475 nm) and red-blue (70%:30%) light were affixed to a ceramic and steel support to facilitate efficient heat transfer to the mounting substrate. The same arrays were applied by Folta et al. (2005). All the LED lights were 1 W (0.25 A of input current) and were driven by a circuit consisted of a standard 2 A power supply delivering 110 VDC to a common bus that feeds 1 W LED lights (Kaming, Taiwan) in series. Voltage to the arrays that is the illumination intensities was tuned via a self-made potentiometer at 500 µmol m-2 s-1 on each separate incubator at the leaf surface. The light intensity was also measured via a light meter (LI-250A, LI-COR Inc., USA) with a 2 π quantum sensor (LI-190, LI-COR Inc., USA) during the plants growth. A 0.72 K Ω (50 W) power resistor was placed in the circuit as a current limiter. Input and output capacitors were also provided to improve transient response. This configuration was repeated for each growth chambers. The CU was outfitted with two 100 mm 12 V fans, one facing into, and one facing out of the CU. Each individual LED sheet was also outfitted with an individual heat sink to ensure adequate cooling.

A microcontroller containing the control logic for setting the growth parameters was written in the assembly language of ASM51 (Arvin Tajhiz Espadana Co., Iran) and applied on each growth cabinet to adjust temperature, LED's brightness and light/dark duration (16/8 h).

Mineral elements analysis

Roots were separated from shoots at the crown and each part (root and shoot) was rinsed in distilled water and dried for 48 h at 60°C. From shoots, exterior and interior leaves were also separated for analysis. Dried tissues were weighed and ground to obtain homogenous samples. A 0.5 g subsample of each plant was then dissolved in 2M sulfuric acid (H_2So_4) and Salicylic acid (SA) (Bremner and Mulvaney, 1982). Aliquots were diluted with distilled water and analyzed for their potassium (K+) contents by flame emission (Flame Photometry 410, Corning). The concentration of Manganese (Mn), Copper (Cu), Zinc (Zn), Magnesium, Calcium, and Ferrous (Fe) were determined by atomic absorption spectroscopy (Perkin-Elmer 800). Total nitrogen was determined bymicro-Kjeldahl analysis and phosphorus was measured using the Murphy and Riley reagents for phosphorus determination (Olsen and Sommers, 1982)

Statistical analysis

Plant pots at three replications were arranged in growth cabinets as environmental conditions. Data were analyzed using the Statistical Analysis System (SAS Institute Inc. 1999) program package according to completely randomized design and combined analysis to compare different environments. After an analysis of variance (ANOVA), significant differences among means were determined by Least Significant Difference (LSD) Test ($p< 0.05$).

Results and Discussion

Impact of LED irradiation on lettuce growth

The lettuce plants (*Lactucasativa* L. Cv. Grizzly) grown under red+blue LED were better than those grown traditionally in the greenhouse or under the other LED cabinets (Fig 1). As reported in Table 1, plants grown under red+blue LED irradiation had significantly higher shoot and root fresh weight, although no significant difference was found between red+blue and blue LED incubators regarding lettuce fresh weight. In contrast, under greenhouse conditions, shoot and root dry weights were greater than red+blue LED (Table 1).The highest ratio of shoot weight to root weight, were observed in plants irradiated under red LEDs (Table 1). Okamoto et al. (1997) also found that lettuce had the maximum whole plant dry weight under a red/blue combination; however they did not evaluate control plants grown in a normal greenhouse. In the absence of blue light i.e. in incubator with pure red LED, the fresh growth and dry weight were significantly lowered when compared to pure blue LED (Table 1). This may indicate that pure red LED is not enough to complete full growth of lettuce although red light may have higher contribution to the plant photosynthesis. It has been reported that the spectral composition of red LED matches with the red absorbance area of chlorophylls a and b present in the chloroplasts of higher plants (Schoefs 2002; Wang et al. 2007). Nevertheless, it has been reported that blue light has complementary effect. Brown et al. (1995) compared pepper (*Capsicum annuum* L.) plants grown under red LED with similar plants grown under red LED plus blue light emitted from fluorescent lamps. Pepper biomass was reduced when growth was under red LED without blue wavelengths compared to plants grown under supplemental blue lamps. Therefore, although the significance of red light on plant photosynthesis is evident but it does not mean that plant species could terminate their normal growth under pure red LEDs (Yorio et al. 2001). In the present study, it seems that red light had complementary effect on blue light since blue+red LEDs increased dry weight of lettuce compared to pure blue LEDs.

The white LED light displayed the same fresh weight but lower dry weight than blue+red LED lights (Table 1). White light is composed of a combination of red and blue lights of low intensities and other growth inefficient light wavelengths. Therefore, it may dilute the effect of red-blue light on the net photosynthesis and decrease growth rate.

Table 1. Mean comparison of measured traits on lettuce (Cv. Grizzly) irradiated under different light sources.

Light Sources	Shoot water content (%)	Shoot dry weight (g)	Shoot fresh weight (g)	Root water content (%)	Root dry weight (g)	Root fresh Weight (g)
Ctrl	87.84^{c}	8.42^{a}	33.69^{b}	88.07^{d}	3.49^{a}	29.33^{b*}
Blue LED	97.18^{a}	3.63^{c}	128.79^{a}	95.01^{b}	1.18^{c}	23.83^{c}
Red LED	97.17^{a}	0.62^{d}	22.10^{c}	96.55^{a}	0.05^{d}	1.67^{d}
Blue+Red LED	95.32^{b}	5.99^{b}	128.45^{a}	93.11^{c}	2.50^{b}	36.33^{a}
White LED	97.36^{a}	3.41^{c}	129.31^{a}	93.08^{c}	1.49^{c}	21.67^{c}
LSD	4.27	0.51	5.31	1.50	0.38	3.61

*means following with the same letter are not significantly different ($p<0.05$).

As indicated in Table 1, regarding the irradiation condition, the shoot water content in plants grown in the all cabinets were the same and significantly higher than those grown under greenhouse conditions. The data suggest that the plants grown in LED incubators are barely exposed to water shortage while those experiencing the conditions of greenhouse may have been affected by some water stresses. This also shows that LED light application (red-blue LED) may improve fresh weight and water content of lettuce higher than greenhouse condition as important characteristics for fresh uses.

Figure 1. Left to right: lettuce grown under red+blue, blue, white and red LEDs and in the greenhouse.

Nutritive elements content of lettuce grown under LEDs

The results of elements analysis showed that lettuce plants grown under red LED light had higher concentration of K, N, Ca, Fe, Mn, Zn and P except for Mg in exterior leaves. In interior leaves, the highest concentration of Ca, Zn and Mn was measured in plants irradiated under blue LEDs while Mg and N were significantly concentrated under red+blue LEDs. The concentrations of K, Fe and P were found higher in plants grown under white LED lights (Table 2)

It is well established that light quality constitutes signals that can trigger metabolic modifications (Liu et al. 2004). Our results of element analysis demonstrated that lettuce plants grown under different LED lights accumulated dramatically higher concentration of mineral elements compared to those grown in the greenhouse. Under blue and white LED lights, significant increases in Zn and Fe were observed to about 89 and 100% respectively, compared to the greenhouse condition (Table 2).There is little information on stimulation of the accumulation of mineral elements in plants grown under LED lights. It seems that red LED may affect the metabolic pathways of plants and presumably water absorption leading to increase in mineral elements content in exterior leaves. However, in interior leaves of lettuce which is the edible parts of plants, LEDs may alter the mechanisms intervening active absorption of elements. The effect of LED light on secretion of, stability of or sensitivity to, phytohormones, consistent with the improvement in morphogenesis and productivity of the plant response to LED lighting has been also postulated (Tamulaitis et al., 2005). However, how these changes take place and may affect mineral element accumulation is not understood and warrant further investigations because of their impact on economic value of plants grown under LED lighting.

Table 2. Mean comparison of mineral elements concentrations in lettuce (Cv. Grizzly) irradiated under different light sources.

	K g/100g		N g/100g		Ca g/100g		Fe mg/kg		Zn mg/kg		Mn mg/kg		Mg g/100g		P g/100g	
Light Sources	interior leaf	exterior leaf	interior leaf	exterior leaf	interior leaf	exterior leaf	interior leaf	exterior leaf	interior leaf	exterior leaf	interior leaf	exterior leaf	interior leaf	exterior leaf	interior leaf	exterior leaf
Ctrl	2.60^{c}	2.51^{c}	1.23^{b}	1.07^{c}	0.23^{c}	0.72^{b}	187.12^{c}	218.34^{e}	27.87^{b}	17.04^{d}	16.18^{c}	20.23^{c}	0.16^{c}	0.23^{c}	0.17^{d}	0.15^{c*}
Blue LED	4.16^{b}	3.57^{bc}	2.94^{a}	1.84^{b}	0.52^{a}	2.75^{a}	334.79^{ab}	334.78^{d}	52.65^{a}	15.48^{d}	28.32^{a}	52.59^{b}	0.26^{b}	0.80^{ab}	0.27^{c}	0.16^{cb}
Red LED	_	5.24^{a}	_	2.83^{a}	_	2.52^{a}	_	1387.37^{a}	_	52.91^{a}	_	84.95^{a}	_	0.67^{b}	_	0.48^{a}
Blue+Red LED	2.87^{c}	3.54^{bc}	3.44^{a}	2.62^{a}	0.39^{b}	2.52^{a}	291.12^{b}	436.68^{c}	35.62^{b}	24.77^{c}	24.27^{b}	52.59^{b}	0.31^{a}	0.85^{a}	0.40^{b}	0.22^{b}
White LED	5.37^{a}	4.08^{b}	3.51^{a}	2.06^{b}	0.59^{a}	2.95^{a}	376.35^{a}	494.90^{b}	52.65^{a}	46.46^{b}	28.32^{a}	56.63^{b}	0.27^{ab}	0.87^{a}	0.58^{a}	0.49^{a}
LSD	0.77	1.13	0.58	0.38	0.11	0.56	54.08	19.36	7.82	4.15	0.13	6.52	0.05	0.14	0.05	0.067

*means following with the same letter are not significantly different ($p<0.05$).

Conclusion

Irradiation of lettuce plants by blue LED light increased leaf water content and concentrations of Mn, Zn, Fe, Ca and nitrogen in the plants compared to field conditions. Plants grown under red-blue (70% red-30% blue) LEDs had also the highest wet and dry weight of lettuce and Mg content. Application of LED lamps as a source of light for plants could increase productivity and stimulate their uptake of nutrient elements. LEDs provide a novel tool for new research in agricultural due to its positive influence on plant morphology and composition. They may also improve economic yield and nutrient quality of edible vegetables.

References

Bremner, J.M., Mulvaney C.S. 1982. Nitrogen-total. In: A L Page, R H Miller, D R Keeney(Eds). Methods of soil analysis, Part 2-Chemical and microbiological properties. 2nd ed., Agronomy 9, pp.595-522.

Brown, C S, Schuerger AC, Sager, J C. 1995. Growth and photomorphogenesis of pepper plants under red light-emitting diodes with supplemental blue or far-red lighting. J Am SocHortSci 120: 808–13.

Chin, L. Y. and Chong, K. K. 2012. Study of High Power Light Emitting Diode (LED) Lighting System in Accelerating the Growth Rate of Lactuca Sativa for Indoor Cultiva-tion," International Journal of Physical Sciences, 7: 1173-1781.

Colquhoun, T.A., Schwieterman, M.L., Gilbert, J.L., Jaworski, E.A., Langer, K.M., Jones, C.R., Rushing, G.V., Hunter, T.M., Olmstead, J., Clark, D., Folta, K.M. 2013. Light modulation of volatile organic compounds from petunia flowers and select fruits. Postharvest Biol Tech 86: 37–44. doi:10.1016/j.postharvbio.2013.06.013

Duong, T. N., Hong, L. T. A., Watanabe, H., Goi, M., and Tanaka, M. 2002. Growth of banana plantlets cultured in vitro under red and blue light-emitting diode (LED) irradiation source.ActaHorticulturae, 575, 117–124.

Folta, K.M., Koss ,L.L., McMorrow, R., Kim, H.-H, Kenitz, J.D., Wheeler, R., Sager, J.C. 2005. Design and fabrication of adjustable red-green-blue LED light arrays for plant research. BMC Plant Biol. 5-17.

Goins, G. D., Yorio, N. C., Sanwo, M. M., & Brown, C. S. 1997. Photomorphogenesis, photosynthesis, and seed yield of wheat plants grown under red light-emitting diodes (LEDs) with and without supplemental blue lighting. Journal of Experimental Botany, 48, 1407–1413.

Goto, E. 2012. Plant Production in a Closed Plant Factory with Artificial Lighting, Proceedings of the 7th International Symposium on Light in Horticultural Systems, Wagenin-gen, 15-18 October 2012, pp. 37-50.

Johkan, M., Shoji, K., Goto, F., Hashida, S., Yoshi-hara, T. 2010. Blue Light-Emitting Diode Light Irradiation of Seedlings Improves Seedling Quality and Growth after Transplanting in Red Leaf Lettuce. HortScience, 45: 1809-1814.

Kasuga, M., Liu, Q., Miura, S., Yamaguchi-Shinozaki, K., Shinozaki, K. 1999. Improving plant drought, salt, and freezing toleranceby gene transfer of a single stress-inducible transcription factor. Nat. Biotechnol. 17:287–291

Lichtenthaler, k., Buschmann, C. 2001. Chorophylls and carotenoids:measurement and characterization by UV-VIS spectroscopy. Current protocols in food analystical chemistry F4.3.1-F4.3.8

Liu, Y., Roof, S., Ye, Z., Barry, C., van Tuinen, A., Vrebalov, J. 2004. Manipulation of light signal transduction as a means of modifying fruit nutritional quality in tomato. PNAS 101: 9897–9902.

Martineau, V., Lefsrud, M., TaheraNazanin, M., Kopsell, D.A. 2012. Comparison of light-emitting diode and high-pressure sodium light treatments for hydroponics growth of Boston lettuce. HortSci 47: 477-482.

Moran, J.F., M. Becana, I. Iturbe-Ormaetxe, S. Frechilla, R.V. Klucas, and P. Aparicio-Tejo.1994. Drought induces oxidative stress in pea plants. Planta 194:346–352.

Okamoto, K., Yanagi, T., Kondo, S. 1997. Growth and morphogenesis of lettuce seedlings raised under different combinations of red and blue light. ActaHort 435: 149–57.

Olsen, S.R., Sommers, L.E. 1982. Phosphorus. P. 403-430. In A.L. Page(ed.) Methods of soil analysis, Agron. No. 9, Part 2: Chemical and microbiological properties, 2nd ed., American Society of Agronomy, Madison, WI, USA.

Pinho, P., Jokinen, K. and Halonen, L. 2012. Horticultural Lighting—Present and Future Challenges, Lighting Research and Technology, 44: 427-437.

Ragaee, S., Abdel–Aal, E. M., Noaman, M. 2006. Antioxidant activity and nutrient composition of selected cereals for food use. Food Chemistry, 95: 32–38.

Roxas, V.P., Lodhi, S.A., Garrett, D.K., Mahan, J.R., Allen, R.D. 2000. Stress tolerance in trans-genic tobacco seedlings that overexpress glu-tathione S-transferase/glutathione peroxidase. Plant Cell Physiol. 41:1229–1234.

Schoefs, B. 2002. Chlorophyll and carotenoid analysis in food products. properties of the pigments and methods of analysis. Trends Food Sci Tech13: 361-371.

Schuerger, A. C., Brown, C. S., Stryjewski, E. C. 1997. Anatomical features of pepper plants (CapsiumannuumL.) grown under red light-emitting diodes supplemented with blue or far-red light. Annals of Botany, 79, 273–282.

Tamulaitis, G., Duchovskis, P., Bliznikas, Z., Breive, K., Ulinskaite, R., Brazaityte, A., Novickovas, A., Zukauskas, A. 2005. High-power light-emitting diode based facility for plant cultivation. J Phys D: ApplPhys 38: 3182–3187.

Wang, C.-Y, Fub, C.-C, Liu, Y.-C. 2007. Effects of using light-emitting diodes on the cultivation of Spirulinaplatensis. BiochemEng J 37: 21–25.

Watanabe, H. 2009. Light-Controlled Plant Cultivation System in Japan—Development of a Vegetable Factory Using LEDs as a Light Source for Plants," Proceedings of the 6th International Symposium on Light in Horticulture, Tsukuba, 15-19 November 2009, pp. 37-44.

Yanagi, T., and Okamoto, K. 1997. Utilization of super-bright light emitting diodes as an artificial light source for plant growth. ActaHorticulturae, 418, 223–228.

Yanagi, T., Okamoto, K., Takita, S. 1996. Effects of blue, red and blue/red lights of two different PPF levels on growth and morphogen-esis of lettuce plants.ActaHorticulturae, 440, 117–122.

Yeh, N., Chung, J-P. 2009. High-brightness LEDs-Energy efficient lighting sources and their potential in indoor plant cultivation. Renew Sustain Energ Rev 13: 2175–2180.

Yorio, N.C., Goins, G.D., Kagie, H.R., Wheeler, R.M., Sager, J.C. 2001. Improving spinach, radish, and lettuce growth under red light-emitting diodes (LEDs) with blue light supplementation. Hort.Sci 36: 380–383.

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Spatial distribution of dominant tree species in a tropical rain forest and its relation with site quality

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Abstract

Several investigations at regional or local scale have studied density-dependence and dispersal limitations on the distribution of tropical plants, while the effects of soil and site quality as drivers of tropical rainforest biodiversity has been addressed much less. Some studies have focused on the soil fertility effects on plant communities, but few have assessed the water storage capacity or the aeration and drainage conditions of the soils and their impact on species distribution. This work aims to investigate the relation between site quality and the spatial distribution of tropical rain forest diversity**.** On behalf of geopedological mapping and site quality assessment we studied the plant distribution patterns at the Selva Lacandona, Chiapas, Mexico. Soils and trees with dbh ≥ 10 cm were sampled in 9 plots of 5000 m^2 distributed in three dominant geopedological units. In each plot landform features and soil properties were determined. Site quality considering not only nutrients but also water and aeration capacities as well as rooting depths was evaluated by principal component analysis (PCA). We used cluster analysis as classification technique and the Index of Simpson and plant richness estimated by nonparametric estimators to compare diversity and richness between geopedological units. The relationship between plant diversity and site quality was based on canonical correspondence analysis (CCA). We identified geopedological units with contrasting site quality. The PCA accounted for 65% of the variation was positively correlated with pH, total nitrogen soil aeration, water retention capacity and exchange aluminum. Both the classification and ordination techniques showed that plant diversity and richness respond to site quality conditions. The richness and diversity are smaller in floodplains, although these have the best site quality reflected in the largest growth parameters. Low altitude hills on sand and claystones have a medium site quality but are much more heterogeneous, and also richer in tree species. Limestone mountains show the least site quality, limited particularly by rooting depth and available water holding capacity, and show a very contrasting plant community. In the study area available water holding capacity is one of the most important determinants of tree species distribution.

Keywords: Tropical rain forest, site quality, tree species diversity, Selva Lacandona

Introduction

The theoretical distribution range that allows the species establishment and survival is widely affected by interactions with other species and restricted by historical factors that collectively determine the realized

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niche (Hutchinson, 1959), which consists of a combination of environmental conditions such as climate, soil, disturbance and biotic interactions that operate at different spatial and temporal scales (Gentry, 1988; Clinebell *et al*, 1995; Ter Steege *et al*., 2003; Toledo *et al*., 2012).

Local topographic variation has been widely used for the theoretical distribution range of species, because it is easy to measure and acts as a useful indicator of environmental heterogeneity (Baldeck *et al*., 2012; Brown *et al*., 2013). The tropical forest includes the most diverse communities in the world and niche differentiation (Phillips *et al*., 2003). Numerous studies have identified associations between tropical tree species and environmental variables such as elevation, availability of nutrients and water from the soil, exposure, and light and temperature regimes (Phillips *et al*, 2003; Jhon *et al,* 2007; Baldeck *et al*, 2012; Condit *et al*, 2013; Holl *et al*, 2013; Peña-Claros *et al,* 2013; Toledo *et al*, 2013). These variables can be integrated into the concept of site quality, which reflects the sum of the environmental factors that affect biotic communities of an ecosystem (Daniel *et al*., 1979; Klinka and Wang, 1996).

While some researchers have focused on the relationship between climate and tree diversity, others have emphasized the role of soil nutrients as a determinant of species richness in tropical forest (Clinebell *et al*., 1995). However, the effects of variation in soil resources to the community level have not been examined extensively, existing little research to examine the relative contribution of topographic data and soil variables in shaping local species conformation (Baldeck *et al*., 2012). Consequently, there is still an unresolved debate about the relationship between plant diversity and soil properties (Sollins, 1998, Jhon *et al*., 2007; Peña-Claros *et al*, 2012; Silva *et al*., 2013), likewise, the quantitative relationship between habitat heterogeneity and maintenance of tree diversity is still unclear (Wright *et al*, 2002, Gravel *et al*, 2011; Brown *et al*, 2013). The aim of this study was to investigate the relationship between site quality and spatial distribution of the dominant trees in the tropical rainforest.

Material and Methods

The study was conducted in the area surrounding the Chajul Tropical Biology Station, which is located south of the biosphere reserve of Montes Azules, in the Selva Lacandona, in southeastern Mexico. The annual rainfall is 3000 mm and the average annual temperature is 22°C (MTF, 2013). The site quality determination was performed using the delimitation of geopedologic units using the hierarchical classification system proposed by Zinck (1988) and Zinck and Valenzuela (1990). Obtaining map units was done from visual interpretation of the external features of the relief (Zinck, 2012) at 1:20,000 scale aerial photographs and 1:50,000 scale digital model. Geological information (SGM, 1997), and soil information (Siebe et al., 1995; Celedon, 2006) was included, supplemented by field generated data based on the manual for the description and evaluation of organic soils in the field of Siebe et al. (2006). All information was processed in ArcGIS 9.3 (ESRI, 2009) program and subsequently verified in the field. Vegetation data were obtained from annual surveys in areas of mature forest in permanent observation plots of 20 x 250 m (0.5 ha) since 1994, in which all trees with dbh ≥ 10 cm have been censused (Martinez-Ramos, 2006). Estimating wealth was based on nonparametric estimators: Chao-1 and ACE (Magurran, 2004) with *EstimateS* 8.2 (Colwell, 2009) program. Simpson index was used to estimate the diversity by means of *MultiVariate Statistical Package* program *MVSP* (KCS, 2011). Classification of vegetation was performed using a cluster analysis using the Sorensen coefficient as the measure of distance to define similarity between groups and as linkage method, the average between groups (UPGMA). To estimate the importance of the relief attributes, geology and water and nutrients storage in the soil with vegetation attributes, a principal component analysis (PCA) was performed. Subsequently, a variables discrimination was performed using a collinearity test for the canonical correspondence analysis (CCA) with *Multivariate Statistical Package* program MVSP (KCS, 2011).

Results and Discussion

The main geopedological units can be grouped into Limestone mountains, Low altitude hills and Floodplain. Our results show that the site quality features contrasting conditions determined by the storage of water and nutrients between geopedological units. In the Limestone mountains, the steep topography and high stoniness determine low storage of water and nutrients (Table 1), which represents the main limiting factor richness. The in these units presented mean values (Table 2). In contrast, observed and obtained richness by the nonparametric estimators show to be higher in the Low hills. These are a surfaces complex mosaic with widely contrasting site quality. Shale soils have good nutrients storage, however there is evidence to suggest poor drainage in soil. Soils formed on sandstones have low water storage which can determine water stress for vegetation in the dry season, some soils in this unit could also have aluminum toxicity. Although floodplains have the best site quality, on these sites the lowest diversity was presented. This is consistent with the hypothesis of Huston (1979) which states that according to the increase of available nutrients, species richness should decrease because some competing species exclude others.

Table 1. Site quality per geopedological unit

Sites	Phys. depth	Aireation	Field Cap.	Available water	pH	O.M.	O.C..	Nt	C/N	Al
	Cm	Vol %	L/m/²	L/m²		%	%	%		%
Floodplain 1	67	8	667	325	5.6	15.7	9.1	0.6	14.8	0.0
Floodplain 2	76	13	277	135	6.5	13.4	7.8	0.7	11.3	0.0
Floodplain 3	90	12	463	202	6.9	9.8	5.7	0.7	8.7	0.0
Limestone mountains 1	27	9.5	112.9	55	7.0	3.0	1.7	0.2	10.2	0.0
Limestone mountains 2	45	10.5	166.8	98	7.0	4.0	2.3	0.4	5.7	0.0
Limestone mountains 3	53	8.5	758	237	7.0	4.0	2.3	0.5	5.0	0.0
Low altitude hills 1	66	4	501	174	4.9	4.6	2.7	0.5	5.0	2.5
Low altitude hills 2	60	11	123	53	4.2	9.0	5.2	0.6	9.4	1.3
Low altitude hills 3	63	8	305	116	5.4	16.5	9.6	0.6	16.8	0.0

Phys. Deep = physiological depth; O.M. = organic matter; O.C.= organic carbon; Nt = total nitrogen; C / N ratio carbón-nitrogen; Al = aluminum

Paoli et al. (2006) suggest that in the tropical rain forest, the dominant species in terms of frequency and occupied plots should be generalists to soil conditions. However, our results suggest that even within generalist species, the most abundant species have a response to changes in site quality. Species like *Dialium guianense* (Aubl.) Sandwith, decrease from 115 to 8 individuals in Limestone mountains. Conversely, *Brosimum alicastrum* Sw has its greatest abundance in Limestone mountains (29 ind.) and the lowest in floodplain. Meanwhile, *Pouteria campechiana* (Kunth) Baehni decreases its abundance in the Low altitude hills. In the better site quality group of units values with less richness were found. According to Brenes-Arguedas et al. (2008), a possible explanation is that the site quality may limit the species distribution by influencing their competitiveness. That is, depending on the increase in available nutrients, richness decreases by means of competitive exclusion effects (Huston, 1979). The effect of varying the balance of water and nutrients showed its highest contrast between the floodplain and the Limestone mountains, which could be determining that certain species, as *Castilla elastica* Sessé and *Spondias radlkoferi* Donn. Sm., are not found in Limestone mountains, because even though it would be expected that rainforest species were less limited by water availability, in the study area there is a two month period in which the total evaporation is greater than the precipitation, enough time to generate water stress in the plants in sites with low water storage as Limestone mountains.

The data analysis shows that the distribution of species largely cab be explained based on the quality of the reflected geoecological site units. The effect of balance of water and nutrients changes in the study area accounted for 65% of the variation, in this regard, it has been reported that both, the nutrients availability (Swaine, 1996, Phillips *et al*, 2003.) and the soil water availability (Sollins, 1998) correlate with the species distribution (Brenes-Arguedas *et al.*, 2008). The first axis of the PCA, which explained 41.7% of the variation, is correlated with the content of organic matter and nitrogen as well as the physiological depth. The second axis explained 23.9% of the variation, the main contribution to this axis is from the aeration capacity, water retention and aluminum contents. The indicators obtained from the CCA analysis to explain variation in tree diversity are physiological depth, aeration capacity, field capacity, water availability, pH, Nt, C/N and Al, variables that were used for canonical correspondence analysis (Table 3).

Table 2. Species richness and diversity in the largest surface geopedological units (n = 9) in the Selva Lacandona Lacandona in Chajul.

Sites	S_{obs}	ACE	Chao 1	Mean	Mean SD	%	Simpson´s Index
Floodplain 1	61	98.6	92.8	95.7	4.1	64.2	0.969
Floodplain 2	102	148.3	147.0	147.7	0.9	69.0	0.914
Floodplain 3	131	179.4	181.4	180.4	1.4	72.4	0.956
Limestone mountains 1	156	206.4	209.8	208.1	2.4	75.0	0.967
Limestone mountains 2	177	226.6	230.3	228.4	2.6	77.3	0.961
Limestone mountains 3	195	243.9	248.1	246.0	2.9	79.1	0.953
Low altitude hills 1	207	255.0	258.2	256.6	2.3	80.8	0.95
Low altitude hills 2	219	264.3	268.9	266.6	3.2	82.0	0.959
Low altitude hills 3	229	273.2	278.5	275.8	3.7	83.0	0.941

Total richness observed (Sobs) and obtained richness by nonparametric estimators based on abundance ACE and Chao 1 and the mean (Mean) of both along with the standard deviation (SD) and percentage (%) of recorded species (Sobs / estimators Mean x 100) (Arroyo-Rodríguez and Mandujano, 2006).

Table 3. CCA variable scores

	Spec. Axis 1	Spec. Axis 2	Spec. Axis 3
Physiological depth	-0.361	**-1.028**	**-0.928**
Aireation	-0.213	**0.652**	0.714
Field Capacity	-0.144	0.143	1.2
Available water.	-0.08	0.051	**-0.968**
pH	0.08	**1.131**	**0.922**
Total nitrogen	0.059	**1.043**	0.796
C/N ratio	-0.486	0.607	0.751
Aluminum	-0.334	**1.123**	1.58
Cumulative percentage.	**26.556**	**42.865**	**56.395**

Conclusion

A clear site quality influence on the spatial variation of tree diversity in tropical rainforest was demonstrated. Despite presenting a high rainfall, sites where the soil has low water stores may represent a limiting factor during the dry period. At sites with several limitations and available niches for tree growth the greatest diversity was found. Analyses show that in the absence of information from the local soil variation, the contribution of environmental variables on the distribution of tree diversity may be underestimated.

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References

Arroyo-Rodríguez, V., Mandujano, S. 2006. The importance of tropical rain forest fragments to the conservation of plant species diversity in Los Tuxtlas, Mexico. Biodiversity and Conservation. 15:4159–4179

Bhagwat, S., Willis, K., Birks, J., Whittaker. 2008. Agroforestry: a refuge for tropical biodiversity? Trends in Ecology and Evoloution. 23 (5): 261-267.

Baldeck, C., Harms, K., Yavitt, J., John, R., Turner, B., Valencia, R., Navarrete, H.,Davies, S., Chuyong, G., Kenfack, D., Thomas, D., Madawala, S., Gunatilleke, N., Gunatilleke, S., Bunyyavejchewin, S., Kiratiprayoon, S., Yaacob, A., Nur Supardi, M. y Dalling, J. 2012. Soil resources and topography shape local tree community structure in tropical forests. Proceedings of the Royal Society B. Biological Sciences. 280: 25-32.

Brenes-Arguedas, T., Ríos, M., Rivas-Torres, G., Blundo, C., Coley, P., Kursar, T. 2008. he effect of soil on the growth performance of tropical species with contrasting distributions. Oikos. 117: 1453-1460.

Brown, C., Burslem, D., Bao, L., Brockelman, W., Cao, M., Chang, L., Dattaraja, H., Davies, S., Gunattilleke, C., Gunatileke, I., Huang, J., Kassim, A., LaFrankie, J., Lian, J., Lin, L., Ma, K., Mi, X., Nathalang, A., Noor, S., Ong, P., Sukumar, R., Su, S., Sun, I., Suresh, H., Tan, s., Thompson, J., Uriarte, M., Valencia, R., Yap, S., Ye, W., Law, R. 2013. Multispecies coexistence of trees in tropical forests; spatial signals of topographic niche differentiation increase with environmental heterogeneity. Proceedings of the Royal Society B. Biological Sciences. 280: (1764): 0502.

Daniel, T.W., Helms, J.A., Baker, F.S., 1979. Principles of Silviculture, second edition. McGraw-Hill, Inc., New York
Celedón, H. 2006. Impacto del sistema de roza, tumba y quema sobre las características de tres unidades de suelo en la selva Lacandona de Chiapas. Tesis de Maestría en Ciencias Biológicas (Ecología y ciencias ambientales). Posgrado en Ciencias Biológicas, Universidad Nacional Autónoma de México.
Clinebell, R., Phillips, O., Gentry, A., Stark, N., Zuuring, H. 1995. Prediction of neotropical tree and liana species richness from soil and climatic data. Biodiversity and conservation. 4:56-90
Gravel, D., Guichard, F., Hochberg, M. 2011. Species coexistence in a variable world. Ecology Letters. 14: 828-839.
Gentry, A. 1988. Changes in plant community diversity and floristic composition on environmental and geographical gradients. Ann. Missouri Bot. Gard. 75: 1-34.
Huston, M. 1979. A General Hypothesis of Species Diversity. The American Naturalist. 113(1): 81-101
John, R., Dalling, J., Harms, K., Yavitt, J., Stallard, R., Mirabello, M., Hubbell, s., Valencia, R., Navarrete, H., Vallejo, M., Foster, R. 2007. Soil nutrients influence spatial distributions of tropical tree species. Proceedings of the National Academy of Sciences. 104; 864–869.
Magurran, A. 2004 Measuring biological diversity. Blackwell Publishing Ed. Australia. 215p.
Paoli , G., Urran, L., Zak, D. 2006. Soil nutrients and beta diversity in the Bornean Dipterocarpaceae: Evidence for niche partitioning by tropical rain forest trees. Journal of Ecology. 94: 157 – 170.
Phillips, O., Nuñez-Vargas, P., Monte-Agudo, A., Peña-Cruz, A., Chuspe-Zans, M., Galiano-Sánchez, W., Yli-Halla, M., Rose, S. 2003. Habitat association among Amazonian tree species: A landscape-scale approach. Journal of Ecology. 91: 757–775.
Peña-Claros, M., Poorter, L., Alarcón, A., Blate, G., Choque, U., Fredericksen, T., Justiano, M., Leaño, C., Licona, J., Pariota, W., Putz, F., Quevedo, L., Toledo, M. 2012. Soil Effects on Forest Structure and Diversity in a Moist and a Dry Tropical Forest. Biotropica. 44(3): 276–283.
Servicio Geológico Mexicano SGM. 1997. Carta Geológico-Minera: Las Margaritas. Chiapas. E15-12 D5-3.
Servicio Meteorológico Nacional SMN. 2013. Normales climatológicas Estado de Chiapas, Estación Lacantún. Periodo 1951-2010.
Siebe, Ch., Jahn, R., Stahr, K. 2006. Manual para la descripción y evaluación ecológica de suelos en el campo. Segunda Ed. Sociedad Mexicana de la Ciencia del Suelo. Publicación especial No. 4. México 57 p.
Siebe, C., Martínez-Ramos, M., Segura-Warnholtz, G., Rodríguez-Velázquez, J., Sánchez-Beltrán, S. 1995. Soil and vegetation patterns in the tropical rainforest at Chajul Southeast México. En: D. Sigmarangkir (ed), Proceedings of the International Congress on Soil of Tropical Forest Ecosystems 3rd Conference on Forest Soils (ISSS-AISS-IBG). Mulawarman University Press, Indonesia. 40-58.
Silva, D., Batalha, M., Cianciaruso, M. 2013. Influence of fire history and soil properties on plant species richness and functional diversity in a neotropical savanna. Acta Botanica Brasilica. 27(3): 490-497.
Sollins, P. 1998. Factors Influencing Species Composition in Tropical Lowland Rain Forest: Does Soil Matter? Ecology. 79 (1): 23-30.
Swaine, M. 1996. Rainfall and Soil Fertility as Factors Limiting Forest Species Distributions in Ghana. Journal of Ecology. 84 (39): 419-428.
Toledo, M., Poorter, L., Peña-Claros, M., Alarcón, A., Balcázar, J., Chuviña, J., Leaño, C., Licona, J., Steege, H., Bongers, F. 2011. Patterns and Determinants of Floristic Variation across Lowland Forests of Bolivia. Biotropica. 43(4): 405-413.
Wang, G., Klinka, K. 1996. Use of Synoptic variables in predicting white spruce site index. Forest Ecology and Management. 80: 95-105
Wright, J. 2002. Plant diversity in tropical forests: a review of mechanisms of species coexistence. Oecologia. 130:1-14.
Zinck, J. 2012. Geopedología. Elementos de geomorfología para estudios de suelos y de riesgos naturales. ITC .Faculty of Geo-Information Science and Earth Observation of the University of Twente, The Netherlands.
Zinck, J. 1988. Physiography and Soils. Soil Survey Course. ITC. Enschede, Holanda, 156 pp.
Zinck, J., Valenzuela, C. 1990. Soil geographic database: structure and application examples. ITC Journal. 3: 270-294.

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Effects of selenium application on plant growth, quality and yield of lettuce (*Lactuca sativa L.*) and accumulation in plants

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Abstract

Selenium (Se) is an essential element for humans, animals and plants. The major source of Se in most human diets is provided by plants. The goal of this study was to evaluate the impact of Se on plant growth, quality and yield of lettuce (Lactuca sativa L.). The experiment was carried out in the Department of Horticulture at Ataturk University field condition in Erzurum, Turkey. The three different doses of selenium and three different cultivar lettuce were used. The solutions were applied to plant root zone for three times during plant growth.The results suggested that selenium treatments increased yield, average head weight, head diameter, head length, stem diameter, height dry matter and root dry matter of Iceberg, and romaine lettuce in this study compared to control. The highest yield, average head weight, head diameter, head length, stem diameter, height dry matter and root dry matter were obtained from 50 mg kg $^{-1}$ Se application for ıceberg lettuce, but 100 mg kg $^{-1}$ Se application for romanie lettuce. The increasing ratio of yield , average head weight, head diameter, head length, stem diameter, height dry matter and root dry matter were 116-71%, 105-65%, 26-30%, 17-31%, 18-22%, 6-1% and 14-26 for 50 -100 mg kg $^{-1}$ Se application for ıceberg lettuce and romaine lettuce, respectively. As a result, based on the results of the experiment reported herein, the use of Se treatments may provide a means of improving growth and growth parameters of ıceberg lettuce and romaine lettuce.

Keywords: Lettuce, selenium, yield, plant growth, accumulation

Introduction

Selenium (Se) had long been considered as a toxic element until it was found also to be essential in 1957 (Schwarz and Foltz, 1957). This element is incorporated into the primary structure ofthese proteins as the amino acid selenocysteine (SeCys). Since then ın the1970s, it was discovered that Se was a constituent of the anti-oxidant enzyme glutathione peroxidase (GPX). In addition, it isinvolved in thyroid hormone homeostasis, immunity, and fertility, among other activities (Reilly, 2006). The role of Se in mitigating environmental stress has been extensively investigated in animals and humans and, to alesser extent, in plants.

A current technology to apply Se fertilizer as a foliar spray or base fertilizer has been used to increase the Se content in the edible portion of crops (Broadleyet *al*., 2010; Pezzarossamet al., 2012) and often to simultaneously counteract the injuries generated by different environmental stresses.

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Se in plants which include antioxidative properties that can stimulate plant growt (Hartikainen*et al.,* 2000), delay of plant senescence (Djanaguiraman*et al.,* 2004), protection of plants from phloem feeding aphids by means of deterrence and toxicity to aphids (Hanson *et al.,* 2004), protection of plants from fungal infection and from herbivory by caterpillars (Hanson *et al.,* 2003)

In some countries, inorganic Se compounds are commonlyused as additives in fertilizers to improve the nutritional quality oflocal foodstuffs. This practice of Se fertilization has been appliedmainly in Finland and New Zealand (Eurola *et al.,* 2001).

In our study different cultivars oficeberg lettuce, leaf lettuce and romaine lettucewere chosen due to their abundant growth and high consumption in Turkey and also in other parts of northern Turkey.

Another important advantage is that there is no influence on the surrounding environment when enriched solutions are used. In our case selenium in the form of (Na_2SeO_3) was added to the nutrient solution.

The purpose of our work was to study the yield and yield parameters of selenium in the selected plants after 90 days of cultivation with elevated concentrations of Se.

Material and Methods

The experiment was carried out on Faculty of Agriculture at Ataturk University under field condition in Erzurum (40°31'N; 40°54' E), Turkey.Romaine lettuce (*Lactuca sativa* L. var. longifolia cv. Yedikule), leaf lettuce (*Lactuca sativa* L. var. crispa cv. Güllü) and iceberg lettuce (*Lactuca sativa* L. var. capitatacvOrlyez) plants were maintained during the experiment. Lettuce seeds were sown into plastic trays filled with peat. 30 days after planting they were transplanted to area with covered black polyethylene mulches (10 m length and 1 m width) and seedlings were planted with 30x30 cm distance on second week of June. There were 3 replicates per treatment and 15 plants per replicates. The four different doses (0, 50, 100 and 200 mg kg^{-1}) of selenium (Na_2SeO_3) were applied to the plant root zone at three times, except the control plants which were kept untreated. The experiment was design a completely randomized design with three replicates. All data were subjected to analysis of variance and significant means were compared by Duncan's multiple range test method performed using SPSS 13.0 (SPSS Inc., 2004).

Results and Discussion

The present study demonstrates Se treatments improved the growth parameters of lettuce plants. Different doses Se application affected plants yield and yield parameters there were statistically significant differences in lettuce yield and growth parameters (Table 1-2-3). Se applications increased yield, average head weight, head diameter, stem diameter, head dry matter and root dry matter different lettuce cultivars in this study compared to control (Table 1-2-3). There was significant variety between growth parameters depending on different dosesSe treatment. The highest yield, average head weight, head diameter, head length, stem diameter, height dry matter and root dry matter were obtained from 50 mg kg -1 Se application for ıceberg lettuce, but 100 mg kg $^{-1}$ Se application for romanie lettuce. The increasing ratio of yield , average head weight, head diameter, head length, stem diameter, height dry matter and root dry matter were 116-71%, 105-65%, 26-30%, 17-31%, 18-22%, 6-1% and 14-26 for 50 -100 mg kg^{-1} Se application for iceberg lettuce and romaine lettuce, respectively. As a result, based on the results of the experiment reported herein, the use of Se treatments may provide a means of improving growth and growth parameters of ıceberg lettuce and romaine lettuce.

Based upon highest yield of iceberglettucevarieties (70,20 t ha^{-1})was determined the a dose of 50 mg $kg^{-1}$when compared tothecontrol group, but highest yield of leaf lettuceand romania lettuce varieties (58,68 and 66,99 t ha^{-1}) were determined at a dose of 100 mg $kg^{-1}$when compared tothecontrol group (Table 2-3).

Average head weight, head diameter, stem diameter, head dry matter and root dry mattervaluesincreased with increasing Se application doses, the highest the average head weight, head diameter, head length values, stem diameter, head dry matter and root dry matter valuesof Iceberg lettuce weredetermined from50 mg kg $^{-1}$ Se application whencompared with control groups (Table 1).

The highest average head diameter, head length and root dry matter valuesof leaf lettuce were determined from 100mg kg $^{-1}$ Se application whencompared with control groups (Table 2).

Table 1. The effects of different doses selenium applications on yield and growth parameters of Iceberg lettuce

Applications mg kg^{-1}	Yield (t ha^{-1})	Average head weight (g)	Head diameter (cm)	Head length (cm)	Stem diameter (mm)	Head dry matter (%)	Root dry matter (%)
0	32,40 b*	360,00 b*	16,27 b*	14,43 c*	23,67 c*	5,47 b*	12,29 b*
50	70,20 a	780,00 a	20,53 a	17,00 a	28,10 ab	5,81 ab	14,12 a
100	59,10 a	656,67 a	19,43 a	16,47 ab	28,97 a	6,10 a	14,66 a
200	56,16 a	624,00 a	19,90 a	15,80 b	26,37 b	5,52 b	14,01 a

Means within columns not followed by the same letter differ significantly by DMRT (*P*<0.005)

Table 2. The effects of different doses selenium applications on yield and growth parameters of leaf lettuce

Applications mg kg^{-1}	Yield (t ha^{-1})	Average head weight (g)	Head diameter (cm)	Head length (cm)	Stem diameter (mm)	Head dry matter (%)	Root dry matter (%)
0	38,39 b*	428,67 b*	17,43b*	22,80 ns	12,00 ns	10,33 ns	11,38 ns
50	54,06 a	600,67 a	21,00 a	22,80	14,39	10,16	13,33
100	58,68 a	652,00 a	21,33 a	25,47	13,12	10,03	12,15
200	49,56 ab	550,67 ab	19,00 ab	24,87	12,96	9,79	13,55

*:Means within columns not followed by the same letter differ significantly by DMRT (*P*<0.005), ns: non significant

Table 3. The effects of different doses selenium applications on yield and growth parameters of romaine lettuce

Applications mg kg^{-1}	Yield (t ha^{-1})	Average head weight (g)	Head diameter (cm)	Head length (cm)	Stem diameter (mm)	Head dry matter (%)	Root dry matter (%)
0	39,12 c*	434,67 c*	20,43 c*	18,43 b*	22,77 c*	7,97 b*	14,53 b*
50	63,18 ab	702,00 ab	25,27 ab	22,77 a	31,23 a	10,30 a	17,35 ab
100	66,99 a	744,33 a	26,57 a	24,27 a	27,97 ab	7,79 b	18,42 a
200	54,39 b	604,33 b	23,13 b	22,73 a	26,90 b	8,22 b	16,41 ab

Means within columns not followed by the same letter differ significantly by DMRT (*P*<0.005)

Similar result was obtained from spinach plant on growth parameters like shoot and root fresh weight, shoot and root dry weight, total dry weight, shoot and root length increased by 17, 15, 38, 19, 18 and 34 percent in response to the lowest concentration of Se (1 mg L^{-1}), respectively over control (Saffaryazdi*et al* 2012). A stimulatory effect of foliar application of Se on growth for ryegrass (Hartikainen*et al.,* 2000), lettuce (Xue*et al.,* 2001), potato (Turakainen*et al.,* 2004), soybean (Djanaguiraman*et al.,* 2005) and green tea leaves (Hu *et al.*, 2003) are supported our study result.

Conclusion

In conclusion, applications of Se can be used as plant growth regulator to increase plant growth and growth parameter. This study showed that Se could be use angrowth parameter fertilizer source for plant performance in different plants.

References

Broadley, M.R., Alcock, J., Alford, J., Cartwright, P., Foot, I., Fairweather-Tait, S.J., Hart,

D.J., Hurst, R., Knott, P., McGrath, S.P., Meacham, M.C., Norman, K., Mowat, H.,Scott, P., Stroud, J.L., Tovey, M., Tucker, M., White, P.J., Young, S.D., Zhao, F.J., 2010.Selenium biofortification of high-yielding winter wheat (*Triticumaestivum* L.) by liquid or granular Se fertilisation. Plant and Soil 332, 5–18.

Djanaguiraman M, Durga Devi, Shanker AK, Sheeba A andBangarusamy U 2004 Selenium – An antioxidativeprotec-tant in soybean during senescence. Plant Soil 272, 77–86.

Djanaguiraman, M., Devi, D.D., Shanker, A.K., Sheeba, A., Bangarusamy, U. 2005. Selenium-an antioxidative protectant in soybean during senescence. Plant Soil. 272: 77–86.

Eurola, M., Alfthan, G., Aro, A., Ekholm, P., Hietaniemi, V., Rainio, H., Rankanen, R.,Venäläinen, E.-R., 2001. Results of the Finnish Selenium Monitoring Program,2000–2001 Agrifood Research Finland. Agrifood Research Reports 36.

Hartikainen, H., Ekholm, P., Piironen. V., Xue, T., Koivu, T., Yli-Halla, M. 1997. Quality of the ryegrass and lettuce yields as affected by selenium fertilization. Agric. Food Sci. Finland. 6: 381–387.

Hartikainen H, Xue T and Piironen V 2000 Selenium as an anti-oxidant and pro-oxidant in ryegrass. Plant Soil 225, 193–200.

Hanson B, Lindblom S D, Loeffler M L and Pilon-Smits A H2004 Selenium protects plants from phloem-feeding aphidsdue to both deterrence and toxicity. New Phytol.162, 655– 659.

Hanson B, Garifullina G F, Lindblom S D, WangelineA,Ackley A, Kramer K, Norton A P, Lawrence C B and Pilon-Smits A H 2003 Selenium accumulation protects Brassica junceafrom invertebrate herbivory and fungal infection.NewPhytol. 159, 461–466.

Hu, Q.H., Xu, J., Pang, G.X. 2003. Effect of selenium on the yield and quality of green tea leaves harvested in early spring. J. Agric. Food Chem. 51: 3379–3381.

Pezzarossa, B., Remorini, D., Gentile, M.L., Massai, R., 2012. Effects of foliar and fruit addition of sodium selenate on selenium accumulation and fruit quality. Journal of the Science of Food and Agriculture 92, 781–786.

Reilly, C., 2006. Selenium in Food and Health, 2nd ed. Springer, USA Saffaryazdi, A., Lahouti, M., Ganjeali, A., Bayat, H., 2012.Impact of Selenium Supplementation on Growth and Selenium Accumulation on Spinach (Spinaciaoleracea L.)Plants. Notulae Scientia Biologicae. 4, 95-100.

Schwarz K, Foltz CM (1957) selenium as an integral part of factor 3 against dietary liver degeneration. J.AmChemSoc 79:3292-3293.

Turakainen, M., Hartikainen, H., Seppänen, M.M. 2004.Effects of selenium treatments on potato (Solanumtuberosum L.) growth and concentrations of soluble sugars and starch. J. Agric. Food Chem. 52: 5378–5382.

Valkama E, Kivimaenpaa M, Hartikainen H and Wulff A 2003.The combined effects of enhanced UV-B radiation andselenium on growth, chlorophyll fluorescence and ultrastruc-ture in strawberry (*FragariaÂananassa*) and barley (*Hord-eumvulgare*) treated in the field. Agric. Forest Meteorol.120,267–278.

Xue, T., Hartikainen, H., Piironen, V. 2001.Antioxidative and growth-promoting effect of selenium in senescing lettuce. Plant Soil. 27: 55–61.

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Effect of zinc application on yield and zinc content of corn plant

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Abstract

Zinc (Zn) deficiency is commonly encountered in most of agricultural soils in Turkey and the world. Zinc is one of the most essential elements in human, plant and animal feeding. Zinc deficiency in several plants has been studied to remove with fertilization by lots of researchers. In this study, effects of zinc fertilization (0, 1, 2, 4 kg Zn da^{-1} as $ZnSO_4.7H_2O$) on yield components of corn (*Zea mays L.*) were investigated. Zinc application into soil increased the grain yield (7.09%), 1000 grains weight (7.11%), Zn contents in leaf (24.63%), straw (25.49%) and grain (22.13%) of corn according to the control significantly ($P<0,05$). As a conclusion, optimum Zn application dose to increase grain yield and Zn content of corn was found to be 2 kg Zn da^{-1} while it was 1 kg Zn da^{-1} for silage production.

Keywords: Zinc, fertilization, corn, grain yield, Zn content.

Introduction

Zinc (Zn) is an essential nutrient required in some fertilizer programs for crop production in Turkey and the world. While some soils are capable of supplying adequate amounts for crop production, addition of zinc fertilizers is needed for others. Zn may be needed in fertilizer programs for production of corn, sweet corn, and edible beans (Rhem and Schmitt 2002). Maize grain yield potential is twice as high as compared to other cereal crops (Tollenar and Lee 2002). However, even if quantitative requirements for nutrients are almost the same, actual harvested yields are low (Benton Jones 2003). This nutrient is most effective if applied in a starter fertilizer. Several sources of zinc can be used with both liquid and dry fertilizers to optimize production of corn and edible beans when this nutrient is needed.

Zinc deficient soils are widespread in Mediterranean countries (Çakmak et al. 1997). Some crops (maize, rice etc.) are especially susceptible to Zn deficiency in most countries where they are grown (Khoshgoftarmanesh et al. 2007). The regions with Zn-deficient soils are also the most research on soil and foliar application of Zn regions where Zn deficiency in human beings is focused on alleviating its deficiencies, particularly on widespread, for example in India, Pakistan, China, Iran and wheat and corn cultivated in semiarid or arid regions of Turkey (Alloway 2004; Hotz et al 2004; Aref 2011). Soil Zn deficiency does not only reduce crop production but also causes Zn deficiency in the diet (Bagci et al. 2007; Cakmak et al. 1997; Gao et al. 2005; Wang and Jin 2007).

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Maize was recognized by farmers for a long time as a crop of high response to Zn supply (Benton 2003). Maize is a crop plant characterized by a high potential of biomass and grain yield, especially in comparison with other cereal crops. The basic aspect of a balanced agriculture is a balanced fertilization which should take into consideration all nutritive components indispensable for a correct growth and development of plants. The insurance of the optimal level of plant growth including the availability of nutritive agents guaranties the realization of plant yield-creating potential. Maize grain yield potential is twice as high as compared to other cereal crops (Tollenear and Lee 2002).

As well documented by plant physiologists, Zn exerts a great influence on basic plant life processes, such as (i) nitrogen metabolism - uptake of nitrogen and protein quality; (ii) photosynthesis - chlorophyll synthesis, carbon anhydrase activity; (iii) resistance to abiotic and biotic stresses - protection against oxidative damage (Alloway 2004; Çakmak 2008) In most crops, the typical leaf Zn concentration required for adequate growth approximates 15-20 mg Zn kg^{-1} DW (Marschner 1995). Toxicity symptoms usually become visible at leaf Zn> 300 mg kg^{-1} DW, although some crops show toxicity symptoms at leaf Zn < 100 mg kg^{-1} (Marschner 1995; Chaney 2003).

In Turkey, Zn deficiency is the most widespread micronutrient deficiency in soils and plants. Based on analysis of 1511 soil samples collected from all provinces of Turkey, Eyupoğlu et al. (1994) showed that 50% of the cultivated soils in Turkey are Zn deficient. These Zn-deficient areas are equivalent to 14 million hectar of cultivated land in Turkey. Deficiency of Zn in soils on such a large scale and thus in plant foods, has been suggested to be one of the major causes of the widespread occurrence of Zn deficiency in humans in Turkey (Cakmak et al. 1996).

Among the micronutrients, zinc (Zn) is the most important for activity of various enzymes and proper growth and development of plants, animals and humans (Alloway 2004; Welch and Graham 2004). Dietary Zn deficiency in humans may result in loss of immunity, poor wound healing and dermatitis (van Campen, 1991). Zn nutrition, however, helps to improve resistance to some infectious diseases such as diarrhoea (Black, 1998; Fuchs, 1998) and immunity (Shankar and Prasad 1998).

Zinc deficiency is generally corrected by applying Zn fertilizers. However, only those Zn sources which are soluble or may be solubilized at the plant root are suitable as a source of Zn. Zinc sulfate-containing fertilizers are the most common Zn fertilizers used to correct Zn deficiency (Amrani et al. 1997).

The objective of this study was to determine the effect of zinc application from soil on yield components of maize plant and its leaf, stalk and grain Zn contents.

Material and Methods

Study area and Zn application

The experimental location was conducted in the province Samsun at Çarşamba district in the central Black Sea in northern Turkey. The climate is semi-arid, with average annual precipitation and evaporation levels of 570.5 mm and 676.5 mm, respectively. Altitude of the study area 5 m.

In the soil Zn application trial, the maize (*Zea mays L.*) genotype sowed Karadeniz Yıldızı variety. The experimental design was nested classified randomized complete block design with 4 treatments (0, 1, 2, 4 kg Zn da^{-1} dose as $ZnSO_47H_2O$ fertilizer) with 3 replications. Experimental plots were 5.0 × 6.0 m with 0.70 m row spacing.

The soil was fertilized with 75 kg ha^{-1} N, 30 kg ha^{-1} of P_2O_5, 20 kg ha^{-1} of K_2O as a base fertilization respectively, urea (46 % N) , triple superphosphate (42 % P_2O_5) and potassium sulfate (50 % K_2O), and 75 kg ha^{-1} N upper fertilization as ammonium nitrate (33 % N).

Prepare sample and calculation of increment rate

Corn leaves located near the ear were sampled along the veins, collected from each plot by cutting off the plant on the soil surface. At harvest, five corn shoots composed of four 1m long rows were randomly sampled from each plot for nutrient analysis. The harvested grains were threshed after air-drying, and then stored for milling and nutrient analysis. All plant samples were washed twice with tap water and threefold with distilled water, and then smashed with a stainless pulverizer to pass a screen with 0.2 mm openings after oven-drying at 65 °C for 72 h. The remaining plants in each plot were harvested by hand and weighed to determine the total biomass production and yield, which were expressed as dry weight at 70 °C for all crops. Increment rate was calculated as following (Aktaş 1994).

Increment rate (%) = [(Zn dose – Control) / Zn dose)] × 100 (1)

Plant and soil analysis in the samples

The Zn concentration was determined by atomic emission spectroscopy (AAS-200) after digesting the leaf, straw and grain samples on a hot plate in the presence of concentrated HNO_3 and $HClO_4$ (respectively, 4:1 v/v). Sample analysis results were reported as the mean of three replicates (Kacar and İnal 2008). Also, the routine tests in soil sample (0-30 cm) were determined as follows: mechanical analysis according to the Demiralay (1993); lime by Hızalan and Ünal (1965); pH at saturation mud by Kacar (2009); salinity by Richards (1954); KDK 1N NaOAc by Sağlam (1997); available phosphorus with 0.5M $NaHCO_3$ by Olsen et al., 1954; exchanging potassium 1N NH_4OAc method by Sağlam (1997); organic matter with 1N $K_2Cr_2O_7$ modificated Walkley-Black by Nelson and Sommers (1982) and extractable Zn, Fe, Mn and Cu were determined by DTPA-extractable (Lindsay and Norvell 1978). Some of the physical and chemical properties of the experiment soils are given in Table 1.

Table 1. Physico-chemical properties of the soil

Soil properties	Results
pH*	7,80
EC, dS cm^{-1}	0,06
Lime , %	11,82
OM, %	1,66
CEC, me 100 g^{-1}	43,52
Sand, %	25,51
Silt, %	32,67
Clay, %	41,82
Texture	CL
Available P, mg kg^{-1}	27,16
Available K, mg kg^{-1}	167,15
Available Zn, mg kg^{-1}	0,42
Available Fe, mg kg^{-1}	12,83
Available Mn, mg kg^{-1}	14,24
Available Cu, mg kg^{-1}	1,67

*:Satureted mud; CL: Clay-Loam

Statistical analyses

All data were analyzed using SPSS 17.0 of the SAS software package. The homogeneity of the variances was verified, and the data were subjected to ANOVA. Duncan values were calculated and used to compare treatment means. Simple correlation coefficients were calculated based on treatment means. The level of significance was 0.05 (Yıldız and Bircan 1991).

Results and Discussion

Effect of Zn application on corn yield components

Zinc application significantly increased ($P<0.05$) grain yield and 1000 grain weight of corn compared with the control (Table 2). Response of the corn to Zn was high due to fact that Zn level of the soil was lower than the critical value (0.46 mg kg^{-1}). Most commonly reported critical concentration for the DTPA-Zn ranges between 0.5 to 0.7 ppm (Mortvedt et al. 1991). Çakmak et al. (1996) reported that critical extractable DTPA-Zn concentration in soils is 0.5 mg kg^{-1}. Bickel and Killorn (2001) reported that negative yield responses occurred on soils with low soil test Zn (Zn ≤ 0.8 mg kg^{-1}). Soil Zn fertilizer may increase the grain yield during severe Zn deficiency, i.e., at less than 0.42 mg kg^{-1} DTPA-Zn. Increasing zinc application doses increased grain yield between 1298 and 1390 kg da^{-1}, and 1000 grain weight between 278.40 and 303.83 g. According to the variance analyses results, while the increment in grain yield was significant in 2 kg Zn da^{-1} dose, the increment in 1000 weight was significant in 1 kg Zn da^{-1} dose ($P<0.05$). The highest increments in corn grain yield and 1000 grain weight were 7.09% and 9.13%, respectively (Table 2). Soleimani (2012) reported that soil application of 75 kg ha^{-1} of Zn sulfate (1.65 kg Zn da^{-1}) gave the highest yield showed an increase of % 25 in compared with nil-Zn 7.5

kg Zn SO4. Ahmad et al (2012) reported that a reduction in yield of approximately 28 % for maize was recorded when Zn was omitted from the fertilizer treatment applied to Zn deficient soils. Application of 50 kg $ZnSO_4$ ha^{-1} was obtained more than 22% increase in the grain yield of corn and positive relationship was obtained between Zn application and Zn uptake (Orabi et al. 1981). There are several reports in literature showing that grain yield of maize can be increased up to 50% by applying 10 kg zinc per hectare either in form of $ZnSO_4$ or ZnO (Mortvedt et al. 1991). Özgüven and Katkat (2001) informed that increasing doses of zinc application (0, 2.5, 5, 10 ppm Zn) increased stalk+leaf dry matter content in corn by 37%.

The maximum corn grain yield was obtained in 2 kg da^{-1} Zn application, higher than 2 kg da^{-1} Zn doses caused decreases in corn grain yield (Figure 1). Zn application increased bioavailability of zinc in plant nutrition. Zinc (Zn) deficiency is a major yield-limiting factor in most crops (Ahmad et al. 2012). Yılmaz (2007) reported that 3 kg Zn da^{-1} application from soil to corn plant was sufficient and higher dose applications did not show an effect on yield. The addition of Zn fertilizer to the soil did not affect the crop yield, which may also be attributed to the lowered availability of Zn caused by other factors, including high pH and high calcite, as well as high concentrations of several minerals, such as Ca, Mg, and phosphate in soil solutions or labile forms (Alloway 2009; Lindsoy 1972; Meng et al. 2004). The exchangeable Zn used to estimate Zn availability decreases with increased soil pH (Harter, 1983; Iyengar et al. 1981; Loosemore et al. 2004).

Effect of Zn application on Zn content of corn

Zinc application to the corn plant significantly increased ($P<0.05$) leaf, stalk and grain Zn contents according to the control (Table 2). Zn content changed between 38.77 and 48.32 mg kg^{-1} in leaf, between 29.30 and 36.77 mg kg^{-1} in stalk and between 21.37 and 26.10 mg kg^{-1} in grain. While Rehm and Schmitt (1997) reported that the content of 15-70 mg kg^{-1} Zn in corn leaf is sufficient, Butzen (2014) reported that the sufficient level of Zn content in corn leaf is 26-75 mg kg^{-1}. Zn fertilization increased Zn contents in leaf, straw and grain of corn according to the control.

Table 2. Effect of Zn fertilization on yield, Zn contents and % increments

Zn Doses	Yield	1000 grains	Leaf	Straw	Grain	Yield	1000 grains	Leaf	Straw	Graine
kg da^{-1}	kg da^{-1}	g	Zn mg kg^{-1}			%				
0	1298b*	278,40c	38,77c	29,30d	21,37d	-	-	-	-	-
1	1318b	298,20a	48,32a	36,77a	24,70b	1,54	7,11	24,63	25,49	15,58
2	1390a	291,97b	42,59b	31,71b	26,10a	7,09	4,87	9,85	8,23	22,13
4	1387a	303,83a	41,58b	30,87c	22,33c	6,86	9,13	7,25	5,36	4,49

*There is not a significant difference between the values showed with the same letters in the same column at 5% level.

It was found that Zn contents were significant ($P<0.05$) in leaf and stalk with 1 kg Zn da^{-1} dose (14.32 and 36.77 mg kg^{-1}, respectively) and in grain with 2 kg Zn da^{-1} dose (26.10 mg kg^{-1}) statistically (Figure 2). Demirkıran (2009) reported that Zn content of corn plant grown in Kahramanmaraş varied between 16.31 and 130.56 mg kg^{-1}. Also, increments in Zn contents of leaf, stalk and grain have been found as 24.63, 25.49 and 22.13%, respectively (Table 2). While the average Zn content of corn varieties in control condition (-Zn) was 24 mg kg^{-1}, the application of 3 kg da^{-1} $ZnSO_4.7H_2O$ from soil increased this value to 37. 5 mg kg^{-1} with an increment of 56% (Erdem 2011). Bukvić et al. (2003) reported that there were significant increments in the green section Zn concentrations of some corn varieties (Os86-39 and Os87-24) with the application of 1 kg Zn da^{-1} from soil.

Amrani et al. (1997) reported that in the application of 0, 2, 4, 8 kg Zn da^{-1} doses from soil to corn, 2 and 4 kg Zn da^{-1} dose applications were significant. In another study with corn, Prado et al (2008) informed that 1 and 3 kg da^{-1} Zn dose application from soil were significant. Bly et al (2000) informed that the Zn application dose to corn plant changes according to result of soil analysis, 2 and 4 kg da^{-1} Zn application doses are recommended for 0.5 and 0.75 ppm available Zn contents in soil, respectively. According to the results, it was determined that increasing doses of Zn fertilization increased Zn content of the corn plant in leaf, straw and grain parts.

Conclusion

In conclusion, to increase of bioavailability of Zn in grain and straw, 2 and 1 kg Zn da^{-1} fertilization doses from soil were recommended in corn plant, respectively. Zn fertilization not only helps to remove Zn deficiency and to increase yield in corn plant, but also may help to increase Zn nutrition levels in food chain for human and animal.

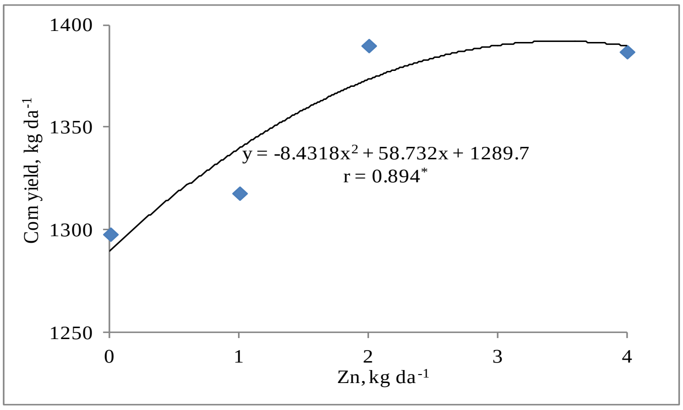

Figure 1. The effect of Zn applications on corn grain yield

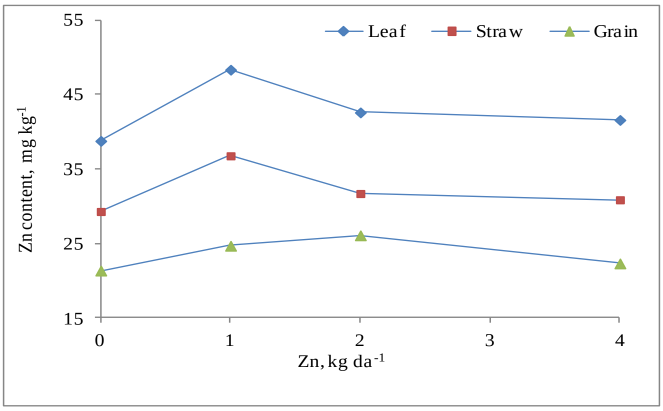

Figure 2. The effect of Zn fertilization on leaf, stalk and grain Zn contents

References

Ahmad, W., Watis, M.J., Imtiaz, M., Ahmed I. and Zia, M. 2012. Zinc deficiency in soils, crops and humans. Agrochimica, 56: 65-97.

Ali Riza Demirkiran , 2009. Determination of Fe, Cu and Zn Contents of Wheat and Corn Grains from Different Growing Site. Journal of Animal and Veterinary Advances, 8: 1563-1567.

Alloway, B., 2004. Zinc in soils and crop nutrition. Areas of the World with Zinc Deficiency Problems. Available at: http://www.zinc-crops.org/Crops/ Alloway- all. php.

Alloway, B.J. (2004) Zinc in soils and crop nutrition. Online book, 127 (www.zinc/-crops/-org).

Alloway, B.J., 2004. Zinc in soils and crop nutrition. IZA Publications. International Zinc Association, Brussels, pp: 1-116.

Alloway, B.J., 2009. Soil factors associated with zinc deficiency in crops and humans. Environ. Geochem. Health 31, 537–548.

Amrani M., Westfall D. G and Peterson G.A. 1997. Zinc plant availability as influenced by zinc fertilizer sources and zinc water-solubility. Technical Bulletin TB97-4, Colorado state University, 17 p.

Amrani, M.D., Westfall, G. and Peterson, G.A. 1997. Zinc plant availability as influenced by zinc fertilizer sources and zinc water-solubility. Technical Bulletin, Colaroda State University, p. 1-17.

Aref F. 2011. Zinc and Boron Content by Maize Leaves from Soil and Foliar Application of Zinc Sulfate and Boric Acid in Zinc and Boron Deficient Soils. Middle-East Journal of Scientific Research 7 (4): 610-618

Bagci, S.A., Ekiz, H., Yilmaz, A., Cakmak, I., 2007. Effects of zinc deficiency and drought on grain yield of field-grown wheat cultivars in Central Anatolia. J. Agron. Crop Sci. 193, 198–206.

Benton Jones J. Jr. (2003): Agronomic Handbook. CRC Press, Boca Raton, 17–227.

Benton, J.J., 2003. Agronomic Handbook. CRC Press, Boca Raton, pp: 17-227.

Bickel, A. and Killorn R. 2001. Spatial Response Of Corn To Banded Zinc Sulfate Fertilizer In Iowa Proceedings Of The Thirty-First North Central Extension-Industry Soil Fertility Conference 17: 144-155

Bilgisi Introduction'da

Black, R.E. 1998. Therapeutic and preventive effects of zinc on serious childhood infectious diseases in developing countries. American J. Clin. Nutr. 68, 476-479.

Bly, A., Gerwing, J., Gelderman, R., Erickson, G., Bade, R., Schumacher, J. and Winther, D. 2000. Response to Sulfur and Zinc across Soil Landscapes in Northeast South Dakota. Soil/Water ResearchSouth Dakota State Universit, Progress Report, Agricultural Experiment StationPlant Science Department, p. 17

Bukvić, G., Antunović, M., S. Popović, S. and Rastija, M., 2003. Effect of P and Zn fertilisation on biomass yield and its uptake by maize lines (*Zea mays* L.). Plant Soil Env., 49, (11): 505-510.

Butzen, S. 2014. Zinc Deficiencies and Fertilization in Corn Production. https://www.pioneer. com/...CONTENT/guid.

Cakmak, I., 2008. Enrichment of cereal grains with zinc: agronomic or genetic biofortification? Plant and Soil, 302: 1-17.

Cakmak, I., Ekiz, H., Yilmaz, A., Torun, B., Köleli, N., Gültekin, I., Alkan, A., Eker, S., 1997. Differential response of rye, triticale, bread and durum wheats to zinc deficiency in calcareous soils. Plant Soil 188, 1-10.

Cakmak, I., R. Derici, B. Torun, I. Tolay, H.J. Braun and R. Schlegel, 1997. Role of rye chromosomes in improvement of zinc efficiency in wheat and triticale, Plant Soil, 196: 249-253.

Cakmak, I., Yilmaz, A., Kalayci, M., Ekiz, H., Torun, B., Erenoglu, B., Braun, H.J., 1996. Zinc deficiency as a critical problem in wheat production in Central Anatolia. Plant Soil. 180, 165-172.

Chaney, R.L., 1983. Plant uptake of inorganic waste constituents. In: J.F. Parr, P.B. Marsh and J.M. Kla, eds. Land treatment of hazardous wastes. Park Ridge, NJ, USA: Noyes Data Corporation, pp: 50-76.

Demiralay, İ., 1993. Toprak Fiziksel Analizleri. A.Ü. Ziraat Fak. Yayınları No:143, Erzurum.

Erdem, H. 2011. Silajlık Mısır Çeşitlerinin Verim ve Kalitesine Çinko Gübrelemesinin Etkilerinin Belirlenmesi. GOÜ, Ziraat Fakültesi Dergisi, 28(2):199-206

Eyupoğlu, F., Kurucu, N., Sanisa, U., 1994. Status of plant available micronutrinets in TuÈrkish soils, in TuÈrkish. In: Annual Report. Report No. R-118. Soil and Fertilizer Research Institute, Ankara, pp. 25-32.

Fuchs, G.J. 1998. Possibilities for zinc in the treatment of acute diarrhea. American J. Clin. Nutr. 68, 480-483.

Harter, R.D., 1983. Effect of soil pH on adsorption of lead, copper, zinc, and nickel. Soil Sci. Soc. Am. J. 47, 47–51.

Hızalan, E., Ünal, H., 1965. Topraklarda Önemli Kimyasal Analizler. A.Ü. Zir. Fak. Yay. No:278, Yrd. Ders Kitabı No:97, A.Ü. Basımevi, Ankara.

Hotz, C. and K.H. Brown, 2004. Assessment of the risk of zinc deficiency in populations and options for its control. Food Nutr. Bull. 25: 94-204. J.N.A. Lott and E. Spitzer, 1980. X-ray analysis studies of elements stored in protein body globoid crystals of Triticum grains. Plant Physiol., 66: 494-499.

Iyengar, S.S., Martens, D.C., Miller, W.P., 1981. Distribution and plant availability of soil zinc fractions. Soil Sci. Soc. Am. J. 45, 735-739.

Kacar, B. 2009. Toprak Analizleri. Nobel Yayınları (Genişletilmiş 2. Baskı), 467s. Ankara

Khoshgoftarmanesh A.H., H.R. Sharifi, H.M. Mirzapour and R. Schulin, 2007. Plant genotype and Zn fertilization effects on nutritional quality of wheat grain produced in saline soils. 9th International Conference of the Biochemistry of Trace Elements (ICOBTE), July 2007, Beijing, China.

Lindsay, W. L. and Norvell, W. A., 1978. Development of a DTPA soil test for Zn, Fe, Mn and Cu. SSSAJ. 42(3): 421-428.

Lindsoy, W.L., 1972. Zinc in soils and plant nutrition. Adv. Agron. 24, 147-186.

Loosemore, N., Straczek, A., Hinsinger, P., Jaillard, B., 2004. Zinc mobilisation from a contaminated soil by three genotypes of tobacco as affected by soil and rhizosphere pH. Plant Soil 260:19-32.

Marschner, H., 1995. Mineral Nutrition of Higher Plants, 2nd ed., Academic Press, London.

Meng, F.H., Wei, Y.Z., Yang, X.E., Lin, J.J., Liu, J.X., 2004. Effects of bicarbonate and high pH conditions on zinc and other nutrients absorption in rice. Rice Sci. 11:290-296.

Mortvedt, J.J., Cox, F.R., Shuman L.M. and Welch, R.M. 1991. Trace Elements in soils. Ed: Peter S. Hooda. ISBN 978, p. 579

Nelson DW, Sommers LE (1982) Total carbon, organic carbon, and organic matter. In 'Methods of soil analysis'. American Society of Agronomy Inc., Soil Science Society of America Inc.: madison, WI (Eds AL Page, RH Miller, DR Keeney) pp. 539-579.

Orabi, A.A., Mashadi, H., Abdallah, A. and Morsy, M. 1981. Effect of zinc and phosphorus on the grain yield of corn (**Zea mays** L.) grown on a calcareous soil. Plant and Soil. 63:291-294.

Özgüven, N. ve Katkat, V. 2001. Artan Miktarlarda Uygulanan Çinkonun Mısır Bitkisinin Verim Ve Çinko Alımı Üzerine Etkisi. Uludağ Üniversitesi, Ziraat Fakültesi. Dergisi, 15: 85-97

Prado, R.M., Romualdo, L.M., Rozane, D.E. 2008. Method of Zinc Application in The Nutrition and The Productıon of Dry Matter of Maize Brs 1001. Bioscience Journal, 24:67-74

Rehm, G. and Schemitt, M. 1997. Zinc for crop production. www.extension.umn.edu/ agriculture/zinc-for-crop-production

Rehm, G. and M. Schmitt. 1997. Zinc for crop production. University of Minnesota Extension publication FO-00720-GO. Available at: http://www.extension.umn.edu/distribution/ cropsystems/DC0720.htm (verified August 13, 2008).

Richards, L.A. 1954. Diagnosis and Improvement of Saline and Alkalin Soils. U.S. Dept. Agr. Handbook, 60, 109. Riverside

Sağlam, T., 1997. Toprak ve Suyun Kimyasal Analizleri. Trakya Üniv. Tekirdağ Ziraat Fakültesi Yayın No:189, 164 s.

Shankar, A.H., Prasad, A.S. 1998. Zinc and immune function: the biological basis of altered resistance to infection. American J. Clin. Nutr. 68, 447-463.

Soleimani, R. 2012. Cumulative and residual effects of zinc sulfate on grain yield, zinc, iron, and copper concentration in corn and wheat. Journal of Plant Nutrition 35: 85-92

Tollenaar M., Lee E. (2002): Yield potential, yield stability and stress tolerance in maize. Field Crops Research, 75: 161-169.

Tollenaar, M. and E. Lee, 2002. Yield potential, yield stability and stress tolerance in maize. Field Crops Res., 75: 161-169.

Van Campen, D.R. 1991. Trace elements in human nutrition. In: J.J. Mortvedt, F.R. Cox, L.M. Shuman, R.M. Welch (eds.). Micronutrients in Agriculture. pp. 663-701. Soil Science Society of America, Inc. Madison, Wisconsin, USA.

Wang, H., Jin, J.Y., 2007. Effects of zinc deficiency and drought on plant growth and metabolism of reactive oxygen species in maize (Zea mays L.). Agric. Sci. China 6: 988-995.

Welch, R.M. and Graham, R.D. (2004) Breeding for micronutrients in staple food crops from a humannutrition perspective. Journal of Experimental Botany, 396, 353-364.

Yıldız, N., Bircan, H., 1991. Uygulamalı istatistik Atatürk Üniversitesi Yay. No: 704, 290 s. Erzurum.

Yılmaz, A. 2007. Topraklarımızdaki çinko noksanlığının bitki besleme ve insan sağlığına etkileri. www.tarimkutuphanesi.com

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Effect of humic acid on yield under irrigation with saline water

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Abstract

In most irrigation situations, the primarily water quality concern is salinity levels, because salts can affect both the soil structure and crop yield. Good quality irrigation waters' scarcity leads using saline or the other type waters for agricultural irrigation. However, there are some technical precautions to use these type waters. Recently, researchers try to use soil conditioner material. Some chemical and organic substances are used to improve the structure of the soil and increase its porosity. One of them is a humic acid production called "Base Actosol". Base Actosol contains 12% humic acid. Humic acids are active elements in organic soils and important for the conversion of fertilizer into available plant nutrients. It is said that humic acid prevents nutrition loss by making chelate and pressured some undesirable ions effects. A factorial pot experiment was conducted in greenhouse as randomized plots. Our aim was to determine this material can or not inhabited ions impactions in saline waters and what is effect on plant growing degree under saline irrigation condition. And we wanted to see that humic acid can provide or not to save fertilizer with N. We studied with two levels nitrogen fertilizer (optimum dose of N and 75% of N), five humic acid levels (0.0; 350; 700; 1050 and 1400ppm) and five different salinity levels of irrigation water (0,0; 0,75; 1.5; 2,25 and 3.0dS/m). Maize was grown (*Zea mays*) in pots along 50 days and we applied saline water 9 times. Finally, we measured soil salinity and the yield. Statistical datas showed us that interaction of humic acid and water salinity on plant dry yields was significant with level 99% probability. In addition, we tried to find out interaction between some ions (Ca, Mg, Na, K etc.) contained by plant and humic acid.

Key words: Humic acid, base actosol, saline water, soil salinity, nitrogen fertilizer, yield.

Introduction

Soil and water are the worthy natural resources for all of countries in the World. These resources must be used by developing with cleverly. This is important for people the social and economic development. It is the fact that, irrigation is very valuable for agricultural activities. However, water quality is not fresh adequately for irrigation every time. Therefore, farmers have to use lower quality water for irrigation. Salinity is the measure of the all salts dissolved in water. Concentration of dissolved material in water is important. Plants take up dissolved elements from irrigation water but these must be in a good balance as a view of plant nutrition. Otherwise, sometime plants and also soil can be affected worst. Salinity or alkalinity comes into

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existence. High salinity creates osmotic potential in soil. This potential cause's physiological water scarcity and these stress depends plants species. During the growing session, plant begins to dry, and yield and quality of production reduce. Plants uptake some dissolved anion or cation may be has toxic effects. So plants are affected negatively (Van Hoorn and Van Aart, (1980) and Hoffman, (2001)). For these reason, scientists make research with this soil conditioner to minimize bad salt effects. Recently some chemical and organic substances are used to improve the structure of the soil and to decrease salinity effects on plant. One of them is a humic acid. Humic Acids derivatives of naturally occurring humus matter in soil. Humic acids are active elements in organic soils and important for the conversion of fertilizer into available plant nutrients.

The benefit of Humic acid; • to enhance soil structure and fertility through the addition of vital organic matter in the soil.; • By efficient transfer of fertilizer nutrients and micronutrients because of the high chelation and cation exchange proportion of the active humic acid also, • By holding on to soil itself prevents losing nutrients materials, • By pressuring some undesirable ions effects, • By increasing moisture holding capacity of soil, • By increasing microbial activity in the soil; and • By enhancing plant cell biomass.

Because of the humic acids have high cation capacity, calcium (Ca), magnesium (Mg), ferrum (Fe) and aluminum (Al) etc minerals don't react with phosphorus in soil and they stay free to take up by plants. This feature increased performance of mineral fertilizers.

Humic materials have positive effects on roots' morphologic. Humic materials can stimulate to take up the nutrients and nutrients metabolism by affecting directly (Nardi and ark., 2002; Muscolo and ark., 1998). Humic acid productions can be used kindly purposes that provide to evaluate natural resources. Humic acids are the conditioner material and can provide to utilize salty drainage water and regained water from irrigated areas (Anonymous 1992). Humic materials compose basic structure of organic materials in soil and water (MacCharty, 2001). Humic materials are found every place in nature and they are rich sources for inorganic materials (Hedges and Oades, 1997).

We used a product called "Base Actosol" commercially. Base Actosol contains 12% humic acid. In this study, there are two aims;

- to determine this material can or not inhibit ions impactions in saline waters and what is effect on plant growing degree under saline irrigation condition,
- to find out humic acid can provide or not fertilizer saving.

Material and Methods

Material

Irrigation waters were obtained from natural sources and make some modifications by diluting and adding some chemical materials ($CaCl_2$, $MgSO_4$and Na_2CO_3). Prepared irrigation waters' SAR values are nearly 5; EC values were 0.71 – 1.56 – 2.25 – 2.94dS/m.

The soil texture filled in pots is clay. Soil didn't have salinity, alkalinity or boron problems. Soil electrical conductivity: 0.72dS/m; pH: 7.59; boron: 0.72; exchangeable sodium percentage: 0.8; cation exchange capacity: 31me/100g dır.

Source of humic acid is "Base Actosol" and contains 12%HA. Electrical conductivity value of "Base Actosol" 61.62dS/m and pH: 9.94. This material provided by TCE (TKİ in Turkish)

Methods

Design of experiment is factorial as randomized plots in greenhouse. The experiment established with 3 factors and 3 replications. The pots filled with soil-7 kg and sowed 6 maize seeds. After germination 3 seedlings were left in pots.

In study five different salinity concentration waters were used for irrigation. Five humic acid and two Nitrogen fertilizer doses were applied. Irrigation water used with different salinity levels are S_o= 0.04 (distilled water); S_1=EC~0.75; S_2=EC~1.50; S_3=EC~2.25; S_4=EC~3.00 dS/m. Humic acid doses are H_0=0.00; H_1=350; H_2=700; H_3=1050; H_4=1400 ppm and Nitrogen fertilizer G_1=Optimum dose (OD); G_2=% 25 of OD.

At the begining of experiment, half of Base Actosol and of nitrogen fertilizer were given together during the seedling into soil. The other half of actosol and nitrogen were given when plants have 5-6 leaves into soil.

Optimum nitrogen fertilizer dose was 104 ppm and used NH_4SO_4. Also Fe and Zn required were given at same times. Half of Fe and Zn doses were given into soil but second half of the dose by spraying on leaves.

The pots were weighed and deficient soil water was completed to field capacity (FC). Whenever available soil water was consumed in 40-50%, pots were irrigated. The control pots were $S_0H_0G_1$ and $S_0H_0G_2$. These pots weight were taken as base. First irrigation water for all pots was distilled water, after then salty water. Applications continued to 50 days. The pots were irrigated 9 times with salty water covered different level saline. After applications of humic acid, N-fertilizer and salty irrigation water maize plant harvested. After harvesting maize plants dried in 65-70°C and weighted for measuring PDW and the other plant growing criteria. Also on dried plant materials made chemical analyses to understand content of some elements. Because, we want to know applications in this study are affected plants containing elements. For this aim obtained values were compared criteria according to Jones et al. (1991). All of the results analyzed as statistically. Variance analysis method and LSD test are used.

Results and Discussion

Generally, the most important parameter is the plant dry weight (PDW) in terms of the vegetative development criteria. Therefore, for maize, PDW values taken into consideration. Obtained PDW values analyzed in statistically that placed as A-groups in statistically, is taken into consideration. In this case; in this study PDW discussed only between the other plant growing factors.

Plant Dry Weight (PDW)

Plant dry weight (PDW) obtained with salty irrigation water, humic acid and fertilizer applications given Table 1. PDW values were analyzed statistically. Results of variance analysis and comparison of means were given in Table 2 and Figure-1.

Table 1. Plant Dry Weight (PDW)

Treatments		SalinityLevels of irrigation waters									
		S_0		S_1		S_2		S_3		S_4	
HA Level	HA (ppm)	G_1	G_2	G_1	G_2	G_1	G_2	G_1	G_2	G_1	G_2
H_0	0	26,60	28,38	30,50	31,93	35,00	30,71	35,44	29,17	27,89	26,25
H_1	350	27,80	29,41	30,31	37,43	47,14	35,25	34,78	30.49	26,14	25,90
H_2	700	29,13	35.07	34,32	43,39	47,49	33,29	29,11	31,82	27,94	26,36
H_3	1050	27,75	33,42	32,60	42,73	46,33	32,86	29,96	31,55	25,51	22,90
H_4	1400	28,57	28,65	30,36	29,81	40,99	27,32	31,36	31,28	27,70	26,86

According to statistical analyses, SHG's triple interaction is found significant ($F=2.71$; $P=0.0013$) for PDW. That is to say, the effect of humic acid on to PDW depends on salinity of irrigation water and fertilizer with nitrogen. Also it can be said that the effects of salty irrigation waters depend on humic acid doses and fertilizer. Or the fertilizer's effects depend on humic acid doses and salinity of irrigation water. When the means of PDW is compared, the highest values of PDW (47.49g) obtained from application with $S_2H_2G_1$. This application is in the same group-A together with applications $S_2H_1G_1$, $S_2H_3G_1$, $S_1H_3G_2$, $S_1H_2G_2$ (respectively; 47.14; 46.33; 43.39 ve 42,73g). Value of LSD is 5.236. Therefore, any application is preferred to take into account of quality of irrigation water, costs, resources etc.

Table 2. Results of variance analysis for Plant dry weight (PDW)

Variation sources	Degree of freedom	Sum of squares	Mean of squares	F values	Probability
S (Salinity)	4	821.095	205.274	19.6491	0.0000**
HA (Humic acid)	4	295.540	73.885	7.0724	0.0000**
SH	16	416.104	26.007	2.4894	0.0031**
G (Fertilizer)	1	48.712	48.712	4.6628	0.0332*
SG	4	2710.399	677.600	64.8607	0.0000**
HG	4	63.011	15.753	1.5079	0.2056 ns
SHG	16	452.913	28.307	2.7096	0.0013**
Error	100	1044.700	10.447		
Sum	149	5852.475			

Variation coefficient (cv):%10,15

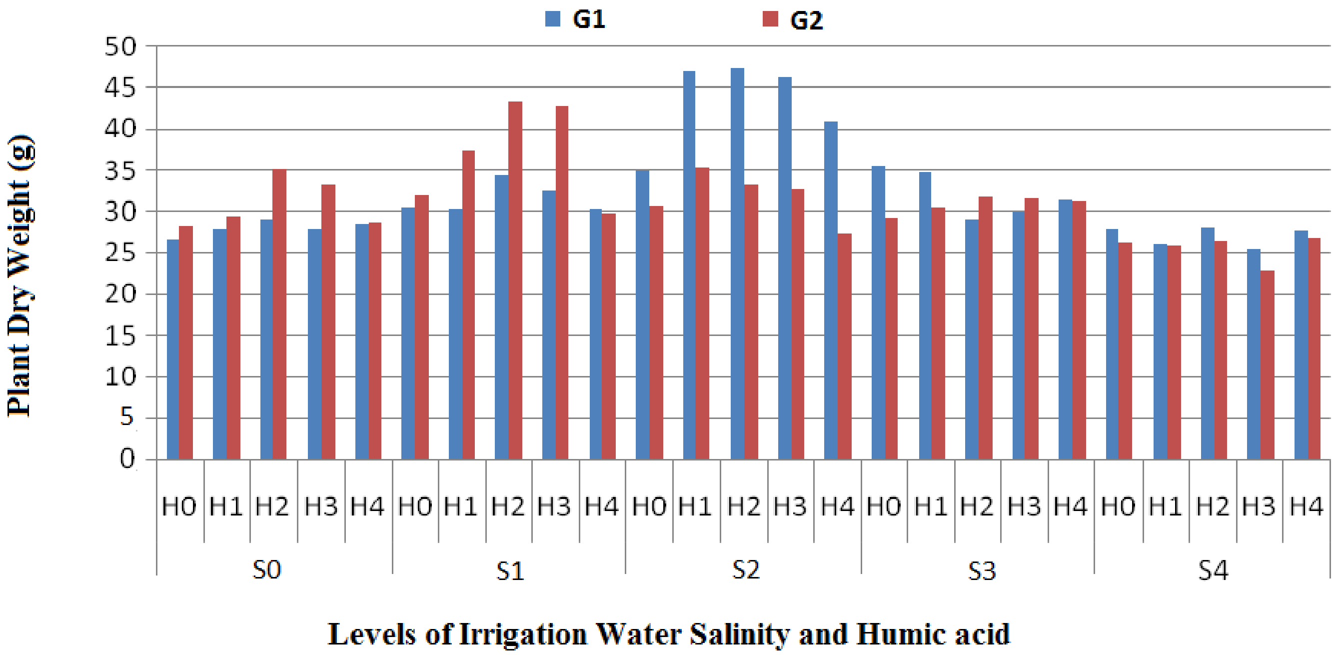

Figure 1. Diagram of changes on plant dry weight (PDW) after applications

If we want to summarise these results:

1. In LSD test, $S_1H_2G_2$ and $S_1H_3G_2$ applications (with humic acid H_2 and H_3 doses respectively; 700 and 1050ppm per da) can be advisable, but keep in view of money savings H_2 dose must be preferred.
2. The S_1 salinity level with G_2 fertilizer dose enables 25% fertilizer savings.
3. Treatments ($S_2H_2G_1$; $S_2H_1G_1$ and$S_2H_3G_1$) with humic acid doses H_1, H_2 and H_3 (350; 700 and 1050 ppm per da) which place A-group in LSD test, can be advisable. All three humic acid doses are suggestible, but H_1 dose is more affordable. When take into accout S_2 level salinity for irrigation water, we notice that we can offer 350 ppm (H_1) humic acid dose ($S_2H_1G_1$). Because, although application with $S_2H_2G_1$ gives us the highest PDW humic acid level-H_1 may provide saving.
4. The irrigation water with S_2 salinity level should be used together with the optimum dose of fertilizer is one of the results of the research.
5. Scientifically, the salt resistance of maize is 1.7dS/m (Anonymous, 1992). In this case irrigation water salinity levels of S_1 and S_2 are already suitable for cultivating quality of the plant/maize. In this case, the use of HA doses and fertilizer applications will depend on the practitioner's choice and resource.
6. Humic acid doses are ineffective in decreasing salinity hazards that comes from high salty irrigation water. (S_3 and S_4).

Effects of Applications on Some Macro Elements in Maize Plants

Maize plants dried in 65-70°C after harvesting and analyzed to understand content of some elements. Because, we want to know applications in this study are affected plants containing elements. For this aim obtained values compared criteria according to Jones et al, (1991). Mean values of plants contening Ca, Mg, Na and K given Table 3.

Effects of Applications on Calcium (Ca) in Maize Plants

According to the variance analysis, SGH's triple interaction is not found significant (F=3.26; P=0.0147) statistically for determined calcium (Ca) values in plants. Calcium content is effected only irrigation waters' salinity. LSD test shows that the highest calcium content is in S_2, S_4 and S_3 applications respectively in term of % 0.857; 0.745 and 0.722. These treatments take place in same group-A. Subjects S_1 and S_0 -follow the others respectively. Results of variance analyze and comparison of means given in Table 4 and Figure-2. When the calcium content in plants is taken into account noticed that is in adequate for nutrition.

Table 3. Mean values of plants contening calsium (Ca), magnesium (Mg), sodium (Na) and potasium (K)

Treatments			Ca (%)		*Mg (%)		**Na (%)		**K (%)	
Salinity levels	Humic acid levels	Humic acid (ppm/da)	G_1	G_2	G_1	G_2	G_1	G_2	G_1	G_2
S_0	H_0	0	0,632	0,576	0,267	0,204	0,009	0,017	4,167	4,770
	H_1	350	0,641	0,556	0,278	0,209	0,009	0,017	4,373	4,017
	H_2	700	0,717	0,638	0,377	0,228	0,009	0,017	4,000	4,473
	H_3	1050	0,641	0,609	0,237	0,205	0,009	0,017	3,570	4,703
	H_4	1400	0,552	0,673	0,231	0,230	0,008	0,017	3,533	4,653
S_1	H_0	0	0,527	0,871	0,265	0,344	0,038	0,039	3,490	4,380
	H_1	350	0,635	0,579	0,303	0,228	0,039	0,029	3,037	4,153
	H_2	700	0,670	0,566	0,245	0,213	0,028	0,029	2,940	4,380
	H_3	1050	0,676	0,599	0,260	0,254	0,031	0,014	3,347	4,133
	H_4	1400	0,729	1,015	0,287	0,258	0,031	0,014	3,363	4,533
S_2	H_0	0	0,733	0,715	0,361	0,314	0,046	0,032	3,020	4,447
	H_1	350	0,736	0,848	0,351	0,305	0,040	0,038	3,007	3,907
	H_2	700	0,769	0,809	0,426	0,303	0,041	0,031	2,936	4,137
	H_3	1050	0,768	0,682	0,328	0,286	0,040	0,031	2,860	3,703
	H_4	1400	0,757	1,440	0,323	0,318	0,027	0,022	2,713	4,017
S_3	H_0	0	0,745	0,702	0,357	0,296	0,052	0,017	4,417	3,913
	H_1	350	0,763	0,543	0,305	0,233	0,034	0,018	4,183	3,713
	H_2	700	0,779	0,665	0,351	0,291	0,025	0,023	4,870	4,013
	H_3	1050	0,776	0,776	0,345	0,356	0,023	0,025	4,783	3,807
	H_4	1400	0,757	0,712	0,379	0,298	0,023	0,032	5,050	3,687
S_4	H_0	0	0,660	0,616	0,360	0,295	0,046	0,028	4,803	3,570
	H_1	350	0,690	0,769	0,327	0,349	0,071	0,062	4,647	4,613
	H_2	700	0,815	0,674	0,370	0,286	0,072	0,040	4,913	3,880
	H_3	1050	0,833	0,859	0,371	0,380	0,068	0,078	4,740	4,700
	H_4	1400	0,881	0,584	0,388	0,291	0,061	0,064	4,660	3,965

Table 4. Results of variance analysis for Calcium (Ca) content in maize plant after applications

Variation sources	Degree of freedom	Sum of squares	Mean of squares	F values	Probability
S (Salinity)	4	0.717	0.179	3.2611	0.0147*
HA (Humic acid)	4	0.212	0.053	0.9651	ns
SH	16	0.862	0.054	0.9796	ns
G (Fertilizer)	1	0.018	0.018	0.3241	ns
SG	4	0.223	0.056	1.0148	0.4035 ns
HG	4	0.355	0.089	1.6146	0.1765 ns
SHG	16	0.981	0.061	1.1155	0.3515 ns
Error	100	5.498	0.055		
Sum	149	8.866			

Variation coefficent (cv) % 31.95

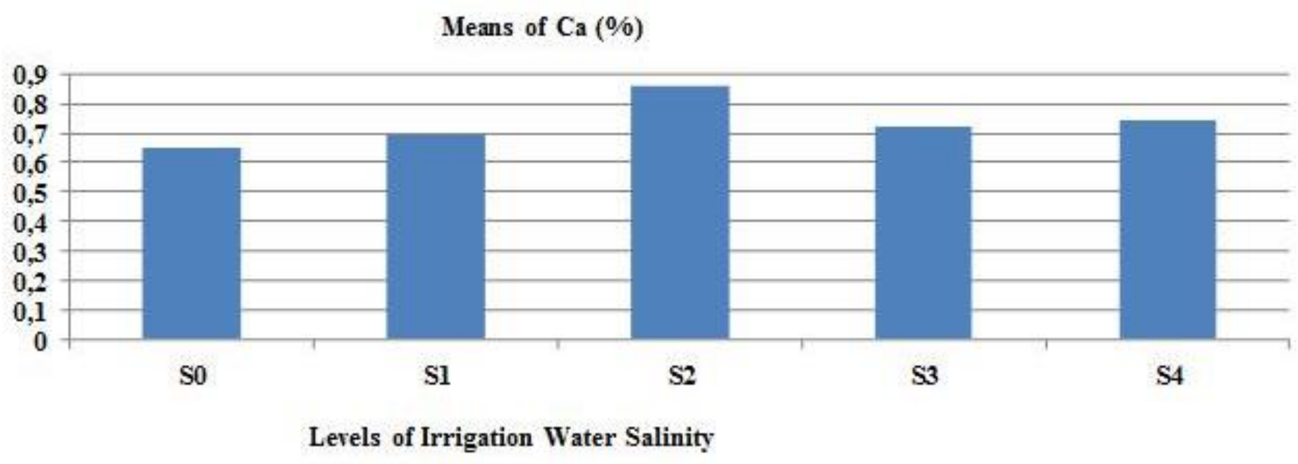

Figure 2. Diagram of changes on plants calcium (Ca) content (%) after applications.

Effects of Applications on Magnesium (Mg) in Maize Plants

On determined the values of plants' magnesium (Mg) content made statistical analyzed. It's found that SGH's triple interaction is significant (F=2.18; P=0.0102). It means, the effect of humic acid on to magnesium depends on irrigation water's salinity and fertilizer with nitrogen. LSD test shows that the highest magnesium content gotten from $S_2H_2G_1$ (0.4257%) which is in group-A. Treatments $S_4H_4G_1$, $S_4H_3G_2$, and $S_3H_4G_1$ are in same group-A. Application values are respectively in term of % 0.3880; 0.3797and 0.3787. Although $S_2H_2G_1$ gives the highest value magnesium (Mg) generally, noticed that if irrigation water's salinity goes up magnesium content in plants also goes up. Results of variance analyze and comparison of means given in Table 5 and Figure-3. It is noticed that the calcium content in plants is generally found in adequate for nutrition.

Table 5. Results of variance analysis for Magnesium (Mg) content in maize plant after applications

Variation sources	Degree of freedom	Sum of squares	Mean of squares	F values	Probability
S (Salinity)	4	0.216	0.054	37.3571	0.0000
HA (Humic acid)	4	0.007	0.002	1.2349	0.3010
SH	16	0.079	0.005	3.4354	0.0001
G (Fertilizer)	1	0.075	0.075	51.8159	0.0000
SG	4	0.011	0.003	1.9328	0.1108
HG	4	0.025	0.006	4.2835	0.0031
SHG	16	0.050	0.003	2.1799	0.0102*
Error	100	0.144	0.001		
Sum	149	0.608			

Variation coefficient (cv) % 12.61

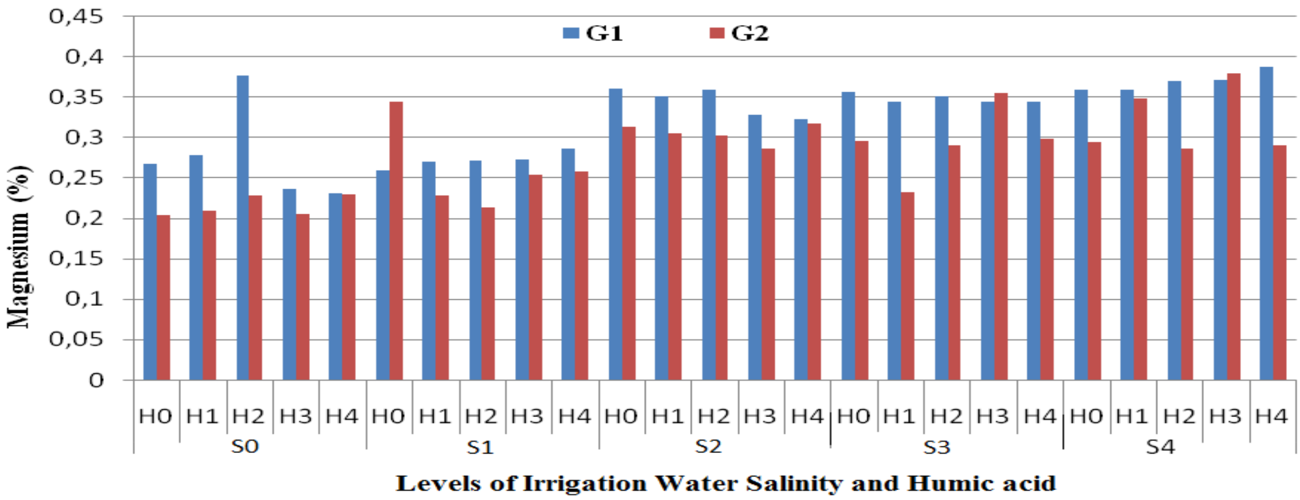

Figure 3. Diagram of changes on plants magnesium (Mg) content (%) after applications.

Effects of Applications on Sodium (Na) in Maize Plants

Values of sodium (Na) plants containing determined statistically. Triple interaction of SGH is found significant (F=1.92; P=0.0267). The changing of effects of humic acid on to sodium depends on salinity of irrigation water and fertilizer with nitrogen. Differences of means analyzed with LSD test. It seems that the highest sodium level got from practice $S_4H_3G_1$. This application's Na value (0.09467%) placed in group-A and as alone. The nearest value comes from practice $S_4H_3G_2$ placed group-B. Least Na content of plants was determined from testifier subjects (S_0). When irrigation water's salinity goes up sodium content in plants also goes up. Because, HA levels were inadequate to inhibit high salinity water conditions (S_3 and S_4). But, humic acid levels were affected on Na content in plants especially less salinity water conditions (S_0, S_1 and S_2). If humic acid levels increased Na contents of plants decreased. Results of variance analyze and comparison of means given in Table 6 and Figure-4.

Table 6. Results of variance analysis for sodium (Na) content in maize plant after applications

Variation sources	Degree of freedom	Sum of squares	Mean of squares	F values	Probability
S (Salinity)	4	0.030	0.007	40.6429	0.0000**
HA (Humic acid)	4	0.001	0.000	1.0885	0.3664 ns
SH	16	0.010	0.001	3.4815	0.0001**
G (Fertilizer)	1	0.002	0.002	12.7568	0.0005**
SG	4	0.001	0.000	0.7021	
HG	4	0.000	0.000	0.1060	
SHG	16	0.006	0.000	1.9214	0.0267*
Error	100	0.018	0.000		
Sum	149	0.067			

Variation coefficient (cv) % 39.76

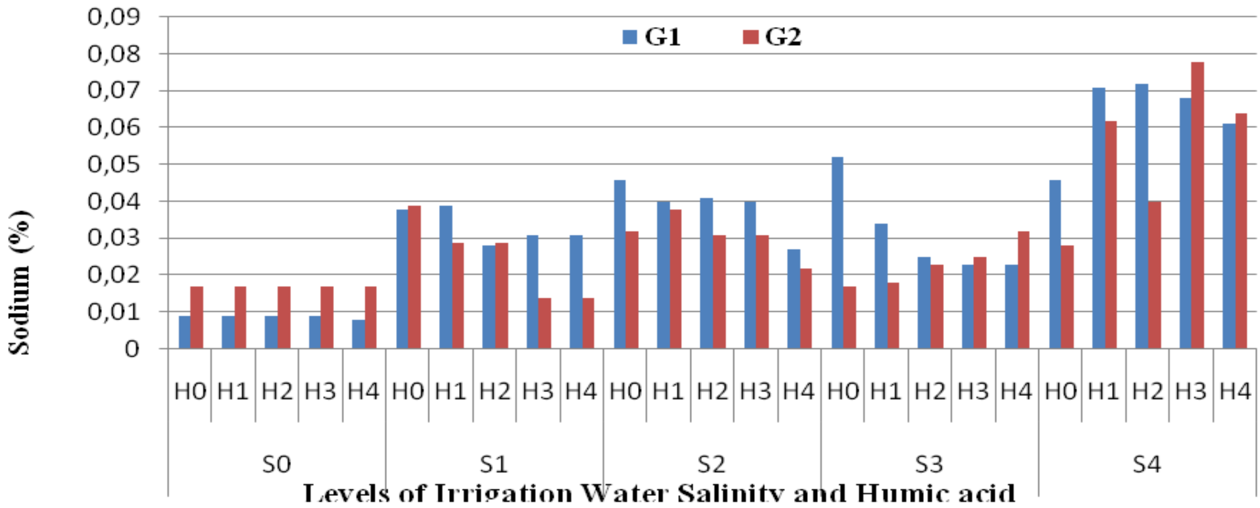

Figure 4. Diagram of changes on plants sodium (Na) content (%) after applications.

Effects of Applications on Potassium (K) in Maize Plants

Potassium values (K) obtained from dried plants' content are analyzed statistically and determined that triple interaction is found significant (F=3.78; P=0.0000) for potassium. That is to say, the effect of humic acid on to potassium depends on salinity of irrigation water and fertilizer with nitrogen. Content of potassium in plant is chanced between adequate and over levels. The highest K (%) level found in plants irrigated with high salty water as S_3 and S_4. Maize plant grown with application $S_4H_2G_1$ contains the highest K level (5.08). According to LSD test, following treatments are $S_3H_4G_1$, $S_3H_2G_1$ place in group-A (respectively; 5.05 and 4.87), $S_4H_0G_1$, $S_3H_3G_1$, $S_4H_3G_1$ place in group-AB (respectively; 5.05; 4.87; 4.803, 4.783 and 4.74 ;) $S_4H_3G_2$, $S_4H_4G_1$, $S_4H_1G_2$ place in groups-ABC and ABCD-in LSD test (respectively; 4.7 0; 4.66 and 4.613). These result show that generally high salinity level, high humic acid and optimum fertilizer affect to increase potassium content. Results of variance analyze and comparison of means given in Table-7 and Figure-5.

Table 7. Results of variance analysis for Potassium (K) content in maize plant after applications

Variation sources	Degree of freedom	Sum of squares	Mean of squares	F values	Probability
S (Salinity)	4	16.612	4.153	35.8898	0.0000**
HA (Humic acid)	4	0.643	0.161	1.3890	0.2432ns
SH	16	2.981	0.186	1.6099	0.0797*
G (Fertilizer)	1	2.449	2.449	21.1604	0.0000**
SG	4	23.799	5.950	51.4163	0.0000**
HG	4	0.218	0.054	0.4700	ns
SHG	16	7.002	0.438	3.7817	0.0000**
Error	100	11.572	0.116		
Sum	149	65.275			

Variation coefficient (cv) % 8.41

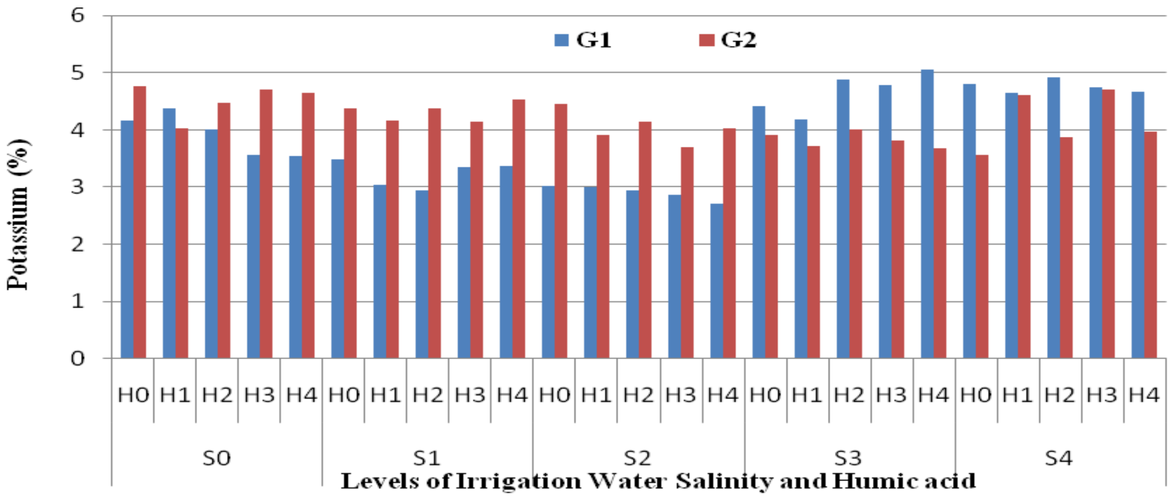

Figure 5. Diagram of changes on plants potassium (K) content (%) after applications.

Conclusion

For contents of macro elements in plants

If calcium, magnesium, sodium and potassium are taken into account, we can say these results.

1. When irrigation water salinity is increased calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) contents of maize plants are also increased.
2. After application of humic acid, salty irrigation water and fertilizer-N, elements within the structure of the plant in terms of nutritional quality for Maize are in sufficient levels. As a result;
3. According to statistical analyses, triple interaction between salt, humic-acid and fertilizer-N (SHG) is, significant all parameters except calcium. Calcium content of plants is affected only by irrigation water salt concentrations.
4. There is effect of the triple interaction (SHG) on contents of K, Mg and Na. These parameters are changing by water salt concentrations, humic acid and fertilizer doses. Plant's potassium content is significant at level of 1% as statistically ($p<0.01$). Magnesium and sodium contents are significant 5% level ($p<0.05$).
5. As results, plants easily uptake free sodium and magnesium from irrigation water. Humic acid doses are insufficient in preventing the uptake of these ions generally. This event occurs especially at high salty water conditions. But, the critical values given by literatures for contents of the plant are not yet arrived to the level of the toxic dose.

For Plant Dried Weight (PDW)

Briefly we can say that, if we have irrigation water with S_1 salinity level (0.75dS/m) G_2 fertilizer dose will be enough for the highest production. Also G_2 fertilizer dose enable us 25% fertilizer savings. But, if salinity level goes up to S_2 (1.5dS/m), fertilizer dose must be optimum level (G_1) for the highest plant dried weight (PDW). That means, if we want to obtain the highest production when we have irrigation water with S_2 salinity level, we have to use optimum fertilizer dose (G_1).

Application with $S_2H_2G_1$ gives us the highest PDW humic acid level. On the other hand, when humic acid doses take into account, although we can save the fertilizer-N at S_1 level it is noticed that we can offer less humic acid for S_2 salinity level, than S_1 level salinity. Because, $S_1H_2G_2$ and $S_1H_3G_2$ are taking place group-AB but, application with 350ppm (H_1) humic acid dose ($S_2H_1G_1$) is also taking place group-A with as statistical analyzed. So that, to prefer H_1 dose may be provides saving humic acid expence.

In this study, applied doses of humic acid are ineffective to decrease salinity hazards that come from high salty irrigation water (S_3 and S_4). Because of these reasons, higher humic acid doses may need to be retried.

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References

Anonymous, 1989. Water Quality for Agriculture.FAO Irrigation and Drainage Paper Rev. 29-1. Rome.

Anonymous, 1992. The use of saline waters for crop production. FAO, Irrigation and Drainage Paper, 48. Rome.

Hedges, I.J., Oades, J.M., 1997. Comparative organic geochemistries of soils and marine sediments, Org. Geochem. 27, 319-36.

Hoffman, G.J., 2001. Water Quality Criteria for Irrigation. http//ianr.unl.edu/pubs/irrigation/ec.

MacCarthy, P., Rice, J.A., 1991. An ecological rationale for the heterogeneity of humic substances. In: S. H. Schneider, P. J. Boston (eds.), Proceedings of Chapman Conference on the Gaia Hypothesis, San Diego, CA, March 7-11, 1988, MIT Press, Cambridge, pp. 339-345.

Muscolo, A., Cutrupi,S., Nardi, S., 1998. IAA Detection in Humic Substances. Soil Biology and Biochemistry. 30: 1199.

Nardi, S., Pizzeghello, D., Muscolo, A., Vianello, A., 2002. Physiological Effects of Humic Substances on Higher Plants. Soil Biology and Biochemistry. 34: 1527.

Van Hoorn, J.W., Van Aart R., 1980. The use of saline water for irrigation. Land Reclamation and Water Management. P:148, ILRI.

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What are the facilities of using saline soil as a forage area with halophytic plants?

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Abstract

A halophyte is a plant which is capable of surviving in a highly salty environment. Halophytic plants also can grow areas which have seriously problem as saline, alkaline or eroded etc. So that these plants provide to evaluate lots of empty areas. For examples; saline grasslands can be riched with halophytic forage plants for grazing or can be used to obtain hay. By adopting halophytic plants to get income can be provided from highly saline soil. Halophytic plants provide erosion on these kinds of areas and also existing erosion can be stopped by covering on eroded areas. The goals of this study were to evaluate saline areas by planting halophytic plants and to determine these plants adaptation to environment. For these goals, first step was perennial halophytic forage plants' seeds were collected from their native environments of the Central Anatolian region Second step was nursing plants were produced in greenhouse. One of these was producted with rhizomes. The last step was nursing plants were moved and planted on salty pasture area in Gölbaşı-Ankara-Turkey. The field experiment was conducted in fixed plots designed as randomized blocks with four replications. The test plants were A-*Leymus cappadocicus,* B-*Agropyron elongatum,* C-*Puccinellia*, D-*Kochia prostrata*, E-*Atriplex lentiformis,* F-*Halimione verrucifera,* G-*Artemisia santonicum*, L-*Camphorosma monspeliaca*, M-*Petrosimonia nigdensis*, N-*Control (native vegetation)*. All plots were irrigated to support growth in the first year. After the first year, irrigation was cancelled. Every year, after the harvesting, soil samples were collected from each plots per 20cm soil strata till 60cm depth. Soil samples were analyzed to determine the salinity parameters. The plants were observed to understand adaptation conditions and yields were measured. Plants samples were analyzed to assess some salinity parameters. The amount of salt taken from the soil by plants was calculated.

Keywords: Halophyte, salinity, soil remediation, *Leymus cappadocicus, Halimione verrucifera, Agropyron elongatum, Puccinellia, Camphorosma monspeliaca, Atriplex lentiformis.*

Introduction

The world population is expected to be 9.3 billion by 2050 (Anonymous, 2008). Populations in developing countries are growing so quickly that land and water are unable to sustain them. Rozema and Flowers (2008) relay that, humans use about half of the fresh water readily available to them to support a growing world

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population. Good quality water is becoming a limited and expensive resource. Agriculture has to compete with domestic and industrial uses for this fresh water. Although, nearly 1% of the water on earth is fresh, the rest of the water is brackish (1%) and seawater (98%).

In most developing countries, prime farmland and fresh water are fully utilized. Although irrigation can be employed to bring additional areas into production, it often leads to salinization. Salinity is affecting fresh water and soil especially arid and semi-arid zones. Annual rainfall is 200-300mm or less in arid zones. In this zone the crops is growth without irrigation or the irrigation is vital input for agriculture. When fertile soils become salinized the yields of conventional crops decreased. In overtime soils are not be suitable for conventional crops.

The United Nations Food and Agriculture Organization estimate that there are 4 million square kilometers of salinized land. Salt-affected soils cover about 10% of the total surface of dry land on all continents. Soil salinization especially affects economically less-developed countries located in arid climatic zones (includes Pakistan, India, Egypt, Tunisia, Morocco, Peru and Bolivia) (Anonymous).

The evolution of plant life on Earth started 3 billion years ago in saline ocean water. With the advance of land plants about 450 million years ago, primary adaptation of plants to the high concentration of Na^+ and Cl^- were effectively lost. (Choukr-Allah,1996). Now, 1% of species of the land plants can grow in costal line saline condition. Many of them are not resisting half of seawater salt-concentration (Flowers, and Colmer, 2008). Many of these salt-adapted plants cover more species (shrubs, trees, grass are annual or perennial) and are called as "halophytes". If the halophytes growing rate compare with conventional forage crops, it can be seen that biomass of halophytes greater than the others (Gleen and Brown., 1999 and Niazi et all., 2000).

Sardo and Hamdy (2005), point out that the halophytes are precious plant. In recent years, it has been demonstrated that revegetation of saline habitats with halophytic species is profitable and provides many additional benefits (Marcar et al., 1993). For many developing countries, salt-tolerant plants provide an important alternative solution to evaluate saline area because, these areas are not suitable for growing conventional crop. In some cases, successful rehabilitation of degraded land is usually preferable, in terms of natural resource conservation, to opening new arable land. In many cases, groundwater is too saline for irrigation conventional crops, but it can be used to growhalophytes. Even the thousands of kilometers of coastal deserts in developing countries may serve as new agricultural land, with the use of seawater for irrigation of salt tolerant plants. These plants can be grown in saline condition, where is unsuitable for normal plants, can provide food, fuel, fodder, fibber, resin, essential oils and pharmaceutical products, and can be used for landscape integration (R. Choukr-Allah, 1991).

Le Houérou, (1992) reported that there are about 6000 species of terrestrial and tidal halophytes in the world and 700 species in the Mediterranean climate area. Le Houérou, (1994) also reported that there are about 1100 species of halophytes in the Mediterranean Basin, when considered in its broadest meaning i.e. from the Aral Sea to the Atlantic Ocean. These halophytes include annual and perennial herbaceous species, shrubs and trees. They are represented *Chenopodiaceae (*30% of them*),* Poaceae (15% of them) and Fabaceae (10% of them). Saline rangelands cover in the vicinity of 50 million hectares in the Basin. The most of them located to the south and the east of the Mediterranean Sea. 70% of halophytes is perennial and 30% of them is annual.

R. Choukr-Allah, (1991) and Le Houérou, (1994) points to that, in general, these species are neglected and usually considered impediments rather than opportunities for agricultural development. Increased research on the selection of halophytic species of economic uses, with appropriate management, could result in the rehabilitation and revegetation of salt-affected land and the use of marginal water. Where there is a lack of feed, or lack of green feed, consider a plantation with halophytic plants. The planting of salt-tolerant forage species is also one way to rehabilitate and reclaim salty soils.

In the Mediterranean Basin, *Atriplex* spp. (includes *A. halimus*, *A. leucoclada*, *A. glauca* and among the latter *A. nummularia*, *A. amnicola*, *A. lentiformis*, *A canescens)* have been planted. These are capable of high productions forage, either under rainfed or irrigation conditions including in the Mediterranean arid zone, with rainfalls as low as 150 mm yr^{-1}. It is reported that, Rain and Water-Use Efficiencies of these plants are high. Feeding trials have shown that livestock accustomed to this feed can make good use of this forage (Le Houérou, 1994).

It is reported that, because of halophytes diversity, they have been regarded as a rich source of potential new crops. Halophytes have been tested as vegetable, forage, and oilseed crops in agronomic field trials. The most productive species yield 10 to 20 ton/ha of biomass on seawater irrigation. This means that, yields of some halophytes can be equivalent to conventional crops. The oilseed halophyte, *Salicornia bigelovii*, yields 2t/ha of seed containing 28% oil and 31% protein, similar to soybean yield and seed quality. Halophytes at lower salinities they can give more crops yield than conventional crops. In addition, halophytes have higher water use efficiency than conventional plants. Halophyte forage and seed products can replace conventional ingredients in animal feeding systems, with some restrictions on their use due to high salt content and antinutritional compounds present in some species. Halophytes have applications in recycling saline agricultural wastewater and reclaiming salt-affected soil in arid-zone irrigation districts (Glenn and Brown, 1999).

It is known that, salts in soil surface are leached down by winter and spring rainfall. If it is not enough to produce conventional plant, excess leaching is necessary. However excess leaching also requires more water and drainage system. However, generally its mean is the more money. In this case growing halophytes the best alternative. Most halophytes utilize the controlled accumulation and sequestration of inorganic ions as the basic mechanism. Their mechanism provides to adjust the osmotic potential of their internal tissues to the external salinity (Flowers and Yeo, 1986; Cheeseman, 1988). Halophytic species differ widely in the extent to which they accumulate ions and their overall degree of salt tolerance (Glenn and O'Leary, 1984; Glenn *et al*., 1996).

This paper will cover the experiences about the agricultural use of saline land with growing halophytic forage plants and some results of different measurement on plants and soil. The goals of this study were to evaluate saline areas by planting halophytic forage plants and to determine these plants adaptation to environment.

Material and Methods

Material

The field experiment was conducted on salty pasture area in Gölbaşı-Ankara-Turkey. Soil didn't have alkalinity problem. Soil texture was clayey (~85%). Means of soil analysis result are presented for the depth of 60cm soil layer, respectively; electrical conductivity (EC): 14.37dS/m; pH: 8.10; boron (B): 5.48ppm; exchangeable sodium percentage (ESP): 13.16; cation exchange capacity (CEC): 56.99me/100g, organic material 0.46%. Soluble cations concentration (Ca^{+2}, Mg^{+2}, Na^{+} and K^{+}) are in me/l respectively; 13.76; 26.13; 101.10 and 0.25 , soluble anions concentration (Ca^{+2}, Mg^{+2}, Na^{+} and K^{+}) are in me/l respectively; (CO_3^{-2}, HCO_3^{-}, Cl^{-} and SO_4^{-2}) are in me/l respectively 0.32; 2.92; 72.71 and 65.28. Soil is calcerous ($CaCO_3$ =11-12%) These results belongs to 2006 May.

In trial tested halophytic plants are perennial forage plants. Their family are Graminea *(Leymus cappadocicus, Puccinelliakoeiana* and *Agropyron elongatum),* Chenopodiaceae (= Amaranthaceae; *Atriplex lentiformis, Halimione verrucifera Kochia prostrate, Camphorosma monspeliaca and Petrosimonia nigdensis*) and Compositae (*Artemisia santonicum).* Their seeds were collected from their native environment of The Central Anatolian Regionof Turkey. Only seeds of *Atriplex lentiformis* were provided from ICARDA-Syria.

Means of annual climate datas (rainfall, temperature and humidity) of the nearest station to Gölbaşı were respectively; 328.18mm 10.17°C; 64% in years of trial. Although the table shows that there is rainfall in important periods necessary for growing but farmers of region said that there is no or less rain in trial area in springs and early summers. So that some of years there was hard drought in area except 2009. Especially, spring and summer were too dry periods in 2007. Table-1 shows climate datas of the nearest station to Gölbaşı (Meteorological Station of Haymana Research Institue).

Method

The aims of this study are to evaluate saline areas with planting halophytic plants and to determine these plants adaptation to environment. Our subjects were composed the plants. The test plants, except *Atriplex,* generally were selected from Middle Anatolian region.The subjects were; A-*Leymus cappadocicus,* B-*Agropyron elongatum,* C-*Puccinellia*, D-*Kochia prostrata*,E-*Atriplex lentiformis,* F-*Halimione verrucifera,* G-*Artemisia santonicum*, L-*Camphorosma monspeliaca*, M-*Petrosimonia nigdensis*, N-Control (native vegetation) and added four mixed planted plots (H-I-J-K).*Leymus cappadocicus* was produced from rhizoms. The others are produced in greenhouse. Our first step was to collect plants' seeds from their native environments of the Central Anatolian region (in 2005). Second step was to produce nursing plants were in plastic bags or seedbeds in greenhouse. In the last step, nursing plants were moved and planted on salty pasture area in Gölbaşı-Ankara-Turkey (2006). The field experiment was conducted in fixed plots designed as randomized blocks with four replications. The fourth replication was used for observing improvement of plants. So that, the plants in fourth replication was never harvested. After germination of Atriplex *lentiformis* seeds in seedbed, they were placed plastic-bags to develop in it. Plants of *Leymus cappadocicus* were reproduced with rhizomes in field.

Table 1. Climate data of the trial years (2006-2011-Haymana-Ankara-Turkey)

Meteorological Data	Years	Months												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Means temperature (^{o}C)	2006	-4,7	-2,0	5,7	11,4	12,5	19,1	20,8	25,4	16,5	12,3	3,7	-2,5	9,85
	2007	0,8	0,2	5,2	7,3	18,1	20,0	24,3	24,4	17,6	12,3	5,4	-4,8	10,90
	2008	-5,7	-2,4	7,9	11,3	12,7	19,5	22,2	24,3	17,4	10,5	6,3	-0,9	10,26
	2009	-0,3	1,9	2,9	8,7	13,2	18,9	21,1	20,4	16,7	14,5	5,2	3,4	10,55
	2010	1,3	4,0	6,8	9,4	14,6	19,1	20,6	25,5	17,1	12,3	11,8	4,3	12,22
	2011	0,2	-0,6	-11,9	-1,5	12,3	16,8	22,6	21,0	17,8	9,1	0,76	0,6	7,26
Means rainfall (mm)	2006	15,8	44,4	33,2	53,2	37,0	51,2	1,6	0.2	51,0	37,0	7,4	1,0	332,9
	2007	1,2	6,8	41,2	10,4	6,6	30,8	2,2	14,9	0,0	14,0	64,6	100,6	293,3
	2008	4,0	5,4	50,0	21,4	39,0	15,8	1,8	0,0	40,0	16,4	33,8	23,6	251,2
	2009	41,2	56,0	41,6	55,8	38,4	46,2	24,6	0,0	3,0	16,4	26,4	65,6	415,2
	2010	56,2	40,4	41,0	13,8	21,7	75,8	19,8	0,0	0,0	81,6	10,0	13,2	373,5
	2011	28,0	5,0	42,0	34,6	86	36,8	12,8	0,2	1,6	34,0	2,2	19,8	303,0
Means Humidity (%)	2006	85,9	93,0	74,1	60,0	73,5	57,0	48,6	37,9	62,1	79,6	84,2	80,0	69,7
	2007	78,0	84,0	73,0	64,6	48,7	55,3	33,9	39,5	41,4	60,0	77,3	83,5	61,6
	2008	84,0	77,0	56,0	54,2	42,4	47,8	42,0	41,2	88,1	74,5	82,3	93,4	65,24
	2009	91,2	87,5	81,0	74,0	56,3	54,9	43,9	58,1	58,1	57,8	87,5	90,9	57,18
	2010	89,1	76,7	75,9	65,9	54,6	63,3	49,1	38,8	44,3	67,8	56,34	85,3	63,92
	2011	73,9	66,5	59,2	81,4	76,6	68,9	51,4	49,0	48,3	66,6	74,9	80,7	66,45

This was easy way to reproduced leymus for us. Because its seeds could be never germinated in plastic bags. Seeds of *Petrosimonia nigdensis*were sowed to plots directly in the field. The other plants' seedswere sowed and germinated to plastic bags. At the beginning, seedling time,fertilizer with nitrogen and phosphore was applied to plots. Following years fertilizer with N was used only in spring time. All plots were irrigated to support growth in the first year. After the first year, irrigation was cancelled and rainfed condition is choosen. Level of water table was observed and measured along all growing period. Some observed values are given in Table-2. This table shows us, levels of water table were under 1.50m depth all trial years except 2011. This means there was no capillarity rising from water table to soil surface. However, in the year of 2011, water table rised up to soil surface notably.

Table 2. Values of observation wells water levels in trial fields

Years	Periods	Depths of watertable in wells	
		A	B
2006	May-August	155+	155+
	September-October	180+	180+
2007	June	167	170
	July	165	169
2008	June	160	167
	July	160	164
2009	June	148	173
	July	151	163
2010	June	151	155
	July	154	156
	November	155	185
2011	05 July	37	40
	18 July	54	97
	27 July	74	80
	28 July	67	73
	07 December	123	135

Every year, after the harvesting, soil samples were collected from each plots per 20cm soil strata till 60cm depth. Soil samples were analyzed to determine the salinity parameters. The plants were observed to understand adaptation conditions, yields were measured and some ions content of plants were analyzed to assess some salinity parameters. The amount of salt taken from the soil by plants was calculated.

Results and Discussion

Soil

In spring season top soil layer (0-20cm) is generally unsalted (EC<4dS/m)but following depths of soil are saline (EC>4dS/m). However in harvested season, EC values of top soil were increase more than 4dS/m. Soil pH level was bigger than 8.2 and Exchangeable Sodium Percentage value (ESP) was bigger than 15 in top soil layer in spring season. This means there is alkalinity in top soil. However, these high pH and ESP values are lower in deeper soil layers than top soil. We found that, these high values were decreasing to lower degree in top soil layers at harvested season. Therefore, alkalinity is disappeared in harvested time.

The soil samples were analyzed after all harvesting to determine salinity parameters. These parameters are EC, soluble cations (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}) and soluble anions (CO_3^{-2}, HCO_3^{-}, Cl^{-}, SO_4^{-2}) in saturation extract and exchangeable cations. Results of some important salinity parameters belong soil samples were given in Table-3 as comparatively for first year (2006) between last year (2011). It is noticed that given parameters are generally reduced in soil except control (N= native plants) and *Agropyron elongatum* (B) plots. The other parameters gave similar results.

Table 3. Means of soluble Na concentration and total soluble cations in soil layer of 0-60cm and Rate of salt (EC-as dS/m) reduced from trial plots (2006-2011)

Plants	Treatments	Years	Sum of Soluable Sodium (me/l)	Total Cation (me/l)	EC (dS/m)	Reducing Rate of EC (%)
Leymus cappadocicus	A	2006	102.09	140.83	14.05	17.30
		2011	83.70	119.41	11.62	
Agropyron elongatum	B	2006	76.05	102.64	10.66	8.07
		2011	76.25	104.61	9.80	
Puccinellia koeiana	C	2006	95.76	133.92	13.61	21.75
		2011	89.13	120.85	10.65	
Kochia prostrata	D	2006	107.95	149.27	15.01	27.71
		2011	91.55	123.10	10.85	
Atriplex lentiformis	E	2006	115.02	160.41	16.12	47.46
		2011	64.85	89.74	8.47	
Halimione verrucifera	F	2006	98.30	157.88	15.74	41.55
		2011	68.24	95.68	9.2	
Artemisia santonicum	G	2006	89.13	116.47	11.88	31.65
		2011	54.23	81.81	8.12	
Camphorosma monspeliaca	L	2006	105.93	152.11	16.06	37.30
		2011	69.08	99.02	10.07	
Control (native vegetation)	N	2006	101.10	141.23	14.37	-1.81 (non sense)
		2011	109.55	142.27	14.63	
H (=A+C+F)	H	2006	93.22	125.44	12.35	31.01
		2011	60.39	86.27	8.52	
I (=A+C+G)	I	2006	99.78	147.69	14.84	26.95
		2011	81.24	112.54	10.84	
J (=A+B+F)	J	2006	118.27	170.27	17.26	39.57
		2011	77.78	107.98	10.43	
K (=A+B+G)	K	2006	103.22	136.77	14.59	19.12
		2011	89.61	125.64	11.8	

It is known that, salts in soil surface are leached down by winter and spring rainfall. Therefore salts are low in soil surface in spring, some plants can grow, and pastures are become green. Depending on hot weather, evaporation is increased and salts are accumulated to surface. For these reason plants dried and finally died. This event also was seen in control plot in our trial. Whenever plants died, leaves and other parts of them dropped in soil and mixed with soil. Therefore, salts consisted in by plant returned again to soil. However, salt content in forage plants spread around to environment while harvesting or grazing. This event provides to decrease soil salinity especially if area is suffered from secondary salinization. Halophytes have not any effect on reclamation in primary salinization but, they are very valuable for creating excess income in saline area.

Rainfall and drought created different EC levels (up or down) of the soil in years. According to Table-3 soil EC and total solubled ions reduce finally. Given values in Table-3 shows reduction of soluble sodium concentration and sum of soluble cations in soil layer of 0-60cm.

According to Table-3, reduction rates (as in %) of soil EC show us the highest reduction level is provided from *Atriplex lentiformis* (47.46%) plots. It is followed by *Halimione verrucifera* (41.55%) and *Camphorosma monspeliaca* (37.30%). The values of plots consisted mixed plants (J-39.57 and H-31.06) gives the other high reduction rates. We thougt that because there are halimione plants in these plots.*Artemisia santonicum, Kochia prostrata* (37.30 and 31.65) and *Gramineas* follow them.The lowest reduction of soil EC is determined from *Agropyron elongatum* plots. Because their growing was damaged heavily when they were harvested as explained under title-3.2.

In addition the study period is not enought to say about soil exchangable ions changes. Because it is not too easy changing exchangable ions by plants. The Russian scientists say that it is need at least 7 years for soil reclaimation secondary salinization.

Plants

Because of the too short growing season, we could not get harvesting opportunity in control-plot. Generally, there were annual plants in control plot. They are intolerant to salinity and dried in late spring. In addition, different species plants were occurred on control plot in every different year.

The first year (2006), seeds were sowed in plastic bags or seedbeds in greenhouse. After sufficient number of nursing plants were provided they were moved to trial plots and planted. But only *Petrosimonia nigdensis* seeds were sowed to plots directly in spring season. Because of the germination was not provided first time its seeds are sowed again in fall. In 2007, their germination and growing were good, plants height almost was 15-20cm but at following years plants disappear in plots. Shortly, we were not successful to grown *Petrosimonia nigdensis.* So that any soil analyse result isn't given about Petrosimonia under text- title- 3.1. But there is some information about plants' ion content on Tables-5 and 6. There was a native plant (*Petrosimonia spp*) between experiment plots and we noticed that its improvement was very good. That's why, we want to mention about it in text, additionally. Because of grazing, native plant can never grow taller in pasture. Our trial area was saved against grazing so that they could improve very well.

We also sampled and analized it. There was no problem relevant to other plants.

In the year of 2006, we didn't harvest plants because ofthey need more time good improving and it is only first year for the plants. Also some source advice this option. For example, upper parts of leymus baby plants dried and did not become green again untill roots were improved well. Occuring green parts of *Leymus cappadocicus* took long time. So that we couldn't see good improved leymus plant on soil surface until third year.

In 2007, only four plants harvested because they were good improved. They were agropyron, Puccinellia, halimione, and camphorosma. In addition baby plants were come into existence in camphorosma plots. They were reproducedby their seeds. This year was very dry in all season. All plants which is on pasture around trial area and also in our control plot never was become green. However, all plants on trial plots were green and alive.

In 2008- July, eight plants harvested. Leymus was not occured yet and agropyron couldn't be improved again for following 2 years along. We think about that first harvesting (in 2007) of agropiron were heavy or it was early to harvest or both of two. Some literature said that halophytic plants must be not harvested before then 3 years. Because they need more time for roots improving and also other parts of body. May be this was our mistake. It is saying that ifagropyron is harvested close of soil level, roots-improving and also tillering is being weak. Agropyron stopped their improvement while the other plants were going on to develope. Althougt some of the other halophytic plants still were weak. Because of that we took agropiron plant samples for analyse from mixed plots.

In following years they were showed different performance, in some years good, in some years stabile. Because of harvesting, plants couldn't cover on soil surface except halimione. It could cover soil surface wery well. But, non-harvested plants which are in fourth replication could be improved better and also some of them were transcended their plots. For example; puccinellia plant was improved wery well and also spreaded out by seeds depend on wind direction. Leymus plant was spread out of its plots because rhizoms transcended under soil. Agropiron plantswhich were in non-harvested plot were not spreaded but their height were longer than plants in harvested plot. Their height was arrived to 1.80cm.*Camphorosma monspeliaca* was had woody body and weak shoots.

In 2011, water table was gone up towards soil surface and its level was arrived 40cm deptht of surface. In this year leymus, agropiron, puccinellia and halimione were alive but the others was dried and perished. *Halimione verrucifera* was living but stopped to improve. *Camphorosma monspeliaca* had woody body and weak shoots.

Improving of plants which is grown in mixed plots was similar to others. For example, if plot had leymus, its area covered by leymus. It is mean that *Leymus cappadocicus* is dominant plant than the others. The other dominant plant is *Halimione verrucifera*.

To determine some salinity parameters about plants content we analyzed them. For this, plant samples were dried in 65°C and grinded. Then samples were treated with method of wet decomposition. Also samples were treated with method of Zn-acetate for salt (NaCl) analyse, We will mention about some plant analyses results for 2008. Because we managed to harvest all kind of plants in trial area in this year. In other years we could harvest only some. However we saw that all years' results are similar. Results for 2008-July is given Table-5. According to Table-5 and 6 it is seen that halimione and atriplex have the highest salts content (as NaCl) respectively 15.5% and 14.23% and these are followed by Native plant (6.70%). Salt level content is important parameter for forage. These plant have high salinity for animal feeding but it is not trouble. Because they have been able to mixed with other forage. This case is important when drought and forage scarcity.

Table 5. Results of plants analysis (2008)

Plants	Salt (NaCl)	Total Na		Total K		Total Ca		Total Mg		Total Cl	
	(%)	(ppm)	(%)	(ppm)	(%)	(ppm)	(%)	(ppm)	(%)	(ppm)	(%)
Leymus	2.52	8504	0.86	9482	1.11	5032	0.50	1586.91	0.16	17547	1.75
Agropiron	3.10	6110	0.71	15640	1.01	1523	0.15	492.27	0.05	25105	2.51
Puccinellia	3.03	2973	0.29	6764	0.31	2070	0.21	1003.27	0.10	19436	1.94
Kochia	1.08	2550	0.32	36005	2.60	4209	0.42	2829.41	0.28	13929	1.39
A. lentiformis	14.23	57637	5.78	31687	2.02	8090	0.81	7259.18	0.73	78069	7.81
Halimione	15.50	74583	7.49	18898	1.45	6524	0.65	4905.76	0.49	107871	10.79
Artemisia	1.48	5763	0.79	15249	1.45	5878	0.59	2224.29	0.22	9556	0.96
Camphorosma	2.92	16819	3.62	22808	1.36	2790	0.28	2153.83	0.22	18950	1.90
*Native plant	6.70	53694	5.38	19387	3.51	6905	0.69	9355.68	0.94	43084	4.31

*Native plant (may be *Petrosimonia spp*) was between plots

Table 6. Results of NaCl contents of plants in July (2007-2008-2009)

Plants	Salt (NaCl) (%)			
	2007	2008	2009	Mean
Leymus		2,52	5,24	3,88
Agropiron	3,28	3,10	4,15	3,51
Puccinellia	3,25	3,03	2,99	3,09
Kochia		1,08	2,17	1,63
A. lentiformis		14,23	7,11	10,67
Halimione	14,33	15,50	18,79	16,21
Artemisia		1,48	1,38	1,43
Camphorosma	2,41	2,92	3,74	3,02
*Native plant		6,70	13,40	10,05

In the same time these plants take up Na, K, Ca, Mg and Cl. Halimione contains the highest Na and Cl (followed by atriplex and native plant). Atriplex contains the highest Ca (followed by native plant and halimione). Native plant contains the highest K and Mg (followed by kochia, atriplex and halimione).

On the other hand, if we want to investigate how much salt taken away from soil we can see results of in Table-7. Table shows us some yields and taken away amount of salt by some plants. Just in this point we noticed that biomass is very important to take up salt from soil. However much plant content is high, if biomass is lower taken total salt will be lower. In the contrary even if salt content of plant is low, if biomass is high, taken total salt can be higher.

Finally we can say, *Halimione verrucifera* and *Atriplex lentiformis* are the best chosen for taking up salts from soil. Also we can say *Leymus cappadocicus, Agropyron elongatum and Puccinellia*, can be the best chosen for high water table condition but also they can be produced in dried conditions. In spide of their growing and taking up salts is weak, they can tolerant against salinity. In addition soil is not be bare and unworthy for farmer.

Table 7. Amount of salt taken up to by plants (Kg/ha)

Years	2007	2009	2011	2007	2009	2011	2007	2009	2011	2007	2009	2011
Yields (Kg/ha)	307,5	1290	5120	911,3	2530	12600	1686,8	7820	4140	763,7	2810	-
		Puccinellia			Agropiron			Halimione			Camphorosma	
Salt (NaCl)												
Kg/ha	10	42	166,5	29,9	83	413,4	241,7	1120,5	593,2	18,4	67,7	-
Mean		135,43			339,50			851,91			57,16	

Conclusion

- The best behavior of growth to grow halophytic plants is firstly their seeds or cutting collect from their native habitat. However, they are not moved to too different climate or soil condition otherwise success cannot be too difficult.
- Although halophytic plants can grow in drought condition, irrigation provides better improving and productivity. Even irrigation with saline water can be useful.
- Until, roots and stems developed well (nearly 3 years), the plants must not be harvested or grazed. Particularly roots developing are needs time.
- Heavy harvesting causes to stop or perish plants improvement.
- Selection of halophytic plants to produce it must be known that favorable condition of plants (dried or saline, high or low water table etc.)
- When ground water was risen up at trial area only graminea plants went on to live. Almost all the others died.
- Biomass is very important to take up salt from soil. Because, in spite of biomass is low, even if salt content of plant is high, total salt taken from soil can be lower. In the contrary, in spite of biomass is high, even if salt content of plant is low, total salt taken from soil can be higher.
- In conclusion we can say, *Halimione verrucifera* and *Atriplex lentiformis* are the best chosen for taking up salts from soil. *Leymus cappadocicus, Agropyron elongatum and Puccinellia* are the best chosen not only for high water table condition but also for arid conditions. In spide of their taking up salts is weak they can tolerant against salinity. So that saline soil can be productive for farmer. This means that, soil is not being bare and unworthy.
- The trial area soil was tilled, but it was not necessary. May be it will be better planting with no tillage than with tillage farming. This will gives opportunities soil water conservation and saving native plants in area.
- The study period is not enough to reduce to soil exchangeable ions.
- The soil EC was showed differences because of rainfall and drought conditions during the experiment years, but finally soil EC were decreased. However it is too early for saying that case is created by plant. Because of the study-period and harvested-times are not enough to say this results. In the trial, some plots could be harvested two times and some plot three only.

The general consensus, about this type of field trial should be going on long years that must be at least seven years.

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References

Anonymous, (2008) In: United Nations Population Information Network; www.un.org/popin/data.html.

Anonymous (2009) FAO. Global network on Integrated Soil Management for Sustainable Use of Salt-Affected Soils. 17.07.2009. www.fao.org/agl/agl1/spush. In

Cheeseman, J. 1988. Mechanisms of salinity tolerance in plants. *Plant Physiology.* 87:104–108.

Choukr-Allah, R. 1991. The use of halophytes for the agricultural development of the Southern part of Morocco. Plant Salinity Research. Proc. Int., Cons. Agric. Management Salt Affected Soils. 377-386, April 26-May 3.

Choukr-Allah, R., Malcolm, C.V., Hamdy, A. 1996. Halophytes and Biosaline Agriculture, pp:17-30. Dekker, New York.

Flowers, T.J. and Colmer, T.D. (2008). New Phytology. 179, pp:945.

Flowers, T.J and Yeo, A. 1986. Ion relations of plants under drought and salinity. *Australian. Journal of Plant Physiology*. 13:75–91.

Glenn EP, O'Leary JW. 1984. Relationship between salt accumulation and water content of dicotyledenous halophytes. Plant, Cell and Environment 7: 253-261.

Glenn EP, Pfister R, Brown JJ, Thompson TL, O'Leary JW. 1996. Na and K accumulation and salt tolerance of *Atriplex canescens* (Chenopodiaceae) genotypes. *American Journal of Botany* 83: 997±1005.

Gleen, E.P., and Brown, J.J. 1999.Salt Tolerance and Crop Potential of Halophytes. Critical Reviews in Plant Sciences, 18(2):227–255.

Le Houérou,H.N.,1992. The Role of Salt Bushes (*Atriplex spp*) in Arid Land Rehabilitation in The Mediterranean Basin. A Review, Agroforestry System (18): 107-148.

Le Houérou, H.N. 1994. Forage halophytes and salt-tolerant fodder crops in the Mediterranean Basin. Halophytes as a resource for livestock and for rehabilitation of degraded landsTasks for vegetation science 34, 1994, Volume 32, Part C, 123-137, DOI: 10.1007/978-94-011-0818-8_10. http://link.springer.com/book/10.1007/978-94-011-0818-8

Le Houérou, H.N. 1996. Forage Halophytes in The Mediterranean Basin. In Halophytes and Biosaline Agriculture. R. Choukr -Allah, C.V. Malcolm and A.Hamdy (eds). Marsel Dekker publ. http://www.nhbs.com/halophytes_and_biosaline _agriculture_tefno_101082.html

Marcar, N.E., D.F. Crawford and P.M. Leppert. 1993. The potential of trees for utilisation and management of salt-affected land. *In* Productive. Use of Saline Land. Eds. N. Davidson and R. Galloway. ACIAR Proceedings 42:17--22.

Niazi, B.H., Rozema, J., Broekman, R.A. and Salim, M. 2000. Journal of Agricultural Crop Science-184, pp:101.

Rozema, J and Flowers, T. (2008). Crops for a Salinized World. Ecology in: Science-2. Vol; 322. pp:146-148. 10.1126/science.1168572. 5 December 2008. www.sciencemag.org

R. Choukr-Allah, 1997.The potential of salt- tolerant plants for utilisation of saline water. 313- 325. Options mediterraneans. CHIEAM----

Sardo, V. and Hamdy, A. 2005. Halophytes-A Precious Resource. In. Non-conventional water use: WASAMED project. Hamdy A., El Gamal F. , Lamaddalena N. , Bogliotti C. , Guelloubi R (eds). Bari : CIHEAM / EU DG Research. Options Méditerranéennes : Série B. Etudes et Recherches; n. 53. 2005. pages 119-128

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Detoxication of irrigated soils contaminated by nickel in Southern Kazakhstan

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Abstract

Currently, a significant negative factor in reduction of soil fertility is the factor of soil contamination with heavy metals, pesticides and other pollutants. Our research results show the increase of heavy metals concentration in irrigated soils in particular Pb, Ni and Cu. In addition, deterioration of environmental, soil and reclamation conditions of irrigated areas has also led to reduction of soil protection features in terms of Pb and Ni and 4.1 to 3.3 respectively. River water – the irrigation sources become more contaminated. Currently, the majority of irrigated areas in the south of the country are characterized by a regular increase of Pb and Ni concentration from irrigation to ground water (Otarov, 2007, pp.73-105). In this regard, the main objective of research work is to develop a method of detoxification (reduction of income to plants) of irrigated soils contaminated by Nickel. Experiments on developing of detoxication method of soils contaminated by nickel have been performed in Shieli rice area by conducting field vegetation experiment. Coal sorbent obtained by means of rice husk cracking was used as detoxicant for conducting experiment. The obtained data showed that a small dose of coal absorbent 0.4 g/vessel in comparison with the control, enhances nickel intake by rice plants, especially by corn and root to 24-25 %. And the following two tested doses 4.0 and 8.0 g per vessel, on the contrary, contributed to the decline of nickel intake by rice plants, and as the dose increases, the effect of soil detoxification increases. Coal sorbent depending on the applied dose reduces the flow of nickel in the most valuable part of rice - corn to 12.6-27.1 %. A similar pattern is typical for other organs of rice - straw and roots. Therefore, we suggest to use coal sorbent in periodically flooded rice soils, depending on the degree of pollution to reduce the intake of nickel by rice plants. Using this data, the regression equation (y =-2.06x2 +7.79 x +15.85) has been done which clearly describes (R2 = 0.7482) the dependence of intake of nickel in the most valuable part of rice - wheat from coal sorbent dose. This equation can be used to determine the appropriate dose of coal sorbent when concentration of nickel content in soil is known.

Keywords: soil pollution, heavy metals, detoxification, rice.

Introduction

The main areas of irrigated soils are located mainly in the south and southeast of the country in four regions. Productivity of irrigated soils of Kazakhstan is 4-6 times higher than of non-irrigated. They cover approximately 6 % of arable lands, and they provide more than 30 % of gross agricultural production of the republic. However, extensive development of irrigation soils in the valleys of large rivers without sufficient scientific justification, which was practiced before, has led to unsustainable use of water resources, their

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almost complete depletion, soil degradation, particular in salinity, water logging and desertification at the same time, reduction of profitability of agricultural production.

Currently, a significant negative factor in reduction of soil fertility becomes a factor of soil contamination with heavy metals, pesticides etc. Irrigated areas usually occupy subordinate hydromorphic terrains, which therefore are subject to contamination. Results of our researches have shown soil contamination in main irrigated areas with heavy metals, in particular Pb, Ni and Cu (Otarov, 2007, pp.73-105). In addition, environmental degradation, soil reclamation and soil conditions also resulted in reduction of their protection capabilities with regard of heavy metals (Otarov, 2005, pp.131-132). River water, irrigation sources become increasingly polluted, due to increasing human pressure on the environment. According to our data waters in Kyzylorda region have particularly critical ecological status, which is characterized by steady increase of the content of Pb and Ni from irrigation water to ground water (Otarov, 2007, pp.73-105).

Based on the foregoing, we can say that assessment of current environmental state of soils in irrigated areas, study of biogeochemical parameters of heavy metals and development of scientific foundations of technology of improvement of their ecological condition are the relevant issues of soil science, which have both fundamental and practical importance.

Moreover, despite the great diversity of soil surface in irrigated areas in the republic, the problem of establishing regional background levels of heavy metals concentration in irrigated soils remains unresolved. In this regard the study and systematization of data on background content of heavy metals in irrigated soils at regional level is also very relevant issue needed for the assessment of sustainability and stability of irrigated ecosystems to global and regional anthropogenic impact.

The relevance of this work is of particular importance also in terms of the upcoming accession of Kazakhstan to the World Trade Organization, which activity is based on the document "Agreement on Application of Sanitary and Phytosanitary (SPS) Measures" dated 1994 designed to ensure food safety. Upon accession to the WTO the natural choice is to use internationally recognized and actually "objective" standard. Such international standards, which are based on the results of scientific analysis of risks to human health, have been adopted by the following authoritative bodies aimed to establish international standards: Commission «Codex Alimentarius» on implementing joint program of FAO and WHO on food safety standards, Office International des Epizooties (OIE), World Plant Protection Convention (IPPC) .

In connection with the abovementioned, the main objective of the project is to assess the current ecological status of irrigated soils in Shieli area and development of scientific principles to improve their ecological status.

Material and Methods

The object of the research included different saline soils in Shieli irrigation area (Figure 1). The area is located on the right bank of the Syr Darya river in its pre-delta part. The area surface has characteristic of alluvial-accumulative plains in desert region (Otarov, 2007, pp.73-105).

On its territory there are four more or less significant depressions of channel form. The oldest of them, with most smooth features, is observed along the foothills of the southwestern slopes of Karatau mountains. Second channel shape depression has more strict features; in some places there are the oxbow lakes filled with water; the third and the fourth - modern riverbeds of Syr Darya river and duct Chiilinka with already formed near channel banks. In addition to these two macrorelief elements, on the plain there are developing levees and flat ridges, which make shapes of the hollows of inter channels depressions. The height oscillation amplitude between interchannels depressions and flat watershed ridges is small and only in some places is more than 1 m.

Specific types of precipitation correspond to the mentioned elements of accumulative relief which deposition occurs in certain hydrodynamic conditions, i.e., the process of litomorphogensis unity occurs which is manifested in close interaction between facial composition of alluvium and its horizon forms. The essence of this interaction determined in Syr Darya lowlands (Otarov, 2007, pp.73-105), is that Syr Darya river being the main suppliers of ancient and modern alluvium, unevenly, but naturally distributes it along its flow in general and along normal during floods.

Accordingly, in summing of the river bed banks the silty - sandy and silty light loam soils are prevailing and they are underlain by channel alluvium - silty fine sand. Hollows of inter-channel slides are formed predominantly from clay and loam - lake type alluvium. In structuring of the flat watershed ridges participate grounds with more varied grain composition with predominating dusty loam and sandy loam soils.

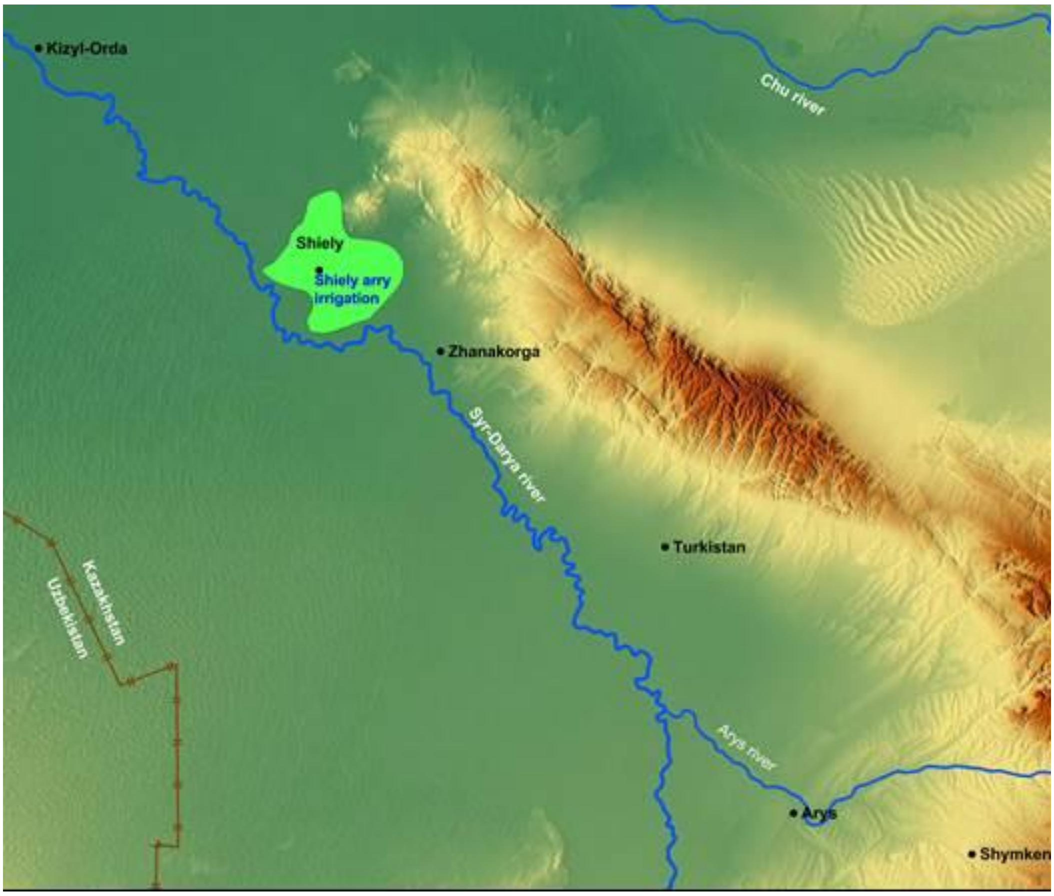

Figure 1 – Scheme of location of research object - Shieli irrigation area

In the structure of the quaternary stratum of 50 m capacity, prevail sandy loam and sandy sediments. The section is characterized by two-component structure - loam- clay deposits cover the sandy loam and sandy layers. Capacity of loamy cover in the area of ancient river bed of Syr Darya reaches 3-4 m, towards the modern riverbed its power reduces to 1 m. Quaternary alluvium is underlain by saline clays of Tertiary age.

Main direction of farms in the area is crop production. Rice is the main crop in the structure. Crops in crop rotation with rice are alfalfa as previous crop and winter wheat cover crop.

Earlier here takyr soils of various degrees, marsh and meadow- marsh soils have been used for rice growing. After long use of these soils for rice growing they have evolved in classification of Kazakhstan soil scientists (Borovsky, 1959, 418 p., Karajanov, 1973,171 p., Volkov, 1983, pp.46-50) as *irrigated (rice) marsh* soils. Changes in soils under this crop are associated with specific growing conditions - periodic long flooding and drying.

By type of salinity the soils are chloride-sulfate, with significant predominance of sulfates. Soil salinity regime consists of summer wash cycle (during flooding of fields) and autumn cycle of salinity restoration (after irrigation period).

Described soils are characterized by low humus content - 1.2-2.4 %. Soil humus profile is leveled and strongly stretched. Significant amount of humus (about 1 %) can be found at a depth of 1 m and below, that is not typical for other soils. Within the topsoil of paddy fields changes can be found, which appeared again as a result of flooding: gray very thin surface layer of 0-1 cm, in which aerobic processes are observed; black iron sulfide horizon 1-5 cm, sometimes a second iron sulfide horizon at a depth of 16-19 cm or some spots up to 30 cm; white- bluish horizon 5-20 (30) cm. Thus, we can say that irrigated (rice) marsh soils on morphological characteristics are characterized as extremely varied on profile and highly variable in time. All these qualitatively new soil features of periodically flooded rice soils are described in details by V.M. Borowsky et al. (1959).

Soil-forming processes in the territory of the research object occur in conditions of the desert climate, predetermined by a significant continental character and low precipitation (less than 100 mm per year), high value of evaporation (1500-1700 mm per year), high summer and low winter temperatures and significant amplitude of daily temperatures fluctuations. Because of this, here land cultivation is only possible with irrigation. Moisture is a critical condition, which determines the direction of the soil formation process and productivity of agriculture.

Management and regulation of water balance components of the territory, in general, have important influence on the crop yield capacity and direction of soil formation. Excessive intake of water on the territory causes a deterioration of the state of reclamation condition, and leads to waterlogging and salination. Shortage of water causes damage of crops and changes of direction of soil formation towards desertification. Syrdarya *river is a source of irrigation water* in the area. Water is supplied by Novoshieli main canal with capacity of 122 m^3/sec. It was built in earth channel and has a low efficiency coefficient. Removal of drainage sewage waters is carried out by Telikul irrigation channel.

In carrying out soil- ecological survey, were used official manuals and instructions (All-Union guideline, 1973, 95 p., Guidelines, 1979, 137 p.). Definition of soil ecological state was conducted in accordance with the requirements of GOST and Methodological recommendations governing the work on study of soils in general and local pollutions (GOST, 1985a, 1983b, Guidelines, 1981, p. 62, Methodological guidelines, 1989, 62 p.) In the process of soil-ecological survey, determining of regional background levels of heavy metals in soils was done in sections. Also soils of the arable soil horizon have been selected. In total 266 soil samples have been selected and analyzed for composition of mobile and total forms of 5 heavy metals.

Map - schemes of heavy metals concentrations in the environment have been done with the use of GIS computer program MapInfo professional. To develop methods of improvement of the ecological state of soil status and reduction of the entry of heavy metals in plants, field experiments on artificially contaminated soils were carried out with conditions maximally close to production conditions. Experiment schemes and detailed conditions of the experiment will be presented in the relevant chapters of the work .

Heavy metals were determined by atomic absorption method on spectrometry AA - 6200 of the Company «Shimadzu» (Japan). For determining total forms of heavy metals was used acid digestion, mobile form was determined by acetate ammonium extraction buffer solution with pH 4.8.

Statistical processing of obtained data was carried out by conventional methods of mathematical statistics, described in (Dmitriev, 1995, 320 p., Dospekhov, 1979, 416 p., Savic, 1972, 103 p., Wolf, 1966, 255 p) using analyzes package program «Excel - 97" and «Atte Stat».

Results and Discussion

When contaminants get into the soil and form a technogenic stream which in the soil profile meets soil geochemical barriers (carbonate, gypsum, saline, gley, illuvial-iron- humus horizons). Part of toxic elements can transfer into compounds which have difficult access for plants. Other part of the elements which are mobile in the soil-geochemical environment can migrate in soil, and represent a potential danger to the plants.

In modern agriculture, various activities are held on detoxification of soils contaminated with heavy metals and restoration of their fertility. These include: liming of acidic soils, application of organic fertilizers, use of phosphate fertilizers, deep tillage, selection of resistant crops and others. However, the effectiveness achieved by these techniques depends on many factors related to the soil properties, cultivated crop, as well as type and dose of fertilizer, chemical composition and properties of heavy metals.

Different methods used to reduce the content of heavy metals in soils and plants, have both disadvantages and advantages. At present there are no universal methods of detoxification of soils contaminated with heavy metals. Therefore, we believe that the methods of soil detoxification should be developed to specific agrolandscapes based on properties of its main components - soil, crops, groundwater and surface water, which makes the method more effective. All of them, depending on soil properties, cultivated crops and metals-pollutants are carried out in two main directions. The first is based on leaching of mobile forms of metals by washing or removal by plants. Second - transfer of metals in forms which are hard soluble and inaccessible for plants.

Soil of Shieli irrigation area, as well as all soils of rice fields are very specific due to the existing system of their use. Their specificity is determined primarily by soil formation process characteristics, which takes place in conditions of annual periodic flooding under rice during the whole growing season and subsequent intensive drying of soils in the desert climate. Constant alternation of cycles of increased wetting and drying of soils, the development of contrasting modes inevitably causes damage of certain systems prevailing in the soil. Especially sharp changes occur in the soil oxidative and restoration regime, which largely determines the nature of soil formation process, in particular, migration of elements in the soil mass, the processes of humus formation nutrient regime, etc.

In the result of long term flooding also occur significant changes in mineralogical composition, properties and profile distribution of fine fractions, especially in those regions where the excess moisture of soil is not a natural feature (Otarov, 2007, pp. 73-105). Taking the above mentioned factors of unfavorable soil properties of paddy fields and the general reclamation state of the area, especially ineffective performance of drainage network, we used the second direction - transfer of metals into forms which are hard soluble and inaccessible for plants, in order develop a method for reducing heavy metals in rice plants. We took into account the fact that the inflow of HM in plants depends not only on the total content of element in the soil, but also on the form of metal in the soil. Most often plants easily absorb mobile form of metal, the amount of which depends on various soil properties. At the first stage of work, by conducting soil- ecological survey were determined heavy metals priority for Shieli irrigation area. Moreover, evaluation of heavy metals concentration, taking into account the abovementioned facts, was carried out on environmentally hazardous mobile form. Priority metals for the area were lead and nickel, hazard ratios (exceeding MPC) of mobile forms, which are respectively 2,4 ± 0,04 and 1,6 ± 0,04. Therefore, for conducting the experiment was used soil contaminated with nickel. Methods of reduction of lead intake in rice plants and rotation crops have been developed in different project (Otarov, 2009, 16 p.).

In the experiment carbon sorbent produced at the Institute of Combustion by cracking from rice husk at Bakanas rice plant was used as detoxicant. Prior to mixing with the soil, sorbent were sifted through 2 mm soil sieve. Experiments in 2010 were carried out on the territory of the Shieli rice cultivation area in conditions of field experience. Experiments were conducted in plastic containers holding 7 liters with open hole at the bottom which provided appropriate hydro-module of drainage flow. Pebbles, washed river sand and clean gauze circles were used as filters. For the experiment, soils from rice fields were used which were artificially contaminated by priority metal - nickel at 4 MPC of rice plot soil. The sorbent was also introduced into the soil by mixing during filling the vessel. Besides the control, three doses of sorbents - 0.8; 1.6 and 2.4 g/pot were used. The experiment was conducted 3 times.

Rice variety of local breeding Marjan which was zoned for conditions of Shieli irrigation area was used for sowing. At each vessel 15 seeds were sown. After germination in 2-3 leaf stage, plants were thinned out and 7 plants were left in each container. Vessels were located directly in the production environment in paddy fields, i.e. plant care, irrigation regime, fertilizer application system were fully consistent with production conditions. According to the growing technology adopted in the farm, in the phase of 2-3 leaf, ammonium sulfate at the rate of 300 kg/ha in bulk was applied.

After ripening of rice, harvest and concentration of nickel in rice grain have been analyzed. As the results show, carbon sorbent at all tested doses had increasing impact of income of cadmium in rice grain (figure 2). Maximum intake of cadmium in rice grain was observed at the first dose. Rice grain in first variant had concentration of Cadmium by 12.3 mg/kg higher than in control variant. The following two variants also had concentration of cadmium higher than in control variant, respectively, 10.1 and 8.9 mg/kg. But at the same time, in the experiment variants with increasing dose of carbon sorbent, a regular significant (R2 = 0,8018) decrease in intake of nickel in rice grain was observed. So, we concluded that the doses of carbon humate taken for the experiment were insignificantly high. For checking the hypothesis on insufficient experimental doses (amounts) of carbon humate for transfer of nickel into the form which is unavailable for rice plants, which was done based on the results of experiment in 2010, in 2011 the experiments on developing the ways of reducing nickel in rice plants were repeated.

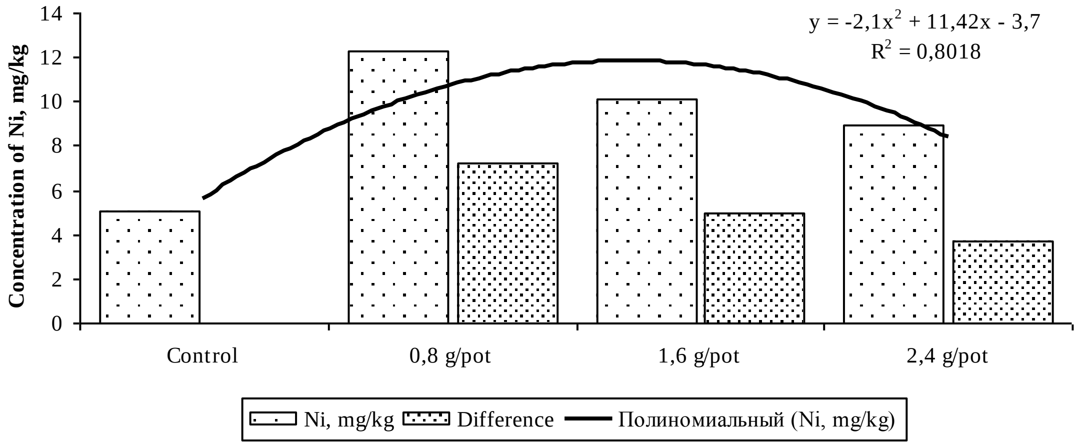

Figure 2 - Effect of different doses of carbon humate on income of nickel in rice grain

Taken doses of carbon sorbent were low dose (2.4 mg/pot) and high dose (4.0 and 8.0 mg/pot) than in the experiments in 2010. Experiment method was similar as in 2010. The only difference was that in 2011, after ripening of rice for determination of patterns of distribution of nickel in rice plant organs, nickel was identified not only in grain but also in rice straw and roots.

The experimental results showed that on concentration of nickel in rice plant organs regardless of the dose of carbon sorbent, its regular decrease from roots to grain has been observed (table 1).

For example, in control variant, organs of rice depending on concentration of nickel are located in the following decreasing line: root > straw > grain with corresponding nickel content in mg / kg 121.9 > 27.7 > 20.7. A similar pattern of distribution of nickel in plant organs is also characteristic feature of other variants of the experiment (doses of carbon sorbent).

It is known that in plants different heavy metals are accumulated differently. In certain organs and tissues of some plants their concentration may increase greatly, without any specific limits. In most plants it is a root system. In most cases, the plant root system by absorbing and holding heavy metals at the boumdary "root - stem" performs the role of a barrier, and as it is seen from the results of our experiment, root of rice also served as barrier for nickel.

As can be seen from the obtained data, a small dose of carbon sorbent 2.4 g/pot compared with control variant facilitated income of nickel in rice plants, especially in grain and root, to 24-25 %, which complies with experimental data in 2010 (figure 3).

The following two tested doses 4.0 and 8.0 g per pot, as expected, on the contrary contributed to the decline in nickel intake by rice plants, and as the dose increases, the effect of detoxification of soils increases.

Depending on the applied dose, carbon sorbent reduces the flow of nickel in the most valuable part of rice - grain to 12,6-27,1 %. A similar pattern is typical for other organs of rice - straw and roots. Therefore, in periodically flooded rice soils, depending on the degree of pollution, for reduction of income of nickel in rice plants, we suggest to use carbon sorbent.

Table 1 - Effect of carbon sorbent on income of nickel to rice plant organs

Variants	Concentration in organs, mg/kg			Outlet of Ni in comparison with control, (+ increase, - reduction)					
	grain	straw	roots	grain		straw		roots	
				mg/kg	%	mg/kg	%	mg/kg	%
Control	20,7±3,69	27,7±10,3	121,9±12,5	-	-	-	-	-	-
0,4 g/pot	25,9±8,70	28,6±9,55	151,7±50,8	+5,2	+25,1	+0,9	+3,2	+29,8	+24,4
4,0 g/pot	18,1±2,37	15,1±0,13	81,6±13,04	-2,6	-12,6	-12,6	-45,5	-40,3	-33,1
8,0 g/pot	15,1±5,33	18,3±5,42	106,3±6,65	-5,6	-27,1	-9,4	-33,9	-15,6	-12,8

Using the obtained data, regression equation ($y = -2.06x2 + 7.79 x + 15.85$) was done which authentically describes ($R2 = 0.7482$) the dependence of intake of nickel in the most valuable part of rice - grain on carbon sorbent dose. We propose to use this equation to determine the required dose of carbon sorbent in case when nickel concentration in soil known.

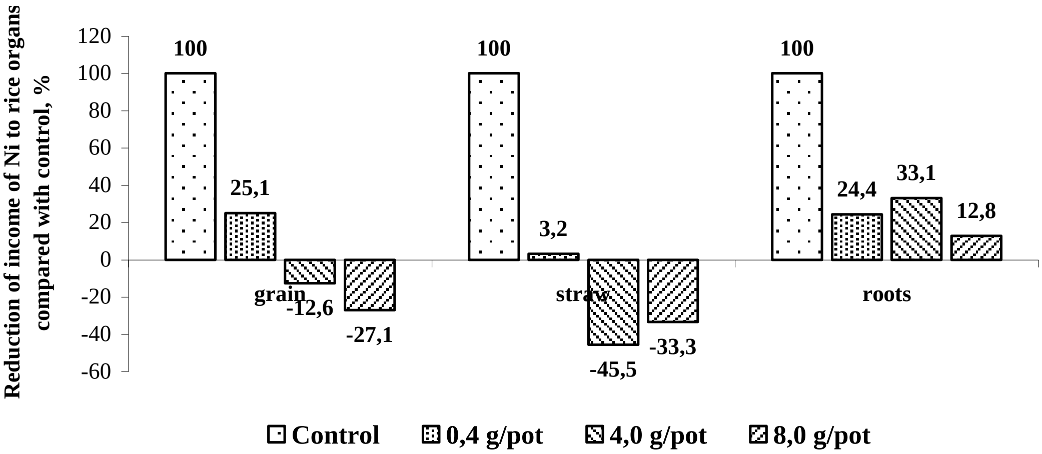

Figure 3 - Reduced income of nickel in various organs of rice crop, depending on the dose of carbon sorbent

Conclusion

Thus, in conclusion, we can note that carbon sorbent depending on the applied dose reduces the flow of nickel in the most valuable part of rice - grain to 12,6-27,1 %. A similar pattern is typical for other organs of rice - straw and roots. Therefore, in periodically flooded paddy soils in case of soil contamination with nickel, for reduction of its income in rice plants, we suggest to use carbon sorbent produced from rice husk. Rice husk - is a product obtained during processing of raw rice to milled rice. Currently, it is almost never used, its use is problematic issue of rice plants in the country.

References

All-Union guideline for soil surveys and developing of large-scale soil maps of land use. 1973. “Kolos”, Moscow. 95 p.

Borovsky V.M., Ablakov E.B., Kozhevnikov K.Y. 1959. Ancient delta of the Syr Darya river and Northern Kyzyl Kum. V.2 . Academy of Sciences of the Kazakh SSR, p.418.

Dmitriev E.A. 1995. Mathematical statistics in Soil Science. Moscow State University Press, Moscow, 320 p.

Dospekhov B.A. 1979. Technique of field experience. Publishing House "Kolos", Moscow. 416 p.

Guidelines for large-scale soil survey in Kazakh SSR. 1979. Alma- Ata, 137 p.

GOST 17.4.3.03-1985 Conservation of nature. Soils. General requirements for methods of determination of pollutants.

GOST 17.4.3.01-1983 Conservation of nature. Soils. General requirements for sampling.

Guidelines on field and laboratory studies of soils and plants in environmental pollution by heavy metals. 1981. Publishing house "Gidrometeoizdat", Moscow, 107 p.

Karajanov K.D. Soils in Kazalinsk area and prospects for their use. Science Kaz SSR, Almaty. 171 p.

Methodological guidelines on determination of heavy metals in soils and agricultural crop production. 1989. Gosagroprom USSR, Moscow, 62 p.

Otarov A., Ibrayeva M.A., Saparov A.S. 2007. Degradation processes and current soil- ecological condition of rice areas in the republic. Ecological bases of formation of soil conditions in Kazakhstan in terms of anthropogenis and development of theoretical framework of fertility reproduction. 73-105.

Otarov A. 2005. Protective measures of periodically flooded paddy soils in terms of heavy metals. Status and prospects of soil science. Materials of the international scientific conference dedicated to the 60th anniversary of the Institute of Soil Science named after U.U. Uspanov, Tethys, 131-132.

Otarov A., Ibrayeva M.A., Ustemirova A.M. 2009. Recommendations on reduction of the intensive income of heavy metals in main crops in rice-alfalfa rotation. Almaty, 16 p.

Savic V.I. 1972. Application of variation statistics in soil science. Teaching aid. Publishing House of the TAA, Moscow, 103 p.

Volkov A.I. 1983. Systematic description of soil. For. Soils of the Kazakh SSR. “Nauka” Kazakh SSR, Almaty, pp. 46-50.

Wolf V.G. 1966. Statistical processing of the experimental data. Publishing House "Kolos", Moscow, 255 p.

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Changes in the physical and chemical absorbing power and nutritive regime of replantosol formed on loess in the foothills of Ile Alatau

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Abstract

Long-term researches of soil-formation process on reclamate freshly exposed loess are conducted by soil permanent study area of Agriculture University which is situated in Kastanozem soils zone in the foothills of Ile Alatau. Soil permanent study area consists of 72 concreted plots measuring 2 m^2. They were filled with loess to a depth of 60 cm in the spring of 1991. Quantity of long studied variants is 5, one of them has natural undisturbed profile of Kastanozem. There is also variant with loess filled in 1971. Different doses of ameliorants were applied and phyto-improvers were seeded on variants, which were filled from 1991. In 1994-1995 test sowing were made and from 1996 it was left as neglected field. According to the research of 1991-2012 years, it was established, that calcium cation is predominant in composition of absorbed bases. Its content of total cations has increased from 66% to 82% after 18 years (1991 -2009) of pedogenenic process. The highest rates of exchange capacity and calcium content in absorbed bases are set on variants Natural Kastanozem, Loess, since 1971, Phytocontrol, Vermicompost, 27 ton ha^{-1}. This confirms the dominant role of the time factor and the reclamation of syngenetic pedogenenic process. Gradual increase of the exchange capacity (from 13.55 to 20.18 meq 100 g^{-1}) in time was established for explored variants. pH on loess in the 0-point of pedogenenic process was 8.2, and it was 7.8 after 21 years of pedogenenic process. The highest content of hydrolyzable nitrogen, after variant Natural Kastanozem (57.9 mg kg^{-1}) is established on variants: Loess since 1971y. (38 years) – 44.9 mg kg^{-1}; Vermicompost, 27 ton ha^{-1} (18 years) – 43.0 mg kg^{-1}; Manure, 60 ton ha^{-1} (18 years) and Phytocontrol (18 years) – 41.6 mg kg^{-1}. The same variants (13 years) – 30.8-39.2 mg kg^{-1}. The same variants (3 years) – 16.8 mg kg^{-1}. Then and there, the content of hydrolyzable nitrogen in replantosols depends on the duration of pedogenenic process and types of bioreclamation. Content of labile phosphorus in replantosol does not particularly depend on pedogenenic process and varies from 13.0 to 19.6 mg kg^{-1}. Maximum content of exchange and water-soluble potassium is observed in the upper horizon of r replantosols, it gradually decreases with depth. Exchangeable potassium content was low in the initial 3 years with fluctuations within 204,1-217,1 mg kg^{-1}. For 13 years and 18 years, their number stabilizes at 384-403.8 mg kg^{-1}. Content of mobile nutrients for 2009 shows that the best conditions for plant nutrition is observed on variants Loess since 1971, Vermicompost, 27 ton ha^{-1}.

Keywords: Physical and chemical absorbing power, nutrient status, soil formation, reclamation, loess, replantosols, vermicompost.

Introduction

Loess deposits are widespread in the uppermost part of the Earth's lithosphere and presented mainly by Quaternary continental formations of different genesis (Trofimov V.T. et al. 2001; Kadyrov E.V. 1979;

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Bolikhovskaya N.S. 1995; Lomonovich M.I. 1955). Currently it is the practice to combine a variety of loess and loess-like deposites under loess or loess deposite formations (Bolihovskaya N.S. 1995, P.8; Denisov N.Y. 1953; Lysenko M.P. 1967). It is distributed mainly in the steppe and semi-desert areas of the temperate zone of Eurasia, North and South America. It occurs in the form of covers with thickness from a few meters up to 100-200 m in the interstream areas and slopes» (Trofimov V.T. et al. 2001).

Loess area on our planet according to various estimates takes about 4.2 million km^2 or more of the total land surface (Trofimov V.T. et al. 2001. P.10; Bolihovskaya N.S. 1995; Lomonovich M.I. 1955. P.12). Now it is generally recognized Now generally accepted that the genesis of loess may be different. Most often, these deposits are represented by eolian, talus and proluvial types of sediment. (Trofimov V.T. et al. 2001, P.331).

The soils formed on loess (loess soil) are one of the most fertile soils in the world. Chernozems, Kastanozems, Calcisols, Cinnamonic soils etc. are formed on loess. Cultural centers of agriculture appeared in these loess soils (sierozem, cinnamonic soils of, etc.), along floodplain soils (Encyclopedia of Soil Science 2006, P.1040; Bakels C.C. 2009). Today loess soils are the primary support for agriculture and are the most urbanized areas. In spite of all these advantages loess soils are subject to erosion most of all (Encyclopedia of Soil Science 2006, P.537; Bakels C.C. 2009. P.1; Trofimov V.T. et al. 2001, P.6; World Bank…url). For example, the extent of erosion at loess table land are the most eroded in the world (Encyclopedia of Soil Science 2006. P.1768; World Bank…url), as loess soils have a low «elastic limit». Low «elastic limit» of ecosystems, formed on loess, is based on their properties. Buol S.W. in 1994 emphasized the problem for every type of soil «elastic limit», beyond which the soil loses the ability to regenerate itself and it is rapidly destroyed (Buol S.W. 1994). Therefore, the reconstruction of loess lands in the Republic of Kazakhstan is very important.

Soil and environmental conditions

The climate of piedmont and steppe zone of Ile Alatau is described in terms of the following properties: average annual air temperature is 6,4-9,8°C; the period with temperatures above +10°C lasts 164-182 days with the sum of effective temperatures (>10°C) 2510-3140 degrees; Annual atmospheric precipitation varies between 313-977 mm. A characteristic feature of Ile Alatau terrain is a broad skirt of foothills, extending along its northern slope. Sloping piedmont plains are located at the bottom of the mountains (Sokolov S.I. et al. 1962). Low-hill terrains and piedmont plains of Ile Alatau, where our experiments were carried out, are covered with a continuous cover of loess deposits, with thickness 30-40 m and more (Loess of USSR 1986, P.101-181), which are underlain at different depths by proluvial rubbly-pebble deposits.

Loess of Ile Alatau foothills has the following physical properties: weight ratio - 2,7-2,8; specific weight - 1,3-1,85 g/sm^3; poriness - 42-45%; dispensability – high level. bulk chemical composition (%): SiO_2-55,2; Al_2O_3-11,64; Fe_2O_3+FeO-4,0; CaO-10,3; P_2O_5-0,14, MgO-2,2; K_2O+Na_2O-4,36; carbonaceous rock - content $CaCO_3$ -15,9%. The amount of humus at loess reaches 0,30%. Medium reaction of deposite – alkali-type, and the dry residues are less than 0,1%. At the virgin Kastanozem the folloing gramineous is dominated - Stipa capillata, Festuca sulcata, Agropyrum repens, Koeleria cristata, Bromus inermis, Dactylis glomerata, Poa bulbosa, Avena fatua; motley grasses - Holosteum umbellat, Tulipa patens, Inula grandis, Allium caesium, Artemisia dracunculus, Artemisia glauca, Viola suavis, Peania hibrida, Origanum vulgare and others. Currently virgin vegetation is preserved mainly on the steep slopes of the ridges, near the forest plantations and inarable lands.

Kastanozem foothills of Ile Alatau, where experience is laid, have humus horizon (35-45 cm), with a humus content of 3 to 4.5%. Total absorbed bases comes up to 23-25 meq 100 g^{-1} g of soil. Soil solution reaction is mildly alkaline – pH 6,8-7,7. The soil is well supplied with moving nutrients. In the layer of 0-20 cm hydrolysable nitrogen comes up to 70,3 mg kg^{-1} N, labile phosphorus – 33,4 mg kg^{-1} P_2O_5, exchange potassium – 390 mg kg^{-1} K_2O. The total nitrogen content comes up to - 0,23-0,28% N, total phosphorus - 0,22-0,20% P_2O_5, total potassium 3,0-3,1% K_2O, carbon dioxide of carbonates in the upper horizons– 2,2-2,5%.

Material and Methods

To study the effect of reclamation on the recovery of disturbed lands the plot field experiment was laid with artificial horizon C (loess), turned out to the surface (Methodological … 1983; Golubev B.A. 1967; Kaurichev I.S. et al. 1996). The experience is laid on soil of KazNAU station, located in the piedmont plain of Ile Alatau. For this concreted plots size of 2 sq.m. each were used, they were filled with loess to a depth of 60 cm in the spring of 1991. Quantity of long studied variants is 5, one of them has natural undisturbed profile of Kastanozem (name of the variant - Kastanozem). . There is also variant with loess filled in 1971 (name of the variant - Loess since 1971y.). Different doses of ameliorants were applied and phyto-improvers were seeded on variants, which were filled from 1991 - Phytocontrol (loess + alfalfa), Manure, 60 ton ha^{-1} (loess + manure 60 ton ha^{-1} + alfalfa), Vermicompost, 27 ton ha^{-1} (loess + vermicompost 27 ton ha^{-1} + alfalfa). In 1994-1995 test sowing were made and from 1996 it was left as fallow land. Replication of the experiment is three times.

Vermicompost containing 50% moisture, total nitrogen - 1,0%, total P_2O_5 - 1,05%, K_2O - 1,27% were used in the experience. Bulk chemical composition of manure of cattle (half fire fang with litter) is following: total nitrogen - 0,46%, total P_2O_5 - 0,30% and total K_2O - 0,78%.

Soil samples were selected by soil sampler from each plot of variant from the depths of 0-10, 10-20, 20-30 and 30-50 csm in the third decade of July, 1993 (3 years of pedogenenic process), 2004 (13 years of pedogenenic process), 2009 (18 years of pedogenenic process) and 2012 (21 years of pedogenenic process). The obtained results were compared with the data of the original loess that was filled the concreted plots in spring of 1991 (Loess 0-moment of pedogenenic process).

In carrying out of experimental works conventional research methods were used (Arinushkina E.V. 1970; Case study on Soil Science 1986): hydrolyzable nitrogen – according to I.V.Turin and M.M. Kononova; labile phosphorus - according to B.P. Machigin, colorimetric; exchange potassium – according to B.P. Machigin, spectrophotometer; absorbed bases – according to E.V. Bobko and D.L. Askinazi; pH of aqueous extract – by potentiometry.

To establish the magnitude of the random error, the degree of accuracy and reliability of the results of the experiment mathematical methods (statistical) of data handling were used (Dospehov B.A. 1968; Dmitriev E.A. 1995).

Results and Discussion

Base exchange capacity is an important diagnostic feature and has a great influence on the physical and chemical properties of soils. The obtained results characterize increase of base exchange capacity depending on the duration of the pedogenenic process and applied ameliorants. It is known that the amount of absorbed bases also depends on the mineralogical composition and particle-size distribution of the deposits, pH and humus content (Makhonina G. I. 2003). Soil solution reaction or all variants of the experiment is mildly alkaline, near-neutral (pH 7,7-7,8).

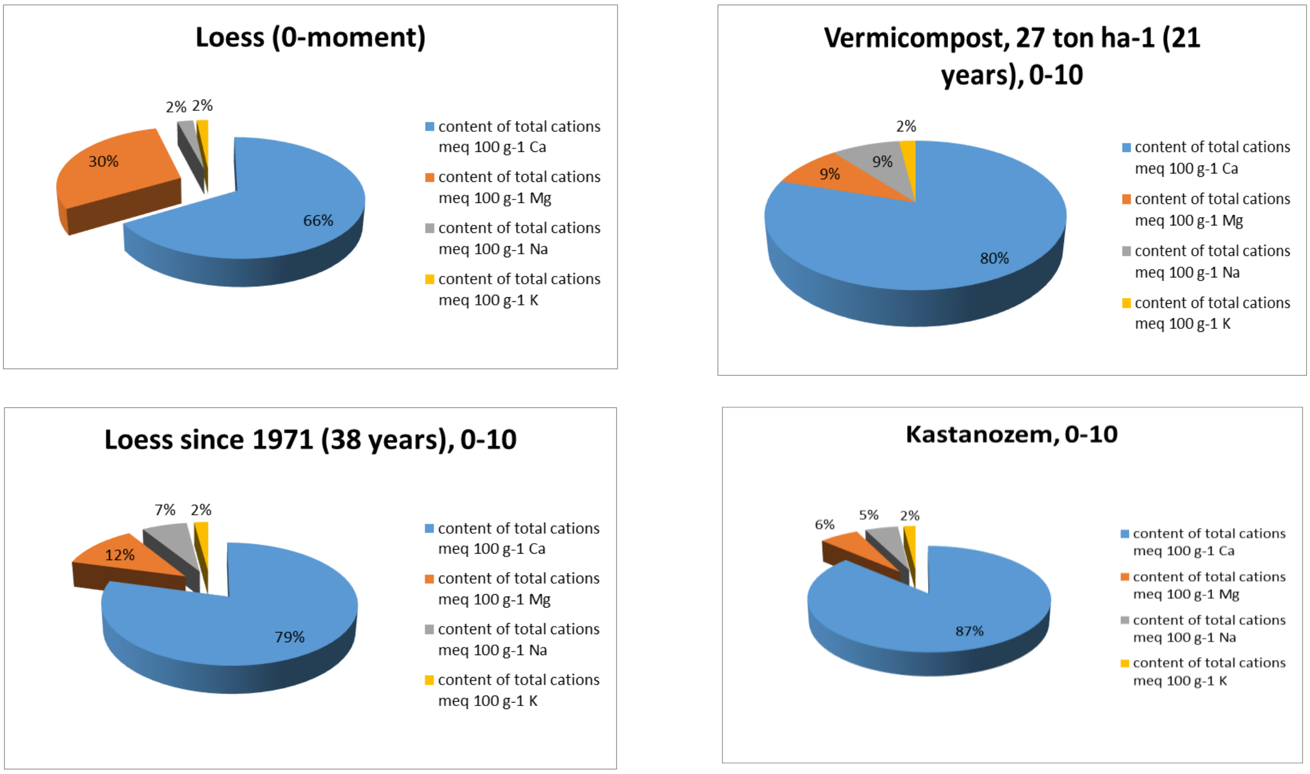
According to the research for the 1991 – 2012 yrs (Table 1), it was found that calcium cation is predominant in the absorbed bases composition. The highest parameters of exchange capacity and calcium content in the absorbed bases composition were identified on the following variants: Kastanozem, Loess since 1971y., Phytocontrol, Vermicompost, 27 ton ha^{-1} (Picture 1). Effective fertility, i.e the soil's ability to provide heavy yields, is characterized by containing of moving or digestible nutrients in the soil. The plants can absorb nutrients, which are in the soil in the form of compounds soluble in water, weak acids or weakly alkaline reaction of soil solution. The highest content of hydrolyzable nitrogen, after Kastanozem variant (57,9) was found in the variants: Loess since 1971y. (38 years) – 44,9 mg kg^{-1}; Vermicompost, 27 ton ha^{-1} (18 years) - 43,0; Manure, 60 ton ha^{-1} (18 years) и Phytocontrol (18 years) - 41,6 mg kg^{-1}. The same variants (13 years) – 30,8-39,2. The same variants (3 years) - 16,8 mg kg^{-1} (Picture 2). Thus, the content of hydrolyzable nitrogen in replantosols depends on the duration of the pedogenenic process and types of soil modification.

In loess and replantosol formed on it, the phosphorus content ranges 0,14-0,16%, and in Kastanozem it is 0,19%. Pedogenic loess deposits in their composition have almost no organic materials and the nearest source of phosphorus for them can be phosphorus minerals. Containing of moving phosphorus in replantosols is not particularly dependent on the soil-forming process (Picture 3) and ranges 13,0-19,6 mg kg^{-1}.

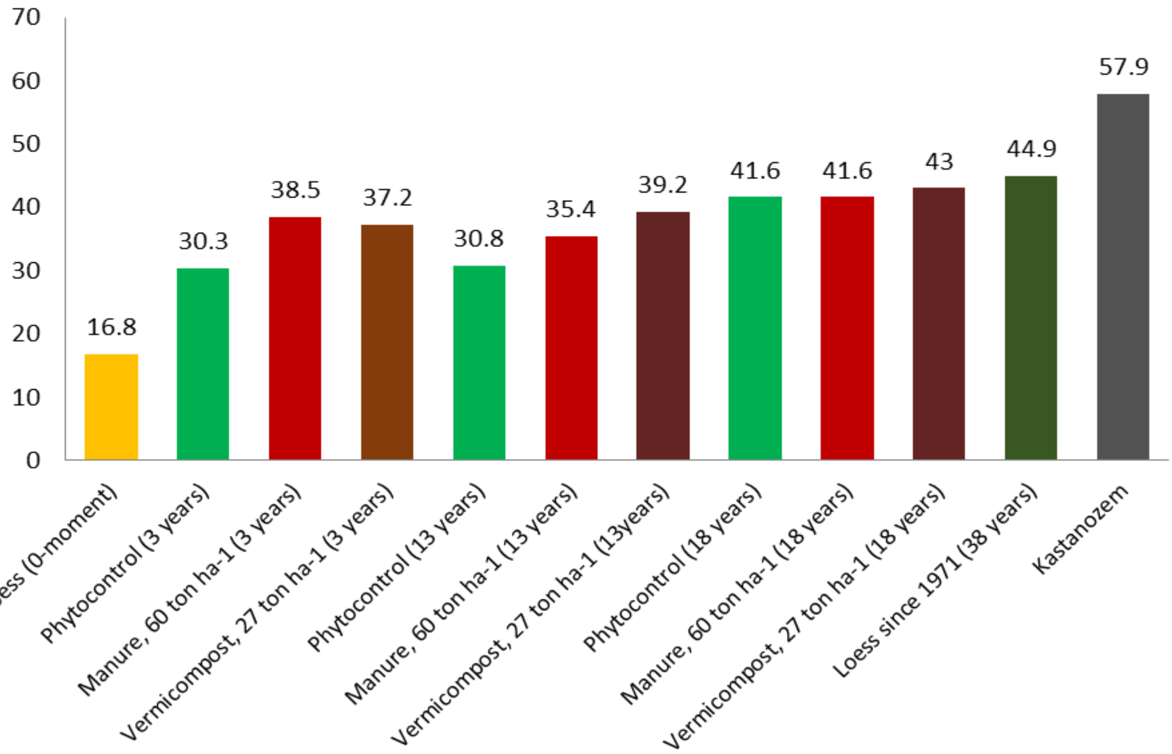
Maximum content of exchange and water-soluble potassium is registred in the upper horizon of replantosol, it gradually decreases with depth. Exchange potassium content was low in starting 3 years with ranges from 204,1-217,1 mg kg^{-1} (Picture 4). At 13 years and 18 years, their amount has stabilized at 384-403,8 mg kg^{-1}г. Content of moving nutrients for 2009 shows that the best conditions for plant nutrition are on the variants Loess since 1971y., Vermicompost, 27 ton ha^{-1}.

Table 1 - Change of physical and chemical properties of replantosol formed on loess of foothills of southeast of Kazakhstan, in the pedogenenic process (1991 – 2009)

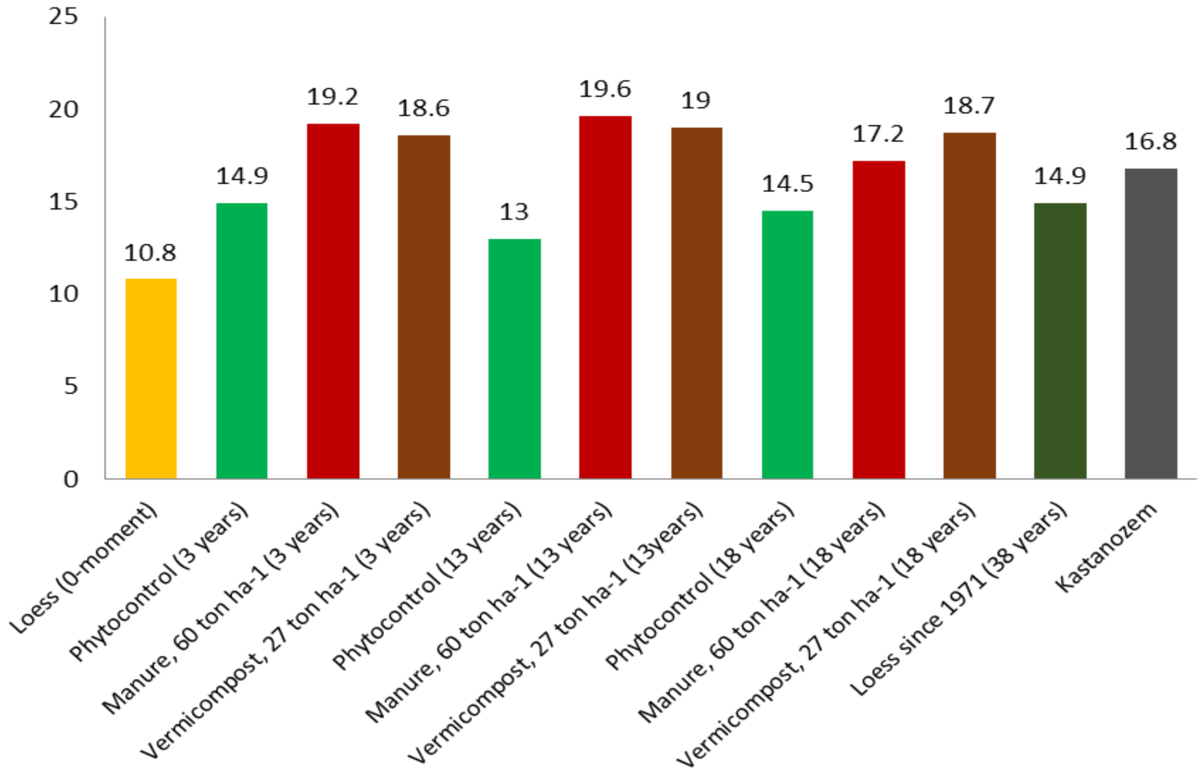
Variants	Depth, cm	adsorbed cations meq 100 g^{-1}								
		Ca^{2+}		Mg^{2+}		Na^{+}		K^{+}		Total
		$\overline{X} \pm m_{\overline{X}}$	Cv,%	$\overline{X} \pm m_{\overline{X}}$	Cv,%	$\overline{X} \pm m_{\overline{X}}$	Cv,%	$\overline{X} \pm m_{\overline{X}}$	Cv,%	
1	2	3	4	5	6	7	8	9	10	11
Loess (0-moment)	-	9,00 ±1,9	29	4,00 ±0,7	25	0,32 ±0,06	25	0,23 ±0,04	26	13,55
Phytocontrol (13 лет)	0-10	12,0 ±1,9	17	0,0	-	0,41±0,13	44	0,24 ±0,03	21	12,65
	10-20	12,0 ±2,1	25	0,0	-	0,41±0,07	24	0,24 ±0,1	50	12,65
Manure, 60 ton ha^{-1} (13 лет)	0-10	9,0 ±2,8	43	4,0 ±1,4	50	0,41±0,2	73	0,25 ±02,05	28	13,66
	10-20	9,0 ±4,8	75	4,0 ±0,7	25	0,41±0,1	44	0,25 ±0,05	28	13,66
Vermicompost, 27 ton ha-1 (3 лет)	0-10	12,0 ±1,4	17	0,0	-	0,41±0,1	49	0,28 ±0,08	43	12,69
	10-20	12,0 ±2,9	33	0,0	-	0,41±0,1	49	0,28 ±0,05	25	12,69
Phytocontrol (18 лет)	0-10	13,60 ±2,2	22	4,80 ±0,5	15	1,36 ±0,6	59	0,38 ±0,03	13	20,14
	10-20	13,60 ±1,04	11	4,80 ±1	29	1,36 ±0,2	22	0,33 ±0,08	36	20,09
Manure, 60 ton ha^{-1} (18 лет)	0-10	13,20 ±1,4	16	4,0 ±0,7	25	0,41 ±0,14	49	0,25	-	17,86
	10-20	12,80 ±2,2	25	4,0 ±1,2	43	0,26 ±0,1	52	0,31 ±0,1	23	17,37
Vermicompost, 27 ton ha^{-1} (18 лет)	0-10	14,40 ±5,4	53	2,40 ±1	2	1,16 ±0,6	68	0,42 ±0,2	74	18,38
	10-20	13,60 ±4,6	48	2,60 ±0,7	26	1,16 ±0,8	93	0,34 ±0,2	91	17,72
	20-40	12,00 ±1,9	22	1,40 ±0,6	55	1,36 ±0,9	95	0,27 ±0,04	22	15,03
Loess since 1971 (38 лет)	0-10	16,00 ±1,3	16	2,40 ±1,5	88	1,36 ±0,5	51	0,42 ±0,3	95	20,18
	10-20	15,20 ±0,4	77	1,60 ±0,4	31	1,36 ±0,3	29	0,27 ±0,04	18	18,43
Kastanozem	0-10	20,00 ±5	35	1,40 ±0,7	72	1,16 ±0,2	26	0,42 ±0,2	71	22,98



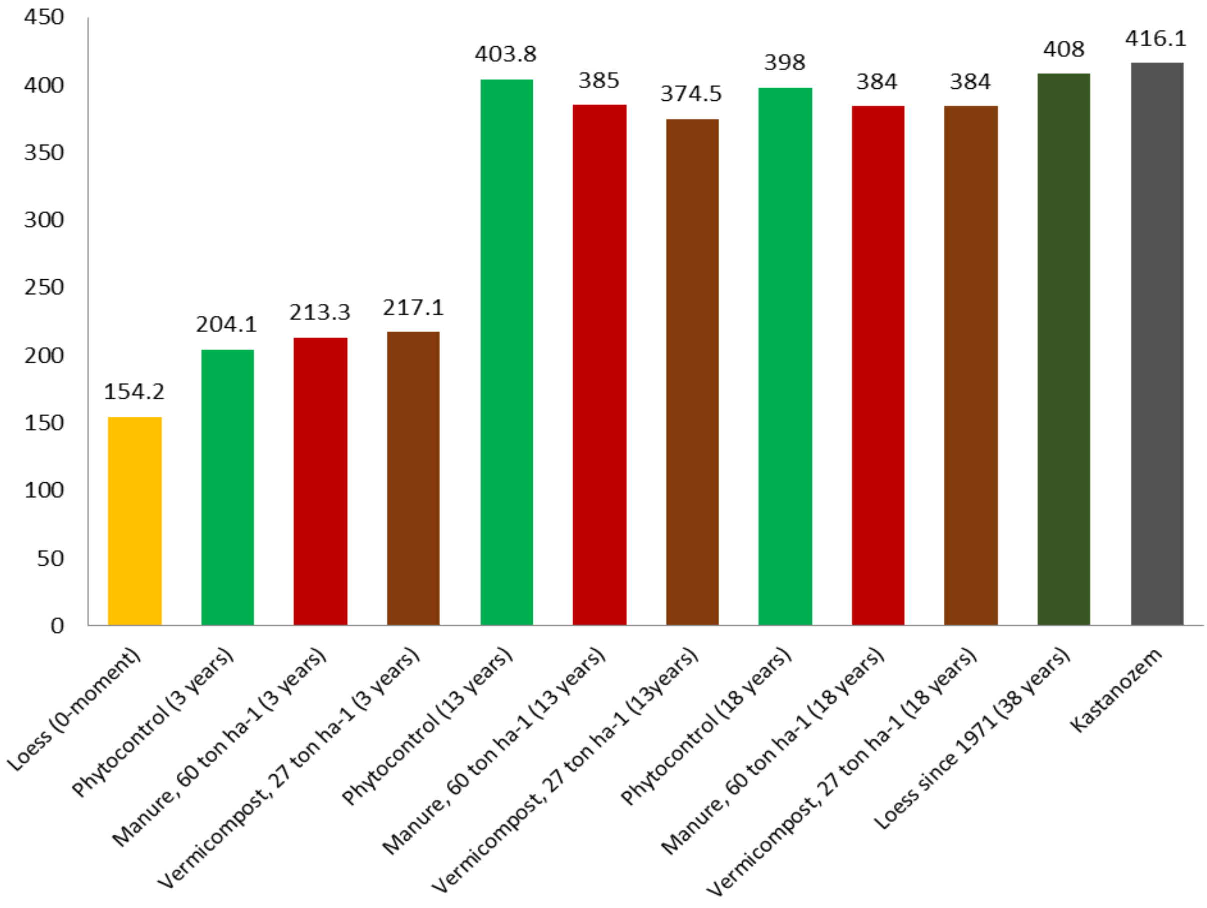
Picture 1 Time change of the proportion of absorbed cations in replantosols formed on loess foothills of Ile Alatau, in the pedogenenic syngenetic process (1991 – 2012)



Picture 2 - The dynamics of high hydrolyzable nitrogen in replantosols formed on loess foothills of Ile Alatau, in the pedogenenic syngenetic process (mg kg^{-1} N, 1991 – 2009.)



Picture 3- The dynamics of moving phosphorus in replantosols, formed on loess foothills of Ile Alatau, in the pedogenenic syngenetic process (mg kg^{-1} P_2O_5, 1991 – 2009.)



Picture 4 - The dynamics of moving potassium in replantosols, formed on loess foothills of Ile Alatau, in the pedogenenic syngenetic process (mg kg^{-1} K_2O, 1991 – 2009)

Conclusion

According to the research for the 1991 – 2012 yrs, it was found that calcium cation is predominant in the absorbed bases composition. The highest parameters of exchange capacity and calcium content in the absorbed bases composition were identified on the variants of Kastanozem, Loess since 1971y., Phytocontrol, Vermicompost, 27 ton ha^{-1}. It confirms the dominant role of the time factor in pedogenenic process. Content of moving nutrients for 2009 shows that the best conditions for plant nutrition are on the variants Loess since 1971y., Vermicompost, 27 ton ha^{-1}. Ameliorants materially affected increasing the effective fertility of experienced loess.

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References

Arinushkina E.V., 1970. Guidance on chemical analysis of soils. - M.: Publishing house of MSU – 487 (rus).
Bakels C.C., 2009. The Western European Loess Belt. Agrarian History, 5300 BC - AD 1000 Springer Science+Business Media B.V., – 295.
Bolihovskaya N.S., 1995. Evolution of the loess-soil formations in Northern Eurasia. - M.: Publishing house of MSU,- 270. (rus)
Buol S.W., 1994. Soil, Societies Yoke to the Earth. 15th World Congress of Soil Science. Acapulco, Mexico, july 10-16. Transactions. Volume 1: Inaugral and state of the art Conferences, 89-104.
Big Encyclopaedic Dictionary // http://www.megabook.ru/Article.asp?AID=646387
Denisov N.Y., 1953.Construction properties of loess and loesslike loams. - Moscow, – 154.
Dospehov B.A., 1968. Technique of field experience (with the basics of statistical processing of the research results). – Moscow: Kolos, -336. (rus)
Dmitriev E.A., 1995. Mathematical Statistics in Soil Science. -Moscow: Publishing house of MSU, - 320. (rus)
Encyclopedia of Soil Science, 2006, 2nd edition. Two Volumes. / Edited by R. Lal. Boca Raton, Fl, USA: Taylor & Francis, - 1923.
Golubev B.A., 1967. Lysimetric research methods in soil science and agricultural chemistry. - M.: Nauka, – 111. (rus)
Kadyrov E.V., 1979. Loess deposits: origin and construction properties. - Tashkent, - 168. (rus)
Kaurichev I.S., Yashin I.M., Chernikov V.A., 1996. Theory and practice of the sorption lysimeters method in Environmental Studies. - M.: Publishing house of MACA, - 144. (rus)
Loess deposits of the USSR. 1986. In two volumes. Regional features / under the editorship of E.M. Sergeyev, V.S. Bikova, N.N. Komissarova. - Moscow: Nedra, – V. 2. – 276. (rus)
Lomonovich M.I., 1955. Loess in Kazakhstan and its significance in the national economy. - Almaty: Publishing house of Academy of Sciences of the Kazakh SSR, – 79. (rus)
Lysenko M.P., 1967. Loess deposits of the European part of the USSR. - L.: Publishing house of LSU, - 208. (rus)
Mavlyanov G.A. Genetic types of loess and loesslike deposits of the central and southern part of Central Asia and their engineering and geological properties. - Tashkent, 1958. – 609 p.
Makhonina G.I., 2003. Environmental aspects of pedogenesis process in technogenic ecosystems of Ural. - Ekaterinburg: USU, - 356. (rus)
Methodological recommendations to improve the planning and carrying out of small plot field experiments. - Moscow, 1983. - 40. (rus)
Case study on Soil Science, 1986./ under the editorship of I.S. Kaurichev - Moscow: Agropromizdat, – 336. (rus)
Sokolov S.I., Assing I.A., Kurmangaliyev A.B., Serpikov S.K., 1962. Deposits of the Kazakh SSR. Deposits of the Almaty region. / under the editorship of A.I. Bezsonova. - Almaty: Publishing house of Academy of Sciences of the Kazakh SSR, - Edt.4., – 424. (rus)
Trofimov V.T., Balykova S.D., Bolihovskaya N.S., Andreeva T.V., et al., 2001. Loess cover of the Earth and its properties / under the editorship of V.T. Trofimova. - Moscow: Publishing house of MSU, - 464. (rus)
World Bank Helps Reduce Run-off Soil on Loess Plateau // http://www.china.org.cn/english/environment/125463.htm

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Changes properties some of the physical and chemical parameters in soil quality index some of a cultivated field and rangeland in different topographical positions

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Abstract

This study was carried out to expose changes some of the physical and chemical parameters in soil quality index some of a cultivated field and rangeland in different topographical positions. Soil surveys were done in three different fields at Tuzcu and Tepeköy villages. At different positions (performed-back slope–foot slope) and two different profiles (cultivated-non cultivated) were excavated. From ın described profiles, soil samples were collected. Soil sampling was done in 2005 on August. In this study; soil texture, bulk density, organic matter and KDK were examined. Result indicated that organic matter increased from summit to bottom but bulk density decreased. And the disaggregated in texture was established. It was found soil samples collected from cultivated fields were similar to properties of foot slope soil as to land use form. It was demonstrated that the parameters of soil quality index were more favorable results in horizon A than those horizon B.

Keywords: Topographical positions, soil quality indicators, physical, chemical and biological properties of soil

Introduction

Sustainability of plant production potential is closely related to agricultural activities implemented in agricultural areas. Practices changing in parallel with technological developments influence the physical properties of soil and consequently chemical properties of soil change, too. These influence the soil quality as a result. Soil quality is a significant criterion for the assessment of the administration practices determined for the sustainability of land use, land degradation or reclamation. Soil quality is the basic property of soil as it is related to soil administration practices, ecosystem, environment, socio-economic and political priorities.

Recently, the use of chemical fertilizers, pesticides, soil improvers, implementation of waste mud practices and the use of dirty water in irrigation corrupted the physical and chemical properties of agricultural lands and soil quality was harmed consequently. Soil quality parameters shall be determined for sustainable agriculture.

This study was carried out in order to reveal the physical and chemical change of some index parameters for the quality of soil found in cultivated lands and meadows at different positions.

Material and Methods

The study was carried out at three different locations in the lands of Tuzcu and Tepe villages. Two different profiles in cultivated and uncultivated lands were taken from three positions as the foot, slope and peak and

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soil samples from horizons were taken in the profiles opened. The sampling was performed in August 2005. Soil penetration resistance was calculated by a penetrometer during sampling (Barik, 2004). Samples taken were taken to the laboratory, they were dried in air first, then they were beaten, sieved through a 2 mm sieve and made ready for analysis.

Analysis Methods

Texture was assigned by Bouyoucos hydrometer method and soil mass density was determined by clod method (Demiralay, 1993). Soil organic substance content was calculated through multiplying the organic carbon content determined by Smith-Weldon method by the coefficient of 1,724. (Aydın and Sezen, 1995). Cation exchange capacity of soil samples (CEC) was calculated by saturating soil samples with sodium acetate (1N, pH=8,2) and processing with ammonium acetate (1N, pH=8,2) and reading the sodium extracted from flame photometer (Rhoades, 1982).

Statistical Methods

Statistical-6 package programme was used on the results of this study to carry out variance analysis and multiple comparison (Duncan) tests. In the multiple comparison test, the differences of averages were analysed at a significance level of 5% (Dowdy and Wearden, 1983).

Results and Discussion

Properties of the soil samples subject to study are given in Table 1, results of variance analysis are given in Table 2 and the results of multiple comparison test are given in Table 3. Soil texture, mass density (MD), organic substance content (OS) and cation exchange capacity (CEC) are analysed in the study.

Table 1. Findings on some physical, chemical and biological properties of the soil samples subject to study.

Soil properties	Topographical position											
	Foot				Slope				Peak			
	Land use				Land use				Land use			
	Cultivated land		Meadow		Cultivated land		Meadow		Cultivated land		Meadow	
	H	H	H	H	H	H	H	H	H	H	H	H
	A	B	A	B	A	B	A	B	A	B	A	B
S	23	42	26	25	24	27	48	24	30	49	33	29
Si	34	27	39	40	35	40	26	44	38	30	41	41
C	43	31	35	35	41	33	26	32	31	21	26	30
OS	3,8	3,0	3,7	2,3	3,5	2,2	3,4	1,8	3,7	2,1	2,9	1,3
MD	1,20	1,34	1,30	1,32	1,22	1,33	1,34	1,34	1,30	1,43	1,37	1,34
CEC	37,8	28,2	32,9	28,1	35,5	26,5	26,8	24,6	30,8	19,6	25,2	21,8

Table 2. Variance analysis results for the sampled soil properties in terms of topographical position, land use and horizons

Variance sources	S.D.	Sand	Silt	Clay	Organic substance	Mass density	Cation exchange capacity
Topographical position (TP)	2	72,1**	6,7*	141,7**	23,9**	52,2**	94,9**
Land use (LU)	1	16,5**	59,6**	37,1**	31,8**	38,8**	52,4**
Sampling horizon (H)	1	17,9**	6,5*	58,1**	262,6**	123,0**	235,7**
TP×LU	2	197,6**	38,0**	43,9**	3,5 NS	16,1**	6,2*
TP×H	2	201,4**	76,0**	11,6**	3,3 NS	2,8NS	1,56NS
LU×H	1	689,2**	71,5**	234,6**	2,4 NS	122,7**	54,3**
TP×LU×H	2	5,3*	2,0NS	0,54NS	0,89 NS	1,3NS	1,04NS
Error	12						

* P<0.05 **P<0.01

Table 3. Multiple comparison test (Duncan) results fort he samples soil properties in terms of topographical positions, land use and sampling horizon

	Sand	Silt	Clay	Organic substance	Cation exchange capacity	Mass density
Topographical position (n: 8)						
Foot	28,7 c	35,2 a	36,2 a	3,22 a	31,7 a	1,29 c
Slope	30,5 b	36,4 ab	33,1 b	2,71 b	28,4 b	1,30 b
Peak	35,0 a	37,8 b	27,2 c	2,49 b	24,4 c	1,36 a
Land use (n: 12)						
Cultivated land	32,3 a	34,2 b	33,5 a	3,05 a	29,7 a	1,30 b
Meadow	30,5 a	38,7 a	30,8 b	2,56 b	26,6 b	1,33 a
Sampling horizon (n: 12)						
A	30,5 b	35,7 b	33,8 a	3,52 a	31,5 a	1,29 b
B	32,3 a	37,2 a	30,5 b	2,10 b	24,8 b	1,35 a

Texture

Results of the variance analysis made in order to assess the influences of topographical position, land use and horizons on textural fractions of soils are given in Table 2. As can be seen in Table 2, sand, silt and clay content were found to be significantly different statistically depending on the topographical position, land use and soil horizon. Concerning the interactions; TPxLU, TPxH and LUxH were found to be influential on sand, silt and clay content whereas TPxLUxH was found to be influential on sand content. Results of the multiple comparison test made in order to assess which topographical position, land use and sampling horizon is different from the others in terms of soil textural fractions are given in Table 3. When Table 3. is viewed; the foot, slope and peak lands topographical positions shows significant differences. Whereas sand content was low in foot land, clay content was high. On the opposite, sand content was higher than clay content in the peak land (Figure 1 and Figure 2). Considering the land use; lands with cultivated soil were found to have a higher sand and clay content than those with uncultivated soil. Considering soil depth; sand content was higher in horizon B and clay content was higher in horizon A. Afyuni et. al. (1994) stated that clay content increased from foot position to peak position whereas silt and sand content decreased. Onstad et. al. (1984) stated that soil depth decreased in slope position whereas clay content increased compared to peak and foot positions.

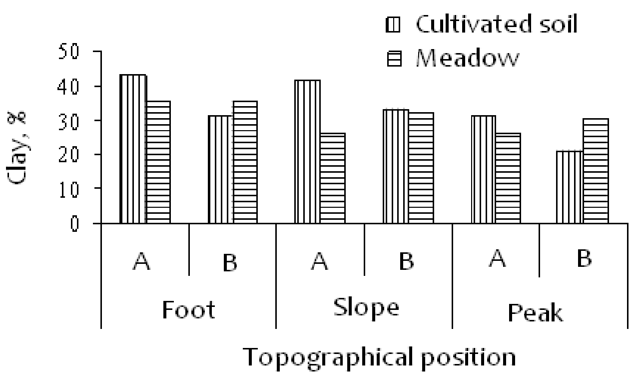

Figure 1. Effects of topographical position, land use and horizons on clay content

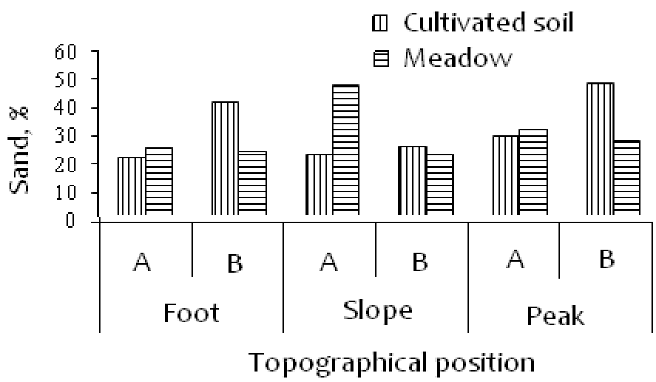

Figure 2. Effects of topographical position, land use and horizons on sand content

Organic substance

Statistical analysis results for the effects of topographical position, land use and horizons on soil organic substance content are given in Table 2 and Table 3. According to the results of variance analysis given in Table 2, organic substance content values were significantly different in terms of topographical position, land use and soil depth. Interactions weren't found to be influential on organic substance content.

According to the results of multiple comparison test given in Table 3, in terms of topographical positions, there was no significant difference between slope and peak lands whereas the foot land was found to have organic substance content that was different from both (Figure 3). In terms of land use, organic substance content in land with cultivated soil was found to be higher than in land with uncultivated soil. In terms of soil horizons, organic substance content was found to be higher in horizon. A. Birhan (1999) recorded no significant difference among topographical positions in terms of organic substance content and no significant relationship between organic substance content and topographical positions.

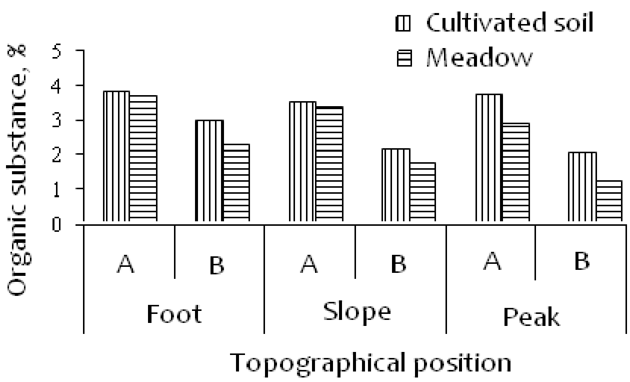

Figure 3. Effects of topographical position, land use and horizons on organic substance content

Mass Density

Results of the variance analysis made in order to assess the differences of mass density according to topographical position, land use and soil depth are given in Table 2. Results of variance analysis showed statistically significant differences in mass density values in terms of topographical positions, land use and horizons.

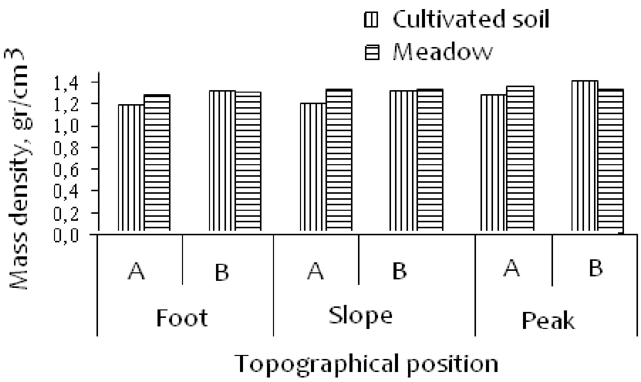

Figure 4. Effects of topographical position, land use and horizons on mass density

TPxLU and LUxH was found to be 1% influential on mass density. Duncan test (Table3) was performed to find out which topographical position, land use and horizon was different from the others in terms of mass density. Average values were obtained for mass density values, Duncan groups showing the differences among these averages are given in Table 3. When Figure 4 is viewed; the foot, slope and peak lands topographical positions shows differences and foot land is the one with the lowest mass density average value. In terms of land use; soil cultivated land was found to have a lower mass density than uncultivated land. Mass density average values were found to be lower in horizon A.

Clay and organic substance contents are two significant factors affecting the structure of soil. In this study as well, soil mass density was found to show a general change in terms of the influence rate of clay and organic substance contents.

Cation Exchange Capacity

Results of the variance analysis made for the effects of topographical position, land use and horizons on soil cation exchange capacity are given in Table 2. According to the results of the variance analysis, soil cation exchange capacity was found to be significantly different in terms of topographical position, land use and horizons. TPxLU and LUxH among the interactions were found to be 1% influential on cation exchange capacity. Duncan test was performed to find out which topographical position, land use and horizon was different from the others. Average values obtained for cation exchange capacity values, Duncan groups showing the differences among these averages are given in Table 3. When Table 3 is viewed; the foot, slope and peak lands topographical positions shows differences in terms of cation exchange capacity. Foot land is the one with the highest average value whereas the peak sand is the one with the lowest average value (Figure 5). In terms of land use; soil cultivated land was found to have a higher average value of cation exchange capacity than uncultivated land. In terms of soil horizons; cation exchange capacity average values were found to be lower in horizon B that in horizon A.

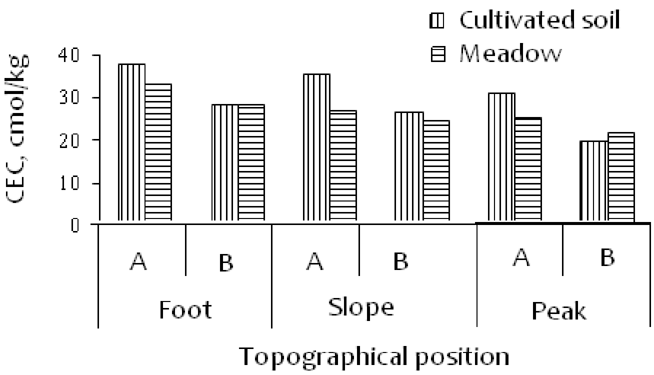

Figure 5. Effects of topographical position, land use and horizons on cation exchange capacity

The differences among cation exchange capacity values can be stated to be arising from the clay and organic substance contents. Stevenson (1982) stated that organic substance was responsible for 20-70% of the cation exchange capacity in soil.

Conclusion

This study was carried out in order to reveal the changes of some physical and chemical soil quality index parameters of cultivated soil and meadow land in horizon B and A depending on topographical positions. The foot, slope and peak topographical positions were found to be influential on soil quality index parameters and this influence was found to be affirmatively higher in foot land position whereas it was generally lower in slope and peak positions mostly due to two main reasons as limited soil growth and erosion. It was also stated in terms of land use that; quality index parameters found in cultivated land was generally better that the lands described as weak meadows. Physical and chemical soil quality index parameters were also found to be more favourable in sampled horizon A than horizon B.

References

Afyuni, M.M., D. K. Cassel, and W.P. Robarge, 1994, Leteral and vertical bromide ion transport in Piedmond landscape. Soil Sci. Soc. Amer. J. 58: 967-974.

Aydın, A. ve Sezen, Y., 1995. Toprak Kimyası Labaratuar Kitabı. Ata. Üni. Zir. Fak. Ders Yayınları No: 174.

Barik, K., 2004. Erzurum İli Pasinler Ovasında İşlenen Tarım Arazilerindeki Toprak Sıkışma Durumlarının Belirlenmesi. Basılmamış doktora tezi, Atatürk Üniversitesi Fen Bilimleri Enst. Toprak Anabilim Dalı, Erzurum.

Birhan, H., 1999. Farklı topoğrafik pozisyonların verim ve bazı topak özellikleri bakımından karşılaştırılması. Atatürk Üni. Fen Bilimleri Enst. Toprak ana bilim dalı (basılmamış yüksek lisans tezi) Erzurum.

Demiralay, İ., 1993. Toprak Fiziksel Analizleri. Atatürk Üni. Yayınları No: 143. Erzurum, s:90-95.

Dowdy, S. and Wearden,S., 1983. Statistics for Research. John Wiley and Sons, Inc. USA.

Onstad, C.A., Pierce, F.J., Dowdy, R.H. and Larson, W.E., 1984, Erosion and productivity interrelations on a soil landscape. Proceedings of the National Symposium on Erosion and Soil Productivity. p: 193-200.

Rhoades, J.D., 1982. Cation Exchange Capacity. Methods of Soil Analysis Part 2. Chemical and Microbiological Properties Second Edition. Agronomy. No: 9 Part 2 . Edition pp. 149.

Stevenson, F. J., 1982. Humus Chemistry, John Wiley&Sons. New York

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Response of soil organic matter to changes in the differing intensities of grazing in semi-arid rangelands in Iran

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Abstract

Carbon dioxide is one of the most important greenhouse gases in the atmosphere. Ranges and based on Carbon sequestration and soil conservation have a key role and known as dominant species in the region. In Iran, Overgrazing of rangelands, during the process of soil erosion is happening that this fact resulted to decrease soil carbon. In present study, comparative assessment of carbon sequestration capacity in the rangeland with different grazing intensity was investigated. Systematic random transect sampling with square plots was established in the region. After grinding the dried samples, organic carbon by electric furnace combustion method were measured and multiply to the conversion ratio of organic carbon in plant biomass, Carbon Sequestration by total weight in both plant and finally the base case was calculated per hectare of range. Total organic carbon stock in the ecosystem, in plant biomass and soil in site1 (low Stocking grazing) and site2 (high Stocking grazing) was 7/5 and 4/7 ton/ha, respectively. The results of the study showed that rangelands have a major role in mitigating the effects of elevated atmospheric carbon dioxide levels on global climate change. Also, the results indicated that management practices, such as grazing, and improved plant species will be concluded to increase soil organic carbon storage in the study area.

Keywords: Carbon sequestration, rangeland, soil carbon capacity

Introduction

Human activity has adversely affected global C and N cycles, and contributed to an alteration of climate that will generate discernible feedbacks to all organisms and ecosystems on earth. In recent decades, extensive work has been conducted toward improving our understanding of global C reserves and quantifying the pools and fluxes that constitute the cycles. Since the amount of C stored in soil organic matter is approximately twice that in the atmosphere (Schimel, 1995), the accumulation of C in the terrestrial biosphere could partially offset the effect of anthropogenic carbon dioxide (CO_2) emissions at the atmospheric CO_2 level (Houghton et al., 1999).

Reducing emissions from electrical power generation is one of the most important steps than can be taken in an overall GHG mitigation effort. Electricity production contributes approximately 25% of the total of direct man-made GHG emissions today (NAS, 2010). On March 27, 2012, the U.S. Environmental Protection Agency

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(EPA) proposed a new rule that would limit emissions to no more than 1,000 pounds of carbon dioxide (CO_2) per megawatt-hour of production from new fossil-fuel power plants with a capacity of 25 megawatts or larger. EPA proposed the rule under Section 111 of the Clean Air Act. According to EPA, new natural gas fired combined-cycle power plants should be able to meet the proposed standards without additional cost. However, new coal-fired plants would only be able to meet the standards by installing carbon capture and sequestration (CCS) technology (Peter et al., 2012).

Carbon capture and storage (CCS) is one of a host of technical Rangelands are one of the most widely distributed landscapes in the world. Found at the more arid end of the earth's climates, approximately 30% of the ice-free global land surface can be considered rangeland (FAO, 2009), although estimates vary widely depending on the particular definition used (Lund, 2007). In turn, rangelands are thought to have as much as 30% of terrestrial carbon stocks (FAO, 2009). Because rangeland vegetation mediates and constrains the carbon flux from the atmosphere into soils and plants, three major non-exclusive carbon management principles can be identified when rangeland ecological dynamics are considered. First, in rangeland ecosystems carbon flux into plants and soils is low, highly spatially and temporally variable, strongly influenced by stochastic events like weather, and largely outside the control of management. Second, in some rangeland environments, because of limited and slow plant growth, and significant storage of carbon in mineral form close to the surface, management that causes soil loss can significantly increase carbon flux to the atmosphere. Finally, carbon flows and pool sizes may be less variable and more amenable to enhancement through management at the less arid end of the rangeland climate gradient. These principles largely determine the outcome of carbon sequestration strategies in rangelands, and must be considered in assessing the ability to mitigate climate change through rangeland management (Booker et al., 2012).

It has been estimated that grazing lands contribute about 15% of U.S. soil carbon sequestration potential (Lal et al., 2003). U.S. rangeland livestock producers, generally operating with low and variable financial returns, continue to express considerable interest in diversifying income streams to include payments related to carbon sequestration (Diaz et al., 2009). Land management and conservation organizations also seek to promote management for increased carbon sequestration on private and public rangelands (Audubon California, 2012). As the U.S. failed to ratify the Kyoto treaty, the voluntary markets for trading carbon credits have thus far been the main thrust of initiatives for incentivizing management for carbon sequestration domestically. Rangelands have been defined as a type of vegetation, a land use, or what is left when other types are excluded. Definitions of rangeland that include specific uses, usually livestock grazing are not a good basis for stable descriptions of extent or processes.

In the past few decades, it has become clear that the C storage in grasslands has been significantly affected by changes in land-use and various ecosystem management strategies (Lugo and Brown, 1993; Post and Kwon, 2000; Jones and Donnelly, 2004; Billings, 2006; Elmore and Asner, 2006; Liao et al., 2006).

Schlesinger (1990) compiled data on long-term rates of soil organic carbon accumulation in Holocene age soils. He found a slow rate of carbon increase in soil even after thousands of years. Such as he indicates that faster rates of change over short time periods are possible as a result of changes in environmental conditions. Various land-uses result in very rapid declines in soil organic matter (Jenny, 1941; Davidson and Ackerman, 1993; Mann, 1986; Schlesinger, 1985; Post and Mann, 1990).

To assess soil C sequestration in rangelands one must deal with the variability in soils and vegetation at multiple spatial scales ranging from plant community interspaces to the landscape (Derner et al., 1997). In rangeland ecosystems where environmental conditions support plant growth sufficient for plant competition and other biotic interactions to play a major role in vegetation development, grazing management that leads to increased soil carbon storage by plants, and increased woody and perennial vegetation with extensive root systems, can positively influence carbon sequestration, in scenarios similar to those of other mesic ecosystems. In fact, most information documenting carbon response to grazing is from less arid rangelands (Gilmanov et al., 2010; Conant and Paustian, 2002) and the highest estimates of potential rangeland carbon sequestration (Conant and Paustian, 2002; Ogle et al., 2004; Morgan et al., 2010).

Shifang et al. (2008) study Vegetation and soil properties after enclosure and why in the desert steppe Alxa to conclude which were grazing enclosure compared with 2 and 6 Year caused a significant decrease in soil organic carbon Nitrogen. Semi-steppe region is the richest country in the direction of the dominant plant species Artemisia aucheri are the plant has an important role in carbon sequestration. Therefore, to study carbon sequestration capacity in the rangeland with different grazing intensity was investigated.

Material and Methods

Study areas in present study selected in areas with different grazing intensity (low and high intensity) located on rangeland around khoy city (44° 28´ Longitude and 38° 56´ Latitude) of west Azerbaijan Province (Figure1). Characteristics of the study area are shown in Table 1. Average annual rainfall in the study area is 265/4 mm and average annual temperature is 12/9 (C°) The lowest and the highest amount of rainfall in the month of May is 125/8 mm. Texture of surface soil of both site was loam-sandy Dominate.

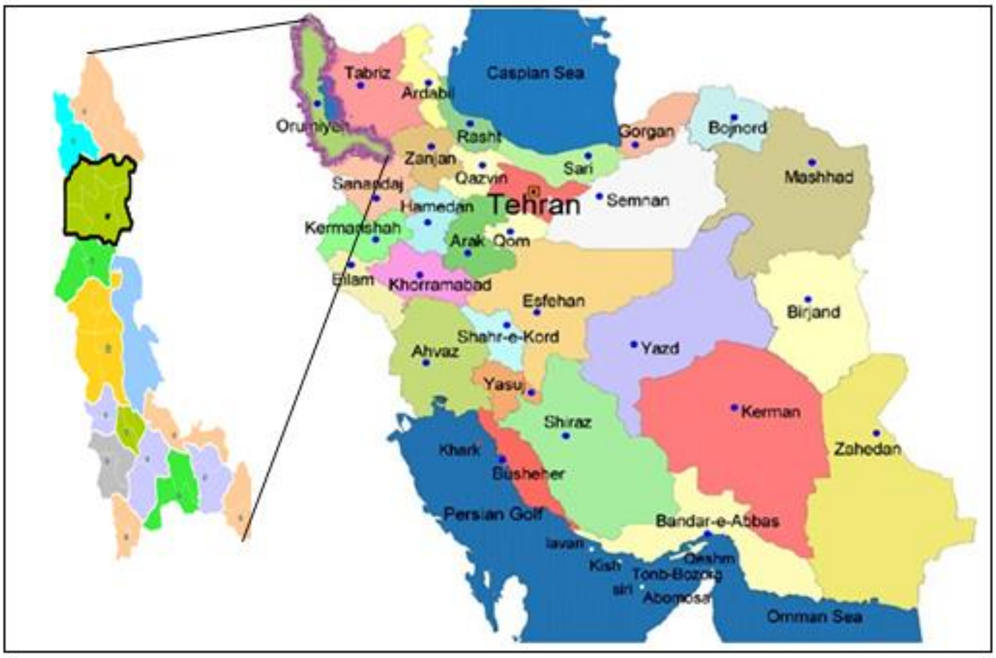

Figure 1. Location of the study area

Table1. Characteristics of the study area

Site	The dominant type of vegetation	Range condition (Based on four factor method)	Grazing intensity	Mean canopy area (percent)	The average slope (percent)
1	*Artemisia aucheri*	Average	low	30	30
2	*Artemisia aucheri*	Weak	high	20	25

Sample size was obtained 1 Squares meters by minimal areas (Derner et al., 1997). It was 1 Squares meter in the long term enclosure in both sites. Sample volume was calculated 30 plots per site using statistical method (Bruce et al., 1999). Dominated Species (*Artemisia aucheri*) were selected in order to obtain the aboveground biomass by way of clipping method (Allen-Dias, 1996). Also all roots with diameter (Arzani et al., 2007). Along subsurface biomass were clipped about 200 grams from each section include aerial and subsurface biomasses were collected in order to determine the carbon and moisture percentage. Ignition method was used to obtain the convention factor of carbon sequestration of biomass (Scurlock, 2002). The biomasses of species were corrected as "Belowground biomass samples were ground after oven-dried at 40 degree Celsius for 24 hours because some parts of water (moisture) were present in plant material (bulk and chemically bound water) and data are correct. Then, 15 samples were provided from each biomass. Samples were burned by Furnace about 6 hours in 600 degree Celsius (Andrew et al., 2006). Obtained ash, after exiting from oven, setup in desiccators to coot and then it was weighted. The rate of organic carbon (OC) for each biomass was calculated by ash weight, primary weight, and ratio of organic carbon to organic material (OM) (Equation1).

Conversion factor for each organ was calculated by primary weight percentage and percentage of the organic carbon.

(1) $OC = 0/45 \times OM$

Soil bulk density measurements are required to calculate a carbon amount from studies that report only carbon or organic matter concentrations (Equation 2).

(2) $Sc = 100 \times OC \times Bd \times D$

S.C= Organic carbon (ton/ha), O.C= Organic carbon (%), Bd= Soil bulk density (g/cm^3), D= study depth (m)

The analysis of data was done by SPSS version 16. In order to investigation and comparison of Carbon sequestration between different parts of the carbon sequestration places, one-way analysis of variance (ANOVA) was employed. For the purpose of comparison between the Carbon sequestrations rate of corresponding biomasses, independent sample t-test and between aboveground biomass and subsurface biomasses for each site, paired t-test were employed.

Results and Discussion

Vegetation: The average percentage of treatment in site1 (low Stocking grazing) was 35%, also the average percentage 0of vegetation in the treatment calculated 30% for site2 (high Stocking grazing).

Aboveground and Subsurface biomasses: The average carbon stocks in site1 (low Stocking grazing) regarding biomass sector, Aboveground and Subsurface biomasses calculated 1/18 and 1/15 ton/ha, respectively. Also, The average carbon stocks in site 2 (low Stocking grazing) regarding biomass sector, Aboveground and Subsurface biomasses calculated 0/57 and 0/27 ton/ha, respectively. The results show that the average total carbon stock in site1 (low Stocking grazing) of biomass sector is further than site2 (high Stocking grazing) (Table2). The results of t-test showed that there are significant differences between biomass carbon stocks (Table3).

Soil: The rate of average soil carbon stocks in site1 (low Stocking grazing) in different depths (0-15 cm and 15-30 cm) calculated 33/59 and 15/74 ton/ha, respectively, also total carbon stock of soil is equal to 24/66 ton/ha (Table2). The rate of average soil carbon stocks in site2 (high Stocking grazing) in different depths (0-15 cm and 15-30 cm) calculated 11/36 and 24/94 ton/ha, respectively, also total carbon stock of soil is equal to 18/15 ton/ha (Table2). The result of t-test showed that there is no significant difference between the two areas of soil carbon stocks (Table3).

Table2: The amount carbon stock of study area

	Treatment	Sites	Mean (ton/ha)	Standard Error
Carbon stock	Aboveground biomass	Site1	1/18	0/3
		Site2	0/57	0/8
	subsurface biomass	Site1	1/15	0/04
		Site2	0/27	0/2
	Biomass Total	Site1	1/17	0/05
		Site2	0/42	0/2
	Soil (0-15 cm)	Site1	15/74	0/06
		Site2	11/36	0/12
	Soil (15-30 cm)	Site1	33/59	0/03
		Site2	24/94	0/03
	Soil Total	Site1	24/66	0/06
		Site2	18/15	0/08

Table3: Comparison of the carbon stock Between Aerial, Subsurface biomass and Soil of study areas

treatment	$t_{statistic}$	df	Sig (2-tailed)
Aboveground biomass	-2/796	29	0/009
subsurface biomass	-3/970	29	0/001
Soil	-1/582	29	0/12

Whole ecosystem: Total organic carbon stocks in the ecosystem including plant biomass and soil in site1 (low Stocking grazing) and site2 (high Stocking grazing) calculated 7/5 and 4/7 ton/ha, respectively (Table 4).

Table4: Estimated Total organic carbon stocks per hectare in study sites

Treatment	Sites	Carbon mean (ton/ha)	Sd
Total Ecosystem	1	7/5	12/45
	2	4/7	8/89

Rangeland carbon sequestration research over the past decay has addressed the effects of management practices on soil carbon dynamics. Management practices such as grazing, nitrogen inputs via fertilization and dibber of nitrogen fixing legumes into rangelands, burning, woody plant encroachment, and restoration of degraded rangelands have been shown to influence soil carbon sequestration.

Carbon and nitrogen storage will decline in the heavily grazed grasslands (Cui et al., 2005; Elmore and Asner, 2006; Han et al., 2008; Steffens et al., 2008). In contrast, some studies have reported that soil carbon storage is higher in heavy grazing sites, mainly because of increased root production in the surface soil that accompanies changes in species composition (Frank et al., 1995; Reeder and Schuman, 2002; Liebig et al., 2006). Soil erosion and deposition can also play an important role in spatial distribution of soil organic carbon. Over long time periods, soil erosion and deposition are responsible for many of the landscape-level differences in carbon sequestration potential. Much of the soil organic C in rangelands is concentrated near the soil surface (Weaver et al., 1935; Gill et al., 1999). Where it is more susceptible to loss or redistribution by wind and water. Therefore, sampling points should be spatially distributed based on the relative proportion of erosional and depositional surfaces.

The results showed that the total amount of carbon stock in biomass in site1 (low Stocking grazing) is smaller than site2 (high Stocking grazing) (1/17 and 0/42 ton/ha).

The results of other researcher’s studied proved that crops are most important and most sensitive parts of a range ecosystem that is not directly affected. The combination of livestock grazing on rangeland vegetation, net primary production, compared to root crops and pasture had great influence on the nutrient cycle (Milchunas and Lauenroth, 1993). The highest proportion of carbon sequestration in soil has been allocated to the study site and sake soil carbon in the ecosystem which is the largest carbon storage tank (Abdi et al., 2008; Schuman et al., 1999; Yong zhong, 2007).

The total amount of soil carbon stock in site1 (low intensity gazing) and site2 (high Stocking grazing) calculated 24/66 and 18/15 ton/ha, respectively. This fact shows that soil organic carbon of low stocking grazing rangeland is more. This indicates a direct role in the reduction because of its indirect role in reducing carbon in vegetation and soil erosion (Su-Young and Zhao, 2003). The results of the study proved that Carbon storage declined in the heavily grazed grasslands, and soil acted as a C source. Declines in soil C and N storage under long-term heavy grazing have been reported previously (Cui et al., 2005; Elmore and Asner, 2006; Han et al., 2008; Steffens et al., 2008). Henderson (2004) as a general rule, carbon in the soil is further than of carbon in the root Biomass (Aradottir, 2000).

Total organic carbon stocks in the study area including in biomass and soil parts in site1 (low Stocking grazing) and site2 (high Stocking grazing) calculated 7/5 and 4/7 ton/ha, respectively. Zhiming et al (2012) stated that rangeland ecosystems cover about 50 percent of land. Also, he demonstrated that soil carbon and nitrogen storage in grassland ecosystem increasingly influenced by better grazing management.

Levels of grazing intensity and frequency of rotation as an effective management tools in rangeland ecosystems will be affected carbon storage positively (Bruce et al., 1999). The estimates of soil C storage and rates of carbon sequestration for rangelands are being used by scientists and policymakers to estimate the potential of rangelands to help mitigate the elevated atmospheric levels of carbon dioxide (co_2). Considerable interest is being generated in terrestrial carbon storage and marketing of stored carbon is being initiated to be used by industry that is emitting CO_2 into the atmosphere. Continued research, data synthesis and modeling will help to further refine estimates of terrestrial carbon storage in rangelands.

The results demonstrated rangeland ecosystem has a potential to enhance carbon sequestration and reduce the problems of climate change. By management practices such as reduction in grazing intensity can increase carbon sequestration potential that concluded to increasing capacity of rangeland carbon sequestration.

References

Audubon California (2012). The Carbon Breakfast Club seeks a new way to fight global warming. Available from: http://ca.audubon.org/lsp_carbon_break- fast.php (accessed 10.02.12).

Allen-Dias B (1996). Rangelands in a changing climate: impacts, adaptations and mitigation. In: Watson, R.T., et al. (Eds.), Climate Change 1995. Impacts, Adaptations and Mitigation of Climate Change: Scientific- Technical Analyses. Cambridge University Press, Cambridge, Published for the Intergovernmental Panel on Climate Change, pp. 131–158.

Arzani H, Azarnivand H, Mehrabi AA, Nikkhah A, Fazel Dehkordi L (2007). The minimum rangeland area required for pastoralism in Semnan. province.Pajouhesh & Sazandegi, No 74, pp: 107-113.

Abdi N, Maddah Arefi, Zahedi GH (2008). Estimation of carbon stock in Astragalus rangelands of Markazi province (Case study: Malmir rangeland in Shazand region). Journal of researches on forest and rangelands, No 15, pp: 269-282.

Aradottir A, Savarsottri L, Kristin H, Jonsson P, Gudbergsson G (2000). Carbon accumulation in vegetation and soils by reclamation of degraded areas. Icelandic agricultural sciences 13, 99-113.

Billings SA (2006). Soil organic matter dynamics and land use change at a grassland/ forest ecotone. Soil Biology & Biochemistry 38, 2934–2943.

Booker k, Huntsinger L, Bartolome J, Sayre N, Stewart W (2012). What can ecological science tell us about opportunities for carbon sequestration on arid rangelands in the United States? Global Environmental Change. JGEC-1036: No. of Pages 12. journal home page: www.elsevier .com /locate/gloenvcha.

Bruce JP, Frome M, Haites E, Joanne H, Lal R, Faustion K (1999). Carbon sequestration in soils, Journal of soil and water conservation, first quarter.

Conant RT, Paustian K (2002). Potential soil carbon sequestration in overgrazed grassland ecosystems. Global Biogeochemical Cycles 16, 901–909.

Cui X Y, Wang Y F, Niu HS, Wang S P, Schnug E, Rogasik J, Fleckenstein J, Tang YH (2005). Effect of long-term grazing on soil organic carbon content in semiarid steppes in Inner Mongolia. Ecological Research 20:519–527.

Davidson EA, Ackerman IL (1993). Changes in soil carbon inventories following cultivation of previously untilled soils. Biogeochemistry 20, 161-193.

Derner JD, Briske DD, Boutton TW (1997). Does grazing mediate soil carbon and nitrogen accumulation beneath C4 perennial grasses along an environmental gradient? Plant Soil 191, 147–156.

Diaz DD, Charnley S, Gosnell H (2009). Engaging Western Landowners in Climate Change Mitigation: A Guide to Carbon-Oriented Forest and Range Management and Carbon Market Opportunities. Pacific Northwest Research Station FSRNPNWGTR-801, Portland, OR.

Elmore AJ, Asner GP (2006). Effects of grazing intensity on soil carbon stocks following deforestation of a Hawaiian dry tropical forest. Global Change Biology 12, 1761–1772.

Houghton RA, Hackler JL, Lawrence KT(1999) The US carbon budget: contribution from land-use change. Science, 258, 574-578.

Han GD, Hao XY, Zhao ML, Wang MJ, Ellert BH, Willms W, Wang MJ (2008). Effect of grazing intensity on carbon and nitrogen in soil and vegetation in a meadow steppe in Inner Mongolia. Agriculture, Ecosystem and Environments 125:21–32.

Henderson DC (2004). Carbon storage in grazed prairie grasslands of Alberta. M.S. Thesis,University of Alberta, Edmonton, AB, Canada.

Frank AB, Tanaka DL, Hofmann L, Follett BF (1995). Soil carbon and nitrogen of northern great plains grasslands as influenced by long-term grazing. Journal of Rangeland and Management 48:470–474.

FAO [Food and Agriculture Organization of the United Nations] (2009). Review of evidence on drylands pastoral systems and climate change. In: Neely, C., Bunning, S., Wilkes, A. (Eds.), Land and Water Discussion Paper 8. Land Tenure and Management Unit (NRLA) Land and Water Division, Rome, Italy, ftp:// ftp.fao.org/docrep/fao/012/i1135e/i1135e00.pdf (accessed June 17.06.11).

Gilmanov TG, Aires L, Barcza VS, Baron L, Belelli L, Beringer J (2010). (plus 40) Productivity, respiration, and light-response parameters of world grassland and agroecosystems derived from flux-tower measurements. Rangeland Ecology and Management 63, 16–39.

Gill RA, Burke IC, Milchunas DG, Lauenroth WK (1999). Relationship between root biomass and soil organic matter pools in the shortgrass steppe of eastern Colorado: Implications for decomposition through a soil profile. Ecosystems 2:226-236.

Jenny H (1941). Factors of Soil Formation. McGraw-Hill, New York.

Jones MB, Donnelly A (2004). Carbon sequestration in temperate grassland ecosystems and the influence of management, climate and elevated CO2. New Philologist, 164, 423–439.

Lugo, A.E., Brown, S., 1993. Management of tropical soils as sinks or sources of atmospheric carbon. Plant and Soil 19, 27–41.

Liebig MA, Gross JR, Kronberg SL, Hanson JD, Frank AB, Phillips RL (2006). Soil respiration to long-term grazing in the northern great plains of North America. Agriculture, Ecosystems and Environment 115:270–276.

Liao JD, Boutton TW, Jastrow JD (2006). Storage and dynamics of carbon and nitrogen in soil physical fractions following woody plant invasion of grassland. Soil Biology & Biochemistry 38, 3184–3196.

Lal R, Follett RF, Kimble JM (2003). Achieving soil carbon sequestration in the US: a challenge to the policy makers. Soil Science 168, 827–845.

Lund HG (2007). Accounting for the world's rangelands. Rangelands 29, 3–10

Mann LK (1986). Changes in soil carbon after cultivation. Soil Science 142, 279-288.

Milchunas DG, Lauenroth WK (1993). Quantitative effects of grazing and soils over a global range of environments. Ecology Monographs, 63: 327-366.

Morgan JA, Follett RF, Allen LH, Del Grosso S, Derner JS, Dijkstra F, Franzluebbers A, Fry R, Paustian K, Schoeneberger M (2010). Carbon sequestration in agricultural lands of the United States. Journal of Soil and Water Conservation 65, 6A–13A.

NAS (National Academy of Sciences) (2010). *Advancing the Science of Climate Change. Expert Consensus Report, America's Climate Choices*; NAS: Washington, DC, USA, 2010.

Ogle SM, Conant RT, Paustian K (2004). Deriving grassland management factors for a carbon accounting method developed by the intergovernmental panel on climate change. Environmental Management 33, 474–484.

Petter C, Steven, Alfredo H, Vanessa G (2012). Terrestrial carbon sinks for the United States predicted from MODIS satellite data and ecosystem modeling. *Earth Interactions* 11:13.

Post WM, Mann LK (1990). Changes in soil organic carbon and nitrogen as a result of cultivation. In: Soils and the Greenhouse Effect (ed Bouwman AF), pp. 401-406. John Wiley & Sons, New York.

Post WM, Kwon KC (2000). Soil carbon sequestration and land-use change: processes and potential. Global Change Biology 6, 317–327.

Reeder JD, Schuman GE (2002). Influence of livestock grazing on C sequestration in semi-arid mixed-grass and short-grass rangelands. Environmental Pollution 114:87–93.

Schlesinger WH (1990). Evidence from chronosequence studies for a low carbon-storage potential of soils. Nature 348, 232-234.

Schimel DS (1995). Terrestrial ecosystems and the carbon cycles. Global Change Biology 1, 77–91.

Schlesinger, W. H., 1985. Changes in soil carbon storage and associated properties with Disturbance and recovery. In: The Changing Carbon Cycle: A Global Analysis (eds Trabalka JR, Reichle DE), Springer-Verlag, New York.

Steffens MA, Totsche KU, Knabner Kg (2008). Grazing effects on soil chemical and physical properties in a semiarid steppe of Inner Mongolia (P.R. China).

Su- Young Z, Zhao HL (2003). Influences of grazing and exclosure on carbon sequestration in degraded sandy grasslands. Inner Mongolia, north china, New Zealand journal of agricultural research 46: 4, 321-328.

Schuman GE, Reeder JD, Manley JT, Hart RH, Manley WA (1999). Impact of grazing management on the carbon and nitrogen balance of a mixed-grass rangeland. Ecol. Appl. 9 (1), 65–71.

Shifang P, Hua F, Changgui W (2008). Changes in soil properties and vegetation following enclosure and grazing in degraded Alxa desert steppe of Inner Mongolia, China. Agriculture, Ecosystems and Environment, 124: 33–39.

Weaver JE, Hougen VH, Weldon MD (1935). Relation of root distribution to organic matter in prairie soil. Botanical Gazette96:389-420.

Yong Zhong Su (2007). Soil Carbon and nitrogen sequestration following the coniersion of cropland to alfalfa land in northwest china, journal of soil and Tilage Research, Volume 92, Pages. 181-189.

Zhiming Qi, Patricia NS, Bartling Lajpat R, Ahuja Derner D, Gale H, Dunn Liwang Ma (2012). Development and evaluation of the carbon–nitrogen cycle module for the GPFARM-Range model. Computers and Electronics in Agriculture 83: 1–10.

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Soil salinization and sodisation in the irrigated perimeter of Mina (northwest Algeria). Diagnosis by combined measurements of electromagnetic and saturated hydraulic conductivities

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Abstract

Abiotic constraints of drought and salinity are common causes some land degradations in arid and semi-arid areas characterized by low and irregular rainfall and long drought periods. In Algeria, 95% of country area is characterized by arid and semi-arid climate. Under these conditions, soil salinization combined to sodisation often causes not only a reduction in crop yields but also a reduction in arable land by degradation. Thus, both abiotic constraints pose a threat to a food balance of affected areas. In Algeria, salinity and sodicity affect more than 15 % of total irrigated area. The irrigated perimeter of Mina located 350 km west of Algiers is one of the most affected by salinization and sodisation and occupies nearly of 10 600 hectares. In this study, we performed the diagnosis of contamination state by salinity and sodicity of a parcel of 17 hectares, which is among the most contaminated of the perimeter. This analysis is based on combined measure of apparent electrical conductivity (ECa) and saturated hydraulic conductivity (SHC). The Electromagnetic conductivity measured in situ according to a systematic grid of (30 x 25 meters), had permit to deduce by correlation with some soil samples and by processing with ArcGIS, some maps. These latter relates the electrical conductivity of the saturated paste extract of soil (ECe), soluble cations and anions and SAR. Total salinity map shows that 98 % of studied area has ECe > 8 $dS.m^{-1}$. SAR map combined to the saturated hydraulic conductivity data, shows that the site is weakly affected by sodicity (SAR < 13, SHC = 0,4 to 1,8 $cm.h^{-1}$). In this case, it is not advised to produce salt-sensitive crops. For that soils physical properties be not affected by clay deflocculation phenomenon (clay rate 10 to 60%), it should opt for sustainable management solutions specifically preventive. Like non-destructive method, this approach to diagnosis salinization and sodisation state of soils, seems advantageous in cost and time. It allows mapping various parameters indicator of salinity and sodicity on large areas in arid and semi-arid. In this case, the analysis can be distributed seasonally in time for determining salinity and sodicity thresholds variations in soil profiles and be able to intervene by an optimized hydro-agricultural sustainable management.

Keywords: salinity and sodicity, irrigated perimeter, electromagnetic conductivity, saturated hydraulic conductivity, SAR.

Introduction

The land degradation problematic is a complex approach that must be approached in an integrated manner for several reasons:

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- diversity of degradation forms, their inter-relationships and their inter-connections, their extension, their severity and their reversibility,
- diversity of degradation factors, that may be natural but mostly anthropogenic,
- difficulty to establishing indicators and thresholds necessary to understand relationships of cause and effect between a form of degradation and its impacts and
- difficulty of assessing the social, economic and environmental impacts, immediately and long term, in areas affected by damage and beyond.

Moreover, the different disciplinary perceptions and utilities, of soil role, led to various definitions of land degradation. This has contributed to an insufficient consideration of the importance of soil which, consequently, has resulted in a lag in assessing the degradation gravity and thus to the need of their supported.

Among the various forms of soil degradation, the salinization is the most important one in arid and semi-arid areas. In Algeria, 95 % of the country area is characterized by arid and semi-arid climate (Halitim, 1984). Effectively, 10 to 15 % of irrigated land are affected by the phenomenon of secondary salinisation (Cheverry and Robert, 1998). This often results in a reduction of cultivable land and constitutes a threat to the food balance in the affected regions.

In this work, we carried out a diagnosis of the degradation state, of a plot 17 hectare, considered one of the most affected by salinization-sodisation phenomena, in the irrigated plain of Mina north-West of Algeria. The plain of Mina covers nearly 10 600 ha and is characterized by clay soils. Diagnosis is based on joint measurements of apparent electrical conductivity ECa and saturated hydraulic conductivity SHC.

Material and Methods

Materials

Area Descriptions

The study site is a parcel 17 ha located in the irrigated perimeter of the plain of Mina (Fig. 1), about 350 km north-west of Algiers. The geographical coordinates of points that circumscribe the plot are:

$x_1 = 0° 29' 35''$	$y_1 = 35° 44' 9''$	;	$x_2 = 0° 29' 46''$	$y_2 = 35° 44' 10''$
$x_3 = 0° 29' 34''$	$y_3 = 35° 43' 57''$	;	$x_4 = 0° 29' 46''$	$y_3 = 35° 43' 57''$

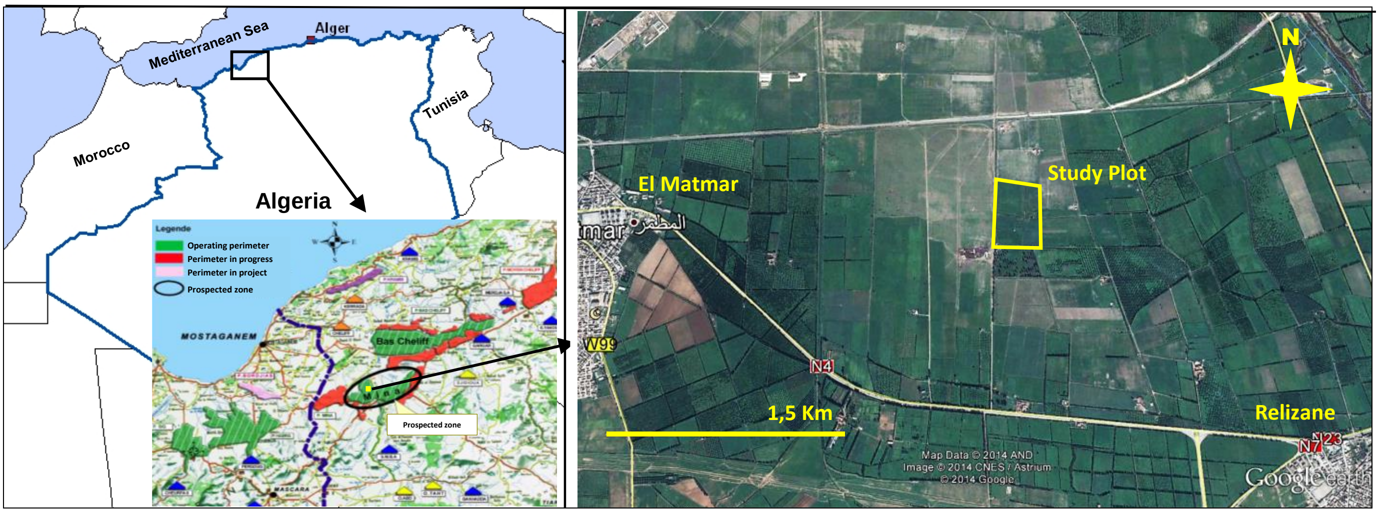

Fig.1. Geographical location of the study plot

The climate is Mediterranean-type, with annual rainfall not exceeding 350 mm distributed from November to March. Soils are mostly clay (10 to 60 %, mean 34.92 %). Structure is polyhedral-type on soil surface and prismatic-massif in depth. Young olive plants occupy the western part of the plot, while the rest contains the oats. (Fig. 2).

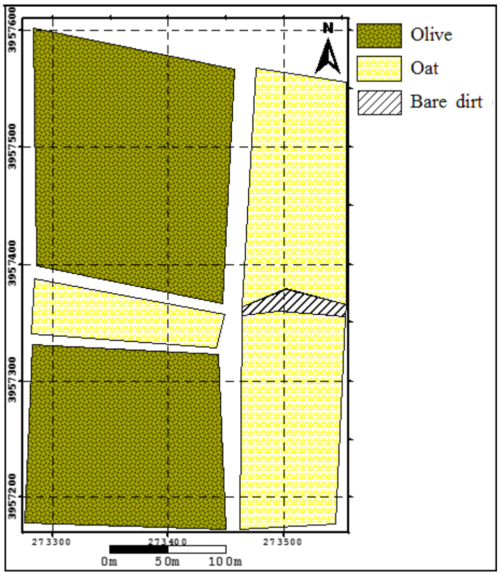

Fig. 2. Land occupation

Between the lines of the olive grows a halophyte vegetation characterized in particular by chenopodiaceae like salsola and wild spinach. Water table located at an average depth of 2 m in dry season, has an electrical conductivity (EC_W) 5,6 dS.m^{-1}, SAR 12,5 and pH 7,5. The orchard is irrigated by an drip system from the dam of Sidi M'Hamed Benaouda (CE_W 1,71 dS.m^{-1} ; SAR 2,74).

Measure apparatus of electrical conductivity

This is an electromagnetic conducti-meter, EM38RT of Geonics (McNeill, 1980). The EM-38 has had considerably greater application for agricultural purposes because the depth of measurement corresponds roughly to the root zone (1,5 m), when the instrument is placed in the vertical position. In the horizontal position, the measurement depth is 0,75 to 1,0 m (Corwin et *al*., 2006). This means that if the salt profile is decreasing with depth, then the measure vertical mode is less than the measured horizontal and conversely. ECa data were obtained using the Geonics EM38 instrument in horizontal position.

Methods

Methodology

The methodology adopted for this study (Fig. 3), is initially, 165 in-situ measurements in a systematic grid of (30 x 25 m) of CEa with the EM38 instrument while 15 samples were collected for the determination of CEe. CEa data are calibrated against those of ECe (Douaik et *al*., 2005).

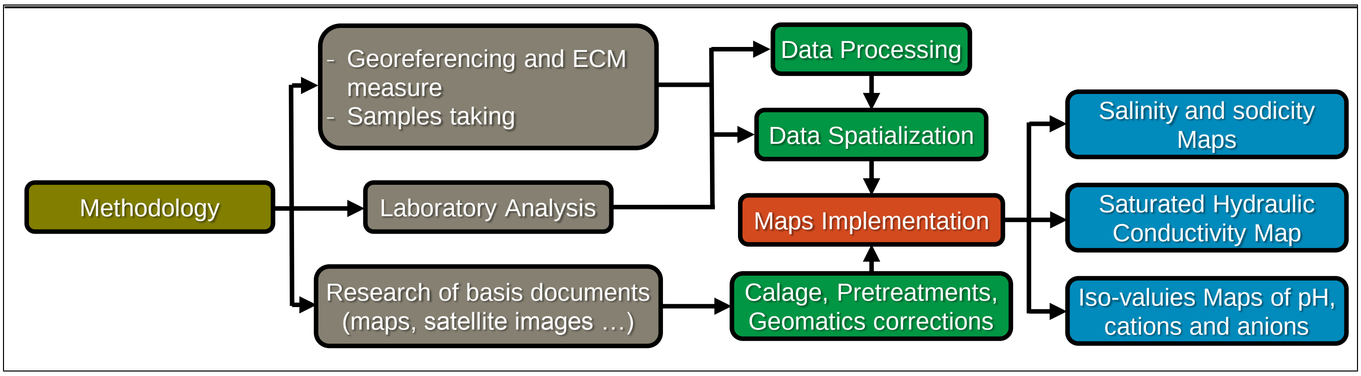

Fig. 3. Methodological adopted Organogram

Analytic Methods

The soil samples collected in the study site underwent the following analysis:

- Granulometry: by the international method of sedimentometry using the Robinson pipet.

- Soil pH: determined on the saturated paste extract using the pH meter instrument.
- Electrical Conductivity: determined on the saturated paste extract using the Conductimeter at 25C°.
- Total limestone: by the Bernard calcimeter method.
- Dosing anions: determined on the saturated paste extract. Chlorides by titration method with silver nitrate (Mohr method). The sulphates by the gravimetric method with Barium chloride. The carbonates and bicarbonates by titration method in presence of sulfuric acid.
- Dosing cations: Na^{+}, K^{+}, Mg^{2+} and Ca^{2+} cations are determined on the saturated paste extract by atomic absorption spectrophotometry.
- Permeability (coefficient K in the Darcy law) by the permeameter method at constant load on overhauled sample.
- Saturated hydraulic conductivity: in situ by the method of the dual cylinders of Müntz.

Results and Discussion

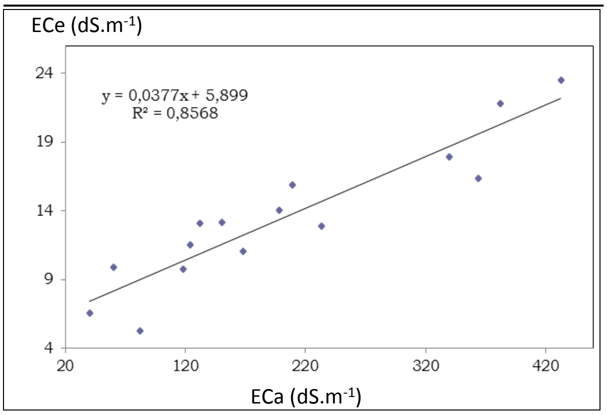

Fig. 4. Correlation between ECa and ECe

Linear correlation between the electrical conductivity of the saturated extract paste ECe and apparent electrical conductivity ECa (Fig. 4) allows us to deduce the ECe data for all the grid points where was systematically measured the ECa using the linear correlation equation:

$$ECe = 0{,}0377\ ECa + 5{,}899 \qquad (1)$$

This allows, implementing the map of ECe for the full study plot. The map of spatial variations of total soil salinity (Fig. 5), shows that 98 % of the area of studied plot records an ECe superior to 8 dS.m^{-1}. The remaining 2 % of area, have an ECe superior to 4 dS.m^{-1}. The studied plot is highly affected by salinity if we based to the threshold of 4 dS.m^{-1} reported by many authors (Corwin et *al*., 2006 and Horneck et *al*., 2007).

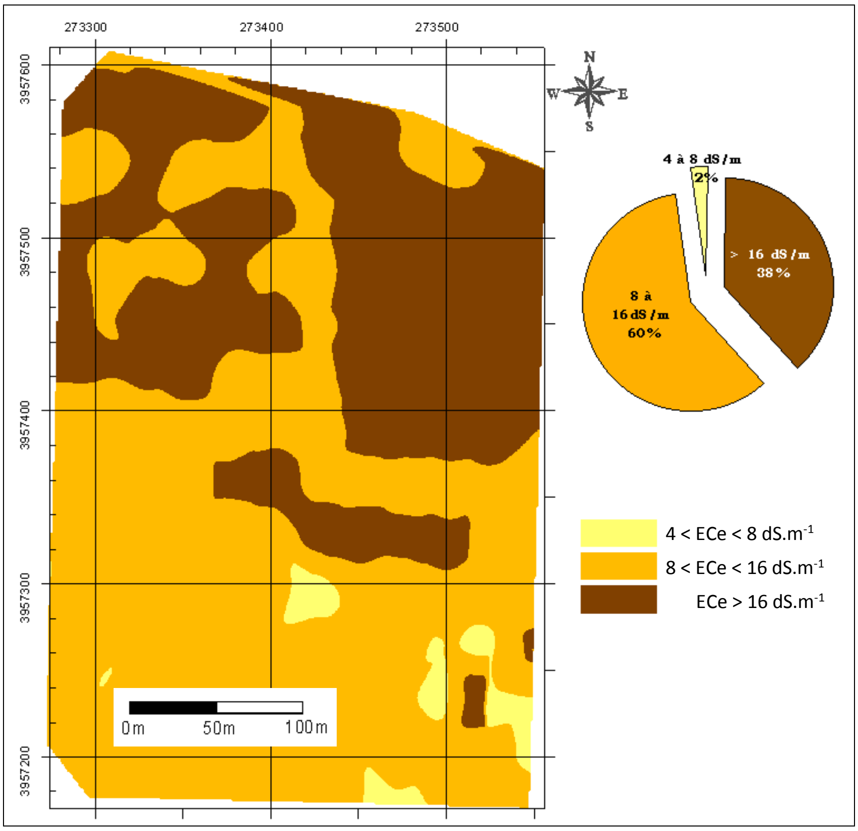

Fig. 5. Map of spatial variations of total soil salinity

The literature reports the existence of relationship between ESP (exchangeable sodium percentage) and SAR (sodium adsorption ratio) of soil saturated paste extract. Thus, soil SAR can be used to estimate ESP variations with sufficient accuracy. For guidance, we cite two models, respectively that reported by the United States Salinity Laboratory (Richards 1954) (2) and that proposed by Seilsepour et *al.* (2009) (3):

$$ESP = -0{,}0126 + 0{,}01475\ SAR \qquad (2)$$

$$ESP = 1{,}95 + 1{,}03\ SAR \qquad (3)$$

The general relationship between these two parameters, although linear, varies specifically from one region to another one in function of ionic strength of soil solution and its clay content (Seilsepour et *al.*, 2009). Besides, SAR can be determined quickly and easily since it requires only the concentrations of soluble cations: Na^{+}, Ca^{2+} and Mg^{2+}, which are extracted in the same saturated paste extract of soil used for evaluating ECs (Younes et *al.*, 2010).

$$SAR = Na^{+} \Big/ \sqrt{(Ca^{2+} + Mg^{2+})/2} \qquad (4)$$

In contrast, ESP requires analysis difficult delicate as they relate to the exchangeable Na^{+} concentration in the soil solution and the CEC (cation exchange capacity of total soil). This is why we opted for SAR as indicator of soil sodicity. Indeed, SAR data (Fig. 6), shows that soil of the studied plot are weakly affected by sodicity (Table 1).

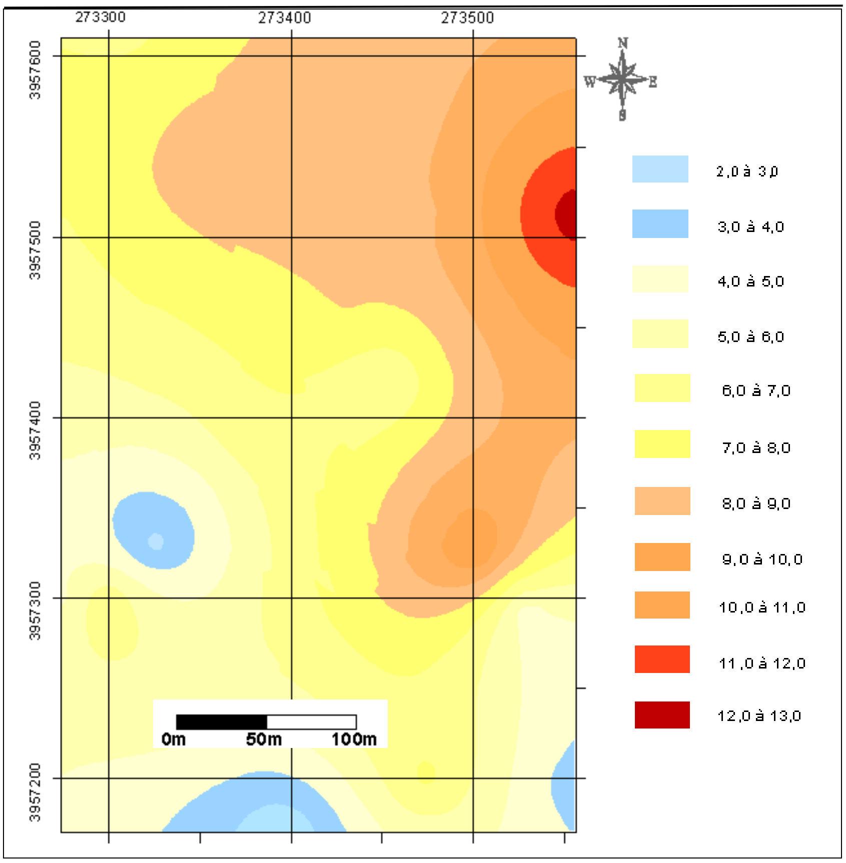

Fig. 6. Map of spatial variations of soil SAR

However, it is interesting to note that the SAR map shows a gradient Sodicity that evolves between contours in blue colors to those in maroon colors passing through the different bands of intermediate colors. In this case, the northeastern part of the plot (SAR near 11 to 13) will have to undergo a particular hydro-agricultural treatment (leaching doses) to spare him the risk to go to critical thresholds sodicity (> 12). Especially, that clay is present in high proportions in the soil profile (10 to 60 %, mean 34,92 %).

Table 1. Risk scale of soil contamination by salinity and sodicity

Risk	Low	Medium	High	Extreme
ECe ($dS.m^{-1}$)	< 2	2 < EC < 4	4 < EC < 8	> 8
SAR	> 4	4 < EC < 8	8 < EC < 12	> 12

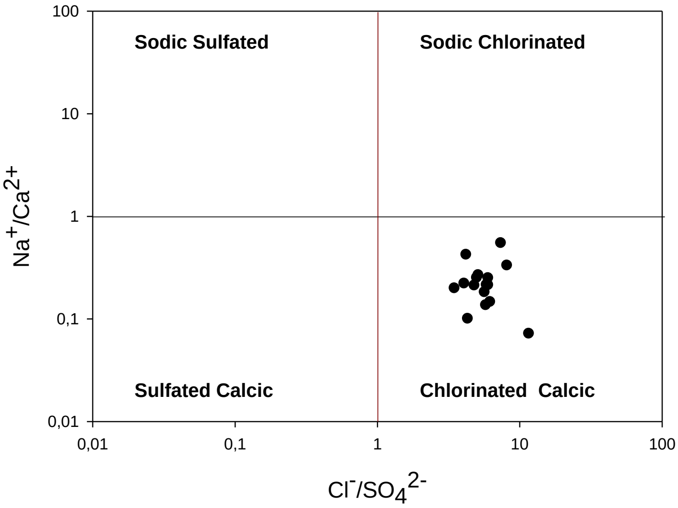

Fig. 7. Soil solution facies

Examination of changes in cations concentrations in soil solution shows a presence of Ca more greater than of Na. Indeed, the Na^+/Ca^{2+} report is less than one (Fig. 7). Nevertheless, we have seen that there is, at least, the northeastern part of the plot that records a high SAR value.

Moreover, we note that Cl^- concentration prevails compared to those of sulfates and bicarbonates, the ranking in descendant order concentration is $Cl^- > SO_4^{2-} > HCO_3^-$. The Cl^-/SO_4^{2-} ratio is greater than one, it confer a calcium-chlorinated facies to soil solution.

Presence of Na^+ and Cl^- can be probably attributed to halite dissolution that may be encountered in clay formations containing salts.

However, the sodium like les chlorides can have various origins naturals and/or anthropogenic. The main sources of ions are :

- local dissolution (ie in the soil itself) ;
- capillary rise of some loaded water from a water table ;
- irrigation water of poor quality ;
- flood by wadis (runoff water from the heights).

The evolution of the average concentrations of Na^+ according to those of Cl^-, shows an excess of concentration of this last (Fig. 8), this may be due to two trends that can be overlapped. The first is the existence of an ions origin other than Cl^- halite since it gives an amount of sodium ions equal to that of chlorine at its dissolution. The second is the existence of a different dynamic of chloride compared to that of sodium in the soil.

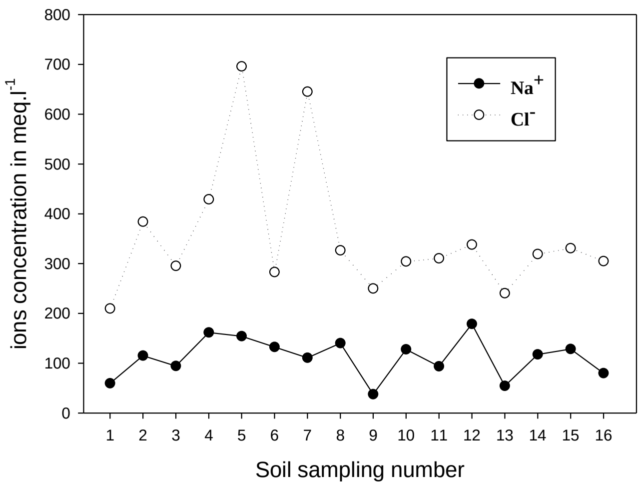

Fig. 8. Chlorine variations compared to sodium

In the other hand, data of saturated hydraulic conductivity (SHC) of soils (Fig. 9), show that it is located in the class of low to very low permeability, according to the O'Neal scale (Duchauffour, 1979). This data confirm the evolution of spatial variation map of SAR. It is important to note that the hydro-agricultural management is far from being optimized. Indeed, the drainage network is not fully functional and farmers do not furnish extra doses of leaching.

That which lead to question to know what is the influence of the drainage state on the diagnosis of salinity and sodicity of the plot. In this case, the diagnosis is affected by the nature and intrinsic properties of the middle but also by the current hydro-agricultural conduct (state of drainage network and absence of leaching requirement). In the next step, a similar diagnosis is necessary in conditions of fully functional drainage and leaching doses made. This in the perspective to stabilizing salinity and sodicity to tolerable thresholds for the chosen crops. It will, in this case possible to extend the experiment to the rest of plots of the plain for implement an integrated management and sustainable development of environment.

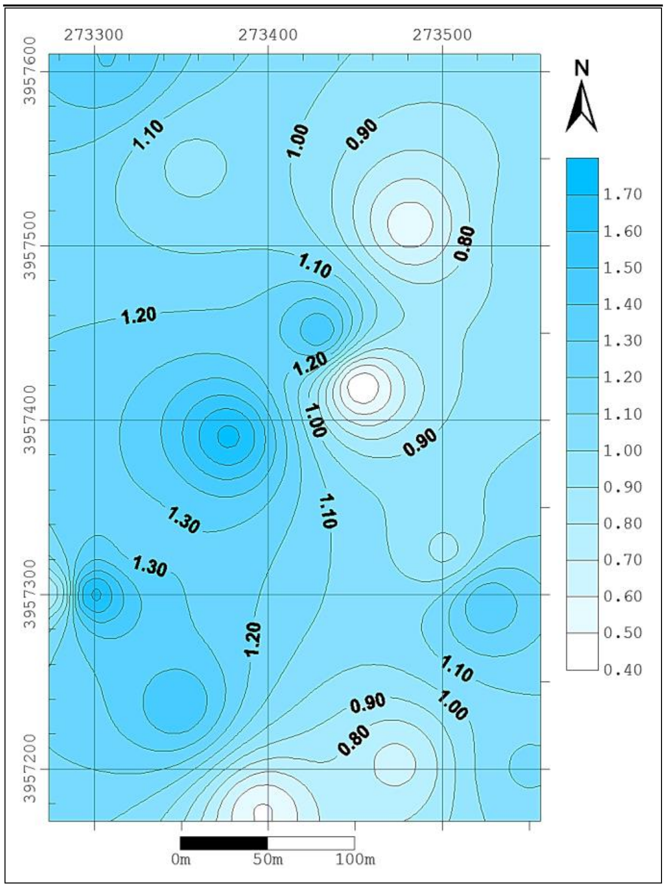

Fig. 9. Isovalue maps saturated hydraulic conductivity (cm.h^{-1}).

Conclusion

The salinity and SAR maps combined to the saturated hydraulic conductivity data, shows that the studied site is both affected by salinity and weakly sodicity. These results were obtained in a situation of insufficient land drainage, and operational doses of salt leaching depth not made. That which imposes opt for a preventive hydro-agricultural management of middle. This latest must take into account primarily a fully functional network of drainage and leaching doses satisfied. However, it is essential to diagnose the state of salinization and soil sodisation to guide the choice of scenario of hydro-agricultural conduct adequate. In effect, this approach to diagnosis of the state of degradation of soils contaminated by salinization and sodisation seems interesting to cover large areas of irrigated land and is a useful tool for optimizing the hydro-agricultural management.

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References

Corwin D. L., Lesch S. M., Oster J. D. and Kaffka S. R., 2006. Monitoring management-induced spatio-temporal changes in soil quality through soil sampling directed by apparent electrical conductivity. Geoderma, 131 (3/4), 369-387.

Douaik A., Van Meirvenne M., and Toth T., 2005. Soil salinity mapping using spatiotemporal kriging and Bayesian maximum entropy with interval soft data. Geoderma 128, 234-248.

Duchauffour P., 1979. Constituants et propriétés du sol. Pédologie2. Editions Masson, Paris, 460p.

Emerson, W.W. and Bakker A.C., 1973. The comparative effects of exchangeable calcium, magnesium and sodium on some physical properties of red-brown earth sub-soils. II. The spontaneous dispersion of aggregates in water. Australian J. Soil Res., 11, 151-157.

Halitim A., 1984. Contribution à l'étude des sols des zones arides (hautes plaines steppiques de l'Algérie). Thèse de Doc. Es Sciences. Université de Rennes. 384p.

Horneck, D.S., Ellsworth, J.W., Hopkins, B.G., Sullivan, D.M., Stevens, R.G., 2007. Managing Salt-Affected Soils for Crop Production. PNW 601-E. Oregon State University, University of Idaho, Washington State University.

McNeill J.D., 1980. Electrical conductivity of soils and rocks. Note Tech. TN-5. Mississauga (Ontario, Canada): Geonics Ltd.

Seilsepour M., Rashidi M. and Khabbaz B. G., 2009 - Prediction of Soil Exchangeable Sodium Percentage Based on Soil Sodium Adsorption Ratio. American-Eurasian J. Agric. & Environ. Sci., 5 (1), 01-04. Richards, L. A., 1954. Diagnosis and improvement of saline and alkali soils. United States Department of Agriculture, Washington, DC.

Cheverry C. et Robert M., 1998 - La dégradation des sols irrigués et de la ressource en eau : une menace pour l'avenir de l'agriculture et pour l'environnement des pays au sud de la Méditerranée. Etude et Gestion es Sols, 5(4), 217-226.

Younes D. Ezlit, Rod J. Smith and Steven R. Raine, 2010 - A Review of Salinity and Sodicity in Irrigation. CRC for Irrigation Futures Irrigation Matters Series No. 01/10. © 2010 IF Technologies Pty Ltd. 70p.

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The impact of conservation tillage in soil quality and yield in semi-arid conditions

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Abstract

The uncertain rain-fed agriculture in semi-arid and need annual water negatively affects the production and grain yield. These characteristics are an obstacle to rapid changes in varietals' lines or culture systems to cope with climate changes. Soil loss is very advanced by the various phenomena of erosion. These phenomena are exacerbated by production systems (monoculture cereal and fallowing) and the methods and tools used tillage. The wait for the rains to begin the initial tillage of soil is necessary. This situation leads them to significantly reduce the period of crop growth, already reduced in recent years because of climate change, including drought and global warming. The performance impacts of conservation tillage (such as direct seeding) are discussed successively, through the results of tests conducted in the region. A field experiment was conducted during 2007-2012 at farmers' field located in two regions. We proceed to the study of soil parameters such as moisture and organic matter and the parameters of crop yield. The direct drilling studies on cereal crops are beginning to draw tracks and paths for further research and understanding of why not to integrate this system on the farm more respectful towards natural resources and system production sustainability.

Keywords: Conservation tillage, direct drilling, Humidity, Organic matter, Semi-arid, Wheat

Introduction

Cereal production in Algeria remains dependent on soil and climatic factors and techniques and crop rotation factors. Crop productivity and soil fertility in semi arid area is influenced by tillage and crop rotation management. Rain-fed croplands conditions in the high plains of Setif are highly prone to land degradation due to their extensive agricultural practices. Technical itinerary flap mainly tillage can lead short or long period the degradation of soil structure, loss of organic matter, erosion and declining of biodiversity. These phenomena are primarily related to the production system, cereal and livestock as well as many other problems related to the land preparation. As well as many other problems related to the land preparation. The soil became more susceptible to wind and water erosion under conventional tillage system. Conventional tillage especially on plowing layer disturb aggregates of soil and increase soil temperature and soil organic decay (Islam, 2011; Benniou, 2012; Aziz et *al*., 2013).

Many scientific studies drawing attention to the consequences of conservation systems, they emphasize the economic, agronomic interest and respect for the environment that characterizes direct seeding (no till) and Simplified cultivation techniques. But very few experiments were conducted on the interest of this agricultural technique practiced on cereal's crops in semi-arid areas (Benniou, 2012). The greatest portion of

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the work concerns on the environmental aspects (reduction of soil erosion), crop husbandry (production, control of residues, weed control and crop rotations) and agricultural machines (seeders). But few works has been carried on the impact of this new technology on soil properties and their evolution.

Therefore, it is important to study different tillage system in this region. Conservation tillage leaves most of the crop residues on the surface, thus has positive influence to soil chemical, biological and physical quality properties. Tillage practices can modify soil environment, improve porosity, increase disintegration of aggregates and mix plant materials into plow depth which increases crop biomass and soil contact (Aziz et *al.*, 2013).

Conservation tillage such as reduced tillage (or simplified cultivation techniques) that aims at minimum disturbance of soil and maintaining optimal levels of crop residues on soil surface can reduce the adverse effects of convention tillage (Sayre and Hobbs, 2004). Reduced tillage is a suitable alternative to retain crop residues and maintain soil quality on degraded land of arid or semi-arid zone (Wang and al., 2006). The substantial benefits associated with conservation tillage are moisture conservation (Hassan et al., 2005), which saves 25-30% of irrigation water, improved nutrients availability (Govaerts et al., 2005) through proper placement of fertilizer, reduced soil salinity (Bakker et al., 2010), reduced production costs (Gupta et al. 2009), and similar or higher yields compared to convention tillage (Govaerts et al. 2005; Hassan et al. 2005). Crop residue holding capability of conservation tillage practices increase soil organic matter content (Egamberdiev, 2007), decrease soil salinity, reduce soil evaporation losses and thus increase water use efficiency (Deng et *al.* 2003). Tillage effect on weed restriction is also confirmed as part of sub-parts-till were less grass than subparts witnesses and on other hand weeding seem work to have parties was facilitated direct seeding, using a weeding post seedlings (Benniou, 2012).

In this study we assessed the comparable effect of conservation, minimum and convention tillage system based crop rotation system to cereals crop yield and soil fertility in semi arid conditions of Setif High Plain agro-ecosystems.

Material and Methods

Our field experiments were set at farmers' field located Setif district of East Algeria's region. The soil of the selected area has been identified as silty clay. The sol is alkaline whose pH slightly higher than 7 and unsalted (0.31 mmhos / cm). Soils were cut to the monoculture of cereals for the past 50 years under the rainfed regime.The climate of the region is typically continental with an average annual rainfall of 320 ± 30 mm and over 90% of the total rainfall is between October to April. The average monthly minimum temperature air is 0°c in January and maximum of 37°c in July. The highest average relative humidity is a little over 80% in January and the minimum is less than 45% in June.

The plots of the preceding cultures were placed in three repetitions in a stript-plot. The trial was planted on land where direct drilling is practiced for the fifth year. The previous crop was durum wheat was planted after the lens, which was planted after durum wheat, which was planted after the lens. So the rotation during the last four years is the following: Wheat- Lens -Wheat-Lens.

The object studied is the technology of tillage at three levels: direct seeding, conventional tillage and minimum tillage: (a) Direct drilling (DD): total absence of tillage. (b) Tillage treatments comprised of conventional tillage (CT, including disc plow, tiller, rotavator, and leveling operations) and (c) reduced tillage (RT, one tiller followed by harrowing).

The experiment consists of three treatments: direct drilling (zero tillage) conventional tillage and reduced tillage and was replicated thrice in a strip plot design. The size of each experimental plot was 50 m x 20 m. A buffer zone spacing of 1 m and 2.5 m was provided between plots and blocks, respectively. The tools used for preparing the soil are: disc plow, vibrashank cultivator, disc harrow and roto-harrow. During the season of experience, the culture cultivated followed was conducted in rainfed conditions without irrigation.

Culture Under all cultural methods was planted on 2 of December, but preparing soil tillage, disking and seedbed preparation respectively have over twenty, fifteen, ten and four days before setting up of cultivation. The dose applied seeding is 155 kg / ha to obtain a seeding rate of 270 seeds/ m^2. Seed rate is calculated based on the germination of seed, which was about 95%. Spreading fertilizer background in the form of MAP was performed on 2 of December 2 for the three treatments (DD, CT and RT). The dose application was 90 kg /ha used by Units: 10.80N + 46.80P.

Maintenance fertilizer: at the beginning of April, early-tillering stage, nitrogen fertilization using Uree 46% was applied at 100 kg / ha. Full tillering stage, the second nitrogen fertilization was performed on the three plots (DD, CT, RT), in late April, where it was also used Uree but the applied dose is 130 kg/ ha.

Weeding before sowing on DD plot with Roundup to 2.5 liters/ ha. Early tillering another weeding treatment stage was performed using Granstar fight against broadleaf weeds at a dose of 15 g/ ha. In late April as Topic various products including the applied dose is 180 liters/ ha, with a slurry of 185 liters/ ha.

Soil samples were collected from 0-20 and 20-40 cm layers in the beginning, at the end of experiment and of each replicate during the crop vegetative stages. The soil samples were air-dried, ground to pass through à 2 mm sieve and analysis for chemical and physical contents. The water profile was measured through the soil samples throughout the physiological cycle.

Results and Discussion

Soil parameters

Evolution of soil moisture

The evolution of soil moisture content by weight in two depths (0-20 cm and 20-40 cm) curves shown in figure 1, show variations from the crop cycle. The average test at the beginning vegetative stage (germination-emergence) amounted to 33.4%, with a standard deviation of 1.79%. Conventional tillage (CT) gave this point a slightly higher moisture (34.76%), followed by the reduce tillage (RT) with 34.03% and lastly direct drilling (31.38%). At this stage, the roughly differences low compared to the average is recorded the test, respectively: 1.36%, 0.63% and 2.02%. These differences clearly demonstrate that the moisture is accumulated in the ground at least further worked, as the TC and RT.

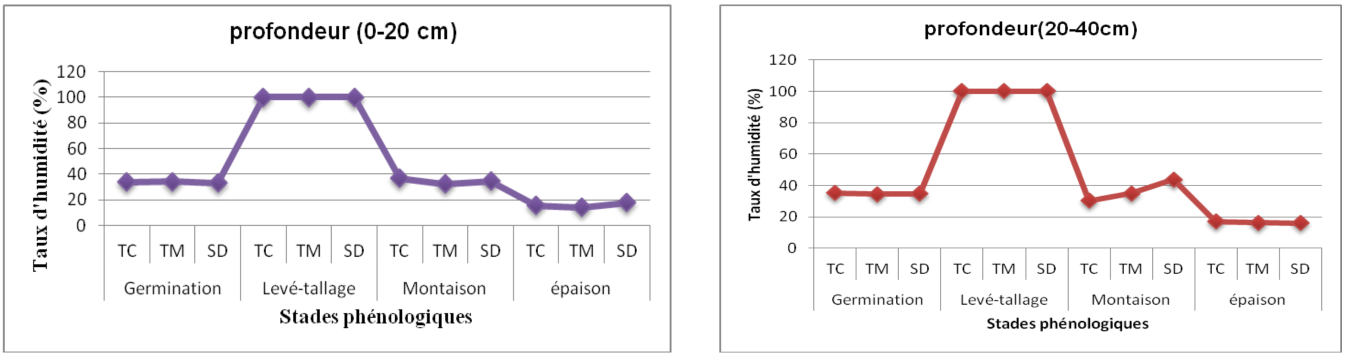

Figure 1: Evolution of soil moisture. (Legend: SD: DD, TM: RT, TC: CT.)

In stage from stem elongation, the humidity changes and lowered in the three cultural techniques relative to the beginning of cycle. The average test humidity rises to 34.64% with a standard deviation of 1.79%. Note that humidity is higher in cultural direct drilling (DD) with 36.71% respectively compared to the reduce tillage (RT) (33.65%) and conventional tillage (CT): 33 57%, with differences, calculated relative to the average, at least low: SD (2.07%), RT (-0.99%) and CT (-1.07%). Also, the differences between work cultivation are more or less varied: 3.06% (DD-RT), 3.14% (DD-TC) and 0.08% (RT-CT).

However, heading stage, the humidity changes and also lowers in the three farming techniques. But it was noted that the moisture through cultural techniques is that unlike start of vegetation. The average humidity at heading stage amounted to 16.11%, with a standard deviation of 0.87%. The humidity recorded is higher in direct drilling, which amounts to 16.83% compared with conventional technique (CT) and reduce tillage (RT), respectively 16.33% and 15.16%. Small differences are noted with respect to the test average: 0.72%, 0.22% and -0.95%. It was explained that variation soil moisture between vegetative cycle beginning (germination-emergence stage) and of the cycle end (heading stage), the profile of direct drilling is due to several effects:

(i) Direct drilling can be considered as a means of managing water resources including water saving at the vegetative end of cycle plant, particularly in rainfed farming conditions in semi-arid (Belgueri et al. 2007).

(ii) In conventional tillage, deep plowing, affects soil structural stability. Of fact, the soil becomes more permeable and allowed accelerating the water evaporation.

As compared to depth, it was noted that soil moisture is higherely in soil depth (20-40 cm) compared to the superficial (0-20 cm) across cropping techniques, except direct drilling and germination stage, soil moisture was higher in surface (0-20 cm). This seems logical because at this stage, the soil is not waterlogged much where tillage is zero. Overall, the underlying soil portion (20-40 cm) holds more water than 0-20 cm depth.

Organic matter

The organic matter content (OM) varies by cultivation technique and depth. The assay MO average is 2.7%, with a standard deviation of 0.15%. It was noted that cultivation technique, namely direct drilling and reduce tillage, occupied the first places in comparison to the conventional technique. Reduced tillage has the highest average with 2.80% a difference compared to the average test of 0.1%. In technical conservation, the average organic matter content amounts to 2.73%. Finally, there has been the conventional technique (2.56%), a difference of -0.44% from test average. These results seem to us logical because the organic matter accumulation soil direct drilling is done in several years (six years) and no-till farming with diversified cropping (cereals, legumes).

By depth and cultivation techniques, it was noted that in 0-20 cm depth, the rate of the higher organic matter is recorded in direct drilling (2.93%), followed by the 20-40 cm depth (2.54 %). This means that the organic matter is in direct drilling relatively higher surface compared to the soil depth. The difference recorded between depths is 0.39%; this is due to the fact of residues presence permanently in surfaces (effect of previous crops).

In reduce tillage, the soil organic matter percentage is also high in the surface portion (0-20 cm): 2.82% compared to the depth (20-40 cm): 2.77%. This is explained by the residues of cereals which are incorporated superficially by the superficial work. However, the opposite is observed in conventional tillage, where the organic matter soil percentage of depth was higher (20-40 cm): 2.77% in comparison to that of the surface portion (0-20 cm) 2.36%. Because tillage facilitates and promotes the organic material burial and accelerates the surface mineralization.

Table 1: Statistical results of the organic matter (U:%).

Technology tillage	Depth 1 (0-20 cm)	Depth 2 (20-40 cm)	Average	Ecart-type
CT	2,36	2,77	2,56	**0.15**
RT	2.82	2,77	2.80	
DD	2.93	2.54	2,73	
Average	2,70	2,69	2,70	

Parameters linked to weeds

Weeds Infestation

The weeds concurrent cultivated plants in nutrients needed for growth such as water, mineral elements, and more space. A density of 75 plants/ m² can reduce 20% of wheat yield (Arnal, 2006). The variance analysis results showed an insignificant effect of cultivation technique on weed infestation with 37.89% of variation coefficient as shown in Table 2. The essay average of weed infestation totaled 139 feet's/m² with 53 feet's/m² at standard deviation. By cultural technique, we recorded the highest weeds number in conservation technique, namely direct drilling (DD) with a count of 172 plants/ m². Then, the lowest value is obtained by conventional technique (CT) with enumeration of 85.33 plants/ m².

It should be remembered that treatment post planting concerned the three treatments using the Roundup; this is to eliminate weeds, especially in no-till plot that did not receive mechanical control.

It was explained that the high weed infestation registered direct drilling is due to potential stock in weed seeds at the soil surface although the rotation applied alternating crops of grasses and legumes crops (wheat-Lens-wheat-Lens). Direct drilling greatly reduces the labor regulator role on weeds development, but weed control in post planting and crop rotation in rotation can reduce in a significant way the weed infestation. For the reduce tillage one can say that the preparation of seedbed allow to create a favorable environment for germination and weeds growth. However, in conventional tillage, lower weed, that role plowing to bury and distribute weed seeds evenly in soil depth by turning land strips. Therefore tillage helps fight against weeds.

Table 2: Statistical results of weeds infestation (U: Feets/ m²)

Average technology tillage			Average essay	Standard Deviation	Probability F1	VC%
DD	RT	CT				
171,66	161	85,33	139,33	52,789	0,208 (NS)	**37,89**

Parameters linked to culture

Stocking densities (Feet's Up/ m²)

Analysis of variance results showed that the cultivation technique has a significant influence on the seeds lifting with a 14.43% for variance coefficient as shown in the table 2. The average population density assay/ m² rises to 258 feet/m² with 37 feet/ m² for standard deviation. This density is slightly lower compared to the theoretical density of the area (300 feet/m²), given the potentialities area. By cultural technique, it was noted that parcels under direct drilling (DD) have a low density compared to conventional tillage (CT) and reduce tillage (RT), respectively: 172 feet's/m², 252 feet's/m² and 350 feet's/m²).

One can interpret these variations by the installation conditions. The average population density is important in conventional techniques (350 feet/m²). It exceeds the average of the test (258 feet's/m²) and even the theoretical density (300 plants/ m²). Probably, the conditions of seed germination seed remained favorable in conventional tillage. This is due to the favorable creation environment for growth and seed germination, ie loosening. Loosening the soil has a positive effect on the flow of water and air and nutrient utilization in depth as highlighted (Soltner, 2005). According to him, soil preparation provides a good structure to the ground while improving. Then, reduce tillage preparing the seedbed has created a favorable environment for the seed's germination and the recovery rate of land is homogeneous.

So, direct drilling, probably the presence of previous residues crops interfere a little penetration tubes runs the drill into the ground, suddenly, it will not have a good seeds collection. Also, the loss to seeds direct drilling removal is due to unfavorable weather conditions in post exercise, including snow fell during the germination-emergence favored, saturation soil water and is asphyxia plants. This means that direct drilling technique is probably less resistant to weather this stage compared to other cultural techniques that allow good drainage. However, germination and emergence of crops are based on the structural condition and physical properties of the soil during planting.

Table 3: Statistical results of stocking density (pieds/m²).

Average technology tillage			Average essay	Standard Deviation	Probability F1	VC%
DD	RT	CT				
172	252	350	258,11	37,25	0,012 (S)	14,43
A	B	B				

Grain yield (t/ha)

The calculated averages showed that the average real assay grain yield amounted to 2.26 t/ha, with 0.31 t/ ha for a standard deviation. The variance analysis showed an insignificant effect on the threshold of 5% between the three cultural techniques with 3.30% at variation coefficient.

The conventional technique has captured the first place with 2.5 t/ha grain, followed by the reduce tillage (2.38 t/ha) and finally direct drilling (1.92 t/ha). The recorded between conventional tillage and direct drilling gap stood at 0.58 t/ha. One can say that spite of the yield is lower in direct drilling in comparison to conventional tillage and reduce tillage. But it is interest to the environmental preservation plan, improvement of soil physico-chemical properties, reduction of soil erosion and also economic terms.

Table 4: Results of the real yield (t/ha)

Average technology tillage			Average essay	Standard Deviation	Probability F1	VC %
DD	RT	CT				
1.92	2.38	2.5	2.26	0.31	0,852 (NS)	3.30

Conclusion

The experimentation results obtained show that the soil physical properties, including the water profile and organic matter varies per technology tillage by classifying direct drilling (DD) in the first place with respect to reduce tillage (RT) and conventional tillage (CT). Examination of these soil parameters showed that the no-tillage has changed soil properties (moisture and organic matter). The soil moisture evolution measures at the vegetative cycle end, shows that DD (no-till) and reduce tillage (RT) have stored more water. What is fundamental in a country where water is the main limiting factor in agricultural production? Also, there has been the organic matter accumulation generally beneficial for soil conservation in favor of direct drilling, especially after a judicious rotation during last five years. As for the weed infestation, the differences are more or less weak, but the advantage is given to conventional tillage. The simplification tillage (RT) and no-tillage (DD) cause infestation by weeds, which are unfavorable for crop establishment, therefore, we must fight against these weeds per proper rotations and weeding first. So the crop monitoring showed that the grain yield was best expressed in conventional conduct (CT) in relation respectively to the reduce tillage and direct drilling. Through our study we noticed the problem of weeds, especially in direct drilling plots, which must be taken into consideration. At the end of the vegetative cycle, increasing the humidity in the soil direct drilling can be beneficial in case of drought. By way of conclusion, we can say that direct seeding should be considered as a system and not as a simple method of soil preparation.

References

Arnal Atres, P., 2006. Semis direct dans la vallée moyenne de l'Ebre : Résumé des résultats et analyses économique. Troisième rencontres méditerranéennes du semis direct-Zaragoza. Ed ; option méditerranéenne, série A, n°69: 77-80.

Aziz, I., Mahmood, T., Islam, RK., 2013. Effect of long term no-till and conventional tillage practices on soil quality / Soil & Tillage Research 131- 30: 28–35.

Bakker, DM., Hamilton, GJ., Hetherington, R., and Spann, C., 2010. Salinity dynamics and the potential for improvement of water logged and saline land in a Mediterranean climate using permanent raised beds. Soil and Tillage Research 110(1):8–24

Belguerri, H., Bellameche, F., Habitouche, F., 2007. Contribution a l'étude de l'effet de la technique de semis direct sur la production céréalière en milieu semis aride. Cas de la région nord de Sétif. Mémoire d'ingénieur: University of M'sila.47p.

Benniou, R., 2012. Agriculture Conservation Role Of Moisture And Soil Organic Matter Semi-Arid. Journal Of Materials And Environmental Science, 3 (1) (2012): 91-98.

Deng, L., Chen, M., Liu, Z., Shen, Q., Wang, H., Wang, J., 2003. Effects of different ground covers on soil physical properties and crop growth on saline-alkaline soil. Chinese J Soil Sci 34(2): 93–97.

Egamberdiyeva, D., Gafurova, L., Islam, KR., 2007. Salinity effects on irrigated soil chemical and biological properties in the Syr-Darya basin of Uzbekistan. In: Lal R, Sulaimonov M, Stewart BA, Hansen D, Doraiswamy P (eds) Climate change and terrestrial C sequestration in Central Asia. Taylor and Francis, New York, pp 147–162.

Govaerts, B., Sayre, KD., Deckers, J., 2005. Stable high yields with zero tillage and permanent bed planting. Field Crop Res 94: 33–42.

Gupta, R., Kienzler, K., Martius, C., Mirzabaev, A., Oweis, T., De Pauw, E., Qadir, M., Shideed, K., Sommer, R., Thomas, R., Sayre, K., Carli, C., Saparov, A., Bekenov, M., Sanginov, S., Nepesov, M., Ikramov, R., 2009. Research Prospectus: A Vision for Sustainable Land Management Research in Central Asia. ICARDA Central Asia and Caucasus Program. Sustainable Agriculture in Central Asia and the Caucasus Series No.1. CGIAR-PFU, Tashkent, Uzbekistan.

Hassan, I., Hussain, Z., Akbar, G., 2005. Effect of permanent raised beds on water productivity for irrigated maize–wheat cropping system. In: Roth CH, Fischer RA and Meisner CA (eds.) Evaluation and performance of permanent raised bed cropping systems in Asia, Australia and Mexico. ACIAR Proceeding no 121.

Islam, KR., 2011. Continuous No-Till Impacts on Soil Biophysical Carbon Sequestration Soil Science Society of America Journal 09/ 75.

Sayre, K., Hobbs, P., 2004. The raised-bed system of cultivation for irrigated production conditions. In: Lal R, Hobbs P, Uphoff N, Hansen DO (eds) Sustainable agriculture and the Rice-Wheat system. Ohio State University, Columbia, Ohio, USA. pp. 337-355.

Soltner, D., 2005. La base de la production végétale. Science et technique agricoles. Tom I. 20ème Edition, pp : 472.

Wang, XB., Cai, DX., Hoogmoed, WB., Oenema, O., Perdok, UD., 2007. Developments in conservation tillage in rainfed regions of North China. Soil Till Res 93: 239–250.

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Some key concepts of urban soils classification

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Abstract

Based on investigations and mapping of the soils of Saint-Petersburg, there were established principles of urban area soils classification. Possible scenarios of changes in the initial structure of the natural soil profile have been considered, which are invariably associated with urbanization process. A new diagnostic horizon has been outlined, namely the Introduced horizon. Having regard to specific structure of anthropogenic soils and peculiarities of soil formation in the urban milieu, it was suggested to indentify, within CDSR, a novel unit – "Introduced soils". This unit groups the soils wherein the introduced horizon with depth of less than 40 cm lays on a mineral bedrock formed in situ or introduced from outside. Six types of soils have been identified within the unit "Introduced soils" in terms of the humus and organic horizon and the characteristics of the mineral bedrock. All these types allow for identifying certain subtypes depending on presence in the bedrock of evidences revealing mechanisms of its formation and depending on "natural" attributes such as gleying, carbonate content, ferritization, and that is reflected by complex subtypes. In the WRB system, on the basis of the aforesaid principles, it was proposed to introduce a new qualifier to group the soils that feature an introduced horizon and underlaying mineral bedrock.

Keywords: Classification, anthropogenic soils, introduced horizon, introduced soils

Introduction

There is no standard classification of urban soils. At the same time, there are works by individual authors on soil classification for Moscow [8] and Saint-Petersburg [1, 2], a significant German experience [3, 5, 7], and proposals by international working groups (SUITMA, INCOMMANTH, and WRB). Currently, an active search for a place in the system of urban soils WRB takes place [6, 7].

The WRB system [9] identifies two reference soil groups, the morphological appearance and properties of which have been significantly changed by man: Anthrosols and Technosols, as well as a number of qualifiers. Much attention is paid to anthropogenically transformed soils in "The Classification and Diagnostics of Soil in Russia" (CDSR) [4], too. The soils, in the profile of which the results of anthropogenic impacts are reflected, are distinguished at different taxonomic levels – from units to subtypes. However, not all urban surface formations that may refer to soils are dealt with in WRB and CDSR.

The experience of research and mapping of soils of Saint-Petersburg showed that soil classification of urban areas may be integrated into the overall structure of WRB and CDSR based on the following principles.

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Material and Methods

Studies of soils as an environmental basis of life quality of the population were conducted in the city of St. Petersburg. St. Petersburg was founded 300 years ago in the estuary of the Neva River. The construction of the city in the historic center of St. Petersburg resulted in the destruction and burial of all natural soils under a layer of anthropogenic deposits of up to 4 m or more. Today, St. Petersburg occupies an area of about 1,400 square kilometers and numbers a population of 5 million inhabitants. The city's soil covering is very diverse. Here, there are natural soils characteristic of this geographical area, man-influenced soils, man-changed soils and man-made soils.

Results and Discussion

Principles of classification of soils in urban areas:

- common approaches to the classification of all surface-exposed solid-bodies forming topsoil of the metropolis;
- admission that the objects of soil classification of urban areas are both natural and anthropogenically transformed soils, and man-made formations that on the surface have the introduced material of the humus (or biogenic) horizon
- taking account of signs that reflect the extent and depth of the anthropogenic transformation of the soil profile. Human activities as a factor of the soil formation lead to the soil destruction or burring and mixing, or moving the material of the soil horizon.
- taking account of not only the sequence of horizons (layers), but also the presence or absence of a genetic relation between them (an abrupt transition from one layer of soil to the subsequent one with the absence of conjugate signs between adjacent layers – substance wasting and accumulation).
- recognition that in the conditions of the urban ecological systems, the profile forming process, occurring under the influence of natural factors, is often accompanied by constant or periodic shift of the material to the soil surface. This causes an increase in the soil profile upwards and the formation of the layered strata of various thickness and composition.
- recognition that for diagnosing the horizons in anthropogenic soils and for determining the classification position of these soils at the type level in CDSR and qualifiers in WRB, as well as for natural and anthropogenically transformed soils, the priority signs are the signs inherited from natural soils.

Search for a position of urban soils in WRB and CDSR

To determine the classification position of a metropolis soil variety in the system of CDSR and WRB, let us consider possible variants of changes in the structure of the original natural soil profile, which always accompany the urbanization process. There are only four types of changes in the soil profile under the direct influence of human activities (Fig.1) – the burying the soil (profiles numbered 1-6), mixing of soil horizons (profiles numbered 7-8), cutting part of the profile (profiles numbered 9, 10), and "designing" a new profile (profiles numbered 11-13).

Profiles numbered 2, 3, and partially numbered 7, 8 retain signs of natural soils. They are singled out as Anthrosols in the WRB system. Profiles numbered 9, 10 with initial signs of soil formation are singled out as Regosols and Arenosols. Profiles numbered 5, 6, 11, 12 that contain more than 20% artifacts are classified as Technosols. Soil bodies, which have preserved their natural structure, and soil bodies, which are under asphalt ("sealed" soils) are classified as Ekranic and Linic Technosols according to WRB (Profiles numbered 4, 5). Profile numbered 13 with low content of artefacts have no clear signs allowing for classifying them as natural soils or Tehnosols according to the WRB system.

Profiles with the structure numbered 4, 5, 6, 11, 12 (Technosols) and 13 are widespread throughout the hight-density development area. They form a very heterogeneous group of surface formations in terms of their structure, composition, properties and functions.

The soils, the large part of the profile of which is represented by humus stratified layer of introduced material, are combined, according to CDSR, into the composite soil unit (stratozem) (profiles numbered 2, 3, 6, 12). If stratified layer contains more than 20% of artefacts and more than 35% of construction waste, the qualifier Urbic is used, according to WRB, for such soils.

At the burial of the natural soil profile by the layer of natural or artificial material of small capacity (up to 40 cm), bodies are formed which are classified according to CDSR at the subtype level as humus, arte-, urban- and toxi-stratified soils (in the WRB system, the qualifier Novic is used for similar soils).

Only the upper part of the natural soil profile may be disturbed during the reduction of the tree vegetation or levelling. According to CDSR, these soils are classified as disturbed at the subtype level in the types of natural soils. With the prolonged mixing of the upper horizons associated with the agricultural use of the soils, agricultural natural soils and agricultural soils are formed according to CDSR, and Anthrosols are formed according to WRB.

As a result of cutting one or two surface horizons, abraded soils are formed. In case of deeper cutting or severe erosion, when the median horizon, which has been preserved in this or other degree, comes to the surface, the soil belongs to the unit of abrasols (CDSR) (profile numbered 9). Often soil is completely destroyed during construction and rock appears on the surface (profile numbered 10); in this case abraliths are distinguished, no more representing soil but man-made surface formation.

Within the framework of the CDSR system, all variants, except for profiles numbered 11-13, have been considered, or have their place in the system or are not subject to soil classification. The remaining variants are the man-made anthropogenic soils.

Anthropogenic soils are formed in the city when the man, based on the objective function of providing conditions of growth and development of plants, deliberately creates a physical model of the rooting layer. For this, the man brings organic-and-mineral or organic material to the urban environment – a product of a long natural soil formation, which was formed under the different ratio of factors. Typically, this material is taken from different soils in the adjacent areas. Thus, as a result of human activity, the most biologically active part of the soil from its natural area is transferred to the urban area. Such a deliberate introduction of the material of the humus (peat, peat-and-mineral) horizon to the new formation environment, which is alien for the material, is a kind of introduction, like the introduction of a species in biology. As a result, soils with a new diagnostic horizon are formed.

The introduced horizon (I). This is a humus or organic horizon, consisting of one introduced and one man-modified material of the horizons of natural or anthropogenically transformed soils and having a sharp lower bound with a mineral substrate below it – bedrock D (CDSR) or C*(fig.1). Often there is heterogeneity with respect to the combination, the composition and density. Inclusion of common artefacts and carbonates is usual. The horizon is characterized by high levels of heavy metal contamination.

Proposals for the introduction of new taxa in CDSR and WRB

The peculiarity of the process of soil formation in urban environments is rejuvenation of the soil profile as a result of permanent or periodic supply of humified material to the soil surface. Estimating the age of soils in urban areas, one should take into account that the age of the surface introduced by the humus horizons and the underlying mineral stratum can be very old, up to several thousand years, while the age of the soil profile itself can be under one year. The soil-forming process in the metropolis is, on the one hand, not fundamentally different from the natural process and, on the other hand, the speed of the process is much higher in the city.

The basis for the classification of soils with the introduced horizon is a morphological and genetic analysis of the profile: the structure, composition and properties. For the conditions of Saint Petersburg, the profile depth up to 100 cm is taken account of, i.e. to the bottom of a clear manifestation of soil forming processes in natural soils of the region, differentiating the profile into genetic horizons.

Given the specific structure of anthropogenic soils and soil forming peculiarities in the urban environment, we suggest to introduce the unit "Introduced soils" into the stem of sinlithogenic soils, alongside the composition, volcanic, underdeveloped and alluvial soils.

The unit combines the soils, in which the introduced humus or organic horizon (I) with the capacity of less than 40 cm lies on the mineral substrate (D), formed in situ or introduced from outside.

If the introduced horizon with the capacity below 40 cm lies on the soil with intact structure or any median horizon, the soil is classified under CDSR as humus-stratified subtype within the corresponding type [4]; and where the capacity of the introduced horizon is more than 40 cm, the soil is classified as composition soil.

In the unit "Introduced Soils", 6 types of soils are distinguished according to the nature of the humus or organic horizons and the peculiarities of the mineral substrate.

It is possible to distinguish subtypes in all the types by the presence of signs in the underlying substrate that indicate the mechanisms of its formation.

- Typical soils (in situ) I-D: the underlying mineral stratum has no signs of mechanical movement. Typical introduced soils are formed when the introduced horizon is laid on the soil forming stratum, which has remained of the damaged soil.
- Urban layered soils I-RDur: they feature a well-defined stratification, often with a high degree of industrial inclusions (bricks, construction and household waste, clay, gravel, artefacts, etc.). The underlying urban layered mineral stratum can be up to several meters thick, and subtypes of such soils are characteristic of the areas where construction works have been repeatedly performed.
- Urban filled-in soils I-RD: the underlying mineral stratum is heterogeneous in respect of its composition and structure, it often contains artefacts; the fuzzy structure indicates stratification of the material. These subtypes are formed at construction sites or at sites where various underground utilities are repaired. In most cases, the underlying mineral stratum is not more than 2 meters thick and has bedrock of a natural structure.
- Urban layered humus soils I-RDur [h]: They feature well-defined stratification, often with the inclusion of introduced buried humus layers. In Saint Petersburg, urban layered humus soil subtypes have been found in squares and parks in the city centre.
- Water-accumulative soils (wash) I-Daq: The underlying mineral stratum is homogeneous in respect of its composition and has a thin layering.

Besides the above subtypes, which are specific for introduced soil types, subtyping by “natural” characteristics is possible, such as gleying, carbonate and iron accumulation, which is reflected by complex subtypes.

It is reasonable to single out soils with the introduced horizon into an independent soil reference group, Introdusols in the WRB system. These soils are numbered 6, 11, 12, 13 (Fig.1). Other members of the group which are classified as Technosols (profiles numbered 4, 5) constitute non-soil formations.

It is the ratio of soil formations to non-soil formations in urban environmental space that determines the environmental basis of life quality.

Introdusols form a homogeneous group according to the following signs:

- Availability of surface humus or organic horizons inherited from natural soils and constituting the product of a long process of soil formation
- Lack of a genetic connection between the surface humus horizon with an underlying substrate of different origin, composition and properties that has been formed by man and constitutes the remnants of parent rock (in situ)
- Implementation of major environmental functions that ensure the life quality of the population

The singling out of the reference soil group, Introdusols, fully complies with the WRB principles.

The following Introdusols have been identified in St. Petersburg in terms of the nature of organic horizons and those of the characteristics of mineral substrate: Umbric Introdusols, Histic Introdusols, Pachic Introdusols, Urbic Introdusols, Spolic Introdusols, Mollic Introdusols, Gleyic Introdusols, Arenic Introdusols.

The prefix and suffix qualifiers are used for further division of Introdusols.

Conclusion

Within the CDSR system we suggest to introduce the unit “Introduced soils” into the stem of sinlithogenic soils, alongside the composition, volcanic, underdeveloped and alluvial soils.

Within the WRB system and based on the above principles, introduction of a new reference group is suggested, in which soils with an introduced horizon having an underlying mineral substrate will be grouped.

Inclusion of natural, anthropogenically transformed soils and actual anthropogenic soils into a single classification scheme will allow treat a variety of soils and their changes in topsoil of any metropolis from a unified position, both in space and in time.

References

1. Aparin, B., Sukhacheva, E. 2013. Soil cover of St. Petersburg: "from the woods' dark and marshes' cold" to the modern megalopolis. Biosphere. 5/3. 327-352. [in Russian].
2. Aparin, B., Sukhacheva, E. 2014. Principles of creating a soil map of metropolis. Soil science. 7. 790-802. [in Russian].
3. Burghardt W. 1994. Soil in urban and industrial environments. Zeitschrift Pflanzenernahr., Dung., Bodenkunde. 157. 205-214.
4. Classification and diagnostic System of Russian Soils. 2004. Oikumena, Smolensk. [in Russian].
5. Lehmann A., Stahr K. 2007. Nature and Significance of Anthropogenic Urban Soils. J.Soils Sediments. 7 (4). 247-260.
6. Naeth M.A., Archibald H.A., Nemirsky,C.L., Leskiw L.A. Brierley J.A. Bock M.D., Vanden Bygaart A.J. and Chanasyk D.S. 2012. Proposed classification for human modified soils in Canada: Anthroposolic order. Can.J.Soil Sci. 92. 7-18.
7. Rossiter D.G. 2007. Classification of Urban and Industrial Soils in the World Reference Base for Soil Resources. J. Soils Sediments 7 (2). 96-100.
8. Stroganova M.N., Gerasimova M.I., Prokof'ieva T.V. 2005. Approaches to Grouping Technogenic Soils. Euroasian Soil Science. 38/1. 566-571.
9. World Reference Base for Soil Resources. 1998. FAO, Rom.

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Reclamation of disturbed areas in the industrial zones of Bulgaria

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Abstract

A huge problem exists in the industrial zones of Bulgaria on the cleanup and reclamation of pollution caused by construction debris. Old industrial areas almost dysfunctional in large part are gradually clearing parts. The problems are in their high spatial dimensions. These sites are mainly situated in 28 regional urban centers, some small and very small towns. Their functions will now be changed after their demolition and wrecking of buildings and technical infrastructure. Reclamation of disturbed areas is carried out in two stages: 1. Technical reclamation in which are carried out cleaning and site preparation; seizure and transportation of soil for their intended purpose, alignment and landscaping in its final stage, adding enhancers, seizure, transportation and spreading of the humus layer, construction of temporary and permanent roads, construction of erosion control and irrigation facilities, forming ponds. 2. Biological reclamation , whereby when the site is reclaimed for agricultural use - a complex of agricultural, agrochemical , technological and ameliorative measures for restoring the productivity of reclaimed land for 5 years after completion of technical rehabilitation and when the site is reclaimed for forestry use - forestry , agrochemical, technological and ameliorative measures for the creation of forest plantations of trees and bushes in the first three years after the implementation of technical rehabilitation and afforestation. These sites can be again mostly industrial or other functions. According to the Law on Spatial Planning and the Ordinance on rules and regulations for the structure of different types of territories and development zones in three varieties industrial area green area needs to take 20-40 % of it, with one third of it must be provided for landscaping with trees. The problem is exposed to the example of part of the industrial area of the regional town of Blagoevgrad.

Keywords: construction debris, disturbed areas, industrial areas, technical and biological reclamation.

Introduction

There is a huge problem in the industrial zones of Bulgaria on the cleanup and reclamation of pollution caused by construction debris. Old industrial areas already barely functioning in large part are gradually clearing apart. The problems are in their high spatial dimensions. Sometimes they take from ⅓ to ¼ of the city. These sites are mainly situated in 28 regional urban centers of the country, and some small and very small towns. Their functions will now be changed after their demolition and wrecking of buildings and technical infrastructure. They can be re-productive or other functions such as landscaping. With the development of new General plans of cities and Integrated plans for urban regeneration and development these industrial zones delineate in the

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majority of cases of high-tech industries (technology park, etc.), and sometimes remain the same kind of industrial zone. According to the Law on Spatial Planning and the Ordinance on rules and regulations for the structure of different types of territories and development zones define three types of industrial zones [7].

The objectives of this study are to determine the influence on the soil quality in 'anthropogenic' soils on the development of green area and to establish the extent to which the soils are affected by human and industrial activities. To achieve this purposes, the developed GIS of Soil Resources (GISoSR) is used and by following the approach for sustainable green area by maintaining and improving soil fertility.

Material and Methods

Industrial zones are intended for planning and construction mainly with buildings and facilities for production and storage activities. Industrial zones as eligibility for combining activities may relate to the following types of industrial development zone:

1. Clean industrial zone;
2. Mostly industrial zone;
3. High-tech industrial zone (Technology Park, etc.).

Areas of variation "clean production area" are built only with production, storage and service buildings and facilities. Service buildings and facilities are health centers, shops and catering restaurants for the daily needs of workers, office buildings and scientific experimental facilities for businesses, garages and parking lots, and security houses.

In conducting construction of regulated properties of enterprises in the territories of the variety "clean industrial zone" are used the following regulations:

1. Density (percentage) of construction (P built.) - from 50 to 80 %;
2. Intensity of development (K int.) - from 1.0 to 2.5.

Areas of variation "mostly industrial zone" are built up mainly with production, storage, administrative, commercial and service buildings. They are not produced with harmful emissions, such as:

1. Enterprises of the chemical and rubber industry with technological waste products;
2. Lime concrete and asphalt plants;
3. Any type foundry for ferrous and nonferrous metals.

Areas of variation "mostly industrial zone" allow construction of residential buildings and dormitories for staff in businesses, shops and catering establishments, hotels, hospitals, vocational-technical schools, vocational facilities and buildings of scientific and experimental facilities to businesses.

In the construction of the regulated lots of businesses in the areas of diversity "primarily industrial zone" are used the following regulations:

1. Density (percentage) of construction (P built.) - From 40 to 80 %;
2. Intensity of development (K int.) - from 1.0 to 2.5.

Areas of variation "high-tech industrial zone" (technology parks, and the like) are separate, distinct areas ranging for one or several undertakings related to technological development, and necessary service, administrative, scientific, educational, recreational and other objects. They are not produced with harmful emissions and environmental impacts. In areas of the variety "high-tech industrial zone" are built companies with high-tech industries, laboratories, centers and buildings for educational, scientific and experimental innovation activity, administrative and business buildings and offices, exhibition halls, residential buildings and dormitories for researchers, teachers and working for businesses, shops and catering and domestic service, hotels, hospitals, sports and entertainment facilities, green areas.

In the construction of the regulated lots of businesses in a variety of areas "high-tech industrial zone" are used the following regulations:

1. Density (percentage) of construction (P built.) - From 40 to 50 %;
2. Intensity of development (K int.) - from 1.0 to 1.5.

Typical Soil Types Blagoevgrad.

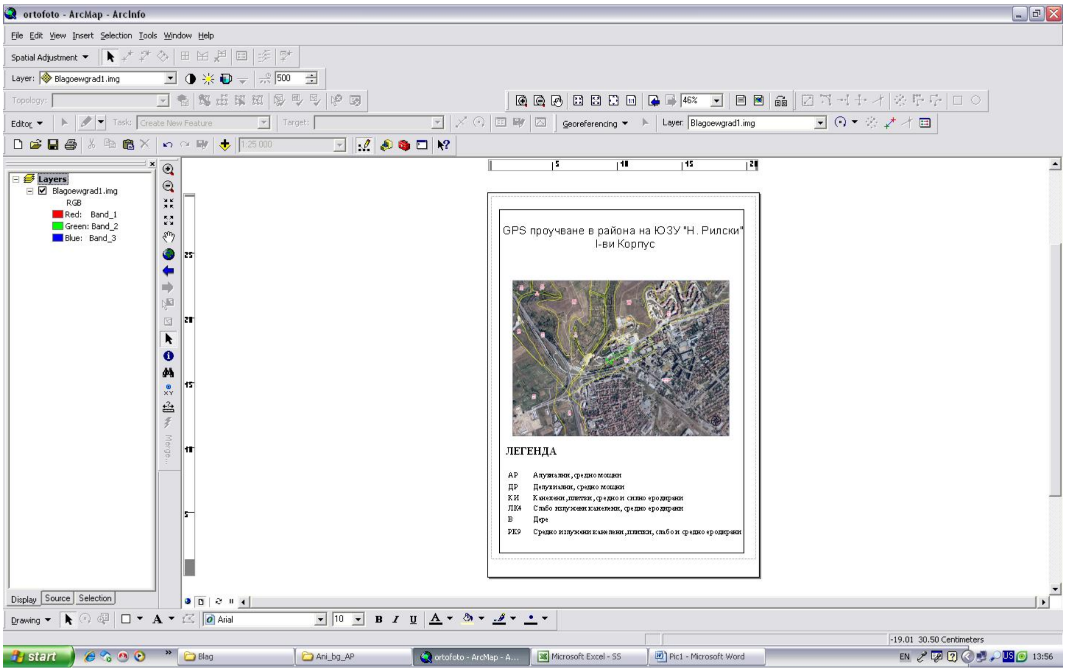

Fig. 1. GPS survey near SWU "Neofit Rilski".

Legend:
AP - Alluvial, medium power;
AP - Deluvial, medium power;
KI - Cinnamonic, shallow, medium and heavily eroded;
LK4 - Low leached cinnamonic, medium eroded;
RK9 - Average leached cinnamonic, shallow, low and medium eroded;
W – Spruit.

Soils in Blagoevgrad.

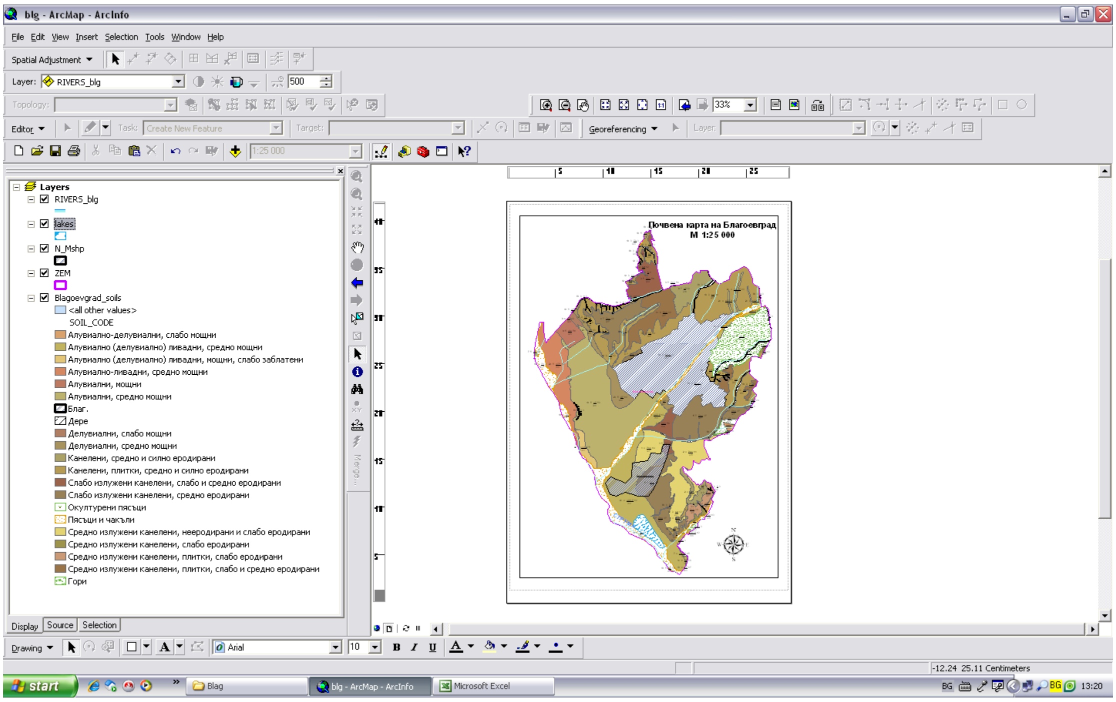

Fig. 2. Soil Map of Blagoevgrad.

Arable soils are not characterized by great diversity. Along the Struma River and its tributaries in soil characteristics are leached cinnamon forest and alluvial, alluvial-meadow soils. For some of arable separate arrays, there are small differences manifested by the presence of some additional soil types. In Radomir field that have served the black earth. Along the Dzherman, near Dupnica appear talus and deluvial soils. In the lower section of the valley Rilska River - are alluvial and deluvial - soils and along the Strumeshnitsa River - deluvial deluvial and meadow soils.

In normal years, winter rains provide soil profile stocks that reach almost to the limit field capacity. Of these productive water supplies in leached cinnamon forest soils are 1624 m^3/ha, and for alluvial - meadow are 1694 m^3/ha. For all soil types are opportunities to accumulate a watering from spring rains fall and create conditions for growing wheat without irrigation. However, for the valley irrigated and irrigated conditions, they are ineffective. For other crops, in normal years, irrigation provides increased yields.

Climate

Blagoevgrad district is located in the continental climate of the European continental climate zone. The climate varies from temperate to Mediterranean in the southern parts. Mediterranean air coming from the valley of the Struma influences the climatic characteristics of the region. The average temperature is +12,4 ° C, the average winter temperature - +3,4 ° C, the average summer temperature - +16,5 ° C and average annual rainfall: 560 mm.

Agroecological regions

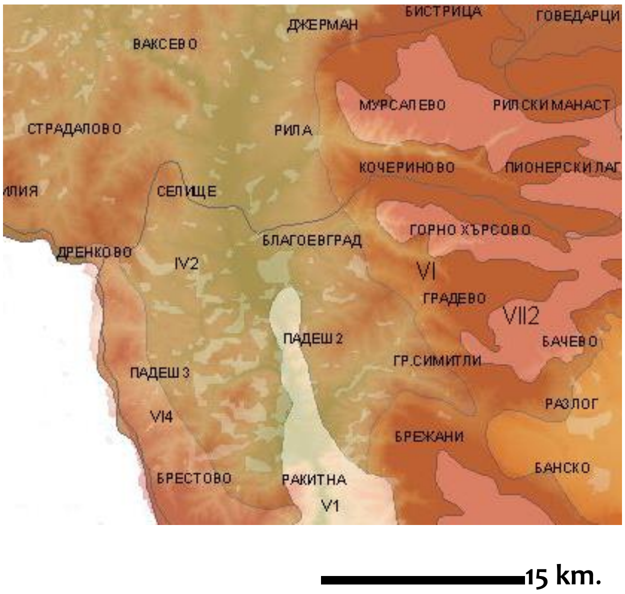

Fig. 3. Map of agroecological regions in Blagoevgrad District.

Legend:
IV2 - Kyustendil region;
VI - the Rila-Pirin region;

IV2 Kyustendil region.

Kyustendil region covers the territory between Milevska, Maleshevska and Rila mountains. The terrain is mountainous valleys and valley and determines the manifestation of the erosion process has hinged. The soil cover is similar to that described in the previous region, with the difference that the surface area of the cinnamon soils is significantly greater than that of Vertisols. Moreover cinnamon soils have less power on the horizon, lighter and skeletal mechanical structure, lower humus content and a larger area of eroded lands. Rendzinas are also low in organic matter and have a frame. The area falls within the continental climatic sub-region and the climate is formed under the influence of the Struma River, Rila and Osogovska. Thermal resources are more favorable - the average annual temperature is 10.6 °C, precipitation is about 640 mm, the majority of them fall during the growing period. The balance of the atmospheric humidity is very negative - with a deficit of 310 mm. Autumn and winter stock is reduced due to terrain and soil characteristics, the balance turned negative in July that requires irrigation. Total productive capacity of the land is characterized by medium (agronomic) bonitet score 52, which belongs to them bonitet group "middle land". Most suitable for wheat, pastures and meadows, vineyards, apples, sugar beets, maize, alfalfa and oriental tobacco (bonitet score in the range 59-41 ball (the "middle land"). Less suitable are potato (37 ball), soybeans (33 ball) to include them in the group "bad lands."

VI6 Rila-Pirin region.

Rila-Pirin region occupies areas with an altitude of 800 to 2000 m. It has alpine character. Soil forming materials are granite, gneiss, schist, limestone and their weathering products. The greatest contribution of the brown mountain forest soils, which are similar to their peers case treated areas but the humus horizon is more powerful (20-60 cm) and dark colored. The annual rainfall is about 840 mm, and about 440 mm falling during the growing season. The average annual temperature is about 5 °C, with a temperature sum of the growing season about 2000 °C. Land in this area is characterized by medium (agronomic) Bonitet Ball 52, i.e. a bonitet group "middle land", but it concerns the lower areas with an altitude of 700-800 to 900-1000 m, where climatic conditions still allow their growing (and here they favor the aid of a strong Mediterranean influence). Outside the forest zone the land is unsuitable for normal land use, except for potatoes, pastures and meadows. The lower parts are suitable for potatoes and wheat productivity class 71 and 60 ball (i.e. the group "good land." Less is the suitability of environmental conditions for grassland, oriental tobacco, sugar beets, grapes, apples (credit rating ranging from 52 to 41 prom, i.e. the group "middle land" for maize, sunflower and alfalfa productivity class is in the group "bad lands" and for soybeans - "unfit." Like other areas assessments land for different crops vary considerably, which is associated with the altitude, the nature of the soil that is affected in varying degrees of erosion.

Methods

The study used the tools of ArcGIS - ArcMap and remote sensing for the objects describtion, Visual Basic and Access for analysis of water-physical and hydrological properties of the different soils after Kolev et al. (1996) and SWOT-analysis.

Results and Discussion

Soil Resources in Blagoevgrad

Data that are discussed below were made soil mapping (1:25000). The overall appearance of the object by means of ArcGIS 9.3 - ArcMap is presented in Fig.5. Dominated by the brown forest soils (1-7 KG) - *Figure* 2 and found browner, shallow, medium eroded (KGE) and brown, shallow, heavily eroded (KGC). They are the most widespread soils in mountain areas and occupy the area of 17 million hectares or 15%. These soils are rich in humus, but the average stock of available nitrogen and phosphorus absorbed. They need to be combined fertilization. In the higher parts of the mountains brown forest soils in passing dark colored forest and mountain meadow.

On the riverbanks it meet alluvial (AP - alluvial, medium power) and on the slopes - delluvial (DL - (delluvial, less powerful) and talus (DR - delluvial, medium power) soils. Higher in parts of the municipality is dominated by mountain meadow, shallow, low and medium eroded (PL). Cinnamoning soils are presented by cinnamoning and cinnamoning immature, shallow and heavily eroded and rocks (NKK). Represent the most common soil type in the country. Occupy 25 % of the total soil area of Bulgaria, mostly in the Central Forest Mountain and Southern Bulgaria. These soils are medium humus in humus like gray forest soils, poorly maintained to absorb nitrogen and phosphorus. For improving soil fertility fertilization and irrigation are recommended.

The general data for a pseudopodzolic soil is presented in Fig. 4 and the results obtained after using methodology after Kolev et al. (2007) – in Fig. 5.

The three factions of the mechanical composition in USDA classification Sand (sand fraction), Silt (silt fraction) and Clay (clay fraction) are calculated, and some water and physical and hydrophysical properties - total porosity, filtration coefficient, field water capacity and wilting point in soil horizons and for the entire soil profile since Kolev et al. (2007). Soil horizons varies from loam true silty clay loam to light clay, an average the soil profile is defined as clay loam - clay, sandy loam , with an average content of Sand (sand) - 43 %, Silt (silt) –

23 % and clay (clay) – 34 %. Total porosity varies horizons from 41.2 to 49.3 % on average 43.3 %. Filtration coefficient is 12.2 cm/day in plugging horizon to 20.5 cm/day in the under plugging horizons, with average value of 15.9 cm/day. Field capacity (PPW) varies between 25 % in plugging horizon to 30.3 % in the under plugging horizons, with average value of 27.4 %. Wilting point (WZ) follows the PPW - from 9.3% in plugging horizon to 20.42 % in the under plugging horizons, with an average value of 17.14 %.

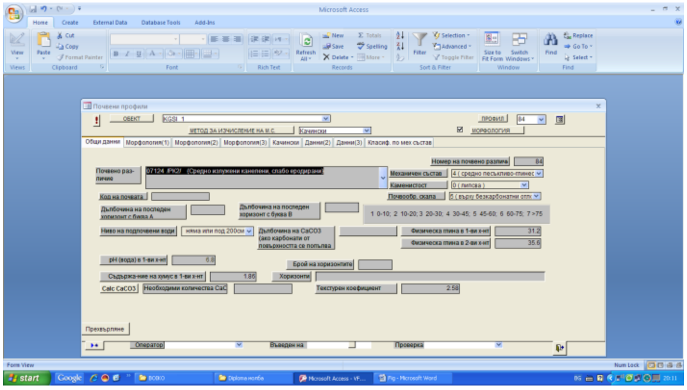

Fig. 4. General data for mean pseudopodzolic soil.

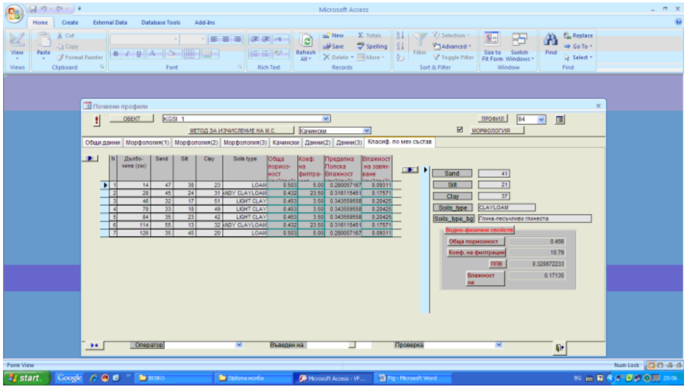

Fig. 5. Classification of soil texture and determination of some water-physical and hydrological properties.

Analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT - Analysis)

Blagevgrad Municipality has 11333.6 ha cultivated land. Arable land - 5548.5 ha including 1261.7 ha of meadows and 5785.1 ha pastures and other agricultural lands. Land is managed entirely by private owners, as in the municipality operate two agricultural cooperatives. The largest shares in the structure of culture are potatoes, corn and cereals. Tobacco is a major industrial crop. There is a base for mechanical drying, which is a prerequisite for growing deciduous variety Virginia. Due to lack of markets in recent years such cultivation is suspended.

Analysis of the data shows that the Municipality of Blagevgrad operates from extensive farming type, characterized crop cultivation and livestock primarily to meet the needs within households. There is a very low growth rate of investment in the agricultural sector, a high degree of fragmentation of farmland, uncertain markets for selling their produce. Soil and climatic conditions in the municipality are suitable for growing tobacco, potatoes, some autumn cereals and fruit. Base dimensions overlapped during those four years are relatively unchanged. As of December 2005 the property in agriculture and forests are 85 registered agricultural producers, with no agricultural cooperatives. SWOT analysis is presented in Table 1.

Table 1. Analysis of the strengths, weaknesses, opportunities and threats.

STRENGTHS	WEAKNESSES
➢ Absence of industrial pollution, ecologically pure area; ➢ Developed wood processing industry; ➢ Water resources and power generation; ➢ Availability of significant woodland and forest resources; ➢ Traditional experience in agriculture.	➢ Fragmentation of agricultural land and insufficient opportunities for their consolidation; ➢ Availability of large areas affected to varying degrees by erosion; ➢ Remoteness of the municipality of economic and administrative centers.
OPPORTUNITIES	THREATS
➢ Ability to develop alternative forms of agriculture, rural and ecological tourism; ➢ Traditional tourism; ➢ Opportunities to attract inward investments and the activation of economic links with the business in Greece.	➢ Total economic decline; ➢ Quality deterioration of the technical infrastructure; ➢ Road and village infrastructures deformations

The green areas in all three varieties are the same, from 20 to 40 %, as one third of it must be provided for landscaping with trees. The problem is illustrated on the example of part of the industrial zone in the district town of Blagoevgrad. This production area illustrated below in Fig. 6-11 before its destruction when it was kind of "clean production zone". So after its destruction it is contaminated only with debris. Ordinance of the municipality to settle such land and disposal of construction waste is incomplete and inefficient [8,]. It should be supplemented by a new requirements of the Ordinance on management of construction waste and use of recycled building materials approved by Decree № 277 of 5.11.2012, publ., SG. 89 of 13.11.2012, effective 13.11.2012 [9].

Fig. 6. Part of the industrial territory Blagoevgrad variety of "clean industrial zone"

Fig. 7. Construction of a building in "clean industrial zone " designed to store

Fig. 8. View from "clean industrial zone" - silos and office building

Fig. 9. View from "clean industrial zone " after its destruction

Fig. 10. View from "clean production zone" after its destruction

Fig. 11. Construction waste closeup of "clean industrial zone" after its destruction

Conclusion

Estimates of the SWOT analysis of the development of Blagevgrad municipality showed higher values in the part of the strengths and opportunities, which requires aggressive implementation of priority development strategy using the strengths and opportunities as actions aiming at increasing the share of strengths and opportunities and gradually reduce the share of weaknesses and threats. Significant difference in the distance between the strengths and weaknesses demonstrates the need for a certain period of time to implement the necessary results. The level of threat is realistic high, which determines the presence of a particular risk in the implementation of strategic objectives and the program should focus on the development of the municipality to overcome the subjective weaknesses and taking full advantage of the opportunities and benefits in order to achieve long-term goals while avoiding teething. This SWOT analysis allows concluding that tourism in Blagevgrad also has significant potential for future development, especially in the directions for the establishment of a national and international center for winter tourism and sports and rural development. Looking at the estimates of the SWOT analysis for human resource development, education and culture in the municipality is apparent difference in favor of the weaknesses, i.e. in the overall development of the municipality, education is the weak link. Measures are needed to reduce or stop the impact of weaknesses and prevent the emergence of threats by supporting schools in municipal administration, and active work with non-governmental organizations working in these fields. Better land management, land resources and environmental objectives implementation of the approved NAEP (NAEP) and especially of international commitments such as the Kyoto Protocol and the Convention on the conservation of biodiversity, combating desertification and climate change. Recommendations are made to minimize negative impacts on the environmental components and agro-ecological resources. Of the sites as potential contaminants are not expected to significantly impact on a territorial scale. It is envisaged that the introduction of a monitoring system and a strict effective control and management of air, land and water resources.

References

[1] Gurov G, Artinova N., 2001. Soil Science. Plovdiv, Bulgaria, pp. 355-365; Bulgarian edition: Makros 2001.

[2] ISSAPP-Sofia - http://www.iss-poushkarov.org/Bgzanas.htm

[3] Kolev B. 1994. Abstract of dissertation for obtaining PhD degree. Sofia, Bulgaria, pp 10-35; (Bulgarian).

[4] Kolev B, Kastreva P, Miteva N, Samuilova S., 2007. Use of GIS of soil resources for assessment soil fertility in Razlog municipality. Annual reports of Shumen University "Bishop Konstantin Preslavsky", T. XVII B 3 "Natural Science". Shumen. 2007, Bulgaria, 182-201; (Bulgarian).

[5] National Strategic Plan for Rural Development 2007-2013. http://prsr.government.bg/Admin/upload/Media_file_1268272388.pdf. (Bulgarian).

[6] Municipality Blagoevgrad Development Plan from 2007 to 2013. (Bulgarian).

[7] Ordinance № 7 on rules and regulations for the structure of different types of territories and development zones Chapter Five Planning of industrial zone, (Promulgated, SG. 3 of 2004, as amended. Amended and supplemented. № 10 2005, Decision № 653 of the SAC 2005 - issue. 11 of 2005; amend. and supplemented. № 51 of 2005; Decision № 7028 of SAC 2005 - pc. 63 2005; amend. No.. 41 of 2008 pcs. 76 of 2012 and №. 21 of 2013)

[8] Ordinance waste management the municipality of Blagoevgrad, Section VII Management and organization of activities treatment of construction waste and earth masses 13.17.10.2006.

[9] Ordinance on management of construction waste and use of recycled building materials approved by Decree № 277 of 5.11.2012, publ., SG. 89 of 13.11.2012, effective 13.11.2012

[10] Hershkovich E., 1984. Agroclimatic resources of Bulgaria. BAS publishing, Sofia, Bulgaria, pp 72-103, (Bulgarian).

[11] Kolev B, Mihalev D., Zhivkov D, Miteva N., 2007. The Geographic Information System of Soil Resource Using for Sustainable Agriculture Realization, In: International Conference on Cartography and GIS, January 25-28, 2006, Borovets, Bulgaria. (In CD copy).

[12] Kolev B, Rousseva S, Dimitrov D., 1996. Derivation of Soil Water Capacity Parameters from Standard Soil Texture Parameters for Bulgarian Soils, Ecological Modelling 84, N° 1-3, Elsevier, Amsterdam, Holland, 315-319.

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Problems and perspectives for the agriculture in Blagoevgrad District

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Abstract

Blagoevgrad district is situated in Southwestern Bulgaria. The district area is characterized by a wide variety of natural resources that underlie the formation of a very diverse soil cover. A major problem is the non-use of the land for the benefit of us and indiscriminate wastage of this precious resource so out of ignorance and low interest for understanding the nature of the problem. Large number of agricultural land is misused. There is a very high percentage of uncultivated agricultural land, which in some cases can enhance their erosion. Arable land, combined with soil - climatic diversity, creates the conditions for agricultural production, which is the main raw material base for the development of Food Industry. The objective of this study was to determine the influence of soil diversity on the development of agriculture and to establish the extent to which the soils are affected by human activities. To achieve this purpose, the developed GIS of Soil Resources (GISoSR) is used and by following the approach for sustainable agricultural production in Arc-GIS environment by maintaining and improving soil fertility.

Keywords: Arc-GIS environment, GIS of Soil Resources (GISoSR), erosion and degradation of soils, organic pollutants, heavy metals and metalloids.

Introduction

Since ancient times the soil was the main subject of labor, subsistence and livelihood, a source of wealth. In the process of increasing its active use people explore getting better and fuller its properties and capabilities, resulting in their impact became more active and purposeful. This has contributed initially by a minor accident and subsequently to consciously change the properties and quality of natural soils. The extent of this impact and change was proportional to the overall development and improvement of human society, the development of scientific and technical progress. Therefore, it is expressed most strongly in modern conditions. Active use of soil in the business of man naturally raises the question as to determine the nature and extent of change and the initial properties and the appropriate classification for certain signs of soil formed by different influences.

Initially, the relatively long period of time the soil was used exclusively in agriculture. So the first studies in this area are associated with changes in natural soils in the process of their agricultural use. Changes that occur in

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the natural soil formation process under these conditions is due, on the one hand, the change of vegetation, and the other - the direct impact on the soil by applying different agronomic and melioration measures. Under the influence of human activities can occur either positive or negative in the properties of natural soils. This causes a lively discussion on using the terms "culture" and "agricultural" soils. Some of the terms used in a narrower sense, only be used in cases where human activity has had a positive impact. For example, according Stolygane the term "to make the soils cultural" means root modification of the natural soil of labor rights, which dramatically improves the properties as a means of production. According Grichenko in the development of modern soil formation process are two possible directions: development of soil formation process in which soils become negative agronomic qualities and development of "cultural" soil formation process, which preserves the positive agrochemical properties of natural soils and develop new valuable biological, chemical, physical and other properties. The study of the "to make the soils cultural" soils is important, but poorly developed problem of modern soil science, which requires primarily used to clarify concepts and terms. However, human intervention, resulting in improved properties of the soil. So usually use the term "to make the soils cultural" or "cultural" soils do not always reflect the real situation. Their use should be limited to cases where there actually cultural rather than soil degradation. In this regard Nadezdin suggests that a more general term 'anthropogenic' soils. It indeed covers any exposed to impact human soils, even if the changes are positive or negative.

The objectives of this study are to determine the influence of soil diversity in the 'anthropogenic' soils on the development of agriculture and to establish the extent to which the soils are affected by human activities. To achieve this purposes, the developed GIS of Soil Resources (GISoSR) is used and by following the approach for sustainable agricultural production in Arc-GIS environment by maintaining and improving soil fertility.

Material and Methods

Typical Soil Types for the Area.

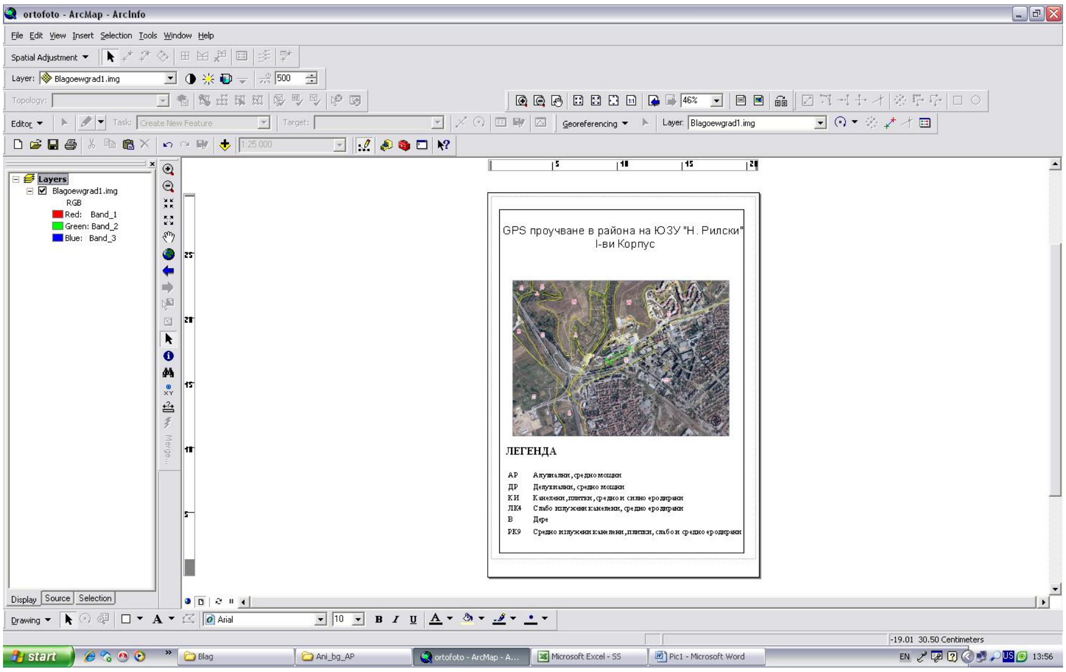

Fig. 1. GPS survey near SWU "N. Rilski".

Legend:
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Soils in Blagoevgrad.

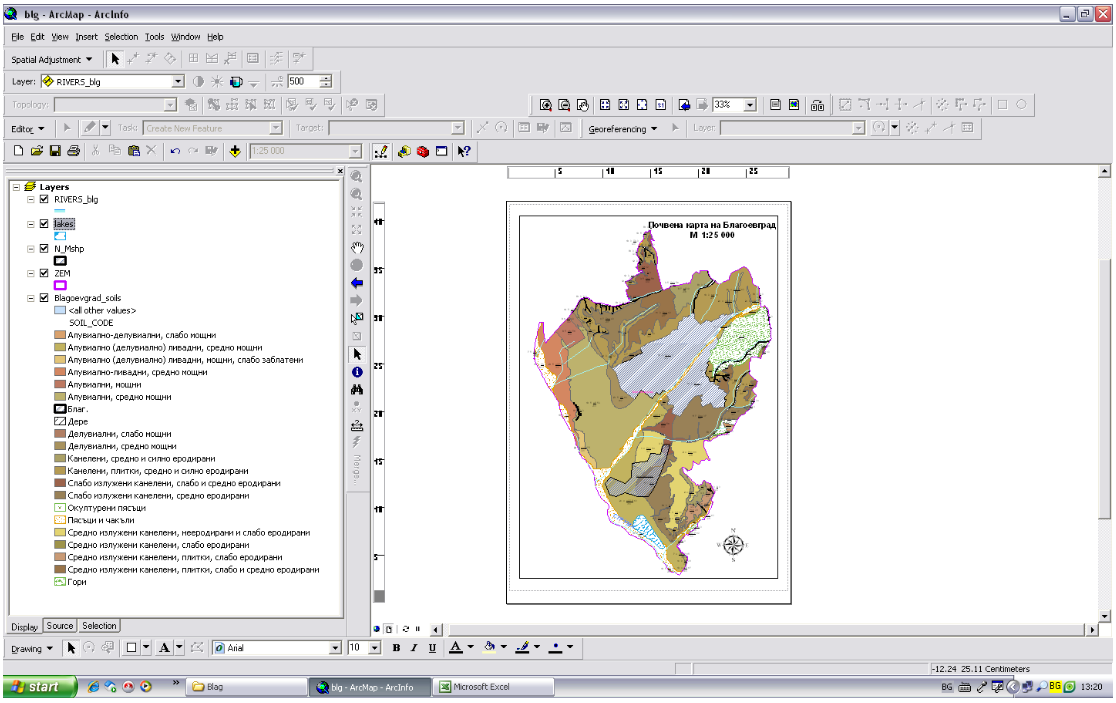

Fig. 2. Soil Map of Blagoevgrad.

Arable soils are not characterized by great diversity. Along the Struma River and its tributaries in soil characteristics are leached cinnamon forest and alluvial, alluvial-meadow soils. For some of arable separate arrays, there are small differences manifested by the presence of some additional soil types. In Radomir field that have served the black earth. Along the Dzherman, near Dupnica appear talus and deluvial soils. In the lower section of the valley Rilska River - are alluvial and deluvial - soils and along the Strumeshnitsa River - deluvial deluvial and meadow soils.

In normal years, winter rains provide soil profile stocks that reach almost to the limit field capacity. Of these productive water supplies in leached cinnamon forest soils are 1624 m^3/ha, and for alluvial - meadow are 1694 m^3/ha. For all soil types are opportunities to accumulate a watering from spring rains fall and create conditions for growing wheat without irrigation. However, for the valley irrigated and irrigated conditions, they are ineffective. For other crops, in normal years, irrigation provides increased yields.

Soils in Blagoevgrad District.

The main soil types in Blagoevgrad district are:

1. Alluvial and alluvial-meadow, mostly neutral, sandy and sandy-loamy
2. Leached cinnamon forest soils, heavy sandy loam
3. Eroded leached cinnamonic soils
4. Shallow leached cinnamonic forest soils
5. Shallow mountain meadow and alpha humic soils
6. Shallow brown forest soils, mostly acidic

Alluvial-meadow soils.

Alluvial-meadow soils are fertile soils that are formed along the major rivers. Alluvial-meadow soils are common in the river valleys of the plains and hilly areas. Form along the floodplains of the on alluvial deposits in the presence of high groundwater (related to the water level of the river), creating favorable conditions for the growth and development of meadow vegetation and flow of meadow soil formation process, representing one of most important factors for the formation of alluvial-meadow soils. These soils have unformed genetically profile. Characterized by the presence of a genetic horizon - humus accumulative horizon is powered ranging from 30 to 70 cm. It features mostly loose structure, grain-crumb structure sprayed-on plowed land. Alluvial-meadow soils are characterized by relatively high fertility and favorable physical, physical and mechanical properties and water. These are loose and not form a hard crust after precipitation. Alluvium is a material that is formed by the constantly flowing water. It accumulates in the river terraces as fine material rich organic and mineral content that gives him extraordinary fertility. Examples of such soils are soils available near the currents of Bulgarian rivers - Iskar, Maritsa, Struma and Tunga. Alluvial-meadow soils are thick soil horizon and high humus content. An interesting fact is that earthquakes the most damage is caused exactly the places with alluvial soils. This is due to their high water content and lack of stable elements therein. In this way, the seismic wave is amplified in areas with alluvial soils. An example of this effect is the earthquake in Vrancea, Romania, which causes greater damage in Svishtov than in the nearby slopes of the Carpathians, built of massive rocks.

Brown forest soils.

These are the most widespread soils in mountain areas and occupy an area 17 million ha or 15%. These soils are rich in humus, but the average stock of available nitrogen and phosphorus absorbed. They need to be combined fertilization. In the higher parts of the mountains brown forest soils passing dark colored forest and mountain meadow.

Cinnamonic forest soils.

They are the most common soil type in the country. They accounted for about 25% of the total soil area of Bulgaria, mainly in the forest and southern Bulgaria. These soils are medium humus content of humus like gray forest soils, poorly maintained to absorb nitrogen and phosphorus. To improve their fertility recommended fertilizer and irrigation.

Meadow soils.

Meadow soils have a yellowish color. They are formed along the rivers in the valleys and the valleys. Rich in humus, loose, keep enough air and water, so are fertile. The soil layer is thicker and easier to handle. In the meadow soils there are planted vegetables, alfalfa, clover and others.

Brown forest soils.

Brown forest soils are sandy clay and low in humus. They occupy the mountainous areas that are wooded and are good for growing cereals. They are distributed in the lower part of the middle forestry vegetation belt. All our mountains are brown forest soils. There are distributed in three regions – Balkan mountain, Macedonian - Rhodopean and Vitoshko-Srednogorian Mountains. Soil formations are characterized by a large amount of rainfall, high humidity, thick snow cover, average temperature 6-10 ° C. The climate is transitional alpine forest. The vegetation is formed under the influence of trees, beech, black and white pine, fir and spruce. The soil formation is by rocks - carbonate without - granite, slate, sandstone, etc. On carbonate were formed calcareous brown forest soils. The terrain is hilly to mountainous foothills. A characteristic feature of our brown forest soils is the lack of podzolic process in humus horizon in the absence of $CaCO_3$ in the bedrock and the availability of very brightly brown to reddish color. Classification: dark brown soils are characteristic of northern and exhibitions close to them. They have a large capacity pronounced humus - accumulative horizon and small skeletal. Have large stocks of nutrients and High Capacity active moisture. This makes them mostly soils with high-forestry plant properties to successfully grow crops of beech, fir, spruce, pine and others. Light brown soils are characteristic of southern and exhibitions close to them. They are low power, a shortened humus horizon and availability of many skeletons. There are occupied mainly by different productive white pine plantations. There are also beech, spruce, fir - poor growth and low productivity. Morphological characteristics: They are the most typical representative of forest soils in the country. Even now the forest soil formation process continuous. There is intense clay formation. Forestry plant properties: In terms of forestry are very fertile. You grow the most productive beech and coniferous forests. Because of the relief flow erosion processes where forestry-plant soils properties are bad. And the same is for shallow soils of southern exhibitions.

Cinnamonic forest soils.

Cinnamonic forest soils have the largest footprint soil type in Bulgaria. Located in Southern Bulgaria; to the lowlands and valleys bordering the Vertisols and to the foothills - with Pseudopodzolic soils. They are formed in transition continental climate on different scales and under the influence mainly of deciduous forests. In the border areas with Vertisols feel the influence of grassy vegetation. Cinnamoninc forest soils are divided into: typical and leached.

Typical cinnamon forest soils in Bulgaria occupy 2 million ha area, rather mottled and distributed in Chirpan, forest environment, Petrich and Sandanski around. It is assumed that no great economic importance. Leached cinnamon forest soils have a sharp differentiation between the humus and iluvial horizons. The humus is rated 25-40 cm, is cinnamon color and compact to dense construction. Iluvial horizon is powerful (70-80 cm) clay, compacted, reddish-brown. The carbonates are washed at a depth of 80-100 cm and soil reaction is slightly acidic. The content of humus fallow-land is about 2% and the soils are poorly stocked with nitrogen and phosphorus and potassium well. The physical properties of these soils are unfavorable - low permeability when wet swell, while drying and processing courtney solid lumps. Their natural fertility is low, but can give satisfactory yields good agro technology. These soils are suitable for cultivation of field crops, vineyards, tobacco and perennials. It has unique properties fertility. Soil fertility is a property of the soil to provide nutrients, water, air and heat plants indispensable for growth and development and their productivity. Soil fertility is the result of the simultaneous flow of two large groups of processes: weathering and soil formation. The soil is a habitat, except on the plant roots, and millions of species of micro-organisms, insects and small mammals (particularly rodents).

Climate

Blagoevgrad district is located in the continental climate of the European continental climate zone. The climate varies from temperate to Mediterranean in the southern parts. Mediterranean air coming from the valley of the Struma influences the climatic characteristics of the region. The average temperature is +12,4 ° C, the average winter temperature - +3,4 ° C, the average summer temperature - +16,5 ° C and average annual rainfall: 560 mm.

Agroecological regions

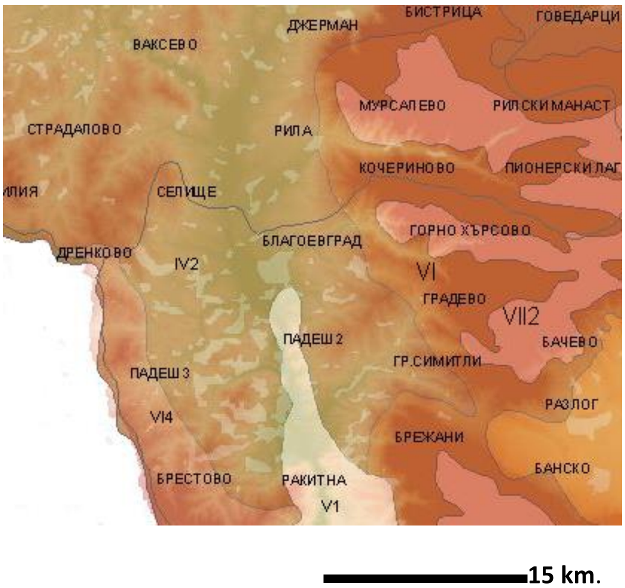

Fig. 3. Map of agroecological regions in Blagoevgrad District.

Legend:
IV2 - Kyustendil region;
VI4 - Ograzhden region;
V1 - Sandanski-Petrich region;
VI - the Rila-Pirin region;
VII2 - High Rila-Pirin region.

IV2 Kyustendil region.

Kyustendil region covers the territory between Milevska, Malashevska and Rila mountains. The terrain is mountainous valleys and valley and determines the manifestation of the erosion process has hinged. The soil cover is similar to that described in the previous region, with the difference that the surface area of the cinnamon soils is significantly greater than that of Vertisols. Moreover cinnamon soils have less power on the horizon, lighter and skeletal mechanical structure, lower humus content and a larger area of eroded lands. Rendzinas are also low in organic matter and have a frame. The area falls within the continental climatic sub-region and the climate is formed under the influence of the Struma River, Rila and Osogovska. Thermal resources are more favorable - the average annual temperature is 10.6 °C, precipitation is about 640 mm, the majority of them fall during the growing period. The balance of the atmospheric humidity is very negative - with a deficit of 310 mm. Autumn and winter stock is reduced due to terrain and soil characteristics, the balance turned negative in July that requires irrigation. Total productive capacity of the land is characterized by medium (agronomic) bonitet score 52, which belongs to them bonitet group "middle land". Most suitable for wheat, pastures and meadows, vineyards, apples, sugar beets, maize, alfalfa and oriental tobacco (bonitet score in the range 59-41 ball (the "middle land"). Less suitable are potato (37 ball), soybeans (33 ball) to include them in the group "bad lands."

VI4 - Ograzhden region

VI4 Ograzhden region area does not differ in character of the landscape and soil forming rocks and soil do not differ from those of Tran-Osogovo. The area falls within the Southern Bulgarian climatic region, its climate in the mountain area and thermal resources are reduced. It is characterized by a cool summer, but the rainfall is less for areas of such altitude - an average of 670 mm, thus emerged as arid region compared to other climatic regions in this area.

V1 Petrich-Sandanski region

Petrich-Sandanski region includes the river valley and surrounding slopes of Pirin Mountain Malashevska, fencing and Belasitza up to 800 m altitude. The terrain is hilly, deeply affected by Rovinj and sheet erosion. In soil forming materials dominate crystalline schist, limestone, marble, sandstone, talus, alluvial and places Pliocene sediments. Crossed hilly topography occupied by shallow maroon and undeveloped soils. Properties and characteristics of the region are not different from their analogues in the Kyustendil region. At the foot of Belasitza on alluvial cones were formed deluvial meadows soils of light mechanical composition, stony, humus and less acidic. In terms of climate, it is the warmest area in the country - an average annual temperature 13.9 °C. Temperature sum of the growing period is 4800 °C, and the annual rainfall is about 550mm, of which only 240 mm falling during the growing season. The deficit in the balance of atmospheric humidity is the biggest in the country - 650 mm, for period (April-June), he is now 230 mm. Valley part is suitable for all crops under irrigation, and the higher parts - Oriental tobacco, vines, perennials, and wheat. Pastures in this arid climate overcook quickly, especially on the southern slopes. Total productive capacity of the whole area is characterized by medium (agronomic) bonitet score 70 - "good land". Most suitable for vineyards and oriental tobacco bonitet score is over 80. Less suitable for wheat, pastures and meadows - 60 ball, i.e. "good land". Slightly lower is their suitability for maize, sugar beet, alfalfa (respectively 53-43 ball - "middle land". Least they are suitable for soybean, sunflower and potatoes that fall in the "bad lands."

VI6 Rila-Pirin region.

Rila-Pirin region occupies areas with an altitude of 800 to 2000 m. It has alpine character. Soil forming materials are granite, gneiss, schist, limestone and their weathering products. The greatest contribution of the brown mountain forest soils, which are similar to their peers case treated areas but the humus horizon is more powerful (20-60 cm) and dark colored. The annual rainfall is about 840 mm, and about 440 mm falling during the growing season. The average annual temperature is about 5 °C, with a temperature sum of the growing season about 2000 °C. Land in this area is characterized by medium (agronomic) Bonitet Ball 52, i.e. a bonitet group "middle land", but it concerns the lower areas with an altitude of 700-800 to 900-1000 m, where climatic conditions still allow their growing (and here they favor the aid of a strong Mediterranean influence). Outside the forest zone the land is unsuitable for normal land use, except for potatoes, pastures and meadows. The lower parts are suitable for potatoes and wheat productivity class 71 and 60 ball (i.e. the group "good land." Less is the suitability of environmental conditions for grassland, oriental tobacco, sugar beets, grapes, apples (credit rating ranging from 52 to 41 prom, i.e. the group "middle land" for maize, sunflower and alfalfa productivity class is in the group "bad lands" and for soybeans - "unfit." Like other areas assessments land for different crops vary considerably, which is associated with the altitude, the nature of the soil that is affected in varying degrees of erosion.

VII2 High Rila-Pirin region.

High Rila-Pirin region includes the highest ridges treeless parts of the Rila, Pirin and Vitosha 1700-1800 m altitude. The terrain is alpine, alpine character. Soil forming materials are granite, syenite, crystalline schist, marble and limestone. The soils here are represented by mountain meadow Chime, but peat soils. They are similar to those described in the above area, but have a low-power (30-60 cm), a frame and more acidic (pH 4.4-5.4 in H_2O).

The region, as well as the previous one, has unsuitable conditions for agricultural production. The average annual temperature is 3-4 ^oC, the temperature sum of the growing period is about 1500 ^oC. Annual fall here is about 1000 mm rainfall. Soil, climate and topography are extremely unfavorable, so they may grow to inferior grasses dominated by *Nardus stricta* (Achkov, N., P. Bozhinova, 1986). Productive capacity of the area for pasture and meadows with bad bonitet - 26 ball. The average agronomic ball reaches the symbolic value of 2 ball.

Methods

The study used the tools of ArcGIS - ArcMap for the objects, Visual Basic and Access for analysis of water-physical and hydrological properties of the different soils, remote sensing since Kolev et al. (1996) and SWOT - analysis in the economic development sector – agriculture-

http://prsr.government.bg/Admin/upload/Media_file_1268272388.pdf. .

Results and Discussion

Soil Resources in Blagoevgrad Region

Data that are discussed below were made soil mapping (1:25000). The overall appearance of the object by means of ArcGIS 9.3 - ArcMap is presented in Fig.5. Dominated by the brown forest soils (1-7 KG) - *Figure* 2 and found browner, shallow, medium eroded (KGE) and brown, shallow, heavily eroded (KGC). They are the most widespread soils in mountain areas and occupy the area of 17 million hectares or 15%. These soils are rich in humus, but the average stock of available nitrogen and phosphorus absorbed. They need to be combined fertilization. In the higher parts of the mountains brown forest soils in passing dark colored forest and mountain meadow.

On the riverbanks it meet alluvial (AP - alluvial, medium power) and on the slopes - delluvial (DL - (delluvial, less powerful) and talus (DR - delluvial, medium power) soils. Higher in parts of the municipality is dominated by mountain meadow, shallow, low and medium eroded (PL). Cinnamoning soils are presented by cinnamoning and cinnamoning immature, shallow and heavily eroded and rocks (NKK). Represent the most common soil type in the country. Occupy 25 % of the total soil area of Bulgaria, mostly in the Central Forest Mountain and Southern Bulgaria. These soils are medium humus in humus like gray forest soils, poorly maintained to absorb nitrogen and phosphorus. For improving soil fertility fertilization and irrigation are recommended.

The general data for a cinnamonic forest soil is presented in Fig. 4 and the results obtained after using methodology after Kolev et al. (2007) – in Fig. 5.

The three factions of the mechanical composition in USDA classification Sand (sand fraction), Silt (silt fraction) and Clay (clay fraction) are calculated, and some water and physical and hydrophysical properties - total porosity, filtration coefficient, field water capacity and wilting point in soil horizons and for the entire soil profile since Kolev et al. (2007). Soil horizons varies from loam true silty clay loam to light clay, an average the soil profile is defined as clay loam - clay, sandy loam , with an average content of Sand (sand) - 41 %, Silt (silt) – 21 % and clay (clay) – 37 %. Total porosity varies horizons from 43.2 to 50.3 % on average 45.6 %. Filtration coefficient is 5 cm/24 h in plugging horizon to 23.5 cm/24 h in the under plugging horizons, with average value of 10.79 cm/24 h. Field capacity (PPW) varies between 28% in plugging horizon to 34.36% in the under plugging horizons, with average value of 32.10 %. Wilting point (WZ) follows the PPW - from 9.3% in plugging horizon to 20.42 % in the under plugging horizons, with an average value of 17.14 %.

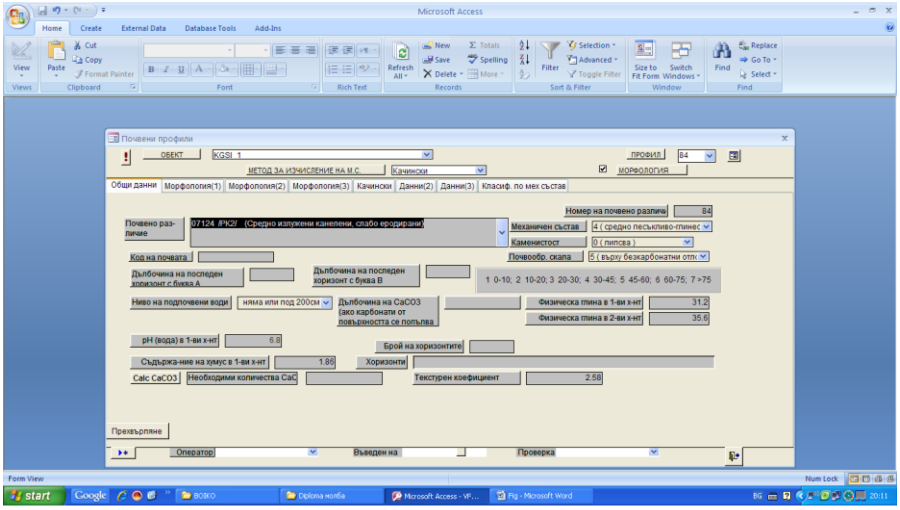

Fig. 4. General data for mean cinnamoning forest soil.

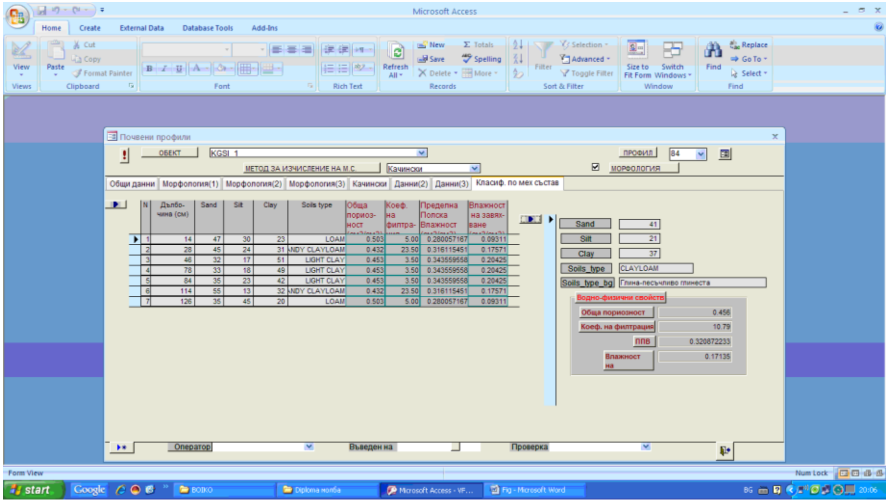

Fig. 5. Classification of soil texture and determination of some water-physical and hydrological properties.

Analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT - Analysis)

Crop production

Blagevgrad Municipality has 11333.6 ha cultivated land. Arable land - 5548.5 ha including 1261.7 ha of meadows and 5785.1 ha pastures and other agricultural lands. Land is managed entirely by private owners, as in the municipality operate two agricultural cooperatives. The largest shares in the structure of culture are potatoes, corn and cereals. Tobacco is a major industrial crop. There is a base for mechanical drying, which is a prerequisite for growing deciduous variety Virginia. Due to lack of markets in recent years such cultivation is suspended.

Other industrial crops – in village Banya started working workshop for distillation of essential oils, but due to low prices of raw materials, interest in planting other crops, do not. Machine and Technology Park: outdated depreciated, high cost of services offered. Not enough mainly collecting technique: mowers, balers, potato lifting and plant protection machinery.

Analysis of the data shows that the Municipality of Blagevgrad operates from extensive farming type, characterized crop cultivation and livestock primarily to meet the needs within households. There is a very low growth rate of investment in the agricultural sector, a high degree of fragmentation of farmland, uncertain markets for selling their produce. Soil and climatic conditions in the municipality are suitable for growing tobacco, potatoes, some autumn cereals and fruit. Base dimensions overlapped during those four years are relatively unchanged. As of December 2005 the property in agriculture and forests are 85 registered agricultural producers, with no agricultural cooperatives. SWOT analysis is presented in Table 1.

Table 1. Analysis of the strengths, weaknesses, opportunities and threats.

STRENGTHS	WEAKNESSES
➢ Absence of industrial pollution, ecologically pure area; ➢ Developed wood processing industry; ➢ Water resources and power generation; ➢ Availability of significant woodland and forest resources; ➢ Traditional experience in agriculture.	➢ Fragmentation of agricultural land and insufficient opportunities for their consolidation; ➢ Availability of large areas affected to varying degrees by erosion; ➢ Remoteness of the municipality of economic and administrative centers.
OPPORTUNITIES	**THREATS**
➢ Ability to develop alternative forms of agriculture, rural and ecological tourism; ➢ Traditional tourism; ➢ Opportunities to attract inward investments and the activation of economic links with the business in Greece.	➢ Total economic decline; ➢ Quality deterioration of the technical infrastructure; ➢ Road and village infrastructures deformations

Family farms are closed; the land is cultivated almost without the use of equipment not carried out agricultural activities, leading to lower yields. The marketing of agricultural produce is very difficult, and the proposed prices are below the cost of production. An exception is the implementation of the tobacco, where despite the possibility of delayed payments to producers purchasing campaign is at a satisfactory level. There is no modern agricultural technology and modern buildings, and financial resources for technological innovation farm. Lack knowledge of proper implementation of agro technical measures, incorporation of fertilizers and pesticides is done randomly. Family farms are not market-oriented, market appear surplus households. The production quality is low due to lack of knowledge among farmers about feeding and housing of animals. The above problems mark negative trend of decreasing arable land, degradation of technical support agriculture and reduce yields. In animal husbandry, tends to reduce the numbers of animals continued deterioration breed and yields. Blagevgrad municipality is included in the project "Sustainable Rural Development ", funded by UNDP and the Ministry of Agriculture and Food, in which it appears expert and financial support to farmers. Prospects for the development of agriculture in the municipality Bansko associated with introducing alternative crops such as herbs, raspberries and blueberries. Important for the development of agriculture is the development of related industries, especially the food industry and rural tourism. Opportunities for economic development are related to:

Lack of significant pollution of the environment and the ability to produce ecologically clean agricultural products, subject to the technological requirements;

The development of short-term programs for rural and eco-tourism based on the resources of the Rila National Park and Resort „Treshtenik";

Active marketing investment to attract private investment in agriculture and industry with significant growth potential;

Opportunities for mining of wild mushrooms and herbs, as well as cultivation of medicinal plants as an alternative form of employment and reduction of unemployment for unemployed and for a significant proportion of growers.

Conclusion

Estimates of the SWOT analysis of the development of Blagevgrad municipality showed higher values in the part of the strengths and opportunities, which requires aggressive implementation of priority development strategy using the strengths and opportunities as actions aiming at increasing the share of strengths and opportunities and gradually reduce the share of weaknesses and threats. Significant difference in the distance between the strengths and weaknesses demonstrates the need for a certain period of time to implement the necessary results. The level of threat is realistic high, which determines the presence of a particular risk in the implementation of strategic objectives and the program should focus on the development of the municipality to overcome the subjective weaknesses and taking full advantage of the opportunities and benefits in order to achieve long-term goals while avoiding teething. This SWOT analysis allows concluding that tourism in Blagevgrad also has significant potential for future development, especially in the directions for the establishment of a national and international center for winter tourism and sports and rural development. Looking at the estimates of the SWOT analysis for human resource development, education and culture in the municipality is apparent difference in favor of the weaknesses, i.e. in the overall development of the municipality, education is the weak link. Measures are needed to reduce or stop the impact of weaknesses and prevent the emergence of threats by supporting schools in municipal administration, and active work with non-governmental organizations working in these fields. Better land management, land resources and environmental objectives implementation of the approved NAEP (NAEP) and especially of international commitments such as the Kyoto Protocol and the Convention on the conservation of biodiversity, combating desertification and climate change. Recommendations are made to minimize negative impacts on the environmental components and agro-ecological resources. Of the sites as potential contaminants are not expected to significantly impact on a territorial scale. It is envisaged that the introduction of a monitoring system and a strict effective control and management of air, land and water resources.

References

[1] Gurov G, Artinova N., 2001. Soil Science. Plovdiv, Bulgaria, pp. 355-365; Bulgarian edition: Makros 2001.

[2] ISSAPP-Sofia - http://www.iss-poushkarov.org/Bgzanas.htm

[3] Kolev B. 1994. Abstract of dissertation for obtaining PhD degree. Sofia, Bulgaria, pp 10-35; (Bulgarian).

[4] Kolev B, Kastreva P, Miteva N, Samuilova S., 2007. Use of GIS of soil resources for assessment soil fertility in Razlog municipality. Annual reports of Shumen University “Bishop Konstantin Preslavsky”, T. XVII B 3 "Natural Science". Shumen. 2007, Bulgaria, 182-201; (Bulgarian).

[5] National Strategic Plan for Rural Development 2007-2013. http://prsr.government.bg/Admin/upload/Media_file_1268272388.pdf. (Bulgarian).

[6] Municipality Blagoevgrad Development Plan from 2007 to 2013. (Bulgarian).

[7] Hershkovich E., 1984. Agroclimatic resources of Bulgaria. BAS publishing, Sofia, Bulgaria, pp 72-103, (Bulgarian).

[8] Kolev B, Mihalev D., Zhivkov D, Miteva N., 2007. The Geographic Information System of Soil Resource Using for Sustainable Agriculture Realization, In: International Conference on Cartography and GIS, January 25-28, 2006, Borovets, Bulgaria. (In CD copy).

[9] Kolev B, Rousseva S, Dimitrov D., 1996. Derivation of Soil Water Capacity Parameters from Standard Soil Texture Parameters for Bulgarian Soils, Ecological Modelling 84, N° 1-3, Elsevier, Amsterdam, Holland, 315-319.

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Evolution of clayey soil irrigated with groundwater of positive calcite residual alkalinity in the Lower Cheliff plain (Algeria): An experimental study

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Abstract

Over the last decades, groundwater irrigation has become the currency of many arid and semiarid regions, mainly North African regions. But the use of groundwater irrigation of poor quality may have an impact on soil salinization and physical degradation. This work focuses on a particular situation of clayey soils irrigated with groundwater of a positive calcite residual Alkalinity in the Lower Cheliff plain (Algerai). Our aim is to predict the salinization process and structural degradation under the effect of water concentration by evaporation. Clay textural soil (S) is distributed in pots made by PVC tubes of 5cm diameter and 12cm high in the laboratory. The water with a positive calcite residual alkalinity (W: $AR_{Ca}>0$) is added to pots till over-saturation of soil then, after 24 hours, the water excess dries off naturally and the soil reaches his retention capacity. The weight difference between the wet pot and the dry one gives the necessary water volume to push the soil into his field capacity. The total evaporation of the resulted water volume is the concentration factor (CF). Soil solution contained in the pots is extracted for chemical analysis. Fifteen concentration factors were performed. As far as the waters are concentrated, the calcium ion was precipitate leading to an increase in the sodium molality of the soil solution. The increase of the concentrations factors leads to sodium desorption of the exchange complex under the effect of depletion of elements with big solubility (Ca). It was thus observed an increase in the SAR which led to the destruction of the structure.

Keywords: Clayey soil, Salinization, calcite residual alkalinity, soil degradation, Lower Cheliff

Introduction

In the Lower Cheliff plain (northwest of Algeria), plus the rainfall deficit that exists for many years, the shortage of surface water has been worsened following the transfer to coastal cities, where water is originally intended for irrigation [1] [2]. In addition, the degradation of the collective irrigated scheme prevents all farmers from having access to irrigation water. These conditions have led to increase the use of groundwater by farmers to secure water access and having more flexible management of irrigation [2] [3]. However, most of groundwater used in irrigation usually show alkaline compositions, where alkalinity (Alk.) is the dominant aqueous species. It is defined as the algebraic difference between the strong base cation and strong acid

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anion equivalents [4], and can be expressed as: Alk. = (HCO_3^-)+(CO_3^{2-}) + (OH^-) + (H^+) where ( ) denotes the total concentration in $mol_c.l^{-1}$. Moreover, most of the groundwater irrigation, show also a positive calcite residual alkalinity (RA_{Ca}> 0) which corresponds to the alkalinity of the solution after calcite precipitation: RA_{Ca}= Alk.– (Ca^{2+}),[5] [6] [7]. RA_{Ca} has also been shown as a conservative tracer of the soil solution [8] [9] [10]. Continuous concentration of such waters in the soil root zone may lead to the formation of alkaline and sodic soils [11] [12]. Indeed, when we have this type of water concentration in the soil, the carbonate content will continue to grow according to the concentration of the solutions, meanwhile the calcium shows a decrease, therefore, the sodium and the SAR $\left[Na/\sqrt{0.5(Ca+Mg)}\right]$, reach high values which may give the soil unsuitable properties [13] [14]. Such soils are less productive because of the pH-induced loss or low availability of several plants nutrients (e.g.: Fe, P, Zn) and poor physical proprieties [15].

Many studies report about the adverse effects of irrigation water quality on soil physicals properties especially the soil's hydraulic conductivity [16]. This study was conducted mostly in laboratory using disturbed soil in columns under continuous water flow and saturation conditions [16] [17] [18]. It is based also, on the response of a soil to solution salinity and composition that have been conducted on arid land soils aiming to determine the suitability of water for irrigation. These studies used usually the EC and SAR to assess irrigation water quality measured from the irrigation water itself [16] [19].

In this study, we focus also, on one of irrigation situation in Lower Cheliff plain (Algeria). It is about using the groundwater with a positive RA_{Ca} in irrigation. The study is conducted in the laboratory; a groundwater with a positive RA_{ca} is imposed in clayey soil to address the underlined aims (i) change of soil solution in contact with a positive calcite residual alkalinity, (ii) identify the irrigated soils salinity path (neutral or alkaline salinity), (iii) clarify the risk of irrigated soils physical degradation to better preserve these agronomic ability.

Material and Methods

Description of the experimentation

Soil and water used for the experiment

The clayey soil (S) is selected according to the soils map established by McDonald and BNEDER, (1990) [20]. Textures were confirmed according to [21] Rowell (1994). Mineralogy and chemical composition of soil S are shown in Table I.

Table I: Mineralogy and chemical composition of soil solution

Soil	A	L	S	pH	CE	Cl	SO_4	AlK.	Ca	Mg	Na	K
	%				dS/m	$mmol_c/L$						
S	57,8	33,4	8,8	8	1,76	12	4,16	3,14	8	8	1,2	0,47

The water used in this experiment (W) is taken directly from a drill usually used for irrigation in the study area. This choice is based essentially on the positive sign of the residual calcite alkalinity (RA_{Ca}> 0), reflecting the aim of this study. The projection of "W" on the RIVERSIDE diagram showed that it belongs to the class C3S1, which presents a moderate danger of salinity and low alkalizing risk for irrigated soil [22] (Richards,1954). Chemical characteristics of W are presented in Table II.

Presentation of the Plan

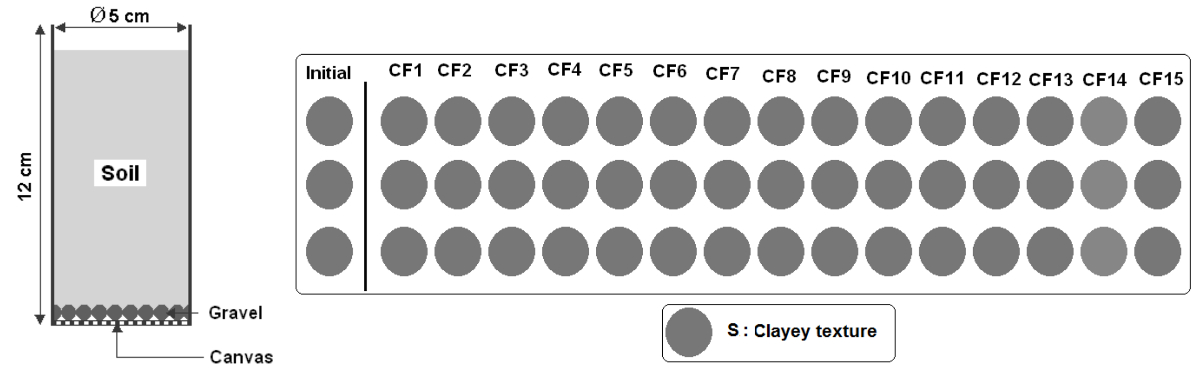
The soil S is distributed in pots made by PVC tubes of 5 cm diameter and 12 cm high and obstructed by canvas on one side (fig. 1a). Each pot was filled by 200 g of soil. The bottom of

Table II: Chemical parameters of Water (W)

	Cl	SO_4	AlK	Ca	Mg	Na	K	AR_{ca}*	SAR
	$mmol_c/L$								$(mmol_c/L)^{0,5}$
W	5,5	1,9	5,6	1,4	5,2	6,2	0,04	4,2	3,4

* *RA_{ca} = AlK – (Ca)*

each pot is covered with a layer of gravel to prevent their clogging. Water is added into balance to the soil retention capacity. Initially, we add water from 4 to 5 times to the interstitial space of the pot. After 24 hours, the water excess is shipping dry naturally and the soil reaches his retention capacity. The weight difference between the wet pot and the dry one gives the necessary water volume to push the soil into his field capacity. The evaporated water is measured by double weighting method. The aim is to evaporate water and reach up the same loss in a day. Once the pot back to its field capacity, a concentration factor (CF) is reached. The operation is carried to avoid salts drained (by avoiding the triggering of drainage). When each CF is reached, the soil is taken from the pot in order to be analysed. 15 CF are made. This number is quite sufficient to characterize tendencies of soil S salinization process in contact with W. One pot is added as a witness in order to characterize the initial state of W in the S. There are one type of soil distributed in 15 pots including tree repetitions for each pot we will have 45 pots (fig. 1b).



a. The pot **b**. Disposal of the pots

Figure 1**.** The experimental Plan.

Protocol of analysis

Two follow-ups were conducted in this study: a geochemical monitoring of irrigated soils and structural stability. For the first, after soil recovery in the pot giving a concentration factor, the soil was air dried and a part was passed through a 2 mm mesh sieve to extract the soil solution by saturated past method according to [23] Mathieu and Pieltain. (2003). The EC and soluble ion concentrations were measured in the soil solution extract. The EC of soils is measured by electrical Method. Calcium and magnesium (Ca and Mg) cations were analyzed by complexation volumetry with ethylene diamine tetra acetic acid (EDTA). Sodium and potassium (Na and K) were analyzed using flame photometry. SO_4^{2} by spectrophotometric turbidimetry with an UV–vis spectrophotometer. The chlorides ions (Cl^-) were analyzed by argentometric volumetry using silver nitrate (AgNO3). The alkalinity was determined by Gran titration method [24].

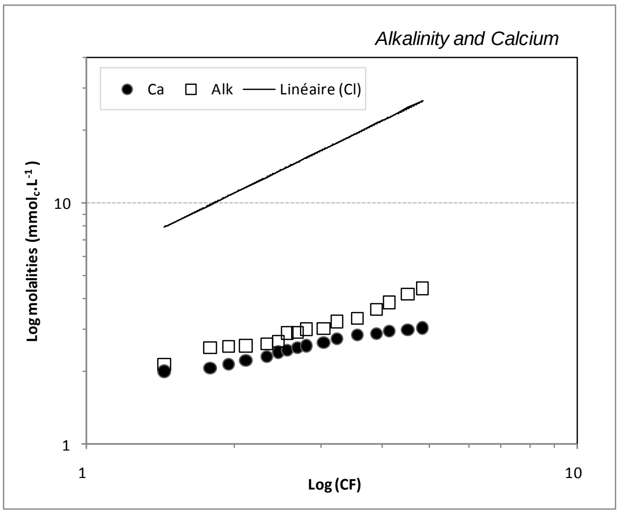
For the second one, we measured the soil aggregate stability according to LeBissonnais (1996) [25] for aggregate from the concentration factors: FC1, FC5, FC10 and FC15. This method distinguishes three degradation mechanisms: slaking, mechanical degradation and micro-cracking. We conducted a slaking test only in this study. Briefly, the test is performed on 3–5 mm aggregates, dried at 40°C for 48h. 5 g of aggregates are immersed in deionized water for 10 min. subsequently, the soil sample is sifted in alcohol at 50 µm and dry the resulting fraction (>50 µm). Dry sieving was performed by hand with a sum of six sieves (2000, 1000, 500, 200, 100 and 50 mm) and the mean weight diameter (MWD) was calculated as the sum of the mass fraction remaining after sieving, multiplied by the mean aperture of the adjacent sieves [25] [26].

Geochemical diagrams presentation

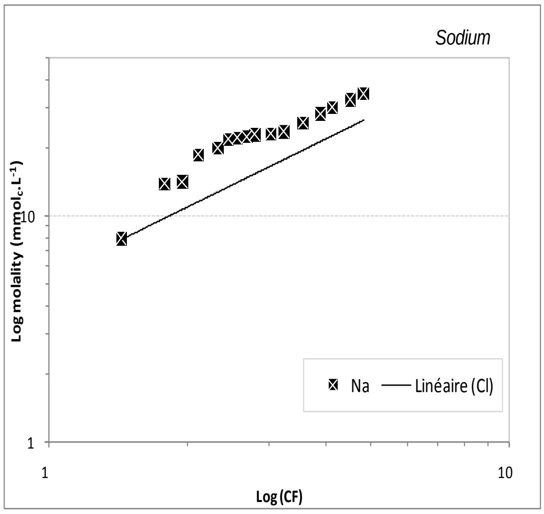
The composition of soil analysis was plotted in concentration diagrams against chloride, which does not interact with the solid matrix [27], and was consequently used as a tracer and indicator of concentration factor (CF). CF is obtained by dividing the contents of the soil chlorides (Cl) on the content chloride of water W (Cl*) $[\mathrm{CF} = \mathrm{Cl}/\mathrm{Cl}^*]$

Results and Discussion

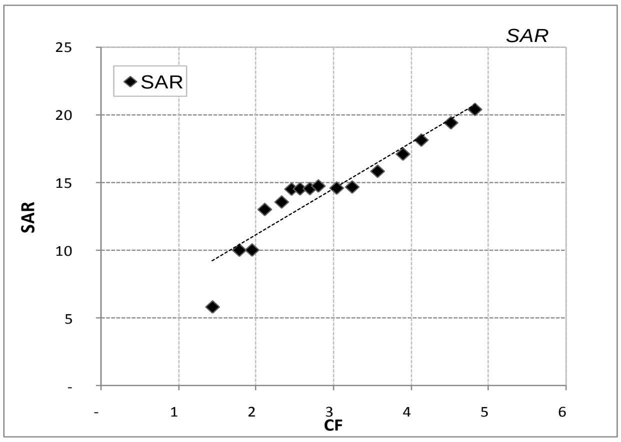
Ionic concentration diagrams from soil S chemical analyzes are represented in figure 2. In figure 2a, there is calcium precipitation along the concentration. Moreover, alkalinity increases in the same direction with a molality always higher than the Ca in particular the latter factors. Contrary the calcium, the sodium (Na) molality has increased. Figure 2b shows the evolution of sodium, which does not precipitate and remains in the soil solution. This rate of sodium, growing in the soil solution, had a direct impact on the SAR whereas, its value is nearly doubled (from 5.8 to 20.4 $(mmol_c/L)^{0,5}$ (fig. 2c). Residual alkalinity calcite remains positive and increases throughout factors concentrations (fig. 2d).



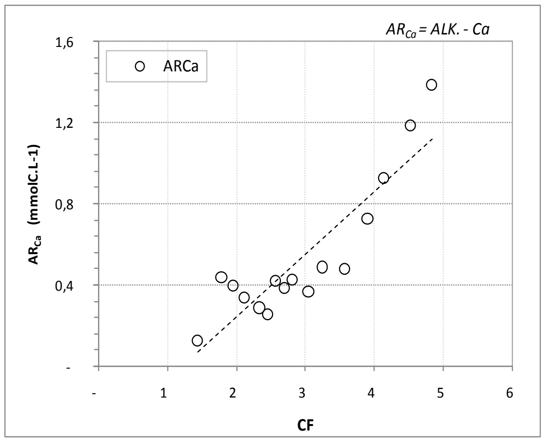
a. Alkalinity and Calcium



b. Sodium



c. SAR



d. Residual Alkalinity Calcite

Figure. 2. Ionic concentration diagrams of soil solution S in contact with groundwater of a positive residual alkalinity calcite (W).

The presented diagrams analysis shows an increase of sodium in the soil solution and precipitation of (Ca) in both cases. These results make it plausible for the hypothesis of sodium adsorption and desorption of calcium also, magnesium to neutralize the alkalinity through precipitation of calcite or/and sepiolite [10] [13] [28] [29]. These changes are characteristic of an alkaline salinization (alkalinization) and thereafter sodisation [27] [29].

Several research organizations and agricultural institutes are conducting field experiments on different crops to provide water quality guidelines for irrigation purposes [16] [22]. The risk of sodicity and alkalinity of irrigation water is estimated by the SAR in these guidelines. The use of SAR concept leads to a wide underestimation of the sodicity hazard [14] [30] [31] ; (1) the assessment of sodicity hazard from the SAR is a static view of the problem that do not take into account the changes in the water chemistry due to concentration by evaporation; (2) the assessment of sodicity hazard from the SAR has been established empirically from data collected mainly in North America [22] from waters with a negative residual alkality calcite (saline way) which is not the case in semiarid and arid regions where the residual alkalinity could be positive [10]. The adjusted SAR $[SAR_{adj} = (1+(8.4-pH_c)]$ instead of SAR [19] [32] was also used in order to check in the effect of carbonates by the theoretical formula pH_c; the pH value must have water to dissolve the calcium carbonate [32]. The approach considers that the solution is in equilibrium with calcite, where as the formation of this mineral can continue if, thus, the carbonates molality is important. So it does not consider how changes in the process of concentration and sodicity risk is underestimated using this indicator where solutions evolve towards an alkaline [14] [28]. This is the case of our study when the RA_{Ca} of soil S remain positive as far as the concentration increases because the RA_{Ca} has been shown as a conservative tracer of the soil solution [8] [9] [10] and the molality of carbonates is more important in soil solution.

The increase in SAR, especially for clayey soil is not without consequences on the physical degradation of soils. Indeed, the evolution of the structural state of soils treated with each type of water was followed by measuring the structural stability. The groundwater with the positive RA_{Ca} has a destructive effect on the texture processed; this is even more visible than the concentration factor increases. This type of water is much more degrading for clayey soils, which show lower structural stability factors of high concentrations despites the good structural stability of this soil in the initial state (fig.4).

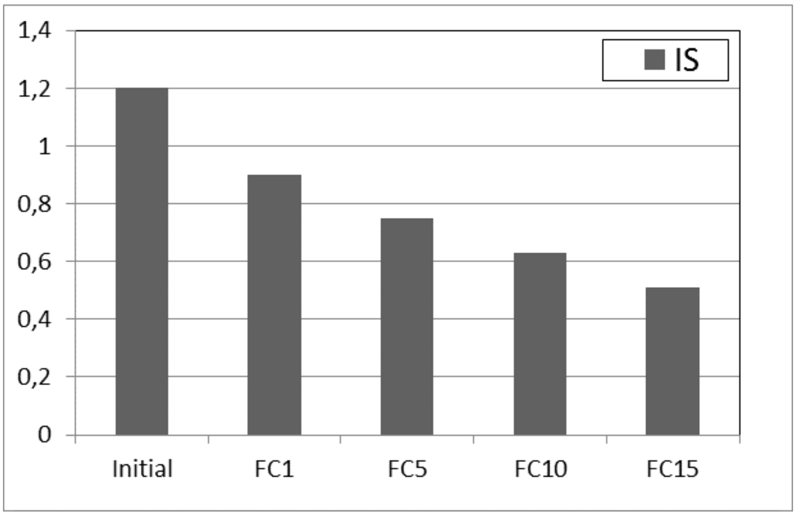


Figure 4. Changes in the structural stability of soils S under the influence of water with a positive RA_{Ca}(W).

This important structural degradation of the clayey texture, as a result of this type of groundwater can be explained by both (i) the positive sign of RA_{Ca} water geochemical evolution which allows a high concentration of Na in soil solution, (ii) high CEC in the presence of clay is dominated by Na, which can lead to a high ESP.

Conclusion

The aim of this study was to evaluate the use of groundwater for irrigation in the Lower Cheliff plain. The results show that the concentration of groundwater irrigation with a positive residual alkalinity calcite leads to an increase of SAR, in the clayey soils textures, so they do not show sodisation risk by traditional classification methods [as in: Richards, (1954), or Ayers and Wescot, (1985)]. The RA_{Ca} is an indicator of the quality of irrigation water, while the SAR may not be in some cases, according genuinely to the positive sign of RA_{Ca}.

Finally, the degradation of soil physical properties is due to these water types, which alter the structural stability following concentration factors. In this case also, the action of groundwater with alkalinity residual calcite positive has a significant effect on the soil with clayey texture.

References

[1] Bouarfa S., Marlet S., Douaoui A., Hartani T., Mekki I., Ghazouani W., Ben Aïssa I., Vincent B., Hassani F. and Kuper M. 2009. Salinity patterns in irrigation systems: A threat to be demystified, a constraint to be managed: Field evidence from Algeria and Tunisia, Irrigation and Drainage 58 - 273-284.

[2] Bradaï A., Douaoui A., Hartani T. 2012. Some problems of Irrigation Water Management in Lower Cheliff Plain (Algeria), Journal of Environmental Science and Engineering A, 271 -278

[3] Amichi H., Bouarfa S., Kuper M., Ducourtieux O., Imache A. Fusiller J. L, Bazin G., Hartani T., Chehat F.2012. How does unequal access to groundwater contribute to marginalization of small farmers? the case of public lands in Algeria. Irrigation and Drainage **DOI:** 10.1002/ird.1660

[4] Stumm W., Morgan J.J., 1970. Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters. Wiley, New York.

[5] Vallès V., Pachepsky Y.A., Ponizovsky A .A ., 1991. Invariant Criteria for Irrigation Water quality assessment in arid and semi arid regions. In: Genesis and Control of Fertility of Salt Affected Soils. ISSS Sub-Commission on Salt Affected Soils Science, USSR, V.V. Dokuchaev Soil Institute, Moscow, pp. 330– 333.

[6] Bertrand R., Keita B., Ndiaye K.M., 1993. La dégradation des sols des périmètres irrigués des grandes vallées sud-sahariennes: Cas de l'Office du Niger au Mali. Cahiers Agricultures 2, 318– 329.

[7] Hammecker C., Van Asten P., Marlet S., Maeght J.L., Poss R. 2009. Simulating the evolution of soil solutions in irrigated rice soils in the Sahel. Geoderma 150, 129–140

[8] Ribolzi O., Valles V., Bariac T., 1996. Comparison of hydrograph deconvolutions usingresidual alkalinity, chloride and oxygen 18 as hydrochemical tracers. Water Research Resources 32, 1051 – 1059.

[9] Barbiero, L., Valles, V., Regeard, A ., Cheverry, C. 2001. Residual alkalinity as tracer to estimate the changes induced by forage cultivation in a non-saline irrigated sodic soil. Agricultural Water Management 50, 229 – 241.

[10]Barbiero L., Ould Mohamedou A., Laperrousaz C., Furian S., Cunnac, S. 2004. Polyphasic origin of salinity in the Senegal delta and middle valley. Catena 58, 101 –124.

[11] Hardie, L.A ., Eugster, H.1970. The evolution of closed basin brines. Mineralogical Society of America 3, 273 –290.

[12] Van Beek C.G.E., Van Breemen N., 1973. The alkalinity of alcali soils. Journal of Soil Science 24, 129 – 136

[13] Cheverry, C. 1974. Contribution à l’étude pédologique des polders du lac Tchad. Dynamique des sels enmilieu continental subaride dans les sédiments argileux et organiques. Thesis. Science, U.L.P. Strasbourg, 257 pp.

[14] Barbiéro L., Vallès V. et Cheverry C., 2004b. Reply to J.W. Van Hoorn “Some observations with respect to sodicity hazard of irrigation waters”. Letter to the Editor. Agricultural Water Management 68 : 177–184.

[15] Arbol, I.P., Yadav, J.S.P., Massoud, F.I. 1988. Salt-affected soils and their management. Soils Bulletin, vol. 39. Food and Agricultural Organization of the United Nations, Rome.

[16] Suarez D. L., Wood J.D., Lesch S. M. 2006. Effect of SAR on water infiltration under a sequential rain–irrigation management system. Agricultural water management 86. 150–164

[17] McNeal, B.L., Coleman, N.T.1966. Effect of solution composition on soil hydraulic conductivity. Soil Sci. Soc. Am. Proc. 30, 308–312.

[18] McNeal, B.L., Layfield, D.A., Norvell, W.A., Rhoades, J.D., 1969. Factors influencing hydraulic conductivity of soils in thepresence of mixed-salt solutions. Soil Sci. 187–190.

[19] Ayers RS, Westcot DW. 1985. Water quality for agriculture. 29 rev.1, FAO, Rome, Italy.

[20] McDonald et BNEDER, 1990. Etude de l’avant-projet détaillé des extensions de Guerouaou et de Sebkhet Benziane et du réaménagement du Bas-Chéliff. Pub. Ministère d’Hydraulique d’Algérie.

[21] Rowell, D.L. 1994. Soil Science: Methods and Applications. Longman Group, Harlow, p. 350.

[22] Richards, L.A., 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA Agricultural Handbook 60, Washington, 160 pp

[23]Mathieu C. et Pieltain F. 2003. Analyse chimique des sols, méthodes choisies. Ed. Tec & Doc, Lavoisier. 388p.

[24] Pansu M., Gautheyrou J. 2006. Handbook of Soil Analysis Mineralogical, Organic and Inorganic Methods. Ed. Springer ed., 2006, p. 788.

[25] Le Bissonnais, Y.1996. Aggregate stability and assessment of soil crustabiliy and erodibility: Theory and methodology. European Journal of Soil Science.

[26] Le Bissonnais Y. et Le Souder Ch., 1995. Mesure de la stabilité structurale des sols pour évaluer leur sensibilité à la battance et à l’érosion. Etude et Gestion des Sols, 2, 1, pp 43 – 55.

[27] Barbiéro L. , Vallès V. 1992. Aspects géochimiques de l’alcalinisation des sols dans la vallée du Dal101 Bosso (République du Niger). Cah. Orstom, sér. Pédol., vol. XXVII, no 2, (1992) : 143-1.52

[28] Prasad A., D. Kumar, Singh D.V., (2001). Effect of residual sodium carbonate in irrigation water on the soil sodication and yield of palmarosa (Cymbopogon martinni) and lemongrass (Cymbopogon flexuosus). Agricultural Water Management 50 (2001). 161-172.

[29] Marlet S., JOB J. O.2006. Processus et gestion de la salinité des sols, In Tiercelin, J,R, Traité d’irrigation, seconde édition, Tec & Doc Lavoisier, p, 797-822.

[30] Vallès V., Bertrand R., Bourgeat. N'diaye M., 1989. le concept d'alcalinité résiduelle généralisée et l'irrigation des sols sodiques. Agron. trop., 44, 3, 157-163.

[31] Barbiero, L., Valles, V., Regeard, A., 1995. Précipitation de la fluorine et contrôle géochimique du calcium dans les sols alcalins du Niger. Conséquence pour une estimation quantitative de l’évolution géochimique des sols. C. R. Acad. Sci. Paris, t. 321, Série II a, 1147 – 1154.

[32] Suarez, D.L. 1981. Relations between pHc and sodium adsorbtion ratio (SAR), and an alternative method for estimating SAR of soil and drainage waters. Soil Sci. Soc. Am. J. 45, 469–475.

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The effect on some macro-micro element contents and growth of rocket plant (*Eruca Sativa M.*) of growing media and salt applications

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Abstract

In this study, effects of different growing media and salt applications on microelement contents and growth of rocket plant *(Eruca Sativa M.)* in greenhouse conditions were investigated. Trial was established according to randomized hazelnut husk (NHH) and tea waste compost + hazelnut husk compost (TWC+HHC)), three salt treatments (control, NaCl and $CaCl_2$) and a three replicates. Physico-chemical and chemical analyses of the different media were made. Plant growth and macronutrient (N, P, K, Ca, Mg), micronutrient (Fe, Cu, Mn, Zn, B) contents of plants were determined. For rocket growth, salt applications have a negative impact, and the highest dry matter weight was obtained with the hazelnut husk compost and control (no salt). On the other hand, $CaCl_2$-treated media had the greatest content of macro and micronutrients of plants except for K, Na and B. Natural hazelnut husk media with $CaCl_2$ application was highest B, Mn and Zn contents of plants, the highest Mg content was obtained with TWC + HHC media.parcels experimental design and as five media (torf (T), tea waste compost (TWC), hazelnut husk compost (HHC), natural

Keywords: rocket, media, $CaCl_2$, NaCl, macro and micro nutrients

Introduction

The increasing human population and food necessities for achieve more output from the unit area caused deterioration in natural resources. One of the most important and worrying problems in today and in the future is environmental problem that threatening sustainability of production systems; thus there is a need for new solutions.

Soil is the major supplier of plant nutrients, but it may be eliminated or greatly modified in artificial growing media, especially when growing plants in greenhouses (1). In recent years, protected horticulture has changed from soil-grown systems to soilless systems. Initially, these were run-to-waste systems (2). The use of soil-less substrates in horticulture has become common, not only for growing seedlings and propagation of plants but also for vegetable production (3). One option to approach this subject is the use of compost that is the most economical and sustainable for organic waste management (4).

Compost offers a forceful choice the use of soil in the agricultural production. Recently there has been resurgence with the use of compost to decrease requirement of chemical fertilizers. Compost is the product of the controlled biological decomposition of organic materials. Composting of organic materials is a

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stabilization process that reduces odors, destroys pathogens and produces humus-like organic material that can be conveniently stored and easily handled (5). Also, compost products improve the properties of the soil and also provide environmental benefits (6, 7, 8). Therefore, usage in agriculture is an efficient way for them (9).

Salinity is a major ecological factor that creates grave problems for agricultural productivity in many parts of the world. Salinization is defined as the accumulation of salts in the soil profile to an extent that reduces crop growth and productivity (10). Some studies indicate that 20–50% of all irrigated croplands are affected by high salt concentration, resulting in considerable economic losses (11). There are three major constraints for plant growth on saline substrates: I) water deficit II) ion toxicity associated with excessive chloride (Cl^-) and sodium (Na^+) III) nutrient imbalances (12). While the water request for different uses is increasing, the supply of water to fulfill these demands is declining. The continuous decrease in water resources in the world especially in semiarid and arid regions has forced to use low quality water of farmers. Salinity and nutrient deficiencies are the main factors that reduce plant productivity and unbalanced nutrition (13). Plant species differ greatly in their growth response and nutrient uptake and utilization in saline conditions (14).

Therefore, this study was aimed to investigate the influence of different growing media and saline water on microelement contents and growth of rocket plant *(Eruca Sativa M.)* in greenhouse conditions.

Material and Methods

Experiment was carried out on rocket plants *(Eruca Sativa M.)* grown in a greenhouse. Four organic growing media were used: torf (T), tea waste compost (TWC), hazelnut husk compost (HHC), and the experiment comprising the four media alone, one combination (tea waste compost + hazelnut husk compost (TWC+HHC)) and one control. Torf was bought from a commercial supplier, others media were composted in Ordu University, Faculty of Agriculture. The composition of the five growing media is shown in Table1. Experiment was established according to randomized parcels experimental design with three replicates and three salt treatments (control, NaCl (2500 ppm) and $CaCl_2$ (2500 ppm)). Growing media were filled in the plastic pots (75x16x14cm) as gravimetrically. Rocket seed (2 g m^{-2}) was sown in each pot. Plant was irrigating with saline water.

Table 1. Plant nutrients in the growing media

Media	P (%)	K (%)	Ca (%)	Mg (%)	Fe ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	B ($mgkg^{-1}$)
NHH	0.51	1.48	0.62	0.219	913	19.82	479.6	42.36	21.22
T	0.35	0.20	1.26	0.132	612	32.98	60.64	15.15	14.74
TWC	0.84	0.54	1.50	0.270	3111	25.98	1005.9	102.55	12.05
HHC	0.35	0.60	1.52	0.330	3343	19.82	342.53	37.47	10.57
TWC+HHC	0.67	0.59	1.49	0.235	3186	23.84	776.9	72.73	12.56

NHH: Natural Hazelnut Husk, T: Torf, TWC: Tea Waste Compost, HHC: Hazelnut Husk Compost, TWC+HHC: Tea Waste Compost + Hazelnut Husk Compost

The rocket plant was harvested after 35 days by cutting with scissors approximately 20mm from growing medium surface. Fresh weight and height of plant was determined immediately after harvest and then plant material was dried in an oven at 65 °C for 48 h to measure dry weight [15]. The dried samples were ground to fine powder in a vibrating agate cup mill. About 200 mg of ground sample was digested in 2 ml 30% H_2O_2 and 5 ml 65% HNO_3 in closed vessel of a microwave system (CEM MarsExpress, USA). The digested samples were filtered and analyzed for mineral nutrients (except N) by ICP-AES (inductively coupled plasma-atomic emission spectrometry) (Vista Pro Axial, Varian Inc., Australia). Analytical methods were validated by using a certified standard reference material (SRM 1547, Peach Leaves) acquired from the National Institute of Standards and Technology (Gaithersburg, USA). Statistical analysis was performed using a JUMP software programme and differences among the groups were separated by Tukey test at $p<0.01$ and $p<0.05$.

Results and Discussion

The nutrient contents belonging to growing media were presented at the Table 1. While HHC media is high with regard to K, Ca, Mg and Fe contents, TWC media is rich with regard to P, Mn and Zn contents. Torf has high Cu and B contents. Kacar and Katkat (16) report that HHC has insufficient amounts of nitrogen and phosphorus to within limits, but potassium and trace elements have values sufficient or more amount. Bender

Özenç and Özenç (17) stated that K content of HHC is high, and it's Ca, Mg, Mn and Fe contents increased steadily during decomposition. Tea waste, which is a major organic matter and macro and micro nutrient elements source, makes a positive impact on soil structure and on the amount of product (18). Some growth parameters of rocket plants in different growing media and salt treatments are given in Table 2 and Table 3.

Table 2. Some growth parameters of rocket plants

Growth parameters	Media	Treatments			Means of media
		Control	$CaCl_2$	NaCl	
Dry weight (g)	NHH	9.89	9.94	10.85	10.23B**
	T	12.32	10.68	10.77	11.26B
	TWC	11.68	10.03	10.03	10.58B
	HHC	13.84	12.71	12.89	13.15A
	TWC+HHC	11.61	10.31	9.35	10.42B
Means of treatments		11.87A*	10.73B	10.78B	
Plant height (cm)	NHH	11.79d**	11.73d	11.02de	11.51D**
	T	12.88d	15.47bc	12.78d	13.71C
	TWC	15.78bc	21.46a	20.69a	19.31A
	HHC	7.83f	9.62ef	8.56f	8.67E
	TWC+HHC	12.50d	17.14b	14.91c	14.85B
Means of treatments		12.15C**	15.09A	13.59B	
Yield (g)	NHH	71.38	89.49	73.04	77.97B**
	T	59.38	114.10	86.23	86.57B
	TWC	90.62	155.13	146.06	130.61A
	HHC	40.06	57.75	53.16	50.32C
	TWC+HHC	99.68	147.42	123.29	123.46A
Means of treatments		72.23B**	112.78A	96.35A	

Three replicates were used for each parameter. Means in columns followed by the same letter are not significantly different according to Tukey's test at *$p<0.05$ and **$p<0.01$ probability levels.

Plant development is generally reduced under saline conditions. The depressing effect of salinity on plant growth has been reported by various researchers (14, 19, 20). Table 2 shows that for rocket plant the increment in dry weight was slightly affected by growing media and salinity. Plant dry weight varied in the order: HHC>T>TWC>TWC+HHC>NHH. HHC media had statistically significant difference on dry weight of plants. While obtaining the maximum dry matter production of rocket plant (13.84 g pot−1) in Hazelnut Husk Compost and the control (salt-free), the minimum value (9.35 g pot−1) was recorded in Tea Waste Compost + Hazelnut Husk Compost and NaCl treatment (Table 2). Bender Özenç (21,22) reported that all sizes of composted hazelnut husk fraction affected soil properties and it can be used for tomato growing, especially with 4% and 8% ratios of 0-2 mm and 2-4 mm CHH fraction sizes mixed with soil.

Salt tolerant taxa include desert plants *L. fendleri* (23) and *E. vesicaria subsp. sativa* (24). The amount of average yield increased through salinity; especially $CaCl_2$ treatment (112.78g) was more effective than the others (Table 2). Barbieri et al. (25) stated that leaf weight loss of rocket plant during storage was not affected by salinity which, in contrast, enhanced the percent leaf dry matter. At 100mM NaCl, the average dry matter percentage was 16% and 10% higher than non-salinized controls, respectively. Salinity has considerable adverse impacts on plants productivity. As it was stated, the detrimental effects of high salinity on plants can be observed at the whole-plant level as the death of plants and/or decreases the productivity (19). When considering the growing media, tea waste compost, and the combination (TWC+HHC) effects are prominent. Kütük et al. (26) indicated that 0-2mm fraction of composted and enriched composted tea wastes were determined suitable as plant growth medium. Tea waste compost increased dry grass yield, seedling dry weight, tiller number in dm2, basal covering, regeneration capability, total N and K content of lawn more than farmyard manure and peat (27).

Both parameters were significant differences on the plant height of rocket plant; contrary to expectations, the plant height increased by salt application. The plant height has ranged 21.46 cm from 7.83 cm. A high NaCl concentration causes a reduction in growth parameters, but decrease in growth characteristics varies species wise (28).The $CaCl_2$ treatment and Tea Waste Compost was the most effective medium. This effect is thought to be tolerated by mediums. Examining the macro elements given in Table 3, it can be seen that P content decreased while other macronutrient concentrations increased with salt treatment.

Table 3. Some macro nutrient contents of rocket plants

Nutrients	Media	Treatments			Means of media
		Control	$CaCl_2$	NaCl	
P (%)	NHH	0.5213	0.4284	0.4142	0.4547D**
	T	0.7704	0.7161	0.7595	0.7487A
	TWC	0.6908	0.6118	0.5169	0.6065B
	HHC	0.6002	0.5489	0.4529	0.5340C
	TWC+HHC	0.5754	0.5381	0.5321	0.5485C
Means of treatments		0.6316A**	0.5687B	0.5352B	
K (%)	NHH	4.7126	4.8352	4.8566	4.8015A**
	T	3.4720	3.3569	3.6659	3.4983C
	TWC	3.9967	4.9442	4.1296	4.3568B
	HHC	3.9718	4.7827	4.4930	4.4158B
	TWC+HHC	4.5710	4.9829	4.4486	4.6675AB
Means of treatments		4.1448B*	4.5804A	4.3187AB	
Na ($mgkg^{-1}$)	NHH	543.68e**	511.01e	7948.85cd	3001.17BC**
	T	652.62e	1231.87e	17618.33a	6500.93A
	TWC	387.46e	442.36e	11343.27bc	4057.69BC
	HHC	663.07e	594.78e	12599.82b	4619.22AB
	TWC+HHC	588.326e	539.74e	6034.65d	2387.57C
Means of treatments		567.029B**	663.951B	11108.98A	
Ca (%)	NHH	0.6353	1.2711	0.7638	0.8901C**
	T	1.7941	3.0642	1.9942	2.2842A
	TWC	1.1810	1.5545	1.0826	1.2727B
	HHC	0.8114	1.3078	0.8633	0.9942C
	TWC+HHC	1.2552	1.7704	1.3664	1.4640B
Means of treatments		1.1354B**	1.7936A	1.2140B	
Mg (%)	NHH	0.3317	0.4244	0.3571	0.3711B**
	T	0.2909	0.3322	0.3202	0.3145C
	TWC	0.4021	0.3969	0.3471	0.3820B
	HHC	0.3141	0.3579	0.3164	0.3295C
	TWC+HHC	0.4692	0.4714	0.4435	0.4613A
Means of treatments		0.3616B*	0.3966A	0.3569B	

Three replicates were used for each parameter. Means in columns followed by the same letter are not significantly different according to Tukey's test at *$p<0.05$ and **$p<0.01$ probability levels.

The percantage of P content in rocket plant changed between 0.7704% and 0.4142%, and Torf media was the most effective medium. The uptake of P decreased with increasing levels of salinity. The decrease in the P uptake could be regarding the reduced root system. In fact, in salt-free conditions despite low phosphorus content of peat increased phosphorus uptake. The salinity × phosphorus interaction is not clear with higher levels of salinity (29). The low uptake could also have been due to ionic strength effects that reduce the activities of phosphate or low solubility of P caused by Ca and Mg minerals (14).

Gomez et al.(11) reported that uptake of K by plants at high salinity levels was reduced by increasing availability of Na from added salts. Similary, Tahir et al.(30) and Irshad et al.(14) have presented that K content in the plant tissue is reduced as the salinity increased. As seen in Table 3, $CaCl_2$ treatment increased K content of plant while NaCl treatment decreased compared to control. The highest K content was recorded as a % 4.5804 by $CaCl_2$ irrigation water. Khan et al. (31) observed an increase in K^+, Na^+, Ca^{++} and Cl^- content in a halophyte *Atriplex griffithii* with increasing level of salinity. On the other hand, natural hazelnut husk medium is the highest potassium content; thus it was the most effect on K content at the rocket plant. Hazelnut husk is a material, especially K-rich emphasized by Kacar and Katkat (16).

With applying NaCl and $CaCl_2$, the Na and Ca contents at the plant increased significantly (Table 3). The increased uptake of these cations obviously resulted from the addition of these nutrients to the mediums in the form of added salts. Results show significant diffreneces Na and Ca contents of plants grown in mediums. Na and Ca content increased strongly with NaCl and $CaCl_2$ treatment. Na and Ca were at considerably higher levels in torf (6500.93 $mgkg^{-1}$ and 2.2842% respectively). Mg content of the rocket plant was slightly affected by salinity, especially $CaCl_2$. Mane et al.(28) stated that very little attention has been paid towards the role of Mg in the plants in their salt tolerance; some researchers did not exhibit any definite Mg content relationship with the increase in salinity; however, the leaf Mg concentration decreased with increasing salinity in halophyte. Maximum Mg content was achieve for 0.4613 $mgkg^{-1}$ with Tea Waste Compost + Hazelnut Husk Compost media. Among mediums the uptake of Mg was in the order: TWC+HHC > TWC = NHH > HHC > T. Also, it is thought that Mg content has increased with preventing of intake of P by salt treatments.

There is often an interaction between macronutrients and micronutrients in the root medium and in plants (32). It is confirmed that the micronutrients are generally less affected by salt stress than macronutrients (33). As seen in Table 4, the results did not show any significant differences in Fe content of plants compared to mediums and salt treatment. Salinity had no effect on leaf Fe^{+3} content in lettuce [(34)], in the root part of wheat, rice (35) and zucchini (36). On the other hand, natural hazelnut husk has been more effective on micro element contents of rocket plant.

Table 4. Some micro nutrient contents of rocket plants

Nutrients	Media	Treatments			Means of media
		Control	$CaCl_2$	NaCl	
Fe ($mgkg^{-1}$)	NHH	284.14	248.30	391.68	308.04
	T	322.34	258.06	295.44	291.95
	TWC	230.09	240.41	279.16	249.90
	HHC	308.48	242.08	293.44	281.33
	TWC+HHC	369.02	287.07	247.36	301.15
Means of treatments		302.82	301.41	255.18	
Cu ($mgkg^{-1}$)	NHH	5.62a*	5.46a	5.45a	5.51A**
	T	2.82d	2.80d	3.62bcd	3.08C
	TWC	4.18bc	5.37a	4.06bc	4.54B
	HHC	3.35cd	3.07d	3.45bcd	3.29C
	TWC+HHC	4.27b	4.08bc	4.07bc	4.14B
Means of treatments		4.05	4.13	4.16	
Mn ($mgkg^{-1}$)	NHH	145.05bc*	215.15a	169.09b	176.43A**
	T	91.84def	125.94cd	106.74de	108.17B
	TWC	65.91fg	99.02def	74.58efg	79.83C
	HHC	51.61g	53.40g	70.96efg	58.65C
	TWC+HHC	98.28def	76.89efg	64.59fg	79.92C
Means of treatments		90.53B*	114.08A	97.19B	
Zn ($mgkg^{-1}$)	NHH	154.40bc**	216.94a	170.04b	180.46A**
	T	48.14h	47.44h	72.36gh	55.98C
	TWC	123.94de	161.98b	95.57efg	127.17B
	HHC	74.21gh	78.98fg	67.26gh	73.48C
	TWC+HHC	110.34de	129.37cd	109.19def	116.30B
Means of treatments		102.21B**	126.94A	102.88B	
B ($mgkg^{-1}$)	NHH	29.81	28.45	26.81	28.36A**
	T	26.72	22.85	24.52	24.69B
	TWC	31.53	30.03	23.90	28.49A
	HHC	22.11	19.83	17.46	24.12B
	TWC+HHC	24.97	24.30	23.07	19.80C
Means of treatments		27.03A**	25.09B	23.15C	

Three replicates were used for each parameter. Means in columns followed by the same letter are not significantly different according to Tukey's test at *$p<0.05$ and **$p<0.01$ probability levels.

As is known, hazelnut and tea plant are grown intensively in Eastern Black Sea region which has low pH. Because it is low pH of these orchards, micro element contents of plants are high, but macro elements are low. This condition could cause to be high of these elements in the husk and the tea waste. Cu content was not affected by salinity, but there was a significant difference in Cu content of plants grown in varied mediums. The highest Cu was recorded at the 5.62 $mgkg^{-1}$ with natural hazelnut husk medium and salt-free. Very little attention has been given towards copper as an essential micronutrient in relation with salinity which may be due to its less contribution in ionic balance and osmoregulation in plants (28). Similarly, boron content of plants is higher in salt-free conditions (27.03 $mgkg^{-1}$), has been found most effective in natural hazelnut husk and tea waste compost medias (28.36 $mgkg^{-1}$ 28.49 $mgkg^{-1}$, respectively). Mn and Zn contents of rocket plant increased strongly with effects of salt treatments and growing medias (Table 4). Especially, $CaCl_2$ treatment and natural hazelnut husk medium were the most effective on the rocket plant, and Mn and Zn contents of plant determined 215.15 $mgkg^{-1}$, 216.94 $mgkg^{-1}$, respectively. Nurzyńska-Wierdak et al.(37) reported that potassium fertilizers applied at different levels affected the accumulation of microelements by rocket plants. The application of K_2SO_4, as a source of potassium, contributed to an increased accumulation of iron, while the application of KCl caused an increased concentration of manganese in rocket. Natural hazelnut husk to have fairly high potassium content has led to the increase of content of microelements in plants.

Conclusion

To sum up, the present study shows that $CaCl_2$ and NaCl treatments in the different growing media influenced growth of rocket plant; especially plant height and yield increased with compost tea media applied to $CaCl_2$, except for dry weight. Salt treatments did not affect the intake of P, but the amounts of K, Ca and Mg increased through the application of $CaCl_2$, except for the amount of Na. The amount of Ca, Na and P of rocket plant were significantly higher in the peat medium, the K content was higher in the natural hazelnut husk medium. The most effective media on examining the micro element contents was the natural hazelnut husk media, whereas the natural hazelnut husk media and $CaCl_2$ treatment was higher for Mn and Zn contents. Salt treatment did not affect Fe, Cu and B content of the plant. The nutrient content of the media influences the salt tolerance of plants. Therefore, it is considered to continue to salinity study in media.

References

(1)Kelay, A., Harris, P. J. C., Bateman, M. J., 2010. Relationship between phosphorus in organic growing media and its uptake by ryegrass. Communications in Soil Science and Plant Analysis 41, 98–107.

(2)Martínez, F., Castillo, S., Borrero, C., Pérez, S., Palencia, P., Avilés, M., 2013. Effect of different soilless growing systems on the biological properties of growth media in strawberry. Scientia Horticulturae 150, 59–64.

(3)Perez-Murcia, M.D., Moral, R., Moreno-Caselles, J., Perez-Espinosa, A., Paredes, C., 2006. Use of composted sewage sludge in growth media for broccoli. Bioresource Technology 97, 123–130.

(4)Nair, J., Sekiozoic, V., Anda, M., 2005. Effect of pre-composting on vermicomposting of kitchen waste. Bioresource Technology 97, 2091–2095.

(5)Chen, L., Tubail, K., Kost, D., Dick, W.A., 2010. Effects of gypsum enhanced composts on yields and mineral compositions of broccoli and tall fescue. Journal of Plant Nutrition 33,1040–1055.

(6)Adesodun, J.K., Mbagwu, J.S.C., Oti, N., 2005. Distribution of carbon, nitrogen and phosphorus in water-stable aggregates of an organic waste amended Ultisol in southern Nigeria. Bioresource Technology 96(4), 509-516.

(7)Montemurro, F., Maiorana, M., Convertini, G., Ferri, D. 2006. Compost organic amendments in fodder crops:effects on yield, nitrogen utilization and soil characteristics. Compost Sci. Util. 14,114-123.

(8)Kadono, A., Funakawa, S., Kasaki, T., 2009. Factors controlling potentially mineralizable and recalcitrant soil organic matter in humid Asia. Soil Sci. Plant Nutr. 55,243-251.

(9)Zubillaga, M.S., Lavado, R.S., 2006. Phytotoxicity of biosolids compost at different degrees of maturity compared to biosolids and animal manures. Compost Sci. Util. 14,267–270.

(10)Reddy, N., Crohn, D.M., 2012. Compost induced soil salinity: A new prediction method and its effect on plant growth. Compost Science & Utilization Vol. 20, No. 3,133-140.

(11)Gomez, L.E., Angeles Botella, M., Moreno-Martinez, J.A., Mataix-Beneyto, J.J., Garcia-Legaz, M. F., 2010. Effect of rootstock on salt tolerance of loquat: Growth and mineral composition. Journal of Plant Nutrition 33,1324–1337.

(12)Marschner, H., 2008. Mineral Nutrition of Higher Plants. SanDiego, CA: AcademicPress

(13)Shannon, M.C., Crieve, C.M., Francois, L.E., 1994. Whole-plant response to salinity. In plant enviroment Interactions; Wilkinson, R.E., Ed.; Marcel Dekker, Inc. New York. 199-244.

(14)Irshad, M., Yamamoto, S., Eneji, A. E., Endo, T., Hona, T., 2002. Urea and manure effect on growth and mineral contents of maize under saline conditions. Journal of Plant Nutrition (1), 189–200.
(15)Kacar, B., 1984. Plant Nutrition. University of Ankara, Agricultural Faculty Publishing, 899., Lesson book:250., Ankara, pp.317
(16)Kacar, B., Katkat, A.V., 1998. Plant Nutrition. Uludağ University Reinforcement Foundation. Publish No:127, VİPAŞ Publishing: 3., 595 s., Bursa.
(17)Bender Özenç, D., Özenç, N., 2009. Determination of hazelnut husk decomposition level and of the content of some plant nutrient elements under natural conditions. Proceedings of the Seventh International Congress on Hazelnut, Viterbo-Italy, Acta Hort. 845,323-330.
(18)Kacar, B., 1992. Yapraktan bardağa çay. T.C. Ziraat Bankası Kültür Yayınları. No:23, T.C. Ziraat Bankası Matbaası, Ankara.
(19)Parida, A.K., Das, A.B., 2005. Salt tolerance and salinity effects on plants:A review. Ecotoxicology and Environmental Safety 60, 324–349.
(20)Ould Ahmed, B.A., Inoue, M., Moritani, S., 2010. Effect of saline water irrigation and manure application on the available water content, soil salinity, and growth of wheat. Agricultural Water Management 97, 165–170.
(21)Bender Özenç, D., 2005. "Usage of hazelnut husk compost as a growing medium. Proceedings of the Sixth International Congress on Hazelnut, Tarragona-Reus, Spain, Acta Hort. 686,309-314.
(22)Bender Özenç, D., 2006. Effects of composted hazelnut husk on growth of tomato plants. Compost Science & Utilization Vol. 14(4), 271-275.
(23)Dierig, D.A., Tomasi, P.M., Salywon, A.M., 2004. Improvement in hydroxy fatty acid seed oil content and other traits from interspecific hybrids of three *Lesquerella* species:*Lesquerella fendleri*, *L. pallida*, and *L. lindheimeri*. Euphytica 139,199–206.
(24)Ashraf, M., 1994. Organic substances responsible for salt tolerance in *Eruca sativa*. Biol Plant 36, 255–259.
(25)Barbieri, G., Bottino, A., Di Stasio, E., Vallone, S., Maggio, A., 2011. Proline and light as quality enhancers of rocket *(Eruca sativa Miller)* grown under saline conditions. Scientia Horticulturae 128, 393–400.
(26)Kütük, A.C., Çaycı, G., Baran, A., 1995. Çay atıklarının bitki yetiştirme ortamı olarak kullanılabilme olanakları. Ank. Üniv. Ziraat Fak. Tarım Bilimleri Dergisi 1(1):35–40.
(27)Aşık, B.B., Kütük, C., 2012. Çay atığı kompostunun çim alanların oluşturulmasında kullanım olanağı. U.Ü. Ziraat Fakültesi Dergisi 26(2), 47-57.
(28)Mane, A.V., Deshpande, T.V. , Wagh, V.B. , Karadge, B.A., Samant, J.S., 2011. A critical review on physiological changes associated with reference to salinity. International Journal of Environmental Sciences Volume 1(6), 1192-1216.
(29)Grattan, S.R., Grieve, C.M., 1999. Salinity-mineral nutrient relations in horticultural crops. Scientia Horticulturae 78, 127–157.
(30)Tahir, M.A., Ibrahim, M., Sarwar, G., Iftikhar, Y., Ha, S-K., Han, K-H., Zhang, Y-S., 2013. Impact of indigenous ıindustrial compost on the growth of coarse and fine rice varieties under saline environment. Pertanika J. Trop. Agrie. Sci. 36 (1): 61–70.
(31)Khan, M.A., Ungar, I.A., Showalter, A.M., 2000. Effects of salinity on growth, water relations and ion accumulation of the subtropical perennial halophyte, *Atriplex griffithii* var. *stocksii.* Annals of Botany 85(2), 225-232.
(32)Marschner, H., 1995. Mineral Nutrition of Higher Plants. 2 nd Edn., Academic Press, London.
(33)El-Fouly, M.M., Salama, Z.H., 1999. Can foliar fertilization increase plant tolerance to salinity; Dahlia Greidinger International Symposium: Nutrient Management under salinity and water stress. 1-4 March, Teknion-ITT Haifa.
(34)Lazof, D.B., Bernstein, N., 1999. Effects of salinization on nutrient transport to lettuce leaves: consideration of leaf developmental stage. New Phytol. 144(1), 85-94.
(35)Alpaslan, M., Güneş, A., Taban, S., Erdal, İ., Tarakçıoğlu, C., 1998. Variations in calcium, phosphorus, iron, copper, zinc and manganese contents of wheat and rice varieties under salt stress. DOGA, Tr. Journal of Agriculture and Forestry, 22, 227-233.
(36)Villora, G., Moreno, D.A., Pulgar, G., Romera, L., 2000. Yield improvement in zucchini under salt stress: determining micronutrient balance. Scientia Horticulturae 86(3), 175-183.
(37)Nurzyńska-Wierdak, R., Dzida, K., Rożek, E., Jarosz, Z., 2012. The effect of nitrogen and potassium on N-NH_4 and N-NO_3 accumulation and nutrient contents in rocket *(Eruca sativa mill.)* leaves. Acta Sci. Pol., Hortorum Cultus 11(3), 211-221.

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The effect of compost treatments on some nutrients element intake of corn plant (Zea Mays L.)

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Abstract

In this study, effects of hazelnut husk compost and tea waste compost applications on nitrogen intake of corn plant *(Zea mays L.)* in greenhouse conditions was investigated. Trial was established according to randomized parcels experimental design and as three corn variety (early, medium and late varieties), two organic materials, (hazelnut husk compost and tea waste compost) four different mixing ratio (0%, 2%, 4% and 8%, volumetrically) and a three replicates. Mixing compost into the soil improved root and shoot growth of corn plant and the content of N, P, K. Compostapplications,shoot and rootdry weightof plantswas higherinearly varieties (51.74g, 7.88g, respectively); however, the content of N, P, K of plants increased in late variety. Tea waste compostand the dose of 8% were found to be the most effectivemedium and the dose on the content of root and leaf N, P and K. The compost and dose applications have affected nitrogen uptake, but varieties has not significant. Leaf N% content of plant changed depending on variety; and 8% dose of tea waste compostwas more effectiveinearly (1.27%) and late (1.25%) varieties.Hazelnut husk compost, especially 4 % dose has been relatively effective on the root and leaf N content in early varieties. Root and leaf K, root P contents of the plant increased in late variety (134.80mgkg^{-1}, 57.91mgkg^{-1}, 36.91mgkg^{-1}, respectively), in the tea waste compost and 8% dose conditions, but leaf P content of the plants growing early varieties (42.94 mgkg^{-1}) has been higher.

Keywords: compost, nitrogen, potassium, phosphorus, root and shoot weight

Introduction

The production of urban, industrial and agricultural organic wastes is increasing worldwide and strategies for disposal must be developed and optimized (1). Recently, this waste has been increasing interest in the use of alternative fertility. These wastes are a serious source of organic matter for sustaining of soil fertility and nutritional content, have significant potential.Dostal(2) reported that balance of soil organic matter in agricultural systems is an important indicator of sustainability.Organic wastes such as animal manures, by-products of several kinds and composted residues can be used as amendments to increase soil fertility, since they are important sources of nutrients for growing crops and means for enhancing the overall soil quality (3,4). Many researches have been carried out for agricultural suitability of these wastes of organic origin, and have been reported that they can be used as a source of organic matter and plant growing media (5,6,7,8,9,10).

Cornisan importantagriculturalcropin terms of cultivated areaandconsumption. It is a well-known fact that the yield potential of a crop is mainly dependent upon its genetic make-up as well as the environment in which it is

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grown. The genetic potential however, can be exploited to the maximum by providing favorable growth environments. Agronomic practices such as seed rate, plant population and fertilizer management are known to affect crop environment, which influence the growth and ultimately the yield (11). Nutrition plays an important role in increasing the maize yield and their contribution is 40-45 percent. Balanced and optimum use of nitrogen, phosphorus and potassium fertilizers plays a vital role in increasing the yields of cereals(12). Corn plant are faced with many factors during the development period such growth promoting, or causing the decline; thus the root development is crucial in this period. Many researchers have carried out the studies examining the effects of some organic and inorganic fertilization on root and stem growth of the corn plant (13,14,15).

Our country is made of intensively tea and hazelnuts cultivation in the Eastern Black Sea region. During the black tea conversion of the fresh tea leaves, solid waste of organic origin consisting from fiber, litter and dust occurs. Owing to variety of plant nutrients and high organic matter content, should be evaluated as an important organic material reserve and plant growing media after composting (16,17).Abdulghani(18)stated that black tea waste reduced EC, pH and bulk density of the soil, increased porosity, and plant growth affected positively.Hazelnut husk is called as waste remaining after harvest of hazelnut. The physical and the chemical properties of the husk can be evaluated in terms of its use as an organic material have values (19,20,21,22) expressed that hazelnut husk compost affected positively on soil properties depending on aggregate size.

Therefore, the aim of this study was to assess the influence of tea waste compost and hazelnut husk compost on some nutrients contents and growth of thedifferent genotypes of corn plant(*Zea mays* L.) in greenhouse conditions.

Material and Methods

A greenhouse experiment with different maize (*Zea mays* L.) varieties carried out with clay loam soil. Compost was used to know the effects on the uptake of nitrogen, phosphorus and potassium nutrients in different parts of maize plant. Soil and compost materials were sieved through 4 mm. Before the experiment, the general properties of soil (0-20cm) and compost are given in Table 1.

Table 1. Some physical and chemical properties of soil and compost, on a dry matter basis

Properties	Soil	Hazelnut Husk Compost	Tea Waste Compost
Texture	Clay loam	-	-
Bulk Density (gcm^{-3})	1.20	0.16	0.12
Aeration Capacity (%)	-	21.85	23.47
Easily Available Water (%)	-	13.83	11.39
Water Balance Capacity (%)	-	6.84	6.51
Field capacity (%)	25	-	-
Wilting Point (%)	14	-	-
Organic matter (%)	2.25	36	65
pH	6.29 (1:2.5)	7.26 (1:3)	6.38 (1:3)
EC (dSm^{-1})	2.874	1.092	3.967
$CaCO_3$ (%)	2.2	-	-
Total Nitrogen (%)	0.163	1.054	2.718
P (mg kg^{-1})	4.79	68	145
K (mgkg^{-1})	220	521	1103

Soil sample was analyzed using the following methods: Texture was determined by hydrometer methods (23), bulk density according to Blake and Hartge (24), field capacity and wilting point according to Klute (25), pH and EC according to U.S.Salinity Lab. Staff (26), organic matter according to Nelson and Sommer (27), total nitrogen according to Bremner (28), available P according to Bray and Kurtz (29), available K according to Knudsen et al.(30). Compost samples were analyzed using the following methods: Aeration capacity, easily available water and water balance capacity according to De Boodt et al. (31), organic matter according to DIN 11542 (32), pH and EC according to Gabriels and Verdonck (33), total nitrogen according to Bremner(28), total P and K according to Kacar (34).

In according to aim of the trial was used in 6 kg pots. The experiment was designed as a randomized parcels design with three variety (early, medium and late), two organic materials (TW compost and HH compost), four application rates (0%, 2%, 4% and 8%, w/w) and three replications per treatments. The total number of pots used in experiment was 72. Prepared mixtures were filled in the plastic pots as gravimetrically. Five grains per pot were placed manually to a depth of 5 cm, which was previously watered for conditioning purposes. After germination, four seedlings from each pot were removed to leave only one, the most developed one. During the experiment, only basic fertilization (100ppm/pot KH_2PO_4, 200 ppm/pot $Ca(NO_3)_2$ and 2.5ppm/pot Fe) was performed. In choosing of the fertilizer material, the dissolution rate in the soil, the application time and method were based on. The necessary cultural operations were also conducted until the end of the trial. Plants were harvested after 70 days (stem elongation period) and were divided in to shoot and root samples. The roots in the soil were separated by washing on the sieve to prevent loss of root, and then were taken excess moisture with blotting paper. All plant material was dried in an oven at 65 °C for 48 h to measure dry weight and was weighted (35). Total nitrogen content was analyzed by kjeldahl methods (28). Phosphorus was measured by the molybdate-vanadate calorimetric method as described by Kacar (34). Potassium was assayed by flame photometry according to Kacar (34). Statistical analysis was performed using a JUMP software programme and differences among the groups were separated by LSD (least significant difference) test at $p<0.05$ and $p<0.01$.

Results and Discussion

TW compost and HH composthave suitable as physical properties and also have sufficient and high levelsof N, P and K contents (Table 1). For plant growth, especially for root growth is an important role of physical properties.A good root growth will provide a good development of soil-top parts.The root and shoot growth of maize varieties in compost-mixture soil at different doses are given in Table 2.

Table 2.Root and shoot dry weights of different maize varieties in compost applications (g)

	Root					Leaf			
	DOSE	TW compost	HH compost	Dose x Variety	VARIETY	TW compost	HH compost	Dose x Variety	VARIETY
Early	0	6.60	5.31	5.95	7.36A	47.50c-e	43.91g	45.71bc	48.59A
	2	6.93	7.37	7.15		48.28b-d	48.64b-d	48.46a	
	4	8.39	7.16	7.78		50.59ab	49.69bc	50.14a	
	8	9.59	7.59	8.58		51.74a	48.41b-d	49.60a	
Media x Variety		7.88a	6.85b			49.52a	47.66b		
Medium	0	5.59	3.70	4.65	5.57B	45.19e-g	40.66h	42.92de	45.52B
	2	6.74	3.79	5.26		47.65c-e	40.92h	44.28cd	
	4	7.02	4.33	5.67		48.72b-d	43.48g	46.10b	
	8	8.66	4.76	6.71		50.78ab	46.74d-f	49.24a	
Media x Variety		7.00b	4.14c			48.09ab	42.95d		
Late	0	6.32	3.28	4.80	5.34B	42.88gh	35.97l	39.43g	41.33C
	2	6.74	3.43	5.09		44.57fg	36.67l	40.62fg	
	4	7.09	4.37	5.73		47.38c-e	36.08l	41.73ef	
	8	7.05	4.42	5.73		49.25a-c	37.85l	43.55d	
Media x Variety		6.80b	3.88c			46.02c	36.64e		
MEDIA		7.23A	4.96B			47.88A	42.42B		
	0	6.17	4.10	5.14D		45.19	40.18	42.68D	
	2	6.80	4.86	5.83C		46.83	42.07	44.45C	
	4	7.50	5.29	6.39B		48.90	43.08	45.99B	
	8	8.43	5.58	7.01A		50.59	44.33	47.46A	

Three replicates were used for each parameter. Means in columns followed by the same letter are not significantly different according to LSD (least significant difference) test $p<0.01$ and $p<0.05$ probability levels.
The root dry weight: Variety ($p<0.01$)= 0.405, Dose ($p<0.01$)= 0.468, Media x Variety ($p<0.01$)= 0.573
The shoot dry weight: Variety ($p<0.01$)= 0.885, Dose ($p<0.01$)= 1.022, Media x Variety ($p<0.01$)= 1.251,
Dose X Variety ($p<0.05$)= 1.770, Media x Variety x Dose ($p<0.05$)= 2.503

As is known, the growth period of plant is related to closely variety properties, and the early varieties are grown in a shorter period. Thus, the root and shoot growth (7.36g, 48.46g, respectively) have been more in the early variety maize. In general, significant increases in maize growth with TW compost and HH compost presence in the soil were observed. The effectsof compost applications have changed depending on varieties. TW compost applications (7.88g, 49.29g, respectively) were higher early variety than medium and late varieties. Organic amendments influence soil characteristics by the interdependent modification of biological, chemical and physical properties (36). Also, fertility improvement through an effective management of these properties has the capability of optimizing crop production.Tea waste, which is a major organic matter and macro and micro nutrient elements source, makes a positive impact on soil structure and on the amount of product (37,17,38). Nitrogen source influenced the root growth of maize, but high nitrogen dose decreased the root dry weight (39). Composted tea waste developed significantly the root and the shoot dry weight of acacia seedling (40) and in the plant dry weight of maize (41). On the other hand, the development of soil-top parts is more complicated system. As seen in Table 2, the shoot growth was significantly affected through both varieties and compost application and their doses. The highest shoot dry weight (51.74 g) was found at 8% dose of TW compost-mixture soil in early variety. TW compost has higher aeration capacity and organic matter content, nitrogen, phosphorus and potassium contents than HH compost (Table 1). Walsh et al. (42) specified that the incorporation of crop residues into soil is beneficial to soils, improving one or more essential soil attributes. Poultry manure (43), chicken manure and farm manure (44) as organic fertilizers have been impact positively on growth and yield parameters of maize.

Nitrogen has been found to be the most important nutrient for maize production (45). The N dynamics in compost-amended soils could be affected by different site-specific factors, e.g. compost matrices, composting conditions, climate, soil properties and management practices and the greatest total N content in compost is not readily available (1). The root and leaf N contentsof maize were significantly affected onlytype of compost and doses (Table 3).Total concentration of N in the compost-mixturesoil showed statistically significant differences ($p<0.01$) as compared to the control soil. The most effective compost was TW and maximum the root N contents (0.925%) were observed at 8% compost-mixture soil.This can be explained through enhancing build- up of nitrogen in the soil of high organic matter. TW compost has approximately two times higher organic matter content than HH compost in terms of chemical properties (Table 1). Regular addition of organic material to soil for many years, through compost or manures, enhanced both soil C and N stocks and resulted in build-up of N, indicating a physical protection of this nutrient within macro aggregates (46,47). Kacar et al. (48) denoted that tea waste has been equally effective to animal manure on the growth of maize. The leaf N contents of maize were significantly affected through both varieties and compost application and their doses (Table 3).

Considering the interaction, the highest nitrogen uptake followed as early, late and medium varieties at8% of TW compost-mixture soil,1.268%, 1.248%,1.141%, respectively. The N release from different composts and its relationship with plant N uptake are quite complex (49,50). Tuna and Girgin(51) reported that used low dose-fly ash as a medium (MuğlaYatağan thermic reactor) caused positively effect on the growth parameters and mineral nutrition of maize. In a study by Habteselassie et al.(52)informed thatsoils with about 100 t ha^{-1} dairy waste compost maintained N supply to the plants through continuous mineralization on silage corn yield and plant N content. On the other hands, HH compost and its 4% dose on early varietyhas remarkable in terms of the root and leaf N nitrogen content (0.836%, 0.931%, respectively) HH compost has insufficient amounts of nitrogen and phosphorus to within limits, but potassium and trace elements have values sufficient or more the amount (19).

Compost applications significantly affected root and leaf P contents of plantdepending on maize varieties (Table 4). The create more root of plants compared to green parts and the increase in root length, the more active P uptake of plant from the medias is to provide (53).

Table 3. The root and leaf N contents of different maize varieties in compost applications (%)

		Root				Leaf			
	DOSE	TW Compost	HH Compost	Dose x Variety	VARIETY	TW Compost	HH Compost	Dose x Variety	VARIETY
Early	0	0.533	0.533	0.534	0.760	0.503g	0.503g	0.503	0.747
	2	0.639	0.743	0.691		0.548g	0.787c-f	0.657	
	4	0.955	0.836	0.896		0.778c-e	0.931bc	0.854	
	8	1.080	0.761	0.921		1.268a	0.675d-g	0.972	
Media x Variety		0.802	0.719			0.77bc	0.72cd		
Medium	0	0.506	0.506	0.506	0.763	0.521g	0.521g	0.521	0.715
	2	0.746	0.768	0.757		0.686d-g	0.511g	0.599	
	4	1.063	0.645	0.854		0.962bc	0.552fg	0.758	
	8	1.130	0.740	0.935		1.141ab	0.824cd	0.983	
Media x Variety		0.862	0.665			0.828ab	0.60e		
Late	0	0.627	0.627	0.627	0.765	0.533g	0.533g	0.533	0.773
	2	0.819	0.668	0.744		0.789c-e	0.584e-g	0.686	
	4	0.802	0.737	0.769		1.076ab	0.646d-g	0.860	
	8	1.044	0.793	0.918		1.248a	0.776c-e	1.011	
Media x Variety		0.823	0.707			0.911a	0.63de		
MEDIA		0.829A	0.697B			0.840A	0.652B		
	0	0.556	0.556	0.556C		0.519e	0.519e	0.519D	
	2	0.735	0.727	0.731B		0.675cd	0620de	0.647C	
	4	0.940	0.739	0.839AB		0.938b	0.709cd	0.84B	
	8	1.084	0.765	0.925A		1.219a	0.758c	0.989A	

Three replicates were used for each parameter. Means in columns followed by the same letter are not significantly different according to LSD (least significant difference) test $p<0.05$ and $p<0.01$ probability levels. The root N content:Dose ($p<0.01$)=0.144
The leaf N content: Dose ($p<0.01$)= 0.088, Media x Variety ($p<0.05$)= 0.1076, Dose x Variety ($p<0.01$)= 0.124, Media x Variety x Dose ($p<0.01$)= 0.215

Table 4. The root and leaf P contents of different maize varieties in compost applications (mg kg^{-1})

		Root				Leaf			
	DOSE	TW compost	HH compost	Dose x Variety	VARIETY	TW compost	HH compost	Dose x Variety	VARIETY
Early	0	24.92	24.92	24.92	28.70B	50.21	31.90	41.05	42.94A
	2	26.23	31.46	28.84		50.60	35.65	43.32	
	4	27.27	31.28	29.28		46.72	39.92	43.32	
	8	35.38	28.15	31.76		46.98	41.14	44.06	
Media x Variety		28.45c	28.95c			48.73	37.15		
Medium	0	29.45	25.01	27.23	33.84A	41.66	29.28	35.47	36.87B
	2	33.38	34.60	33.99		43.23	29.74	36.49	
	4	36.08	35.12	35.60		45.24	29.98	37.61	
	8	40.27	36.82	38.55		46.20	29.63	37.91	
Media x Variety		34.80ab	32.89b			44.08	29.66		
Late	0	33.73	24.26	28.99	32.03A	42.19	28.32	35.25	34.64B
	2	36.43	25.79	31.11		42.45	28.06	35.25	
	4	37.48	28.58	33.02		36.69	32.24	34.47	
	8	40.01	29.98	34.99		37.74	29.45	33.60	
Media x Variety		36.91a	27.17c			39.76	29.52		
MEDIA		33.39A	29.66B			44.19A	32.11B		
	0	29.37	24.73	27.05C		44.69	29.83	37.26	
	2	32.01	30.62	31.31B		45.56	31.15	38.35	
	4	33.61	31.66	32.63AB		42.88	34.05	38.47	
	8	38.55	31.65	35.10A		43.64	33.41	38.52	

Three replicates were used for each parameter. Means in columns followed by the same letter are not significantly different according to LSD (least significant difference) test $p<0.05$ and $p<0.01$ probability levels.
The root P content:Variety ($p<0.01$)= 2.322, Dose ($p<0.01$)= 2.681, Media x Variety ($p<0.01$)= 3.284
The leaf P content: Variety ($p<0.01$)= 2.500

While the root P contents in medium and late variety were higher (33.84 mg kg^{-1}, 32.03 mg kg^{-1}, respectively), the leaf P content increased in early variety (42.94 mg kg^{-1}). This may be explained by appropriation between the growth period of the plant and plant requirement for nutrients. Güneş (54) specified that between maize genotypes are significant differences in terms of phosphorus use efficiency. Also, TW compost was more effective media and maximum the root P content (36.91mg kg^{-1}) was observed at TW compost-mixture soil in late variety; however, interaction of compost on varieties did not show any difference in leaf P content. He et al. (55) reported that compost applications can increase plant available P in the soil. Plants in the first period of development absorbed a large part of phosphorus, can be said that gradually decreases towards maturity period. Furthermore, generally, the effect of phosphorus on the development of the above-ground organs of plants is relatively much more than its impact on the root system (56). Therefore, the amount of phosphorus transported to the leaves in early varieties, which has a shorter development period, was expected as a result to be higher.

Potassium is important a caution in terms of more than in plant tissues and physiological and biochemical functions,K intake has been increasing during periods of growth and development(56). The root K content was affected significantly by compost applications and varieties (Table5).

Table 5. The root and leaf K contents of different maize varieties in compost applications (mg kg^{-1})

		Root				Leaf			
	DOSE	TW compost	HH compost	Dose x Variety	VARIETY	TW compost	HH compost	Dose x Variety	VARIETY
Early	0	58.50	58.50	58.50	95.72A	42.81	42.81	42.81	49.13B
	2	85.64	69.68	77.66		48.29	50.95	49.62	
	4	125.10	119.22	122.16		52.30	51.69	51.99	
	8	174.36	74.71	124.53		50.17	54.06	52.12	
Media x Variety		110.90b	60.94d			48.39cd	49.88bc		
Medium	0	32.72	30.21	31.46	55.62B	44.22	39.76	41.99	47.69B
	2	33.34	57.50	45.42		47.15	41.70	44.42	
	4	61.05	72.33	66.69		53.34	46.82	50.08	
	8	116.65	41.14	78.90		56.67	51.84	54.25	
Media x Variety		80.53c	50.30d			50.34bc	45.03d		
Late	0	90.82	52.22	71.52	95.57A	51.11	51.11	51.11	55.44A
	2	111.78	60.94	86.36		54.87	51.53	53.20	
	4	138.22	66.97	102.60		60.12	53.41	56.76	
	8	198.40	53.20	125.80		65.52	55.83	60.67	
Media x Variety		134.80a	58.33d			57.91a	52.97b		
MEDIA		102.21A	63.05B			52.21A	49.29B		
	0	60.68de	46.98e	53.83C		46.05	44.56	45.30C	
	2	76.92cd	62.71de	69.81B		50.11	48.06	49.08B	
	4	108.13b	86.18bc	97.15A		55.25	50.64	52.95A	
	8	163.14a	56.35de	109.74A		57.45	53.91	55.68A	

Three replicates were used for each parameter. Means in columns followed by the same letter are not significantly different according to LSD (least significant difference) test p<0.05 and p<0.01 probability levels.
The root K content: Variety (p<0.01)= 13.448, Dose (p<0.01)= 15.528, Media x Variety (p<0.01)= 19.018,
Dose x Media (p<0.01)= 21.960
The leaf K content: Variety (p<0.01)= 3.009, Dose (p<0.05)= 3.474, Media x Variety (p<0.05)= 4.255

The compost applications and its doses increased K content of root that TW compost-mixture soil at 8% produced highest (163.14 mg kg^{-1}) compared to control conditions (46.98 mg kg^{-1}). TW compost has rather high K content than HH compost (Table 1); thus, it is an expected result that parts of plants grown in this medium have a high Kcontent. Considering the varieties, the root K content was higher in early variety (95.72 mg kg^{-1}), followed late and medium varieties (95.57 mg kg^{-1}, 55.62 mg kg^{-1}). However, interaction of compost applications on varieties showed significantly difference in root and leaf K contents. Maximum the root and leaf K contents were observed at TW compost-mixture soil in late variety, 134.80 and 57.91, respectively. Balanced nutrition with potassium has enhanced stem strength and root development, which caused sturdiness and healthiness of plants (57). Soil available potassium (K) content increased on average by 26%, as compared with control, in 5-year compost treatments derived from organic household wastes and yard trimmings (58).

Conclusion

The present study shows that compost- mixture soil influenced positively on growth and intake nutrient of corn plant. Withincreasing ratesof compostapplication,this effectfurtherincreased;especially the additions of TW compost has provided a more significant increase.In addition, the effects of compost applications have changed according to varieties. Root and shoot dry weight, leaf N and P contents in early variety, other parameters in late varietyincreased during the stem elongation period.

References

(1)Diacono, M., Montemurro, F., 2010. Long-term effects of organic amendments on soil fertility. A review .Agron. Sustain. Dev. 30, 401–422.

(2)Dostal, J., 2002. Results of the long-term organic matter balance investigations in ustinad orlici district and the trends in the whole Czech Republic. Agronomy and Soil Science 48(2), 155-160.

(3)Davies G., Lennartsson, M., 2005. Organic Vegetable Production. A Complete Guide, Henry Doubleday Research Association, The Crowood Press Ldt., ISBN 1 86126 788 6.

(4)Montemurro F., Maiorana M., 2008. Organic Fertilization as Resource for a Sustainable Agriculture, Fertilizers: Properties, Applications and Effects, in: Elsworth L.R. et al. (Eds.), pp. 123–146, ISBN 978-1-60456-483-9.

(5)Pascual, J.A., Ayuso, M., Hernandez, T., Garcia, C.A., 1997. Phytotoxicity and fertilizer value of different organic materials. Agrochemical 41, 50–62.

(6)Bhattacharyya, P., Chakrabarti, K., Chakraborty, A., 2003. Residual effects of municipal solid waste compost on microbial biomass and activities in mustard growing soil. Archives of Agronomy and Soil Science 49, 585-592.

(7)Özenç, N., 2004. Fındık zurufu ve diğer organik materyallerin fındık tarımı yapılan toprakların özellikleri ve ürün kalitesi üzerine etkileri. Ankara Üniversitesi Fen Bilimleri Enstitüsü Doktora Tezi, Ankara.

(8)Bhushan, L., Sharma, P.K., 2005. Long-term effects of lantana residue additions on water retention and transmission properties of a medium-textured soil under rice–wheat cropping in northwest India. Soil Use Manage. 21, 32–37.

(9)Benito, M., Masaguer, A., Moliner, A., De Antonio, R., 2006. Chemical and physical properties of pruning waste compost and their seasonal variability. Bioresource Technology 97, 2071-2076.

(10)Verma, S., Sharma, P.K., 2008. Long-term effects of organics, fertilizers and cropping systems on soil physical productivity evaluated using a single value index (NLWR). Soil & Tillage Research 98, 1–10.

(11)Tajul, M.I., Alam, M.M., Hossain, S.M.M., Naher, K., Rafii, M.Y., Latif, M.A., 2013. Influence of plant population and nitrogen-fertilizer at various levels on growth and growth efficiency of maize. Scientific World Journal. Published online Sep 15, 2013. doi: 10.1155/2013/193018

(12)Asghar, A., Ali, A., Syed, W., Asif, M., Khaliq, T., Abid, A.A., 2010. Growth and yield of maize (*zea mays* L.) cultivars affected by NPK application in different proportion. Pakistan Journal of Science Vol.62 No.4, 211-216.

(13)Sharif, M., Ahmad, M., Sarir, M. S., Khattak, R. A., 2004. Effect of organic and inorganic fertilizers on the yield and yield components of maize. Pakistan Journal of Agriculture, Agricultural Engineering, Veterinary Sciences 20(1), 11–16.

(14)Şeker, C., Ersoy, İ., 2005. Değişik organik gübreler ve leonarditin toprak özellikleri ve mısır bitkisinin (*zea mays* l.) gelişimi üzerine etkileri. S.Ü. Ziraat Fakültesi Dergisi 19(35), 46-50.

(15)Özyazıcı, M.A., Özyazici, G., Özdemir, O., 2009. Yeşil gübre uygulamalarının mısır-buğday münavebesinde bitkilerin verim ve bazı tarımsal özellikleri üzerine etkileri. Anadolu Tarım Bilim. Derg. 24(1), 21-33

(16)Kacar, B., Taban, S., Kütük, C.A., 1996. Çay atıklarının zenginleştirilmiş organik gübreye dönüştürülerek kullanılması. Araştırma Geliştirme Uygulama Projesi, Çay İşletmeleri Genel Müdürlüğü, Rize.

(17)Kütük, C., Çaycı, G., Baran, A., Başkan, O., Hartmann, R., 2003. Effects of beer factory sludge on soil properties and growth of sugar beet (*Beta vulgaris saccharifera* L.). Bioresource Tech. 90, 75-80.

(18)Abdulghani, E.T., 2012. Effect of black tea wastes on some of soil properties and barley *(Hordium vulgar L.)* growth and yield. Journal Tikrit Univ. For Agri. Sci. 12 (3), 186-189.

(19)Kacar, B., Katkat, A.V., 1998. Bitki Besleme. Uludağ Üniversitesi Güçlendirme Vakfı Yayın No:127, VİPAŞ Yayınları: 3., Bursa, 595 s.

(20)Özenç, N., Çalışkan, N., 2001. Effect of husk compost on hazelnut yield and quality. Proceedings of the Fifth International Congress on Hazelnut. Acta Hort. 556: 559-566.

(21)Zeytin, S., Baran, A., 2000. Influences of composted hazelnut husk on some physical properties of soils. Bioresource Tech. 88(3), 241-244.

(22)Bender Özenç, D., 2006. Effects of composted hazelnut husk on growth of tomato plants. Compost Scince&Utilization Vol. 14, No.4, 271-275.

(23)Bouyoucos, G.J., 1951. A Recalibration of the hydrometer method for making mechanical analysis of soils. Agron. J. 43, 434-438.

(24)Blake, G.R., Hartge, K.H., 1986. Bulk Density, Particle Density. In: Methods of Soil Analysis. Part I. ASA-SSSA, Madison, WI, 363-382.

(25)Klute, A., 1986. Water Retention. Laboratory Methods. In:Methods of Soil Analysis, Part II, ASA-SSSA, Madison, WI, 635-662.

(26)U.S.Salinity Laboratory Staff, 1954. Diasgnosis and Improvement of Saline and Alkali Soils. U.S.D.A. Agricultural Handbook, No: 60.

(27)Nelson, D.W., Sommer, L.E., 1982. Total carbon, organic carbon, and organic matter. In A.L. Page (ed.) Methods of Soil Analysis. 2nd Ed. ASA Monogr., Amer. Soc. Agron. 9(2), p. 539-579, Madison, WI.

(28)Bremner, J.M., 1965. Methods of Soil Analysis Part II. Chemical and Microbiologial Properties. In.ed. C.A.Balack. American Soc.of Agronomy. Inc. Pub. Agron Series. No:9 Madison USA.

(29)Bray, R.H., Kurtz, L.T., 1945. Determination of total organic and available forms of phosphorus in soils. Soil Science 45, 39-45.

(30)Knudsen, D., Peterson, G. A., Pratt, P. F., 1982. Lithium, Sodium and Potassium. Methods of Soil Analysis. Part II. ASA-SSSA, WI, 225-245.

(31)De Boodt, M., Verdonck, O., Cappaert, I., 1973. Method for measuring the water release curve of organic substrates. Proc. Sym. Artificial Media in Horticulture 2054-2062.

(32)DIN 11542, 1978. Torf für Gartenbau und Landwirtshaft. Germany

(33)Gabriels, R., Verdonck, O., 1992. Reference methods for analysis of compost. In: Composting and compost quality assurance criteria. 173-183.

(34)Kacar, B., 1972. Bitki ve Toprakların Kimyasal Analizleri II. Bitki analizleri. Ankara Üniversitesi Ziraat Fakültesi Yayınları, 453. Uygulama Kılavuzu, Ankara, 155, 646 s.

(35)Kacar, B., 1984. Plant Nutrition. University of Ankara, Agricultural Faculty Publishing, 899., Lesson book:250., Ankara, pp.317

(36)Van-Camp, L., Bujarrabal, B., Gentile A.R., Jones, R.J.A., Montanarella, L., Olazabal, C., Selvaradjou, S.K., 2004. Reports of the Technical Working Groups Established under the Thematic Strategy for Soil Protection, EUR 21319 EN/3, 872 p., Office for Official Publications of the European Communities, Luxembourg.

(37)Kacar, B., 1992. Yapraktan Bardağa Çay. T.C. Ziraat Bankası Kültür Yayınları. No:23, T.C. Ziraat Bankası Matbaası, Ankara.

(38)Çıtak, S., Sönmez, S., Öktüren, F., 2006. Bitkisel kökenli atıkların tarımda kullanılabilme olanakları, Derim 23 (1), 40-53.

(39)Wang, Z.R., Rui, Y.K., Shen, J.B., Zhang, F.S., 2008. Effect of N fertilizer on root growth in *Zea mays* L. seedlings. Spanish Journal of Agricultural Research 6(4), 677-682.

(40)Yalınkılıç, M.K., Altun, L., Kalay, H.Z., 1996. Çay yaprağı fabrikaları atıklarının kompostlaştırılarak orman fidanlıklarında organik gübre olarak kullanılması. K.T.Ü. Orman Fakültesi, Trabzon

(41)Erdal, T., Tarakçıoğlu, C., 2000. Değişik organik materyallerin mısır bitkisinin (*Zea mays* L.) gelişimi ve mineral madde içeriği üzerine etkisi. OMÜ. Zir. Fak. Dergisi 15 (2), 80-85.

(42)Walsh, E., McDonnell, K.P., 2012. The influence of added organic matter on soil physical, chemical, and biological properties: a small-scale and short-time experiment using straw. Archives of Agronomy and Soil Science 58(1), 201-205.

(43)Boateng, S. A., Zickermann, J., Kornahrens, M., 2006. Poultry manure effect on growth and yield of maize. West Africa Journal of Applied Ecology (WAJAE) Vol (9), 12-18.

(44)Khan, H.Z., Malik, M.A., Saleem, M.F., 2008. Effect of rate and source of organic material on the production potential of spring maize (*Zea Mays* L.). Pak. J.Agri. Sci. Vol. 45(1), 40-43.

(45)Sanjeev, K., Bangarwa, A.S., 1997. Yield and yield components of winter maize (*Zea mays* L.) as influenced by plant density and nitrogen levels. Agricultural Science Digest. 17, 181–184.

(46)Mallory, E.B., Griffin, T.S., 2007. Impacts of soil amendment history on nitrogen availability from manure and fertilizer, Soil Sci. Soc. Am. J. 71, 964–973.

(47)Meng, L., Ding, W., Cai, Z., 2005. Long-term application of organic manure and nitrogen fertilizer on N2O emissions, soil quality and crop production in a sandy loam soil, Soil Biol. Biochem. 37, 2037–2045.

(48)Kacar, B., Kovancı, I., Atalay, I.Z., 1980. Utilization of tea waste products of tea factories in agriculture. A.Ü.Z.F. Yıllığı 29(1), 158-173.

(49)Zhang, M., Heaney, D., Henriquez, B., Solberg, E., Bittner, E., 2006. A four year study on influence of biosolids/MSW cocompost application in less productive soils in Alberta: nutrient dynamics. Compost Sci. Util. 14, 68–80.

(50)Barbarick, K.A., Ippolito, J.A., 2007. Nutrient assessment of a dryland wheat agroecosystem after 12 years of biosolids applications. Agron. J. 99, 715–722.

(51)Tuna, A.L., Girgin, A.R., 2005. Mısırda (*Zea mays* L.) gelişme, mineral beslenme ve ağır metal içeriği üzerine termik santral uçucu küllerinin etkisi. Muğla Üniversitesi Fen Edebiyat Fakültesi, Biyoloji Bölümü, 48100.

(52)Habteselassie, M.Y., Miller, B.E., Thacker, S.G., Stark, J.M., Norton, J.M., 2006. Soil nitrogen and nutrient dynamics after repeated application of treated dairy-waste, Soil Sci. Soc. Am. J. 70, 1328–1337.

(53)Güneş, A., Alparslan, M., İnal, A., 2010. Bitki Besleme ve Gübreleme (5. Baskı) Ankara Üniversitesi Ziraat Fak. Yayın No: 1581, Ders Kitabı:533, Ankara Üniversitesi Yayınları No: 261, Ankara Üniversitesi Basımevi, Ankara.

(54)Güneş, A., 2000. Fosfor eksikliğine dayanıklı mısır *(Zea mays L. Cvs.)* genotiplerinin belirlenmesi. A.Ü.Z.F. Tarım Bilimleri Dergisi 6(3), 144-148.

(55)He, Z., Yang, X., Kahn, B.A., Stoffella, P.J., Calvert, D.V., 2001. Plant nutrition benefits of phosphorus, potassium, calcium, magnesium, and micronutrients from compost utilization, in: Stoffella P.J., Kahn B.A. (Eds.), CRC Press LLC, Compost Utilization in Horticultural Cropping Systems, pp. 307–317, ISBN 1-56670-460-X.

(56)Kacar, B., Katkat, A.V., 1997. Tarımda Fosfor. Bursa Ticaret Borsası Yayınları No:5, Uludağ Üniversitesi Basımevi, Bursa.

(57)Ahmed, F., Abid, M.M., Mahmood, T., Ali, N., Anwar, M.A., Sandhu, N.A., 1992. Effect of potassium in different proportions with nitrogen and phosphorus on growth, yield and oil contents of sunflower (*Helianthus annus* L.). Journal of Agricultural Research 30, 353-357.

(58)Hartl, W., Putz, B., Erhart, E., 2003. Influence of rates and timing of biowaste compost application on rye yield and soil nitrate levels. Eur. J. Soil Biol. 39, 129–139.

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Effect of pumice on water retention capacity in soil, growth and yield of spring safflower in dryland conditions

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Abstract

Application of superabsorbent material is one of the new methods for moisture storage in the soil. This research was performed in the Khajeh research station on the basis of randomized complete block design with three replications in the plots with dimension of 4×5 for investigate the effect of different amounts of pumice on water retention capacity in the soil, growth and of spring safflower in rainfed condition. Experimental treatments were five levels of pumice (A: zero, B: 5, C: 10, D: 15 and E: 50 ton ha^{-1}). Before cultivation, amounts of pumice calculated for each plot and then mixed with soil to depth of 20 cm. Then, cultivation was performed in the seeding and the number of germinated seeds at first ten days of cultivation was determined. Soil volumetric water content and plant height was measured at various times during growth season, 1000 grain weight and grain yield of safflower was measured in the end of growth season. The results showed that application of pumice in the soil led to significant increase ($P < 0.01$) in volumetric water content, germination, 1000 grain weight and grain yield. So adding pumice soil improves soil physical conditions (total porosity, water retention capacity of the soil and prevent the formation of crust on the soil surface) that it leads to increase in growth and yield of plants.

Keywords: crust, pumice, safflower, volumetric water content

Introduction

Soil moisture and its effective use in agriculture is one of the main priorities in the world, especially in arid and semi-arid regions (Forouzani and Karami, 2011). Iran, is one of the world's arid and semiarid countries, which is always faced with the problem of water shortages, due to lack of rainfalls and inappropriate distribution of rainfall in time and space. Therefore, applying the proper managements, and advanced methods, it becomes important to maintain water reserves and increasing production (Allah Dadi et al, 2005). Plants are continuously exposed to environmental stresses, and some factors such as lack of soil moisture may cause the most stress on the plant, after a short time. Hayat and Ali (2004) reported that in arid and semi-arid regions due to low rainfall, water stress is a major factor which limited plant growth. One of the modern methods in science of soil and water is the use of super absorbent material in order to store moisture in the soil and prevent waste, and increasing irrigation efficiency (Abedi Koupai and Sohrab, 2004) that in most cases problems related to stress can be eliminated through the use of this materials. Many conducted studies showed that application of super absorbent polymers, such as polyacrylamide, causes to reduce erosion, improve soil structure, and increase seed germination. Cook and Nelson (1980) germination of cotton in a

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loam soil were examined by using 45 to 67 kg ha^{-1} of polyacrylamide. Their results showed that soil infiltration rate and areation of the soil improved, in effect the use of polyacrylamide, which led to the creation of favorable conditions for seed germination and seedling emergence of them, which ultimately increased its performance. Choudhary et al. (1995) observed that water retention capacity increases and evaporation rate is reduce in effect of application of four synthetic polymer (Broadleaf P4, Agrihop, Aquasorp and Hydrogel). Effects of hydrogel amendment on water storage, and seedling growth of barley, pea and wheat were studied by Akhter et al. (2004) in loam and sandy loam soils. They found that the moisture retention capacity at field capacity and the amount of available water were increased significantly, with application of hydrogel into soil in both loam and sandy loam soils in comparison with control treatment. Khadem et al. (2010) stated that the use of 65% organic matter and 35% super absorbent polymer, grain yield relative to the control 16.2% increase. Khadem et al. (2011) studied the effect of different amounts of super absorbent polymer (Superb A200), and manure on yield and yield components of maize; their results showed that the number of grains per ear, 1000-grain weight and grain yield increased with application of manure and super absorbent polymer. Rafiei et al. (2013) reported an increase in yield of maize, in application of super absorbent polymer (Tawarat A200). Pumice is one of the superabsorbent materials, which is a mineral with the chemical composition of non-crystalline from aluminum silicate with high moisture absorption properties. Pumice is very useful in preparing hydroponic growing environment. This material can be widely used in agriculture to improve infiltration and soil water retention capacity. In terms of consumer prices is also very cheap compared to similar materials such as perlite and vermiculite. Pumice makes the soil light, plowing facilitates, improves air and soil water retention. Pumice was mixed with various amounts of soil and improved soil hydraulic conductivity and ventilation and reduces the negative effects of crusting, cracking, water logging in the soil. Pumice mixed with soil in specific amounts improves soil air and water conductivity, and reduces negative effects of crusting, cracking, flooding, and shrink- swelling. It can also be used for a long periods because of its stable physical and chemical properties (Gur et al.) and it can be provided easily since there are many pumice deposits around the world. Pumice used only after sieving has a high water retention capacity, and very low bulk density value compared to soil (Sahin et al 2004). Sahin et al. (2005) showed that the addition of pumice to the soil, increased water retention of the soil in the pots. Malekian et al. (2012) investigated the effect of different amounts of pumice on the amount of water stored in the soil and grow maize and reported that pumice increased significantly, soil moisture retention and growth of maize. Safflower is suitable for planting in dry land areas due to high tolerance to cold, drought and salinity stresses. One of the great advantages of safflower in our country is a native and compatibility with the climate. Therefore, it is worthy that further studies being conducted to better understand of this plant and its talent. Sufficient information and knowledge sources are very limited, which may indicate the use of pumice in improving soil physical conditions and plant growth. The aim of the present investigation was to determine whether pumice amendments to soil could improve both soil properties and safflower plant growth.

Material and Methods

This research was conducted in the spring of 2011, in research station Khajeh, located 30 km north east of Tabriz, with a height of 1550 meter above sea level, mean annual temperature of 9.9 ° C and average annual rainfall of 270 mm, in randomized complete block design with three replications in plots with dimensions of 5 × 4 meters, in a the soil with properties listed in Table 1.

The treatments consisted of:

1 - Treatment A (control): Not using pumice;
2 - Treatment B: 5 t ha-1 of pumice
3 - Treatment C: 10 t ha-1 of pumice;
4 - Treatment D: 15 t ha-1 of pumice;
5 - Treatment E: 30 t ha-1 of pumice

Pumice values were calculated for each plot according to experimental plot area of 5 × 4 (20 m^2), before planting. This amount was distributed evenly in each plot and was mixed by plowing to a depth of 20 cm. Safflower seeds were sown with 60 g (with a density of 30 kg ha^{-1}), on 30 March 2011, after preparing the plots. Because of this study condition, the plots were not irrigated and plant water requirement was supplied from rainfalls during growing period.

Several physical and chemical properties of experimental soil included soil texture (Gee and Bauder, 1979), organic carbon (Nelson and Sommers, 1996), electrical conductivity of the saturation extract, and the pH (Richard, 1969) were measured.

The measurement of average volumetric soil water content of 20 cm of soil was performed by TDR, from second week of planting to flowering stage once every 5 days and 24 hours after each rainfall. The moisture was measured in four points in each plot. Green seeds were determined at 10 days after planting in per square meter. Plant height was measured by a meter in each plot at ten points, and have been reported their average. 1000-grain weight was determined using a sensitive microbalance for each plot. Grain yield was measured in each plot by digital scale. Analysis of variance was performed by SPSS software and diagrams were drawn with EXCEL software. For comparison of the measured traits were used from Duncan test in 5% probability level.

Table 1 - Physical and chemical characteristics of the studied soil

pH	ECe(dS m^{-1})	Organic carbon (%)	Texture class,USDA	Clay(%)	Silt(%)	Sand(%)
7.3	3.9	0.68	Clay loam	30.4	30	39.6

Results and Discussion

The obtained results of the analysis of variance showed that soil water content, the number of germinated seeds per square meter, 1000-seed weight and seed yield of safflower plant were influenced by pumice values at 1% probability level (Table 2). Application of pumice on plant height had a significant effect in mid-season, while this effect was not significant at the end of the growing season.

Table 2 - Variance analysis of measured characteristics

MS (Mean square)					d.f.	Sources of variation
Seed Yield	1000- Seed Weight	Plant height	Number of buds	Volumetric water content		
28.06^{ns}	0.16 ns	26.57*	0.16 ^{ns}	0.24 ^{ns}	2	R
32075.6**	71.26**	157.34 ^{ns}	71.73**	30.19**	4	Treatment
25.15	1.29	22.29	1.29	0.64	8	Error
1.12	3.53	11.94	0.81	9.78	-	CV (%)

** , * and ns are significant at the 1%, 5%, and none significant, respectively

Volumetric soil water content

Soil volumetric water content was affected from the application of pumice as significantly ($P < 0.01$) (Table 2). In treatment of A that has been not added pumice; the average volumetric soil water content was 3.87% during the growing season. While with increasing of pumice application, retained volumetric water content in the soil, showed a significant increase, so that the largest value of added pumice (treated pumice of 30 tons/ha), the largest soil water content (12.2%) was obtained (Figure 1). This can be due to increasing of absorption and retention of water by pumice after rainfall. Adding pumice to the soil increases total porosity that this makes infiltration of rainwater into the soil and lack of runoff in treatments. These findings are consistent with results of Malekian et al. (2012) based on increased infiltration of water into the soil, due to use of pumice.

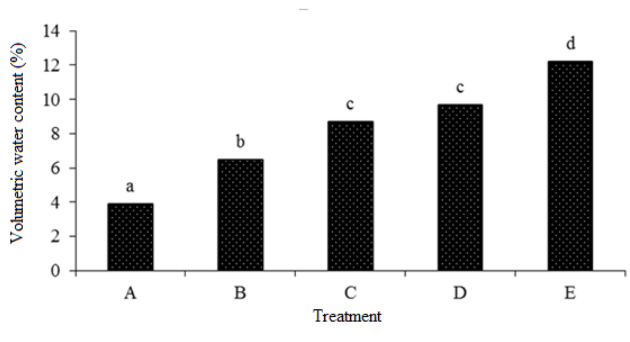

Figure 1 - Comparison of mean effect rate of pumice on the soil moisture content at 0-20 cm of the soil depth

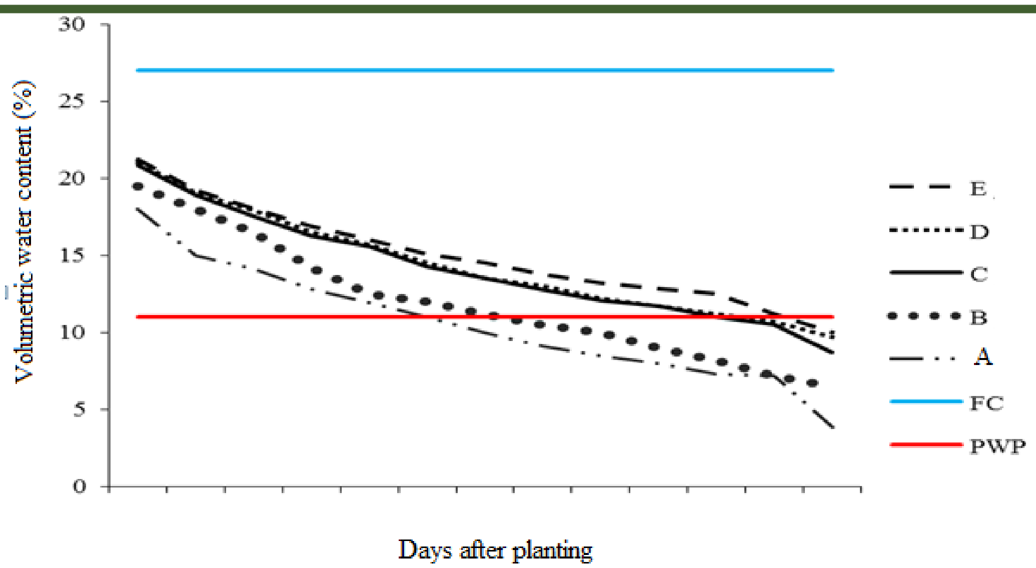

Figure 2 - The variations of soil moisture at 0-20 cm depth in the experimental treatments during the growth period

Figure 2 shows the volumetric soil water content at 0-20 cm depth in different treatments during the experimental period. The volumetric water content of soil increased with increasing of pumice value. In treatments of E, D and C, volumetric water content was high, compared to treatments of B and A, which is due to further increases soil porosity and consequently infiltration more water from rainfalls into the soil and keep it by pumice. Also in the treatment of B, there was a significant increase in water content relative to the control (treatment of A), but this increase in moisture was less than treatments of E, D and C. In the treatments of E, D and C, soil moisture was higher from permanent wilting point, apart from the end of of growth period, while it in treatments of B and A were lower than wilting point on most days of the growth period (figure 2). It should be noted that, in the whole growth period, soil moisture was close to the field capacity moisture point, in three treatments of E, D and C than the other two treatments.

The results of the analysis of variance showed that the effect of the application of pumice is statistically significant on number of germinated seeds, in ten days after planting in each square meter (Table 2). In most plants, the germination stage is more sensitive to the presence of water in the soil and soil surface physical conditions. One of the most important factors for germination is adequate soil moisture. In present research that was conducted in dry land condition, moisture was very important for germination and emergence of planted seeds. The cultivation stage was associated with the atmospheric precipitation; this precipitation was caused to increasing in soil moisture and creates suitable conditions for germination. However, increase in soil moisture content were not the same in all treatments, so that in A (control) and B treatments, volumetric water content of soil was low compared to other treatments (Figure 1). Another reason for the higher number of germinated seeds within 10 days after planting, in treatments of C, D and E can be linked to create good physical condition at the soil surface (no crust formation). In addition, in the treatment of B, relative to the control treatment A, greater number of buds was germinated (figure 3). Because in treatment of B, the amount of used pumice relative to treatments of C, D and E was low (5 tons per hectare), so that it had less effect in increase of soil moisture. In this treatment, crust formation was observed on the soil surface, to a lesser extent relative to the control condition, whereas in the other treatments, crust formation was not observed in the soil.

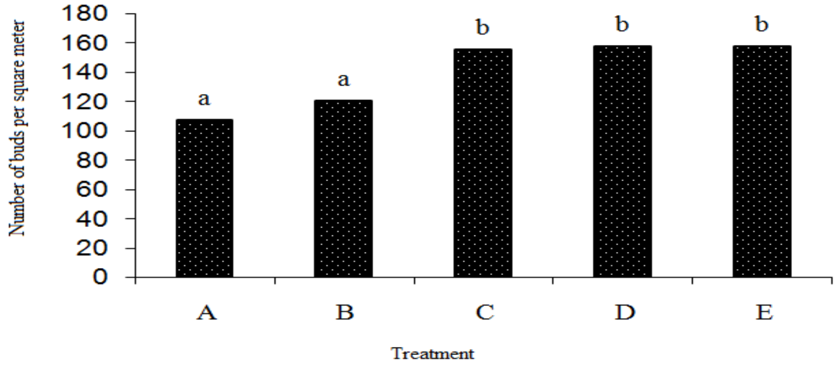

Figure 3 - Comparison of mean effect rate of pumice on number of germinated seeds in the first 10 days of cultivation.

1000 seeds weight

Pumice caused a significant increase (P <0.01) in 1000 seeds weight compared to the control treatment (Table 2). The largest amount of 1000 seeds weight (38.9 g) was obtained in treatment of E, while the its lowest (27.2 g) was observed in the control (treatment A), which created a difference of 43 percent, in the safflower 1000 seeds weight (Figure 4). These results are consistent with the findings of Malekian et al (2010) that expressed the use of pumice increase corn 1000 seeds weight.

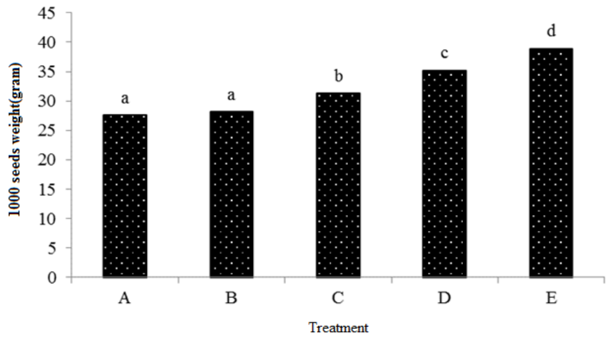

Figure 4 - Comparison of mean effect rate of pumice on safflower 1000 seeds weight.

Seed yield

The results of variance analysis illustrated that seed yield was affected significantly by pumice application (Table 2). Grain yield increased significantly with increasing pumice application (Fig. 5). Highest (606 kg per hectare) and lowest (348 kg per hectare) seed yield was observed in treatments of E and A (control), respectively, which had difference of 74 percent (Figure 5). In other words, in this study application of pumice at its highest level (30 ton per hectare), caused an increasing on yield in ratio of 74 percent. Mainly, the final products yield depends on factors that affecting on growth during the vegetative and reproductive of plant.

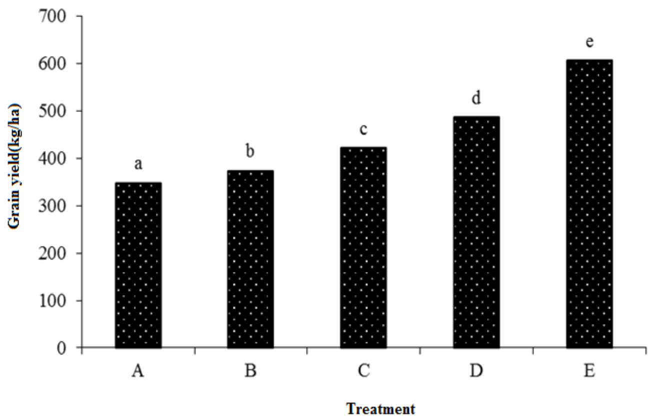

Figure 5 - Comparison of mean effect rate of pumice on safflower grain yield

Conclusion

Application of pumice in the soil led to a significant increase (P<0.01) on soil moisture content, the number of germinated seeds, 1000 seeds weight and seed yield. It could be due to increased water retention capacity of the soil, and prevents the crust formation on the soil surface due to of mixing soil and pumice. Because pumice is very cheap compared to similar materials, therefore it can be used economically in dry conditions to increase production and yield.

References

1. Abedi-koupai, J., and Sohrab, F. 2004. Effect of super absorbent polymers on soil hydraulic properties. Proceedings of 8th national conference on hydraulics in engineering. Gold Coast, Australia.
2. Akhter, J., Mahmood, K., Malik, K.A., Ahmad, M., and Iqbal, M.M. 2004. Effects of hydrogel amendment on water storage of sandy loam and loam soils and seedling growth of barley, wheat and chickpea. Plant Soil Environment, 50(6):463-469.
3. Allah Dadi, A., Moazen Ghamsari, B., Akbari, G. H., and Zohoorian Mehr, M. 2005. Investigation of the effect of different amount of water super absorbent polymer 200-A and irrigation levels on growth and yield of forage corn. Proceedings of 3rd Specific Symposium on Application of Super Absorbent Polymer Hydrogels in Agriculture. Petrochemistry and Polymer Research Center Iran. (In Persian)
4. Choudhary, M.I., Shalaby, A.A., and Al-emran, A.M. 1995. Water holding capacity and evaporation of calcareous soils as affected by four synthetic polymer. Soil Sci. Plant Anal. 26:2205-2215.
5. Cook, D.F., and Nelson, S.D. 1980. Effect of polyacrylamide on seedling emergence in crust-forming soils. Soil Science, 141(5):328-333.
6. Forouzani, M., and Karami, E. 2011. Agricultural water poverty index and sustainability. Agronomy for Sustainable Development, 31:415-432.
7. Gee, G.W., and Bauder, J.W. 1979. Particle size analysis by hydrometer: a simplified method for routine textural analysis and a sensitivity test of measured parameters. Soil Science Society of American Journal, 43:1004-1007.
8. Gur, K., Zengin, M., and Uyanoz R. 1997. Importance of pumice in agriculture and environment. Pp. 125-132. Proceedings of the Isparta Pumice Symposium. 26-28 June, Isparta ,
9. Hayat, R., and Ali, S. 2004. Water absorption by synthetic polymer (Aquasorb) and its effect on soil properties and tomato yield. International Journal of Agriculture and Biology, 6:998–1002.
10. Kadem, S. A., Galavi, M., Ramroudi, M., Mousavi, S.R., Rousta M.J., and Rezvani-moghadam, P. 2010. Effects of animal manure and superabsorbent polymer on corn leaf relative water content, cell stability and leaf chlorophyll content under dry condition. Australian journal of Crop Science. 4(8):642-647.
11. Khadem, S.A., Ramroudi, M., and Rousts, M.J. 2011. Effects of drought stress and different rates of manure and super absorbent polymer on yield and yield component of grain corn. Iranian Journal of Field Crop Science, 1:115-123. (In Persian)
12. Malekian, A., Valizadeh, E., Dastoori, M., Samadi, S., and Bayat, V. 2012. Soil water retention and maize (Zea mays L.) growth as affected by different amounts of pumice. Australian Journal of Crop Science, 6(3):450-454.
13. Nelson, D.W., and Sommers, L.E. 1996. Total carbon, organic carbon, and organic matter. In: Methods of Soil Analysis, Part 2, 2nd ed., A.L. Page et al., Ed. Agronomy. 9:961-1010. Am. American Society of Agronomy, Inc. Madison, WI.
14. Rafiei, F., Nourmohammadi, G., Chokan, R., Kashani, A., and Heidari Sharifabad, H .2013. Investigation of superabsorbent polymer usage on maize under water stress. Global journal of medicinal plant research, 1(1):82-87.
15. Richard, L.A. (ed). 1969. Diagnosis and improvements of saline and alkali soils. Agriculture Handbook, No. 60. USDA, WA. DC.
16. Sahin U., Ors S., Ercisli S., Anapali O., Esitken A. 2005. Effect of pumice amendment on physical soil properties and strawberry plant growth. Journal of Central European Agriculture, 6(3):361-366.
17. Sahin, U., Ercisli, S., Anapali, O., and Esitken, A. 2004. Regional distribution and some physico-chemical and physical properties of some substrates used in horticulture in Turkey. Acta Horticultur, 648:177-183.

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Features of functioning permafrost soils in Cryolitozone

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Abstract

In most parts of Eastern Siberia widely developed the so-called frozen soils, the functioning of which has no analogues in the world. This is mainly due to the omnipresence of the low-temperature permafrost here, have a direct impact on the formation of specific hydrothermal regime, physical and chemical properties of soils. Regional feature of the functioning of permafrost soils is primarily due to a kind of redistribution of solar radiation flux coming directly into the soil, as some of it is spent on the process of seasonal thawing, ie by increasing the temperature to values in the range of positive active layer, and a rise in temperature within the negative deep-layer. As a result of this redistribution of solar radiation heat flux directly consumed in the warm-layer is significantly reduced, which is the main reason for the low thermal conditions of permafrost soils compared with soils of temperate latitudes. And throughout all the long cold period, starting from late October to mid-May (in the northern regions) and from late September until June (in the central regions) in the soil profile is established stable negative temperature. Naturally, in such low thermal resources flowing all biochemical, biological and physico-chemical processes slows. This situation is exacerbated by the fact that during freezing of soil moisture vertical shifts occur a certain part of the soil mass, within the seasonally thawed layer. Therefore, the character of the soil processes depends mainly from the seasonally thawed layer, because the formation of heat and water is closely related (in many cases directly) with this parameter. On the other hand, the value-layer on the flat territory, particularly in Yakutia has zonal character, ie from north to south there is a gradual increase in its capacity. In this case there is a general pattern that with the seasonally thawed layer direct influence on the course of the permafrost soil-forming processes decays.

Keywords: Soil, permafrost, biochemistry, cryolitozone, soil physics, ecology.

Introduction

In most parts of Eastern Siberia widely developed the so-called frozen soils, the functioning of which has no analogues in the world. This is mainly due to the omnipresence of the low-temperature permafrost here, have a direct impact on the formation of specific hydrothermal regime, physical and chemical properties of soils.

Regional feature of the functioning of permafrost soils is primarily due to a kind of redistribution of solar radiation flux coming directly into the soil, as some of it is spent on the process of seasonal thawing, i.e. by increasing the temperature to values in the range of positive active layer, and a rise in temperature within the negative deep-layer. As a result of this redistribution of solar radiation heat flux directly consumed in the warm-layer is significantly reduced, which is the main reason for the low thermal conditions of permafrost soils compared with soils of temperate latitudes. And throughout all the long cold period, starting from late

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October to mid-May (in the northern regions) and from late September until June (in the central regions) in the soil profile is established stable negative temperature.

At these elevated heat flow resources of the whole complex of chemical, biological and physico-chemical processes slows. This situation is exacerbated by the fact that during freezing of soil moisture occur vertical and horizontal shifts of a certain part of the soil mass in the range of seasonal thawing layer.

Consequently, the character of the soil processes depends mainly on the capacity of seasonal thawing layer, since the formation of both thermal and water resources is closely related (in many cases directly) with this parameter. On the other hand, the value of seasonal thawing layer in flat territory, particularly in Yakutia has zonal character, i.e. from north to south there is a gradual increase in its capacity. In this case there is a general pattern in which during a seasonal rise of seasonal thawed layer, a direct impact on the course of the permafrost soil-forming processes decays.

Thus, in the subarctic and northern regions of Cryolithozone where capacity does not exceed 0.8-1.0 m, relatively active soil-forming processes occur only within a 0.5 m soil layer. Here, despite the lack of precipitation (year not more than 250 mm), due to the low potential evapotranspiration and thawing of the soil thawing period, the lower strata of mineral soil are constantly in a state of excess moisture. So here recovery processes are in dominate in which these horizons became gley. In these specific conditions, the mineralization of litter in the upper horizons is slow, which leads to accumulation of decomposed plant residues in the soil, i.e. to strengthen of peat-forming processes.

In the middle taiga, due to increased solar radiation and air temperature, capacity of seasonal thawing layer reaches 1.3-1.5 m in loamy soils under deciduous masses, and in sandy soils under pine to 2.5-3.0 m. On the treeless seasonal thawing layer sites in loamy soils reaches 1.8-2.0 m, in sandy loam - 3 meters.

In arid conditions of Central Yakutia, not only cultural vegetation, but also wild have deficit of productive moisture in the upper root half-meter layer. At the same time, mineral stratum, overlying deeper meter layer contains relatively high soil moisture reserves. But the moisture of lower layers not easily absorbed by the root system of plants, as in the cryolitozone, firstly, the large mass of roots concentrated within the upper 30 cm layer, secondly, the lower layers melts completely in the second half of the summer season, i,e, in the thawed state dwell briefly, and, thirdly, there is always the lower cold shield significantly inhibits vertical movement of soil moisture. Consequently, the lower strata lying directly at the junction with permafrost are moisture saturation.

This peculiar formation of hydrothermal regime of soil and seasonal dynamics of causes of seasonal thawing layer oxidation processes within only the first meter layer or even less depth, and recovery processes is most clearly expressed in the lower moisture saturation permafrost horizons. Such a pattern is broken, if the soil cover is formed under the moss or moss larch-bilberry group, where capacity of seasonal thawing layer does not exceed 0.8-1.2 m.

With limited soil and heat resources, intensity of decomposition litter under larch forests, which occupy a dominant position, is markedly understated than in the temperate latitudes of other areas. Therefore, in the qualitative composition of forest soil humus fraction of the insoluble residue is high compared with other similar soils. At the same time in the open treeless areas due to deeper seasonal thawing and higher thermal resources in the upper layers of the soil conditions are favorable for intensification of the processes of mineralization of organic matter, i.e here forms sod-steppe chernozem soil (permafrost meadow steppe chernozem soil). Limiting factor in obtaining stable crop yields on these soils is moisture. Therefore, they need irrigation. Moreover, because of shallow permafrost below the surface here possible only minor irrigation norms. At high standards occurs lifting the upper level of the permafrost that once accompanied by a deterioration of water, heat and permafrost regimes of seasonal thawing layer, i.e. begins almost swamping the root layer and simultaneous secondary salinization.

In the southern and south-western districts of Yakutia in connection with a noticeable increase in precipitation (350-400 mm) and active-layer thickness, especially in soils of light granulometric composition, the degree of influence of seasonal and permafrost markedly attenuated. In conditions of good drainage and deep layers of permafrost a process of strong wetting of the soil profile is not occurs. Naturally, deformation processes of integrity soil horizons attenuated as a result of seasonal freezing-thawing.

In general, the functioning of the soil here does not differ fundamentally from similar soil landscapes of other areas. So here are formed soil, similar in morphological structure and physico-chemical properties of soils to closely spaced regions of Eastern Siberia (Iruktskiy region, Buryatia).

Thus, in areas of continuous permafrost soils are formed, which have no analogues, in functioning and agricultural use, in other areas of the world.

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The perspectives for the typical sampling of soil samples with bioassay on the example of the development of chemical industry

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Abstract

To identify patterns of anthropogenic impacts on soil contamination it is not always possible to find the control over the uncontaminated (background) site as contaminated and background areas often vary in a range of other environmental factors (moisture regime, soil disturbance, etc.). On the territories of settlements this heterogeneity is most noticeable and is associated not only with the chemical transformation of natural soils of varying degrees of disturbance, but also with the functional zoning of the urban area. Therefore, to justify the sampling in urban areas a special study is required. In October 2013, a soil bioassay was carried out using garden cress on a garden plot within the boundaries of Sterlitamak city at the intersectionof Gragdanskaya andBabushkinastreets with the area of 50 × 100 m at different distances from the road. The city territory is contaminated with a large number of organic and inorganic compounds, which makes integral evaluation of soil toxicity necessary. The following indicators were used: the percentage of emerged seeds, the average length of sprouts, length above- and belowground parts of seedlings, seedling dry weight. The results obtained (48 experiments) show that the dimensional indices of seedling overwhelmingly correlated with each other. No significant influence of the distance from the road on soil phytotoxicity was found out, but within the investigated area a plot with an increased toxicity was identified, which appears to be a consequence of storage of pesticides in this location. The results obtained can be used in determining the reference soils for subsequent mapping of soil toxicity within territory of Sterlitamak city. Since the structure of soil in different functional areas of cities varies considerably, significant differences in soil phytotoxicity can be detected at a distance of several meters. Sampling is recommended in areas currently or previously used for growing agricultural products. In other functional areas it is viable to allocate phytocenoses with spontaneous vegetation, performing in this case a controlling functon (Seifert et al, 2000).

Keywords: soil bioassay, garden cress, agrotehnogenic area

Introduction

Standardization of ecological statuses of various urban territory soils undergoing various types of impacts requires the development of adequate ecological indicators. Such indicators are expected to be cost-effective and highly informative. Phytotesting methods satisfy these criteria (ISO 11269-2:2012, Bagdasaryan 2005, Mayachkina and Chugunova, 2009). The objective of this contribution is the evaluation of how various factors

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influence the parameters of phytotesting carried out with garden cress (Seifert and Gamerova, 2013). Earlier publications demonstrate that the most adequate ecological interpretation is provided for the urban territory soils used for the agricultural production (Seifert et al., 2000).

Material and Methods

The studies were carried out between October, 2013 and April, 2014 at the territory of "Michurinets" gardening community located at the intersection of "Babushkina" and "Grazhdanskaya" streets (see Fig. 1). Soil samples were placed into plastic containers, 3 samples were taken for each point. Toxicity evaluation of soil samples was based on the comparison of the germinability (%), the total length (LO, mm) the overground (LN, mm) and the underground (LP, mm) length, and the dry weight (W) of germs. Flower soil "Fialca" (produced by OJSC "Udmurttorf", Izhevsk city) was used as the reference sample. Correlation was revealed for all the used parameters. The duration of testing was seven days. The statistical treatment of data was carried out by the "Statistica-5.0 for Windows" software. Student's test was used to estimate the significance of the difference of arithmetic mean values. The following diagram demonstrates the sampling algorithm used in April, 2014 (see Fig. 2).

× – sampling points

Fig. 1 – October 2013 soil sampling chart with distances between sampling points and street names (the numeration of sampling points is from the left lower corner to Babushkina street etc.).

× – sampling points

Fig. 2 - April 2014 soil sampling chart with distances between sampling points and street names (the numeration of sampling points is from the left lower corner to Babushkina street etc.).

Snow water toxicity evaluation was carried out according to "Procedure for Toxicity Testing of Drinking, Ground and Waste Waters as Well as Solutions of Chemicals by Germinating Ability, Average Length and Average Dry Weight of Garden Cress (*Lepidium sativum*) Seedlings", Federal Nature Protection Documents 14.1:2:4.19-2013, approved for the state ecological monitoring. This method is based on the revealing of correlation between dilution coefficients of initial samples (a toxicity indicator) and the characteristics of garden cress seedlings (length, dry weight and germinating ability). A tested sample is considered to be non-toxic if its degree of dilution from an initial concentration is sufficiently high for zero suppression of parameters under control (length, dry weight, and germinating ability) in comparison with the reference samples. The following procedure was used: filter paper was placed on the bottom of Petri dish, followed by 30 garden cress seeds. Filter paper was wetted with snow samples diluted in 100 ml of distilled water. The degrees of dilution were: 2x, 4x, 8x and 16x. Three solutions were prepared from each sample. Distilled water was used as the reference.

Results and Discussion

The city territory is considerably contaminated by organic and inorganic compounds, thus, integral toxicity analysis is required for soils. The results obtained in October (48 experiments) demonstrate that phytotesting parameters are in good agreement with each other in most cases (Table 1).

Table 1. The matrix of pair correlation coefficients of the soil toxicity parameters studied in October 2013.

Germinability, %			Length, mm			Dry weight, mg
			Overground	Underground	Total	
Germinability		-	**0.31**	**0.34**	**0.42**	0.23
Length	Overground	**0.31**	-	0.20	**0.74**	**0.33**
	Underground	**0.34**	0.20	-	**0.77**	**0.29**
	Total	**0.42**	**0.74**	**0.77**	-	**0.37**
Weight		0.23	**0.33**	**0.29**	**0.37**	-

The significant values (P>0.95) of correlation coefficients are marked bold.

The total length of seedlings is reliable correlation with all the analyzed phytotoxicity parameters. The phytotesting parameters demonstrated the following behavior in April, 2014 (Table 2):

Table 2. The matrix of pair correlation coefficients of the soil toxicity parameters studied in April 2014.

Germinability, %			Length, mm			Dry weight, mg
			Overground	Underground	Total	
Germinability		-	0.00	0.32	- 0.01	- 0.40
Length	Overground	0.002	-	**0.61**	**0.89**	- 0.20
	Underground	0.00	**0.61**	-	**0.69**	- 0.27
	Total	0.33	**0.89**	**0.69**	-	- 0.15
Weight		- 0.40	- 0.20	- 0.27	- 0.15	-

The significant values (P>0.95) of correlation coefficients are marked bold.

Significant dependences were observed for this period only for the length of seedlings. These results allow using only one phytotesting parameter: an average total length of seedlings. The data on the total length of seedlings in the studied samples are summarized in Table 3.

Significant differences between the reference and the sample values have been revealed for the samples 1, 2, 4, 6, 7, 8, 11, 13, 14, and 15. The sample 1 demonstrates significant difference from all the samples, except 7. The sample 2 demonstrates significant difference from the samples 4, 7, and 14. Sample 3 demonstrates significant difference from samples 4, 6, 7, 8, 11, and 14. Sample 4 demonstrates significant difference from samples 5, 7, 9, 10, 11, 12, and 15. Sample 5 demonstrates significant difference from samples 7, 13, and 14. Sample 6 demonstrates significant difference from sample 7. Sample 7 demonstrates significant difference from samples 8-15. Sample 8 demonstrates significant difference from sample 9. Samples 9, 10, and 12 demonstrate significant difference from sample 14. Sample 14 demonstrates significant difference from Sample 15. These results confirm local differences in soil toxicities for the samples taken at the studied area. Extremely low total length of seedlings may be related to the effect of pesticides stored at this territory. There is the gradient revealing reduction of the total length of seedlings with the increase of the distance from Babushkina street. The same significant effect has been revealed for the increase of the distance from Grazhdanskaya street (Table 4). No such gradients were observed in April, 2014 (Table 5).

Table 3. Average parameters of the overground parts of seedlings (mg) for the sampling points studied in October, 2013.

Sample Number	n	Average Value	Minimum Value	Maximum Value	Standard Deviation	Standard Error
1	27	40.92	13.0	61.0	13.38	2.57
2	29	57.20	34.0	8 0.0	9.82	1.82
3	29	62.93	2 0.0	87.0	12.68	2.35
4	29	49.82	18.0	7 0.0	12.99	2.41
5	26	61.88	36.0	81.0	11.72	2.29
6	26	55.26	2 0.0	8 0.0	15.50	3.04
7	22	37.90	12.0	54.0	12.30	2.62
8	27	53.40	13.0	75.0	14.51	2.79
9	26	61.73	24.0	79.0	11.96	2.34
10	28	60.25	20.0	83.0	13.06	2.46
11	26	55.96	7.0	74.0	13.20	2.58
12	26	61.23	33.0	72.0	1 0.04	1.96
13	23	55.78	35.0	81.0	12.54	2.61
14	25	48.64	25.0	78.0	13.09	2.61
15	27	58.22	30.0	78.0	11.92	2.29
Reference	29	66.48	46.0	92.0	12.42	2.30

Table 4. The intensity of gradients with the increase of the distance from Babushkina (A) and Grazhdanskaya (B) streets respectively. October, 2013.

Streets	Correlation Coefficients				
	Germinating Ability (%)	Average Overground Length of Seedlings (mm)	Average Underground Length of Seedlings (mm)	Average Total Length of Seedlings (mm)	Average Dry Weight of Seedlings (mg)
Babushkina	- 0.15	**- 0.61**	- 0.42	**- 0.79**	0.27
Grazhdanskaya	**- 0.32**	0.09	- 0.15	0.01	- 0.37

The significant values (P>0.95) of correlation coefficients are marked bold.

Table 5. The intensity of gradients with the increase of the distance from Babushkina (A) and Grazhdanskaya (B) streets respectively, April, 2014.

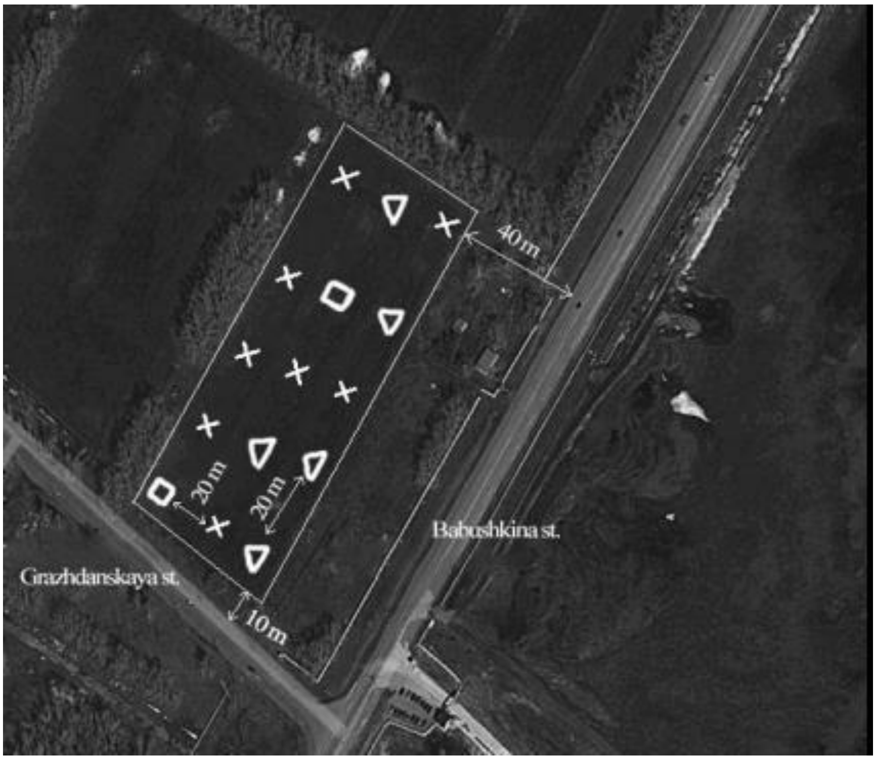
Streets	Correlation Coefficients				
	Germinating Ability (%)	Average Overground Length of Seedlings (mm)	Average Underground Length of Seedlings (mm)	Average Total Length of Seedlings (mm)	Average Dry Weight of Seedlings (mg)
Babushkina	0.10	0.08	- 0.37	- 0.39	- 0.23
Grazhdanskaya	0.40	- 0.22	- 0.21	- 0.23	0.06

The total length of seedlings demonstrated significant growth in April, 2014 as well as the reliability between two repeated measurements (See Table 6). Table 7 summarizes the results on the total length of seedlings for the snow water samples studied in February, 2014. Garden cress phytotesting parameters are influenced by duration of photoperiod and an average monthly air temperature (Seifert, 2010). The threshold temperature effect has been found. The average monthly temperature of 16°C inhibits the growth of seedlings. No temperature effects were observed in the 18.1-21.9 °C temperature range.

Table 6. The total length of seedlings for the studied samples in April, 2014.

Sample Number	N	Average Value	Minimum Value	Maximum Value	Standard Deviation	Standard Error
1	15 15 14	99.0 147.2 139.1	50.0 77.0 57.0	140.0 181.0 195.0	30.14 37.81 40.73	7.78 9.76 10.89
3	12 12 12	108.16 141.50 133.83	82.0 96.0 52.0	152.0 96.0 187.0	22.36 23.91 36.89	6.45 6.90 10.64
8	14 14 13	95.35 100.07 123.69	58.0 36.0 8 0.0	131.0 134.0 175.0	20.91 22.26 29.84	5.58 5.95 8.27
13	14 13 15	100.50 97.46 108.66	74.0 73.0 8 0.0	140.0 136.0 155.0	16.15 16.39 23.12	4.31 4.54 5.97
15	15 15 14	139.40 130.40 135.21	90.0 86.0 102.0	190.0 190.0 160.0	29.67 31.27 17.65	7.66 8.07 4.71
Reference	14 13 14	117.50 118.69 116.78	50.0 90.0 58.0	163.0 151.0 150.0	29.78 16.76 27.55	7.96 4.65 7.36

Figure 3 demonstrates the results of phytotesting carried out for the snow water in February, 2014.



cross – no effect;
square – toxic effect;
triangle – stimulating effect.

Fig. 3. The sampling chart with the phytotesting results.

The road distance gradient is the most clearly marked for the snow cover study. 15 samples were studied, 2 samples demonstrated toxic effect, while another 5 ones revealed stimulation. No effects were found in the rest of samples. The stimulating effect can be caused by biogens. The concentration of NH_4^+ ions in precipitates is higher during the warm season, while NO_3^- ions are more abundant during the cold season (Eryomina, 2013). These results confirm that nitrate ions can be responsible for the snow water toxicity. The stimulating effect in the surface waters of the Belaya River in the Sterlitamak urban area is caused by the ammonium ions (Askarov et al., 2014). The emissions of nitrogen compounds are usually associated with the motor transport. Our results confirm such a conclusion and allow quantitative evaluating of the distance of such toxic effects. Stimulation is observed at the distance of 40 m and 60 m from the road with intensive traffic (Babushkina street), while no effects are observed at the 80 m distance (see Fig. 3). In addition, biotesting effects demonstrate intensive variability, so large-scale and systematic sampling (with at least 15 sampling points) is required for making significant conclusions.The results demonstrated in this paper provide an opportunity of applying garden cress as a reference bioindicator for ecological monitoring of soils, with meteorological factors taken into consideration.

Table 7. The Total Length of Seedlings in Relation to the number of a Snow Water Sample Taken in February, 2014.

Sample Number	N	Average Value	Minimum Value	Maximum Value	Standard Deviation	Standard Error
1	27	106.257	9	203	46.4467	8.93
2	25	127.72	10	203	48.94	9.84
3	26.7	121.93	10	221	59.82	11.64
4	22	99.17	12	203	39.95	8.48
5	21.7	124.05	25	192	46.37	10.0
6	26.7	124.05	25	192	46.37	10.0
7	21.7	61.92	10	98	25.8	5.46
8	23	69.61	15	96	19.15	3.99
9	28	81.63	20	200	37.93	7.16
10	23	105.74	20	206	45.83	9.64
11	27	78.85	10	176	48.40	9.31
12	22	65.90	20	100	23.51	5.01
13	28	75.10	20	151	20.86	3.89
14	26	113.67	25	204	51.0	10.07
15	22	66.19	12	115	21.16	4.56
Reference	23	121.96	10	208	49.66	10.38

References

Askarov R.R., Seifert D.C., Ovsyannikova I.V. 2014. Seasonal Dynamics of Surface Water Eutrophication Parameters in the Middle Reaches of Belaya River in the Sterlitamak City Area // Bashkirskiy Khimicheskiy Zhurnal, vol. 21, #1 (in print).

Bagdasaryan A. S. 2005. Biotesting of Soils in the Technogenic Urban Areas by Plant Organisms // a PhD in Biology Dissertation. – Stavropol, Russia, - 159 p. (in Russian).

Efimenko E.A., Manukyan E.O. 2009. Soil Toxicity in an Urban Environment // Almanac of Modern Science and Education, Part 1. - #11 (30). - p. 129-132 (in Russian).

Eryomina I.D. 2013. Evolution of Acidity and the Chemical Composition of Atmospheric Precipitation in Moscow in the Last 30 Years // Proceedings of the Theoretical and Practical Conference “Contamination of Atmosphere in Cities” (St.-Petersburg, October 1-3, 2013 г.).- St.-Petersburg: Main Geophysical Observatory, p. 115-117 (in Russian).

Hunsaker C.T., Carpenter D.E. 1990. Ecological Indicators for the Environmental Monitoring and Assessment Program. 1990 EPA 600/3-90/060. U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park. NC

Mayachkina N.V., Chugunova M.V. 2009. Biotesting of Soils for Their Ecotoxicological Evaluation // Herald of Lobachevsky State University of Nizhny Novgorod, №1, p. 84-93 (in Russian).

“Procedure for Toxicity Testing of Drinking, Ground and Waste Waters as Well as Solutions of Chemicals by Germinating Ability, Average Length and Average Dry Weight of Garden Cress *(Lepidium Sativum)* Seedlings”, Federal Nature Protection Documents 14.1:2:4.19-2013 (in Russian).

Seifert D.V. Bikbulatov I. Ch., Rudakov K.M., Grigoreva I.N. 2000. Plant Communities and Soil Mesofauna on Chemical Plant Territories in Steppe Zone of Bashkir Preurals / Ed. B. M. Mircin. – Ufa: USPTU Publ., 166p.

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Influence of natural petroleum acids of naphtenic type on the growth of five strains of *Pseudomonas* sp. in liquid culture

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Abstract

Contamination of soil with crude oil and its derivates are causing numerous problems and hazards. These soils need to be remediated before any further use. Application of microorganisms as bioremediating agents is one way of enhancing pollutant degradation, first of all because of their huge biodiversity and metabolitic capability. Microorganisms can utilize different hydrocarbons as source of energy, as well as carbon (C), nitrogen (N) and sulfur (S). The aim of this research was to investigate the potential of five strains of *Pseudomonas* sp. as possible bioremediating agent. Strains are from te collection of the Microbiology Department, Faculty of Agriculture, Novi Sad. Bacterial strains were cultivated on liquid King B medium (tripton: 10 g; pepton: 10 g; $MgSO_4$: 1,5 g; K_2HPO_4: 1,5 g; glicerol: 10 ml; dest.water: 1000 ml; pH 7) and incubated on shaker (BIOSAN Incubator ES-20/60), RPM 120, 28°C. Starter culture were obtained after 24h, CFU 10^8. For the analyses of five different natural naphtenic acids influence, 24 h culture were used. Bacterial growth was determined spectrophotometrically (UNICAM sp600) through optical density, after 24h and 48h. Two bacterial strains (PSVioleta and PS2) had better growth after 48h pointing out the fact that they use C from the derivates. The growth of these strains were increased 72% and 25% when conc. 10^{-5} mol/cm³ and 10^{-6} mol/cm³ derivates were used, respectively. The result of this research showed the potential of certain bacterial strains as bioremediators.

Key words: petroleum acids, *Pseudomonas* sp., degradation.

Introduction

With the increase of industrialization, environmental problems such as soil and/or groundwater contamination have grown as global issues (Ward et al., 2003; Albers, 2007). Most components of crude oil are toxic to humans and wildlife in general, as they easy incorporate into the food chain. This fact has increased scientific interest in examining the distribution, fate and behaviour of crude oil and its derivates in the environment (Stroud et al., 2009). Oil spills in the environment cause long-term damage to aquatic and soil ecosystems, human health and natural resources. Contamination of soil with crude oil and its derivates are causing numerous problems and hazards. These soils need to be remediated before any further use.

Bioremediation can be briefly defined as the use of biological agents, such as bacteria, fungi, or green plants (phytoremediation), to remove or neutralize hazardous substances in polluted soil or water. According to Diaz (2008), application of microorganisms as bioremediating agents is one way of enhancing pollutant degradation, first of all because of their huge biodiversity and metabolitic capability. Many different enzymes

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and metabolic pathways are required to degrade components of crude oil (Nilanjana et al., 2011). Different species of microorganisms including bacteria, yeasts and fungi obtain both energy and tissue-building material from petroleum. The dominant genera of microorganisms that utilize petroleum hydrocarbons are: *Nocardia, Pseudomonas, Acinetobacter, Flavobacterium, Micrococcus, Arthrobacter, Corynebacterium, Achromobacter, Rhodococcus, Alcaligenes, Mycobacterium, Bacillus, Rhodotorulla, Candida, Sporobolomyces, Aureobasidium, Fusarium, Aspergillus, Mucor, Penicillium, Trichoderma* and *Phanerochaete* (Cerniglia and Sutherland, 2001; Kuhad and Gupta, 2009). Among bacteria *Pseudomonas* is well known as one of bacteria with high remediation potential of different types of hydrocarbons (Hong et al, 2005).

Although there are a number of publications about the positive effects of bioremediation, in some cases, this technique has proved to be unsuccessful (Thompson, 2005; Fantroussi and Agathos, 2005). Research indicates that shortly after application of exogenous microorganisms, number of these bacteria significantly reduces. Reasons for this can be numerous: competition between added and naturally occurring microorganisms, antagonism or predation (protozoa, bacteriophages), fluctuations in temperature, content of water, pH and availability of the contaminant and nutrient substances. Because of this, it is more practical to use microorganisms isolated from soil that needs to be decontaminated (Horakova and Nemec, 2000). This technique seems to be more effective because the indigenous bacteria are likely to be better adapted to the soil environment requiring treatment (Rahman et al. 2003).

With regards to the importance of bioremediation of oil-polluted soils, the aim of this research was to investigate the potential of five strains of *Pseudomonas* sp. as possible bioremediating agent.

Materials and methods

Strains *Pseudomonas* sp. denoted as PS4, PS Violeta, Q16, PS2 and PS Dragana are from the collection of the Faculty of Agriculture, Novi Sad. Strains were cultivated on King's B liquid medium (tripton 10 g l^{-1}; pepton 10 g l^{-1}; $MgSO_4$ 1,5 g l^{-1}; K_2HPO_4 1,5 g l^{-1}; glicerol 10 ml; pH 7). Incubation of the bacterial strains was carried out on a rotary shaker (BIOSAN Incubator ES-20/60), RPM 120, at 28°C. After 24 h starter cultures were obtained with the number 10^8CFU/ml.

To determine the impact of petroleum products, the 24h cultures of tested strains were used. 450 µl of derivative was added in each bacterial strain. Control was a pure bacterial culture. Following petroleum producs were used as tretmants: 1- NK/89 (naphtenic acid, 10^{-5}), 2 - NK/89 (naphtenic acid, 10^{-6}), 3- NK-ol (alcohols of petroleum acid, 10^{-5}), 4- NK-ol (alcohols of petroleum acid, 10^{-6}), 5- NK- CH_3 (methyl esters of petroleum acid, 10^{-5}), 6- NK-CH_3 (methyl esters of petroleum acid, 10^{-6}), 7- NK-Aph (secondary amide, 10^{-5}), 8- NK-Aph (secondary amide, 10^{-6}), 9- NK-A (primary amide, 10^{-5}), 10- NK-A (primary amide, 10^{-6}).

The growth of the bacterial strains was monitored by reading the optical density in a spectrophotometer (Unic SP600) at OD600 after 24 h and 48 h.

Results and discission

In this research, petroleum derivatives variously influenced the number of tested strains.

After 24 hours, treatments had inhibitory effect on the number of most strains (Table 1). On average, strains Q16 and PS2 were the most sensitive to the influence of petroleum products. In these cases, decrease in the number of bacteria was recorded in all variants after 24h. On the other hand, application of treatments 3, 5 and 9, had a positive effect to the increase in the number of three bacterial strains: PS Dragana (4.5%), PS Violeta (5.43%) and PS4 (12.2%) respectively.

After 48 hours, the use of treatments had a good effect on the increase of bacterial number of PS Violeta, PS Dragana and PS2 strains pointing out the fact that they use C from the derivates (Table 1).

Application of treatments 5, 7 and 9 mostly affected the number of PS Violeta (72%), while the application of treatments 4,6,7 and 8 led to the increase in the number of strain PS2 for 25% compared to the control. Also, the number of the PS Dragana in variants with tretmants 2, 3, 4, 6 and 10 was higher then in the control. The results suggest that these three strains use the derivates as a source of energy, carbon or nitrogen emphesising their potential to degrade petroleum products.

Table 1. Influence of petroleum derivates on the number of tested strains of *Pseudomonas* ($x10^8$)

Strains	PS4		PS Violeta		Q16		PS2		PS Dragana	
Tretmants	24 h	48h	24 h	48h	24 h	48h	24 h	48h	24 h	48h
Control	1,80	2,24	2,58	1,86	2,48	3,04	2,53	2,56	2,22	2,58
1	1,50	1,38	2,05	2,96	1,50	2,96	1,81	3,04	1,98	2,40
2	0,28	1,47	2,16	2,72	1,60	2,88	1,87	2,80	1,86	2,96
3	0,80	1,30	2,32	2,64	1,56	2,16	1,41	2,72	2,32	3,04
4	0,73	1,25	2,56	2,96	1,66	2,42	1,52	3,20	2,16	2,64
5	1,31	2,64	2,72	3,20	1,71	2,08	1,71	2,86	2,08	2,42
6	0,76	2,08	2,58	2,88	1,88	2,64	1,5	3,20	1,68	3,20
7	0,69	1,74	2,70	3,20	1,63	2,18	1,28	3,20	2,02	2,56
8	1,08	1,92	2,56	2,80	1,50	3,04	1,68	3,20	1,57	2,26
9	2,02	2,80	2,69	3,20	1,80	3,06	1,55	2,72	1,89	2,24
10	0,69	2,42	2,26	3,12	1,26	2,88	1,50	2,86	2,00	2,90

Treatments: 1- NK/89 10^{-5}, 2 - NK/89 10^{-6}, 3- NK ol 10^{-5}, 4- NK ol 10^{-6}, 5- NK CH_3 10^{-5}, 6- NK CH_3 10^{-6}, 7- NK Aph 10^{-5}, 8- NK Aph 10^{-6}, 9- NK A 10^{-5}, 10- NK A 10^{-6}

Similarly to this results, Emtiazi et al (2005) in a study assessed the utilization of petroleum hydrocarbons by *Pseuomonas* sp. They monitored the change of bacterial growth turbidity (OD600nm) at nine days of incubation in liquid media. *Pseudomonas* sp. was able to use different hydrocarbons as source of carbon and energy. Also, utilization of petroleum hydrocarbons by *P. fluorescens* isolated from a petroleum contaminated soil was reported by Bharathi and Vasudevan (2001). Leahy and Colwell, (1990) have reported biodegradation of petroleum oil by *Achromobacter*, *Arthrobacter, Acinetobacter, Alcaligenes, Bacillus, Flavobacterium, Nocardia, Pseudomonas* and *Rhodococcus*. Futhermore, studies of Nasrollahzadeh et al., (2007), Shafiee et al. (2006) and Mesdaghinia et al. (2005) report biodegradation of phenanthrene by isolated bacterium. Isolation of 12 different bacterial species from polluted marine sites was reported by Kayode-Isola et al (2008). They found that *Alcaligenes paradoxus, Aeromonas* sp, *Bacillus licheniformis* and *Pseudomonas fluorescens* were efficient in biodegradation of diesel oil. Ting and coauthors (2009) in an experiment by using *Pseudomonas lundensis* UTAR FPE2 found that utilization of paraffin and mineral oil is easier in comparison to naphthalene.

Conclusions

In this study the utilization and degradation of petroleum producs by five strains of *Pseudomonas* sp. was performed in liquid assay. According to the results of this study, it can be concluded that *Pseudomonas* strains denoted as PS Violeta, PS2 and PS Dragana showed the potential as bioremediators.

References

Albers, P.H., 2007. An Annotated Bibliography on Petroleum Pollution. USGS Patuxent Wildlife Research Center, Laurel, MD.

Bharathi, S., Vasudevan, N., 2001. Utilization of Petroleum Hydrocarbons by Pseudomonas fluorescens Isolated from Petroleum Contaminated Soil, Environ. Int., 26, 413 – 416.

Cerniglia, C., Sutherland, J. B., 2001. Fungi in Bioremediation, G.M. Gadd, Ed., British Mycological Society, Cambridge University Press, Cambridge, 136–187.

Díaz, M. P. , Boyd, K. G. , Grigson, S. J. W. and Burgess, J. G. , 2008. Biodegradation of crude oil across a wide range of salinities by an extremely halotolerant bacterial consortium MPD-M, immobilized onto polypropylene fibers, Biotechnology and Bioengineering, 79, 2, 145–153.

Emtiazi, G., Shakarami, H., Nahvi, I., Mirdamadian, S.H., 2005. Utilization of petroleum hydrocarbons by Pseudomonas sp. and transformed Escherichia coli. African J of Biotechnol. 4(2): 172-176.

Fantroussi, S.I. , Agathos, S.N. , 2005. Is bioaugmentation a feasible strategy for pollutant removal and site remediation, Curr. Opin. Microbiol. 8, 268–275.

Hong, J.H., J. Kim, O.K. Choi, K.S. Cho, H.W. Ryu., 2005. Characterization of a diesel-degrading bacterium, Pseudomonas aeruginosa IU5, isolated from oil-contaminated soil in Korea. World J. Microbiol. Biotechnol., 21, 381-384.

Horakova, D.M.V. , Nemec, M., 2000. Remediation Engineering of Contaminated Soils D.L. Wise, D.J. Trantolo, E.J. Eichon, H.I. Inyang, U. Stottmeister, Eds., Marcel Dekker, New York, 357–372.

Kayode-Isola, T.M., Eniola, K.I.T., Olayemi, A.B., Igunnugbemi, O.O., 2008. Response of resident bacteria of a crude oil-polluted river to diesel oil. American Eurasian J Agro. 1(1): 06-09.

Kuhad, R.C. , Gupta, R., 2009. Advances in Applied Bioremediation, A. Singh, R.C. Kuhad, O.P. Ward, Eds., Springer-Verlag, Berlin, 173–188.

Leahy, J. G., Colwell, R. R., 1990. Microbial Degradation of Hydrocarbons in the Environment, Appl. Environ. Microbiol. 54, 305 – 315.

Mesdaghinia, A.R., Nasseri, S., Arbabi, M., Rezaie, S., 2005. Isolation of polycyclic aromatic hydrocarbondegrading bacteria associated with the petroleum contaminated soils in Iran. Proceedings of the 9th international conference on Environmental Science and Technology Rhodes island, Greece.

Nasrollahzadeh, H. S., Najafpour, G. D. and Aghamohammadi, N., 2007. Biodegradation of Phenanthrene by Mixed Culture Consortia in Batch Bioreactor using Central Composite Face-Entered Design, Int. J. Environ. Res., 1 (2), 80-87.

Nilanjana, D., Chandran, P., 2011. Microbial Degradation of Petroleum Hydrocarbon Contaminants: An Overview. *Biotechnology Research International*, 1-13.

Rahman, K.S.M. , Rahman, T.J. , Kourkoutas, Y., Petsas , I. , Marchant, R. , Banat, I.M., 2003. Enhanced bioremediation of *n*alkane in petroleum sludge using bacterial consortium amended with rhamnolipid and micronutrients. Bioresour. Technol. 90, 159–168.

Shafiee, P., Shojaosadati, S.A., Charkhabi, A.H., 2006. Biodegradation of polycyclic aromatic hydrocarbons by aerobic mixed bacterial culture isolated from hydrocarbon polluted soils. Iran J Chem Eng. 25(3): 73-78.

Stroud, J.L., Paton, G.I., Semple, K.T., 2009. Predicting the biodegradation of target hydrocarbons in the presence of mixed contaminants in soil. *Chemosphere*, 74, 4, 563–567.

Thompson, I.P., van der Gast, C.J., Ciric, A.C., Singer, L., 2005. Bioaugmentation for bioremediation: the challenge of strain selection. Environ. Microbiol. 7, 909–915.

Ting, A.S.Y., Tan, C.H.C., Aw, C.S., 2009. Hydrocarbon-degradation by isolate Pseudomonas lundensis UTAR FPE2. Malaysian J Microbiol. 5(2): 104-108.

Ward, O., Singh, A. , van Hamme, J. , 2003. Accelerated biodegradation of petroleum hydrocarbon waste, J. Ind. Microbiol. Biotechnol. 30, 260–270.

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Ecological evaluation of West Siberia middle taiga peat soils

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Abstract

This study discusses the results of some selected characteristics of typical oligotrophic peat soils, bog water of land adjacent to the drilling sludge pits, as well as water and bottom sediments of water bodies (lakes, rivers). It confirms the drilling sludge pits impacting the neighboring environment; in particular, changes in the composition and properties of soils, water and bottom sediments of water bodies. The main pollutants coming from drilling sludge pits are oil products, chlorides, sodium, calcium and a variety of heavy metals, including zinc, nickel, and copper. Downward movement in the profile and lateral migration of pollutants from drilling sludge pits, causing changes in the properties of wetland ecosystems and bottom sediments of water bodies are revealed.

Keywords: Hydrocarbons, West Siberia peat soils, salt accumulation, environmental impact.

Introduction

West Siberia territory is main area of oil extraction in Russian Federation. Thus, 70% of Russian oil is extracted in the Khanty-Mansiysk Autonomous Okrug (KhMAO). Soil contamination can occur at all oil extraction stages as the spillage result of oil, highly mineralized water, chemicals used in the preparation of drilling fluids and drilling waste disposal. Negative impact of oil extraction to soils means soil degradation, pollutants migration into adjacent environment. Polluted soils can be the source of secondary contamination. Therefore, it is imperative to carry out a study in this environment. The objective of our study was to evaluate the soil quality and establish norms to provide soil system performing its natural ecological functions.

Material and Methods

Site description

The study area is situated in central part of West Siberia. It is the subzone of middle taiga. The central part of the territory is flat bog-lake Sredneobskaya lowland. The climate is continental, with long cold winters and short warm summers. Average annual air temperature is +1.4° C. Average annual precipitation is about 500 mm, moisture coefficient is more than 1, enough to provide a flushing water regime in the soil.

The main territory is covered with bogs. The mineral bottom of wetlands has a slope not more than 10%) and it is composed by brown fine sands, saturated with water and sandy loam fluid and sand interlayers. Runoff from swamps takes place by filtration flow in the marches active horizon towards the greatest relief gradient.

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Swamp waters get to internal swaps lakes, which gives start to streams. Lake bottoms are covered with peat; river sediments texture is mostly sandy. Water-holding ground of swamp is water-saturated peat deposits. Swamp water merges with groundwater. Vegetation cover of the area studied is represented by pine-shrub-sphagnum bog oligotrophic phytocenoces. Typical oligotrophic peat soils cover the swamps areas.

Material studied

Typical oligotrophic peat soils, under impact in multiple-well platform and drilling waste disposal area and their background analogues, were studied. The pollution sources of soils are oil products and drillings wastes: drilling pulps, solutions, sewage, disposed in landfills. The migration of main pollution substances was studied in the direction of relief gradient from oil waste landfills to the lowest landscape. Samples of soils, swamp water, sediments were taken using transect from pollutant sources to internal swap lakes. Chemical parameters for the study were selected based on composition of oil, drilling pulps, solutions and formation water of the study area. The main pollution substances were: oil products, chloride, sodium, calcium ions, heavy metals were determined.

Methods

Oil products in soils were measured by IR-spectrometry, oil products in water by fluorometric method. Heavy metals (zinc, nickel, and copper), sodium, calcium were determined by atomic-absorption spectrometry, chlorides by titrimetric analysis.

Statistica 8.0 and Sigma Plot programs were used to understand the statistical meaning of analytical data. Evaluation of the soil quality and establishment of soil norms were done with mathematic method (Vorobeichick, 1994).

Results and Discussion

The oil product content in background typical oligotrophic peat soils was between 0.5 and 0.9 g/kg of soil, chloride concentration did not exceed 0,085 g/kg of the soil, water soil extract pH varied from 3,8 to 4,6. Background soil analogs are characterized by concentration close to the reports written previously for the soils of our region (Dobrodeev, 1990; Moskovichenko, 1998, 2006; Vodyanitskiy, 2012. Data on heavy metals were: copper 15-18 mg/kg, zinc 17-30 mg/kg, lead 11 mg/kg, manganese 377-787 mg/kg, chromium 39-140 mg/kg, nickel 17-19 mg/kg, cobalt 3-6 mg/kg.

The main soil pollutants, coming from oil field facilities, were oil products, chlorides, sodium, calcium, magnesium, as well as heavy metals. Average content of oil products varied from 2 to 13 g/kg in the soils studied (Fig. 1), sometimes its content reaches maximum of oil pollution equal up to 261 g/kg in upper layer. The content of chlorides in soils varied between 1 and 8 g/kg (Fig. 3). The content of macro-elements such as sodium and calcium can reach concentration of 7 -8 g/kg (Fig. 5), that exceeds the content level of these elements up to nine times. The incoming of sodium and calcium into soils can be due to of entering drilling water, rich in these elements.

Heavy metals such as zinc, copper, nickel accumulated in the peat soils with maximum content in 20-40 cm layer of the profile. Thus, average content of zinc was 90 mg/kg, exceeding the background values in three times. The main source of coming heavy metals is oil.Our analytical data suggested that the downward migration of pollutants in the soil profile was up 2.0 meters (Fig. 2, 4). Penetration to deep layers is connected with the characteristics of different peat layer , moisture content, and degree of peat decomposition. Model experiments with typical oligotrophic peat soil columns, polluted with chlorides in concentration 8 g/kg, show also the vertical migration of chloride ion with water, which was poured to column as rain simulation in amount equal to annual precipitation. The content of chloride ion in the peat soil column studied has decreased in eight times.

The peat horizon, studied at a depth of 1.8-2 m, is characterized by high decomposition degree of organic matter, higher density than the upper horizons, and it can be considered as geochemical sorption barrier which prevents direct pollutant migration into groundwater in the area studied. Pollutant impact on soil composition and properties is revealed in aqueous extract pH changes. pH changes can be as minor in oligotrophic peat soils, so significant when the pH changed up to 1-3 units: pH varies widely from 3.5 to 6.5. Change in pH, probably, can be explained by the present of oil products, as well as salts of zinc in the soils. This fact is confirmed by significant correlation between pH and zink ($R = -0.5$; $n = 31$). Statistically significant correlation between chloride and sodium, calcium, zinc, magnesium in the soils were established. Chloride associated with zinc and calcium (salts), likely explains acidification of soil medium, while oil contamination usually leads to alkalization.

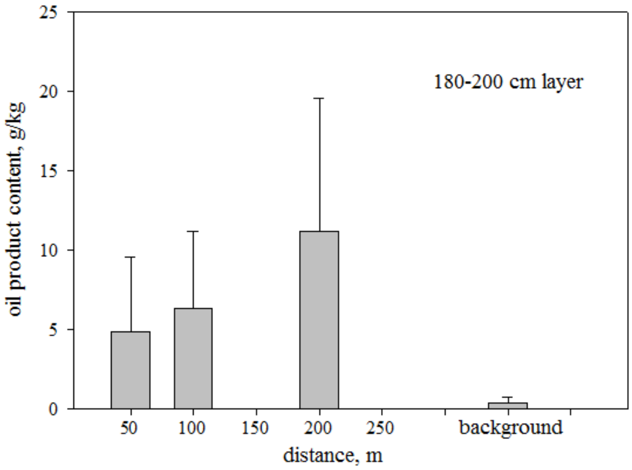

Fig.1. Oil product content in typical oligotrophic peat soils in distance gradient from pollution source

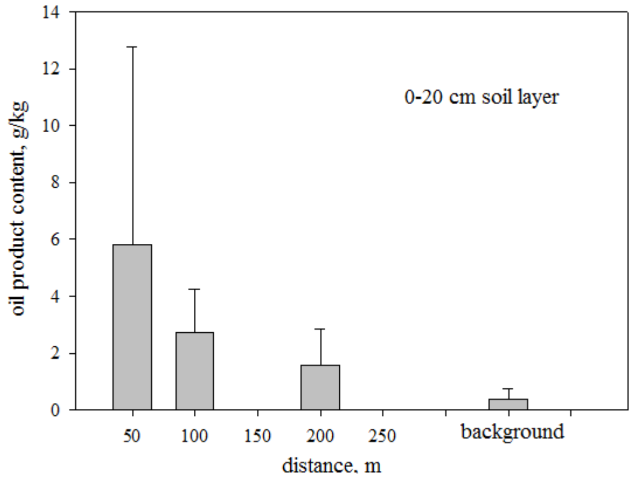

Fig.2. Oil product content in typical oligotrophic peat soils in distance gradient from pollution source

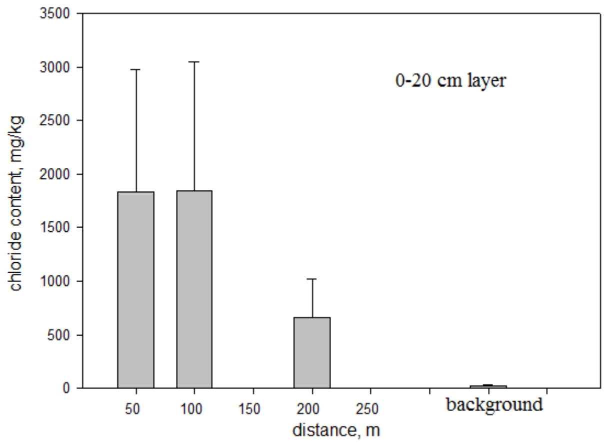

Fig.3. Chloride content in typical oligotrophic peat soils in distance gradient from pollution source

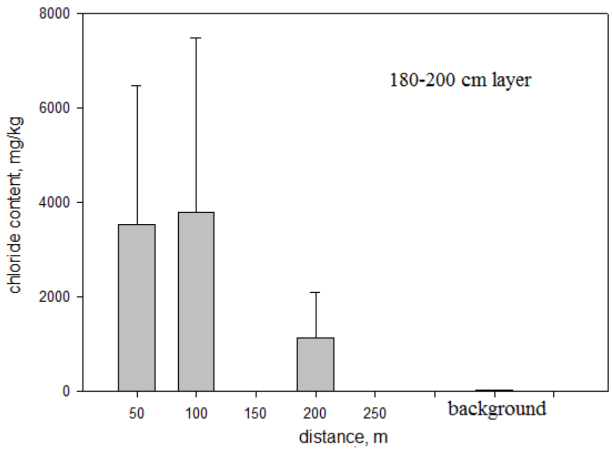

Fig.4. Chloride content in typical oligotrophic peat soils in distance gradient from pollution source

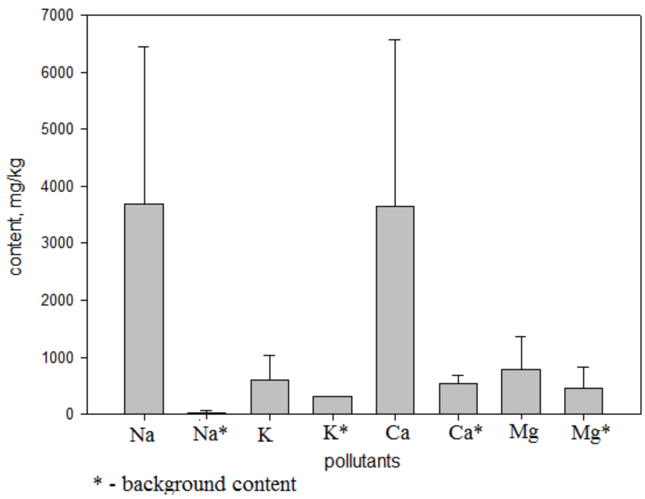

Fig.5. Macroelement content in typical oligotrophic peat soils in distance gradient from pollution source

There is a trend of quick migration of pollutants from upper layers to downwards, depending on the capacity of geochemical barrier. In spring lateral migration of water flow and pollutants in the landscape into water bodies (lakes, rivers) takes place. The content of oil products in the swamp water varied between 0.8-1.0 mg/L. The background swamp water concentrations are 0.05-0.2 mg/L.

Pollutants, typical to oil production, were found in lakes and river sediments. Lakes are situated in the direction landscape flow in distance of 200-300 m from pollution source. Oil products have accumulated in peat sediments in the amount from 3 to 32 g/kg, in mineral sandy sediments – from 1 up to 6 g/kg. These values exceed the background one level up to hundreds times. Such pollutants as chlorides and sodium have accumulated in peat sediments up to approximately 4.5 and 1.5 g/kg.

Conclusion

The main pollutants in the area studied are oil products (hydrocarbons) and salts (chlorides, sodium, calcium, zinc, nickel, and copper). Typical oligotrophic peat soils have accumulated and adsorbed large amount of pollutants as a geochemical barrier. Vertical profile migration of pollutants, such as oil products and salts in the peat soils from surface peat layers to 2.0 m depth, have confirmed the high sorption capacity of peat. However, analyses showed that pollutants migrated laterally and reached to the nearest lake and accumulated in the 20 cm of peat sediments (up to 60 g / kg). Chloride associated with zinc likely explains acidification of soil medium, while oil contamination usually leads to alkalization of the media.

References

Dobrodeev O.P. 1990. Biogeochemistry features of heavy metals in upland bogs // Natural and antropogenic changed biogeochemical cycles. Works of biogeochemical laboretory. V. XXI. Moscow, Nayka (in Russian).

Moskovichenko D.V., 1998 Oil and gas production and the environment: ecological and geochemical analysis of Tyumen region. Novosibirsk: Nauka, Sibirskoe predpriyatie RAN (in Russian)

Moskovichenko D.V., 2006. Biochemical features of Western Siberia upland bogs // Geography and natural resources.1 (in Russian).

VodyanitskiyY.N., Savitchev A.T., Avetov N.A., Trofimov S..Y, Kozlov S.A., 2012. Strong geochemical anomaly in upland peat of Middle taiga Ob river // Vestn. Mosk. Univ. Ser. 17 Soil,3, 7-12 (in Russian).

Vorobeichik E..L, Sadykov O.F., Farafontov M.G., 1994. Environmental regulation of technogenic pollution of terrestrial ecosystems (local level). Yekaterinburg: Nauka (in Russian).

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Dependence of selenium behavior on fertilizer during barley growing

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Abstract

Selenium-enriched food becomes increasingly important in growing crop production in terms of its lack or absence in the soil. This trace mineral is essential for human health in small quantities. This article presents the results of research activities of different concentrations of selenium on the growth and development of spring barley depending on the level of mineral nutrients in the soil.

Keywords: Selenium, soil, barley

Introduction

Selenium (Se) is one of trace elements that necessary for human and animals (in an amount of 40-200 mcg / day) [1-3]. Lack of selenium in the human body leads to a number of diseases, including heart diseases, cancer, immunodeficiency, Kashin-Beck disease, etc [4-8]. Deficiency of this element is associated with a low content or its absence in the soil and, as a consequence, the agricultural products. Therefore, selenium-enriched food becomes increasingly important in the cultivation of crop production. It is an agricultural products that makes an additional input of selenium in dietary intake maximal safety. There is a wide range of forms of selenium containing fertilizers and various methods for their use [10,11]. The effectiveness of these fertilizers depends on agrochemical and environmental factors [5,8]. Selenium has strongly pronounced antioxidant properties [12]. That is especially important in connection with environmental pollution. It is a part of a series of proteins, the active center of which contains «selenium» amino acids: selenocysteine and selenomethionine. These proteins include, first of all, glutathione peroxidase, participating in the establishment of hydrogen peroxide.

The aim of our research was to study the effect of selenium on plants of spring barley (Hordeum vulgare L) at different levels of soil nutrition (NPP).

Material and Methods

Investigations were carried out in greenhouse pot experiments under natural conditions of photoperiod, temperature and light within two years in the spring-summer period. Agrochemical characteristics of soddy-podzolic loamy soils in the experiments was the following (first year): humus content - 2.3%, hydrolytic acidity - 2.8 mg-eq/100g, sum of exchangeable bases - 22.8 mg-eq/100g , pH = 5.54, the content of mobile phosphorus

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and exchange potassium was 197.3 mg / kg and 151.7 mg / kg soil (in 0.2 HCl extract). This data coincided to a high level of phosphorus availability in the soil and increased level of potassium.

In the second year the soddy-podzolic soil was more fertile: humus content - 3.4%, pH – 5.9, the sum of exchangeable bases - 47.9 mg-eq/100g, content of mobile phosphorus and exchange potassium was 200.0 mg / kg and 70 mg / kg respectively. The seeds of spring barley Raushan (Hordeum L.) were used for the experiment. Strict regulation of irrigation (according to a mass up to a standard weight of 2.5 kg) was observed. Seeds were held in water for a 24 h. 12 seeds per pot were taken. The experiment was repeated for 4 times.

Nutrients (NPP) in a doze of 0.1 g of active substance/ kg were added as aqueous salt: NH_4NO_3, PCl, Ca $(H_2PO_4)_2$ * H_2O. Dining following experiment was:

NPP (in a doze of 0.1 g of active substance/ kg),
2NPP (in a doze of 0.2 g of active substance/ kg),
NPP + 0,05% Se,
2NPP + 0,05% Se.

In the second year of the experiment additional variants were added: NPP + 0.01% Se and 2NPP + 0.01% Se.

On the 22 day in the beginning phase of branching and on the 42 day in the beginning phase of branching (second year) experienced variants were treated with a solution of sodium selenite at concentrations of 0.01% and 0.05% in doze 20 ml/m^2. Meteorological and phenotypic monitoring was carried out, as well as insecticide treatment (remedy "Aktara" against *Puccinia anomala Rost* and *Aphidinea*).

Plant samples were analyzed by standard agrochemical methods [9]. For the evaluation of selenium content in the soils a modified method of fluorometric analysis was used. This method is based upon the wet combustion of the sample with a mixture of nitric and perchloric acid, reduction of hexavalent selenium to Se +4 and condensation formed selenium acid with 2.3-diaminonaphthalene. As a result a fluorescent complex piazoselenol is formed. We used a fluorometer "Hitachi MPF-2A" (Japan).

Results and Discussion

Selenium influence is observed on generative part of barley biomass, as well as on the nitrogen content in the grain and nitrogen loss. This points out to the selenium role in the plant nitrogen metabolism.

In the first experiment use of 0.05% selenite concentration allowed to determine decrease of straw mass (21 and 29%) and grains (between 31 and 19%), depending on background nutrients (Table 1). However, decrease in the yield in the NPP + 0.05% variant is expressed. This indicates selenite behavior depending on the soil nutrients supply.

In the second experiment, in order to avoid yield loss from the examine factor, the doze of selenite was reduced (up to 0.01%), but a negative effect on the concentration of 0,05% Se was not confirmed. This is obviously associated with higher soil fertility in the experiment. The impact of 0.05% selenite caused a significant decrease in straw weight from 11.6 to 8.6 g, which was accompanied by an increase in grain weight from 3.1 to 4.3 g (39%) when adding 2NPP (Table 1).

Without additional fertilizer application (background NPP) only trend of such changes were found. Thus, improvement of soil nutrients reserves (2NPP) combined with positive application of selenite via leaves. Impact of lower selenite concentration (0.01%) had an intermediate character.

In the first experiment, the selenium content and its removal from the grain increase. (Table 2). Selenium accumulation in straw is 2-3 times more than in the grain in the case of its use. This may evidence Se redistribution within the plant. It should be noted that its removal on variants with fertilization increased almost in 2 times in case of biomass decreasing.

Use of selenium on 2NPP background led to lower the nitrogen content in the grain from 3.83 % to 3.17 % (17% less), as well as removal of nitrogen from the grain 33 % less (Table 2). It shouldn't be ignored that it is the dwarf rust (Puccinia hordei Otth.) diseases of barley on NPP +0.05% Se in these experimental variants. It is known that selenium is included in the amino acids - selenocysteine, selenomethionine. The assimilation of sulfate (sulfur) and selenium in the plant occurs in certain organelles - plastids, so they compete and complement each other in the metabolism of organic compounds. Inclusion of excess of amino acid containing selenium into proteins may cause disturbance of their functions.

Table 1. The results of the vegetation experiment on spring barley Raushan (Hordeum vulgare L) depending on the selenium treatment on different NPP backgrounds (2011-2012) (average data per pot)

variants	straw mass,g	%	grain mass,g	%
2011 year				
NPP	2.9	100	3.6	100
NPP+0.05%Se	2.3*	79	2.5*	69
2 NPP	5.8	100	6.2	100
2 NPP+0.05%Se	4.1*	71	5.0*	81
LSD $_{0.05}$	0.33		1.08	
2012 year				
NPP	8.4	100	6.2	100
NPP+0.01%Se	8.8	105	5.9	95
NPP+0.05%Se	7.6	86	6.0	102
LSD $_{0.10}$	1.96		0.98	
2 NPP	11.6	100	3.1	100
2NPK+0.01%Se	10.3	89	3.6	116
2NPK+0.05%Se	8.6*	74	4.3*	139
LSD $_{0.10}$	1.72		0.83	

* - reliably significant result

Table 2. The content and removal of NPP and Se in barley Raushan (Hordeum vulgare L) depending on selenium treatment (2011),

Variants	nitrogen,%	N removal, g	phosphorus, %	P removal, g	potassium,%	P removal, g	selenium, mcg/kg	Se removal, mcg
grain								
NPP	3.62	0.13	1.2	0.04	0.57	0.02	114	0.3
NPP+0.05%Se	4.55	0.11	1.41	0.03	0.71	0.02	2674	6.0
2 NPP	3.83	0.24	2.21	0.14	0.64	0.04	73	0.4
2 NPP+0.05%Se	3.17	0.16	1.53	0.08	0.76	0.04	3120	12.9
straw								
NPP	1.68	0.048	0.22	0.006	3.0	0.085	100	0.3
NPP+0.05%Se	2.5	0.056	0.2	0.005	2.7	0.06	8461	19.1
2 NPP	2.05	0.118	0.14	0.008	3.2	0.186	58	0.3
2 NPP+0.05%Se	2.01	0.083	0.17	0.007	3.7	0.153	7330	30.2

If these proteins are antibodies to various pathogens, their dysfunction leads to a decrease in plant resistance to disease, in the present case dwarf rust. On 2NPP background it does not take place because of a sufficient supply of nitrogen. However, the nitrogen content in grain (variant NPP +0,05% Se) increases from 3.62% to 4.55% (26% more). This may be related to the carbohydrates outflow in connection with the damage of their exchange as a result of fungal lesions and increase the nitrogen share in the mass.

In this situation nitrogen removal remains relatively unchanged, that is connected with grain mass decrease on the background NPP +0,05% Se. Having saturated the grain and straw with selenium, we did not receive a positive impact on the crop. Selenium concentration in the grain and straw exceeded maximum permissible level (MPL for barley is 800mkg/kg). In this connection the test concentration was obviously overstated.

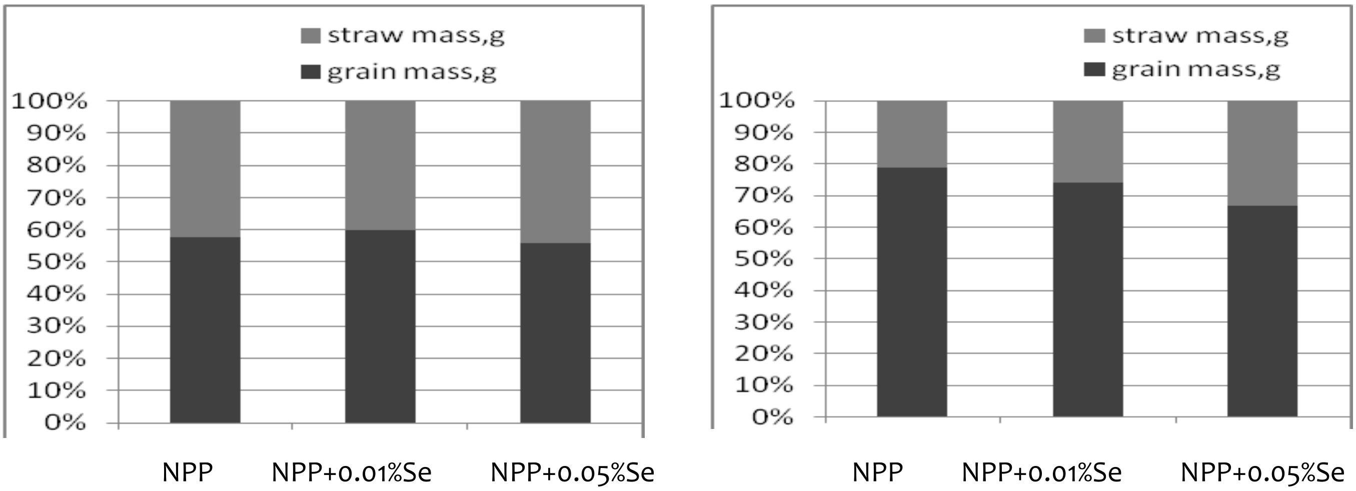

Fig. 1. The ratio of the straw mass to the ears mass at different levels of mineral nutritions under selenium treatment (experiment 2)

Carrying out a green pot experiment on the same soil type with higher fertility level (the second experiment) showed that the additional NPP introduction (background 2NPP), led to yield reduction due to changes in the biomass structure (Fig. 1). Additional nitrogen supply extended growing season, increasing the nonproductive biomass. The grain mass decreased almost twice. Treatment with 0,05% Se on background 2NPP decreased nonproductive biomass by 20%. The ratio of ears mass to the straw mass approached 1:1 , as it was in the variant with a single dose of NPP. The straw mass became 26% less, and the mass of ears became 36% more (Table 1).

Under the selenium influence (concentrations of Se 0.01% and 0.05%) the nitrogen content increased from 2.4% to 2.7% on background NPP and from 2.3% to 3.8% - 3.9% on background 2NPP respectively (Table 1). Growth of nitrogen removal in grain is associated with grain mass raise. The content and removal of selenium in grain increased under selenium treatment, proportional to its concentration, while the background has not played a significant effect on the selenium accumulation in grain (Fig. 2) So, on both backgrounds Se concentration 0.01% led to the content of Se in plants 1000-1100 mcg / kg, and the concentration of 0.05% Se led to 4000 mcg / kg.

The indicator of selenium content in grain under Se treatment (both selenium concentrations) exceeds MPL (800 mcg / kg), but at concentration 0.01% Se it is substantially lower than at 0.05% Se concentration (4 times), approaching to the MPL.

Conclusion

1. At low soil fertility and effective additional application of NPP (2NPP) on crop the selenium treatment (0.05%) has no any positive influence on the yield and biomass of barley.
2. Under conditions of high fertility and inefficient actions of additional application of 2 NPP on productive processes (had a greater influence on the formation of green mass and hardly had any effect on the grain formation), the usage of selenium via leaves has positive effect on grain yield.
3. Connection between selenium treatment and the level of nitrogen in the soil is observed. This may affect the stability of barley to pathogenic diseases that require additional research.
4. The selenium concentration in sodium selenite 0.05% was established to be more effective than the concentration 0.01% according to the influence on weight of the vegetative and generative parts of the plant. The increase in yield and increase in the content of nitrogen and its grain removal takes place.
5. Treatment by selenite via leaves in vegetation conditions can not be recommended for the safe grain saturation with selenium due to its accumulation exceeding the maximum permissible level (800 mg / kg).

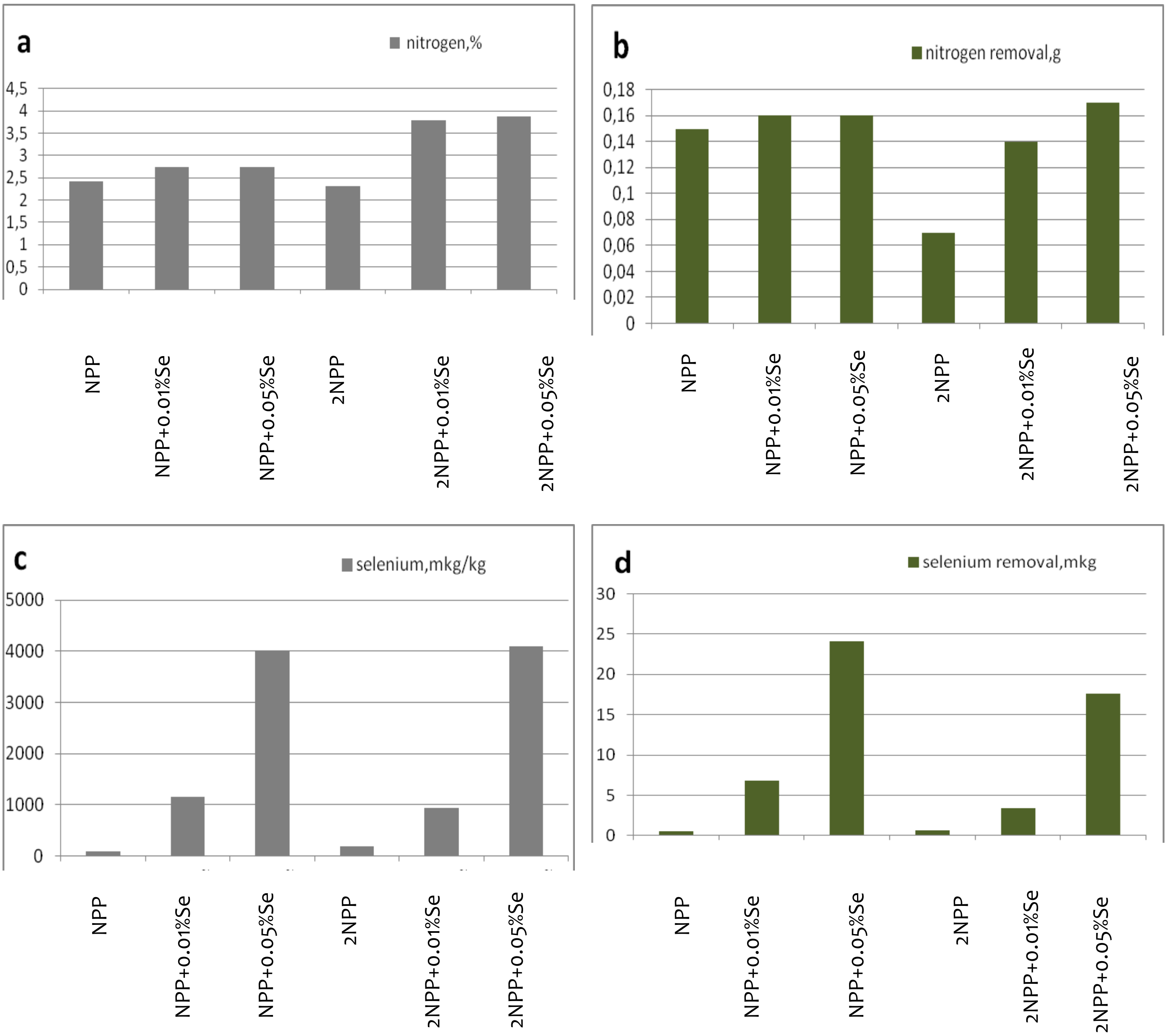

Fig.2. Content and removal of nitrogen and selenium in grain (experiment 2).

References

1. Golubkina N.A., Papazyan T.T., 2005. Selenium in Russia: plants, animals, man.
2. Ermakov V.V., Kovalskiy V.V., 1974. Biological importance of selenium.
3. Gissel G.: Selenium fertilizers and foliar application, danish experiments // Annals of Clinical Research 18: 61-64, 1985
4. Bityutskaya N.P., 2010. Trace elements of higher plants.
5. Vichreva V.A., 2011. Ecologo-agrochemical aspects of selenium treatment under cereals and French lilac on the chernozem soils in the middle Volga region.
6. Nimazalova T.B., Abasheeva N.E.: The influence of selenium on the productivity and quality of agricultural crops // Plant growing, selection and seed growing.- 2009.- № 1(14).
7. Postnikov A.V., Illarionova E.S.,1991. New in the use of selenium in agriculture: the overview.
8. Seregina I.I. Effect of selenium on the productivity of spring wheat depending on nitrogen nutrition and water delivery // Fertility. – 2007. - №5. – p. 15-17.
9. Practical course of agrochemistry, 2001
10. Butler G.W., Peterson P.J. Uptake and metabolism of inorganic Se-75 by Spirodela oligorrhiza Australian J. Boil. Sci. 1967. V. 20. pp. 77-86.
11. Gissel G.: Selenium fertilizers and foliar application, danish experiments // Annals of Clinical Research 18: 61-64, 1985
12. Combs GF (2001). Selenium in global food systems. British Journal of Nutrition 85, 517-547

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Comparative analysis of radionuclides in chernozems under different types of land

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Abstract

The results of a comparative analysis of radionuclides (^{226}Ra, ^{232}Th, ^{40}K, ^{137}Cs) are presented. The consistent patterns of their activity distribution (the content) in the profile of chernozems exploiting in agriculture and their analogues under forest (field-protective forest) and old idle land are shown. Red clay and loess are parent rocks in these soils. The soil samples were selected in the Volgograd, Rostov and Orenburg regions and Republic of Bashkortostan. Most of the soils characterized by a maximum content of radionuclides in the upper part of the profile, the minimum is in the middle of. The content of radionuclides in the soil profile depends on their original content in the parent rock (the more radionuclides in parent rock, the more of them in the humus horizon). Under agricultural use of soil with fertilizers, this pattern may not be observed. ^{137}Cs is observed significantly more than arable land in the humus horizons of soils under forest and long-term fallow. This may be associated with features of the biological cycle. In the soils under arable permanent estrangement of agricultural biomass leads to a decrease of ^{137}Cs. There is the pattern for ^{226}Ra? But less pronounced (except soil long-term fallow). The differences in the content of ^{40}K in soils of different lands were hardly observed. In most cases the content of ^{232}Th in soils under arable land and long-term fallow is more than a field-protective forest.

Keywords: : radionuclides, chernozem, types of land

Introduction

Natural radionuclides are widely distributed in the earth's crust, so people are under the influence of radiation in a varying degree [2]. The Earth's crust is the main reservoir of natural radionuclides in the world. radionuclides and other elements were a part of the primary substance of the Earth.

Pedosphere, occupying the contact position between the lithosphere, atmosphere and biosphere, performs an important regulatory function in the migration of radionuclides in the links of the ecosystem. Natural radionuclides (NRN) in the soil are inherited from the soil-forming rock. However, their number and profile distribution is closely linked to the genetic soil characteristics, the presence of geochemical barriers, quality and content of humus, mechanical and mineralogical composition and other soil properties.

The soil cover of Russia is characterized very more genetic soil's diversity, due to a wide variety of hydrothermal conditions and the soil-forming rocks.

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Now, there are a lot of material for radioactive contamination of World and Russian soils. However, it touches the soil exposed to anthropogenic contamination due to nuclear weapons testing, nuclear accidents, transportation and storage of industrial waste.

In this study, we have investigated contain of radionuclides (^{226}Ra, ^{232}Th, ^{40}K, ^{137}Cs), their patterns of distribution in the chernozem profiles under arable land, field-protective forest and old idle land.

Material and Methods

Soil analyses were performed using Russian standard methods [3, 6, 8]. Determination of radionuclides (^{226}Ra, ^{232}Th, ^{40}K, ^{137}Cs) was performed on a gamma - beta spectrometer - radiometer ICBG-01 "RADEK".

Results and Discussion

The research was performed at 5 sites in the steppe zone of the European part of Russia (the Volgograd, the Orenburg and the Rostov-on-Don regions and the Republic of Bashkortostan) (Fig.1). The samples were taken in the upper (0-10 cm), middle (40-50cm) and lower (90-100cm) layers of investigated soils.

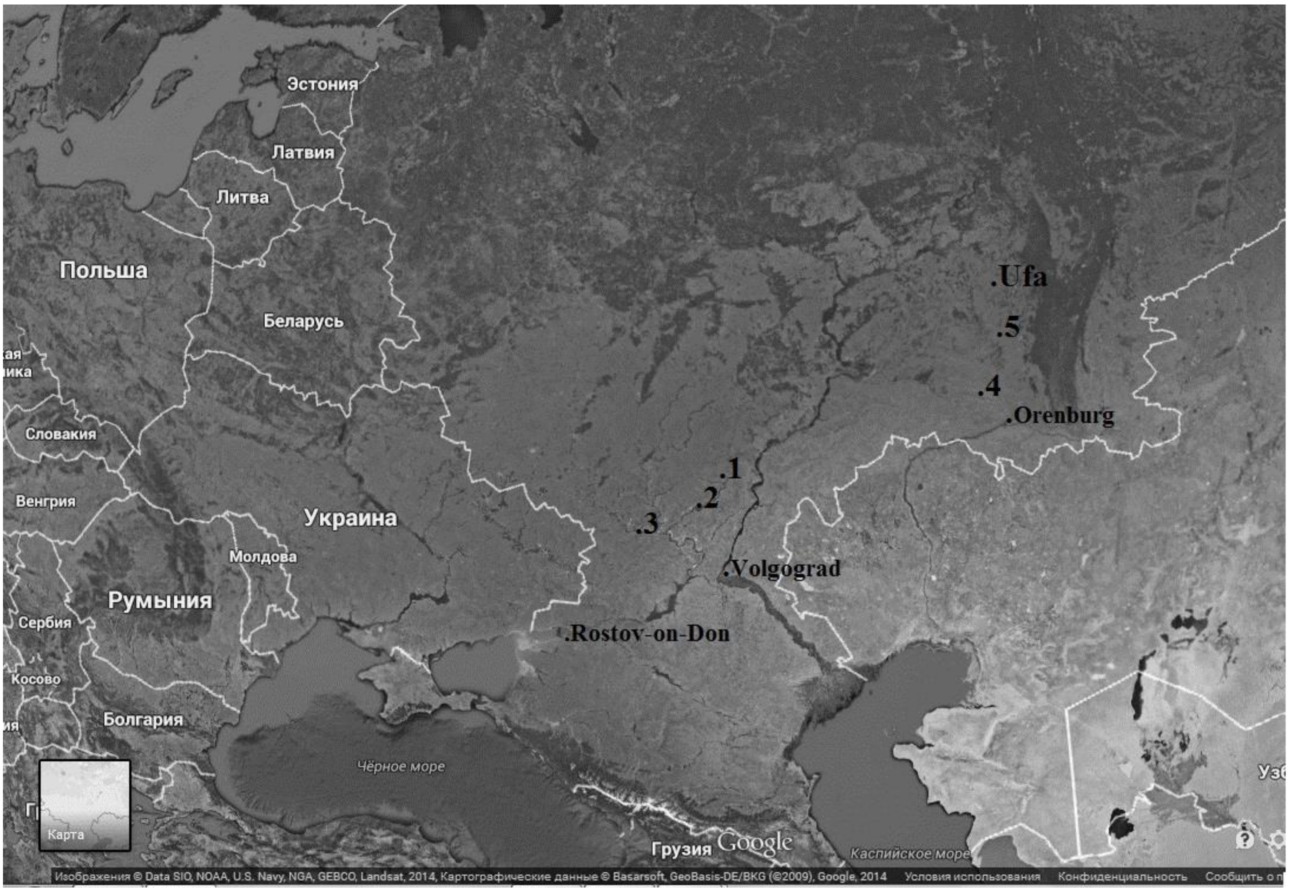

Fig.1. Location study points

Sites №1 and 2 are located in the Northen part of The Volgograd region:

Site №1 is Kozlov forest and adjoining arable land (Rudyankovsky district). Kozlovski forest was created in the form of wide (630 m) forest band length 7 km near the village Kozlovka in 1896. Field-protective forest stretches along the watershed (west to east) is perpendicular to the predominant wind direction [4, 5]. Cuts are arable land and shelterbelt. Soils are migration-micellar chernozem on loess (Classification and Diagnistic System of Russian soil 2004).

Site №2 is located 40km to the south the site №1. It is former Beloprudsky research base USSR (Danilov district). Cuts are: 1) in the arable land between the eastern and middle field-protective forest; 2) in the eastern shelterbelt (planted 60 years ago). This place is characterized by strongly developed erosion processes [4, 5].]. Soils are segregation chernozem on loess (Classification and Diagnistic System of Russian soil 2004).

Site №3 is Sholokhov district, Rostov region. The cut is arable land. The soil is texture-carbonate chernozem on loess (Classification and Diagnistic System of Russian soil 2004).

Site №4 is Krasnoguard district, Orenburg region. The cut laid old idle land (age of old idle land is 80 years). The soil is segregation chernozem on loess (Classification and Diagnistic System of Russian soil 2004).

Site 5 is Aurgazinsky district, the Republic of Bashkortostan. The cut laid arable land and field-protective forest (planted 80 years ago). The soil is segregation chernozem on loess (Classification and Diagnistic System of Russian soil 2004).

All research sites are testing polygons. They are constantly being soil-ecological monitoring.

General characteristics of soils:

Humus. All studied soils are divided into 3 groups of humus content:

- Humus content is above 8% - Site №4 and Site№5 (field-protective forest). Humus horizon in these soils reaches 50-60 cm. Such content and the depth may be due to the location of these soils in the lowland. The soil-forming rock is red and brown clay.
- Humus content is 4 to 6% - Site №3 and Site №4 (arable land). The soil-forming rock is red and brown clay.
- Humus content is less than 4% - Site №1, 2. The soil-forming rock is loess.

In general, the humus content in soils under arable land is less than their equivalents in the field-protective forest and old idle land.

Mechanical composition. In this case, the clear separation is observed depending on the soil-forming rock. The first group is the soils on loess (Sites №1-3). The second group is the soils on red and brown clay.

The first group is characterized by: 1. Almost complete absence of coarse, fine and very fine sand fractions; 2. Dominated fractions are sandy silt, fine silt, clay. The content medium silt fraction is significantly less. An exclusion is the soil of Site 3 (the medium silt content is more than the sandy silt content); 3. The content of same fractions of arable land and field-protective forest soils is less than 5%.

The second group is characterized by: 1. Almost complete absence of coarse, fine and very fine sand fractions; 2. Dominated fractions are very fine sand, sandy silt and clay. Soils of Site 5 are characterized by a low content of very fine sand fraction on the depth 90-100 cm; 3. The content of dominated fractions is changed on soil profiles.

Soil acidity (pH). Neutral and alkaline reaction of soils is observed for Sites №1-3. Alkaline reaction of soils is observed for Site №4. Soils of Site №5 are characterized slightly acidic reaction in the upper part of the profile and alkaline reaction in lower part of the profile.

Features of distribution of radionuclides in the studied soils:

Radionuclides absorbed by the soil, migrate through the soil profile under the influence of various factors. Their redistribution in the soil is the result of convective transport, diffusion, ion uptake by the root system of plants, as well as the activity of microorganisms and people [7].

^{226}Ra. Radium content in the surface layer (0-5cm) changes from 10 to 30 Bq/kg. Moreover, the main values of radium activity exceed 20 Bq/kg. Soils of Sites 1-2 (arable land) in the surface layer contain the least amount of radium as compared with other Sites. Overall, the character of radium distribution on the soil profiles varies from highly differentiated to undifferentiated.

All soils under arable land are characterized halving the radium content in the surface layer (0-5cm) as compared to the soil-forming rocks (90-100cm). This may be due to the removal of nutrients from the humus horizon together agricultural products.

Accumulated amount of radium in different types of land increases in the series: arable land, field-protective forest and old idle land.

^{40}K. The difference in the ^{40}K content in studied soils varies from 458 to 700 Bq/kg in upper layer 0-5cm. Most potassium contains in the soil under old idle land (Site 4), less - in the layer of 0-5 cm in the soil under field-protective forest (Site 5).

The potassium activity in soil-forming rocks varies in a wider range (420 (275) - 750 Bq/kg). Smallest value (275 Bq/kg) is observed in the soil under old idle land (Site 4).

Most differentiation in the potassium content in soil profiles is observed in the soil under a old idle land in Site 1 (275 – 694 Bk/kg), and the lowest - in the Orenburg region in the soil under field-protective forest (405-713 Bq/kg).

^{137}Cs. Cesium content in studied soils more extensively changed in humus horizons (9 to 64 Bq/kg). Minimum range cesium content is observed in the middle part of the profile (3 Bq/kg). The greatest number of ^{137}Cs is found in the layer of 0-5 cm of soil under field-protective forest (Site 1). The particularity of studied soil-forming rocks is absence of cesium.

^{232}Th. Thorium activity varies over a rather wide range from 30 to 46 Bq/kg. The maximum ^{232}Th amount in the surface layer is observed in soil under field-protective forest (Site 2). All other investigated soils have approximately equal values of thorium content.

Thorium content in the soil-forming rocks (90-100 cm) varies in the same range (33 to 48 Bq/kg). Most active ^{232}Th observed in soils under field-protective forest (Site 2) and in the arable land (Site 1). Differences in the content of thorium between humus horizon and the soil-forming rocks are not observed.

Conclusion

The most accumulation of studied radionuclides (an exception is cesium) is in the soil under old idle land. Soils under field-protective forest contain more radionuclides than in soils upper other land. The radium content in upper layers (0-5cm) of soils under field-protective forest and old idle land is more than in soil-forming rocks. The radium content in soils under arable land dominates as compared with soil-forming rocks. Accumulated amount of radium in different types of land increases in the series: arable land - field-protective forest - old idle land. The potassium is characterized the similar content both the upper layer of soils and soil-forming rocks. The exception is the soil under old idle land (Site 4), wherein the potassium content in the soil-forming rocks is more than three times. The main part of the cesium is accumulated in the upper layer 0-5cm. Cesium is characterized by greater range of activity, than radium and thorium. The cesium content in soils under field-protective forest is 2.5-3 times more than in soils under different types of land. Soil-forming rocks are characterized by the absence of cesium (<1.5 Bq/kg). Thorium tends sufficiently homogeneous distribution profile. All investigated soils are characterized by similar thorium content in humus horizons and soil-forming rocks.

References

1. Гавриленко В.В. Геохимия радиоизотопов и жизнедеятельность человека //Биокосные взаимодействия в природных и антропогенных системах: мат. тез. IV Международного симпозиума – СПб: ВВМ, 2011.- С. 41
2. Резункова, О.П. Роль природного радиоактивного фона в управлении физиологическими процессами в живых системах: Учебное пособие / О.П. Резункова, Е.З. Гак // С.-Петерб. гос. ун-т телекоммуникаций им. А.М. Бонч-Бруевича СПб.: Изд-во ГОУВПО СПбГУТ. 2008. 34с.
3. Аринушкина Е. В. Руководство по химическому анализу почв. МГУ, 1970;
4. Афанасьева Е.А.. Водно-солевой режим обыкновенных и южных черноземов Юго-Востока европейской части СССР. М.: Наука, 1980. 216с
5. Афанасьева Е.А. Влияние корневых систем дубовых насаждений на водный режим и другие свойства обыкновенных и южных черноземов //Труды института леса. Работы совещания по лесному почвоведению. – 1952г. – М.: Академия наук, 1954. - С. 83-102
6. Растворова О.Г. практическое руководство по физике почв ЛГУ, 1983.
7. Нейтрализация загрязненных почв: монография. Под общей редакцией Ю.А. Мажайского. Рязань: Мещерский ф-л ГНУ ВНИИГиМ Россельхозакадемии, 2008. 512с.
8. Химический анализ почв: Учеб. Пособие/ Растворова О.Г., Андреев Д.П., Гагарина Э.И., Касаткина Г.А., Федорова Н.Н. - СПб, 1995
9. Министерство природных ресурсов и экологии Российской Федерации. Государственный доклад «О состоянии и об охране окружающей среды Российской Федерации в 2006 г», http://www.mnr.gov.ru/regulatory/list.php?part=1101

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Principles of soil mapping of urban areas

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Abstract

Soil cover of urban areas is radically different in composition and organization from the natural and agricultural landscape soil cover. In the course of soil mapping of the city, it is necessary to introduce the concept of a soil urban space, the characteristic features of which are the discrete soil cover and clear geometric shapes of areas due to purely anthropogenic factor. The soil urban space is characterized by fractional area pattern, much of which cannot be reflected in the map scale. Man-made introduced soils are dominating. The soil urban space is represented by a combination of soil areas and non-soil formations in various proportions: urban pedological combinations. The anthropogenic factor is the leading one in shaping the composition and geometry of the urban pedological combinations. In Saint-Petersburg, based on analysis of the percentage of soil formations and non-soil formations, the soil contours geometry and their distribution, there were identified 6 types of soil urbanized space. When showing soil contours on the map, the following was taken into consideration: the type of organization of the soil urban space, the nature of the distribution of the soil areas and non-soil formations in urban pedological combinations, the soil composition in urban pedological combinations. The legend of the soil map of St.Petersburg consists of three groups of mapping units. The units showing one predominant soil belong to the first group. It includes natural, man-influenced soils, man-changed soils and man-made soils. The second group includes a combination of soils. This group consists of three subgroups: combination of natural soils, combination of natural and anthropogenically transformed or introduced soils, urban pedological combinations – combinations of natural and anthropogenically transformed and introduced soils, and non-soil formations. The legend of the soil map of St.Petersburg contains more than 60 soil-mapping units. The soil map is implemented in the scale of 1:50,000 using MicroStation V8i software.

Keywords: Soil map, man-made soils, anthropogenic factor, composite soils.

Introduction

Soil mapping is based on the knowledge of the objective laws of formation of soil natural landscapes and agriculturally used areas. Soil cover of a metropolis is radically different in composition and organization from the natural and agricultural landscape soil cover. Therefore, new approaches to the analysis of the spatial distribution of soils in urban areas are necessary for city soil mapping [1, 2].

In the course of soil mapping of the city, it is necessary to introduce the concept of a soil urban space, the characteristic features of which are the discrete soil cover and clear geometric shapes of areas due to purely anthropogenic factor. The soil urban space is represented by a combination of soil areas and non-soil formations in various proportions: urban pedological combinations. Non-soil formations are the areas under asphalt and buildings, and the buildings themselves.

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Material and Methods

Studies of soils as an environmental basis of life quality of the population were conducted in the city of St.-Petersburg. St.-Petersburg was founded 300 years ago in the estuary of the Neva River. The construction of the city in the historic center of St.-Petersburg resulted in the destruction and burial of all natural soils under a layer of anthropogenic deposits of up to 4 m or more. Today, St.-Petersburg occupies an area of about 1,400 square kilometers and numbers a population of 5 million inhabitants.

Traditional and digital soil mapping methods were applied in the process of soil mapping of St. Petersburg using a scale of 1:50,000. One of the main stages of any soil mapping is to prepare a cartographic basis. In addition to maps showing the natural factors of soil formation, an additional digital map of functional zoning was used for mapping the territory of St.-Petersburg distinguishing 20 zones – industrial, settlement, residential, public and business, production, agricultural, recreational.

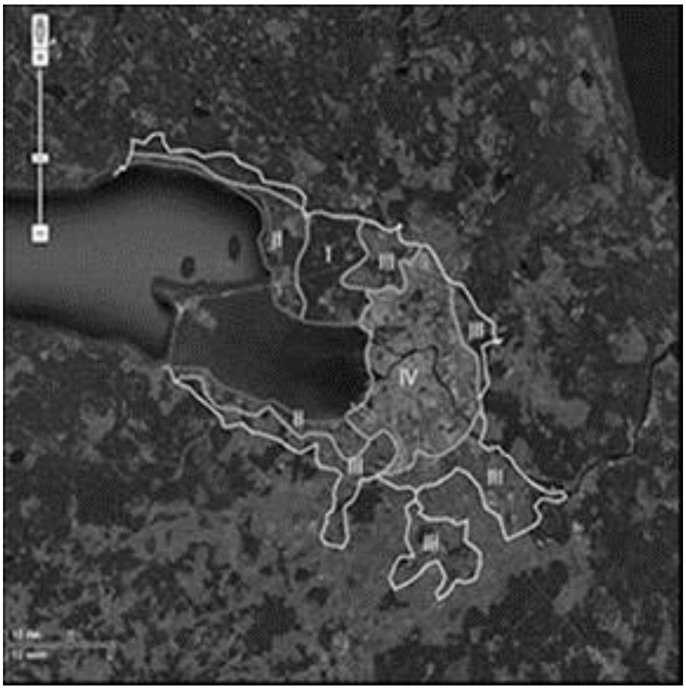
Materials of soil route studies and large-scale soil mapping in key areas, as well as materials of morphological studies of soils in trenches laid for communications and the results of studies of buried soils of the city were used for the soil mapping. Identified patterns of soil and soil cover transformation at different stages of construction of the city were taken into account while mapping built-up areas [1].

Interpretation of satellite photographs of St.-Petersburg performed using the general-to-specific method. Initially, the researched area was subdivided into larger units – built-up areas, agricultural fields and natural landscapes; then a complex of interpretive signs was determined in each of them.

Maps of the hydrographic network, topography and vegetation in the scale of 1: 50,000, obtained by analyzing satellite data directly in the digital form, a map of quaternary sediments and the soil map of the Leningrad region in the scale of 1:300,000, large-scale soil maps of key areas, melioration facilities and protected areas have been put forth in the process of mapping natural and agricultural landscapes within the administrative area of St.-Petersburg.

Results and Discussion

The city's soil covering is very diverse. Here, there are natural soils characteristic of this geographical area, man-influenced soils, man-changed soils and man-made soils (Fig.1).When performing soil mapping of St.-Petersburg according to the type of organization of soil cover natural, agricultural landscape and the actual urban areas were identified.



I – natural soils
II - man-influenced soils
III - man-changed soils
IV - man-made soils

Fig.1 Distribution pattern of soils in St. Petersburg

In natural ecosystems, the soil cover has the continual nature, the soil cover completely covers the earth's surface, and during a long period of time genetic links have formed between the soils. Combinations of soils are formed under the influence of the surface pattern as a re-distributor of moisture and vegetation. Natural soil differences with an undisturbed structure dominate in the soil cover. Soil areas are of an irregular geometric shape, which is often unclosed and has rounded borders. In natural landscapes located within the administrative boundaries of St.-Petersburg, the man has mostly indirect effects on soil and soil cover. Soils of suh areas are shown on maps with separate contours or combinations of soil.

In agricultural landscapes, including agricultural landscapes within the territory of St. Petersburg, the man has both indirect and direct impact on the formation of the soil and soil cover. Here, agrogenically modified soils dominate, the characteristic diagnostic feature of which is the presence of the plough layer. Soil areas often have regular geometric shape due to borders of agriculturally used areas or drainage channels. In agricultural landscapes, soil cover is formed equally under the influence of natural factors and anthropogenic influence. Genetic relations between the components of the soil cover are preserved only partially. Many of them have been destroyed during the construction of the road and drainage network. Combinations, the formation of which is due to the redistribution of moisture in the space limited by drainage network pattern, dominate.

The next type is the actual soil urban space with fragments of soil cover, genetic relationships between which are absent. The anthropogenic factor is the leading one in shaping the composition and geometry of the urban pedological combinations. The soil urban space is characterized by fractional area pattern, much of which can not be reflected in the map scale. Man-made introduced soils are dominating.

Introduced soils [2] are soil with an introduced humus or organic horizon, consisting of human-introduced and modified material of the horizons of natural or anthropogenically transformed soils and having a sharp lower border with the mineral substrate – bedrock below it. Often there is heterogeneity with respect to the soil texture, composition and density. Inclusion of artefacts and carbonates is usual. The soils are characterized by high levels of contamination with heavy metal.

The mandatory elements of the structure of the soil spaces are non-soil formations that disrupt the continuity of the soil cover.

Thus, during soil mapping of St.-Petersburg, we proceeded from the following provisions:

- The soil cover of the city is heterogeneous. It combines elements of the natural, agricultural landscape and urban space soil cover. Soil mapping each of the three types requires separate approaches and methods.
- In a large area of the city there are no soil combinations formed by genetically interrelated components. The connection between the components of the soil cover was destroyed during the construction of buildings, streets and avenues or absent initially, as most soils were constructed by man. Soil mapping of this part of the city requires knowledge about the particularities of the soil and soil cover formation at various stages of the construction of the city.
- A certain type of surface was geometrically formed in the space limited by the pattern of streets and avenues, which represents areas with urban pedological combinations. For soil mapping, it is necessary to classify by types the urban pedological combinations according to the ratio of soil areas and non-soil formations, the area geometry, the nature of their distribution and composition.
- Introduced soils are widespread in the composition of the soil urban space as compared to the natural and agricultural landscapes. Showing these areas while mapping introduced soils requires taking into account their spatial distribution in the urban pedological combinations.

The soil map of St.-Petersburg: the stages and methods of mapping.

While mapping the soil urban space, the areas where there was no soil or where the surface of the latter was less than 5%, were identified using primarily photographs. These areas were surfaces that were either under construction or under asphalt. They were shopping centres with adjoining asphalt territory, industrial areas, and rarely the quarters of the "old city" and streets.

After that, based on analysis of the percentage of soil formations and non-soil formations, the soil contours geometry and their distribution, there were identified 6 types of soil urbanized space (Fig.2).

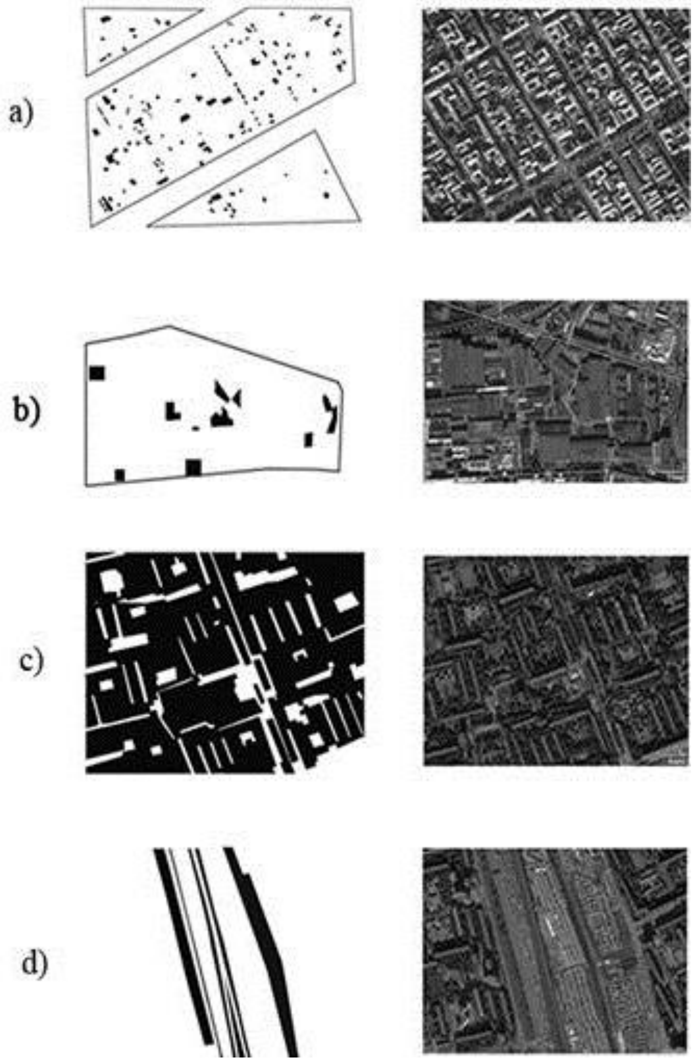


Fig.2. Types of soil urbanized space

Dispersive type (Fig. 2, a)

In urban pedological combinations, the soil areas are scattered among non-soil formations, occupying 5 to 20 % of the area. The soil contours are small in size (300–500 sq.m) and they are generally of square or rectangular shape, enclosed and insulated from each other. The soil cover is dominated by soils with introduced soil horizon, which were formed on anthropogenic layered deposits – the cultural layer, reaching in some parts of the city of 4 meters or more. The cause of the soil monotony in the “old city” is their similar origin. The humus horizon in small squares and lawns inside yards of St.-Petersburg for over 3 centuries has been periodically overlapped (with each new construction or renovation of buildings) with a layer of building materials. Then a new humus layer was formed or artificially deposited. Thus, the vast majority of soils in the blocks of the “old city” are introduced soils formed on the layered formation with buried humus horizons. The soils formed on the layered cultural formation without humus layers are much less common.

Fragmentary type (Fig. 2, b)

Soil areas of various geometry (rectangular, elongated, rounded, irregularly shaped) and 300–500 sq.m to 1000 sq.m are located in fragments without any pattern, and among non-soil formations. Typically, the soil contour is a unique soil. The soil cover in the central areas of the city is dominated by introduced soils, and to a variable degree disturbed natural or agricultural soils prevail in the suburbs.

Background type (Fig. 2, c)

In urban pedological combinations, soil areas cover over 50% of the surface. The soil contours may be both basic soil areas and soil combinations. Their composition is diverse – from introduced soils to agricultural and natural soils.

Linear type (Fig. 2, d)

Soil areas with a narrow and elongated shape (20–50 m wide and up to several kilometres long) are interspersed with patterns of non-soil formations. The following areas can be distinguished in the metropolis:

- long and narrow areas of introduced soils combined with patterns of non-soil formations. These soil areas are characteristic avenues with vegetation.
- long and narrow plots of introduced soils interspersed with contours of non-soil formations and areas of regosols. The contours are distinguished in the areas along the railway lines.

Mono-contour type

The map unit is distinguished on the soil map and coincides with the area of unique soil, such as the soil of the football field.

Continuous type

In urban pedological combinations, soil areas prevail absolutely. Non-soil formations are located in fragments and occupy less than 5% of the area. These areas are usually occupied by natural vegetation, parks, forest parks and farmland with preserved genetic connections between the soils. Natural or agrogenically transformed differences of the soil prevail.

When showing soil contours on the map, the following was taken into consideration:

- The type of organization of the soil urban space (dispersive, background, linear, mono-contour, continual)
- The nature of the distribution of the soil areas and non-soil formations in urban pedological combinations (dispersive-ordered, dispersive-non-ordered, foraminated, background, fragmentary, regularly-fragmented, regularly-striated and linear)
- The soil composition in urban pedological combinations (types and subtypes of natural and anthropogenically transformed [3] and introduced soils).

Conclusion

The legend of the soil map of St.-Petersburg consists of three groups of mapping units. The units showing one predominant soil belong to the first group. It includes natural and man-influenced soils (Histosols, Podzols, Albeluvisols, Umbrisols, Arenosols [4]), man-changed soils (Anthrosols), man-made soils (Introdusols).

The second group includes a combination of soils. This group consists of three subgroups:

- combination of natural soils,
- combination of natural and anthropogenically transformed or introduced soils;
- urban pedological combinations – combinations of natural and anthropogenically transformed and introduced soils, and non-soil formations.

In order to show the peculiarities of the urban pedological combinations, the legend includes the geometry features of soils and non-soil formations. In order to show the peculiarities of the urban pedological combinations, the legend includes the geometry features of soils and non-soil formations. For example: Spodic Anthrosols (background) and non-soil formations (dispersive-ordered). These units are characteristic for gardening.

Thus, the legend to the soil map of Saint-Petersburg with a scale of 1:50,000 comprises more than 60 units, including 12 natural soil units, 4 anthropogenically transformed units, 5 introduced soil units, 3 units with combinations of natural soils, 4 units with combinations of natural and anthropogenic transformed or introduced soils, more than 30 units with combinations of natural and anthropogenically transformed, introduced and non-soil surface formations.

References

1. Aparin, B., Sukhacheva, E. 2013. Soil cover of St. Petersburg: "from the woods’ dark and marshes’ cold" to the modern megalopolis. Biosphere. 5/3. 327-352. [in Russian].
2. Aparin, B., Sukhacheva, E. 2014. Principles of creating a soil map of metropolis. Soil science. 7. 790-802. [in Russian].
3. Classification and diagnostic System of Russian Soils. 2004. Oikumena, Smolensk. [in Russian].
4. World Reference Base for Soil Resources. 1998. FAO, Rom.

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Growing of fenugreek (*Trigonella foenum-graecum* L.) in dependence on water regime and inoculation with nitrogen fixing bacteria Rhizobium

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Abstract

Fenugreek (Trigonella foenum-graecum L.) is an annual legume crop. It is widely cultivated in India, China, Egypt, Ethiopia, Morocco, Turkye, etc. Fenugreek plants and seeds are used in foods as a spice but are medicinal plants, too. In Bulgaria this crop is known only as a kind of spice. Fenugreek is a dryland crop but it well responds to a minimum application of irrigation. Fenugreek plants were grown in the condition of pot trial. The effect of inoculation with nitrogen fixing bacteria Rhizobium spp was tested in an experiment with Leached Vertisol (FAO, 2006) from Bojurishte (Sofia district) at 60% and 40% water holding capacity of the soil. Fenugreek seeds were inoculated with three Rhizobium spp strains. Different strains showed different virulence in the conditions of the trial. Rhizobium strain No333 had the highest efficiency. Results showed that fenugreek inoculation led to increased plant yield at two water regimes. The seed yield was highest at the variant with 60% WHC and No333 strain inoculation. The crude protein content in seeds was higher in plants grown at 60% water holding capacity than in plants grown at 40% WHC. The macroelement contents (P, K, Ca, Mg) in seeds did not show significant differences. The best variant of growing fenugreek inoculated with strain No 333 Rhizobium spp at 60% water holding capacity of the soil could be recommended for future experiments.

Keywords: Fenugreek, Rhizobium spp, soil moisture, seed yield, protein yield

Introduction

Fenugreek (Trigonella phoenum-graecum) is an annual plant member of the legume family. It is currently widely grown in the world in regions with tropical and temperate climate: Mediterranean countries, India, China, Northern and Eastern Africa, North America and parts of Australia. The origin of the plant is from two geographical areas in the world: Eastern Mediterranean region and Indian subcontinent (Petropulos, 2002). India is the leading fenugreek producer in the world. Fenugreek leaves and seeds are consumed in different countries around the world for different purposes such as a spice, vegetable (young seedlings) and medicinal plant. Fenugreek seeds are used in making food (stew with rice in Iran, flavor cheese in Switzerland, syrup and bitter rum in Germany and United States, curries in India, mixed seed with powder with flour for making flat bread in Egypt, etc.) (Ahari et al., 2009, Basu et al. 2009, Slinkard et al., 2009). Roasted grains are coffee-substitute in Africa. As a medicinal plant fenugreek has anti-diabetic, lowering blood sugar and cholesterol level, anti-cancer, anti-microbial properties, immunostimulating activity, etc. (Petropoulos, 2002, Acharya et al, 2004, Lee, 2009, Tuncturk et al., 2011). Diosgenin (precursor of hormones in humans and animals) and 4-hidroxyisoleucine's content of fenugreek determine its important medicinal properties. In Bulgaria this plant is

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only known as an ingredient of the famous Bulgarian spice "sharena sol", as a conservant for meat and traditional Bulgarian meat products (Madjarova et al., 1989, Atanasova, 2011).

Fenugreek produces high forage yield and quality, it is a bloatfree legume, having animal growth promoting substances, not present in other forage legumes (phoenum-graecum means greek hay) (Acharya et al., 2008). Fenugreek can be a very useful legume crop for incorporation into short-term rotation, as a green manure (Tunkturk et al., 2011) and for hay and silage for livestock feed. Fenugreek is a rain-fed crop but responds well to minimum application of irrigation (Kumar et al., 2000, Acharya et al., 2008, Basu et al., 2009,). As a leguminous crop fenugreek realizes symbiosis with nodule bacteria Rhizobium (Moyer et al. 2003, Singh et al., 2008, Slinkard et al., 2009). Symbiotic nitrogen-fixation and enrichment of the soil with nitrogen could be increased through the inoculation of the seeds with specific Rhizobium spp strains. This is the way for decreasing farmer's expenses and producing good quality crops. Symbiotic system fenugreek – nodule bacteria Rhizobium spp in Bulgaria was not studied.

The objective of this study is to assess the effects of soil water regime and inoculation of fenugreek (Trigonella foenum-graecum L.) plants with different strains of nitrogen fixing nodule bacteria Rhizobium spp under pot trial conditions.

Material and Methods

A pot trial was carried out using Leached Vertisol (FAO, 2006) from Bojurishte, Sofia region. Soil was representative for the widely spread clay soils in Sofia region. The studied soil had the following agrochemical properties: pH_{KCl} – 6,0, soil organic matter - 4,04%, mineral nitrogen – 26,3mg.1000g^{-1}, mobile phosphorus – 55.0mg.100g^{-1}, mobile potassium - 98,3mg.100g^{-1}. In each pot with volumetric capacity 2 kg of air dry soil four plants of fenugreek were cultivated in four replications. The moisture was maintained at two levels – 60% and 40% water holding capacity (WHC) of the soil. In Bulgaria there are no fenugreek cultivars and native forms are grown. Three specific for the fenugreek strains of nodule bacteria Rhizobium spp cultivated in Soil microbiology department in Poushkarov Institute of Soil Science, Agrotechnology and Plant Protection in Sofia were studied. The fenugreek seeds were inoculated in a suspension of three-day old cultures of Rhizobium spp bacteria: strain No330, No331 and No333. The following parameters of plants were studied: height of plants (cm), number of nodules/pot, volume of nodules at the roots (mm^3), number of pods /pot, number of seeds/pot, weight of dry roots per pot (g), seed yield per pot (g). The content of N in dry mass of plants (leaves and stems) was determine by Kjeldahl digestion, macroelements: Ca, Mg – by atomic absorption spectroscopy, K - by flame photometry, P – by the method of Ivanov (1984). The content of crude protein was calculated – Nx6,25.

The virulence of the nodule bacteria (number and volume of the formed nodules) was determined at the bloom stage of the plants (the beginning of pod formation). The fenugreek was harvested at full maturity stage 70 days after sowing.

Data were processed statistically by Microsoft Office Excel.

Results and Discussion

Legume plants live in symbiosis with the nodule bacteria and this system may assimilate atmospheric nitrogen as a source of plant nutrition. Nodule bacteria Rhizobium are specific for the species of plant. According to Singh et al., (2008) the Rhizobium isolates were rod shaped, gram negative, acid and mucous producing and found to be temperature and pH sensitive. They have the potential to produce industrially important enzymes, amylase and cellulase. Rhizobium inoculation of fenugreek has been reported to increase the biomass of plant and seed production). Poi et al., (1991) inform that fenugreek may fix 48% of its total N_2 during the growing season. The results in Fig. 1 show the presence of naturally spread nodule bacteria of the Rhizobium spp in the soil - Leached Vertisol (FAO, 2006) from Bojurishte, Sofia region. At both soil moisture regimes the nodules were few in number and small in size and were situated along the lateral branching of the root system. This fact demonstrates the poor efficiency of the natural bacteria. At water regime 60% WHC bacterial strain No333 forms higher number of nodules -114.

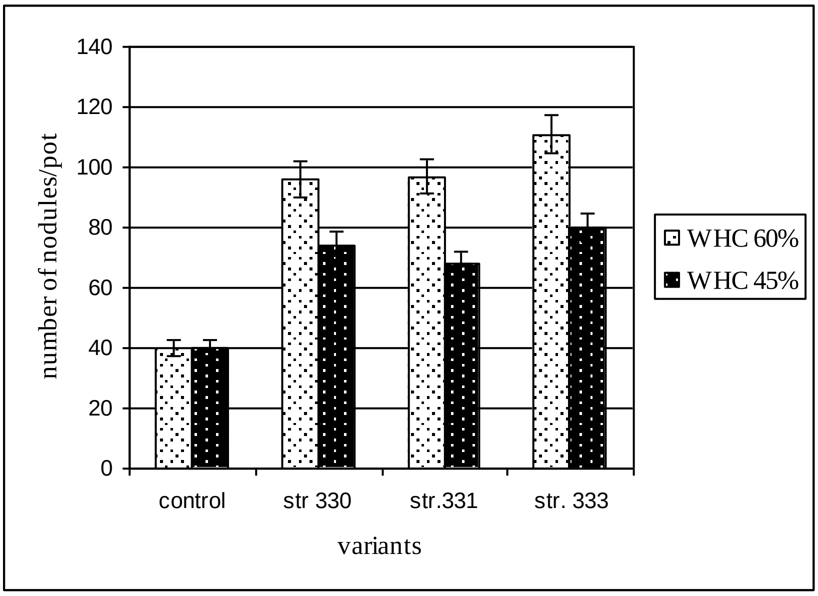

Figure 1 Virulence of different strains Rhizobium measured by number of nodules on the roots at two water regimes of the soil – WHC 60% and WHC 45%

This number is three times higher than the number of the nodules in the control without inoculation. Similar tendency was observed in the variants with lower water regime. The largest nodules were situated mostly on the main roots of the plants inoculated with strain No333 at 60% WHC, suggesting that the nitrogen fixation would be most intensive. In the variants with lower water regime, the number of nodules was lower in comparison with the higher water regime. This fact shows that higher soil moisture creates more favourable conditions for developing plant-bacteria system. With the volume of the formed nodules a similar tendency was observed. The measured volume of the nodules per one pot (mm^3) at field capacity 60% was as follows: for the non-inoculated control – 0,1; strain No330 - 0,5; strain No 331 - 0,4 and strain No330 -1,2mm^3 respectively. The data at field capacity 45% were: 0,1; 0,2; 0,2; 0,9 mm^3 for the same variants.

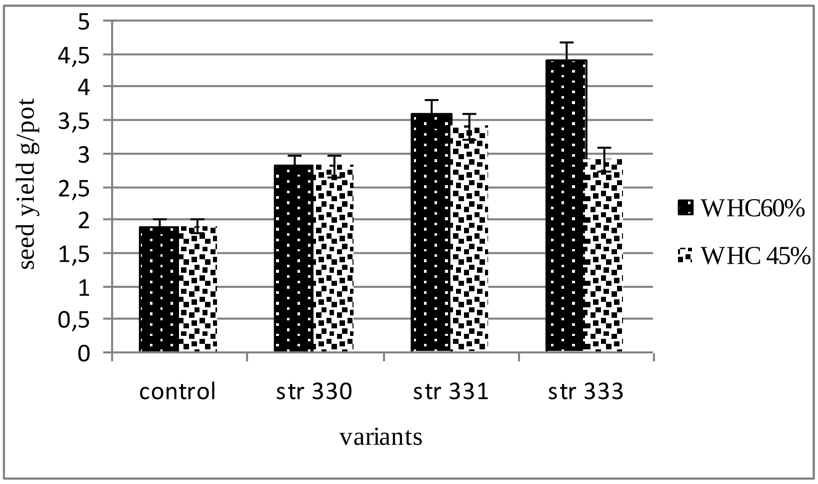

Figure 2. Yield of fenugreek seeds (g/pot) in dependence of inoculation with strains Rhizobium spp and water regime – WHC 60%, WHC 45%

Fig. 2 presents seed yield of the plants (g per pot). At 60% WHC the seed yield of the inoculated plants increased in comparison with the control. This fact proves the effectiveness of the used strains of Rhizobium. Greatest yield was observed with plants inoculated with strain No333 – 133%, followed by strain No331 – 89% and strain No330 – 47% , higher than the control at 60% WHC. At 45% soil moisture the yield increases in the plants with strain No330 and strain No331 (47% and 88% respectively). The rezults show that soil moisture does not affect the efficiency of the two studied Rhizobium strains – No330 and No331 in contrast to strain No333, which at 60% field capacity doubled the yield of the seeds. At stress conditions of low soil moisture the plants are depressed and the yield is lower. Strain No333 has high sensitivity to soil moisture. Rhizobium strains No330 and 331 could be determined as tolerant to soil moisture within 45-60% WHC.

Fenugreek has a high proportion of protein (approximately 20-30%) (Acharya et al., 2006, Tuncturk et al., 2011). The data in Fig.3 shows the content of nitrogen and protein in the seeds of fenugreek in %. The content of N in the seeds of plant changes between 3,70-4,55%. The inoculated plants have higher nitrogen and protein content than the control. The plants grown at 60% WHC nave higher nitrogen content of the seeds. Symbiotic system plant-bacteria under water stress is more effective and accumulate higher protein amount in the seeds. The protein content varies from 25,81 to 28,44% at 45%WHC and from 23,10 to 23,84% at 60%WHC.

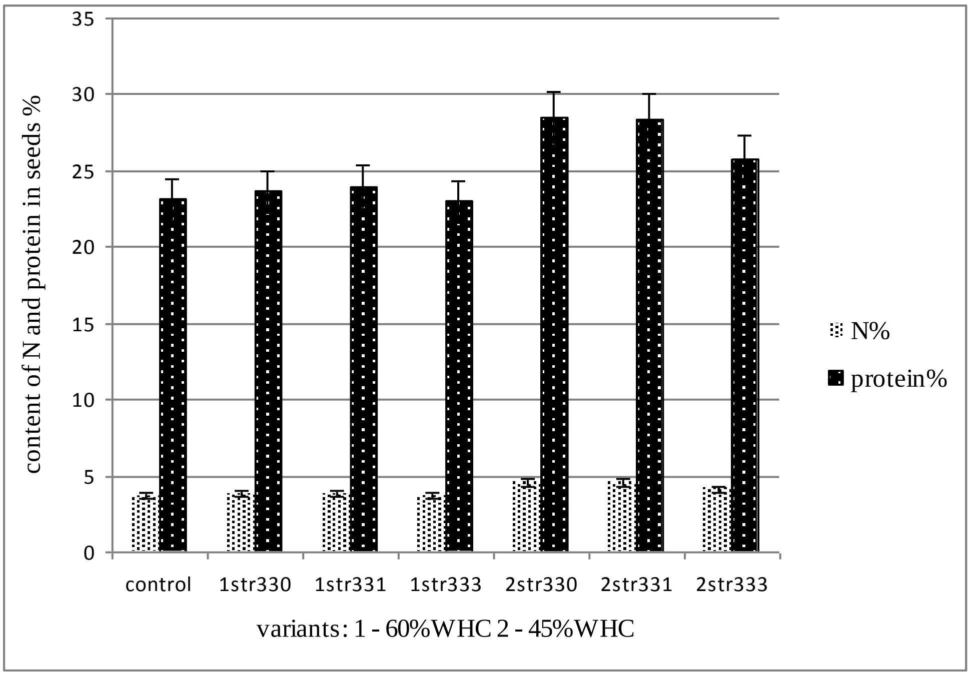

Figure 3. Content of N and protein in seeds of fenugreek (%) at different water regimes (1- 60%WHC, 2 - 45%WHC)

Table 1. Components of the yield of fenugreek (height of plants/cm, number of pods/pot, number of seeds/pot, weight of roots per pot/g)

Strain of Rhizobium spp	60% WHC				45% WHC			
	Heights of plants cm	Number of pods/pot	Number of seeds/pot	Weight of dry roots g	Heights of plants cm	Number of pods/pot	Number of seeds/pot	Weight of dry roots g
control	21,00	10	127	0,4	21,00	10	127	0,4
Str. No330	22,72	11	148	0,5	19,35	9	126	0,8
Str. No331	26,50	11	152	0,5	21.85	9	133	0,7
Str. No333	28,43	12	182	0,6	23,05	10	177	0.8

The results in Table 1 show changes in the studied components of the yield of fenugreek (height of plants, number of pods, number of seeds, weight of dry roots). The plants at 60% WHC are higher than these grown at WHC 45%. The comparison between the heights of the plants at two water regimes and inoculation with different strains of nodule bacteria Rhizobium spp shows the better results of No333 strain – 28,43 and 23.05 cm. In the respect of the value of the number of seeds per pod dependence is the same. The number of seeds of plants is higher in plants grown at more favourable conditions of soil moisture. Highest number of seeds have plants inoculated with strain No333. However, the values of the weight of the roots of fenugreek show the opposite tendency. Plants at lower soil moisture have heavier root weight in comparison with plants at 60%WHC. The values for dry mass of the roots are 0,7-0,8g and 0,5-0,6g respectively. It could be a reaction of fenugreek to the stress conditions of low soil moisture. Plants develop the large spreading root system in search of water necessary for living.

Figures 4A and 4B show values of the content of macronutrients P, K, Ca and Mg in the seeds - 4A and dry mass (leaves and stems) - 4B of the fenugreek. The content of P in seeds is about 0,60-0,66% and there are not differences between the variants. In leaves and stems P content is lower – 0,27-0,48% and the values for different soil moistures are different. At 60%WHC the content of P is higher (0,45-0,48%) than at 45%WHC (0,27-0,33%). In regard to K content in seeds there are not differences in the variants. In leaves and stems K values are higher than in seeds (2,95-3,36). The exception is the control with lower value -2,20% K. Ca content of fenugreek is quite different in the organs of the plants. The Ca content of seeds is several times lower than that of the dry mass of plants. In seeds Ca content is 0,18-0,28% whereas in leaves and stems the values vary between 3,0-3,43% for the variants of the trial. There are not significant differences between the variants. With regard to Mg content in the variants of the trial there are no significant differences. The seeds of plants contain about two times lower Mg (0,19-0,20) than the leaves (0,40-0,47%) – Fig. 4A - 4B.

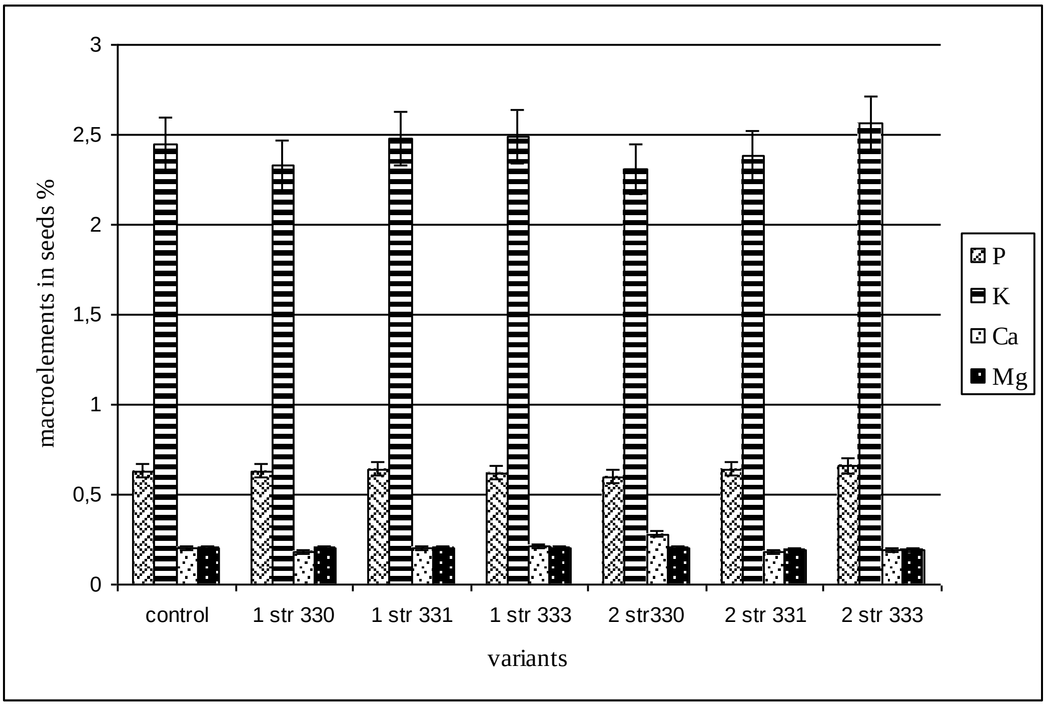

Figure 4 A. Content of macroelements P, K, Ca and Mg in seeds of fenugreek %

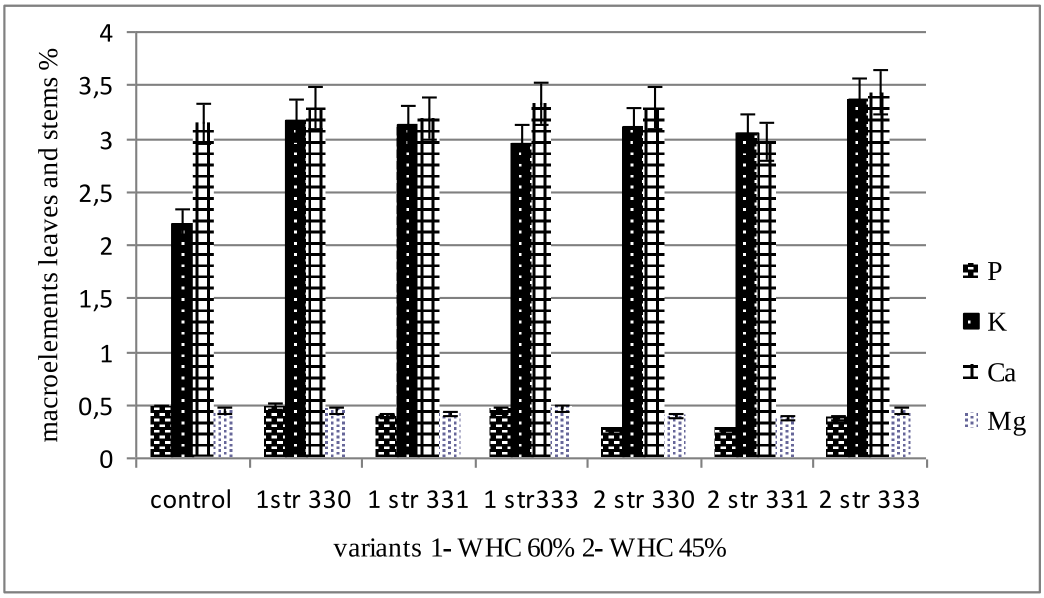

Figure 4 B Content of macroelements P, K, Ca and Mg in leaves and stems (dry biomass %)

Conclusion

Inoculation of fenugreek with specific strains of Rhizobium spp and the influence of different soil water regime on the growth of fenugreek plants in a pot trial has been studied. Treated by three different strains of nodule bacteria Rhizobium spp, plants develop more nodules at the roots in comparison to the control. These plants assimilate larger amount of nitrogen. Soil moisture 60% WHC is a more favourable water regime for growing fenugreek than 45% WHC. Studied indices: height of plants and yield of seeds are higher. Under the influence of different regimes of soil moisture, studied strains of Rhizobium show different sensibility. We conclude that at 60%WHC, plants inoculated with strain No333 show better characteristics. Strain No333 could be recommended for future investigations of fenugreek. Soil moisture and inoculation with nodule bacteria Rhizobium spp don't have a significant influence on the content of macroelements P, K, Ca and Mg in the dry biomass and the seeds of fenugreek.

References

Atanasova, E., 2011. Fenugreek as food and medicine. Zemedelie plus, 3-4, 44-45 (in Bulgarian)

Acharya, S., A. Srichamroen, S. Basu, B. Ooraikul, T. Basu, 2006. Improvement in the nutraceutical properties of Fenugreek (Trigonella foenum-graecum L.), Songklanakarin J. Sci. Technol., 28(1), 1-9.

Acharya, S., J. Thomas, S. Basu, 2008. Fenugreek, an alternative crop for semiarid regions of North America, Crop Science, vol. 48, 841-853.

Ahari, D., A. Kashi, M. Hassandokht, A. Amri, K. Alizadeh, 2009. Assessment of drought tolerance in Iranian fenugreek landraces, J. of Food, Agriculture and Environment, Vol.7 (3&4), 414-419.

Basu, S., S. Acharya, M. Bandara, D. Friebel, J. Thomas, 2009. Effects of genotype and environment on seed and forage yield in fenugreek (Trigonella foenum-graecum L.) grown in western Canada, Australian Journal of Crop Science, 3(6):305-314.

Ivanov, P., 1984. New acetate-lactate method for determination of available forms of P and K in soil. Soil Science and Agrochemistry, 19(4), 88–98 (in Bulgarian).

Kumar, V., J. Yadav, J. Singh, B. Yadav, 2000. Irrigation and Phosphorus Requirements of Fenugreek (Trigonella foenum-graecum L.) on Light Soil, Indian J. Agric. Sci. 70(8), 515-517.

Lee, E., 2009. Genotype X environtment impact on selected bioactive compound content of fenugreek (Trigonella foenum-graecum), MSc Thesis, University of Lethbridge, Canada.

Madjarova, D., N. Bijeva, M. Bubarova, 1989. Root and leaf vegetable plants as spices, 116-119 (in Bulgarian).

Moyer, J., S. Acharya, Z. Mir, R. Doram, 2003. Weeed management in irrigated fenugreek grown for forage in rotation with other annual crops. Can. J. Plant Sci. 83:181-188.

Petropoulos, G., 2002. Fenugreek. In Petropoulos, G.A. (Eds.), The genus Trigonella, Taylor and Francis, London and New York.

Poi, S., T. Basu, K. Behari, A. Srivastav, 1991. Symbiotic effectiveness of different strains of Rhizobium meliloti in selecting inoculants for improvement of productivity of Trigonella foenum-graecum. Environ. Ecol., 9, 286-287.

Singh, B., R. Kaur, K. Singh, 2008. Characterization of Rhizobium strain isolated from the roots of Trigonella foenum-graecum (fenugreek), African Journal of Biotechnology, Vol. 7 (20), 3671-3676.

Slinkard, A., R. McVicar, C. Brenzil, P. Pearse, K. Panchuk, S. Hartley, 2009. Fenugreek in Saskatchewan, Agricultural Ministry of Saskatchewan, Fact Sheet.

Tuncturk, R., A.E. Celen, M. Tuncturk, 2011. The effect of nitrogen and sulphur fertilizers on the yield and quality of fenugreek (Trigonella foenum-graecum L.), Turkish J. of Field Crops, 16(1), 69-75

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Mathematical model for evaluation of soil-ecological situation of mountainous province soils

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Abstract

Offered a math. model gives an opportunity to evaluate soil-ecological situation of soils of landscapes, under various points of view; that is, the assessment of changes of evaluation hierarchic associated/related soils of landscapes under various ecosystems; the evaluation of anthropogenic changes related with the irrigation projects in the area of new irrigation as towards of natural etalon which is distinguished by natural fertility appropriate its highest condition, as well as its initial condition; the evaluation of soil-ecological changes of ecosystems under the influence of natural processes for long-term period. Monitoring has been conducted in Butruc Cambisols and Chromic cambisols in elements of landscape, in various aquipratas, having ecosystems with hierarchic-evolutionary relationships. Introduced multiple-factorial math. model is used DBMS in MS Access. As an indicator of ecological evaluation of soil milieu, introduced math. model of calculating of ecological tension – K_{et} showing general condition of soil at the moment of measuring, adding direct and indirect factors registering changes. Methodological entity of conceptual model consists in identification of quantitative relationships between initial and recurrent monitoring which is summand from direct inert and functional parameters in general expression between ranges from 0 to 1. Depending on the selected etalon of soil and conditions of cultivation, coefficient of ecological tension occasionally goes beyond the range, that is it obeys the conditions $K_{et} > 1.0$. Inclusion of indirect parameters in this formula assures integrity of calculations and provides high level of adequacy in the math. model of calculation of soil environment`s K_{et}.

Keywords: Ecological monitoring, mathematical model.

Introduction

Quality of natural objects depends on conditions of landscape-ecological situation (LES), which is defined by S.V.Jikulin [4,6,7] as the set of natural-territorial complexes, reflecting custom nature human activities within a given natural object. Otherwise, the landscape-ecological situation is considered as a result of the interaction of natural and economic geosystems and most adequately reflected the totality of natural and anthropogenic factors, somehow determining the quality of the natural environment. LES is formed under the influence of natural and socio-economic conditions inherent in a particular area and a particular natural object.

The main parameters to evaluate the landscape-ecological state of natural objects, accepted bioindicator such features as the composition and structure phytocenosis, reserves and annual biomass growth, the pH of the chemical compounds and sulfates in the upper layer (0-20 cm) of soil. The performances of these features are

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compared with their respective baseline indicators. Changes in biomass indicates violations exist in the ecosystem.

Plant species composition of soil cover, forming under the influence of a set of random factors, ultimately, becomes not only a reflection of a particular landscape and ecological situation, but also points to the spatial and temporal variability and dynamics of natural objects. Virtually every type of plant community provides information on the ecological status of the territory. Knowing the optimal growing conditions of a given plant can be judged on the basic processes in the natural territorial complexes. When this is not only important consideration the presence or absence of the form, but the extent of his involvement-abundance in the formation area, tiers, etc.

In practice bioindicative research as rapid evaluations are widely used fitoindikatory some constants [8]. The use of them greatly facilitates the analysis of complex environmental factors and human impact. However, it should be remembered that the plants do not have the adaptability to anthropogenesis. The same biological response may be caused by both natural and man-made gene factors. It must be also taken into consideration the law of substitution vegetation Alekhine, the existence of partial compensation of environmental factors and their synergism and antagonism, the impact on the general geographic zonal processes, especially, floristic composition phytocenoses.

Material and Methods

The object of research is mountain-forest butruc cambisols and mountain-brown forest soils but also ecosystems with evolutionary hierarchy linked ecosystems respectively, mountain-forest steppe brown, mountain-brown after forest soil southern slope of Greater Caucasus found in Governing Body subordinate Ismailli district.

Existing methods of system analysis of soils and environmental monitoring of soils, whereby to provide a comprehensive summary of the proposed development parameters including in the formula for calculating soil inert and functional parameters.

Monitoring soil ecological condition existing at the time of measurement of soil and alluvial fan of the river of Geokchay, irrigated soils of the southern slope of mountain areas of Caucasus points to the need for the implementation of fundamental analysis results of the monitoring required to develop multivariate mathematical models using DBMS.

Conceptual basis of a mathematical model for determining the quantitative development of the basic parameters of a certain historical period. Provides certain summary parameters between the natural soil-ecological model of employment higher vegetation corresponding to its high ecological status of prosperous-natural analogue models and subjected to anthropogenic influence. [1,2,3,5]

Representation of the factors and parameters to ensure the sustainability of soils to differentiate anthropogenic impacts on direct (stable), expressing the chemical, physical; biological properties (density, humus, etc.) and functional (pH, Eh, pF, SAC, salinity, alkalinity), characterizing the dynamic natural and anthropogenic processes. Indirect factors include climatic data, terrain, time.

As an indicator of the environmental assessment of soil condition we propose a mathematical model that expresses the general condition of the soil at the time of measurement, the term of the direct and indirect factors fixing changes. Dynamic indicator ensures that the values of this parameter with respect to genetic soil type, and has a dominant position occupied by their corresponding natural cenoses prosperous high ecological status.

$$\hat{E}_{et} = d_v^e + H_e + P_{Na}^e + S^e / [d_v^f + H_f + \ln(P_{Na}^f / d_v^f C_{si}) + \ln(S_f / S_e)]$$

где, K_{et} – the coefficient of ecological tension of soil environment; d_v^e – soil density, gr/sm^{-3}; H_e – humus content, %; P_{Na}^E – content of *Na* consisting in absorptive complex of soil (SAC), meq 100 g of soil; S^E – salinization of soils under appropriate by natural vegetation, %; d_v^f – плотность почвы в момент измерения, г см$^{-3}$; H_f – humus content of the soil at the time of measurement, %; P_{Na}^f – content of *Na* consisting in (SAC), at the time of measurement), mekv 100 g of soil; S^f – salinization of soil corresponding to the time of measurement (actual values), %; C_{si} – the coefficient expressing content of silt fraction at the time of measurement.

Coverage of parameters included into formula are represent all complex of soil indicators, both direct and indirect. Direct as a density (d_v^e, d_v^f), humus content (H_e, H_f), content of silt fractions (C_{si}) are characterize the changes occurring in the soil environment for a long period of time and are therefore called inert.

Direct functional soil processes are characterized by parameters soil salinity (S^e, S^e), solonetzicity (P_{Na}^e, P_{Na}^f), in other words, the content of *Na* in (SAC), which is the main classification criteria of soil alkalinity.

Indirect soil parameters are scalar derivatives and their influence on specific soil processes impalpable, i.e., existing studies do not provide methods for studying elementary soil processes in the time domain, only the final results are used, the actual performance, neglecting the values of the intermediate stages.

Occurrence of indirect parameters in the formula ensures the integrity of the calculations, but causes inconsistency with the existing system of units of formulas calculating the parameters included in the mathematical model. This circumstance causes a lack of surrogates in the composition of the mathematical model for calculating the coefficient of environmental stress of the soil environment.

Methodological essence of the conceptual model is to determine the quantitative relationships between the initial and repeated monitoring of direct summands inert and functional parameters in cumulative terms in the range of 0-1

Depending on the soil and the standard conditions of its cultivation (raising domesticated completely) environmental stress factor is out of range, that is, subject to the conditions K_{et}>1

Mathematical model allows us to estimate the soil-environmental sustainability of soil landscape from different angles, i.e.: assessment of evolutionary change-related hierarchically subordinate landscape soils under different ecosystems; assessment of anthropogenic changes in connection irrigation projects in the area of new irrigation, both in terms of natural standards released by natural fertility corresponding to its higher state, also on the initial state of the soil; soil-ecological assessment of ecosystem change under the influence of natural processes over a long time.

Results and Discussion

A more thorough analysis of the proposed mathematical model shows the suitability of the formula terms of soil-environmental changes and assess the sustainability of the soil to external influences. The results of these changes are shown below.

Assessing the impact of evolutionary changes, that is the change forestry (high-necks) on the steppe vegetation (grass) on the proposed formula makes it possible to assess the overall condition of the soil and environmental conditions prevailing after the change of ecosystem covering a fairly long period of mining and forest brown typical, mountain-forest brown soils steppe (Table).

Evaluation of soil and environmental changes in relation to the conduct of soils in the agricultural landscape rotation is characteristic of the situation in terms of our republic. It occurred on the territory of Shirvan steppe in relation to the implementation of large irrigation projects during the construction of hydroelectric complex of Mingachaur. As a result, the area of irrigated land occupies two thirds of the central and western area of the steppe.

Researches of the application of mathematical models to estimate soil-ecological situation in the conditions of intensive farming using irrigation, showing the consistency of the formula to track the dynamics of (qualitative and quantitative) changes in the soil environment and soil phase, genetic development and change of soil processes (Table).

Table. Evaluation of soil-ecological status of mountain-forest and mountain brown steppe soils evolutionary stages of development

Soil tipe	Thickness, m	Density gr sm^3	Humus, %	Silt, <0.001 mm, %	SAC, mekv	TDS, %	K_{et}
Mountain-forest butruc cambisols (forest)	0,2 0,5	1,02 1,12	4,12 1,48	4,38 1,74	11,79 4,41	0,04 0,02	0,746
Mountain-forest butruc cambisols (after forest)	0,2 0,5	1,12 1,21	7,54 1,76	8,68 1,98	17,94 17,94	0,07 0,02	0,585
Mountain-brown (forest)	0,2 0,5 1,0	1,18 1,25 1,27	2,71 2,12 1,58	6,70 6,28 6,04	20,81 17,27 11,93	0,17 0,15 0,14	0,893
Mountain-brown (after forest)	0,2 0,5 1,0	1,12 1,21 1,30	2,93 2,18 1,59	7,07 6,75 5,47	30,11 26,53 24,82	0,20 0,15 0,15	0,716

Conclusion

Offered a math. model gives an opportunity to evaluate soil-ecological situation of soils of landscapes, under various points of view; that is, the assessment of changes of evaluation hierarchic associated/related soils of landscapes under various ecosystems; the evaluation of anthropogenic changes related with the irrigation projects in the area of new irrigation as towards of natural etalon which is distinguished by natural fertility appropriate its highest condition, as well as its initial condition; the evaluation of soil-ecological changes of ecosystems under the influence of natural processes for long-term period.

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References

1. Mammedov G.Sh. Environmental assessment of soils of agricultural and forest lands of Azerbaijan / Author's abstract of the dissertation of the doctor of biological sciences, Dnepropetrovsk, 1991, 32 p (in Russian).
2. Mammedov G.Sh. Ecological models of fertility major soil types in Azerbaijan // Az.NRIHM, Baku: 1992, 26 p (in Russian).
3. Mammedov G.Sh., Hasanov V.G., Manaphova F.A. Soil and environmental analysis of soil cover Apsheron // Materials of the Soil Science Society of Azerbaijan. c. X, p. I, Baku: Sci, 2005, p. 62-71 (in Russian).
4. Jekulin V. S. Main directions of landscape-ecological research / Abstracts of the conference « Theoretical and applied problems of landscape»: L., 1988 (in Russian).
5. Israil J. A. Ecology and control of the natural environment // Moscow, Gidgometioizdat, 1984, 560 pp (in Russian).
6. Isachenko A.G., Isachenko G.A. Landscape-geographical principles for assessing the ecological state of the environment / / Geography and Present, Vol. 7, L. 1995 c (in Russian).
7. Karpachevskiy L. O. The diversity of soil in forest ecosystems / Moscow, 1997 (in Russian).
8. Modern methods for assessing the ecological environment: Proceedings of the work session UC SPSU / Ed. V.N. Movchan. St. Petersburg., 1998 (in Russian).

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Biological soil degradation

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Abstract

Soils contains a large number of various living organisms such as nematodes, protozoa, fungi, algae, actinomycetes, bacteria and cyanobacteria, and all these living communities is an important element of the soil ecosystem. These organisms are involved in many important events such as nutrient cycling, decomposition of organic matter, soil carbon sequestration; modify soil physical structure and regulation of water regime. Biological soil degradation means that the significant reduction in population of microorganisms or absence in the soil due to changes in the biochemical processes occurring in the soil ecosystem. Environmental factors that temperature, moisture acidity as well as human activities such as agricultural practices have lead to soil biodegradation. Considering all these important functions of microorganisms in the soil that can be said, biological soil degradation is undesirable. To avoid this situation, primarily better understanding of the biological deterioration indicator in the soil, then it is necessary to analyze the factors which cause. In this review, based on earlier studies, indicators of soil biodegradation will be examined, the factors that cause it to be released and how it effects on soil activities and agricultural practices will be discussed.

Keywords: Soil, microorganisms, fertility, degradation.

Introduction

Soil, due to nutrition's it contains and nutrition cycle which provides reproduction of these, is an environment which feeds and hosts living beings under and on top of it. Therefore, soil is an entirely ecosystem together with living and non-living things under and on top of it. This ecosystem was formed as a result of equilibrium and adaptation with other factor of the environment. Today, about 10.000 years ago with the beginning of human agriculture and animal husbandry have started to degradation this ecosystem and that degradation of this ecosystem for a long time did not reach dangerous levels (Yıldız, 1996).

The term 'Soil Degradation' refers to processes that cause a reduction in its capacity to produce goods and services for needs and benefit of current and future generations. Soil degradation is undesirable since it result in land becoming less useful and productive. The ability of soil to support plants and animals declines due to reduction in its capacity to retain and supply adequate moisture and nutrients required for optimal growth of crops. It is therefore, important that we understand what causes soil degradation and what is required to prevent soil degradation for sustained agricultural productivity and related services that the soil provides (PACA, 2010).

Soils contain enormous numbers of diverse living organisms assembled in complex and varied communities. Microscopic examination of a soil sample reveals the presence of billions of organisms like nematodes, protozoa, fungi, algae, actinomycetes, bacteria and cyanobacteria. These diverse organisms interact in the

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ecosystem, forming a complex web of biological activity. Environmental factors, such as temperature, moisture and acidity, as well as human activities such as agricultural and forestry management practices, affect soil biological communities and their functions. Soil biology is an interesting area of soil research and has yielded considerable information that is used in soil fertility management (Mishra and Dhar, 2004).

Soil microorganisms play key roles in cycling of nutrients, decomposition of wastes and residues, and detoxification of pollutant compounds in the environment. Factors that affect these organisms have received attention in recent years. Biological degradation of soil refers to the impairment or elimination of one or more "significant" populations of microorganisms in soil, often with a resulting change in biogeochemical processing within the associated ecosystem. "Significant" microorganisms are those for which an ecologically significant role is understood (Lal and Stewart, 1990).

When considered all these significant functions of microorganisms, it is clear that biological degradation in soil is an undesirable situation. Biological degradation occurring in soils affects significantly fertility of soils. Biological degradation occurring in soil significantly affect on soil productivity. In this review, biological degradation indicators in soils, factors which affects (triggers) biological degradation factors and subjects which are to be considered in order to prevent these factors will be investigated.

1. Biological degradation of soil

Soils are a habitat to a large variety of flora and fauna that constitute a significant part of our biodiversity resource. Organic matter is the main food base of living organisms in the soil and soil organisms perform vital functions that contribute to sustained productivity of soils. Reduced recycling of organics through the soil is the primary factor leading to a decline in the extent and diversity of living organisms within it. Agricultural practices that do not emphasize integrated nutrient management involving the optimum use of on-farm residues together with such practices as tillage, burning of crop residues etc. cause depletion of organic matter and in turn result in loss of a soil's biological population (Figure 1) (PACA, 2010).

Soil biological degradation is the loss of biodiversity and optimum proportion of different species of soil mesofauna and microorganisms; and soil contamination by pathogenic microorganisms (Snakin et al., 1995).

Living organisms in the soil play the key role in cycling nutrients, in decomposition of organic debris in soils, in detoxification of pollutants, and in suppressing pathogenic microorganisms. Microbiological tests often provide early diagnosis. They can be used to quickly assess an anomaly in the soil functioning even after a slight change of the environment. Therefore the content of the active microbial biomass is used as an informative indicator of soil biological function. Biological pollution of soil can be characterized by the content of pathogenic microorganisms. Soil phytotoxicity is an indicator of biological function. The indicator depends on the total soil pollution and the content of phytopathogenic and toxicogenic microorganisms (Snakin et al., 1995).

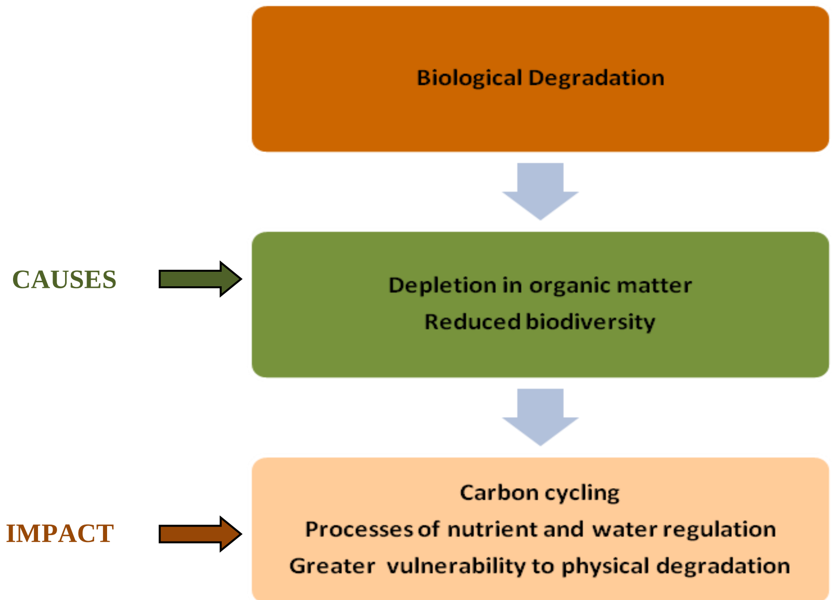

Figure 1. Some Causes and Impacts of Biological Degradation (PACA, 2010)

Indicators of biological degradation in soil

One of the major integral indicators of soil degradation is the reduction in quantity and quality of soil production. However, since soil productivity (yield) is a result of many natural, social, and economic factors, the interpretation of the yield indicator is not simple. The lowering of bonitet which is usually defined to make economic assessment of the soil can also indicate the degree of soil degradation but it is difficult to use because of the lack of a single system of classification of soil quality (Snakin et al., 1995). Some of the biological indicators of soil degradation are given below.

- Community diversity can be used to assess perturbation of soil biology. Bacteria and fungi can be evaluated by 'viable count' methods; most involve plating on nutrient-rich agar. These methods are, however, controversial and sometimes provide erroneous results. Biodiversity of soil microbial communities can also be assessed by various mathematical indices that emphasize richness (number of species), equitability (evenness of allocation of individuals among the various species), or combinations of these two aspects (Mishra and Dhar, 2004).
- Nutrient cycling can be indexed by measurement of soil enzymes, various components of the nutrient cycle, cellulose or wood degradation, and respiration (Mishra and Dhar, 2004).
- Accumulation of pollutants; toxins may accumulate if soil microbial life is degraded. The soil's ability to dechlorinate organic compounds can be impaired, especially in sulfate-rich anaerobic environments. Heavy application of animal wastes to low-pH soils can lead to buildup of ammonium ions and a concomitant reduced functioning of Nitrobacter, which would lead to nitrite accumulation (Mishra and Dhar, 2004).
- Redox status; anaerobic conditions can arise as a result of compaction or water logging. Oxygen diffusion is only 1/10,000 as fast through water-filled soil pores as it is through air-filled pores. Production of large amounts of methane would indicate the strongly reducing conditions associated with anoxia (Mishra and Dhar, 2004).

2. Determination of the degree of biological soil degradation

Biological soil degradation is evaluated by:

- The content of active microbial biomass,
- Phyto- and genotoxicity, and
- The number of pathogenic microorganisms.

The content of the active microbial biomass is determined by the methods reported by Anderson and Domsch (1978). The degree of soil degradation is evaluated by the decrease of the content of active microbial biomass relative to a standard. The non-degraded soil has a less than five-fold decrease and the very highly degraded soil has a more than one hundred-fold decrease in biomass (Snakin et al., 1995).

Soil phytotoxicity is estimated by the method of “soil plates”, that is, the reduction of the number and height of seedlings in relation to non-disturbed soil (Yevdokimova et al., 1984; Zvyagintzev et al., 1989). The decrease of germinating capacity and length of the seedlings in non-degraded soil is less than 1.1 times lower than in non-disturbed soil (Snakin et al., 1995).

Genotoxicity of soil is apprised by the increase of the number of gene mutations in comparison with non-disturbed sites. Genotoxicity is evaluated in short-term tests (Fonstein et al., 1977; Anonymous, 1989). In non-degraded soil the number of mutations is up to 2 times higher than in standard (non-disturbed) soil and in very highly degraded soil mutations are more than 1000 times higher than the standard (Snakin et al., 1995).

The number of pathogenic microorganisms contained in 1 gram of soil is estimated by standard methods (Mishustin et al., 1979). The standard is 1000/g of soil (Snakin et al., 1995).

3. Factors affecting biological degradation of soils

Toxic Substances

Organic compounds are usually more speedily and readily degraded in warm rather than cold climates. Toxic metals, on the other hand, can remain in soils and cause long-term damage to soil microbial communities, even in warm climates (Mishra and Dhar, 2004).

Toxic organic and inorganic pollutants can result from chemical synthesis, coal mining, and petroleum processing. Organic pesticides show less dramatic effects on soil microbiology than do other classes of toxic organics. Oil spills in cold regions cause long-term damage to soil microbial populations, including adverse effects on carbon (e.g., cellulose degradation) and nitrogen cycling (especially nitrification and nitrogen fixation). Contamination by heavy metals (e.g., Cd, Cu, Ni, Pb, Zn) can cause long-term suppression of carbon cycling, microbial biomass, nitrogen fixation, nitrification, dehydrogenase activity, and mycorrhizal incidence (Mishra and Dhar, 2004).

Toxic metals can be abundant in some sewage sludges. Microbes can mobilize and increase the toxicity of cadmium, perhaps by producing water-soluble ligands or otherwise changing soil properties. Acidification can occur when excavation of ores containing iron sulfides leads to oxidative production of sulfates. Discharge waters from mine spiels may have pH values of 1-2, and can result in severe problems related to soil biology. Waters draining from coal mines and associated spiels can be high in potentially toxic metals like Zn, Cu, Ni, or Mn (Mishra and Dhar, 2004).

Tillage

Soil erosion has conventionally been perceived as one of the main causes of land degradation and the main reason for declining yields in tropical regions. Intensive or inappropriate tillage practices have been a major contributor to land degradation. The last four decades has seen a major increase in intensive agriculture in the bid to feed the world population more efficiently than ever before. In many countries, particularly the more developed countries, this intensification of agriculture has led to the use of more and heavier machinery, deforestation and land use changes in favour of cultivation. This has led to several problems including loss of organic matter, soil compaction and damage to soil physical properties. Soil tillage breaks down aggregates, decomposes soil organic matter, pulverizes the soil, breaks pore continuity and forms hard pans which restrict water and air movement and root growth. On the soil surface, the powdered soil is more prone to sealing, crusting and erosion. Improving soil physical fertility involves reducing soil tillage to a minimum and increasing soil organic matter (Sharma and Abrol, 2012).

When it is considered that if soil physical properties are improved well, microbial development of soil would identically increase, the effect of tillage on soil physical properties is considerably important in terms of biological degradation. For example, earthworms thrive where there is no-tillage–generally, the less tillage, the better, and the shallower the tillage, the better. Worm numbers can be reduced by as much as 90% by deep and frequent tillage. Tillage reduces earthworm populations by drying the soil, burying the plant residue they feed on, and making the soil easier to freeze. Tillage also destroys their vertical burrows and can kill and cut up the worms themselves. Emergence times for young worms are spring and fall–their most active periods just when most farmers are interested in tillage. Worms are dormant in the hot part of the summer and the cold of winter (Sullivan, 1999). Table 1 show that the effect of tillage and cropping practices on earthworm numbers (Kladivko, 1995).

Table 1. Effect of crop management on earthworm populations (Kladivko, 1995).

Crop	Management	Worms/foot2
Corn	Plow	1
Corn	No-till	2
Soybean	Plow	6
Soybean	No-till	14
Bluegrass/clover	---	39
Dairy pasture	---	33

Fertilization

Soil protection and balance development between all characteristics of the soil is the key factor to ensure optimum microbe growth and sustainable utilization of the agricultural ecosystems. For example conventional sunflower production utilizing tillage, commercial fertilizer applied through pesticides, and irrigation can improve the grain yield. However, this intensive production system also can degrade soil biological quality (Rice et al., 2001). Alternative systems have been developed that use renewable organic resources and minimize tillage to build soil organic matter and enhance soil quality. Fertilization is one of the soil and crop management practices, which exert a great influence on soil biological quality (Chander et al., 1998). Farmyard manure and compost are organic sources of nutrients that also have been shown to increase soil organic matter and enhance soil quality. It is well known that organic amendments, such as plant residues, manures and composts have a number of benefits in soil physical and biological properties (Mohammadi, 2012).

In a study performed in two types of mulch was applied. Both mulches also substantially increased microbial biomass, as indicated by a doubling of soil respiration (Figure 2). These results are consistent with the hypothesis that soil microbes are carbon limited, and that the addition of organic carbon can increase microbial biomass in the soil (Herms et al, 1999).

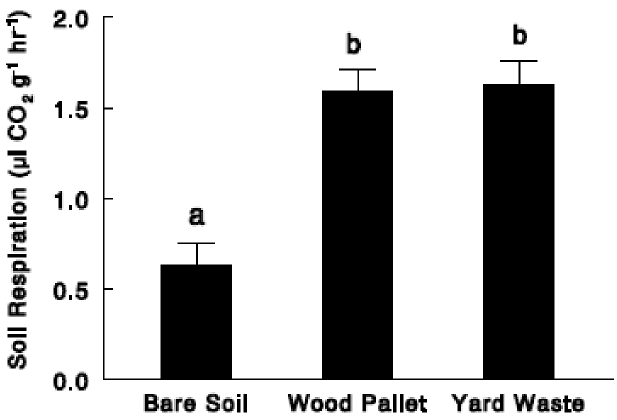

Figure 2 Effects of mulching with composted yard waste and recycled wood pallets on soil respiration (Herms et al. 1999)

Salinity

Salinity and/or sodicity are common problems under irrigated agriculture especially in areas of low rainfall and high evaporative demand (Sumner, 1995). Poor irrigation and drainage management are normally the main causes of salinisation and as the water table rises, salts dissolved in the ground water reach and accumulate at the soil surface through capillary movement. Formation of salt-affected soils is considered the main factor leading to soil degradation (Van Antwerpen and Meyer, 1996; Haynes and Hamilton, 1999).

While the effects of salinity and sodicity on soil chemical and physical properties and plant growth are well known, their effects on soil microbial processes remain relatively unstudied. Indeed, several recent comprehensive reviews on the effects of salinity and sodicity on soil properties do not include their effects on soil microbial and biochemical activity (Sumner, 1995; Keren, 2000; Levy, 2000). Some research has been carried out in naturally saline soils but little is known regarding the effects of sodicity. Where salinity has been induced, results have been rather contradictory and both increases and decreases in mineralization of C and N have been reported (Singh et al., 1969; Laura, 1974; Nelson et al., 1996; Pathak and Rao, 1998). Since organic matter and soil microbial activity are typically concentrated in the top few centimeters of soil changes in chemistry near the surface (such as increased salinity) could greatly affect soil microbial activity. Microbial biomass C decreased with increasing values for E.C. (Figure 3). This also shows that microbial growth affected negatively with increasing salinity (Rietz and Haynes, 2003).

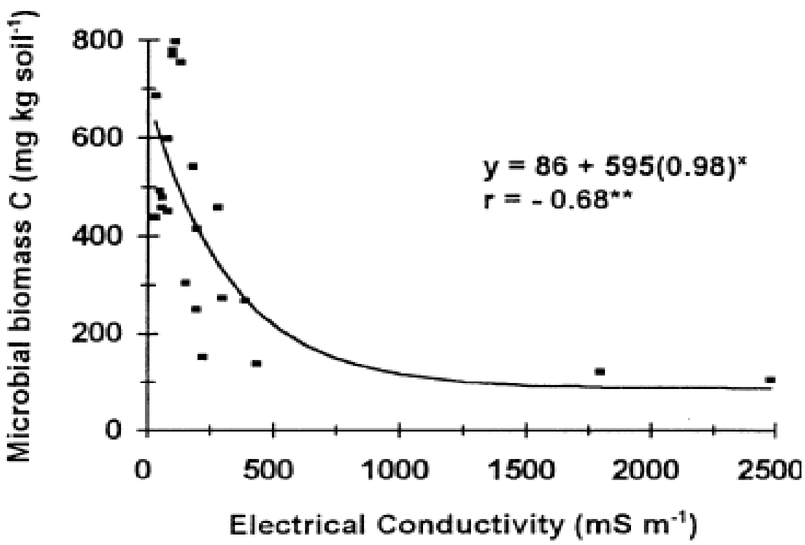

Figure 3 Relationships between microbial biomass C and E.C. (Rietz and Haynes, 2003)

pH

One of the most influential factors affecting the microbial community in soil is pH. Soil pH strongly influences abiotic factors, such as carbon availability, nutrient availability, and the solubility of metals. In addition, soil pH may control biotic factors, such as the biomass composition of fungi and bacteria, in both forest and agricultural soils. An inherent problem in studying soil pH effects is its varied influence on multiple parameters (Rousk et al., 2009).

Although pH is a master variable, the causal relationship between pH and soil biological activity is rarely studied. Studies have been conducted to observe the correlations between diverse soil properties and soil biological activities; however no conclusions about the effect of pH can be drawn, since these studies were not controlled experiments to observe the pH effect as an independent variable (Wang et al, 2006).

Conclusion

Organic practices also enhance biodiversity. Large organic fields (over 15 ha area) has exhibit occurrence of wild flora up to six times more abundant than conventional fields. In organic grassland, the average number of herbs is 25 percent more than in conventional grasslands. Vegetation structure and plant communities in organic grasslands are more even than in conventionally managed systems (Mishra and Dhar, 2004).

Increasing population pressure, unsustainable use of natural resources, continuing loss of farm land for non-agricultural uses and continuing destruction of ecosystems rich in biological diversity are all leading to a situation where ensuring food security may become a serious challenge. Strip mining and metal contamination are serious threats to soil microbial communities, as is the application of pesticides. Remediation of damage caused may require long time. Injudicious use of natural resources, mining for exploitation of earth reserves and industrialization is depleting soil organic matter which in turn may be eroding soil biodiversity and in long term affecting soil fertility and agriculture productivity (Mishra and Dhar, 2004).

In our review, how important microorganisms which live in the soil with harmony and balance has been mentioned. In addition, because of there are a lot of factors that affect microorganisms; it shows that keeping their balance and indentifying them are too difficult. However, if not careful the balance of the soil microorganism population which caused soil biological degradation, there will be very detrimental effects in the long term. In addition, ameliorate of the damage occurring in soil will require very long and difficult processes. Therefore, organic and sustainable agriculture practices should be increased to prevent the biological degradation of soil.

References

Anderson, I. and Domsch, K., 1978. Physiological methods for the quantitative measurement of microbial biomass in soil. Soil Biology&Biochemistry. (3): 215-221.

Anonymous, 1989. Guidelines on Short-Term Testing for Revealing Mutagenic and Carcinogenic Chemical Substances. WHO, Geneva, 212 pp.

Chander K, Goyal S, Nandal DP, Kapoor KK 1998. Soil organic matter, microbial biomass and enzyme activities in a tropical agroforestry system. Biology and Fertility of Soils 27, 168- 172.

Fonstein, L., Abelev, S., Bobrinev, E. and Kalinina, L., 1977. Testing Systems for Estimation of Mutagenic Activity of Environmental Pollutants. Methodic Guidelines. Medicina, Moscow, 89 pp. Russia.

Haynes, R.J., Hamilton, C.S., 1999. Effects of sugarcane production on soil quality: A synthesis of world literature. Proceedings of the South African Sugar Technologists Association 73, 45–51.

John E. Lloyd, Daniel A. Herms, Benjamin R. Stinner, and Harry A. J. Hoitink. 1999. Effects of Organic Mulches and Fertilization on Soil Microbial Activity, Nutrient Availability, and River Birch Growth. Ornamental Plants - Annual Reports and Research Reviews. http://ohioline.osu.edu/sc173/sc173_12.html

Keren, R., 2000. Salinity, Handbook of Soil Science, CRC Press, Boca Raton, pp. G3–G25.

Kladivko, Eileen, J. 1995. Earthworms and crop management. Agronomy Guide, AY-279. Purdue University Extension Service, West Lafayette, in. 5 p.

Lal, R. and Stewart, B.A. 1990. Adevences in Soil Science, Soil Degradation, Volume 11, pp 289-330, Newyork.

Laura, R.D., 1974. Effects of neutral salts on carbon and nitrogen mineralization of organic matter in soil. Plant and Soil 41, 113–127.

Levy, G.J., 2000. Sodicity, Handbook of Soil Science, CRC Press, Boca Raton, pp. G27–G63.

Mishra,U. and Dhar,D,W. 2004. Biodiversity and Biological Degradation of Soil, Indian Agricultural Research Institute New Delhi 110012, India.

Mishustin, Y., Pertzovskaya, A. and Gorbov, V., 1979. Sanitary Microbiology. Nauka, Moscow, 304 pp. Russia.

Mohammadi, K. 2012. Effects of Fertilization and Tillage on Soil Biological Parameters, International Conference on Ecological, Environmental and Biological Sciences, Dubai.

Nelson, P.N., Ladd, J.N., Oades, J.M., 1996. Decomposition of 14Clabelled Plant Material in a Salt-Affected Soil. Soil Biology and Biochemistry 28, 433–441.

PACA Education Series 2010. Soil Degradation, Education Series, Professional Alliance of Conservation Agriculture.

Pathak, H., Rao, D.L.N., 1998. Carbon and Nitrogen Mineralization from Added Organic Matter in Saline and Alkaline Soils. Soil Biology and Biochemistry 30, 695–702.

Rice P.J., McConnell L.L., Heighton L.P., Sadeghi A.M., Isensee A.R., Teasdale J.R., Abdul-Baki A.A., Harman-Fetcho J.A., Hapeman C.J. 2001. Runoff loss of pesticides and soil: a comparison between vegetative mulch and plastic mulch in vegetable production systems. Journal of Environment Quality 30, 1808–1821.

Rietz, D.N and Haynes, R.J. (2003), Effects Of İrrigation-İnduced Salinity and Sodicity on Soil Microbial Activity, Soil Biology & Biochemistry 35 845–854, South Africa.

Rousk, J., Brookers, P. C. and Baath, E. 2009. Contrasting Soil pH Effects on Fungal and Bacterial Growth Suggest Functional Redundancy in Carbon Mineralization, Applied and Environmental Microbiology. 1589–1596.

Sharma, P. and Abrol, V. 2012. Tillage Effects on Soil Health and Crop Productivity: A Review, Crop Production Technologies, India.

Singh, B.R., Agarwal, A.S., Kanehiro, Y., 1969. Effect of Chloride Salts on Ammonium Nitrogen Release in two Hawaiian Soils. Soil Science Society of America Proceedings 33, 557–568.

Snakin, V.V. 1995. The System of Assessment of Soil Degradation, Russia.

Sullivan, P. 1999. Sustainable Soil Management, Appropriate Technology Transfer for Rural Areas, Arkansas.

Sumner, M.E., 1995. Sodic soils: new perspectives. In: Naidu, R., Sumner, M.E., Rengasamy, P. (Eds.), Australian Sodic Soils: Distribution, Properties and Management, CSIRO, Melbourne, pp. 1–34.

Van Antwerpen, R., Meyer, J.H., 1996. Soil Degradation under Sugarcane Cultivation in Northern KwaZulu-Natal. Proceedings of the South African Sugar Technologists Association 70, 29–33.

Wang, A. S., Angle, J. S., Chaney, R. L., Delorme, T. A. And McIntosh, M. 2006. Changes in Soil Biological Activities under Reduced Soil Ph during Thlaspi Caerulescens Phytoextraction, Soil Biology & Biochemistry 38 1451–1461, USA.

Yevdokimova, G.A., Kislyx, E.E. and Mozgova, N.P., 1984. Biological Activity of Soil in the Conditions of Aero-Technogenic Pollution in the North. Nauka, Leningrad, 120 pp. Russia.

Yıldız, N. 1996. Tarımsal Faaliyetlerin Etkileri, Atatürk Üniversitesi Ziraat Fakültesi Dergisi, 27 (2), 324-333, Erzurum.

Zvyagintzev, D., Guzev, V and Levin, M., 1989. Diagnostic Indicators of Different Levels of Soil Pollution by Oil. Pochvovedenie, 1: 72-78 Russia.

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Determination of the some soil fertility status of Rhizomatous Iris (Iris spp.) plant grown in flora of Turkey

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Abstract

This study was carried out to determine fertility status of soils in which rhizomatous irises are naturally growing in flora of Turkey. For this purpose 150 soil samples were taken from 47 regions between 2006 and 2009. For this objective salinity, pH, $CaCO_3$, organic matter, available phosphorus and potassium of soil samples were detected. According to the results of study electrical conductivity values were between 50 to 2290 μmhos cm^{-1} and the soil pH was found to be between 5,15 to 8,60. Soil samples were mostly different calcareous content and highly organic matter. The available phosphorus values were found 3 - 135 mg kg^{-1} and potassium 55 - 1450 mg kg^{-1}.

Keywords: Rhizomatous Iris, Flora of Turkey, Soil, Fertility Status

Introduction

Turkey is one of the richest gene centres in the world in terms of biodiversity with its geographical situation, geomorphologic structure and a particular ecologic environment. There are 9582 flowery plants and fern species classified in 1225 genus from 163 families. 3155 species among these plants (34.3 %) have been classified as endemic ones (Ozhatay, 2011).

Iris species are classified in the group of geophytes; Geophytes is the name of those fern plants having a special underground storage organ such as bulbs, corms or rhizomes (Anonymous, 1996). The majority of the biological richness in Anatolia is composed of plants belonging to the botanical group of geophytes species. Geophytes species, which have widespread habitats all over the world except Australia, are seen especially in the Balkans, Anatolia and Caucasus. The soil on the Anatolian peninsula, with its location where three gene generations fall upon each other, offers habitat for various groups of geophytes plants. There are approximately 40 genus and 700 species of such plants in Turkey (Arslan et al., 1996; Güner et al., 2002).

The species *Iris L.* is an important decoration plant planted in gardens, parks and on balconies. It's very easy to grow them; they have grandiose flowers in vivid and bright colours and they bloom earlier than the other decoration plants. Because of such characteristics it's a preferred plant in the ornamental plants and flowers sector.

Irises are perennial herbaceous plants as far as their botanical characteristics are concerned. They generally have wide leaves; but they can also have narrow, ensiform and bilamellate leaves like the plants in the Gramineae family. The leaves which are generally linear, ensiform and parallel-nerved, are usually found on the ground. One or more flowers bloom on round or angular pedicles. The petals are sextuple and they are

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arranged in two-ranked style; three of them hang out downwards which are called outward petals (falls). The ones which grow upwards curving inwards are called inward petals (standard). Thick fluffs called beards can also be seen at the boom of outward petals (Davis, 1984; Tanrıverdi, 1993; Stebbings, 2001).

Cassidy and Linegar (1982) classify *Iris spp* plants in two groups as bulbous and non-bulbous plants. Almost all bulbous iris plants are beardless. Non-bulbous iris species have a storage root called rhizome. In fact rhizomes are underground organs growing sideways. According to Güner (2012), 23 taxons of all the 56 *Iris spp* taxons in Turkey are endemic ones, 32 of them are rhizomatous and 24 ones are bulbous plants so far as taxonomic grouping is concerned.

Within this study, soil samples from 47 provinces offering habitat to bulbous iris plants were collected from places where 27 species grew in 150 populations and they were analysed to get information about the soil characteristics.

Material and Methods

150 soil samples collected from the habitats of rhizomatous iris (*iris* spp) species in Turkey constitute the material of this study. The soil samples were collected between 2006 and 2009 in the habitats of these species in compliance with general rules in this respect with stainless spades from a depth of 0-20 cm (Jackson 1962) and labelled in polyurethane sacks. As Kacar (1994) put it, the samples were prepared for analysis in the laboratory; pH degree was quantified by means of pH-metre with glass electrode in soil-water mixture in ratio 1:2,5 (Anonymous, 1981) and electrical conductivity was measured with EC-metre in the same mixture. Çağlar (1958) put it that the lime ratio of the samples was identified by means of Scheibler calcimetre; content ratios in terms of organic substances, on the other hand, was identified using the modified method of Walkley-Black, so Jackson (1960). While available phosphorus was identified with the method reported by Olsen et al. (1954), 1 N ammonium acetate (pH 7) extraction was used for the quantification of the available potassium ratio (Anonymous 1980).

Results and Discussion

Information about the plants and the locations from where the soil samples were taken in 47 provinces and the results of the analysis about the physical and chemical properties of soil samples are shown on table 1 and the highest, lowest and average values concerning the analysis results are shown on table 2. Classifications about physical and chemical characteristics of the soil samples are indicated on Table 3.

pH value of the soils range from 5,15 to 8,60. While 2,0 % of the soil samples had light, 8,0 % medium acidity and 30,0 % neutral, 57,3 % of the samples had light and 2,7 % strong alkaline so far as acidity and alkalinity are concerned (Eyüpoğu, 1999). The results showed that the majority of the soils had neutral and light alkaline characteristics. Kandemir (1997) carried out pH analysis on different soil samples collected in different locations within the scope of a study on some endemic iris species and it appeared thereby as a result that the soils in question had pH values varying between 5,85 – 7,60 and neutral and light alkaline characteristics in general. It's obvious that there is a similarity between the results of these studies. While Jett (2005) asserted that the most appropriate range for iris species was between 6,0 – 7,.5; Moris (2011) declared that the optimum soil pH had to be 6,8 in this respect.

When analysed in terms of electrical conductivity (Dellavalle 1992), it was observed that 91,3 % of the soils collected were non-saline soils. The percentage of the soils classified as light saline was 6,7; on the other hand 0,7 % had medium and 1,3 % high saline values. Uysal and Kaya (2013) carried out a study to identify the soil characteristics of locations where solomonsseals, a geophytes genus having natural habitat in Turkey, grew. The results of this study indicated that 93 % of these soils collected in the habitats of solomonsseals had low saline values; the rest was classified as light, medium and high saline soils. The overall results of the analysis concerning the samples showed that the majority of the soils were non-saline and a few ones had high saline values. This result gives rise to thought that rhizomatous irises could be resistant to soils with high saline content.

Table 1. Information about the plants and the locations from where the soil samples were taken and some physical and chemical properties of soil samples

No	Location	Species name	EC µmhos cm^{-1}	pH	Lime ($CaCO_3$) %	Organic matter %	Available P mg kg^{-1}	Available K mg kg^{-1}
1	Muğla	*Iris albicans*	92	7,00	0,00	4,70	27	225
2	Muğla	*Iris albicans*	109	7,52	0,40	4,35	8	85
3	Muğla	*Iris albicans*	224	7,94	1,62	4,47	7	440
4	Kütahya	*Iris attica*	260	8,32	28,80	5,11	7	800
5	Eskişehir	*Iris attica*	383	8,03	19,23	3,77	10	348
6	Bolu	*Iris attica*	200	7,62	0,39	7,11	11	198
7	Balıkesir	*Iris attica*	252	7,63	12,91	9,14	12	283
8	Van	*Iris barnumae f. barnumae*	127	8,23	5,49	2,03	8	346
9	Van	*Iris barnumae f. barnumae*	191	8,15	9,65	2,47	10	340
10	Van	*Iris barnumae f. urumiensis*	222	8,28	25,08	2,28	8	125
11	Mardin	*Iris gatesii*	194	7,88	38,38	3,24	20	403
12	Şanlıurfa	*Iris gatesii*	208	7,78	0,99	2,03	37	188
13	K.maraş	*Iris germanica*	204	7,71	18,79	6,71	13	869
14	Antalya	*Iris germanica*	168	7,54	3,62	20,4	22	525
15	Artvin	*Iris germanica*	254	7,90	19,14	2,54	10	345
16	Kars	*Iris ib.subsp. elegantissima*	158	7,09	0,00	2,21	9	398
17	Kars	*Iris ib.subsp. elegantissima*	158	7,09	0,00	2,21	9	398
18	Erzurum	*Iris ib.subsp. elegantissima*	141	7,78	2,09	2,28	9	265
19	Erzurum	*Iris ib.subsp. elegantissima*	300	7,11	1,71	4,36	29	100
20	Erzurum	*Iris ib.subsp. elegantissima*	168	8,57	1,78	0,66	4	125
21	Van	*Iris ib.subsp. elegantissima*	180	8,04	31,45	3,47	10	380
22	Hakkari	*Iris ib.subsp. lycotis*	105	7,63	0,00	2,09	27	55
23	Hakkari	*Iris ib.subsp. lycotis*	210	8,00	5,02	5,28	14	510
24	Adana	*Iris junonia*	198	7,68	24,96	11,6	21	627
25	Adana	*Iris junonia*	215	7,73	10,47	4,24	15	286
26	Adana	*Iris junonia*	193	7,56	0,80	6,35	21	290
27	Ankara	*Iris kerneriana*	261	7,29	0,39	11,1	14	448
28	Eskişehir	*Iris kerneriana*	244	7,60	1,35	6,17	19	490
29	Bolu	*Iris kerneriana*	210	7,51	1,35	10,75	13	338
30	Ankara	*Iris kerneriana*	394	6,58	0,58	12,35	33	473
31	Eskişehir	*Iris kerneriana*	225	7,12	1,15	11,64	16	320
32	Kastamonu	*Iris kerneriana*	289	6,50	0,00	24,00	19	273
33	Kastamonu	*Iris kerneriana*	178	6,07	0,00	13,42	16	418
34	Çankırı	*Iris kerneriana*	302	7,33	4,81	12,34	20	433
35	Amasya	*Iris kerneriana*	314	7,98	8,71	6,89	7	264
36	Amasya	*Iris kerneriana*	248	7,06	0,40	12,00	8	348
37	Hatay	*Iris kirkwoodii*	230	7,72	1,58	15,20	16	475
38	K.maraş	*Iris kirkwoodii*	210	7,49	2,40	6,89	38	786
39	Trabzon	*Iris lazica*	282	7,30	0,77	6,53	13	310
40	Rize	*Iris lazica*	105	5,32	0,00	8,48	10	148
41	Giresun	*Iris lazica*	175	6,19	0,00	10,22	14	175
42	Giresun	*Iris lazica*	50	6,17	0,00	1,36	22	115
43	Şanlıurfa	*Iris masia*	102	6,93	0,00	2,41	12	425
44	Antalya	*Iris masia*	256	7,80	8,32	6,53	19	450
45	Antalya	*Iris masia*	256	7,80	8,32	6,53	19	450
46	Gaziantep	*Iris masia*	428	8,00	5,15	3,77	24	400
47	Mardin	*Iris nectarifera*	147	7,98	21,79	1,73	7	900
48	Antalya	*Iris orientalis*	124	7,53	0,00	14,86	18	513
49	Antalya	*Iris orientalis*	363	7,66	13,81	6,71	18	145
50	Denizli	*Iris orientalis*	150	7,48	0,78	15,2	45	323

Table 1. Continue

No	Location	Species name	EC µmhos cm⁻¹	pH	Lime ($CaCO_3$) %	Organic matter %	Available P mg kg⁻¹	Available K mg kg⁻¹
51	Burdur	*Iris orientalis*	475	7,95	20,38	12,00	37	675
52	Uşak	*Iris orientalis*	564	8,53	20,00	6,53	12	153
53	Tokat	*Iris orientalis*	289	7,86	13,86	8,26	29	360
54	Van	*Iris paradoxa*	131	8,17	7,45	2,47	13	194
55	Van	*Iris paradoxa*	137	8,20	17,26	3,83	11	528
56	Muğla	*Iris pseudacorus*	234	7,78	5,52	10,75	13	458
57	Muğla	*Iris pseudacorus*	615	8,21	7,89	7,42	15	63
58	Konya	*Iris pseudacorus*	396	7,01	0,00	11,64	38	178
59	Eskişehir	*Iris pseudacorus*	610	8,22	39,17	11,62	60	1450
60	Edirne	*Iris pseudacorus*	226	7,80	2,46	3,59	77	200
61	Balıkesir	*Iris pseudacorus*	822	7,51	2,66	12,34	135	448
62	Rize	*Iris pseudacorus*	344	7,22	0,39	6,17	22	138
63	Artvin	*Iris pseudacorus*	267	6,87	0,00	4,13	50	398
64	Şanlıurfa	*Iris pseudacorus*	154	7,52	4,94	6,17	20	350
65	Bartın	*Iris pseudacorus*	117	5,15	0,00	4,70	9	218
66	Sakarya	*Iris pseudacorus*	688	6,88	1,60	9,90	18	130
67	Samsun	*Iris pseudacorus*	302	6,27	0,00	26,84	20	170
68	Karaman	*Iris purpureobractea*	188	7,85	3,16	23,27	29	373
69	Burdur	*Iris purpureobractea*	120	7,58	0,20	15,20	18	260
70	Uşak	*Iris purpureobractea*	154	7,79	19,59	10,22	14	95
71	Sakarya	*Iris purpureobractea*	214	8,12	5,38	4,13	9	58
72	Antalya	*Iris purpureobractea*	162	8,06	25,75	3,30	8	250
73	Gaziantep	*Iris sari*	234	7,62	26,19	26,12	89	938
74	Gaziantep	*Iris sari*	139	7,80	6,20	6,71	67	824
75	Ankara	*Iris sari*	241	7,95	21,51	2,21	5	165
76	Ankara	*Iris sari*	226	7,86	4,99	2,98	10	208
77	Ankara	*Iris sari*	167	8,00	4,61	2,98	8	190
78	Gaziantep	*Iris sari*	172	7,74	28,99	3,06	11	610
79	Erzincan	*Iris sari*	189	7,55	8,72	4,24	9	940
80	Adıyaman	*Iris sari*	103	6,81	0,38	2,69	58	155
81	K.maraş	*Iris sari*	159	7,36	0,19	5,11	16	170
82	Adıyaman	*Iris sari*	198	7,25	0,95	6,17	43	233
83	Gaziantep	*Iris sari*	249	7,15	0,95	10,74	21	285
84	Çankırı	*Iris sari*	162	7,68	1,60	2,90	10	193
85	Malatya	*Iris sari*	139	8,08	25,35	3,47	6	290
86	Van	*Iris sari*	200	7,56	1,35	9,40	21	625
87	Van	*Iris sari*	217	7,42	2,12	4,95	13	390
88	Erzincan	*Iris sari*	167	7,75	2,34	2,54	12	285
89	Ankara	*Iris sari*	237	8,03	3,49	3,06	9	215
90	Konya	*Iris schachtii*	181	7,74	2,54	5,11	11	300
91	Afyon	*Iris schachtii*	174	6,65	0,00	7,11	10	165
92	Karaman	*Iris schachtii*	125	7,87	9,80	3,42	18	225
93	Konya	*Iris schachtii*	219	7,91	9,01	5,11	13	410
94	Konya	*Iris schachtii*	149	8,04	28,00	3,30	7	250
95	Afyon	*Iris schachtii*	199	6,76	0,00	5,64	33	110
96	Ankara	*Iris schachtii*	73	6,66	0,00	3,42	7	188
97	Çankırı	*Iris schachtii*	223	7,73	18,45	4,47	12	285
98	Sivas	*Iris schachtii*	2280	7,80	11,88	0,93	3	86
99	Sivas	*Iris schachtii*	2290	7,79	24,56	1,63	8	163
100	Sivas	*Iris schachtii*	170	8,28	57,86	1,85	7	326
101	Ardahan	*Iris sibirica*	455	7,02	1,71	13,78	17	460
102	Bolu	*Iris sintenisii*	290	6,77	0,00	13,42	11	133
103	Bolu	*Iris sintenisii*	334	6,88	1,15	11,10	10	223
104	İstanbul	*Iris sintenisii*	139	6,05	0,00	9,90	9	185
105	İstanbul	*Iris sintenisii*	98	5,58	0,00	1,52	6	63
106	Kırklareli	*Iris sintenisii*	185	7,40	0,00	5,11	10	133
107	Edirne	*Iris sintenisii*	155	6,40	0,00	3,30	7	105
108	Tekirdağ	*Iris sintenisii*	160	7,76	0,95	2,61	18	168
109	İstanbul	*Iris sintenisii*	165	6,68	0,00	3,42	8	100
110	Bolu	*Iris sintenisii*	223	6,72	0,19	14,84	14	208

Table 1. Continue

No	Location	Species name	EC µmhos cm-1	pH	Lime ($CaCO_3$) %	Organic matter %	Available P mg kg-1	Available K mg kg-1
111	Kastamonu	*Iris sintenisii*	252	7,05	8,83	13,06	17	340
112	Aksaray	*Iris sprengeri*	150	8,50	29,59	2,90	11	458
113	Niğde	*Iris sprengeri*	201	8,60	44,98	2,54	12	378
114	Aksaray	*Iris sprengeri*	138	7,98	0,41	1,63	9	280
115	Erzincan	*Iris spuria subsp. musulmanica*	458	7,61	11,06	11,28	26	910
116	Niğde	*Iris spuria subsp. musulmanica*	440	7,97	25,86	3,95	29	550
117	Van	*Iris spuria subsp. musulmanica*	352	8,05	25,11	11,28	22	497
118	Van	*Iris spuria subsp. musulmanica*	226	7,93	7,72	4,35	10	600
119	Manisa	*Iris suaveolens*	296	7,45	1,76	15,20	17	275
120	Uşak	*Iris suaveolens*	188	7,83	11,14	5,82	11	225
121	İstanbul	*Iris suaveolens*	136	6,30	0,00	6,53	9	85
122	Kırklareli	*Iris suaveolens*	255	7,65	0,57	14,84	18	208
123	İstanbul	*Iris suaveolens*	145	5,94	0,00	5,28	8	113
124	Edirne	*Iris suaveolens*	155	6,40	0,00	3,30	7	105
125	İstanbul	*Iris suaveolens*	208	6,44	0,00	6,71	11	105
126	Çanakkale	*Iris suaveolens*	194	7,80	3,42	3,30	8	150
127	Çankırı	*Iris suaveolens*	250	7,72	46,54	5,64	13	298
128	Samsun	*Iris suaveolens*	234	7,75	2,77	12,00	15	303
129	Erzurum	*Iris taochia*	180	7,92	0,00	1,31	4	156
130	Erzurum	*Iris taochia*	246	7,34	0,19	5,82	19	785
131	Erzurum	*Iris taochia*	193	7,68	2,51	4,04	10	725
132	Erzurum	*Iris taochia*	224	7,46	0,95	2,15	9	133
133	Erzurum	*Iris taochia*	160	7,84	9,10	1,96	7	180
134	Erzurum	*Iris taochia*	200	7,75	14,78	3,59	10	415
135	Erzurum	*Iris taochia*	141	7,78	2,09	2,28	9	265
136	Erzurum	*Iris taochia*	171	7,93	35,13	1,85	6	398
137	Muğla	*Iris unguicularis*	150	7,56	0,00	10,21	8	188
138	Antalya	*Iris unguicularis*	160	7,60	9,86	13,06	56	250
139	Hatay	*Iris unguicularis*	163	7,92	11,84	6,17	7	280
140	Antalya	*Iris unguicularis*	142	7,89	11,05	4,24	7	93
141	Antalya	*Iris unguicularis*	143	8,01	2,76	7,42	13	410
142	Muğla	*Iris unguicularis*	200	7,75	0,79	6,89	7	223
143	Antalya	*Iris unguicularis*	207	8,02	36,44	6,17	5	420
144	Muğla	*Iris unguicularis*	236	7,70	0,40	10,74	7	268
145	Antalya	*Iris unguicularis*	187	7,99	9,51	7,42	15	143
146	Hatay	*Iris unguicularis*	182	6,62	0,00	6,17	7	407
147	Muğla	*Iris xanthospuria*	140	7,62	0,00	15,2	11	235
148	Hatay	*Iris xanthospuria*	471	7,87	2,37	13,06	33	198
149	Muğla	*Iris xanthospuria*	280	7,98	1,19	13,06	13	160
150	Muğla	*Iris xanthospuria*	357	7,78	0,79	11,28	7	213

The soils were also analysed in terms of their lime content (Çağlar 1958), it was observed that 60 % of them contained low or very low lime. On the other hand, 20 % of the soils contained lime in medium degrees and the rest 20 % had high or very high lime content. Uysal and Kaya (2010), Uysal et al. (2013) and Kandemir (1997) carried out similar studies for peony, bulbous rhizomes and iris respectively and they obtained similar results as in our study indicating that the soils in question possessed lime varying from very little to very high degrees. Although lime contents of the soils analysed vary, the fact that some soils contain about 60 % lime makes us think that the plant is resistant to high degrees of lime in the soil. Kandemir (1997) indicated that iris preferred soils with medium and high lime content.

Table 2. The highest, lowest and average values concerning the results of analysis

Soil Properties	Minimum	Maximum	Average
pH	5,15	8,60	7,51
EC_{25} (µmhos cm^{-1})	50	2290	254
$CaCO_3$ (%)	0,00	57,86	8,13
Organic matter (%)	0,66	26,84	7,07
Available P (mg kg^{-1})	3	135	18
Available K (mg kg^{-1})	55	1450	326

Table 3. Classifications about physical and chemical characteristics of the soil samples

Soil Properties	Limiting value	Interpretation	%
pH (Eyüpoğlu 1999)	4,5-5,5	Moderately acid	2,0
	5,6-6,5	Slightly acid	8,0
	6,6-7,5	Neutral	30,0
	7,6-8,5	Slightly alkaline	57,3
	>8,5	Strongly alkaline	2,7
EC_{25} (µmhos cm^{-1}, Dellavalle 1992)	<400	Non saline	91,3
	400-800	Slightly saline	6,7
	801-1200	Moderately saline	0,7
	1201-1600	Saline	0,0
	1601-3200	Strongly saline	1,3
$CaCO_3$ (%, Çağlar 1958)	<1,0	Very low	37,3
	1,0-5,0	Low	22,7
	5,1-15,0	Medium	20,0
	15,1-25,0	High	8,0
	>25,0	Very high	12,0
Organic matter (%, Anonymous 1985)	<1,0	Very low	1,3
	1,0-2,0	Low	6,0
	2,1-3,0	Medium	14,7
	3,1-4,0	High	12,7
	>4,0	Very high	65,3
Available P (mg kg^{-1}, Olsen et al. 1954)	<3,0	Very low	0,0
	3,0-7,0	Low	16,0
	7,1-20,0	Medium	62,0
	>20,0	High	22,0
Available K (mg kg^{-1}, Pizer 1967)	<100	Very low	6,7
	100-150	Low	12,0
	151-200	Medium	15,3
	201-250	Good	10,7
	251-320	High	14,0
	>320	Very high	41,3

It was also demonstrated (anonym 1985) that the soils contained little, medium, high and very high organic matter with percentage degrees of 7.3, 14.7 and 78 respectively. Uysal and Kaya (2010) showed in a study they executed for peony that almost all the soils collected had high degrees of organic substances. The results of a similar study carried out by Uysal et al. (2013) for bulbous irises certified that 61 % of the soils analysed had high organic substance content.

The soils in Turkey are usually poor in organic matter content. Almost 64 % of the soils contain little or very little organic substances (Güçdemir 2006). The results indicate that irises prefer soils with high organic substance content. Irises aren't generally selective plants, but they prefer deep, well-drained, light-structured soils containing organic substances in high degrees (Moris, 2011, Baker, 2005 and Anonymous, 2007).

Olsen and Sommer (1954) classified the soils in terms of their available phosphorous content and indicated that 16 % of the soils had little, 62 % contained medium and % 22 high degrees of content in this respect.

The results about the soils analysed in terms of available potassium and classified according to Pizer (1967) are shown in table 3. It was identified hereunder that 18,7 % of the soils had very low and low, 26 % medium and good and 55,3 % high and very high content of potassium.

Uysal et al. (2013) identified obtainable phosphorous and potassium values within the scope of a study they carried out to specify the soil characteristics of locations where bulbous irises have habitats in the flora in Turkey. The results they obtained are similar to those values we got in our study concerning iris rhizomes. Accordingly 58 % of the soils had medium and 18 % high phosphorous content. While 26 % of the soils contained potassium in medium degree, 54 % of them had high and very high potassium in their content.

Conclusion

Soil samples were collected from the natural habitats of rhizomatous irises existing in the flora in Turkey within the scope of this study so as to get information about the characteristics of the soils in their natural environment. Although almost all the soils analysed contained saline in low degrees, soil with high saline content was observed in some locations. The study indicated that the majority of the soils contained organic matters in high degrees. The results of the study also showed that the soils had neutral and light alkaline characteristics so far as the evaluation about the soil reaction is concerned. The soils were also analysed in terms of lime content. The study results indicated that there were great differences between soil groups in his respect; there were both soils with no lime content and also soils having high degrees of lime content. Available phosphorous and potassium contents of the analysed soils were specified as 3-135 mg kg^{-1} and 55-1450 mg kg^{-1} respectively.

References

Anonymous, 1980. Soil and Plant Testing and Analysis as a Basis of Fertilizer Recommendations. F.A.O. Soils Bulletin 38/2, p.95.

Anonymous, 1981. The Analysis of Agricultural Materials. Second Edition Ministry of Agri. Fisheries and Food RB 427, Replaces Technical Bulletin 27, p. 226.

Anonymous. 1985. Agricultural Analysis Handbook. Hach Com. 22546-08, p.2/65-69.

Anonymous, 1996. The Report About Production and Natural Populations of Economic Value Geofit. Association of Grower of Natural Flower Bulbs, Istanbul.

Anonymous, 2007. Horticulture Iridaceae Family. MEGEP,

hmogm.meb.gov.tr/modulerprogramlar/kursprogramlari/bahcecilik/moduller/iridaceae_familyasi.pdf (Access data:01.13)

Arslan, N., T., Ekim, M., Koyuncu, 1996. Development on Conservation and Propagation of Natural Howerbulbs in Turkey. 7 th İnternational Symposium on Flowerbulbs. March 10-16, Herzliya, İsrail.

Baker, T., 2005. Growing Different Types of Bearded Iris. British Columbia Iris Society, www.bc-iris.org%iris%20articles /Article-Bearded%20Iris.htm (Access data: Mach 2013)

Cassidy, G.E. and S. Linnegar, 1982. Growing Irises, British Library

Cataloguing in Pupligation Data, ISBN: 0-7099-0706-0, London,

Çaglar, K. Ö., 1958. Soil Information. Ankara University Agriculture Faculty Publication. Publication Number: 10, Ankara, 286 p.

Davis, P. H., 1984. Flora of Turkey and East Aegean Islands. IIIX volume, Edinburgh Un. Pres, Edinburgh, 632.

Dellavalle,N.B., 1992. Determination of Specific Conductance in Supertanat 1:2 Soil:Water Solution. In Handbook on Reference Methods for Soil Analysis. Soil and Plant Analysis Council, Inc. Athens,GA.

Eyüpoğlu, F., 1999. Fertility of Turkey's Soils. Soil and Fertilizer Research Institute Publications, General Publication Number: 220, Technical Publications Number: T.67, Ankara.

Güçdemir, İ.H. 2006. Guide of Fertilizer and Fertilization Republic of Turkey Ministry of Agriculture and Rural Affairs Directorate-General of Agricultural Research Soil and Fertilizer Research Institute Publications, General Publication Number: 231, Technical Publications Number: T.69, Ankara

Güner, A., N., Özhatay, T. Ekim, K., Başer, 2002. Flora of Turkey and East Aegean Islands. XI volumes, ISBN: 1-55297-673-4. USA. 224.

Güner, A., 2012 . Iris L. In: Güner A, Aslan S, Vural M and Babaç T, editors. List of Turkey PlantsTürkiye Bitkileri Listesi (Vascular plants). İstanbul: Nezahat Gökyiğit Botanic Garden and Floristic Research Society, pp. 535-540.

Jackson, M.L.1960. Soil chemical analysis, Prentice- Hall, Inc. Englewood,Cliffs-NJ.

Jackson, M.L., 1962. Soil chemical analysis. Prentice-Hall of India Private Limited, New Delhi.

Jett, J.W., 2005. Plant pH Preferences. Extension Service West Virginia University www.wvu.edu/~agexten/hortcult/homegard/pHpref.pdf (Erişim: Mart 2013)

Kacar, B., 1994. Chemical analyzes of Plant and Soil:III. Soil Analyzes. Ankara University Agriculture Faculty Education, Research and Development Foundation Publications Number: 3 ISBN:975-7717-04-5. Ankara.

Kandemir, N., 1997. A Morphological Anatomical and Ecological

Endemic Iris (*Irıdaceae*) Species. Unpublished PhD Thesis,Graduate School of Science and Engineering, Samsun.

Morris, J., 2011. How to Plant and Grow Bearded Iris. The American Iris Society, www.irises.org/About_Irises/Cultural%20İnformation/ Grow_Bearded.html (Access data: Mach 2013)

Olsen, S.R., V. Cole, F.S. Watanable and L.A. Dean. 1954. Estimation of Available Phosphorus in Soils by Extraction With Sodium Bicarbonate. U.S.D.A. Circular no. 939. Washington D.C.

Ozhatay N., 2011. Grower's Handbook, İstanbul 80 p

Pizer, N. H., 1967. Some Advisory Aspect: Soil Potassium and Magnesium. Teck.Bull. No:14:184

Stebbings, G., 2001. The Gardener's Guide to Growing Irises. ISBN: 0-88192-519-5. 133. SW Second avenue, Suite 450,Portland, Oregon 97204, USA. 160.

Tanrıverdi, F.,1993. Flower Production Techniques, The Textbook that Potted Plants, Cut Flower Growing Principle in Greenhouse and Outdoor. ISBN: 975-10-553-1. İnkılap Publishing Company, İstanbul. 239 p.

Uysal E. and E. Kaya, 2010. Determination of The Soil Fertility Status of Peony (Paeonia spp.) in Flora of Turkey. I. National Soil and Water Resources Congress 1-4 June 2010 Eskişehir, p. 835-842.

Uysal E., and E. Kaya, 2013. Determination of The Some Soil Fertility Status of Solomonsseal (Polygonatum spp.) Plant Grown in Flora of Turkey, III. National Soil and Water Resources Congress 22-24 October 2013 Tokat, p. 724-728

Uysal E., K. Erken, E. Kaya, S. Erken, F. Gulbag, 2013. Determınatıon of The Soıl Fertılıty Status of Bulbous Irıs (*Iris* Spp.) In Flora of Turkey, 5. Ornamental Plants Congress, 6-9 May 2013 Yalova, p. 725-730

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Effect of potassium chloride on some responses of annual shoots of *Citrus aurantium* seedling under low temperature stress

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Abstract

Citrus is one of the most important fruit plants of the tropical and subtropical areas and because of its sensitivity to low temperature stress, it generally suffers from damages of frost occurrence in northern Iran in some years. Potassium nitrate application can help the plant against cold stress. The purpose of this study was to investigate some physiological response of annual shoots of *Citrus aurantium* seedling under low temperature stress to KCl application. Accordingly, a pot experiment with four levels of KCl (0, 2.5, 5, 10 mM) was carried out in a completely randomized design with four replications under low temperature stress (-3°C). ANOVA results showed that the effect of KCl was significant on indices of electrolyte leakage, leaf damage percentage, leaf water content, chlorophyll a, total chlorophyll and carotenoids contents at ambient temperature of -3°C. But these treatments had no significant effect on indices of leaf water potential, water soaked percentage, leaf color, chlorophyll b and damage of shoots. Mean comparisons test indicated that application of 5 mM KCl - through reducing electrolyte leakage and leaf destruction percentage to the lowest amount along with keeping the highest leaf water, chlorophyll a and b and carotenoids contents - was effective on the stability of seedlings against the low temperature stress.

Key words: Citrus, potassium chloride, low temperature, electrolyte leakage, carotenoids

Introduction

Citrus is one of the most important fruit plants of the tropical and subtropical areas that are susceptible to frost stress. Citrus cultivation and training concentrated in latitude 40° north and south of the equator. Of Botany, Citrus belongs to the Rutaceae family and subfamilyof Aurantioideae. Orange (*Citrus aurantium*) is a commercial variety of citrus which is used as a resistant rootstock to biotic and abiotic stresses (Kaanane et al., 1988)[14]. Most plants in this family are evergreen tree or shrub.

One of adverse climatic factors which causes citrus destruction or damage, is severe and sharp cold (temperatures drop below the freezing point) resulting in frost. Low temperature stress including cold and frost causes metabolic imbalances, yield reduction and in some cases death of sensitive plants because of biochemical and physiological changes (Chen et al, 2006)[6] Temperature drop leads to drastic changes in

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membrane fluidity. These changes are different for each cell and depend on the relative composition of phospholipids (Bringer and Troldenier, 1980)[4].

Potassium is an essential micronutrient. Potassium essentiality is related to its key role as a major inorganic osmoticum (Marschner, 1995[17]; Shabala, 2003[23]). Potassium is also essential as a counter ion for the charge balance of ion transport across the plasma- and intra-organelle membranes (Anschütz et al, 2014[1]; Dreyer and Uozumi, 2011[10]; Shabala, 2003[23]). It is important in fruit formation and enhances fruit size, flavor, and color. Potassium helps in reducing the influence of adverse weather conditions like drought, cold, and flooding (Obreza, 2003)[19]. In potassium deficiency condition, cold stress causes photo-oxidative damage to photosynthesis in plants, which can lead to reduction in growth and yield of plant. It seems that large amounts of potassium may reduce the adverse effects of cold damage to the stem and leaves (Kafkafi , 1990)[15]. Citrus fruit quantity and quality are significantly affected by potassium fertilizer sources. Potassium chloride is an important potassium fertilizer source. Both potassium and chloride are the most important osmotic active inorganic compounds in plant cells and textures (Clarkson and Hanson, 1980)[7]. Potassium deficiency is a major nutritional problem affecting quality and production of Citrus. Potassium-deficient plants are sensitive to various stresses (Cakmak, 2005)[5]. Davies et al (1991)[9] in a study on the fertilization of freeze-damaged 'Hamlin' orange trees suggested that mature, non-bearing citrus trees have the capacity to store and mobilize nutrients from the trunk, limbs and roots and require low levels or no fertilization following a frost during which severe wood damage occurs.

Considering frost stress occurring periodically and unexpectedly resulting in damage to citrus production on the one hand and the necessity of attention to global production of citrus on the other, the study of biochemical and physiological reactions of sour orange seedlings at low temperature is essential and necessary. Hence, the purpose of this study was to investigate some physiological response of annual shoots of *Citrus aurantium* seedling under low temperature stress to KCl application.

Materials and Methods

To study the physiological and biochemical responses of potted annual seedlings of sour orange to the application of KCl at -3°C, an experiment carried out in a completely randomized design with four replications. Treatments were 0, 2.5, 5 and 10 mM KCl, respectively. Seedlings were grown in soilless culture and Hoagland solution was used to feed the seedlings. Before applying the treatments in order to adapt the plant to temperature drop, the seedlings were transferred into an incubator with 65 ± 5% relative humidity and light intensity of 15,000 lux (12 h light and 12 h darkness) for 75 days. Immediately after applying the stress - 3 ° C for 24 h, the amounts of ion leakage (Compose et al, 2003) [8] , the percentage of leaf damage, leaf water content (Verslues et al, 2006)[24] , chlorophyll a, b, total and carotenoid (Pietrini et al, 2005)[20] , leaf water potential using a pressure chamber (Ferrat and Lovatt, 1999)[11], water soaking percentage (Sala and Lafuente, 2000)[21], leaf color using a colorimeter (model Minolta CR 400) (Garcia-Sanchez et al, 2003)[12] and damaged shoots were measured. Five weeks after cold stress, traits such as leaf color, leaf water content and leaf and shoot damage were reevaluated (Zhao-Shi, et al. 2007)[27]. Data were analyzed by SAS-ANOVA and SAS-Means procedures (SAS Institute, 1999)[22].

Results and Discussion

Analysis of variance showed that the effect of KCl was statistically significant at *P. value* ≤ 5% on ion leakage, the percentage of leaf damage, Water content, chlorophyll a and total and carotenoid indices of annual sour orange seedlings at - 3°C. But it was not significant on leaf water potential, water soaking, chlorophyll b and shoot damage contents.

Mean comparisons test results (Table 1) showed that with increasing K level to 10 mM KCl, Ion leakage decreased and then increased, but this increase was not significant. The lowest value of ion leakage (avg. 24.19 %) was observed in 5 mM KCl treatment, and the highest value (avg. 47.60 %) was recorded in blank. These data indicate that the concentration of plant cell sap increases with the increase of potassium application, thus plant cell membranes show significant tolerance to frost. Plant tolerance increases in higher K Concentration due to the increase of favorable plant morphological and physiological effects like plant cell turgidity, protoplasmic structures formation and osmotic pressure. Consequently, this results in the decrease of ion leakage in plant (Grewal and Singh, 1980)[13].

The results showed that the percentage of leaf damage significantly reduced with the increase of potassium. The lowest (25/6%) and the highest (36/3 %) percentages of leaf damage were observed in the 5 mM KCl and control treatments, respectively (Table 1). The occurrence of low temperature stress causes membrane lipid peroxidation, reduction of leaf chlorophyll content and finally complete leaf destruction. Potassium affects on the enzymatic reactions, osmotic balance of plant, carbohydrates and proteins assimilation, and it increases the leaf resistance against destruction. Damage or oxidative stress caused by chill decreases with increasing potassium concentration in the plant, and thus leaf damage reduces (Kafkafi, 1990)[15].

Table 1. Mean comparisons test on some physiological and biochemical traits of sour orange under KCl treatments at -3°C†

KCl	Ion leakage	Leaf color	Leaf damage	Shoot damage	Water content	Water soak	ψ_{wleaf}	Chl-total	Chl-b	Chl-a	Carte-noied
mM	%						bar	mg g^{-1} FW			
0	47.6a	-13.0a	29.4a	36.1a	36.0b	21.3a	21.8a	6.4b	1.8a	4.6c	0.16c
2.5	43.6a	-13.4a	28.7a	40.6a	49.9a	0.0a	20.8a	7.1b	1.6a	5.5b	0.20ba
5	24.2b	-13.0a	6.3b	0.0a	53.7a	0.0a	21.5a	8.7a	2.2a	6.5a	0.21a
10	31.7b	-14.3a	13.4ab	65.0a	51.5a	8.5a	20.9a	7.7a	2.1b	5.6b	0.19b

†Means within each column followed by the same letters are not significant (Lsd, α = 5%).

Effect of potassium on leaf water content was also significant. Leaf water content increased with increasing potassium concentrations (Table 1). The lowest leaf water content was observed in the control treatment (36.0%) and the highest value one in 5 mM KCl treatment (53.7%). Sufficient concentration of potassium can be effective in maintaining water content in plants. High and optimum concentrations of potassium reduce stomatal conductance and transpiration rate, which in turn increase the water content in plants (Xu et al, 2011)[25].

The highest amount (avg. 8.70 mg g^{-1} FW) of total chlorophyll was observed in treatment 5 mM KCl and the lowest value (avg. 8.70 mg g^{-1} FW) was in the control treatment (Table 1). Temperature drop reduces the amount of chlorophyll and as a result photosynthesis reduces. Leaf chlorophyll reduction of citrus under cold and frost shock conditions likely associates with an increase in active oxygen radicals, lipid peroxidation, and as a result, destruction of these pigments in the chloroplast membrane and thylakoids can follow it (Pietrini et al, 2005)[20]. Appropriate concentration of potassium can enhance chlorophyll content and photophosphorylase activity and maintain proton gradient of thylakoid membranes, promoting photosynthetic phosphorylation (Yurtseven et al, 2005[26]; Xu et al, 2011[25]).

As seen in Table 1, a significant increase in total chlorophyll with increasing potassium is mainly related to the increase in chlorophyll a. The lowest amount (avg. 63.4 mg gr^{-1} FW) of chlorophyll a and the highest value (avg. 49.6 mg gr^{-1} FW) were observed in the control treatment and in treatment 5 mM KCl, respectively. There was no significant change in the amount of chlorophyll b. whereas, the carotenoid level increased with increasing KCl concentration and the lowest value (avg. 0.16 mg gr^{-1} FW) was observed in the control. Also, carotenoids increase can be possibly result from oxidation of these pigments by reactive oxygen radicals (Berova et al, 2002)[3]. Mikkelsen (2005)[18] stated that the total carotenoid in tomatoes increases with increasing the amount of potassium.

Correlation test (Table 2) revealed that there was a negative significant correlation between ion leakage and leaf water content (r =-0.66 *). With increasing the potassium concentration, Ion leakage reduces but the leaf water content increases. Cold stress causes the accumulation of reactive oxygen radicals in citrus. These radicals have a various effects such as membrane lipids oxidation which caused the increase of ion leakage and reduction of leaf water content (Zia-ur-Rehman, 2006)[28]. Ion leakage had negative correlations with total chlorophyll and chlorophyll a contents at *P. value* ≤ 1%. Destruction of cell membranes and chlorophyll, caused with potassium deficiency, increases ion leakage under abiotic stress (Kaya et al, 2001)[16].

Table 2 - Correlation coefficients of some sour orange biochemical and physiological traits at - 3°C and KCl application (Y1-Y7 stand for ion leakage, leaf damage, leaf water content, chlorophyll a, b and total and carotenoid)

Indices	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Y1	1						
Y2	0.41	1					
Y3	-0.66**	-0.45	1				
Y4	-0.65**	-0.46	0.67**	1			
Y5	-0.35	0.1	0.15	0.37	1		
Y6	-0.63**	-0.21	0.55*	0.88**	0.75**	1	
Y7	0.80**	0.35	-0.67**	-0.56*	-0.33	-0.56*	1

*, ** i.e. statistical significant at *P. values* 0.05 and 0.01, respectively

There was a significant positive correlation between ion leakage and carotenoid at P. value ≤ 1% (r = 0.80 **). With the increase of ion leakage at low concentrations of potassium, photosynthetic pigments also reduced. A significant negative correlation at *P. value* ≤ 1% (r = -0.67 **) was also observed between leaf water and carotenoid contents. Leaf water content was also positively correlated with total chlorophyll and was significant at *P. value* ≤ 5% (Table 2). Azzarello et al (2009) [2] also reported similar results.

Conclusion

The results showed that changes occur in some physiological and biochemical indices of sour orange seedlings at low temperature. Potassium is a nutrient that can increase plant resistance against abiotic stresses. Concentration of 5 mM KCl reduced the adverse effects of low temperature, and increasing the potassium concentration showed a significant increase in photosynthesis rate, chlorophyll a, b and total and leaf water content. Indices such as ion leakage and the percentage of leaf damage decreased with increasing potassium. Potassium effects on increasing the resistance against abiotic stresses can originate from inhibiting role of potassium against the production of reactive oxygen radicals during the process of photosynthesis.

References

1. Anschütz, U., Becker, D., Shabala, S., 2014. Going beyond nutrition: Regulation of potassium homoeostasis as a common denominator of plant adaptive responses to environment. J. Plant Physiol. 18p. (In press).
2. Azzarello, E., Mugnai, S., Pandolfi , C., Masi , E., Marone , E., Mancuso, S., 2009. Comparing image (fractal analysis) and electrochemical (impedance spectroscopy and electrolyte leakage) techniques for the assessment of the freezing tolerance in olive. Trees. 23, 159-167.
3. Berova, M., Zlatev, Z., Stoeva, N., 2002. Effect of paclobutrazol on wheat seedling under low temperature stress. Bulg. J. Plant Physiol. 28, 75-84.
4. Bringer, H., Troldenier, G., 1980. The influence of K nutrition on the response of plants to environmental stress. In: Hoffmann, W. (Ed.), Potassium Research-Review and trends, 11th Congress of the International Potash Institute. Bern, Switzerland, pp. 189 -222.
5. Cakmak, I., 2005. The role of potassium in alleviating detrimental effect of abiotic stresses in plant. J. Plant Nutr. Soil Sci. 168, 521-530.
6. Chen, Y., Zhang, M., Chen, T., Zhang, Y., An, L., 2006.The relationship between seasonal changes in anti-oxidative system and freezing tolerance in the leaves of evergreen woody plans of Sabina. S. Afr. J. Bot. 72, 272-279.
7. Clarkson, D.T., Hanson, J. B., 1980. The mineral nutrition of higher plants. Annu. Rev. Plant Physiol. 31, 239-298.
8. Compose, P. S., Quartin, V., Ramalho, J. C., Nunes, M. A., 2003. Electrolyte leakage and lipid degradation account for cold sensitivity in leaves of Coffea sp. Plants. J. Plant Physiol. 160, 283-292.
9. Davies, F. S., Maurer, M. A., 1991. Fertilization of freeze-damaged Hamlin orange tree. In: FSHS (Ed.), Proceedings of the Florida State Horticultural Society. 103, 9-12.
10. Dreyer, I., Uozumi, N., 2011. Potassium channels in plant cells. FEBS J. 278, 4293–303.
11. Ferrat, I. L., Lovatt, C. J., 1999. Relation between relative water content, nitrogen pools and growth of Phaseolus vulgaris L. and P . acutifolius A. Gray during water deficit. Crop Sci. 39, 467-474.
12. Garcia-Sanchez, F., Carvajal, M., Porras, I., Botia, P., Martinez, V., 2003. Effects of salinity and rate of irrigation on yield, fruit quality and mineral composition of 'Fino 49' lemon. Eur. J. Agron. 19, 427 -437.

13. Grewal, J. S., Singh, S. N., 1980 .Effect of potassium nutrition on frost damage and yield of potato plants on alluvial soils of Punjab (India). Plant soil 57, 105 -110.
14. Kaanane, A., Kane, D., Labuza, T. P., 1988. Time and temperature effect on stability of Moroccan processed orange juice during storage. J. Food Sci. 53, 1470-1473.
15. Kafkafi, U., 1990. Impact of potassium in relieving plants from climatic and soil induced stresses. In: Johnson, A . E. (Ed.), Food security in the WANA region, the essential need for balanced fertilization. International Potash Institute, Basel, pp. 317-327.
16. Kaya, C., Kirnak, H., Higgs, D., 2001. Enhancement of growth and normal growth parameters by foliar application of potassium and phosphorous on tomato cultivars grown at high (Nacl) salinity. J Plant Nutr. 24, 357 -367.
17. Marschner, H., 1995. Mineral nutrition of higher plants. 2nd ed., Academic press, London.
18. Mikkelsen, R. L., 2005. Tomato flavor and plant nutrition: A brief review. Better crops 89 (2), 14-15.
19. Obreza, T. A., 2003. Importance of potassium in a Florida citrus nutrition program. Better crops 87 (1), 19-22.
20. Pietrini, F., Chaudhuri, D., Thapliyal, A. P., Massacci, A., 2005. Analysis of chlorophyll fluorescents in mandarin leaves during photo-oxidative cold shock and recovery. Agric., Ecosyst. Environ. 106, 189-198.
21. Sala, J. M., Lafuente, M. T., 2000. Catalase enzyme activity is related to tolerance of mandarin fruits to chilling. Postharvest Biol. Technol. 20, 81-89.
22. SAS Institute, Inc., 1993. SAS/STAT user's guide. Version 6, 4^{th} ed. Vol. 2. SAS Institute, Inc., Cary, NC. 846 p.
23. Shabala, S., 2003. Regulation of potassium transport in leaves: from molecular to tissue level. Ann. Bot. 92, 627–634.
24. Verslues, P. E., Agrawal, M., Katiyar-Agrwal, S., Zhu, J., Zhu, J. K., 2006. Methods and concepts in quantifying resistance to drought, salt and freezing, abiotic stresses that affect plant water status. Plant J. 45, 523-539.
25. Xu, Y. W., Zou, Y. T., Husaini, A. M., Zeng, J. W., Guan, L. L., Liu, Q., Wu, W., 2011. Optimization of potassium for proper growth and physiological response of Houttuynia cordata Thunb. Environ. Exp. Bot. 71, 292 -297.
26. Yurtseven, E., Kesmez,G. D., Unlukara, A., 2005. The effect of water salinity and potassium levels on yield, fruit quality and water consumption of a native central Anatolian tomato species (Lycopersicon esculantum). Agric. Water Manage. 78, 128-135.
27. Zhao-Shi, X., Lan-Qin, C., Ming, C., Xian-Guo, C., Rui-Yue, Z., Lian-Cheng, L., Yun- Xiang, Z., Yan, L., Zhi-Yong, N., Li, L., Zhi-Gang, Q., You-Zhi, M., 2007. Isolation and molecular characterization of the Triticum aestivum L. ethylene-responsive factor 1 (TaERF1) that increases multiple stress tolerance. Plant Mol. Biol. 65, 719-732.
28. Zia-ur-Rehman, 2006. Citrus peel extract- A natural source of antioxidant. Food Chem. 99, 450-454.

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Evaluation of potassium nitrate effects on some responses of *Citrus aurantium* seedlings in sub-zero temperature

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Abstract

Subzero temperature is one of the most important plant abiotic stresses which reduces citrus yield in northern Iran. One of the strategies to enhance plant tolerance to the frost stress is potassium nutrition. Accordingly, the present pot experiment was conducted in a randomized complete design with four replications to evaluate the effect of KNO_3 application (0, 2.5, 5, 10 mM) on *Citrus aurantium* annual seedlings physiological responses under cold stress of -3°C. ANOVA results indicated that KNO_3 had a significant effect on the indices of electrolyte leakage, leaf color, leaf water, total chlorophyll and carotenoids contents, while other indices such as leaf water potential, water soaked percentage, chlorophyll a and b contents, percentage of leaf destruction and shoots damage were not statistically affected. Mean comparisons test showed that applying 5 mM KNO_3 - due to decreasing electrolyte leakage to less than 50% and keeping the highest leaf water and total chlorophyll contents - was effective on the tolerance of C*itrus* seedlings against cold stress of -3°C.

Key words: Citrus, Subzero temperature, potassium nitrate, water soaking, electrolyte, leakage

Introduction

Citrus is a genus belonging to Rutaeceae *Rutaeceae* family which is classified as a cold susceptible plant among the tropical and subtropical fruits (Fotouhi et al., 2008)[5]. Sour orange is one of the commercial varieties of citrus with scientific name *Citrus aurantium* that has a high potential for tolerating against biological and abiotic stresses (Kaanane et al., 1988)[10].

Some stresses such as cold and frost even for a few hours can lead to fatal destructive effects. Pearce (2001)[15] has quoted, for example, that freezing spreads at 10 mm s^{-1} in mulberry twigs. One of the important activities of plant adaptations to freezing stress is osmotic balance responses to maintain plant water content which is affected by the concentration of compounds such as potassium, proline, soluble carbohydrate and other substances.Fertilizers play an important role in the production of citrus seedlings. Nitrogen is a major nutrient in plant nutrition, especially in nurseries where plants are quickly growing. Girardin et al (1987)[8] stated that nitrogen deficiency affects on the distribution of assimilates between vegetative and reproductive

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organs, and delays the phenological stages of plant. Peng (2000)[16] stated that high nitrogen values increase leaf area and durability of leaves photosynthetic activity. Concerning today's environmental challenges, modifying nitrogen fertilizers Program is essential to reduce production costs and obtain optimum growth (Maust and Williamson, 1994)[13]. Effect of nitrogen on growth of sour orange seedlings has been reported by many researchers. Chlorophyll, water use efficiency and carbon dioxide contents in citrus leaves are closely related to leaf nitrogen content (Syvertsen, 1987)[22]. The critical concentrations of nitrogen for root, shoot, and total dry weight of 'Hamlin' orange [*Citrus sinensis* (L.) Osb.] budded on Cleopatra seedlings rootstocks were 18.5, 18.7, and 18.6 mg N/liter, respectively (Maust and Williamson,1994)[13]. Malondialdehyde (MDA) concentration in leaves, which is an indicator of lipid peroxidation, increases in the stress condition, however, MDA concentration decreases with increasing N application in the stressed plants (Saneoka et al, 2004)[20].

Potassium is another element that affects the freezing point of the liquid inside the vacuoles and enhances the resistance of cells against abiotic stresses. Potassium plays an important role in many biochemical and physiological processes in plants such as photosynthesis, sugars and protein synthesis, enzyme activation, phloemic and water translocations, homoestasis, osmoregulation, cation and anion balance, stomatal movement, cell division and growth (Marschner, 1995[12]; Obreza, 2003[14]; Wang et al, 2013)[25]. Potassium deficiency has undesirable and adverse effects on the plant health and its ability to confront with abiotic stresses and pathogen attack (Prabhu et al, 2007)[17]. The effect of potassium may be due to its favourable effect on turgor of plant cells, binding of water by cell protein, high sugar and carbohydrate reserves, creation of protoplasm structures and reduction of water loss (Grewal and Singh, 1980)[9]. Hence, study of some biochemical and physiological reactions of sour orange seedlings at low temperature to KNO_3 application is essential and necessary.

Material and Methods

Annual seedlings of sour orange were grown in Hoagland solution under controlled and -3°C conditions. The experiment carried out in a completely randomized design with four replications.

Treatments were 0, 2.5, 5 and 10 mM potassium nitrate, respectively. Before applying the treatments, the seedlings were transferred into an incubator with 65 ± 5% relative humidity and light intensity of 15,000 lux (12 h light and 12 h darkness) for 75 days. Immediately after applying the stress - 3 ° C for 24 h, the amounts of ion leakage (Compose et al, 2003)[3], the percentage of leaf damage, leaf water content (Verslues et al., 2006)[24], chlorophyll a, b, total and carotenoid (Pietrini et al, 2005)[18], leaf water potential using a pressure chamber (Ferrat and Lovat, 1999)[4], water soaking percentage (Sala and Lafuente, 2000)[19], leaf color using a colorimeter (model Minolta CR 400) (Garcia-Sanchez et al, 2003)[6] and damaged shoots were measured. Five weeks after cold stress, traits such as leaf color, leaf water content and leaf and shoot damage were reevaluated (Zhao-Shi, et al. 2007)[26]. Data were analyzed by SAS-ANOVA and SAS-Means procedures (SAS Institute, 1999)[21].

Results and Discussion

Analysis of variance showed that the effect of potassium nitrate was statistically significant at *P. value* ≤ 5% on ion leakage, leaf color, leaf Water content, total chlorophyll and carotenoid indices of annual sour orange seedlings at - 3°C. Whereas, the traits such as leaf water potential, water soaking, chlorophyll a and leaf and shoot damages were not significantly affected.

Mean comparisons test (Table 1) showed that Ion leakage decreased with increasing KNO_3 concentration and the highest (avg. 40.6 %) and the lowest (avg. 14.4 %) rates of ion leakage were observed in control and 10 mM KNO_3 treatments, respectively. Similar results are reported by Azzarello et al (2009)[1]. Potassium plays an important role in reducing the Ion leakage in plant through osmotic adjustment, cation and anion balance and homeostasis (Marschner, 1995)[12].

Leaf color index had the highest and the lowest values in 5 mM KNO_3 and control treatments, respectively. This was completely true for total chlorophyll as well. Reduction in total chlorophyll content could be due to the decrease of temperature and destruction of chlorophyll structure (Compose et al, 2003)[3]. Many findings indicate that appropriate concentrations of potassium can maintain chloroplast membrane integrity and increase chlorophyll content, photophosphorylase activity and thus leaf color intensity (Very and Sentenac, 2003)[23].

Table 1. Mean comparisons test on some physiological and biochemical traits of sour orange under KCl treatments at -3°C†

KNO_3	Ion leakage	Leaf color	Leaf damage	Shoot damage	Water content	Water soak	ψ_{wleaf}	Chl-total	Chl-b	Chl-a	Carte-noied
mM	%						bar	mg g^{-1} FW			
0	40.6a	-11.1a	29.4a	50.0a	51.1b	26.3a	21.8a	7.1b	1.6b	5.5a	0.22ab
2.5	29.6b	-11.7a	22.8a	17.3a	51.7b	20.0a	21.3a	7.7ab	2.1ab	6.1a	0.20a
5	26.4b	-12.1ab	6.1a	23.2a	55.2a	12.5a	21.1a	8.4a	2.2a	5.7a	0.21ab
10	26.9b	-11.5b	16.7a	18.7a	51.9b	8.8a	20.5a	8.4a	2.4a	6.1a	0.19b

†Means within each column followed by the same letters are not significant (Lsd, α = 5%).

According to Table 1, leaf water content index had the lowest (51.1 %) and the highest (55.2 %) values in control and 5 mM KNO_3 treatments, respectively. These results are in agreement with earlier reports about leaf water content decline (Verslues et al, 2006)[24]. Lipid Peroxyl radicals produced by oxygen free radicals can accelerate lipid oxidation reactions. Continuity of this condition can lead to more destruction of cell membrane, withdrawal of water from the cell to the intercellular space and finally reduction of leaf water content (Azzarello et al., 2009[1]). These results are in agreement with earlier reports about cold stress (Verslues et al, 2006)[24]. As seen in table 1, the highest amount of carotenoid (avg. 0.22 mg g^{-1} FW) and the its lowest amount (avg. 0.19 mg g^{-1} FW) were observed in control treatment and in 10 mM KNO_3 treatment respectively. The increase of carotenoids amount in low concentrations of KNO_3 could possibly result from the oxidation of photosynthetic pigments, like carotenoids, with active oxygen radicals at cold stress conditions (Berova et al, 2002)[2].

Correlation test (Table 2) revealed that there was a negative significant correlation between ion leakage and leaf color (r =-0.48 *). Potassium deficiency under abiotic stress reduces leaf green color and chlorophyll content and destroys the cell membrane (Kaya et al, 2001)[11] which is followed by ion leakage increase.

Table 2. Correlation coefficients of some sour orange biochemical and physiological traits at - 3°C and KNO_3 application (Y1-Y6 stand for ion leakage, leaf damage, leaf water content, chlorophyll a, b and total and carotenoid)

indics	Y1	Y2	Y3	Y4	Y5	Y6
Y1	1					
Y2	-0.48*	1				
Y3	0.29	0.41	1			
Y4	-0.71**	0.48	0.006	1		
Y5	-0.65**	0.55*	0.78**	0.51*	1	
Y6	0.37	-0.13	0.35	-0.54**	-0.04	1

*, ** i.e. statistical significant at *P. values* 0.05 and 0.01, respectively

There was a significant negative correlation between chlorophyll b and carotenoid contents at *P. value* ≤ 1% (r =0.54**). Leaf chlorophyll reduction of citrus under cold and frost shock conditions likely associates with an increase in active oxygen radicals, lipid peroxidation, and is followed by destruction of these pigments in the chloroplast membrane and thylakoids (Pietrini et al, 2005)[18] which results in the reduction of leaf green color and the increase of carotenoids content.

Conclusion

Several physiological and morphological changes occurred in sour orange seedlings at -3°C. Through affecting on growth indices such as chlorophyll and leaf water contents, the application of KNO_3 can provide appropriate conditions for vegetative growth and plant resistance to cold stress. An important index to assess the damage of sour orange seedlings under cold stress was the ion leakage which decreased with increasing KNO_3 application. Also, a significant increase was observed in the chlorophyll content and leaf green color with increasing KNO_3 application.

References

1. Azzarello, E., Mugnai, S., Pandolfi , C., Masi , E., Marone , E., Mancuso, S., 2009. Comparing image (fractal analysis) and electrochemical (impedance spectroscopy and electrolyte leakage) techniques for the assessment of the freezing tolerance in olive. Trees. 23, 159-167.
2. Berova, M., Zlatev, Z., Stoeva, N., 2002. Effect of paclobutrazol on wheat seedling under low temperature stress. Bulg. J. Plant Physiol. 28, 75-84.
3. Compose, P. S., Quartin, V., Ramalho, J. C., Nunes, M. A., 2003. Electrolyte leakage and lipid degradation account for cold sensitivity in leaves of Coffea sp. Plants. J. Plant Physiol. 160, 283-292.
4. Ferrat, I. L., Lovatt, C. J., 1999. Relation between relative water content, nitrogen pools and growth of Phaseolus vulgaris L. and P . acutifolius A. Gray during water deficit. Crop Sci. 39, 467-474.
5. Fotouhi, G.R., Baghbanha, M.R., Hatamzadeh, A., Heidari, M., 2008. Effect of water stress on freezing tolerance of Mexican lime (Citrus aurantifolia L.) seedlings. Hortic., Environ. Biotechnol. 49, 276-280.
6. Garcia-Sanchez , F., Carvajal, M., Porras, I., Botia, P., Martinez, V., 2003. Effects of salinity and rate of irrigation on yield, fruit quality and mineral composition of ‘Fino 49’ lemon. Eur. J. Agron. 19, 427 -437.
7. Gifford, R.M., Evans, L.T., 1981. Photosynthesis, carbon partitioning, and yield. Annu. Rev. Plant Physiol. 32, 485–509.
8. Girardin , P., Tollenaar, M., Deltour, A., Muldoon, J., Meyer, J. L., 1987. Temporary nitrogen starvation in maize (Zea mays L): effects on development, dry matter accumulation and grain yield. Agronomie (Paris) 7 (4), 289-296.
9. Grewal, J. S., Singh, S. N., 1980 .Effect of potassium nutrition on frost damage and yield of potato plants on alluvial soils of Punjab (India). Plant soil 57, 105 -110.
10. Kaanane, A., Kane, D., Labuza, T. P., 1988. Time and temperature effect on stability of Moroccan processed orange juice during storage. J. Food Sci. 53, 1470-1473.
11. Kaya, C., Kirnak, H., Higgs, D., 2001. Enhancement of growth and normal growth parameters by foliar application of potassium and phosphorous on tomato cultivars grown at high (Nacl) salinity. J Plant Nutr. 24, 357 -367.
12. Marschner, H., 1995. Mineral nutrition of higher plants. 2nd ed., Academic press, London.
13. Maust, B. E., Williamson, J. G., 1994. Nitrogen nutrition of containerized citrus nursery plants. J. Am. Soc. Hortic. Sci. 119, 195-20
14. Obreza, T. A., 2003. Importance of potassium in a Florida citrus nutrition program. Better crops 87 (1), 19-22.
15. Pearce, R.S., 2001. Plant freezing and damage. Ann. Bot. 87 (4), 417-424.
16. Peng, S., 2000. Single-leaf and canopy photosynthesis of rice. In: Sheehy, J. E., Mitchell, P.L., Hardy, B. (Eds.), Redesigning rice photosynthesis to increase yield. Elsevier, Amsterdam. pp. 213-228.
17. Prabhu, A. S., Fageria, N. K., Huber, D. M., 2007. Potassium and plant disease. In: Datnoff, L.E. et al (Eds), Mineral and plant disease. The American Phytopathological Society, St. Paul., pp. 57-78
18. Pietrini, F., Chaudhuri, D., Thapliyal, A. P., Massacci, A., 2005. Analysis of chlorophyll fluorescents in mandarin leaves during photo-oxidative cold shock and recovery. Agric., Ecosyst. Environ. 106, 189-198.
19. Sala, J. M., Lafuente, M. T., 2000. Catalase enzyme activity is related to tolerance of mandarin fruits to chilling. Postharvest Biol. Technol. 20, 81-89.
20. Saneoka ,H., Moghaieb , R.E.A., Premachandra , G.S., Fujita ,K., 2004. Nitrogen nutrition and water stress effects on cell membrane stability and leaf water relations in *Agrostis* palustris Huds. Environ. Exp. Bot. 52, 131-138.
21. SAS Institute, Inc., 1993. SAS/STAT user’s guide. Version 6, 4th ed. Vol. 2. SAS Institute, Inc., Cary, NC. 846 p.
22. Syvertsen, J. H. P., 1987. Nitrogen content and CO2 assimilation characteristic of citrus leaves. HortScience 9, 297-302.
23. Véry, A. A., Sentenac, H., 2003. Molecular mechanisms and regulation of K+ transport in higher plants. Annu. Rev. Plant Biol. 54, 575–603.
24. Verslues, P. E., Agrawal, M., Katiyar-Agrwal, S., Zhu, J., Zhu, J. K., 2006. Methods and concepts in quantifying resistance to drought, salt and freezing, abiotic stresses that affect plant water status. Plant J. 45, 523-539.
25. Wang, M., Zheng, Q., Shen, Q., Guo, S., 2013. The Critical role of potassium in plant stress response. Int. J. Mol. Sci. 14, 7370-7390.
26. Zhao-Shi, X., Lan-Qin, C., Ming, C., Xian-Guo, C., Rui-Yue, Z., Lian-Cheng, L., Yun- Xiang, Z., Yan, L., Zhi-Yong, N., Li, L., Zhi-Gang, Q., You-Zhi, M., 2007. Isolation and molecular characterization of the Triticum aestivum L. ethylene-responsive factor 1 (TaERF1) that increases multiple stress tolerance. Plant Mol. Biol. 65, 719-732.

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Tomographic studies of the soil pore space in swelling and shrinkage processes

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Abstract

Modern scanners allow us to investigate the pore space of the soil with soil water content changes, ie to study the characteristics of pore structure transformation during the swelling and shrinkage. In the field, in special cylindrical containers height 3.8 cm, diameter 3.2 cm samples were taken from basic horizons of sod-podzolic soil with natural moisture. Samples were examined on a SkyScan 1172 microtomograph with a resolution of 15.8 µm. Then the samples were saturated to field capacity and re- examined in the tomograph. Then the samples were gradually desiccated with water content and structure of the pore space in the tomograph control. Characteristic features of the pore space changes during the swelling from natural moisture to field capacity are: (i) reduction of pore volume primarily due to hairline cracks, threadlike linear forms. Pores rounded, apparently biopores retain its shapeand exemplary dimensions during swelling. Presumably, it is a stable functional pore space, (ii) in the B horizon the width of the fine pores was also reduced, and the pores of rounded shape were also stable. Provides statistics on the characteristics of the shape, squares and other geometric parameters of pores of different soil layers during swelling and shrinkage.

Keywords: Soil structure, aggregate, soil organic matter, hydrophilic and hydrophobic properties of the soil solid phase.

Introduction

In soil science, there are new devices that measure the pore space in the 3D- images (imaging), the contact angle, etc. These properties and parameters should find its application in soil investigations; discusses the data relevant to soil parameters obtained with the new equipment [3,4]. New devices and methods require a lot of work on methodological and identify the limits of their applicability, the optimal ranges, measurement conditions and procedures in general standardization of experimental determination [2,3,4] .

Tomography allows to visualize the pore space at any humidity, highlight the solid phase of the soil, especially its shape and spatial organization [1,2,4]. Unlike micromorphological studies 3D imaging allows us to study the pore space in an undisturbed state at any humidity, observe the distribution of moisture in the soil solid phase using special impregnating substances [3]. At the moment in this area published numerous papers. Focuses on the description of the structure of the pore space and the use of this method for the various sections of Soil Science. So far, soil hydrologists present soil pore space pore as a set of cylindrical interference capillaries. Respectively to calculate forms of moisture and its movement in the soil they used as the main, Laplace or Jurin equations [1].

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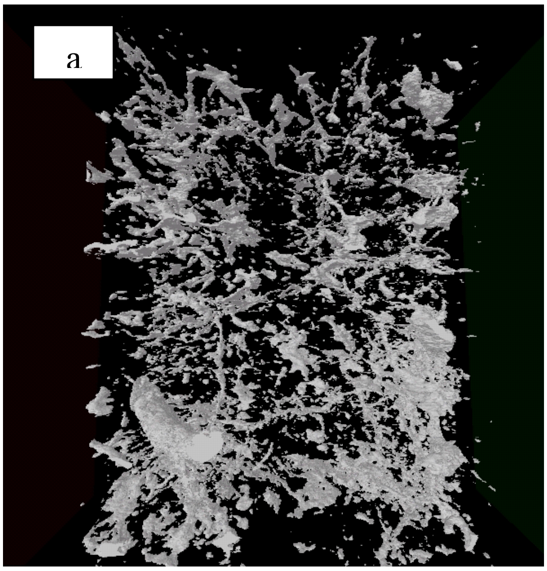

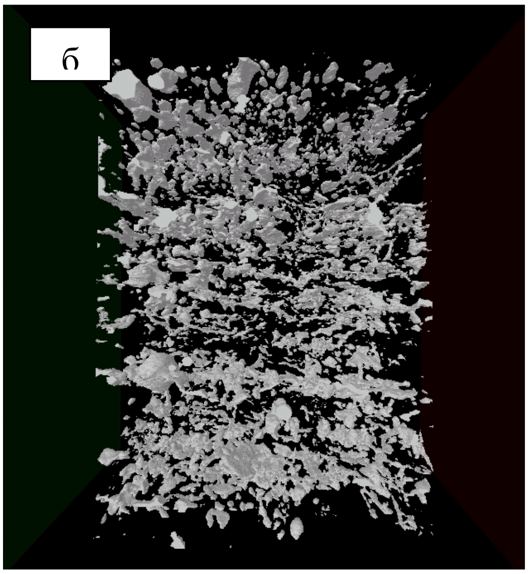

Figure 1. Tomogramm of soil pore space (black color – solid spol phase, grey – pore space).
(a – ElB horizon, б – B horizon) of sod-podzolic soil.

However, according to the 3D imaging (Fig. 1), soil pore space quite unlike the uniformly organized "tube-cylinder" and capillaries is not cylindrical, they are intricately intertwined, that certainly should not affect the water capacity of the soil system and water diffusivity [1]. Apparently the problem in the coming years due to the structure of the pore space moisture and gas capacity, moisture and gas pipeline will be a major in soil hydrology, soil physics, and probably in soil science at all.

It is known that the pore tomography soil through gaps to explore in any soil moisture. So we decided to evaluate the pore space of sod-podzolic soil in dry conditions (humidity limit shrinkage) and saturated soil (full swelling) moisture. The purpose of work is to investigate the soil porosity in swelling and shrinkage processes.

The tasks of the investigation were: (1) to estimte the pore space of various horizons of sod-podzolic soil and (2) to compare the features of the distribution of pore shape and size in the soil at the maximum shrinkage (in dry air) and swelling (with virtually saturated with moisture).

Material and Methods

The object of the study were Silty clay loam sod-podzolic soils with following items horizons A1 AEl, El, ElB, BT1, BT2. Tomography studies were carried out in the Soil Institute named VV.Dokuchaev in the lab of soil physics and hydrology. Scanning was performed with a beam energy of 100 keV and a resolution of 15.8 microns

Results and Discussion

Porosity AEl horizon ranges from 1.5 to 9% in the natural state, and from 1.2 to 8.3% in the wet state. Average porosity in the natural state is 5.48%, 4.48% in the wet (Table 1).

Table 1. The average data of soil pores quantity per tomographic section and soil porosity of different horizons sod-podzolic soils (tomographic data)

Horizon	Pores quantity per tomographic section	Porosity,%
El moist	141.85	3.94
El sec	117.00	2.85
ElB moist	75.40	4.56
ElB sec	79.53	5.95
BT1moist	249.94	4.40
BT1 sec	247.50	6.34
BT2 moist	496.20	7.22
BT2 sec	399.83	6.23

The porosity determined by tomography investigations in any times lower that in traditional physics experiment which use soil density and density of soil solid phase data. This is because the tomography can not not register the micropores which are dominated in this kind of soils, and sizes of micropores are below the threshold of this resolution tomographic shooting (8 microns per pixel). The number of pores in the saturation of the sample not changed much. In El horizon porosity ranges from 1 to 11.5% in the wet state and from 1.1 to 7.3% in the dried. The average porosity in the wet state is 3.94% and 2.85% dried. When dried the number of pores is reduced through shrinkage.

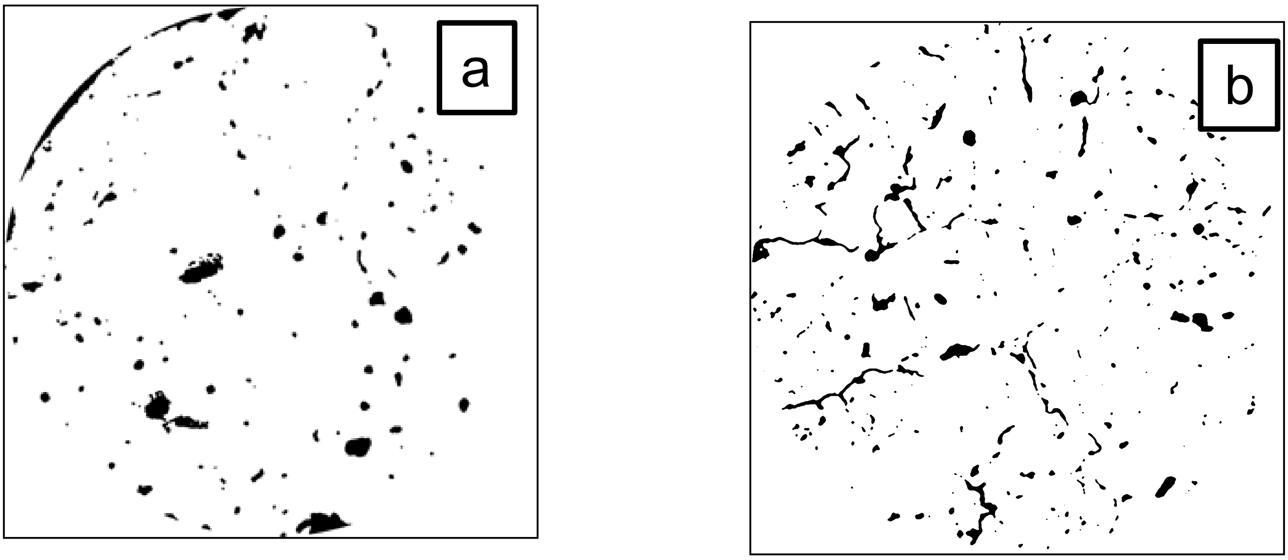

Figure 2. Soil porosity (pores – black color) of ElB horizon in wet (a) and sec (b) conditions.

As can be seen from Figure 2, the change in pore space shrinkage occurred mainly due to long fissure type. During swelling pores fissure type almost disappeared (Fig. 2a), and the pores circular shape preserved apparently continued to function. This indicates the important role of n is then rounded shape in the formation of water-air regime of soil.

Conclusion

- According to the 3-D imaging (qualitative analysis) showed that the horizons of sod-podzolic soils differ greatly in the structure of the pore space: AEl horizon has many small rounded pores, and a transition horizon El, ElB horizon include large closed pores in the horizon BT1 observed pronounced lamellar pore structure, and the horizon BT2 is porous, the structure of which is mainly formed by the root residues.
- Quantitative analyzes tomograms showed that observed on imaging porosity generally varies from 4 to 6.7%. Among the pore size and shape are mainly dominated by the thin circular macropores (pore diameter - between 75 and 1000 microns). Most soil pore investigated (25-30%) is in the field of micro-and nano-tomograms and they can not be quantitatively determined, as their sizes are below the threshold of this resolution tomographic shooting (8 microns per pixel).
- Experiment on the effect on the pore space humidification-desiccation showed that these processes are uniquely affected in different horizons. In general, when swelling of the pores are of round shape. This indicates an important role since it is round shape in the formation of water-air regime of soil.

References

1. Shein E.V. The course of soil physics. Textbook. - Moscow: MGU, 2005. - 432
2. Cormack A.M. Representation of foundation by its line with some radiological application. J. Appl. Phys. 1963. V. 34. P. 2722-2727.
3. Luo L., Lin H., Halleck P. Quantifying soil structure and preferential flow in intact soil using X-ray computed tomography. Am. Soil Sci. Soc. J. 2008. V. 72. P. 1058-1069.
4. Schlter S., Weller U., Vogel H.J. Segmentation of X-ray microtomography images of soil using gradient masks. Computers and Geosciences. 2010. V. 36. P. 1246 - 1251.

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The effects of Clinoptilolite on mineral substance of raisins in organic grape growing

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Abstract

Turkey is a major producer country of grapes growing in the World. Viticulture is one of the major branches of agriculture with respect to production area and its large share of income in Turkish national economy. Since 1985, Turkey producing and exporting organic raisins, is a world leader in the production of raisins. The research was carried out in Alaşehir-Yeşilyurt Enterprise of Viticulture Research Station from 2006 to 2007. The research was established in 15 years old Sultana Çekirdeksiz vineyard under irrigable soil conditions in organic parsel. The objective of this study was to determine the influence of an applied clinoptilolite on mineral substance analyses of the raisins. It was conducted according to randomized block design trials with three replicates consisting of 12 vines per parcel. Mineral substance analyses of the raisins obtained from the applications were performed using the ICP-AES technique. It was found that there was an increase in average potassium (K), magnesium (Mg), zinc (Zn) calcium (Ca) and phosphorus (P) contents and a decrease in copper (Cu) contents application of clinoptilolite as compared to control and a difference of 5% was determined between applications.

Key words: Mineral substance, organic grape, raisins, Sultani Çekirdeksiz, clinoptilolite.

Introduction

Turkey is a major producer of grapes in the world and viticulture is one of the major branches of agriculture with respect to production area and its large share of income in Turkish national economy. Grapevine is grown in almost all parts of Turkey and has been produced commercially in many regions of the country for many years. Turkey is among the largest grapevine growing countries of the world with approximately 478,000 hectares of vineyard area and 4.26 million tones of grape production (5th in area; 6th in production). Grape production mainly consists of 52.9% table grapes, 36.3% raisins and 10.8% must-wine varieties (Anonymous, 2010).

Processed as both table grapes and raisins, Sultani Çekirdeksiz grape variety is one of the most important export products of the country. Sultani Çekirdeksiz grapes variety is mostly grown using conventional methods in the Aegean Region. Of late years, however, it has been observed that companies of European origin have been making contracts with growers for organic grape production through their agencies in Turkey, which increases production based on organic methods.

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Vineyards where organic grapes are grown are generally located in the provinces of Izmir and Manisa, and almost all the grapes are dried and exported to European countries in particular. Organic raisin production constitutes 3.6 % of the total raisin production of Turkey (Altindisli, 2004).

A total of 95.89 % of the organic Sultani Çekirdeksiz raisin producers and % 95.55 of the total production area for organic seedless raisins are found in Izmir and Manisa region. According to records of Aegean Exporters Unions, the income earned from organic seedless raisin exports was approximately 3 million $ in 1977; whereas this figure escalated 79 % and reached 5,257,629 $ in 2004 (Kenanoglu Bektaş and Milan, 2006).

According to Considine and Considine (1982) and also to Fidan and Yavaş (1986), mineral substances found in grape are taken up from the soil by the vine and transferred to the plant and the fruit. Although their quantities are within certain limits, they can vary depending on the variety of the grape, degree of ripeness, soil type, fertilizing and climatic conditions. Generally, the quantities of mineral substances are relatively lower in dry climates and during dry years. The quantities of mineral substances are affected by soil conditions; however, certain elements are influenced by atmospheric conditions and some others by plant protection drugs used for plant diseases and pests. The amount of iron in grapes is directly influenced by the iron content of the vineyard soil. Although content of copper is at significant levels in grapes, it tends to increase in cases where certain pesticides are used.

In their study in which they observed quantities of macro-elements and micro-elements in must made from three Hungarian grape varieties during the course of ripening, Diófási et al. (1986) stated that there was a positive correlation between the sugar quantity and N, P, Ca, Fe, and Mg elements.

In a study conducted by Adamian (1988) comparing substance contents of local Armenian, Western European and Central European table grape varieties, it was reported that Armenian grapes contained more mineral substances and had a higher Fe/Mn ratio; temporary varieties (seeded and seedless) contained more mineral substances compared to early-ripening varieties; and seedless early-ripening varieties contained more Cu and Mn that seeded ones.

Švejear and Okáč (1989) reported that amounts of Fe, Zn, Mn and Cu found in the grape and the wine were not only dependent on the presence of these minerals in the soil and that the composition of the soil, pH as well as climatic conditions were also important factors.

Boselli et al. (1995) stated there was a positive correlation between the pH in the grape must and the K content, and that pH in the must and K content could be affected by the rootstock used in a particular vineyard.

Aykut (2002) determined mineral substances found in musts of Seedless Sultana, Muscat Hamburg and Alicante Bouschet grape varieties in mg/kg as 1540-1750-1255 for K, 24-29.06-34 for Ca, 100-53.75-102.5 for Mg, 53.30-31.32-52.15 for Na, 136.9-97.20-168.2 for P, 1.88-0.71-1.38 for Fe, 2.5-1.69-0.8 for Cu, 0.68-0.79-0.35 for Zn ve 0.80-0.49-1.45 for Mn, respectively.

The mass of the human body is made up approximately 50 elements (Keskin, 1981). Twelve of these elements (O, C, H, N, Ca, P, K, S, Na, Cl, Mg and Fe) constitute 99.9 % of the total. Almost 99% of this ratio is O, C, H, N, Ca and P. These twelve elements are referred to as macro or quantitative elements, whereas the remaining ones are called micro or trace elements. Microelements are substances found in human body and nutrients in concentrations of less than 0.005 % (Keskin, 1981; Gözükara, 1990).

Raisins have been a favorite food since 1490 BC due to their nutritive value and high micronutrients content (Witherspoon, 2000). It was one of the most important and popular dried fruits in the world because their high nutritional value (Fang et al., 2010). Raisins should be of particular interest in these investigations due to their unique phytochemical composition and the natural qualities that make raisins an appealing source of necessary minerals including potassium, iron, vitamin B, calcium, magnesium, sodium, arsenic, cadmuim, chromium, manganese and nickel (Simsek et al., 2004; Fang et al., 2010).

In recent years, attention is paid to development of sustainable agriculture and hence the natural minerals as soil amendments are applied to improve physical and chemical properties soil (Abdi et al, 2006) . The great effectiveness of zeolites as natural sources of trace elements supplementing NPK and its high adsorption ability have been reported (Kolyagin and Kucherenko, 2003). Natural zeolites are used extensively in Japan as amendments for sandy, clay-poor soils. The pronounced selectivity of clinoptilolite $NH4^{++}$ and K^{+} also was exploited in slow-release chemical fertilizers (Minato, 1968). By using clinoptilolite-rich tuff as a soil conditioner, significant increases in the yields of wheat (13-15%), eggplant (19-55%), apples (13-38%) and carrots (63%) were reported when 4-8 ton acre zeolite was used (Mumpton, 1999). The addition of clinoptilolite also increased yields of barley, potato, clover and wheat after adding 15 t ha^{-1} to Ukrainian sandy loam soils (Mazur *et al*., 1986). Clinoptilolite amended to a potting medium for chrysanthemums behaved like a slow-release K-fertilizer, yielding the same growth for the plants as daily irrigation with Hoagland's solution (Hershey, 1980)

The present study was conducted on Sultani Çekirdeksiz grape variety, which has an important place in our national economy. The objective of this study was to determine the influence of an applied clinoptilolite on mineral substance analyses of the raisins. Raisins produced from Sultani Çekirdeksiz grape variety in organic grape parcels during organic production phase (2006-2007). Moreover, the study tries to emphasize the importance of raisins, organic raisins in particular, as a natural source of energy in human nutrition.

Material and Method

The present study was carried out in Alaşehir-Yeşilyurt Enterprise of Viticulture Research Station from 2006 to 2007. The research was established in 15 years old Sultani Çekirdeksiz vineyard under irrigable soil conditions and on its own roots at intervals of 2.4 X 3.3 m long along the row using a "T" wire grape trellis training system in organic parcel.

Sultani Çekirdeksiz is a variety which ripens in midseason. It grows strong with conical clusters, wings, normal density, small oval shaped berries and average berry skin thickness. Although it is a variety for drying, Sultanas are also processed as table grapes through a series of culture procedures.

Soil Composition of the Trial Vineyard

There are no salinity problems whatsoever in soil samples demonstrating slight alkaline reaction. Soils with low lime level show a sandy loam texture. Available phosphorus in soils with low humus level and with medium total nitrogen level was found to be medium (0-30 cm) and low (30-60 cm), whereas available potassium was insufficient. In soils with sufficient (high) levels of available calcium and available magnesium, there are no problems with respect to available sodium. Available micronutrient elements in the soil samples including iron, copper and manganese were sufficient, whereas zinc was insufficient (Table 1).

Table 1. Physical analysis and Macronutrient and Micronutrient Contents of the Soil Sample

Soil Depth		0-30 cm	30-60 cm
pH		7,60	7,65
Soil salinity	(%)	0,025	0,025
Lime	(%)	3,44	3,92
Sandy	(%)	68,40	66,40
Silt	(%)	24,00	25,00
Clay	(%)	7,60	8,60
Texture		Sandy-loam	Sandy-loam
Organic Matter	(%)	1,52	0,95
Total Nitrogen	(%)	0,060	0,038
Available Phosphorus	(ppm)	3,32	1,29
Available Potassium	(ppm)	175	155
Available Calcium	(ppm)	2160	2400
Available Magnesium	(ppm)	934	938
Available Sodium	(ppm)	20,8	19,0
Available Iron	(ppm)	8,51	6,79
Available Copper	(ppm)	6,13	3,48
Available Zinc	(ppm)	0,67	0,52
Available Manganese	(ppm)	7,20	4,09

In the study, 4 kg/vines clinoptilolite that were taken from Gördes region of Turkey were applied to organic parcel and as a control weren't applied to organic parcel. Raisins produced from Sultani Çekirdeksiz grape variety in organic grape parcels during organic production phase (2006-2007).

Potassium (K), phosphorus (P), sodium (Na), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), calcium (Ca) and magnesium (Mg) contents of the raisin samples were determined in a series of analyses carried out using an ICP-AES spectroscopy during organic viticulture phase from 2006 to 2007.

The research was carried out as randomized block design trials with three replicates consisting of 12 vines per parcel. After a variance analysis was performed on the data obtained was using the statistical software package "SPSS 20.0 for Windows", an LSD (< 0.05) test was used for comparison of average values.

Mineral substance analyses were performed on raisin samples obtained from applications using an ICP-AES spectroscopy. A 10g raisin sample is placed in a crucible and dried in an incubator at 100 °C. The samples are then put into the oven when their temperature reaches 250 °C and the temperature is raised to 600 °C. They are left at this temperature overnight (13-15 hours). If the samples are not reduced to white ash, they are moistened with and dried in the oven for another 2 hours until they turn white. The crucibles are put in a desiccator and allowed to cool to room temperature. Later 6 ml extraction acid ($HCl+HNO_3$) and 50 ml distilled water are added to the crucibles and slightly heated to dissolve the ashes. The solution is strained into 100 ml volumetric flask using a black band filter and filled to the top with distilled water (The dilution factor should be 10.).

Desired standards were entered and the device is conditioned. Samples which had passed through the dilution procedure were fed into the device and Potassium (K), phosphorus (P), sodium (Na), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), calcium (Ca) and magnesium (Mg) minerals were read using the emission technique. The results obtained were multiplied by SF and mineral substance quantities were found.

Results and Discussion

Potassium (K), phosphorus (P), sodium (Na), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), calcium (Ca) and magnesium (Mg) contents of the raisin samples were determined in a series of analyses carried out using an ICP-AES spectroscopy organic parcel which were/weren't applied clinoptilolite from 2006 to 2007. Amounts of mineral substances found in raisin samples were given in ppm (parts per million). Mean values belonging to years of organic production were also given in ppm.

It was determined that trial applications conducted according to results of statistical evaluation of mean values of the control and applied clinoptilolite data for raisins obtained during the organic production phase over the years had different important effects on the potassium (K), calcium (Ca), magnesium (Mg) phosphorus (P), sodium (Na), iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) contents at 5 % significance level.

An increase was observed in mean values of potassium (K), calcium (Ca), magnesium (Mg) phosphorus (P), iron (Fe), manganese (Mn) and zinc (Zn) contents on applied clinoptilolite as compared to control. A decrease was observed in mean values of sodium (Na) and copper (Cu) contents on applied clinoptilolite parsel as compared to control.

As can be seen from Table 2, the highest Potassium (K) value was recorded at applied clinoptilolite, while the lowest value was observed control (7553,17 a ppm and 7113,00 b ppm, respectively). These results are similar to those reported by Yağcı and İlter (2007), Emine et al. (2011) and Gary and Arianna (2010) and Simsek et al. (2004) (7.47 mg/g) in seedless raisin. Potassium (K) is a very important component for human health. High-potassium diet lowers blood pressure and reduces cardiovascular disease morbidity and mortality (Whelton et al., 1997). In addition, potassium intake lowers urinary calcium excretion and decreases the risk of osteoporosis (He and MacGregor, 2008).

The highest calcium (Ca) value was recorded at applied clinoptilolite (237,83 a 284.46 a ppm), while the lowest value was observed control (228,00 b ppm) which can be seen in Table 2.

As can be seen from Table 2, the highest magnesium (Mg) value was recorded at applied clinoptilolite, while the lowest value was observed control (573,67 a ppm and 488,67 b ppm,, respectively). These results are similar to those reported by Simsek et al. (2004) and Yagci and İlter (2007). The Mg is essential to all living cells, where they play a major role in manipulating important biological polyphosphate compounds like ATP, DNA, and RNA. (He and MacGregor, 2008)

The highest phosphorus (P) value was recorded at applied clinoptilolite, while the lowest phosphorus (P) value was observed control (237,83 a ppm and 215,33 b ppm, respectively) which can be seen in Table 2. These results are similar to those reported by Simsek et al. (2004) and Yağcı and İlter (2007). Phosphorus can be found in the environment most commonly as phosphates. Phosphates are important substances in the human body, because they are a part of DNA materials and they take part in energy distribution (De Rosa et al., 1998).

Table 2. Minerals content in *Applied Clinoptilolite* and Control of raisins produced from Sultani Çekirdeksiz grape variety during organic phase for Average of Years (K, Ca, Mg, P, Na, Fe, Cu, Mn and Zn).

Aplication	K (ppm)	Ca (ppm)	Mg (ppm)	P (ppm)
Control (2006-2007)	7113,00 b	228,00 b	488,67 b	215,33 b
Z1 (2006-2007)	7553,17 a	237,83 a	573,67 a	237,83 a
LSD 0,05	170,65	6,13	44,63	15,70

Aplication	Na (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
Control (2006-2007)	167,33 a	14,75 b	6,35 b	1,55 b	6,43 b
Z1 (2006-2007)	147,00 b	20,77 a	6,00 a	1,87 a	6,65 a
LSD 0,05	18,15	4,81	0,18	0,21	0,15

Control: not *applied clinoptilolite:*
Z1: *applied clinoptilolite*
Values in the same column with different subscript letters represent significant differences between production phases.
NS = Not significant

As can be seen from Table 2, the highest sodium (Na) value was recorded control, while the lowest phosphorus (P) value was observed at applied clinoptilolite (167,33 a ppm and 147,00 b ppm, respectively) which can be seen in Table 2. These results are similar to those reported by by Simsek et al. (2004) and Yağcı and İlter (2007).

The highest Iron (Fe) value was recorded at applied clinoptilolite, while the lowest value was observed control (20,77 a ppm and 14,75 b ppm, respectively) which can be seen in Table 2. These results are similar to those reported by Simsek et al. (2004) and Yağcı and İlter (2007). Iron is an essential part of hemoglobin; the red colouring agent of the blood that transports oxygen through our bodies. Iron is needed for psychomotor development, maintenance of physical activity and work capacity, and resistance to infection (Stoltzfus, 2001).

As can be seen from Table 2, the highest copper (Cu) value was control, while the lowest value was observed at applied clinoptilolite (6,35 b ppm, a ppm and 6,00 a ppm, respectively).

The highest Manganese (Mn) value was recorded at applied clinoptilolite, while the lowest value was observed control (1,87 a ppm, a ppm and 1,55 b ppm, respectively) which can be seen in Table 2. These results are similar to those reported by Simsek et al. (2004) and Yağcı and İlter (2007). Manganese is a constituent of metalloenzymes (arginase, pyrurate carboxylase and manganese superoxide dismutase) and an enzyme activator (hydrolases, kinases, decarboxylases and transferases). It is reguired for normal brain function (De Rosa et al., 1998)

As can be seen from Table 2, the highest zinc (Zn) value was recorded at applied clinoptilolite, while the lowest value was observed control (6,65 a ppm and 6,43 b ppm, respectively) which can be seen in Table 2. These results are similar to those reported by Simsek et al. (2004) and Yağcı and İlter (2007). Zinc is needed for growth and for maintenance of immune function, which enhances both the prevention of and recovery from infectious diseases (Black, 2003)

An increase was observed in mean values of potassium (K), calcium (Ca), magnesium (Mg) phosphorus (P), iron (Fe), manganese (Mn) and zinc (Zn) contents on applied clinoptilolite as compared to control. A decrease was observed in mean values of sodium (Na) and copper (Cu) contents on applied clinoptilolite parsel as compared to control.

Our results prove that Organic raisins applied clinoptilolite constitute a natural source of energies and many minerals such as potassium (K), magnesium (Mg), copper (Cu), zinc (Zn), calcium (Ca), phosphorus (P) sodium (Na) iron (Fe) and manganese (Mn) that may prevent many diseases.

References

Abdi, Gh. Khosh-Khui, M. and Eshghi, S., 2006. Effects of Natural Zeolite on Growth and Flowering of Strawberry (Fragariaxananassa Duch.). International Journal of Agricultural Research, 1: 384-389.

Adamyan, A. KH., 1988. Content of mineral substances in the berries of table grape varieties, In Nov. v razvitii vinogradar. ArmSSR v svete zadach Prod. Progr. Erevan Armenian SSR (1986) 85-90, Hort. Abst. Vol: 58, No: 5.

Altindisli A., 2004. Organic Grape Growing Practices in the Aegean Region, Turkey. 2. International Conference on Oganic Farming. 7-9 May 2004, Thiava, Greece.

Anonymous (2010). http://www.tuik.gov.tr/bitkiselapp/bitkisel.üzüm.

Aykut, O., 2002. Ülkemiz Ekonomisinde Yeri Olan Üzüm Çeşitleri ile Ürünlerinin Mineral Madde İçerikleri ve Değişimi Etkileyen Faktörler, Ankara Üniv. Fen Bilimleri Ens. Yüksek Lisans Dönem Projesi, Ankara, 61s.

Black RE., 2003. Zinc deficiency, infectious disease and mortality in the developing world. J Nutr.133:1485S–9S.

Boselli, M., Fregoni, M., Vercesi, A. and Volpe, B., 1995. Variation in mineral compositon and effects on the growth and yield of Chardonnay grapes on various rootstocks, Agricolture Ricerca (1992) 14 (138-139) 57-64, Hort. Abst. Vol: 65, No: 1, p27.

Considine, D. M. and Considine, G. D. 1982. Foods and Foods Production Encyclopedia, Van Nostrand Reinhold Co. Inc, USA.

De Rosa, C. T., Pohl, H. R., Williams, M., Ademoyero, A.A.,Chou, C-H. S. J and Jones, D.E., 1998. Public Health Implication of Enviromental Exposures. Reviews in Environmental Health: Toxicological Defense Mechanics (Ed. by Hook, G. E. R. and Lucier, G. W.), 394 p.

Diófási, L., Ijjász, I. and Vezekényi, E., 1986. Changes in the micro-and macroelement content of must during maturation, Borgazdaság (1985) 33 (1): 1-10, Hort. Abst. Vol: 56, No: 9, 732p.

Emine, S., Duygu, A., Ecehan, T., Nilgun, G., 2011. Chemical composition of grape canes. Ind. Crops. Prod. 34, 994–998.

Fang, Y., Zhang, A., Wang, H., Li, H., Zhang, Z., Chen, S., Luan, L., 2010. Health riskassessment of trace elements in Chinese raisins produced in Xinjiang province. Food Control. 21, 732–739.

Fidan, Y. ve Yavaş, İ, 1989. İnsan Beslenmesi ve Ülke Ekonomisi Açısından Üzümün Önemi, I. Uluslar arası Gıda Sempozyumu, 10-13, Bursa.

Gary, W., Arianna, C., 2010. Polyphenol content and health benefits of raisins. Nutr. Res. 30, 511–519.

Gözükara, E.M., 1990. Biyokimya, Baskı Ofset Repromat Ltd. Şti. Ankara, 1104s.

He, F., MacGregor, G., 2008. Beneficial effects of potassium on human health. J. Plant. Biol. 133, 725–735.

Hershey, D.R., J.L. Paul and R.M. Carson, 1980. Zeolite. HortScience, 15: 87-89.

Kenanoğlu Bektaş, Z ve Miran, B., 2006. Manisa ve Izmir Illerinde Geleneksel ve Organik Çekirdeksiz Kuru Üzümün Karşılaştırmalı Ekonomik Analizi . Tekirdağ Ziraat Fakültesi Dergisi (Journal of Tekirdag Agricultural Faculty), 3 (3)

Keskin, H., 1981. Besin Kimyası, T.C. İstanbul Üniversitesi Yayınları No: 2888, Kimya Fak. No: 47, Cilt: I, Fatih Yayınevi Matbaası, İstanbul.

Koljajic, V., N. Djordjevic, G. Grubic and M. Adamovic, 2003. The influence of zeolite on the quality of fresh beet pulp silages. J. Agric. Sci., 48: 77-84.

Mazur, G.A., G.K. Medvid and I.T. Gvigora, 1986. Use of natural zeolite to increase the fertilizer of coarse soils. Soviet Soil Sci., 16: 105-111.

Minato, H., 1968. Characteristics and uses of natural zeolites. Koatsu Gasu, 5: 536-547.

Mumpton, F.A., 1999. La roca magica: Uses of natural zeolites in agriculture and industry. Proc. Natl. Acad. Sci. USA., 7: 3463-3470.

Pamuk, H. H., 1999. Yuvarlak Çekirdeksiz Üzüm Bağlarında Çevre Dostu ve Geleneksel Tarım Uygulamalarının Verim ve Kaliteye Etkileri Üzerine Araştırmalar. E.Ü. Fen Bilimleri Enstitüsü Bahçe Bitkileri Anabilim dalı. Doktora Tezi (yayınlanmamış), İzmir.

Simsek, A., Artık, N., Baspina, E., 2004. Detection of raisin concentrate (Pekmez) adulteration by regression analysis method. J. Food Comp. Anal. 17, 155–163.

Stoltzfus RJ., 2001.Iron-deficiency anemia: reexamining the nature and magnitude of the public health problem. Summary: implications for research and programs. J Nutr. 131:697S–700S; discussion 700S–1S

Švejcar, V. and Okáć, A., 1989. Metals in Tokay musts and wines, Pol'nohospodárstvo (1989) 35 (1):31-37, Hort. Abst. Vol: 59, No: 8, p732

Whelton, P., He, J., Cutler, J., Brancati, F., Appel, L., Follmann, D., Kleg, M., 1997. Effects of oral potassium on blood pressure. Meta analysis of randomized controlled clinical trials. J. Am. Med. Assoc. 277, 1624–1632.

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Recultivation of technologically disturbed lands – One of the methods of carbon sequestration

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Abstract

The soil surface in the Republic of Kazakhstan is exposed to technogenic effects, in the results of which the centuries-old soil-plant cover is disturbed. In the south of the Republic the soil surface is disturbed due to mining of non-ore resources. Careers, dumps and hollows which have various sizes and shapes are formed. Natural recovery of soil surface depends on the productivity of the surrounding undisturbed landscapes, in scarcity and poor vegetation self-restoration of land cover is long. Remediation works were carried out on lands disturbed during the extraction of loess-like rocks for construction materials. Thus, during reclamation of loess-like loams the bio-agrotechnological methods were used. Legume-cereal crops and their grass mixtures were used. The agro-technical method included plowing of loess-like loams, conducting plot experiments, putting on them the fertile layer of common gray soils of different capacity, application of organic and mineral fertilizers and irrigation. The results showed that after 4 years of reclamation the lands could be used for growing grain crops. In remediation of loamy rocks it is not necessary to put a fertile layer. They provide an excellent yield of agricultural crops in conditions of biological re-cultivation and irrigation.Biotechnical methods of reclamation of dumps of phosphorite deposits, which are composed of coarsely fragmented dolomite rocks and shale of various genesis showed positive results with the use of wood chips and bentonite clay in order to preserve moisture. The use of pit-hole method of planting of germinated seedlings of narrow-leaved Elaeagnus and Halimodendron was the most effective and economical. They have a great capacity of seeding, drought-tolerant, undemanding to fertility of the substrate. On dumping waste rock dump was carried out randomly and a comb like hills and ridges of the relief were formed, between them the seeds germinate. Disturbed lands, deprived of soil-plant cover in their biotechnological methods of re-cultivation effectively reduce the carbon emissions.

Keywords: Remediation, biotechnology, blade, loam, legume-cereal grass mixture.

Introduction

The entrails of earth of Kazakhstan store more than 90 kinds of minerals. Almost there are no elements in Table of D.I. Mendeleev that would not be found in the bowels of the Republic (Yesenov, 1968, p. 3). The total area of the Republic of Kazakhstan is 272.5 million hectares. In the agricultural turnover is 222.5 million hectares of which 33.7 million hectares of arable land, 187.0 million hectares of pastures and hayfields, 1.8 million hectares of perennial crops and inarable lands. The great environmental problem of the Republic is disturbances of soil and vegetation cover due to mining of ore and non-metallic resources. The result is that anthropogenic and disturbed land appears. Especially where mining is done by open method. So it causes stone pits the depth of which can reach from 5 up to 250 m.

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Technological landscapes appear on the mining grounds. Empty supra-ore bodies form industrial dumps of rudaceous rock.

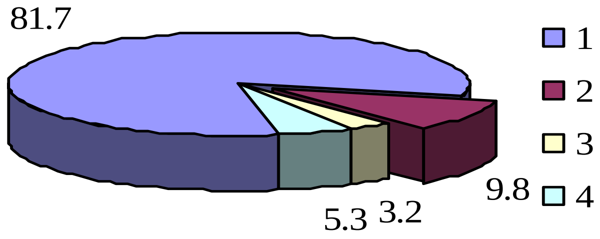

Figure 1. 1 – Agricultural cultivated land (81.7 %); 2 – Forest and tree and shrubbery plantings land (5.3 %); 3 – Land under water and swamps (3.2 %); 4 – Other non-agricultural land (9.8 %).

Material and Methods

The objects of study are: South Kazakhstan Shymkent town loamy deposit, and Zhambyl phosphorite deposit "Kokdzhon". Methods of research are field study, experimental field research and laboratory and analytical studies.

Results and Discussion

On the south of the Republic as the result of loesslike rock mining for purposes of consruction the stone pits appeare with various depth. The development of the loamy rocks field was carried out near the cement and brick factories in the town limits. First reclamation works were carried out in this field. First reclamation works were carried out in this field. First reclamation works were carried out in this field. In the stone pit after loams processing a planning stage of mine technical reclamation was held. Bulldozers cut mounds and filled the deepest part of the stone pit. So in the stone pit the leveled off site was build up for field experiments on the biological stage of loess rocks reclamation. Variants of experiences included cultivation of perennial legume-cereal plants in pure and mixed crops under irrigation (figure 1,2).

Figure 1 - General view of experimental field

Figure 2 - Plot experiments

Variants of experience include loess rocks filling by the fertile layer of zonal soil – grey soil (sierozem) and by application of organic (manure at the rate of 60 t / ha) and mineral fertilizers in different norms (N_{60}, P_{60}, K_{60} double and triple doses). Years of research have shown, that the organic fertilizer was effective only the first 2 years, further there was a decrease of green mass of cultivated grasses and grass mixtures. Option with the application of topsoil on the loess in the first year showed a low yield of cultivated legumes and cereals. It is quite explainable process, which can be called the period of "illness" of the two substrates (soil and rock), which functional properties had been violated. Only in the third year crop yield was on a level with crop yields obtained in the variant without application of topsoil. This experiment proved, that on the loess under irrigation and biological remediation cultivated perennial grasses can be followed by cultivation of crops without application of topsoil. Crop yields and in some cases exceeds the yield of crops cultivated on zonal undisturbed soils.The next object of disturbed lands study should include phosphorite deposits Zhanatas where there are a number of other fields, which includes "Kokdzhon".

The field "Kokdzhon" includes stone pit "Kistas", which consists of two units: "Kistas 1" and "2 Kistas". The total area of disturbed land on the field "Kokdzhon" is 277.83 hectares. The object under study is in the south-west of the town Zhanatas in the mountains Shoshkabulaktau and Ulken Aktau, the height is 500 - 700 m above sea level. A characteristic feature of the deposit dumps "Kokdzhon" is their multistage (figure 3). The upper layer, the upper part of the site has a flattened slope, the middle part has a slope or shoulder angle to 3-40, the lower part has a slope of up to 7-100 (Report of the branch LLP "Kazphosphate", GPK "Karatau". 2008). In the area of semi-desert, where it is hard climatic conditions the question of the development of theoretical problems reclamation of dislocated soil raises for the first time.

Figure 3 - Multilayer dump

Studies provided will allow to justify scientifically reclamation works in the semi-arid conditions for the first time, and to make a prediction about the speed and direction of soil formation, and also to suggest measures for effective rehabilitation of disturbed areas, which can greatly reduce the effect of atmospheric carbon, and provide proper functioning of the biosphere and the ecological balance in industrial populated areas.

"Kokdzhon" is a phosphorite deposits of sedimentary origin belonging to the Proterozoic age, Lower Paleozoic and Quaternary system. Productive horizon is composed of calcareous phosphorite.

Reconnaissance detour technologically - disturbed landscapes allowed to define all forms and types of violations during field development. The forms of dumps are trapezium-shaped with flattened slope and crested forms of technogenic relief. On the dump surface the backfilled chaotically rocks of different genesis found often. Main violations of soil presented by dumps and open pit having a length 1.6-2.98 km, width 360-430 m, 90-95 m depth. The dump height is 50-70 m (Dubinin, 2010, pp. 232-235).

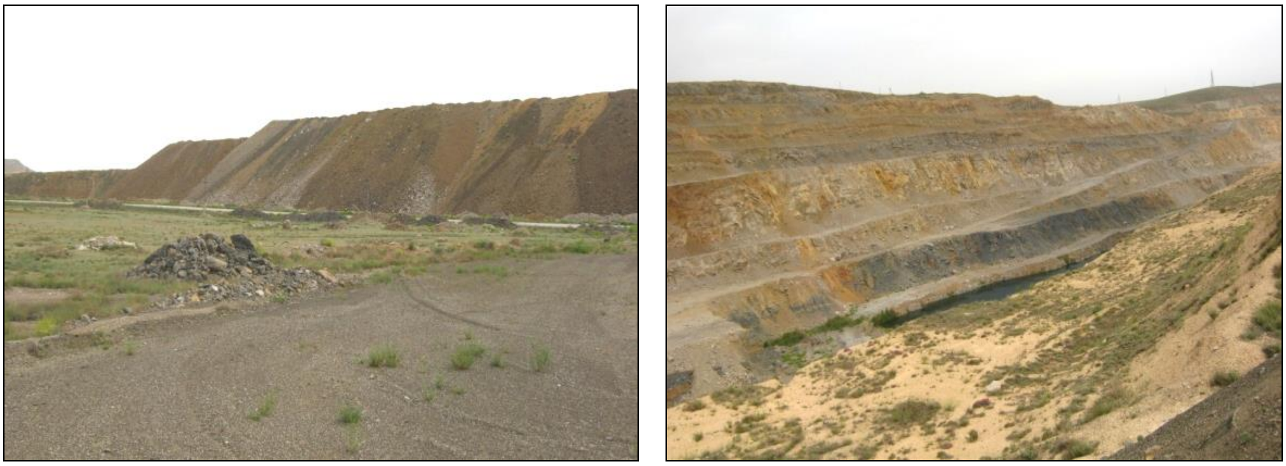

Figure 4 – Phosphorite deposit "Kokdzhon" Dump pit «Kistas 1»

Studies were conducted on the dump unit 2 - 1 field "Kokdzhon". At each selected site of the dump according to the degree encrustation and relief the cuts were laid for the study of initial soil formation processes.

So, in the dump few cuts were laid, which had shortened profile, composed of coarse clastic rocksin places mixed with loamy rocks. The vegetation cover is sparse. In the lower places in the dumps small hollows the last year vegetation litterfall remained. In all sections of the surface profile the sod layer has different capacities from 0.5 to 2 cm. Dark-colored horizon reaches 6-7 cm. The rocks are carbonate and the profile is marked ebullition except for the upper horizon, where the effervescence is less vigorous. It says about the initial processes of leaching and soil formation.

The main source of soil moisture on the investigated objects is atmospheric precipitations, amount and distribution of which in time depend on the climate of the area and meteorological conditions. The second source of moisture in soils is the condensation of atmospheric moisture on the surface of the soil and in its upper layers (10-15 mm). Field moisture content of the profile is slight (table 1). It should be noted that the lower layer is more moisture than the surface. Such a distribution of moisture is due to many factors. Thus, the cuts laid on naturally overgrown dumps mainly are on generally more flattened areas of the relief.

Table 1. Field soil moisture

Cut	Depth, cm	Field moisture, %	Hygroscopic moisture coefficient	Water-content coefficient	Volume mass, g/cm^3
P-1 Zonal soil	0-12	4.94	1.05	0.9559	1.389
	12-45	7.95	1.08	0.9263	1.449
	25-46	9.28	1.09	0.9186	1.496
	46-90	11.2	1.11	0.8989	1.506
	90-120	5.77	1.06	0.9454	1.558
P-2 Dump 2	0-6	1.61	1.02	0.9842	
	6-17	2.14	1.02	0.9790	
P-3 Dump 2	0-7	2.94	1.03	0.9715	
	7-17	6.95	1.07	0.9627	
	17-30	6.50	1.06	0.9390	
P-4 Dump 2	0-7	3.18	1.03	0.9692	
	7-17	4.87	1.05	0.9537	
	17-32	8.64	1.09	0.9284	

Biotechnological methods reclamation of phosphorite deposits dumps, which consist of coarse-grained dolomite and shale of various genesis showed positive results. Under laboratory conditions, *Elaeagnus angustifolia* and *Halimodendron halodendron Pall* were grown using different meliorantov. As meliorants the bentonite clay and sawdust to conserve moisture were used.

Elaeagnus angustifolia and *Halimodendron halodendron Palla* are legumes and have a great seed potential and also have a high drought and salt tolerance and undemanding to fertility substrate.

In the laboratory, in 500 ml beaker filled gravelly loam substrate, mixed with sawdust and bentonite clay. Grown plants were planted in the dump ground. The plants were under severe climatic conditions. Summer heat reached 40-45 °C/winter frosts to strong -25-30 °C. Nevertheless plants were resistant and in the third year they reached 30-40 cm in height (figure. 5 a, b, c, d).

Conclusion

- Experimental and field studies on remediation loess rocks used in the production of building materials (bricks, cement) showed that in the conditions of use of fertilizers and irrigation it is possible to get a crop of forage grasses at harvest with undisturbed zonal soils.
- When reclamation loess rocks there is no need applying of soil fertile layer.
- After the biological reclamation on loess the crops can be cultivated.
- Laboratory and field experiments on reclamation of technogenically disturbed lands caused by the development of phosphorite deposits by using meliorants - bentonite clay and sawdust to retain moisture

in the rocky-gravelly coarse-grained industrial dumps yielded positive results. Planted plants survive in extreme climatic conditions and gave good growth.

- The use of biotechnological methods of remediation technogenically disturbed landscapes in southern Kazakhstan will help accelerate the formation of land cover and reduce carbon emissions.

a b

c d

Figure 5 - Laboratory and field experiments a, b, c, d.

References

Esenov Sh., Kunayev D., Mukhamedzhanov S. 1968. The earth's depths of Kazakhstan. Ed of "Kazakhstan", 3 p.

Report of the Branch LLP "Kazphosphate" GPK "Karatau". 2008. 120 p.

Dubinin A. 2010. Rationale for the potential development area Kasik Tobe field Kokdzhon, "Ensuring environmental safety - the path to sustainable development of Kazakhstan", Senim, Taraz, pp. 232-235.

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Effect of soil properties derived from different parent rocks on teak biomass characteristics in Southwest Nigeria

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Abstract

Understanding the biomass characteristics that influence teak production in soil derived from different parent rocks is imperative in sustaining teak cultivation. In the southwestern ecological zone of Nigeria, teak plantation (*Tectona grandis*) is widely grown in large-scale as a way of meeting the high wood demand and soil conservation. A study was carried out to assess the effect of teak biomass characteristics on soil nutrient derived from basement and sedimentary rock formations. Systematic line transect was employed to establish 36 sample plots of 900m^2 across Ilaro and Olokemeji plantations underlain by sedimentary and basement complex rocks respectively. In each plot, soil samples (topsoil and subsoil) and teak biomass were collected. The Pearson's result showed that at Ilaro and Olokemeji plantation, none of the topsoil and micronutrient properties showed any significant relationship with teak biomass parameters. It showed that at Ilaro, subsoil N, OC, pH, EC and CEC had positive and significant relationships with bole height; and subsoil silt showed positive and significant association with tree height and volume; while none of the subsoil properties at Olokemeji had significant direct relationship with the teak biomass parameters. For micronutrient, only subsoil Zn and Fe had significant relations with volume and total height at Ilaro, while at Olokemeji, only subsoil Fe showed positive and significant association with bole height. The stepwise regression analysis at Ilaro indicated that subsoil organic carbon and subsoil silt exerted significant effects on bole height, total height and volume, while at Olokemeji only topsoil hydraulic conductivity exercised significant effect on total height. It also identified subsoil Fe to influence bole height at Olokemeji plantation, whereas at Ilaro plantation, subsoil Fe and subsoil Zn were identified to influence total height and volume respectively. The study revealed that at Ilaro plantation soil, the contents of K, Mn and Zn were principally influenced by tree height and volume, while basal area positively influenced N content; while at Olokemeji plantation, the contents of K, Mn and Zn were also principally influenced by tree height and volume, while basal area influenced N content. The study concluded that tree height, volume and basal area influenced the proportion of nutrient in the studied plantation soils.

Keywords: Teak biomass characteristics, soil nutrient, parent material, teak plantation

Introduction

High rate of demand for exotic timber products all over the world has led to the current decline in the world natural forest cover due to high rate of conversion of marginal lands and natural forest to plantations (Perez and Kanninen, 2005). It is however on record that despite the conversion of very large expanse of land

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for the growth of these species, the productivity and supply in most of the countries where they are grown in commercial quantities in plantation is generally below their market demand (Perez and Kanninen, 2005). According to Evans and Turnbull (2004), tropical hardwood forests are variable, non-uniform, and difficult to manage ecologically. Evans and Turnbull (2004) further commented that 'even though some of' the tropical hardwoods forest have magnificent wood and mostly desired species, they are slow growing and hard to manage in plantations', therefore, current knowledge about how these tropical hard wood tree species should be handled is generally insufficient. The need for exotic timber species like Teak in Nigeria has been recognized since pre-colonial times and this has resulted in the planting of some plantations around existing natural forests with the planting of Teak (Tectona grandis) and Gmelina (Gmelina-aborea) being the most popular.

Although several studies have been conducted on the effects of cultivated tree plants on soil properties in the rainforest ecosystem of West Africa by (Ekanade, 1988; Aweto and Iyanda, 2003 and Akpokodje, 2007) which revealed that the levels of most soil nutrient properties were significantly lower under tree plants than under adjoining forests. So far, findings in Nigeria have also shown that different tree crops have different interactions with soil properties. Of significant importance are studies conducted on the effect of tree plants on soil characteristics in the forest areas of south-western by Aweto and Iyanda (2003), Aweto and Dikinya (2003), Aweto and Akpokodje (2007), all focused on the influence of tree species on nutrient circling while several other studies by Egunjobi (1974), Nwoboshi (1985) examined the effects of tree plants (in plantations) on forest soils, by comparing soil characteristics between adjoining forest and those under plantation condition. What is conspicuously absent from the literature either in the tropical environment, temperate, Europe, America or other Africa countries is research on the effects of parent material on the growth of teak which is the gap my research intend to fill especially in the field of biogeography. In view of the importance of the above studies, this study investigated the influence of the Parent materials and soil on the growth dynamics of teak under basement rock of Olokemeji and sedimentary sand stone rock of Ilaro formation in Southwest Nigeria.

Material and Methods

The study area

Two Teak plantations established in year 1968 by the federal goverment in the old western region which now falls in south-western Geopolitical zone were purposively selected for this study. These plantations fall within the hot humid tropics which support the tropical rainforest ecosystem (Richards, 1952). The two selected plantations are predominantly single-specie plantations of Tectona Grandis located in Olokemeji and Ilaro withing large areas of land committed to forest reserves in Ogun state.

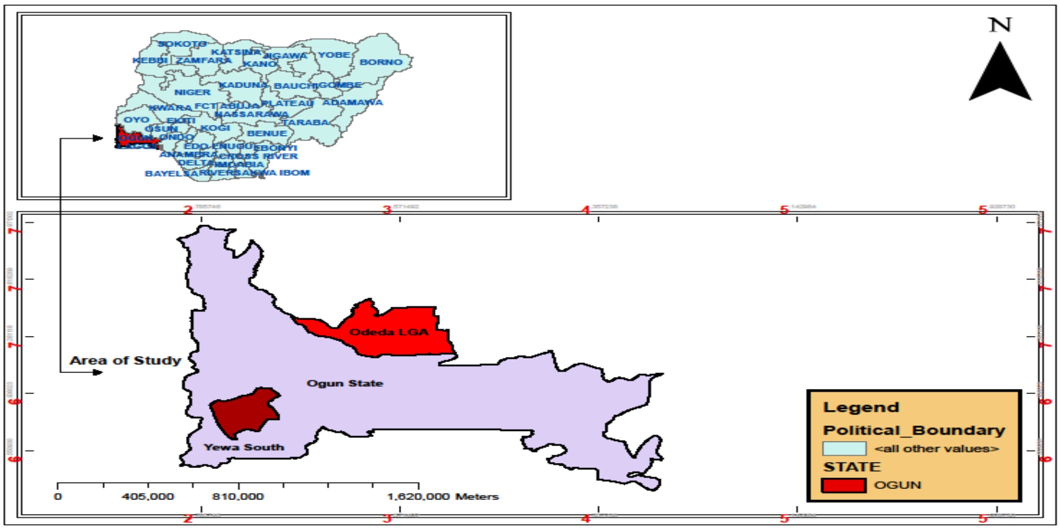

Figure 1. Map of Nigeria Showing the Study Areas

Location and Extent of Olokemeji and Ilaro Plantations : The Olokemeji teak plantation is located in the heart of Olokemeji forest reserve located between latitudes 7° 05' and 7° 40'N and longitudes 3°15' and 3°46'E. According to Aminu-Kano and Marguba, (2002), the plantation occupies a total land area of 58.88 km2 (approximately 5,000 hectares) .The reserve, which was established in 1899 is the second forest reserve in Nigeria. It lies approximately 32km west of Ibadan, and 35km north-east of Abeokuta. It falls within the middle course of Ogun River, which drains the western half of the Basement Complex area of South Western Nigeria. It is bounded to the east by the Oshun basin and in the west, by important tributaries such as the Opeki, Oyan, and Ofiki rivers. Its located in the humid tropical region of high rainfall and high temperatures, where the wind system divides the year into two seasons. The second location (Ilaro) is bounded on the north by the Oyo Province, on the South by Lagos, on the east by the Egba Division and on the west by Dahomey (Republic of Benin). The boundary on the South is defined in the "Colony of Nigeria boundaries order in council 1913" (see page 311 of Vol IV laws of Nigeria). Ilaro forest reserve is defined roughly by latitude 06 38' 51.36 N and 06 57' 24.40 N and Longitude 02 49 06.12'E and 03 10 43.60 E. This reserve covers an area of about 34.2 km² by 39.9 km². The sedimentary rock units of the Ilaro teak plantation consist of the Abeokuta formation which overlay the Basement complex which is in turn overlain by Ewekoro-Oshosun and Ilaro formations which are themselves overlain by the coastal plain sands (Benin Formation). The lithology of the Abeokuta Formation consists of sands, sometimes reddish-brown in colour. It contains interactions of aggrillaceous sediments. The only important river in the Division is the Yewa River.

Plantation, soil and plant biomass sampling Techniques and Statistical Analysis : Sampling design for this study was based on two premises, first, the need to spread sample sites objectively over the study area and second, the needs to ensure that plant and site characteristics are adequately depicted. Therefore, for soil and plant sampling, one Teak reserve each, established on basement complex and sedimentary formation parent rocks were purposefully selected and divided into plantation quadrants based on the information extracted from the forest resources study of Nigeria (FORMECU, 1999). From the selected plantations, one plantation, representing each plantation age per location with a total of three for each location were randomly selected for the study. Therefore, plantations with 41,39 and 36 years of age were ranomly selected as the sampled plantations for the purpose of collecting soil properties and plant biomass parameters for the study. Systematic line transect was employed to establish 18 plots (30m x30m), each in Ilaro (sedimentary rock) and Olokemeji (basement complex rock) plantations which were 37, 40 and 42 years old from June to August 2012. Topsoil (0-15cm) and subsoil (15-30cm) samples were collected. The soil samples were analyzed for soil physicochemical and micronutrients using standard procedures. Mechanical analysis was carried out on the soil samples by the Bouyoucos method to determine the various sizes of particles present in the fine earth (i.e. particle < 2mm) of the soil using international scale. For chemical analysis in the laboratory, available Phosphorus (P) was extracted with 0.1 M sulphuric acid and measured colourmetrically by the ascorbic acid blue method (Olsen et al., 1954). Exchangeable Ca and Mg were measured after extraction using 1M ammonium acetate at pH 7.0. Concentrations for Ca and Mg in the extracts were analyzed using an atomic absorption spectrophotometer, while K was determined by flame photometry (Black et al., 1965). After extraction with neutral 1N ammonium acetate, total N was also determined by the micro-Kjeldahl method (Schnitzer, 1982). Cation exchange capacity (CEC) was estimated titrametrically by distillation of ammonium that was displaced by sodium (Chapman, 1965). For the plant biomas analysis, in each of the (30mx30m) plot, five growth characteristics which have been found to be related to yield i.e total or top height, diameter at breast height, bole height, crown diameter and volume (Bada, 1981; Ogidiolu, 1997), were measured on randomly selected teak stands. Top height was measured with Hagar altimeter, Girth (Diameter at breast height (Dbh) was measured with a girthing tape at breast height or 1.3m height. Crown diameter was obtained by the crown diameter method (Mueller–Dombois and Ellengberg, 1974), while Bole volume was computed using Spurr and Barnes (1980), volume equation was estimated from a known relationship with diameter at breast height using the formula $A=\Pi d$, where d= diameter at breast height (Husch, 1963). Descriptive statistics, such as arithmetic mean were applied in order to determine the general characteristics of all parameters and indices. In addition, pearsons correlation and stepwise multiple regression was employed to determine the effects of soil parameters on biomass. This method enables only potent variables to be retained for model formulation.

Results and Discussion

Effects of soil physico-chemical properties on Teak biomass parameters : Using pearson correlation approach, the research reveal that nitrogen and organic carbon does not show any statistical significant interaction with all the biomass parameters of teak at the two location and at the two depth while Olokemeji sub-soil phosphorous only had significant interaction with total heght with r= -.333, $p<0.05$. However, Ilaro plantation top-soil Potassium (K) significantly correlated with tree volume and crown diameter with r =-0.342 and -0.377, $p < 0.05$ respectively (Table 1).

Top soil manganese (Mn) shows a statistical significant interaction with total height and volume at Ilaro plantation with r= -0.329, -0.334, $p < 0.05$; sub-soil manganese at Ilaro plantation significantly interacted girth (Dbh) and bassal area with r= -0.346, -344l, p< 0.05, respectively while at Olokemeji plantation top-soil, magnessium statistically correlated with tree volume with r = -0.357, p< 0.05. Iron (Fe) also statistically shows a significant interaction with the bole height and bassal area at Ilaro top-soil with r = 0.439 and 0.446, $p < 0.01$ respectively while iron at the top-soil of Olokemeji plantations significantly correlated with bole height with r = 0.416, $p < 0.05$. Sub soil copper shows statistically significant interaction with bole height with r = 0.349 , p< 0.05 and r= 0.388 , p< 0.05 at Olokemeji plantation top soil layer (Table 1). Zinc only interacted with volume at Olokemeji plantation topsoil with r= 0.351, p< 0.05. The pH at Ilaro plantation subsoil had significant interactionwith total height with r= 0.337, p< 0.05 while pH at Olokemeji subsoil layer also had significant interaction s with Dbh, total height, bassal area and volume with r= -0.337, -0.387, -0.337 and -0.434, p <0.05 respectively and finally to and sub soil electrical conductivity at Ilaro plantation had a significant relationship with total height and bole height wit r= 0.368 and 0.385 respectively (Table 1).

Table 1. Pearson's correlation analysis between soil physico-chemical and biomass parameters at Ilaro and Olokemeji plantation topsoil

Top-soil Ilaro Plantation							Sub-soil Ilaro Plantation					
	Hb (m)	Dbh (m)	Ht (m)	Cdia (m)	BA (m2)	Vol (m3)	Hb (m)	Dbh (m)	Ht (m)	Cdia (m)	BA (m2)	Vol (m3)
N(mg/kg)	.091	.316	.045	-.132	.061	.136	.179	.012	.118	-.037	.019	.115
OC(mg/kg	-.087	.032	-.122	-.112	.047	-.101	.046	-.045	.101	-.172	-.041	.057
P (mg/kg)	.039	.059	-.131	-.068	.034	-.087	.059	-.051	.069	-.066	-.041	-.014
K(Cmol/k)	-.214	-.132	-.298	-.148	.204	-.342*	-.163	-.105	-.072	-.377*	-.102	-.160
Mn(mg/g)	-.229	-.089	-.329*	-.149	-.111	-.334*	-.182	-.346*	.063	-.256	-.344*	-.218
Fe (mg/g)	.439**	-.092	.181	-.107	.466**	.117	-.204	.106	-.094	-.038	.099	-.038
Cu (mg/g)	-.211	-.070	-.018	-.034	.318	-.108	.349*	.065	-.092	-.086	.079	-.078
Zn (mg/g)	-.197	.159	-.109	-.188	.103	-.104	-.158	-.105	.114	-.165	-.090	-.008
pH	.000	.155	.222	-.155	-.112	.237	-.138	.053	.337*	.164	.046	.322
E.C(us/cm	-.187	-.017	.368*	.215	.082	-.287	.385*	-.141	-.034	-.136	-.148	-.131
Top-soil Olokemeji plantation							Sub-soil Olokemeji plantation					
N (mg/kg)	.190	.082	-.123	-.116	.082	.020	.052	-.151	-.273	-.245	-.162	-.312
OC(mg/kg)	.212	.076	-.244	-.207	.074	-.057	.016	-.137	-.245	-.247	-.153	-.285
P (mg/kg)	.050	.061	-.082	.118	.063	.001	-.196	.057	-333*	.116	.058	-.158
K(Cmol/k)	.218	-.014	-.270	-.165	-.009	-.140	.010	-.082	-.324	-.218	-.099	-.286
Mn (mg/g)	.087	.135	-.237	-.011	.137	-.015	.149	-.213	-.309	-.202	-.231	-.357*
Fe (mg/g)	.416*	-.193	-.246	-.158	-.197	-.277	-.033	.279	-.046	.104	.274	.139
Cu (mg/g)	.388*	-.023	.111	-.068	-.025	.081	-.152	-.015	-.146	.052	-.014	-.094
Zn (mg/g)	.193	.256	.219	.092	.254	.351*	-.235	-.227	-.156	-.092	-.219	-.231
pH	.244	-.151	-.011	-.092	-.153	-.078	-.271	-.337*	-387*	-.011	-.332*	-.434**
E.C(us/cm	.218	-.009	.090	-.150	-.013	.072	.049	-.032	-.005	-.074	-.032	-.056

* Correlation is significant at the 0.05 level (2-tailed) ** Correlation is significant at the 0.01 level (2-tailed)

Predictive multiple regression equation between soil physico-chemical properties and teak biomass parameters in Ilaro : The stepwise regression analysis for soil physico-chemical parameters indicates that only subsoil organic carbon exerted a significant effect on bole height at Ilaro (t = 2.551, $p<0.05$); while at Olokemeji, none of the topsoil and subsoil property had significant effect on bole height ($p>0.05$). For girth, no topsoil and subsoil properties showed any significant effect at both Olokemeji and Ilaro. The stepwise regression result indicated that for total height, only subsoil silt content showed a significant effect on total height ($t= 2.531$, $p<0.05$) at Ilaro plantation, while at Olokemeji plantation, only topsoil hydraulic conductivity exercised significant effect on total height ($t = -2.679$, $p<0.05$), though, the effect is inverse. Also, no topsoil and subsoil property was observed to exert any significant effect on crown diameter and basal area at both Ilaro and Olokemeji plantations. Moreover, for volume, only subsoil silt content showed a significant effect on volume ($t= 2.308$, $p<0.05$) at Ilaro plantation, while other topsoil and subsoil properties did not have any significant effect; and at Olokemeji, only topsoil hydraulic conductivity yielded a significant effect on volume ($t= -2.584$, $p<0.05$). The effect was also negative. The result of step-wise multiple regression analysis of the effects of soil properties on biomass parameters therefore, identifies subsoil organic carbon and subsoil silt content to exert substantial effect on bole height, total height and volume in Ilaro plantation; whereas, topsoil hydraulic conductivity is identified as the only soil property that wields considerable influence on total height and volume (Tables 2 and 3).

Table 2. Predictive multiple regression equation between soil physico-chemical properties and teak biomass parameters in Ilaro

Ilaro	Growth Parameter	Predict Multiple regression Equation
2*	Bole height (m)	Y = 2.401 + 0.126OC
2*	Total height (m)	Y = 7.185 – 1.255Silt
2*	Volume (m^3)	Y = 2.414 + 0.702Silt

1* = Topsoil (0-15cm) relationship; 2* = Subsoil (15-30cm) relationship; OC = Organic carbon

Table 3. Predictive multiple regression equation between soil physico-chemical and teak biomass parameters properties in Olokemeji

Olokemeji	Growth Parameter	Predict Multiple regression Equation
1*	Total height (m)	16.630 – 0.092HC
1*	Volume (m^3)	10.515 – 0.114HC

1* = Topsoil (0-15cm) relationship; 2* = Subsoil (15-30cm) relationship; HC = Hydraulic Conductivity.

Predictive multiple regression equation between soil micro nutrients and teak biomass parameters in Ilaro : The result of stepwise regression analysis for micro nutrients revealed that only subsoil Fe exercised significant effect on bole height at Olokemeji plantation ($t = 2.810$, $p<0.05$); while at Ilaro, none of the topsoil and subsoil property showed significant effect on bole height ($p>0.05$). For girth, crown diameter and basal area, none of the topsoil and subsoil properties showed any significant effect at both Olokemeji and Ilaro plantations. The stepwise regression result indicated that for total height, only subsoil Fe content showed a significant effect on total height ($t= 3.044$, $p<0.05$) at Ilaro plantation, while at Olokemeji plantation, none of the topsoil and subsoil properties exercised significant effect on total height ($p>0.05$). Also, none of the topsoil and subsoil property investigated exerted any significant effect on volume at Olokemeji plantation, but in Ilaro, only subsoil Zn wielded a significant effect on volume ($t= 2.322$, $p<0.05$).Therefore, the stepwise multiple regression results identify subsoil Iron (Fe) to influence bole height at Olokemeji plantation, whereas at Ilaro plantation, the analysis identifies subsoil Fe and subsoil Zn to influence total height and volume respectively (Tables 4 and 5).

Table 4. Predictive Multiple Regression Equation Based on the Performance of the Growth Parameter for *Teak plantation* on Trace elements in Ilaro

Ilaro	Growth Parameter	Predict Multiple regression Equation
2*	Total height (m)	Y = 28.896 – 0.332Fe
2*	Volume (m^3)	Y = 6.083 + 0.094Zn

1* = Topsoil (0-15cm) relationship; 2* = Subsoil (15-30cm) relationship; Zn = Zinc, Fe = Iron,

Table 5. Predictive Multiple Regression Equation Based on the Performance of the Growth Parameter for *Teak plantation* on Trace elements in Olokemeji

Olokemeji	Growth Parameter	Predict Multiple regression Equation
2*	Bole height (m)	Y = 1.276 + 0.085Fe

1* = Topsoil (0-15cm) relationship; 2* = Subsoil (15-30cm) relationship; Fe = Iron

Conclusion

Few topsoil properties in this study shows significant relationship with biomass parameters only at Olokemeji plantation. This implies that soil properties in both plantations are seriously leached which may be blamed on the high rainfall usually experienced in the area. But subsoil nitrogen and organic carbon show significant direct relationships with bole height at Ilaro, while at Olokemeji, only subsoil electrical conductivity shows a significant direct relationship with volume. For the micro elements, only subsoil Zn at Ilaro reveals a significant direct relationship with volume. Zn is known to promote the formation of growth hormones, starch and seed development (Food and Fertility Technology Centre, 2001). The step-wise regression result identifies subsoil organic carbon and subsoil iron content to exert substantial effect on the biomass dynamics of teak such as bore height, total height and volume mostly in the Ilaro plantation; while in Olokemeji plantation subsoil iron content wields considerable influence on bore height. This finding contradicts those of Boonkird et al., (1960), when they identified surface soil organic matter contents, parent materials, internal drainage status and rooting depth to be directly associated with growth and volume of teak production. The obtained result further means that the biomas dynamic of teak is not principally influenced by soil properties alone, as climatic and other uninvestigated soil properties may exert influence. Kaosa-ard (1989) and Tanaka et al., (1998) opined that among many factors controlling the distribution of teak are edaphic factors. This suggests that growth of a teak is influenced by site conditions. In addition, several authors (Drechsel and Zech, 1994; Zech and Drechsel, 1991; Drechsel et al., 1990 and Ezenwa, 1988) reported that mineral nutrition of soil affects growth of teak in Togo, Benin, Cote d'Ivoire, Liberia and Nigeria. To Watanabe et al., (2010), soil moisture is reported as an important factor for teak growth, as soil organic matter contributes to increasing the water holding capacity and the water content in the soil. They also identified nitrogen and exchangeable Ca and Mg as important factors of teak growth. The variation in factors determining the dynamics in teak growth may be blamed on differences in the studied locations and parent materials and precipitation.

References

Aborisade, K.D. & Aweto, A.O. 1990. Effect of exotic tree plantations of teak (*Tectona grandis*) and gmelina (*Gmelina arborea*) on a forest soil in south-western Nigeria. *Soil Use andManagement* 6, 43-45.

Adejuwon, J.O. and Ekanade, O. (1988): A comparison of soil properties under different land use types in a part of the Nigerian cocoa belt. CATENA 15, 319-331

Akpokodje, U. E. & Aweto, A. O. (2007). Effects of an exotic tree legume on soil in farmland in the Ibadan Area, Southwestern Nigeria. *Land Contamination & Reclamation,* 15 (3): 319 – 326.

Aweto A.O and Dikinya O., 2003. The beneficial effects of two tree species on soil properties in a semi arid savanna rangeland in Botswana. *Land Contamination and Reclamation* 11

Aweto A.O, Aborishade K.D, 2007. Effects of exotic tree plantations of teak (*Tectona grandis*) and gmelina (*Gmelina arborea*) on a forest soil in south-western Nigeria. Wiley 6:43-45

Aweto A.O. (1989) Plantation forestry and forestry conservation in Nigeria. Springerlink 10: 127-134

Aweto, A. O. (1987) Physical and Nutrient Status of Soils under Rubber (Hevea brasiliensis) of Different Ages in South-Western Nigeria. *Agricultural Systems,* 23(1987) 63-72

Aweto, A. O. (2001) Impact of Single Species Tree Plantation on Nutrient Cycling in West Africa. *International Journal of Sustainable Development and World Ecology, 8:356 – 368*

Aweto, A, O. & A.O. Iyanda. (2003). "Effects of Newbouldia Laevis on Soil Subjected to Shifting Cultivation in the Ibadan Area, Southwestern Nigeria." Land Degradation & Development. Vol. 14 (2003): 51-56.

Bada, S.O. (1981). A Study of Growth of Obeche under Different Management System in Southern Nigeria, *Nigeria Journal of Forestry,* 1, 53-63.

Black , C.A. Evans, D.D. White, J.L. Ensminger, L.E. & Cark, F.E. 1965. *Methods of soil analysis. Part I. Physical and mineralogical properties, including statistics of measurement and sampling.* American Society of Agronomy Ins. Madison, Winconsin

Boonkird, S., Dawnson, M. D. & Stone, E. L. (1960). A Preliminary Study of Teak Soils and Sites in Lampang Province, Thailand. *Journal of National Research Council,* 1, 27 – 75.

Chapman, H.D. 1965. Cation exchange capacity. In: C.A. Black et al. (ed.), *Methods of soil analysis.* Agronomy 9: 891-901. American Society of Agronomy, Inc, Madison Wisconsin

Drechsel, P. and W. Zech, 1994. DRIS evaluation of teak (*Tectona grandis*) mineral and effects of nutrition and site quality on teak growth in West Africa. For. Ecol. and Manage 70:122-133

Egunjobi, J.K. (1974). Litterfall and mineralization in a Teak Tectona grandis stand. Oikos 25: 222-6.

Ekanade, O. (1988): The nutrient status of soil under peasant cocoa farms of varying ages in south western Nigeria. Biological Agricultural and Horticulture, 5: 155-167.

Ekanade O, Egbe N.E, 1989. A analytical assessment of agroforestry practices resulting from interplanting cocoa and kola on soil properties in South west nigeria. *Agriculture, Ecosystem and Environment* 30:337-346

Evans, J., and Turnbull, J., 2004. Plantation Forestry in Tropics: The Role. Silviculture, and Use of Planted Forests for Inchdstrial, Social, Environmental, and Agrgfore.strjv Purposes. Oxford University Press. England.

Ezenwa, M. I. S. (1988). Edaphic Factors Affecting the Growth of *Tectona grandis* on Basaltic Soils in the Derived Savanna Area of Nigeria. *Geo- Eco-Trop*. 12,125-132.

Federal Department of Forestry, 1999. Forest Inventory, Management, Planning, and Recommendations (FORMECU). Revised National Report Vol II. Beak Consultants Limited

Hopkins S.B, 1972, the Olokemeji Forest Reserve II. The local history of the reserve, The Nigerian field, 34:171

Iwara, A. I. (2008) *The Concept of Tree Influence Cycle*. Seminar Presentation (GEO 713), Dept. of Geography, University of Ibadan

Kershaw, K.A. (1985). *Quantitaitve and Dynamic Plant Ecology*, Edward Arnold. London.

Kasoa-ard, A., 1989. Teak (*Tectona grandis*), its distribution and related factors. Nat. Hist. Bull. Siam Soc. 29:55-74.

Khan, G.S. and J.H. Ehrenreich, 1994. Effect of increasing distance from *Acacia nilotica* tree on wheat yield. Agroforestry Systems (25):23-29.

Olsen, S.R., Cole, C.V., Watanabe, F.S. & Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *U.S Department of Agriculture Cir. 939*. USDA, Washington D.C.

Nwoboshi, L.C. (1985): Biomass and nutrient uptake and distribution in gmelina pulpwood plantation age-series in Nigeria. J.Trop. For. Res., 1: 53-62.

Ogidiolu A (1997). Productivity of cultivated indigenous tropical tree species (Terminalia ivorensis and Triplochiton scleroxylon in relation to site characteristics in a part of Southwestern Nig. unpublished Ph.D. Thesis, University of Ibadan.

Ogundele, F. O.; Akoteyon, I. S.; Omotayo, A. and Odewumi, S.G. (2011) Assessment of Soil Properties under a Newly Established Teak Plantation in Abia, South-West, Nigeria. *International Journal of Academic Research, 3(3):184 – 190*

Ombina C.A, 2008, Soil Characterization for Teak (Tectona grandis) plantations in Nzara District of South Sudan, Department of Forestry, Stellen Bosch University, Gabon.

Onyekwelu, J.C., Mosandl, R. and Stimm, B., 2008. Tree species diversity and soil status of primary and degraded tropical rainforest ecosystems in south-western Nigeria. Journal of Tropical Forest Science 20(3), 193–204

Perez, D., and Kanninen, M., 2005. Stand Grox,th Scenarios.for Tectona grandis Plantations in Costa Rica. Forest Ecology and Management 210: 425-441. Flsevier.

Raymond, K. M., 1996. A Consortium Support Model for greatly increasing the contribution of quality tropical hardwood plantations to sustainable development. 'The Amazon Teak Foundation. 'teak 2000. Amsterdam. The Netherlands.

Schnitzer, M. 1982. *Total carbon, organic matter*. In: Page, A.L., Miller, R.H., Keeney, D.R., (Eds.), Methods of soil analysis. Part 2. Agronomy Monograph, vol. 9. 2nd ed. *American society of Agronomy*, Madison, WI: 539-577.

Spurr , S.H. & Barnes, B.V. 1980. *Forest Ecology*. 2nd ed. John Wiley & Sons, New York.

Tanaka, N., Hamazaki, T. and Vacharangkura, T. (1998). Distribution, Growth and Site Requirements of Teak. *JARQ*, 32:65-77.

Walkley, A. & Black, I. A. (1934) An Examination of the Detjareff Method for Determining Soil Organic Matter and a Proposed Modification to the Chronic Acid Titration Method. *Soil Science, 37: 29-38*

Watanabe, Y., Owusu-Sekyere, E., Masunaga, T., Buri, M. M., Oladele, O. I. and Wakatsuki, T. (2010). Teak (*Tectona grandis*) Growth as influenced by Soil Physicochemical Properties and Other Site Conditions in Ashanti region, Ghana. *Journal of Food, Agriculture & Environment,* 8 (2): 1040-1045

Weaver, P.L., 1993. *Tectona grandis* L.F. Teak: Verbanaceae family. Kaiser Centre, Oakland. National Agricultural Library. 33-48pp.

Whittaker R.H., Borman F.H., Likens G., Siccama T.G., 1979. The Hubbard Brook ecosystem study: forest biomass and production. Ecology Monograph, 44:

Zech, W. and Drechsel, P. (1991). Relationships between Growth, Mineral Nutrition and Site Factors of Teak (*Tectona grandis*) Plantations in the Rainforest Zone of Liberia. *Forest Ecology and Management* 41:221- 235.

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Spatial variability and availability of micronutrients related to soil properties under different land uses in Bafra alluvial deltaic plain

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Abstract

The main aim of this research conducted in lands of the Fener village located at Bafra Delta Plain where has been used different land usages was to determine spatial variability of micro nutrient elements [Available Fe (Av.Fe), Cu (Av.Cu), Zn (Av.Zn), Mn (Av.Mn)] and affecting soil factors of their variability. Soils of the study area was classified as Inceptisol, Entisol and Vertisol that were intersected points in grid lines sized 300 m x 300 m. Total 131 soil samples were collected from 0-30 cm depth and 14 soil physical and chemical properties such as Clay, Silt, Sand, pH, Electrical Conductivity (EC), $CaCO_3$, Soil Organic Matter (SOM), Total Nitrogen (TN), Available Phosphorus (Av. P), Exchangeable Potassium (Exc. K), Exchangeable Calcium (Exc. Ca), Exchangeable Magnesium (Exc. Mg), Exchangeable Sodium (Exc. Na), micro nutrient elements as well were analyzed. In order to determine affecting soil factors for micro element variation multivariate regression analysis was performed. According to analysis results, it was obtained the highest R^2 value (0.40) for Av. Cu whereas, the lowest R^2 value (0.11) was found for Av. Zn. Moreover, to generate spatial variability of microelements semivariogram and kriging methods were used in the study area in where average Fe, Cu and Mn concentration was found enough level for plant growth whereas average Zn was determined low.

Keywords: Micronutrients, multivariate regression analysis, spatial variability, alluvial soil.

Introduction

Soil fertility is an important factor, which determines the growth of plant. Soil fertility is determined by the presence or absence of macro and micronutrients. Although micronutrients are required in minute quantities but have the same agronomic importance as macronutrients have and play a vital role in the growth of plants. The availability of micronutrients is particularly sensitive to changes in soil environment. The factors that affect the contents of such micronutrients are organic matter, soil pH, lime content, sand, silt, and clay contents. There is also correlation among the micronutrients contents and above-mentioned properties. The quality of soil is controlled by physical, chemical and biological components of a soil and their interactions Papendick and Parr. M. Kumar and A.L. Babel evaluated the available micronutrients status and their relationship with soil properties of Jhunjhunu Tehsil (Rajsthan). Wajahat Nazif, Sajida Perveen and Iftikhar Saleem studied thestatus of micronutrients in soils district Bhimber and their relationship with various physico-chemical properties.

Soil properties exhibit significant spatial and temporal variability posed by both factors of soil formation in natural ecosystems and especially as depending on land use in agricultural ecosystems. The spatial dependence structure of soil properties can be similar or largely different from each other, since they are

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affected by interactions of different processes at various scales. As a consequence, the spatial variability of soil properties may vary along with different scales and resolutions which can be varied from millimetres to kilometres. Agricultural production areas may show besides the changes of natural systems that have been created, depending on management practices as significant spatial variability.

Alluvial soils which have a high productivity capacity and show big variety in their properties at short distances are characterized by sediment transport and deposition during different periods, as well as by soil formation. Moreover, they are characterized by complex ecological systems and are dynamic spatial mosaics, more or less connected with the active channel of the river (Weber and Gobat, 2006). Thus, combination of geomorphic and pedologic processes is the main property of alluvial soils providing high variability in terms of soil fertility case. Bafra Deltaic Plain has also alluvial soils and located on alluvial deposit completely formed by Kızılırmak River. Therefore, study of the variations in soil properties is not only important for soil mapping but also for soil managements (irrigation, fertilization, etc.) that require detailed information on spatial distribution of soil properties.

The aim of this study was to evaluate status of available micro nutrients [Available Fe (Av.Fe), Cu (Av.Cu), Zn (Av.Zn), Mn (Av.Mn)] in of the Fener village located at Bafra Delta Plain and their relationship with soil properties.

Material and Methods

Field Description of the Study Area

This study was carried out at Fener village in the left side of Bafra Plains found in the Kızılırmak delta located in the central Black Sea region of Turkey (Fig. 1). The Bafra Delta Plain is far 30 km from north of the Samsun province. The study area covers about 1801.4 ha. The current climate in the region is semi-humid. The summers are warmer than winters (the average temperature in July is 22.2 and in January is 6.9 °C). The mean annual temperature, rainfall and evaporation are 13.6 °C, 764.3 mm and 726.7 mm respectively. According to Soil Survey Staff (1999), soil temperature regime is mesic and moisture regime is ustic in the study area. The mean annual temperature, rainfall and evaporation are 13.6 °C, 764.3 mm and 726.7 mm respectively in Bafra plain that area is mainly flat and slightly sloped (0-2.0 %). According to soil taxonomy, the study soils were classified as Vertisols, Inceptisols, and Entisols. The study area has been under intensive agricultural activities. Rice, wheat, maize, pepper, watermelon, cucumber and tomato with sprinkler and furrow irrigations in the summer, and cabbage and leek in the winter have been produced in the study area.

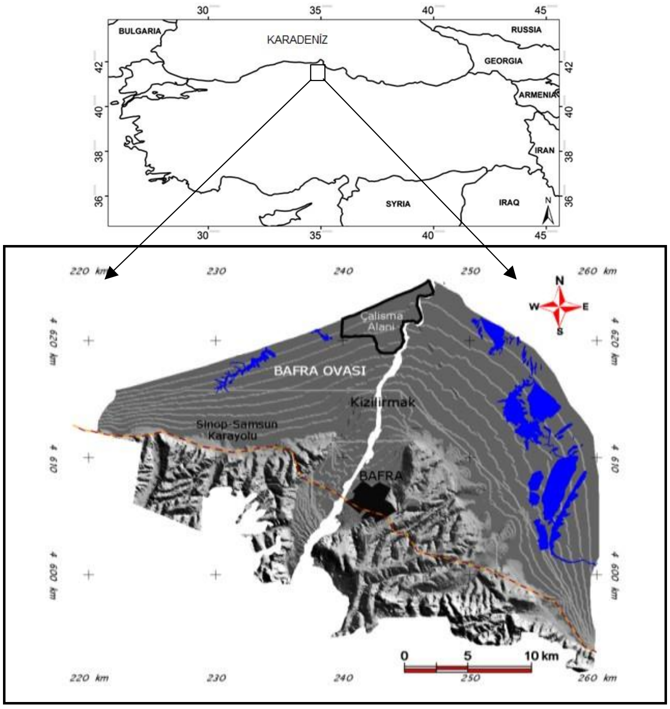

Figure 1. Location map of the study area

Soil Sampling

Soil samples were obtained from the study area order in the July of 2012. The sites divided into 300 x 300 m grid squares (Fig. 2). The total of 140 grid points was obtained and soil samples collected from surface (0-30 cm) depths of each grid centre are 131, respectively. The samples were transported to the laboratory. The soil samples were crumbled gently by hand without root material. These samples were used to determine physical, chemical and fertility status of soils.

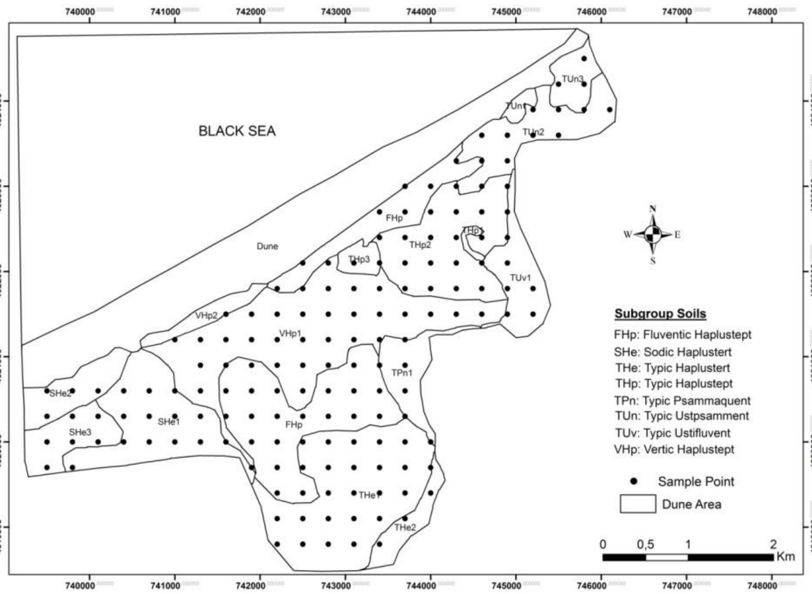

Figure 2. Soil sampling design on the study area

Soil physical and chemical analyses

Physical and chemical analyses were conducted on air-dried samples stored at room temperature and from which crop residues, root fragments and rock larger than 2 mm in diameter had been removed. Selected soil physical and chemical properties were determined by the following methods: soil particle size distribution by the hydrometer method, pH and electrical conductivity (EC) in 1:2.5 (w/v) in soil: water suspension by pH-meter and EC-meter and $CaCO_3$ content by the volumetric method, total nitrogen (TN) by the Kjeldal method, available phosphorus (Av. P) by 0.5 *M* $NaHCO_3$ extraction method, exchangeable potassium (Exc. K) and sodium (Exc. Na) by the 1 N ammonium acetate extraction method (Soil Survey Staff, 1992). All soil samples were sieved through a 150 μm mesh before determining the total organic matter content by the wet oxidation method (Walkley-Black) with $K_2Cr_2O_7$ (Nelson and Sommers, 1982). Available soil micronutrients [iron (Av. Fe), Copper (Av. Cu), Zinc (Av. Zn), Manganese (Av. Mn)] were determined on each sample (Lindsay and Norvell, 1978). Micronutrients (Av. Fe, Av. Cu, Av. Zn, Av. Mn) were analyzed for each soil sample using Atomic Absorption Spectrophotometer (Anonymous, 1990).

Statistical and Geostatistical Analyses

The data sets were analyzed for their descriptive parameters, such as minimum, maximum, mean, median and coefficient of variation (C.V.), skewness, and kurtosis. This can provide first hand information to understand the variation of soil variables. A statistical test of the Kolmogorov–Smirnov (K–S) method together with skewness and kurtosis values was applied to evaluate the normality of data sets, because the asymmetry in the distribution of data set has an important effect on the multivariate regression and geostatistical analyses (Clark and Harper, 2000; Kerry and Oliver, 2007). The high skewness and outliers can endanger making accurate estimations of the multiple regressions and the spatial continuity of the variogram function, as well as influencing the prediction accuracy. Therefore, data transformation is necessary to normalize such data sets. The transformations of logarithmic and square root are often applied in order to normalize positively skewed data sets (McGrath et al., 2004). In addition to, pearson correlation coefficients were used to determine the strength of possible relationships between micronutrients (Av. Fe, Av. Cu, Av. Zn, Av. Mn) and other soil properties (e.g., clay, silt, ph, EC, SOM, TN, Av.P, Exc. Ca, etc). Multiple linear regression analysis

was also conducted to evaluate the statistical significance (at P=0.05) of these dependent variables, and their interactions (Uyak et al., 2007; Kaiser and Rice, 1974; Ramos et al., 2007; Meersmans et al., 2008).
Range, nugget and sill variance values were determined using semi-variograms. The degree of spatial dependence of a random variable Z (x_i) over a certain distance can be described by the following semivariogram function:

$$\gamma(h)=\frac{1}{2N(h)}\sum_{i=1}^{n}(Z_{(x_i)}-Z_{(x_i+h)})^2 \quad [1]$$

Where γ(h) is the semivariance for the interval distance class h, N(h) is the number of pairs of the lag interval, Z(x_i) is the measured sample value at point i, and Z(x_i+h) is the measured sample value at position (i+h). While statistical analysis was performed using SPSS software (SPSS, 1998), geostatistical software GS$^+$ (2007) was used to construct semivariograms and spatial structure analysis for variables.

Results and Discussion

Descriptive Statistics and Correlation Relationships

Main soil description statistic analysis results of the physical and chemical properties of the study area's soils that were classified as Incepticol, Entisol and Vertisol were present in Table 1. Table 1 shows that when evaluated sufficiency of micro nutrient elements level in terms of max. and min. values, it was found that Cu is enough, Fe changes between low and high, Zn is low and sufficient and Mn is very low in soil samples according to Follet 1969; Follet and Lindsay 1970; Lindsay and Norwell 1978.

Table 1. Descriptive statistic values of soil properties

Soil Properties	Mean	Minimum	Maximum	SD	CV	Skewness	Kurtosis
Av.Fe	40.87	1.36	131.22	26.53	64.91	0.67	-0.05
Av.Cu	4.02	0.33	7.08	1.60	39.81	-0.17	-0.91
Av.Zn[a]	0.45	0.06	1.44	0.26	57.27	1.17	1.15
Av.Mn[a]	14.79	1.31	77.02	9.32	63.04	2.58	13.78
Clay	36.83	7.24	67.44	13.66	37.10	0.00	-0.57
Silt	35.46	0.71	64.62	11.84	33.39	-0.84	0.97
pH	8.34	7.74	8.94	0.26	3.11	0.17	-0.76
EC[a]	0.43	0.16	1.56	0.22	52.35	2.05	6.82
$CaCO_3$	8.45	1.47	12.64	2.73	32.33	-0.99	-0.03
SOM[a]	2.12	0.12	9.06	1.21	57.08	2.42	11.20
TN	0.13	0.02	0.35	0.08	61.72	0.37	-0.83
Av.P[a]	12.37	0.87	63.83	9.24	74.72	2.63	10.08
Exc.K	0.59	0.10	2.12	0.32	54.30	1.77	5.38
Exc.Ca	43.56	19.00	57.46	6.81	15.64	-0.93	1.53
Exc.Mg	15.90	2.57	30.91	5.19	32.64	0.20	0.56

Av. Fe: Available Iron; Av. Cu: Available Copper; Av. Zn: Available Zinc; Av. Mn: Available Manganese; SOM: Soil Organic Matter; TN: Total Nitrogen; Av. P: Available Phosphorus; Exc. K: Exchangeable Potassium; Exc. Ca: Exchangeable Calcium; Exc. Mg: Exchangeable Magnesium; Exc. Na: Exchangeable Sodium, [a]: square root transformation.

In addition, it seems that micro nutrient elements have high variability in the study area. Wilding et al. (1994) and Mulla and McBartney (2000) indicated that if CV values are less than 15%, variability is low, when it is between 15-34% viability is moderate and finally if it is bigger than 35%, variability is high. Besides, when evaluated variability of other soil investigated properties in study area according to CV, it were found that pH has low and Silt, $CaCO_3$, Exc. Ca and Mg moderate variability whereas, other properties has high variability
Correlation between micro nutrient elements and soil properties was given in Table 2. According to Table 2, it can be seen that correlation relation between micro nutrient elements and other soil properties was found significantly important as statistical ($p<0.05$; $p<0.01$) whereas, it was determined statistically non-significantly important between micro nutrient elements and Silty, TN, Av.P. On the other hand, the high correlation was found between micro nutrient element and Clay and Av. Cu (r=0.48**) whereas, the lowest correlation was found between Exc.Mg and Av. Mn (r=0.17*). In addition, relationships of the micro nutrient elements are generally positive whereas, correlation relationship between them and $CaCO_3$ and Av.Zn was found as statistically negative (r=-0.28**)

Table 2. Relationships of correlation between micronutrients and soil properties

	Av.Fe	Av.Cu	Av.Zn	Av.Mn
Av.Cu	0.60**			
Av.Zn	0.17	0.21*		
Av.Mn	0.66**	0.58**	0.11	
Clay	0.06	0.48**	0.12	0.10
Silt	0.11	0.14	-0.13	0.06
pH	0.12	0.22*	-0.04	0.20*
EC	0.20*	0.30**	0.00	0.24**
$CaCO_3$	-0.02	-0.05	-0.28**	-0.08
SOM	0.26**	0.31**	-0.02	0.22*
TN	0.03	0.13	0.09	0.00
Av.P	0.04	0.02	0.06	0.04
Exc.K	-0.02	0.29**	0.27**	0.10
Exc.Ca	0.15	0.44**	-0.02	0.13
Exc.Mg	0.18*	0.34**	0.14	0.17*

*:p<0.05; **:p<0.01

Sharma et al. (2003) determined positive correlation between Zn, Cu, Fe, Mn, B and pH, but they found also negative correlation between those elements and $CaCO_3$. In addition, Mathur et al. (2006) indicated significantly negative correlation between Zn content and pH, $CaCO_3$ and sand percentage on the other hand, significantly positive correlation between Zn and organic carbon, CEC and clay content as statistically. The same results were determined by Kumar and Label (2010). They also indicated that there were positive correlations between availability of micro nutrient elements and some soil properties that were clay, silt, organic matter and CEC whereas, that elements has negative relations with sand content, pH and $CaCO_3$ content of soils. Consequently, results of this present study are supported and the similar with some researchers' results that have already mention above

Multiple Regression Analysis of Available Micronutrients

In order to determine effective of some soil properties on available micro nutrient elements, backward multi regression analysis was performed. In regression equation that was calculated for Av. Fe, while there were clay, EC, $CaCO_3$, SOM, Exc. K, Ca and Mg as variable soil properties, that equation explained only 20% of variability belonging to Av.Fe.

In regression equation that was calculated for Av. Cu has the highest R^2 (R^2=0.40) in all regression equations and silty, EC, $CaCO_3$, SOM, Exc. Ca and Mg existed as variable soil properties in equation. On the other hand, equation calculated for Av. Zn explained only 11% whereas, equation calculated for Av. Mn explained 15% (Table 3).

Table 3. The equations of multiple regression between available micronutrients and soil properties

Regression Models	R^2	P
Av.Fe = (19.748*EC) + (6.051*SOM) – (15.339*Exc.K) +(1.364*Exc.Mg) – (2.344*$CaCO_3$) – (0.655*Clay) + (1.517*Exc.Ca) – 15.114	0.20	<0.001
Av.Cu = (0.019*Silt) + (1.263*EC) + (0.227*SOM) +(0.078* Exc.Mg) – (0.148* $CaCO_3$) – (0.094* Exc.Ca) – 1.757	0.40	<0.001
Av.Zn = (0.110*Exc.K) – (0.014* $CaCO_3$) + 0.703	0.11	<0.001
Av.Mn = (1.029*EC) + (0.169*SOM) + (0.048*Exc.Mg) – (0.077*$CaCO_3$) – (0.022*Clay) + (0.043*Exc.Ca) + 1.696	0.15	<0.001

In addition, Exc. K and $CaCO_3$ were used as independent soil variable properties in equation calculated for Av.Zn while, clay, EC, $CaCO_3$, SOM, Exc. Ca and Mg were used as independent soil variable properties in equation calculated for Av.Mn. Regression models calculated for all micro nutrient elements mostly similar with simple correlation relations between soil properties and micro nutrient elements. All soil properties found significantly correlated with Av.Fe and Av.Zn existed as variable in calculated regression equations. However, pH has significantly correlation with Av.Cu and Av.Mn but, it did not exist as a variable property in equations calculated for both micro nutrients. Besides, this case is valid for Exc.K and Av.Cu. Availability of micro nutrient elements decreases along with increasing of pH values. Whereas it was found significantly correlation between pH and Av.Cu, Av.Mn in simple correlation equations, it seems that explanation ratio of micro nutrient elements with pH was decreasing due to high pH values of investigated soils. Therefore it can be say that whereas pH has significant correlation it was not selected as independent variable in regression equations

Spatial Variability of Available Micronutrients

To determination of micro nutrient elements distribution in the study area geostatistical analysis results were given in Table 4. It was not determined anisotropic semivariogram in area distribution of investigated all micro nutrient elements and they were modelled with spherical model. Whereas it was found the longest range value (3308 m) for Av.Cu, Av. Mn has the short distance (range values) about 1068m. In addition, low nugget values were calculated so this case showed that sampling pattern and sampling distance for all micro nutrient elements were suitable for spatial structure of micro nutrient elements. As nugget explains variability for sampling and error during analysis, 0 value of nugget shows that there is no wrong during measurement and no variability in short distance (Trangmar et al. 1985; Webster 1985; Warrick et al. 1986; Goovaerts, 1999; Mulla and McBratney, 2000). Sampling distance and range values used in this study was supported by these researchers.

Tablo 4. Semivarogram parameters related to available micronutrients

Variables	Model	Nugget	Sill	Range	N/S (%)	SDC	R2	RSS
Av.Fe	Spherical	0.40	3.608	1174	11.09	Strong	0.967	0.0766
Av.Cu	Spherical	0.416	2.64	3308	15.76	Strong	0.977	0.0776
Av.Zn	Spherical	0.002	0.018	1365	11.11	Strong	0.943	$4.87x10^{-6}$
Av.Mn	Spherical	0.001	0.72	1068	0.14	Strong	0.956	$4.77x10^{-3}$

N/S: Nugget/Sill Ratio; SDC: Spatial Dependence Class

The nugget effect (the *nugget* parameter) of the semivariogram is a measure of the unexplained variability. The portion of the unexplained variability can be assessed as the ratio between the *nugget* and the threshold variances. The nugget effect < 0.41 and its low ratio to the threshold variance characteristic of Fe, Cu, Zn and Mn attest that there is a strong spatial autocorrelation for these elements (Table 4). Because the ratio was found less than or equal to 25%, the variable was considered strongly spatially dependent (Cambardella et al., 1994). SCD values were found as strong. This case show and it can be understood form range values that there is no variability of micro nutrient elements in short distance in study area. Spatial distribution maps of the micro nutrient elements using kriging method were given Figure 3. According to maps, there are almost no problems in terms of Av.Fe and Av.Cu in the study area. On the other hand, there are some lands that cover only small parts of the total area, in where Av.Zn and Av.Mn are insufficient level. As for Av.Zn, most of the south and south-east part of the study area 'soils have sufficient Av.Zn level. Whereas some part of the study area has been used as pasture, most of it has been used for rice and vegetable cultivations. Av.Zn level was found as sufficient in vegetable growth area whereas, it was determined as insufficient level in almost all rice cultivated lands. Rice is important income for local farmers. Therefore to get more rice yield it should be use fertilizer with Zn. Insufficient Zn level in soil is the problem for both in Turkey and World. While 30% of World soil has this problem (Sillanpaa, 1982), the same problem seems in 50% of our country soils (Eyüboğlu et al., 1995). As for deficient Av.Mn level, it was determined that most south part of the study area in where vegetable has been growth has insufficient Av.Mn. On the other hand, adequate Av.Mn level was determined in pasture land that locate on west and south-west p art of the study area and rice cultivated lands found on north parts of it.

Microelement deficiency was mostly detected in soils that have low organic matter content, high alkaline reaction and sandy texture. This cases can be explained that high leaching process in sandy soils that have low organic matter and clay content leading to retention of micronutrient in soil. In addition availability of micronutrients decrease once soil has alkaline condition. As investigation distribution of micronutrient elements maps, these cases can be observed in near to Kızılırmak river band and closing to Black Sea coast in where high sand ratio was found and they have low micronutrient element concentration as compare to other parts of the study areas (Figure 3).

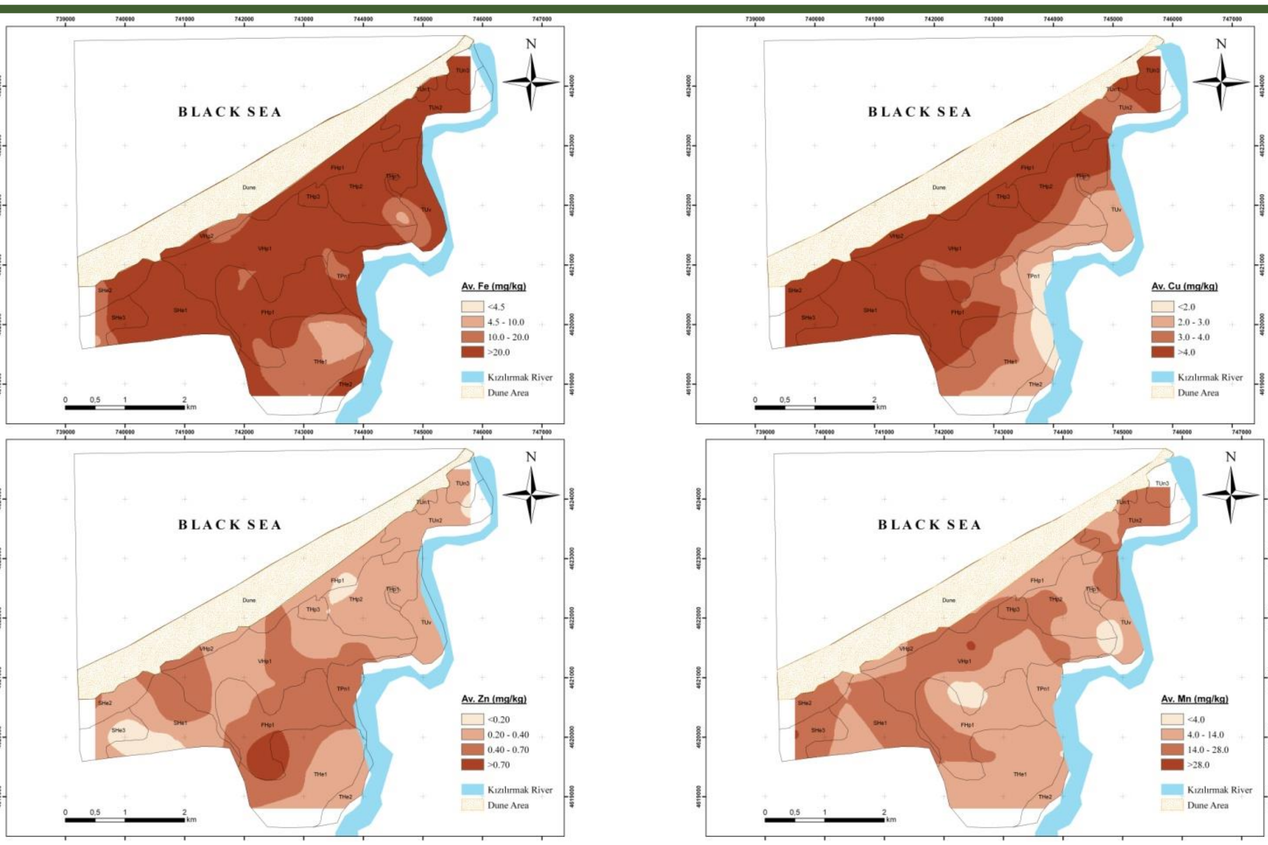

Figure 3. Kriging maps of available micronutrients

Conclusion

Main objective of this study performed infields of the Fener village located in Bafra Aluvial Deltatic Plain was to investigate soil factors that affected on availability of micronutrient elements and their distribution. The study area'soils were classified as Inceptisol, Entisol and Vertisol and have been dominantly used for vegetable growth, rice cultivation and pasture. To make correct expect for availability of micronutrient elements under different parent material and different land use types, at the same time some parameters related irrigation and derange should be added to regression model as independent variability to explain changing founded by applying existing method, which may leads to increase ratio of estimation. Because, most of these are have been used under intensive rice cultivation that requires intensive irrigation and low drainage conditions. Therefore many soil properties have been negatively affected by these conditions. The same case is also valid for micronutrient elements. The successful application of site specific management depends on the competence of differentially managing plant growing to achieve both maximizing yield and simultaneously minimizing environmental impact. The most important difficulty to this is the lack of, and uncertainty in, site specific information (Whelan et al., 1996). Consequently, findings of this study showed that the most of the soil properties had strong spatial dependency and geostatistical modelling is very useful tool to determine the spatial variability structure and spatial dependency of soil properties such as micro nutrient elements.

References

Anonymous. 1990. Analytical for Atomic Absorption Spectro Photometry. Perkin Elmer, Norwalk, Connecticut, USA.

Cambardella, C.A., Moorman, T.B., Novak, J.M., Parkin, T.B., Karlen, D.L., Turco, R.F. and Konopka, A.E., 1994. Field-Scale Variability Soil Properties in Central Iowa Soils. Soil Sci. Soc. Am. J., 58:1501-1511.

Clark, I., Harper, W.V., 2000. Practical Geostatistics 2000. Ecosse North America Llc, Columbus, OH, USA.

Eyüboğlu, F., N. Kurucu, ve S. Talaz. 1995. Türkiye topraklarının bitkiye yarayışlı mikro elementler bakımından genel durumu. Toprak Gübre Araştırma Enstitüsü. 620/A-002 Projesi Toplu Sonuç Raporu.

Follet R.H. (1969). Zn, Fe, Mn and Cu in Colorado Soils. Ph.D. Dissertation. Colorado State University.

Follet R.H. and Lindsay, W.L. (1970). Profile distribution of Zn, Fe, Mn and Cu in Colorado soils. Colorado Exp. Station Tech. Bull. 110.

Goovaerts, P., 1999. Geostatistics in Soil Science: State of the Art and Perspectives. Geoderma, 89(12): 1-45.
Kaiser, H.F., Rice, J., 1974. Little jiffy, mark IV. Educ. Psychol. Meas. 34, 111–117.
Kerry, R., Oliver, M.A., 2007. Comparing sampling needs for variograms of soil properties computed by the method of moments and residual maximum likelihood. Geoderma 140, 383–396.
Kumar M. and Babel A.L.2010. Available Micronutrient Status and Their Relationship with Soil Properties of Jhunjhunu Tehsil, District Jhunjhunu, Rajasthan, India. Journal of Agricultural Science. doi:10.5539/jas.v3n2p97.
Lindsay, W.L., and Norvell, W.A. 1978. Development of a DTPA Soil Test for Zinc, İron, Manganese and Copper. Soil Sicience Society of American Journal 42, 421-428.
M.Kumar and A.L.Babel , Journal of Agricultural Science, 2011, 3, 97-106
Mathur, G. M., Deo, R. and Yadav, B. S. (2006). Status of zinc in irrigated north-west plain soils of Rajasthan. Journal of the Indian Society of Soil Science, 54 (3) : 359-361.
McGrath, D., Zhang, C.S., Carton, O.T., 2004. Geostatistical analyses and hazard assessment on soil lead in Silvermines area, Ireland. Environ. Pollut. 127, 239–248.
Meersmans, J., De Ridder, F., Canters, F., De Baets, S., Van Molle, M., 2008. A multiple regression approach to assess the spatial distribution of Soil Organic Carbon (SOC) at the regional scale (Flanders, Belgium). Geoderma 143, 1–13.
Mulla, D.J., and McBratney, A.B., 2000. Soil Spatial Variability. A-321-A-351. In: Handbook of Soil Science, Malcom E. Summer (Ed. in chief) CRS Press.
Nelson, D.W., and L.E. Sommers. 1982. Total Carbon, Organic Carbon and Organic matter. In: Methods of Soil Analysis, Chemical and Microbiological Methods, 2th ed. (Eds. L.A. Page, R.H. Miller, D.R. Keeney), Part II, American Society of Agronomy, Madison, WI, pp 539-579.
Papendick and Parr, Amer. Journal of Alternative Agric., 1992, **7** (1, 2), 2.
Ramos, M.C., Cots-Folch, R., Martínez-Casasnovas, J.A., 2007. Effects of land terracing on soil properties in the Priorat region in Northeastern Spain: a multivariate analysis. Geoderma 142, 251–261.
Sharma, R. P., Singh, M. and Sharma, J. P. (2003). Correlation studies on micronutrients vis-à-vis soil properties in some soils of Nagaur district in semi-arid region of Rajasthan. J. Indian Soc. Soil Sci., 51 (4) : 522-527.
Sillanpaa, M. 1982, Micronutrients and the nutrient status of soils. A global study. FAO Soils Bulletin No:48, FAO, Rome.
Soil Survey Staff. 1992. Procedures for collecting soil samples and methods of analysis for soil survey. Soil Surv. Invest. Rep. I. U.S. Gov. Print. Office, Washington D.C. USA.
Soil Survey Staff. 1999. Soil Taxonomy. A Basic of Soil Classificationfor Making and Interpreting Soil Survey. U.S.D.A Handbook No: 436, Washington D.C.
SPSS, 1998. Sigma Plot 5.0 Programming Guide. SPSS Inc., Chicago, IL.
Trangmar, B.B., Yost, R.S., and Uehara, G., 1985. Application of Geostatic to Spatial Studies of Soil Properties. Advances in Argon., 38:45-94.
Uyak, V., Ozdemir, K., Toroz, I., 2007. Multiple linear regression modeling of disinfection by-products formation in Istanbul drinking water reservoirs. Sci. Total Environ. 378, 269–280.
WajahatNazif, SajidaPerveen and IftikharSaleem, Journal of Agricultural and Biological Science,2006 **, 1**, 35.
Warrick, A.V., Myers, D.E., and Nielsen, D.R., 1986. Geostatistical Methods Applied to Soil Sciences Methods of Soil Analysis. Part I, Physical and Mineralogical Methods. Agronomy Monograph No:9 (2nd Ed.), 53-82.
Weber, G. B. and Gobat, J. M. 2006.Identification of Facies Models in Alluvial Soil Formation: The Case of a Swiss Alpine Floodplain. Geomorphology. **74**:181-195.
Webster, R., 1985. Quantitative Spatial Analysis of the Soil in the Field. Advances in Soil Sciences, 3: 1-70.
Whelan, B. M., McBratney, A. B. and Rossel, R. A. 1996. Spatial prediction for precision agriculture. Precision Agriculture Proceedings of the 3rd International Conference, Madison. pp. 331–342.
Wilding, L.P., Bouma, J., and Goss, D.W., 1994. Impact of Spatial Variability on Interpretative Modelling, 65-75. In: Quantitative Modelling of Soil Forming Processes R.B. Bryant and Arnold R.W. (eds), SSSA Special Publication Number 39. SSSA Inc. Madison, Wisconsin, USA.

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The role of the conservation agriculture technology in reducing soil erosion in the central region of Azerbaijan

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Abstract

The researches show that the current situation of the fertility of the land areas under agricultural use is not satisfactory in Azerbaijan. Particularly, salinization of the land areas in the central regions and agricultural territories, exposure to erosion (irrigation erosion as well), as well as soil compaction have increased enormously due to the use of heavy agricultural machineries. The deterioration of the potential and effective indicators of the soil fertility, which is considered as the main soil property, has turned into gradual, almost irrevocable process along the whole republic. The fact that reduction of humus content, which is considered very important index of soil fertility, is observed in the majority of the natural zones is very serious warning and should be taken as an ecological soil crisis or degradation. Application of agrotechnical, meliorative and agromeliorative measures is possible in order to ensure the protection of soils from erosion. Aside from these, prevention of soil fertility and reduction of erosion are also possible through application of the Conservation Agriculture (CA) technologies. Conservation (preserved, conserved) agriculture is not only a technical method, but can also be considered as an approach that aimes to environmental protection. Mainly the following technologies are applied in the conservation agriculture: • Laser leveling of soil surface. • Bed planting method. • Crop residue retention on the field. • Reduction of soil tillage (minimum tillage) or zero tillage. • Application of crop rotation system. Apart from these, it's also important to apply plant humus (mulching) on the soil surface and this should be combined specially with crop rotation. Conservation agriculture is based on the reduction of soil tillage or zero tillage. For that reason, such kind of tillage is also called as no-tillage or direct sowing. CA is a long-term process which has a year-by-year impact on the soil fertility. As a result of the 3-year researches conducted by us on CA application, it was found that this approach has the following important advantages: year-by-year reduction in soil erosion, decrease of fuel and labor force costs, increase of the efficiency of water use. Retention of crop residues on the soil surface through the application of bed planting method in this approach provides an opportunity to increase productivity of the crop, to reduce production costs and to significantly increase physical, chemical and biological characteristics of soils. Improvement of the bed planting method provides an opportunity to increase the efficiency of irrigation water use for the irrigated wheat, barley, maize, bean and other crops applied in the crop rotation method, as well as due to the combined application of the regular row-planting method with the retention of crop residues on the soil surface, significant positive changes taken place in the soil quality parameters and erosion of land areas are prevented and this in turn, leads to more sustainable and efficient production system.

Key words: Soil erosion, conservation, conservation agriculture, soil fertility, salinization

Introduction

Increasing productivity of agricultural crops and achieving quality increase are the main important issues in meeting requirements of population towards agricultural products. Just for that reason, soil fertility increase is currently one of the important requirements. During the recent hundred years, rapid growth of population, excessive expansion of settlements, intensive development of transport and other industrial sectors led to the significant increase of adverse impacts towards the environment and natural ecosystems. As a result, the extent of the arable lands and soils of other categories reduced, their fertility indicators got worsened in quality and their biopotential reduced. In addition to the anthropogenic effects, global warming contributes to the current soil degradation, as well. During the last year, high temperature increases take place more quickly and this fact has led to soil desertification and degradation due to the decrease in rainfalls and increase of evaporation. Desertification is also very urgent problem for Azerbaijan which is located in dry climate conditions. And, this deprived many farmers of the use of the significant part of their cropping areas.

The other change observed in the central region of the Republic is that the cropping areas have turned into pastures due to the ongoing soil degradation processes, changeable and absolute weather conditions and damaged irrigation system. Majority part of the irrigated lands of Azerbaijan suffers from different level of soil salinization. Saline soils are observed mainly along the central regions of Azerbaijan, especially in Kura-Aras lowland and this is one of the main important problems observed. Approximately 60% of the land area of Kura-Aras lowland, which has 2,2 mln ha area, consists of medium and severely saline soils (Azizov, 2006).

The irrigated cropping in Azerbaijan was located mainly along Kura-Aras lowland - at the lower parts of Shirvan and Karabakh rivers, along the banks of Kura-Aras rivers, and the irrigation has been carried out generally through primitive methods. Just this reason played major role in soil salinization.

Soil plowing together with enriched fertilizers during hundreds of years has caused decrease of soil organic content. Soil organic matter is not ensured only through nutrients. It is also crucial element for the soil structure stabilization, which is first of all, very important factor. Due to this reason, majority of soils get exposed to degradation after the long-term intensive plowing.

The process of degradation causes erosion. Erosion process is widespread in Azerbaijan. Total area of the land areas exposed to erosion is 3144,7 thousand hectare in Azerbaijan, and this accounts for 36,4% of the republic area. Due to this process, soil is washed and degraded, and the fertility of soil is reduced. This fact, in turn, leads to productivity decrease of agricultural crops, and adversely affects the product quality.

Erosion is taking place sometimes so quickly that land cover is washed out and eroded in a short-course of time and entirely loses its agricultural significance. In the soils with exposure to erosion, firstly, humus content is decreased and water-physical properties get worsened. Erosion process not only reduces the humus content, but also deteriorates its composition and nature.

Under such conditions, protection of arable lands of the republic from erosion is very important (Mammadov, 2007). Maintenance and increase of soil fertility is possible through Conservation Agriculture (CA) technologies. Conservation Agriculture is not only a method, but also a kind of sustainable approach. CA is based upon reducing soil tillage or zero tillage. Application of plant humus (mulching) on the soil surface is also one of the very important issues. Here, continuous biochemical processes, such as synthesis and decomposition of organic substances, soil enrichment with nutrients mainly take place. In addition to them, crop residues retained on the soil surface protects the soil from the sun, wind and negative impact of the rain, irrigation and wind erosion.

Materials and Methods

During 2010-2012 years, experiment activities were carried out in the farmer household in the region of Agjabedi which is located in the Central region of Azerbaijan. The experimentation was conducted in 1 ha area. The experiment was carried out through application of the scheme on control and retention of crop residues sown with bed planting method which is traditionally used by farmers. Application of new technologies jointly with farmers through participatory approach was given special preference during the experiment and this, in turn, will have positive results in long-term and in sustainable manner.

In order to study properties of soils, average soil samples were taken from 5 parts of the field in an envelope form, dried at the laboratory, grinded and sieved from 1mm sieve and analyzed. Local grain varieties were used in the experiment area, an aggregate called laser level and seed sowing aggregate called bed planter were used, as well.

Results and Discussion

As it was noted, the experiment was conducted in 1 ha land plot in the Salmanbeyli village of Agjabedi region to reduce the soil erosion through application of conservation agriculture technologies. For this purpose, soil surface is leveled through a laser level during the first year. In the land plot leveled with laser level, germination and growth of seeds take place in the same level, water is equally distributed on the soil surface during irrigation and soil erosion is avoided. It is possible to level the cropping area through giving zero and slope degree to the relief of the growing area. In general, laser leveling of the soil surface provides great opportunity in preventing water loss and washing out of nutrients. During this time, negative factors like soil erosion and secondary erosion get reduced. Sowing is applied through bed planting method. After the preparation of the field for sowing, this process is carried out via sowing machine. While applying the bed planting method, sowing norm is reduced by 30-40%, irrigation water is saved and labour productivity of the water-carrier is increased by more than two times. In the bed planting method, seed-sowing machine in one move makes both beds and also sows 3 or 4 rows at once with a distance in-between beds to be of 8-14 cm. Application of crop rotation. Proper rotation of crops has great importance in increasing the productivity of agricultural crops, maintaining soil fertility and implementing control measures against pests and diseases. According to the soil-climatic conditions, the below-mentioned crop rotation system is applied in the no-till cropping areas through growing the staple and intermediate crops. Retention of crops residues. In the Conservation Agriculture tillage system, crop residues are cut and applied into the soil surface after the harvesting in order to increase the natural soil fertility. The main purpose here is to strengthen the activity of soil microorganisms through crop residues, to provide them with the favourable nutritious environment, and to increase humus content of the soil through crop residues in the field (Aliyev, 1964).

Grain cereals, grain leguminous crops were systematically rotated and grown on the basis of winter, spring and summer sowings in the common field under the experiment application and crop residues retained on the soil surface after the harvest. The crop residues retained on the soil surface are cut through a special crop residue-cutting machine and applied onto the field surface either during the harvest period or after the completion of the harvesting process. Those crop residues left on the soil not only protects the soil from adverse effects of the sun, wind and rain, but also they cover the surface like mulching and after a certain period of time, prevents germination of weeds and create favourable conditions for killing of weeds gradually. Thanks to these actions implemented in to-till cropping areas, stable production can be achieved through restoration of microflora and microfauna and improvement of soil fertility.

As it was at the beginning of CA planting, the field was leveled with laser level, then wheat was sown in this field in the autumn of 2010 through bed planting method, after the harvest, mash bean as a grain leguminous crop was sown in the stubble-field as an intermediate crop in the summer of 2011, and again after the harvesting, barley as grain cereal was sown in that field with no-till in the autumn of 2011, and after the harvest, in the summer of 2012, maize seed was sown as an intermediate crop and again, barley was sown in that field with no-till in the autumn of 2012. The below-shown staple and intermediate crops were grown with no-tillage in 1 ha field on the basis of the above-mentioned sequence (wheat-bean-barley-maize-barley).

Soil samples of 2010, 2011 and 2012 were taken from the experiment areas and analyzed at the laboratory. The results were as follows in the table 1.

Table 1. Agrochemical characteristics of the soils under the experiment

For years	Total nitrogen %	Active phosphorus mg/kg	Exchangeable potassium, mg/kg	Humus %	Organic carbon %
2010	0.135	25.9	191.0	2.7	1.60
2011	0.140	32.6	209.0	2.8	1.62
2012	0.155	34.3	211.0	3.1	1.80
Difference %	14.8	32.51	10.471	15	12.5

As it's seen from the table, during 2010-2012 years, total nitrogen ranged between 0.135-0.155%, active phosphorus 25.9-34.3 mg/kg, interchangeable potassium 191.0-211.0 mg/kg, humus content 2.7-3.1%, and organic carbon 1.60-1.80%. Exactly as, in the 1 ha conventional growing area of the same farmer, the farmer himself has grown only wheat and barley seeds during those years. As it was during the previous years, in the conventional field, the farmer has grown only seeds of winter grain cereals and crop residues removed away from the field again. Results of the laboratory analysis of the soil samples taken for comparative analysis are provided in the table 2.

Table 2. Agrochemical characteristics of the of control soils

For years	Total nitrogen %	Active phosphorus mg/kg	Exchangeable potassium,mg/kg	Humus %	Organic carbon %
2010	0.150	20.61	218	3	1.89
2011	0.145	18.32	217	2.9	1.68
2012	0.140	17.50	216	2.85	1.64
Difference%	-6.667	-15.1	-0.9174	-5	-13

As it is seen from the table, total amount of nitrogen changed between 0.150-0.140%, active phosphorus 20.61-17.50 mg/kg, interchangeable potassium 218.0- 216.0 mg/kg, humus content 3.0-2.85 %, organic carbon 1.89-1.64% during 2010-2012 years.

At the same time, crop residues retained in CA fields after the harvest, are always under focus and after the harvesting of the yield, crop residues remained in different 1 m^2 area of the field were collected and measured, and the crop residues in the total area defined.

According to 2010-2012 years, crop residues of autumn wheat retained in the experiment area in 2010, summer intermediate bean in 2011, autumn barley in 2011, summer intermediate maize in 2012, autumn barley in 2012, are provided in the following table 3.

Table 3. Amount of the crop residues under the experiment area, kg/ha

Amount of crop residues according to the years in CA fields, kg	2010 (autumn sowing)	2011 (summer intermediate sowing)	2011 (autumn sowing)	2012 (summer intermediate sowing)	2012 (autumn sowing)
	Wheat	Bean	Barley	Maize	Barley
	1300	1150	1050	10500	1200

As it's clear from the table, crop residues collected in the autumn wheat field in 2010 was 1300 kg/ha, in 2011 summer intermediate bean field 1150 kg/ha, in 2011 autumn barley field 1050 kg/ha, in 2012 summer intermediate maize field 10500 kg/ha, in 2012 autumn barley field 1200 kg/ha.

Thus, as a result of the studies of 2010-2012 years, it becomes clear that agrochemical properties of soils, particularly the amount of humus increased in the experiment area compared to the conventional (control) one. The amount of humus changed between 2.7-3.1 % (15% difference), organic carbon 1.60-1.80% (12.5% difference). Its main reason is the retention of crop residues and application of crop rotation in the experiment field. At this time, soil erosion and salinization process are reduced and fertility properties of soils get improved.

Initially, as a result of the visual observations conducted, it can be noted that though partially, crop residues are regularly decomposed due to the retention of crop residues in those areas and in addition to this, increase of small soil creatures, as well as earthworms is observed, as well. This will contribute to direct attention towards the impacts of new farming systems over soil fertility (Mammadov, 2007).

Crop rotation system has a great importance among agro technical measures implemented in the direction of increase of soil fertility and productivity of the grown agricultural crops through the efficient use of cropping areas. Rotation of the crops in the scientific-based manner ensures the increase of the amount of soil nutrients and their effective use enables to carry out the proper control measures against weeds, pests and diseases. Through the harvesting of crops, some part of the nutrients used by them is removed away from the soil, but the other part is returned back to the soil through roots and crop residues. 50% of phosphorus and potassium, and 60% of nitrogen is returned back to the soil through crop residues (Hajıyev et al., 2012). Perennial leguminous and grain crops not only improve the structure of soil, but also ensure prevention from water and wind erosion of the planting layer. So it's possible to improve the agro physical characteristics of soil and increase its humus content through the proper rotation of annual and perennial grain and leguminous crops, as well as the crops grown between rows in the crop rotation system (Altınbash et al., 2006).

According to the soil-climatic conditions, it's possible to apply the below-mentioned crop rotation system in the no-till cropping areas through growing of staple and intermediate crops: Wheat – Bean – Wheat – Maize – Wheat – Barley - Alfalfa. Based upon the major principles of the crop rotation, it's necessary to carry out the rotation of the crops which belongs to different botanical families. It's important because it prevents soil tiredness. It's also clear that pests and diseases of the plants of the same family are also identical, but these pests and diseases don't procreate danger to the crops belonging to other family (Hajıyev et al., 2012).

The soil is a lively being which consists of various mixtures and where small creatures and microorganisms live. The soils that provide plants with water, weather, heat and nutrients that can be assimilated in a sufficient amount and enable their normal vegetation and growth, are fertile soils. Soil composition is regularly changed as a result of the mutual activities of the plant with soil. Natural fertility can be reduced and increased through biological, chemical and other natural factors taken place in the nature. Microorganisms and small creatures living in the soil structure, plants and mutual activities of soil are the major motive power of the natural fertility.

When the biological processes are completed, each creature which have finished its life, are gradually destroyed, i.e. broken to pieces, decomposed and mixed with soil as a result of the microbiological processes in the soil. As a result, rotten stuff - humus content is increased. Organic and inorganic substances are combined and create a new form in the soil. We can conclude that CA improves the mutual relations of plants with minerals through improving the microbiology of soil. (Mammadova and Jafarov, 2005).

At this time, performance of the soil organisms play a significant role while participating in the decomposition processes of organic matters, those organisms also participate in the creation of humus, and brings the soil nutrients to the form of which can be assimilated by the plants through easing of nutrients.

Thanks to the performance of soil microorganisms, soil efficiency is increased and soil aeration, its humidity and soil structure get improved. The soil with good structure and its fertility always increase the soil microorganisms and their biodiversity.

Conclusion

The article is dedicated to the reduction of soil erosion and increase of the soil fertility through application of conservation agriculture technologies in the Central area of Azerbaijan. As a result of the research, it was determined that leveling of the soil surface through laser level and application of the bed planting method prevents water loss and washing out of nutrients and provides great efficiency. Moreover, retention of crop residues in the field improved the agrochemical characteristics of soil and increased specially the humus content. Thus, erosion and salinization processes of soil get reduced and fertility properties of soils improved.

References

Hajıyev.J.A,.Allahverdiyev E.R, Ibrahimov A.G., 2012. Irrigation cropping.Baku.
Mammadov G.Sh., 2007. Fundamentals of soil science and soil geography. Baku.
Altınbas, U., Cengel, M., Uysal, H., 2006. Soil science, Ege University. Bornova, Izmir.
Azizov G.Z..2006. Water-salt balance of meliorated soil-groundwaters of Kura-Aras lowland and scientific analysis of its results. Baku.
Mammadova S.Z., Jafarov A.B., 2005. Soil fertility properties. Baku.
Aliyev J.A.,1964. Organic matter and fertility of Azerbaijan lands. Baku.
www.fao.org/ag/agp

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Changes in structural parameters of soils formed on similar conditions but under different cropping systems

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Abstract

Soil structure is one of the most important soil physical characteristics affecting on soil productivity. Structural development of soil is under the control of many inside and outside factors. The objective of this study was to evaluate changes in structural behaviors of soils under different crop management systems. It is expected that soil structural characteristics change with changes in plant pattern because of differentiations in agronomic properties, root system and amounts of organic matter incorporated into the soil. Soil samples collected from the Agricultural Farmland of Ataturk University-Agricultural Faculty under different plant management systems; sun flower, wheat, beans, corn, potatoes and alfalfa, were analyzed for physical, chemical and mechanical properties and structural characteristics were evaluated based upon plant patterns. The results indicated that soil structural characteristics significantly changed depending on plant patterns. The best structural conditions and aggregate stability (0,25 - 4 mm) were obtained in soils under alfalfa crops (A.S: % 77,415), but the worst structural conditions in soils under potatoes (A.S: % 35,28) and corn (A.S: % 38,42) production.

Keywords: Soil structure, Aggregate stability, cropping pattern

Introduction

Various physical and chemical methods are applied in order to increase the fertility of the soil in our modern agricultural system. Among these methods is especially the chemical fertilization which pollutes the soil rapidly and poses a threat to the ecological balance of the soil. The continuity of fertility and ecological balance of the soil are as vitally important as the fertility increase in the soil. Particularly in the recent years, it is understood that this ecological balance bares utmost consequences and the applications of natural and organic entries to the soil are promoted. It is observed that, with a conscious sensitivity, the soil fertility parameters could be improved by enhancing the physical, chemical and biological properties of the soil with the aid of natural fertilizers and plant residues applied to the soil. Bringing the herbal nutrients closer to the chemically optimum level, these entries prompt aggregation and thus the development of structural characteristic. Aggregates are composed of earth particles which come together with the help of the organic and inorganic substances and take form. Soil plant management and organic substance density are effective in the flocculation of these particles.

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In this study, the relation between the main physical, chemical and mechanical properties of the soils which are under different plant growing types(sunflower, wheat, bean, corn, potato and alfalfa) and the structure parameters is evaluated.

Material and Methods

Material: The soils used in the research are taken from the farm field of Erzurum Atatürk University. The deformed and undeformed soil samples, taken from 20cm of top soil depth which are under the planting system of sunflower, wheat, bean, corn, potato and alfalfa for at least 10 years in this field and which show similar soil formation, are duly dried up and made ready for analysis by using a sieve.

Laboratory Analysis Methods: The soils' textures are identified by Bouyoucos hydrometer method (Gee and Bauder 1986); their pH's by pH meter with glass electrode (Mc Lean 1982), the lime contents by Scheibler's calcimeter (Nelson 1982), the organic substance contents Smith-Weldon method (Nelson and Sommers 1982), nitrogen contents micro Kjheldahl method (Bremner and Mulvaney 1982), the cation exchange capacities and the exchangeable cation contents by ICP OES (Optima 2100 DV Perkin Elmer) spectrophotometer (Rhoades 1982a; Thomas 1982). The soils' phosphor content is identified by molybdophosporic blue color method (Olsen and Sommers 1982), the electrical conductivity values by conductivity device (Rhoades 1982b), the bulk density by the cylinder method (Blake and Hartge 1986), the aggregate stability by using yoder-type wet sieving device (Kemper and Rosenau 1986), the dispersion rate (Bryan 1968; Lal 1988), air permeability value (Corey 1986), water permeability (Klute and Dirksen 1986), the liquid limit and plastic limit (Head 1984) are determined by shrinkage limit (ASTM 1974) method. The soils' COLEbar value, (Shafer and Singer 1976), volumetric shrinkage values (ASTM 1974), free-swelling index, (Ross 1978) are determined.

The data acquired from this research is subjected to the variance analysis and the Duncan multiple comparison test method is applied to the significant ones (SPSS 1999).

Results and Discussion

Soil Physical Properties: The physical properties of the study field soil are given at Table 1. The study field soil are defined as the Farm series and are composed of 30% clay, 29% silt, 41% sand and are in clay loam textural class. There is not any statistically significant difference between the soils' bulk density values ($p \geq 0,05$) (Table 1).

Tablo 1. The physical properties of the research soils

Planting System	Mechanical Analysis			BD gr/cm³	Aggregate Stability (%) Aggregate Size, mm				DR* (%)	AP* μ²	WP μ²
	Clay (%)	Silt (%)	Sand (%)		0,25-0,5*	0,5-1*	1-2*	2-4*			
Sunflower				0,95	39,78c	31,73d	40,13d	57,63b	57,74bc	57,51b	0,74b
Wheat				0,99	57,64b	63,89b	56,27c	58,95b	51,48c	31,76d	1,15b
Bean	30	29	41	0,95	53,86b	66,33b	66,43b	58,21b	65,31b	28,88d	0,52b
Corn				1,06	22,78d	53,38c	63,24bc	14,31d	79,42a	33,44cd	0,54b
Potato				0,99	29,61cd	36d	33,4d	42,11c	62,17bc	46,81bc	0,71b
Alfalfa				0,95	78,46a	85,54a	80,11a	65,55a	39,79d	91,79a	2,04a

(*): Caution ($p \leq 0,05$) BD: Bulk density, DR: Dispersion rate, AP: Air permeability, WP: Water permeability

It is determined that the aggregate stability (AS) of the soil under different planting systems are as follows: highest alfalfa, lowest corn in 0,25 - 0,5 mm aggregate size, highest alfalfa, lowest sunflower in 0,5-1 mm aggregate size, highest alfalfa lowest potato in 1-2 mm aggregate size and alfalfa has the highest AS value while corn soil has the lowest value in 2-4mm aggregate size ($p \leq 0,05$) (Table 1) (Figure 1).

The highest dispersion rate among the soils belongs to corn whereas alfalfa has the lowest ($p \leq 0,01$) (Table 1). Due to the high OS emitted by the alfalfa plant in the alfalfa soil, a powerful attraction is formed between the soil particles and this situation decreased the DR rate. That dispersion, which is described as the diffuse of the structural characteristic and as the aggregates' being dispersed by shattering, is very low in the alfalfa soil and that the aggregate stability values are observed to be at the highest levels in the same soil display that the alfalfa plant improve the structural characteristic by increasing the aggregation.

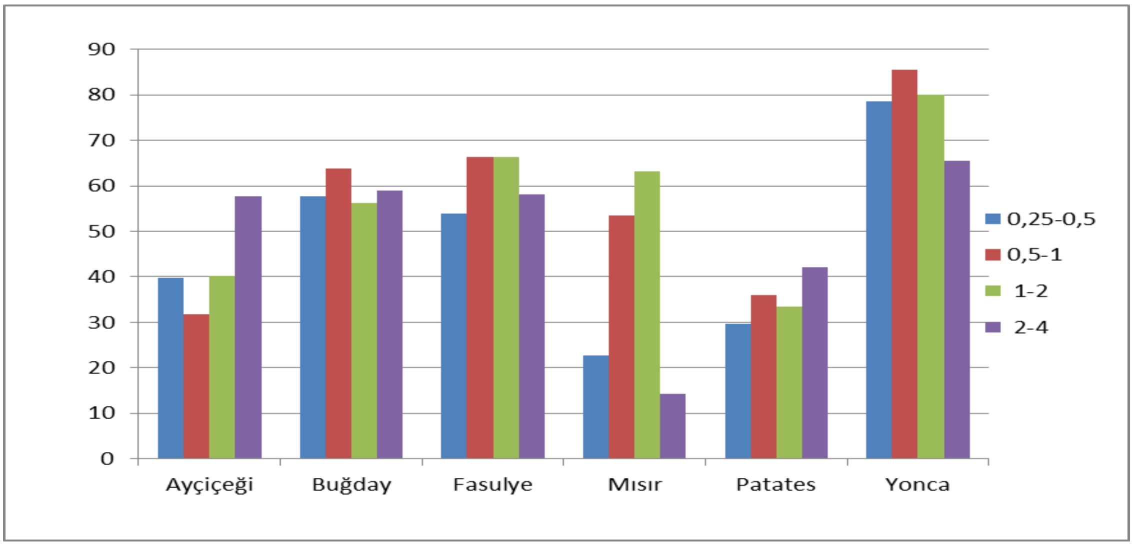

Figure 1. The aggregate stability values of the soils under different planting systems

The highest air permeability value is identified with the alfalfa and the lowest value is identified with the bean soil amongst the soil samples ($p \leq 0,01$) (Table 1). It is an expectable result that the alfalfa soil which contains high levels of aggregate stability and organic substance amount has high air permeability. The highest water permeability level is identified with the alfalfa and the lowest is identified with the bean soil ($p \leq 0,05$) (Table 1). That the aggregate stability value is at its highest level with the alfalfa soil in Table 1 and that the permeability rate is at the highest level with the alfalfa soil are matters related to the aggregate stability. As the structural characteristic of the soil improves, the porosity increases and the water infiltrate into the soil more rapidly.

Soil Chemical Properties: The chemical properties of the study field soils are given at Table 2. The highest organic substance content value is identified with the alfalfa, the lowest value with the bean soil ($p \leq 0,01$) (Table 2), the highest nitrogen amount is identified with the alfalfa, the lowest value with the bean soil ($p \leq 0,05$) (Table 2). Plants might be effective in the aggregation thanks to the mineralization of carbon and nitrogen. That the highest aggregate stability values in Table 2 belong to the alfalfa soil and that the highest nitrogen values are seen in the alfalfa soil as well shows that there is a strong relation between the aggregate stability values and the total nitrogen amount. Amongst the soil samples, the highest pH values belong to the potato, the lowest to the sunflower and alfalfa soils $p \leq 0,05$) (Table 2), the highest EC values belong to the bean and the lowest to the corn soil ($p \leq 0,05$) (Table 2), the highest lime value belongs to the potato, the lowest value to the corn ($p \leq 0,01$) (Table 2), the highest CEC values belong to the sunflower, the lowest to the corn soil ($p \leq 0,01$) (Table 2), the highest phosphor content belongs to the corn, the lowest to the wheat and bean soil ($p \leq 0,01$) (Table 2). It is seen that, amongst the samples, the highest calcium (Ca) level belongs to the alfalfa soil, while the lowest value belongs to the corn soil ($p \leq 0,01$) (Table 2).

Table 2. The chemical properties of the research soils

Planting System	OS* (%)	∑N* (%)	pH*	EC (µmhos/cm)	Lime* (%)	CEC* (me/100gr)	P* (ppm)	Exchangeable Cations (me/100gr)			
								Ca*	Mg*	Na*	K*
Sunflower	1,1b	0,055b	7,55c	341,5	0,42b	25,8a	54,5a	12,97c	2,45bc	0,8b	3,78c
Wheat	0,97b	0,048b	7,80ab	370	0,6b	24,585b	35b	15,02b	2,36c	1,08a	3,35d
Bean	0,84b	0,042b	7,65abc	458,5	0,53b	23,025c	35 b	12,73c	2,7ab	0,93ab	3,86c
Corn	0,94b	0,047b	7,60bc	310	0,14c	22,58c	68,5a	9,61d	2,36c	0,93ab	4,65a
Potato	1,09b	0,054b	7,85a	408,5	0,87a	24,07b	53a	14,04b	2,68ab	1,06a	3,33d
Alfalfa	3,25a	0,162b	7,55c	328,5	0,55b	22,86c	53,5a	16,37a	2,8a	0,83b	4,07b

(*):Caution ($p \leq 0,05$) OS: Organic substance, ∑N: Total Nitrogen, EC: Electrical conductivity, CEC: Cation exchange capacity P: Phosphor, Ca: calcium, Mg: Magnesium, Na: Sodium, K: Potassium

The bivalent calcium and magnesium cations establish cationic bonds with the clay particles and organic-C and improve the soil structure (Bronick and Lal 2005). That the alfalfa soil, which has the highest content of organic substance, has the highest Ca values as well supports this study. Amongst the soil samples it could be seen that; the highest Mg value belongs to the alfalfa soil, the lowest to the corn and wheat soils ($p \leq 0,05$) (Table 2), the highest sodium value belongs to the wheat, the lowest to the sunflower and alfalfa soil ($p \leq 0,05$) (Table 2). The soils do not have any Na problems. When the potassium content is observed, it is seen that the highest value belongs to the corn, the lowest to the potato soil ($p \leq 0,01$) (Table 2). That the potato plant is at the lowest amongst the aggregate stability values and that potassium is low in the potato plant provoke the thought that the deformation in the aggregate structure might be caused by this element's being overexploited by the potato plant.

Soil Mechanical Properties : No statistical difference is observed between COLE-bar, volumetric shrinkage and shrinkage limit values of the soils which are under different planting systems ($p \geq 0,05$) (Table 3). The free-swelling index values belonging to the soils on which different plants are being produced, it is seen that the highest belongs to the alfalfa, the lowest to the potato ($p \leq 0,05$) (Table 3). That the highest organic substance rate according to table 2 and the highest aggregate stability values belong to the alfalfa soil is caused by the relation between the free-swelling index and organic substance content and the aggregate stability values. Amongst the soil samples, it is identified that the highest liquid limit values belongs to the alfalfa, the lowest value belongs to the corn soil ($p \leq 0,05$) (Table 3). That the LL values belongs to the alfalfa soil which has the highest OS content is caused by the mixture of high rate of organic residues from the alfalfa soil with the soil. That the highest plastic limit value again belongs to the alfalfa soil, the lowest belongs to the wheat soil ($p \leq 0,05$) (Table 3) and that the alfalfa soil has the highest organic substance content in Table 2 shows the relation of plastic limit value to the organic substance amount. In a study they have performed, Smith et al. (1985) identified significant positive relations between the soil's organic substance values and the liquid limit (LL), plastic limit (PL) and COLE.

Table 3. The mechanical properties of the research soils

Planting System	COLE	VS (%)	SL (%)	FSI* (%)	LL* (%)	PL* (%)
Sunflower	0,15	61,96	13,5	0,36b	47,8ab	27,04a
Wheat	0,09	57,1	15,53	0,33b	41,65cd	22,97c
Bean	0,12	66,07	11,74	0,4b	47,1abc	24,96bc
Corn	0,11	56,41	12,69	0,28b	40,3d	23,46c
Potato	0,09	60,01	13,45	0,25b	43,07bcd	24,94bc
Alfalfa	0,13	75,44	13,96	0,79a	52,39a	28,48a

(*):Caution ($p \leq 0,05$) COLE: Coefficient linear expansion, VS: Volumetric shrinkage SL: Shrinkage limit, FSI: Free-swelling index, LL: Liquid limit, PL: Plastic limit

No statistical difference is observed between COLE-bar, volumetric shrinkage and shrinkage limit values of the soils which are under different planting systems ($p \geq 0,05$) (Table 3). The free-swelling index values belonging to the soils on which different plants are being produced, it is seen that the highest belongs to the alfalfa, the lowest to the potato ($p \leq 0,05$) (Table 3). That the highest organic substance rate according to table 2 and the highest aggregate stability values belong to the alfalfa soil is caused by the relation between the free-swelling index and organic substance content and the aggregate stability values. Amongst the soil samples, it is identified that the highest liquid limit values belongs to the alfalfa, the lowest value belongs to the corn soil ($p \leq 0,05$) (Table 3). That the LL values belongs to the alfalfa soil which has the highest OS content is caused by the mixture of high rate of organic residues from the alfalfa soil with the soil. That the highest plastic limit value again belongs to the alfalfa soil, the lowest belongs to the wheat soil ($p \leq 0,05$) (Table 3) and that the alfalfa soil has the highest organic substance content in Table 2 shows the relation of plastic limit value to the organic substance amount. In a study they have performed, Smith et al. (1985) identified significant positive relations between the soil's organic substance values and the liquid limit (LL), plastic limit (PL) and COLE.

Conclusion

Along with the mineralogical composition of the soil, compositions such as organic substance, sesquioxides and $CaCO_3$ are effective in multiple levels in the development of structural characteristic. The climate conditions of the soil's region, plant management and management applications take role in the modeling of the structure. The crop pattern being produced is effective on the soil structure thanks to the root secretions and the morphological properties of the roots. While it is known that plants especially like alfalfa which possess long and fringe plant roots prompt the structural development by forming a strong binding effect between the soil aggregates, it is known that plants like sunflower which possess taproots cannot form the same binding effect.

In this study, the physical, chemical and mechanical properties of the soil samples collected from Agricultural Farmland of Ataturk University-Agricultural Faculty where sunflower, wheat, bean, corn, potato and alfalfa are being produced are analyzed and the effect of the grown plants on the structural parameters of the soil is evaluated. The acquired findings show that significant differences occur in the soil's structural parameters according to the cropping pattern being produced. It is stated that, among the soil samples, the most favorable parametric values belong to the alfalfa plant while the most negative values belong to the wheat, potato and corn plant soils. The soil structure is the most significant physical characteristic that defines the soil's fertility capacity. The results of this study proves that the different plant management applications effect the plant's agronomic properties, root system and the organic substance cycle to soil and the structural behavior of the soil within differences at a significant level.

As a result of the data acquired from this scientific research, the goal is to improve the structural properties of the soil by increasing the soil structure which is the main factor in the development of the air, water and food balance that is appropriate for plant growing, making good use of the soil plant management strategy and including plants like alfalfa that improve the structural characteristic into the crop rotation.

References

ASTM, 1974. Annual book of ASTM standarts. American society for testing and materials. part 19: 90-92. race st. pa. USA.

Blake, G.R., Hartge, K.H., 1986. bulk density. methods of soil analysis. part 1. Physical and mineralogical methods. 2nd edition. agronomy no: 9. 363-375, 1188 p, Madison, Wisconsin USA.

Bremner, J.M., Mulvaney, C.S., 1982. Nitrogen-total. methods of soil analysis. part 2. Chemical and microbiological properties. 2nd edition. agronomy no: 9, 595-624, 1159 p, Madison, Wisconsin USA.

Bronick C.J, R. Lal,2005. Soil structure and management: a review. Geoderma 124 (2005) 3–22)

Bryan, R. B., 1968. The development, use and efficiency of indices of soil erodibility. Geoderma, 2, 5-25.

Corey, A.T., 1986. Air permeability. methods of soil analysis. part 1. physical and mineralogical methods. 2nd edition. agronomy no: 9. 1121-1137, 1188 p, Madison, Wisconsin USA.

Gee, G.W., Bauder, J.W., 1986. Particle-size analysis. methods of soil analysis. part 1. Physical and mineralogical methods. 2nd edition. agronomy No: 9. 383-411, 1188 p, Madison, Wisconsin USA

Head K.H, 1984. Manual of soil laboratory testing vol.1. Iowa-USA.

Kemper, W.D., and Rosenau, R.C., 1986. Aggregate stability and size distribution. Methods of soil analysis. part 1. Physical and Mineralogical Methods. 2nd Edition. Agronomy No: 9. 425-442, 1188 p, Madison, Wisconsin USA.

Klute, A., and Dirksen, C., 1986. Hydraulic conductivity and diffusivity: laboratory methods. methods of soil analysis. Part 1. Physical and mineralogical methods. 2nd edition. Agronomy no: 9. 687-734, 1188 p, Madison, Wisconsin USA.

Lal, R., 1988. Soil erosion research methods. Soil and Water Conservation Society,

McLean, E.O., 1982. Soil pH and lime requirement. Methods of soil analysis. Part 2. Chemical and Microbiological Properties. 2nd Edition. Agronomy No: 9. 199-224, 1159 p, Madison, Wisconsin USA.

Morgan, R.P.C. (1985). Soil erosion and conservation. John Wiley and Sons Inc.,New York

Nelson, D.W., and Sommers, L.E., 1982. Total carbon, organic carbon, and organic matter. methods of soil analysis. part 2. Chemical And Microbiological Properties. 2nd edition. Agronomy No: 9. 539-579, 1159 p, Madison, Wisconsin USA.

Nelson, R.E., 1982. Carbonate and gypsum. methods of soil analysis. Part 2. Chemical And Microbiological Properties. 2nd Edition. Agronomy No: 9. 181-197, 1159 p, Madison, Wisconsin USA.

Olsen, S.R., Sommers, L.E., 1982. Phosphorus. methods of soil analysis. Part 2. Chemical And Microbiological Properties. 2nd edition. Agronomy No: 9, 403-427, 1159 p, Madison, Wisconsin USA.

Rhoades, J.D., 1982a. Cation exchange capacity. methods of soil analysis. Part 2. Chemical And Microbiological Properties. 2nd Edition. Agronomy No: 9, 149- 157, 1159 p, Madison, Wisconsin USA.

Rhoades, J.D., 1982b. Soluble salts. methods of soil analysis.part 2. chemical and microbiological properties. 2nd edition. Agronomy No: 9, 167-179, 1159 p, Madison, Wisconsin USA.

Ross G.J., 1978. Relationships of specific surface area and clay content to shring-swell. potential of soils having different clay mineralojical composition. Can. J. Soil. Sci. 58: 159-166

Schafer W.M. And Singer M.J. 1976. A new method of measuring shrink-swell potential using soil pastes. Soil Sci. Soc. Amer. J. 40:805-806.

Scoot N.A 1998, Soil aggregation and organic matter mineralization in forests and grasslands: Plant species effects vol. 62, n°4, pp. 1081-1089 (1 p.1/4) Soil Science Society of America, Madison, WI, ETATS-UNIS (1976) (Revue)

Smith, C.W., Hadas A, Dan J. And Koyumjisky H. 1985. Shrinkage atterberg limits in relation to other properties of principal soil types in israel. Geoderma 35: 47–65.

SPSS, 1999. SPSS for Windows, Release 10.0.5., SPSS Inc., USA.

Thomas, G.W., 1982. Exchangeable Cations. Methods of soil analysis. Part 2. Chemical And Microbiological Properties. 2nd edition. Agronomy No: 9, 159- 165, 1159 p, Madison, Wisconsin USA.

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The study of the structure of a soil cover of Absheron by method of relief sculpture

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Abstract

Absheron is one of the most ecologically unfavorable regions on Earth due to heavy pollution of air, water and soil. The rich flora and fauna is exposed to severe anthropogenic influence. The object of study is the Absheron, which is the largest unit of Azerbaijan. This is a complex industrial cluster, with a predominance of petroleum, petrochemicals, subtropical fruit growing and viticulture. In addition to the major oil and gas fields in the area has a network of health centers, recreation and tourism. We view the foothills on the South-western part of the Absheron peninsula and adjacent territory of Gobustan, which are covered with eruption of mud volcanoes. They create a form of relief in the form of conical hills with relatively steep slopes of a hill near the volcano. Products of eruption of mud volcanoes are common, mainly in the southwestern part of the peninsula (Hasanov V.H., Manafova F.A., 2007). In order to study the structure of the soil surrounding Foothill areas of the north-western part of Absheron we have chosen cartographic method of learning. Were found and examined the types of land cover patterns that differ in appearance (on the map), physico-chemical and biological properties. Ecological mapping is a relatively young discipline. Therefore, analysis of the environmental situation is inseparable from its mapping. Thus, different types of land cover patterns identified in the study area were reflected on the map, which displays plastic geometric properties of the soil surface.

Keywords: Absheron, ecological, soil cover.

Introduction

The soil cover of peace, its fertility creates the irreplaceable foundation of life on the earth; determine the possibility of the growth of the initial basis of the feed circuits of entire living - plants. Therefore, soils - their origin, structure, properties, their fertility, become object of ever closer attention, not only of pedology, but also of many adjacent fields of natural science - ecology, of geobotany, microbiology, ecology of invertebrates animals, of physical geography, geochemistry and others. Absheron is one of the most unfavorable in ecological sense regions on the Earth as a result of strong air pollution, water and soils. Rich flora and fauna undergoes strong anthropogenic action.

Material and Methods

Absheron is one of the most unfavorable in ecological sense regions on the Earth as a result of strong air pollution, water and soils. Rich flora and fauna undergoes strong anthropogenic action.

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On the nature of the morpho-genetic types of relief, the special features of the process of the forming of the relief and the structural special features of the relief of Absheron is separated as independent geomorphological region. Large valleys and extensive shallow flat-bottomed basins correspond to synclinal structures in the relief (Manafova F.A.,2006). In the southwestern part of the peninsula correspond to convex relief forms the monoclinal crests and the extensive Baku synclinal plateau, which is separated from other elements of relief by valleys and ravines, manufactured on the washed away wings of anticline structures, i.e., they are inversion - inverted forms of relief (Salaev M.M.,1983, Sturman B.I. 2003).

For purposes of a study of the structure of the soil cover of the adjacent foothill zones of the North Western part of Absheron we selected the cartographic method of studying the territory. Were discovered and studied the types of the structures of soil cover, which are differed in appearance (on the map), to physical chemistry and biological properties.

The problem of the connection of the structures of the objects of nature (forms and their relationships) with their properties was always urgent, especially for the science about the soils, which needs more detailed and more contemporary cartographic developments for the structure of soil cover and its ecological estimation. It is for this purpose necessary to show the natural structure of soil cover taking into account relief on the map. Map was and remains the most effective method of the demonstration of any phenomena, whose characteristics change in the space. Ecological cartography is comparatively young training discipline. Therefore the analysis of the environmental situation is inseparable from its mapping. As a result different types of the structures of soil cover, revealed in the territory being investigated found their reflection on the map of the plastic of relief, which reflects the geometric properties of soil surface.

Absheron is the largest subdivision of Azerbaijan. This is elaborate productive- territorial complex, with the predominance of oil output, petroleum chemistry, by subtropical fruit-growing and by viticulture. Besides the large layers of oil and gas, in the region are a network of health resorts, organizations of leisure and tourism.

The natural-geomorphological region of Absheron - has total area 388 thousand ha. It is located on the western shore of Caspian Sea and is the southeastern extremity of large Caucasian ridge. In geological and geomorphological terms and according to the nature of relief it is divided into two parts: 1) western - hilly, foothill and 2) eastern - plains. In the western part are widespread mud volcanic clay rocks and their products of weathering. Eastern plains part is covered with sands and shell limestone.

Climate is moderately warm, is semiarid, with the scant moistening (C_S<0, 3-0, 5). In the eastern low part the level of ground water varies from 0,5-2,0 to 4,0-6,0 m, their mineralization varies in the limits of 2,0-30 g/l.

The soil cover of Absheron is the varieties of grayish-brown soils, which is characterized by its colorfulness and variety, by the mechanical composition, the degree of salting, by, which is connected with the colorfulness of the soil-forming species. For studying the structure of the soil cover of Absheron we selected the soil- field, laboratory and cartographic methods of study. The structure of soil cover - this is the heterogeneity of soil cover caused by the factors of the soil formation of relief, climate, plant cover and animal peace, soil-forming species, age and history of shaping of this soil, anthropogenic factor. The structure of soil cover is determined by two main systems of the regularities: zone- climatic and regional- geological.

he concrete structure of soil cover is characterized by repeatedly rhythmically repetitive in the space areas of the specific soils, which create steady composition and figure of soil cover, and the steady mechanisms of the geochemical and geophysical connections between the entering this structure soils. Each concrete structure possesses only in the history of the development of its created processes. From the aforesaid it follows that the specific system- organizational connections are characteristic for the structures of soil cover. Concrete structure (soil cover) is characterized by repeatedly rhythmically repetitive in the space areas of the specific soils, which create steady composition and figure of soil cover, and the steady mechanisms of the geochemical and geophysical connections between entering this structure soils.

Formation SSS is connected, in essence with the zonality and the relief. We isolated a certain variety of structural forms of the soil cover, on which is possible to assume that to each structural form will correspond its content, i.e., its physical, chemical, mineralogical and biological properties. Structure is the most important property of any natural body, since is assumed the establishment of the system of its qual.

Results and Discussion

In our studies we used both the laboratory- field methods of studies and cartographic. Map was and remains the most effective method of the demonstration of any phenomena, whose characteristics change in the space (Stepanov I.N. 2003, Manafova F.A. 2010) . In our case we deal concerning ecological cartography, which is "joint" discipline and is formed the complex unity of specific, in this case ecological, geo-ecological, the methods of obtaining the data about the state of environment, and the general mapping methods of the geographically correct mapping of information. On the basis studies are isolated the following types SPP:

1) Dendritic type of the SSS (Soil Surface Structure) in the piedmont part of Absheron Peninsula

This type of structure occupies the highest point of Absheron, beginning from the cape of Kilyazin's scythe, sett. Shurabad. Structure is not symmetrical, strongly branched, from where proceeds its name. This structure contains the following soils: grey-brown usual, grayish-brown saline- solonetzic, grayish-brown incompletely developed are sandy -clay saliferous- deposits in the complex with the incompletely developed soils.

2) Radial trochal type of the SSS in the Absheron Peninsula

The following soils compose this structure: the grayish-brown solonetzic, grayish-brown incompletely developed, grayish-brown saline - solonetzic, and also sandy-argillaceous deposits from the deflation surfaces. The flows of this structure are directed downward along the slope, taking the dendritic type.

Soils are developed on the chalk- Eocene rhythmical alternating shales, sandstones, aleurolites, tuff stones. Development of ground water occurs sporadically.

3) Dendritic - concentric type. It is strongly dismembered and tangled. It is characterized by diverse soil composition.

Here be present grey-brown usual, weakly-solonetzic, grounds of the strongly dismembered slopes, grey-brown bright weakly-solonetzic, grayish-brown, high(ly)-gypsum-bearing, grayish-brown incompletely developed, on the contemporary alluvial- diluvia deposits slopes. Loams – soils with rare inclusions of the removed fragments of breeds.

The powerful bundles of limestones from the topographic surface (20-50 m), spread thickness of clays with the subordinated pro-plasticity of sands; it is sandstone, shell limestones.

4) The bulbous- gathering type it is located in the western part of Absheron in Cheildag region. It has elliptic form flows they are directed to center bulbs. Soils in essence here are the grey-brown usual, grey-brown bright of the different degree of power, salting and by solonetzic; grayish-brown incompletely developed. It is possible that here there was once the lake cavity. This can be judged from the form of flow direction.

Species: Pleiocene -Akchagyl clay with the layers of sands, is sandstone, marl deposits and by the ejections of mud volcanoes.

5) Dendritic type of volcanic origin (Gobustan-Absheron sagging) occupies the part of the territory of Alyatsk's bank, the part of Gobustan, g. Turagay. Structure, is as is evident according to figure crushed. It is disrupted by numerous mud volcanoes. This is the tectonic disrupted structure.

Here be present grayish-brown saline- solonetzic, grayish-brown incompletely developed soils, and also salines, incompletely developed takyr-like soils, the outputs of the compact rocks, the technogenic lands.

Species: the contemporary deposits of mud volcanoes. Mound breccias its unstratified clays with the angular fragments of the rocks with highly developed ravine- girder erosion.

6) Radial- centripetal type is located in the region of the lake of Shorchala, soil of this type they are subjected to strong erosion; it is weakly or strongly salted.

This type SSS contains the following soils: the grayish-brown saline- solonetzic, grayish-brown deep- salty, grayish-brown gypsum-bearing, salines.

Species: Eocene clays, limestones, marls, sandstones and Miocene clays with the layers of sands.

7) The Bulbous- scattering type of the structure of soil cover. Initial point, i.e., repeller of the flow of this structure is located in the zone of settlement shed, being fixed downward to its attractor, is formed bulbous form it covers the territories of Guzdeka, Puta, Lokbatan, Gobu. Soils here are grayish-brown saline under-developed, grayish-brown saline- solonetzic, partially denuded. Is here located the zone of the outputs of the

radical and dense limestone species of their eluvium of steep slopes and breaks in combination with the salty loamy- sandy loam grounds.

Species: Pleiocene -Absheron tier, with powerful lime bedrock (20-50 cm), underlain by thick clay with shelled limestones.

8) The Dendritic - radial type of Baku tier. The flow of this structure begins from Dzhorat settlement, branching in a semicircle flow covers Baku city, and the located adjacent technogenic earth the settlement of Khodzhasan, Sulu -Tepe, Baladzhary, Binagadi, Balakhany, Romani, Sabunchi. Soils here grayish-brown under-developed watered, the variety of the grayish-brown watered soils.

Species: Average- lower Quaternary Sea deposits, sands, sandy clays, pebble- conglomerations.

9) Radial- centrifugal types. It is strongly branched. It covers territory from the sett. Pirshagi, Mashtagi to the sett. Govsany.

The soils extended here are the differences the grayish-brown watered soils, grayish-brown solonetzic-watered, grayish-brown incompletely developed watered, grayish-brown saline- solonetzic watered.

Species: Pleiocene -Absheron the powerful bundles of limestones, underlain by thick clay with the subordinates with the seams of sands, shelled limestones.

10) Dendritic - dichotomous type occupy on the northeast of Absheron the territory of the settlements of Nardaran, Bilgya. The soils of the eastern part of Absheron are subjected to strong deflation. These are the grayish-brown incompletely developed, grayish-brown under-developed, grayish-brown incomplete developed watered soils.

Species: the Absheron limestones, underlain by thick clay with proplasts of sands, shell limestones, the subjected suffossion.

11) Dendritic type of the eastern plains part of Absheron. It is branched from the previous structure, covers the territories of Buzovny, Mardakyan, Gala, Shuvelyan, Tyurkan, Zirya, Shakhovu scythe.

As all dendritic structures, it strongly branches. Soils are subjected to strong deflation. Types of the soils: the grayish-brown under-developed watered, grayish-brown saline, under-developed, grayish-brown under-developed irrigated, grayish-brown under-developed eroded, grayish-brown saline swamped and also coastal sands, cockleshell.

Species: modern lake and saline deposits of the drying-up lakes, interstratifying loams, sandy loams, silt with thin lenses of salts.

Conclusion

The scientific bases of study of SSS (Soil Surface Structure) were developed with account of relief and geologo-geomorfological structure of researched object. Several types of soil cover structures were selected with the help of relief plastics method. The soil composition, physicochemical, biological properties were determined. The dependence between the SSS and internal contents, lithologic structure of a soil cover was established; the ecologo-biological estimation of SSS were carried out, the distinctions between physicochemical properties and soil biological activity were revealed; the estimated scale of soil differences and separate types of SSS was made at valuation. The Map of ecological estimation of Absheron SSS by a relief plastics method was made and on its basis by computer technology the soil map of Absheron in scale 1:100000 was made.

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References

1. Hasanov V.H., Manafova F.A. (2007) // Modern ecological conditions of soil cover structure of Absheron // Proceedings of Institute of Soil Science and Agrochemistry, vol. XVII, Baku, pp. 234-238.
2. Manafova F.A. (2010) // Change the settings of the structure of soil cover structure Absheron Peninsula depending on anthropogenic impact. // Material of scientific conferences Regularities of changes of soils under human activity, the regulation of the status and functioning of soil cover, Moscow, pp. 348-352.

3. Manafova F.A. (2006) // Abstract of dissertation "Environmental assessment of soil cover structure of Absheron" on competition of degree of candidate of biological Sciences",
4. Manafova F.A., Ismailov B.N., Aslanova R.G. (2012) // Soil-ecological characterization of the structure of soil cover Absheron. // Abstracts of the VI Congress of Soil scientists society of the Name of the V.V. Dokuchaev, book 3, Petrozavodsk-Moscow, pp. 277-278.
5. Manafova F.A., Ismailov B.N. (2008) // Comparative estimation of biological activity of soil cover structure of Absheron. Rostov-on-don, Dokuchaev's society of the name of Dokuchaev, p. 119.
6. Salaev M.M., Aliyeva R.A., Jafarova Ch.M. (1983) // The explanatory report to the soil map of Absheron, Baku, p. 3-10.
7. Stepanov I.N. (2003) "Space and time in the science of soils", Russian Academy of Sciences, Moscow Science, pp. 24-36.
8. Sturman B.I. (2003) "Ecological mapping" the Aspect-Press publishing house, p. 81.

LEGEND
PEDOLOGICAL AND ECOLOGICAL PARAMETERS OF THE SOIL SURFACE STRUCTURE (SSS)

Type of SSC	Name of the type	Relief: Height, m	Precipitations, mm	Level of groundwater, m	Temperature of soil, t°C	Humus	Total: Nitrogen	Total: Phosphorus	Total: Potassium	Dissolved solids	$CaCO_3$	pH hydrogen suspension	Total absorbed bases, mg/equivalent	Granulometric composition: <0,001 mm	Granulometric composition: < 0,01 mm	Quality Score attributed to soil	Square of contours of the SSC
	Radial trochal type of the SSC in the Absheron Peninsula	250-300	150	-	13,5	0,88	0,086	0,129	2,04	0,609	13,6	8,2	18,8	19,89	46,81	76	13900
	Dendritic type of the SSC in the piedmont part of Absheron Peninsula	275-370	150	-	13,5	1,15	0,102	0,140	2,00	0,869	9,3	8,5	23,0	18,11	44,29	65	31790
	Radial centrifugal type of the SSC in the Central part of the Absheron Peninsula	100-200	225	-	13,5	0,69	0,076	0,113	2,43	0,551	19,2	8,1	16,9	6,45	17,59	54	15000
	Radial centrifugal type of SSC in the Eastern part of the Absheron Peninsula	500-100	311	1,5-5,0	13,7	0,67	0,159	0,125	2,61	0,748	23,2	8,0	13,7	8,06	24,76	54	27650
	Dendritic-dichotomic type of the SSC in the Northern-Eastern part of the Absheron Peninsula	5-30	311	3,5-7,0	13,7	1,38	0,123	0,138	2,28	0,279	13,5	8,0	21,7	4,59	18,56	44	8480
	Bulbous dispersive type of the SSC in the South of the Absheron Peninsula	75-150	225	1,0-2,5	13,7	1,37	0,125	0,146	2,27	0,409	6,6	7,9	23,0	10,46	31,93	42	25800
	Dendritic type of SSC in the Eastern lowland part of the Absheron Peninsula	-26-0	225	2,5-5,0	13,7	1,26	0,104	0,101	2,00	0,980	15,5	8,2	21,7	13,86	34,92	31	35950

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Determination of soil erodibility state under different land use and land cover in Madendere watershed

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Abstract

The soil erodibility factor (K-factor) is a quantitative description of the inherent erodibility of a particular soil; it is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Therefore, this indicator also shows potential erosion risk case for that area. The primary objective of this study is to determine effect of different land use and land cover on soil erodibility values in MadenDere Watershed by applying GIS and RS. To determine land use and land cover of the study area, Geoeye satellite image was used. Four main land use and land cover that are forest, orchard, pasture, and cultivated land were determined and their distribution are 38.6 %, 35.5%, 12.8% and 9.5%, respectively. 71 soil samples were collected from surface (0-20 cm) for each land use and land cover. According to statistical analysis, it was found that there were significantly differences between land use/land cover and K factor. The highest mean value belongs to forest land cover flowed by pasture, orchard and cultivated land. This means that top soils of forest are very sensitive to erosion, in other words, forest soils are under high potential erosion risk.

Keywords: erodibility, Land use-land cover, Madendere Watershed

Introduction

Land use and soil cover are considered the most important factors affecting the intensity and frequency of overland flow and surface wash erosion (García-Ruiz, 2010; Kosmas et al., 1997; Mitchell, 1990). Many authors have demonstrated that in a wide range of environments both runoff and sediment loss decrease exponentially as the percentage of vegetation cover increases (Francis andThornes, 1990; Lee andSkogerboe, 1985). Soil erosion is the process of detachment and transport of soil particles caused by water and wind (Morgan, 1995). Opening new agricultural lands, conversion of rangelands, overgrazing, deforestation and mismanagement cause inevitable soil erosion. Similarly, natural vegetation is more effective than most plantings in reducing soil erosion because of its stratified structure. Such a structure can absorb much more of the raindrop energy by multi-interception than can a structure with a single layer (Zhongming et al. 2010).

Soil erosion depends on the erosivity of the rainfall and erodibility of soil. The soil erodibility depends primarily on the physical characteristics of the soils nature and amount of soil aggregates, organic matter content and particle size distribution. These physical characteristics of soils are much affected by the land use and land

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cover. Soil erodibility can be evaluated by using runoff plots, which is quite expensive, time consuming and is not feasible at all places. It can also be estimated using nomograph developed by Wischmeier et al. 1971) but it may not be applicable in many situations (Rejman et al. 1999). Another way to estimate soil erodibility is by using various soil erodibility indices based on soil characteristics. Soil erodibility has been incorporated into many soil erosion models, including the widely used in particularly USLE (Universal Soil Loss Equation, Wischmeier and Smith, 1978).In this model, soil erodibility is called K-factor, which in turn is a function of particle size distribution, organic matter content, structure and permeability (Parysow et al., 2001).The present study was undertaken to evaluate soil erodibility indices under different land uses and land covers.

Material and Methods

Field Description of the Study Area

The study area located in MadenDere Watershed of Kocaeli-Kartepe district is coordinated at 4515500-4518000 N and 262400-264800 E (UTM-m) and the total area is approximately 5.5 km^2. Mean sea level altitude of the watershed is 415 m (Figure 1). Average annual precipitation and temperature of the study area are 730.4 mm and 11.3 °C, respectively (Table 1). Land use and vegetation of the study area are generally, covered by forest, arable land and pasture.

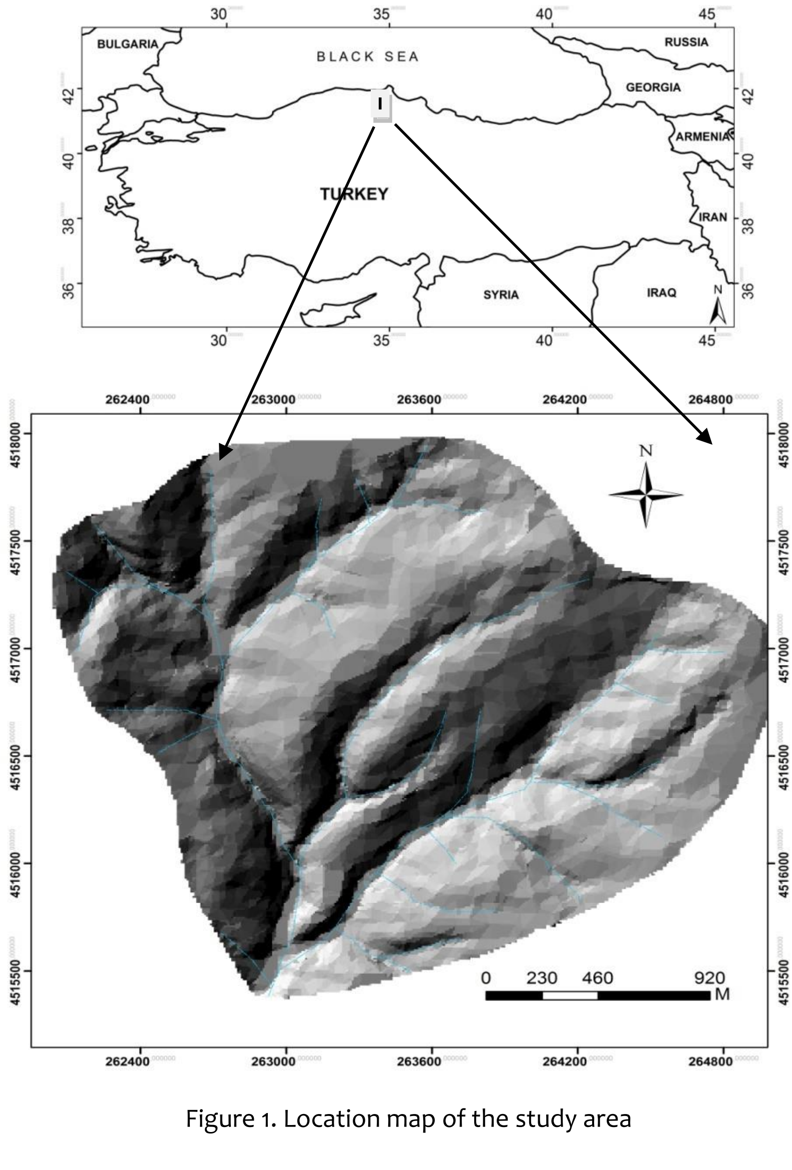

Figure 1. Location map of the study area

Table 1. Meteorological data of the study area

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
T °C	0.0	2.0	5.8	11.0	15.5	19.5	22.0	21.5	18.0	12.2	6.5	1.9	11.3
P (mm)	92.8	82	78.9	76.3	57.7	40.3	14.6	15.1	26.6	54.7	85.4	106	730.4

A range of soil types are present because of the significant differences in climate, geomorphology, vegetation, complicated geohydrologic conditions, parent materials, and cultivation. According to Soil Taxonomy (1999), soils of the study area were classified as Dystrustept, Ustorthent, Haplustept, Haplustalf, Calciustept based on great group level by taking into consideration of pedological development.

Soil Sampling

Two kinds of soil sampling method which are surface and profile were used to determine soil organic carbon density. Soil samples were obtained from surface divided into 300 x 300 m grid squares (Figure 2). 71 soil samples were collected from surface (0-20 cm) for each land use and land cover.

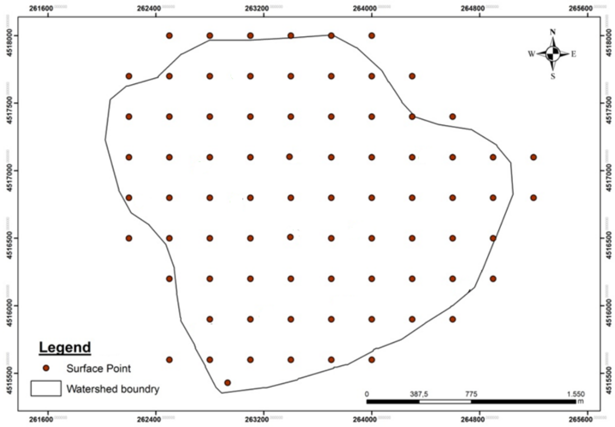

Figure 2. Soil surface sampling design and soil profile on the study area

The samples were transported to the laboratory. The soil samples were crumbled gently by hand without root material. These samples were used to determine some physico-chemical properties such as bulk density and organic matter. Selected soil properties were determined by the following methods: Particle size distribution (GeeandBauder, 1986), hydraulicconductivity (KluteandDirksen, 1986), bulk density (Blacke and Hartge, 1986) and organic matter was determined in air-dry samples using the Walkley-Black wet digestion method (Nelson and Sommers, 1982).

Soil Erodibility Factor (K)

Soil samples were collected from each land use and land covers to determine K values of them. Soil samples were analyzed to determine physico-chemicalsoil properties including sand %, silt %, clay %, organic matter %, and classes for structure and permeability. The values of the soil erodibility factor (K) were computed from these soil properties according to the following equation (Wischmeier and Smith, 1978):

$$K = \frac{1}{100}\left\{2.1\times10^{-4}\times(12-OM)\times\left[SI\times(SA+SI)\right]^{1.14}+2.5\times(PE-3)+3.25\times(ST-2)\right\}$$

Where; K is expressed in units of t ha h ha-1 MJ mm^{-1}. OM, SI, SA, PE and ST are percentages of soil organic matter content, silt content, sand content, permeability class and structure code, respectively. If soil organic matter content was equal or greater than 4 %, OM was constant at 4 % in this equation (Renard et al. 1997). K values classes were given in Table 2.

Table 2.Description and class of K value

Class(t ha h ha^{-1}MJmm^{-1})	Symbol	Description
0-0,05	K1	Very low
0,05-0,10	K2	Low
0,10-0,20	K3	Moderate
0,20-0,30	K4	High
> 0,30	K5	Very high

Statistical analysis

All statistical analysis was carried out in SPSS13.0 (SPSS Inc. Chicago I11inois, USA). An analysis of variance (ANOVA) was performed to evaluate if soil type and land use have a relationship with soil carbon that is significant beyond that which would expected by chance. If there was a significant effect (*P* <0.05), least significant difference (LSD) post hoc multiple comparisons were used to compare means between different groups within each categorical variable, tested with a = 0.05. Prior to analysis of variance, all the data were logarithm transformed to conform to a normal distribution

Results and Discussion

To determine current land use and land cover of the study area, Geoeye satellite image that has 0.5 m x 0.5 m spatial resolution and dated 2013 were used. According to remote sensing analysis, primary land uses are forest, cultivated land, pasture, orchard and settlement (Figure 3). Forest is the highest land cover in the study area and has about 38.6 % of the total area (211.11 ha), followed by orchard (35.5%-192.22 ha), pasture (12.8%-70.14 ha), cultivated land (9.5% 52.02 ha) and settlement (3.6% 19.74 ha).

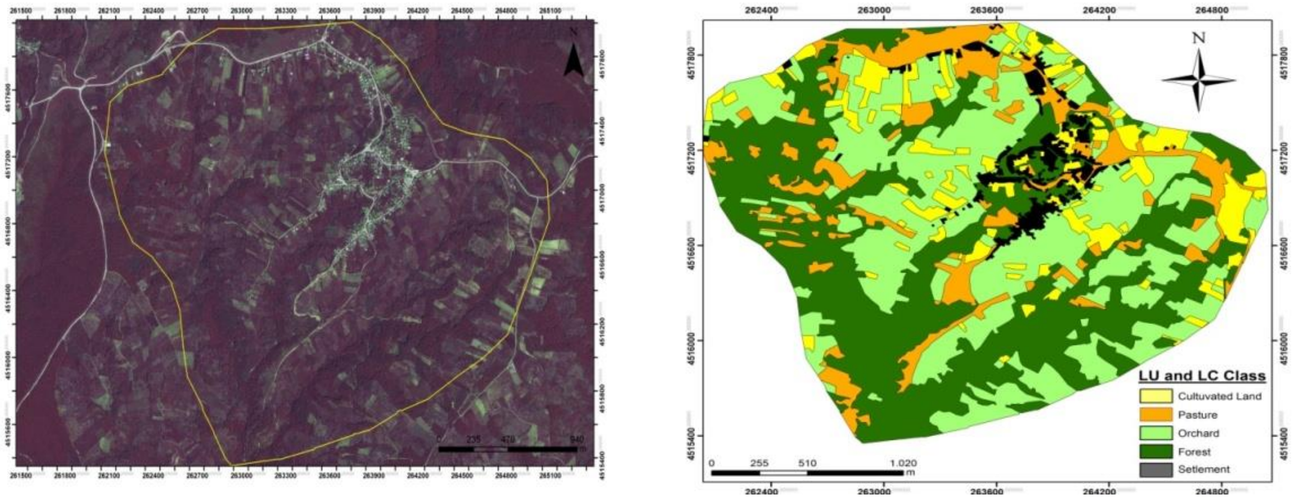

Figure 3.Geoeye image and land use Land Cover maps of the study area

Physico-chemical soil properties including sand %, silt %, clay %, organic matter %, and classes for structure and permeability have vital role on identify of soil erodibility under different land use and land covers. The descriptive statistics as minimum, maximum, mean, and coefficients of variation of physic-chemical properties of K values were presented in Table 3.The values of clay in soil samples ranged between 18.90% and 50.70%, whereas sand had a minimum value of 18.20%and a maximum value of 56.50%. Organic matter varied between 0.70 and 5.5 and the average value of organic matter was 3.25. Permeability has high variation between minimum and maximum values (1.33-27.17).

Table 3.Values of descriptive statistics of the soil physico-chemical properties

	Mean	Min.	Max.	S.D	C.V	Skewness	Kurtosis	n
Clay	33,20	18,90	50,70	7,38	22,22	0,42	-0,62	71
Silt	64,56	42,00	80,60	10,10	15,64	-0,62	-0,35	71
Sand	34,07	18,20	56,50	10,06	29,52	0,62	-0,34	71
Permability	7.75	1.33	27.17	4.62	59.63	1.46	3.34	71
Bulk Density	1,36	1,23	1,53	0,06	4,70	0,28	-0,23	71
Organic Matter	3,25	0,70	5,50	1,00	30,82	-0,03	-0,30	71

n: number of sample; S.D: standard deviation; C.V: Coefficint of Variance (%); Significant differences are indicated by the different letters at *P* < 0.05.

Results of the soil erodibility under four different land use and land cover were given in Table 4. According to grid system, distributions of soil samples are 13, 23, 15 and 20 for each land use and land covers that are cultivated land, orchard, pasture and forest, respectively. The descriptive statistics as minimum, maximum, mean, and coefficients of variation of K valuesunder different land uses and land covers pattern were presented in Table 4. According to statistical analysis, it was found that there were significantly differences between land use/land cover and K factor. The K values of soils collected from forest ranged between 0.244 and 0.414, whereas cultivated land had a minimum K value of 0.013and a maximum K value of 0.153. In addition, Mean K values of pasture and orchard are 0.225 and 0.157, respectively. Consequently, it was found that the highest mean value belongs to forest land cover flowed by pasture, orchard and cultivated land. This means that top soils of forest are very sensitive to soil erosion by taking into consideration of Table 2, in other words, forest soils are under high potential erosion risk.

Table 4.Descriptive statistics values of K under each LU/LC

LU/LC	Mean	Min.	Max.	S.D	C.V	n
Cultivated Land	0.087^{d}	0.013	0.153	0.036	41.38	13
Orchard	$0,157^{c}$	0.121	0.233	0.027	17.20	23
Pasture	0.225^{b}	0.169	0.300	0.031	13.78	15
Forest	0.304^{a}	0.244	0.414	0.042	13.82	20

n: number of sample; S.D: standard deviation; C.V: Coefficint of Variance (%); Significantdifferences are indicated by the different letters at $P < 0.05$.

Conclusion

The present study shows the heterogeneous nature of erodibility. Parysow et al. (2001) indicated that K values had considerable and smooth spatial variation, might prove to be a valuable modeling tool for obtaining estimates and reducing uncertainty in soil erodibility, as well as erosion prediction in their study. However, assessment of soil erodibility should be periodically renewed and spatial data of the MadenDere Watershed updated to provide a quick evaluation of its fragility and sustainable land management, due to dynamical behaviour of soil erodibility in time.

Since soil erosion generally occurs when the soil is displaced by rain and transported from the specific area, therefore rainfall is considered as the driving factor of soil erosion. However, the factor that significantly affects the soil displacement by rain is land cover or vegetation cover. The reduction of vegetation cover can increase soil erosion. This relationship is a reason why vegetation cover and land use have been widely included in soil erosion studies (Szilassi*et al.* 2006; Zhou *et al*. 2008; Solaimani*et al.* 2009; Su *et al.* 2010). In this study, top soils of forest and pasture have the highest potential erosion risk so, if misused or removed canopy from surface of them surface soil can be easily destroyed by atmospheric or anthropogenic factors. Therefore, on the basis of the above findings, there is a need to develop proper land use policy and sustainable soil management and cropping practices to combat the ongoing soil degradation.

References

Blacke, G.R., and K.H. Hartge.1986. Bulk density. In Klute, A. (ed). Methods of soil analysis. Part 1. Physical and mineralogical methods. 2nd ed. Agronomy 9: 363-382.

Francis, C., &Thornes, J. B. (1990). Runoff hydrographs from three Mediterranean vegetation cover types. In J. B. Thornes (Ed.), Vegetation and erosion (pp. 363-384). Chischester: Wiley.

García-Ruiz J.M. (2010): The effects of land uses on soil erosion in Spain: A review. Catena, 81: 1–11.

Gee, G. W. and J. W. Bauder. 1986. Particle-size analysis, pp. 383–409, in A. Klute, ed., Methods of soil analysis, part I, 2nd ed. American Society of Agronomy, Madison, WI.

Komas C., Danalatos N., Cammeraat L.H., Chabart M., Diamantopoulos J., Farand R., Gutierrez L., Jacob A., Marques H., Martinez-Fernandez J., Mizara A., Moustakas N., Nicolau J.M., Oliveros C., PinnaG., Puddu R., Puigdefabregas J., Roxo M., Simao A., Stamou G., Tomasi N., Usai D., Vacca A. 1997. The effect of land use on runoff and soil erosion rates under Mediterranean conditions. Catena, 29: 45–59.

Klute, A. and C. Dirksen. 1986. Hydraulic conductivity and diffusivity, pp. 687–732, in A. Klute, ed., Methods of soil analysis, part I, 2nd ed. American Society of Agronomy, Madison, WI.

Lee, C. R., &Skogerboe, J. G. (1985). Quantification of erosion control by vegetation on problem soils. In A. Swaify,W. C. Moldenhauer, & A. Lo (Eds.), Soil erosion and conservation (pp. 437e444). Soil Conservation Soc. of America.

Mitchell, D. J. 1990. The use of vegetation and land use parameters in modelling catchment sediment yields. In J. B. Thornes (Ed.), Vegetation and erosion, processes and environments (pp. 289e314). Wiley & Chichester.

Morgan, R. P. C. 1995. Soil erosion and conservation. Longman, Essex, England.

Nelson, D.W., L.E. Sommers. 1982. Total carbon, organic carbon and organic matter. In: Page, L.A., Miller, R.H., Keeney, D.R (Eds.), Methods of Soil Analysis, Part 2. Chemical and Microbiological Methods (2 nded). American Society of Agronomy, Madison, WI, pp 539-579.

Solaimani K., Modallaldoust S., Lotfi S. 2009. Investigation of land use changes on soil erosion process using geographical information system. International Journal of Environment Science and Technology, 6: 415–424.

Su Z.A., Zhang J.H., Nie X.J. 2010. Effect of soil erosion on soil properties and crop yields on slopes in the Sichuan Basin, China. Pedosphere, 20: 736–746.

Szilassi P., Jordan G., van Rompaey A., Csillag G. 2006. Impact of historical land use changes on erosion and agricultural soil properties in Kali Basin at Lake Balaton, Hungary. Catena, 68: 96–108.

Wischmeier, W.H., C.B. Johnson and B.V. Cross. 1971. A soil erodibilitynomograph for farmland and construction sites. Journal of Soil and Water Conservation 26: 189-192.

Wischmeier, W. H. and D. D. Smith. 1978. Predicting rainfall erosion losses. USDA Agricultural Handbook, 537, Washington D.C.

Zhongming W., Lees B.G., Feng J., Wanning L., Haijing S. 2010. Stratified vegetation cover index: A new way to assess vegetation impact on soil erosion. Catena, 83: 87–93.

Zhou P., Luukkanen O., Tokola T., Nieminen J. 2008. Effect of vegetation cover on soil erosion in a mountainous watershed. Catena, 75: 319–325.

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Bio-diagnostics of the irrigated soils under fodder crops in the arid subtropical region of Azerbaijan

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Abstract

In the conditions of the intensive anthropogenic influence on the irrigated Irraqri Kastanozems (in WRB) soils of Azerbaijan dry subtropics, first of all, soil biological indices undergo sizable changes. This necessitated developing effective agrotechnical measures with the use of uninterrupted and interrupted sowings of fodder crops. In order to determine the trend of processes of soil formation, as biodiagnostic soil indices microbiological and biochemical indices were used as they are considered the most sensible soil indices to the changes of soil and ecological conditions and fertility.The purpose of the research is to study biogenic transformations of mobile forms of the mineral fraction and humus of irragri Irraqri Kastanozems soils under fodder crops subject to species of plants and types of their sowings, numbers of microorganisms, particular physiological groups, soil enzymatic activity, respiration and cellulose decomposing capacity.The scheme of the experiment : I. winter barley – corn; II. winter rye – corn; III. lucerne ; IV. sainfoin; V. corn; VI. winter barley-corn+soya+sorghum+amaranth - barley+vetch; VII. winter rye+vetch+rape-corn+soya+sorghum+amaranth- barley+vetch. According to the results, during the year, in the variant with winter sowing rye+vetch+rape and the main sowing corn+soya+sorghum+amaranth, uninterrupted summer barley, which provides the uninterrupted field use, the air-dry mass of stubble and root remains is accumulated in every hectare up to112-135 centner per hectare. But in the variant II the air-dry mass of stubble and root remains is accumulated63.67-70. centner per hectare. The long-term researches showed that in the uninterrupted variant VII under different fodder crops in the layer of 0-25см cm, the total number of microorganisms changed within 3261.52-4687.2, nonspore-forming bacteria -2322-3210, spore-forming bacteria-378-600, actinomycetes - 1056-2098, microscopic fungi - 2.28-5.00 thous./ha. In spring the highest invertase activity is observed in variant VII – 26.50 mg of glucose

Key words: soil, stubble and root remains, biological activity, humus, biodiagnostics

Introduction

In the conditions of the intensive anthropogenic influence on the Irraqri Kastanozems of Azerbaijan dry subtropics, first of all, soil biological indices undergo sizable changes (Babayev,1984).

In this connection, in the modern soil formation, particular attention is given to the study of biological processes of matter transformation and possibilities of its further use for biodiagnosis of the ecological state and trend of soil formation (Ramazanova, 2008, p.106; Rondon, 1999, pp. 403-409). This necessitated developing effective agrotechnical measures with the use of uninterrupted and interrupted sowings of fodder crops. In order to determine the trend of processes of soil formation, as biodiagnostic soil indices

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microbiological and biochemical indices were used as they are considered the most sensible soil indices to the changes of soil and ecological conditions and fertility.

Biodiagnosis makes it possible to retrace negative processes in soil and determines most biochemical processes of soil formation and fertility. Some of the factors influencing microbiological and biochemical indices are vegetative residuals, microorganisms and their vital functions (Valkov, 1999; Zvyagintsev,1987).

Uninterrupted and interrupted intermediate sowings of fodder crops - an important reserve of the increase in fodder production - influence positively the soil formation process and have biological, ecological, and agricultural importance. The role of biological agents - the soil microflora, enzymatic activity, respiration and cellulose decomposing capacity - in the current soil processes taking place in the Irraqri Kastonozems under fodder crops is barely studied. In this consideration, the long comparative study of the influence of uninterrupted and interrupted intermediate sowings of fodder crops on microbiological and biochemical indices of Irriagri Kastanozems is_of great interest to solve problems of soil fertility and provide animal husbandry with high-quality cropps in Azerbaijan (Ganja-Gazakh) arid zone.

The aim of the research is to determine the biological activity and biogenic transformations of mobile forms of the mineral fraction and humus of soils under fodder crops during intermediate sowings subject to species of plants and types of their sowings, numbers of microorganisms, particular physiological groups, soil enzymatic activity and cellulose decomposing capacity.

Materials and Methods

The researches were conducted on the territory of Gyanja -Gazakh area on the Irraqri Kastanozems in Azerbaijan dry subtropics. The zone is characterized by mild winters (1.0-2.6°C) and warm summers (23-27°C), accumulated active temperatures -3344-4472°C, total radiation- 122,5-128,5Cal/cm^3 , precipitation-evaporation ratio- 0.30-0.50, the content of humus in the plough-layer is 2.0-2.2%, carbonation is observed along the whole profile, pH-8.0-8.6, the soil is not saline. The constitution of the morphological profile: AUa'z - AY'a'' – BCA-Cscsca (Salaev, 2004; Ramazanova, 2013).

The scheme of the experiment (common sowing): I. winter barley (grain)- corn (silage) II. winter rye (grain)- corn (silage) III. Lucerne (green mass); IV. sainfoin (green mass); V. corn (silage, spring sowing); (uninterrupted sowing) VI. winter barley(green mass)-corn+soya+sorghum+amaranth (silage)- barley+vetch (green mass); VII. winter rye+vetch+rape (green mass) - corn+soya+sorghum+amaranth (silage) - barley+vetch (green mass).

The experimental area under crops is 70m^2, the fourfold replication. Disregarding its pattern of use, each field got annually organic (in autumn- manure 20 ton/ha) and mineral fertilizers - $N_{90}P_{120}K_{60}$. Agrotechnology of crop cultivation during the uninterrupted sowing of intermediate crops - zonal. The terms of sowing of the main crops after intermediate crops are different and timed to the terms of ripening and harvesting of the previous crop. Some soil samples were taken from topsoil and subsoil to study the initial morphological and genetical properties of the examined soil, its physicochemical and biological parameters and their changes under the influence of biological productivity of fodder crops during uninterrupted sowings. The soil samples were analyzed for the main morphological, physicochemical and biological parameters:

- Agrophysical properties: microaggregative soil composition (by Kachinsky); the volume weight- by formula d=B/V, where d-volume weight, B-the mass of the dry soil in a cylinder, g, V-cylinder volume cm^3(by Alexandrova and Naydenova); hygroscopic water- by formula x=100a/b-a (by Alexandrova and Naydenova); agrochemical parameters: humus – by Turin I.V., ammonia nitrogen (absorbed)- by colorimetric method with the Nessler reagent by Konev, nitrate nitrogen- by the Grandval and Lajoux method, phosphorus- labile– by Machigin, exchange potassium - by Protasov, absorbed Ca and Mg - by Ivanov, pH- by potentiometric method; absolute aqueous extract (dry residue and compact residue) by formula x= aV•100/bc (by Alexandrova and Naydenova); soil temperature – by Savinov's thermometer.

Microbiological and biochemical researches were conducted by the methods described in the book by K.Sh. Kazeev (2003). While examining the main vegetative stages of all the variants we conducted phonological and biometrical observations and kept a record of the biological productivity (harvest - 1m^2, the mass of stubbles and roots - 0.25cm^2) by weighting it diagonally from the three grounds under each variant. The determination of the root mass was conducted by monolithic method in 1999-2007 (sectional area 25x25 cm by Kachinsky, 1925).

The samples of aboveground (harvest of the green mass, stubble remains) and underground (root remains) mass of crops were analyzed for: a) absolute dry matter and moisture- by drying at 105°C and calculating by e=d-100:v: absorbed moisture - u=100-e; b) damp ash- by burning it in a muffler; c) total nitrogen- by Kjeldahl; d) raw fat- by the method of dry residue (Soxhlet apparatus); e) AEM - by computing method; f) raw cellulose- by Henneberg and Stohmann ; g) phosphoric acid in ash- by Denigès method modified by Levine; h) calcium in ash – trilometric method; i) potassium in ash- by Tananaeva method.

All the analyses were repeated three times. According to generally accepted methodology, the results were mathematically and statistically processed at 95% significance level.

Results and Discussion

The accumulation of postharvest plant residues

The determination of the intensity of biogenic morphological and physicochemical transformations under fodder crops during intermediate sowing and their impact on the process of soil formation and fertility requires the cognition of the quality and quantity of postharvest plant residues, the total number of microorganisms and certain physiological groups, enzymatic activity and their seasonal dynamics, physicochemical soil characteristics, etc. (Kaimakamis, 2013)

The quantitative content and the qualitative composition of organic matter in the soil can be determined by the characteristics of the processes of synthesis and decomposition of plant residues and bacterial plasma and are dependent on the conditions of the fixation of organic products by the disperse mineral part of soil (Ageev, 1990). The uninterrupted and common sowings of fodder crops influenced the content of organic matter in Irraqri Kastanozems. These changes took place both in the topsoil and even deeper layers.

The researches on the study of the influence of uninterrupted and common sowings of fodder crops on the current process of soil formation and fertility show that the considerable amount of biologically related nitrogen, phosphorus and potassium remains in soil with stubble and root remains after harvesting (Ageev, 1990). According to the results, the uninterrupted sowings on the Irraqri Kastanozems favour a greater accumulation of organic matter in soil than analogous variants under the generally accepted scheme of the use of arable land. During the year, in the variant with winter sowing rye+vetch+rape and the main sowing corn+soya+sorghum+amaranth, uninterrupted summer barley (variant VII), which provides the uninterrupted field use, the air-dry mass of stubble and root remains is accumulated in every hectare up to135 centner per hectare. With winter rye and uninterrupted summer corn (variant II, the air-dry mass of stubble and root remains is accumulated 85.6 centner per hectare. The comparison of these variants with the analogous variants (I,III,IV,V) shows that during the uninterrupted use of the arable land, the soil accumulates organic residues 1.9-3.1times as much. Sainfoin and lucern yield to the uninterrupted variants in the accumulation of organic matter. The least amount of organic matter remains in the soil after corn of pure sowing (50centner/ha). The introduction of intermediate sowings trebles the accumulation of organic matter. The observations on the dynamics of the decomposition of organic residues revealed that all the remains of annual crops, except for sainfoin and lucern, decompose by 70-80% within 3,5 months.

Chemical composition of plant residues

The received data show that the same plants but cultivated in different variants differ in their chemical composition of stubble and root remains. For example, corn of summer sowing (variant V) differs from corn (common sowing) sown in April in the content of nitrogen and potassium in organic residues. So, if in the intermediate sowings corn contains nitrogen- 1.41 %, phosphorus- 0.41%, potassium- 0.79 % in its stubble and root remains, in corn grown in common sowing, the content of nitrogen and potassium decreases to 0.81-0.88 and 0.30-0.35%, but the content of phosphorus increases to (0.46 - 0.51%). Uninterrupted variant VI has the highest content of nitrogen, phosphorus, and potassium. It is important to note that the return of nutritive elements with stubble and root remains into Irraqri Kastanozems in uninterrupted variant VI was in nitrogen 3.46 times, in phosphorus 1.61times, in potassium 2.36 times as high as in the common variants (I, II, III, IV,V).

Humus state

The humus content of the Irraqri Kastanozems is not a constant system and varies from time to time. The continuous presence of postharvest plant residues during uninterrupted sowings became the main reason for the accumulation of the organic matter-humus- in the soil (Ramazanova, 2013). It was found out that in the arable soil layer (0-27cm, uninterrupted variant III), there was a tendency to the increase in the content of humus and nitrogen both from the first level (up to 0.38-0.40%) and in relation to the other variants (up to 0.18-0.27%) and the decrease in the ratio C:N – 7-8.

The comparative analysis of the data on the humus content after 13 years (2000-2013) of the use of Irraqri Kastanozems under uninterrupted and common sowings of fodder crops shows that the continuous cultivation of lucern and sainfoin increases the humus content. However, in the next few years, its content decreases. It was found out that in the arable soil layer (0-27cm, variant VII), there was a tendency to the increase in the content of humus and nitrogen both from the first level (up to 0.38-0.40%) and in relation to the other variants (up to 0.18-0.27%) and the decrease in the ratio C:N – 7-8.

In subsurface horizons (55-95cm) under all the variants we observed the decrease in the humus and nitrogen content (humus: 0.51-1.12%, nitrogen: 0.067-0.105%). The largest amount of humus in the soil was formed under variants VI and VII - 2.50 and 2.67%. Compared to the humus balance under the variants with monosowings of lucern and sainfoin, uninterrupted variants have the advantage of the balance. The changes in the humus content of the Irraqri Kastanozems under sowings of fodder crops influenced the store of humus and nitrogen. So, the humus stores changed from 71.4-75.5 ton/ha in the soil under lucern and sainfoin, but in the soil under variants VI and VII the humus store was 76.4 и 79 ton/ha. Accordingly the nitrogen stores changed (from 5.70 -5.54 to 5.83-5.94 ton/ha). The soil under variants I, II, V, where agrocenosis consisted of cereals, had the equal humus content – 64-68 ton/ha and nitrogen – 4.50-5.15 ton/ha.

Biological activity of the soil

Microbiological activity of soil

The long-term data comparison of the micro flora number in the Irraqri Kastanozems under fodder crops during intermediate sowings indicated that foddergress cultivation according to these agricultural methods favoured intensive development of the main physiological groups of microorganisms. The determination of the intensity of biogenic transformations under fodder crops and their impact on soil fertility requires the cognition of the number of microorganisms and certain physiological groups, enzymatic activity and their seasonal dynamics, etc. Vegetative residuals favour intensive development of the main physiological groups of microorganisms.

Soil fauna do colossal work on the decomposition of a big mass of vegetative residuals that enter yearly into the bioactive layer. The long-term researches showed that in the uninterrupted variant rye+vetch+rape > corn+soya+sorghum+amaranth > barley+vetch under different fodder crops the total number of microorganisms changed within 3860.10 - 4687.24 > 3388.22-3950.17 > 3100.0 – 3261.52, total number bacteria 2578-2690 > 3210-2234 > 2322-2998 , spore-forming bacteria- 430-600 > 378-445 >387-408, actinomycetes – 1230-2098 > 1056-1900 > 1108-1686, microscopic fungi - 4.21 –5.00 >2.28 – 3.09 > 3.59 – 3.98 thous./ha (see table 1). However, in the other uninterrupted variants, these indices were even lower, which indicates the dependence of soil biological activity on the quantity and quality of stubble and root remains entering the soil. While observing the soil profile under all the crops downwards, it was found out that the absolute and relative number of microorganisms decreased drastically.

Biological energy

In addition to the microbiological activity of Irraqri Kastanozems under fodder crops in intermediate sowings, we studied the amount of biological energy accumulated in the biomass of microorganisms with consideration given to energy data of biological objects. As the microbilogical activity in variants VI and VII arouses, the amount of energy accumulated in the biomass of microorganisms increases from 27.87 to 79.85 kcal/m^2, which is related to favorable symbiotic interrelations between root system and microbiota. Most amount of energy accumulated in the biomass of microorganisms is concentrated in bacteria; least amount of energy –in fungi and actinomycetes. In other variants this index is even lower.

Enzymatic activity of soil

Fermentative activity characterizes the intensity and direction of biochemical processes (Rondon, 1999; Ramazanova, 2008). Subject to the hydrothermic regime and biological features of the cultivated crops seasonal fluctuations of fermentative activity of Irraqri Kastanozems are observed and each ferment has its own characteristic features. Invertase participates in saccharose decomposition into glucose and fructose. The research results revealed strong seasonal variation of invertase. In spring the highest invertase activity is observed in variant VII (rye+vetch+rape-26.50 mg of glucose) and in the variant under lucerne - 19.60, then saifoin–17.90,mg of glucose. In the soil under barley and rye invertase activity is almost invariable (see table 1).

Table 1. Biodiagnosis of Irraqri Kastanozems (layer-0-27cm)

Variant, Sequence of fodder crops	Term of harvesting	invertase, mg of glucose in 1 g of soil for 24h	urease, mg NH_3 in 1g of soil for 24h	phosphotase, mg P_2O_5 in 10g of soil for 1h	catalase, cm^3 O_2 in 1g of soil for 2 min	Dehydrogenase, g of thymidine triphosphate in 10g of soil for 24h	Cellulose, decomposing capacity, %	total number of microorganisms, ths/g of soil
Barley I Corn	28.06-05.07 15.09-20.09	14.70 7.70	3.30 2.00	2.10 1.85	16.70 6.20	6.00 4.10	21.85 20.00	3648.45 3200.51
Rye II Corn	03.07-07.07 25.09-30.09	16.85 7.89	3.34 2.31	2.49 1.97	17.0 6.93	7.00 4.33	22.26 21.03	3705.65 3298.73
III Lucerne	15.05-20.05 30.06-04-07 15.08-25.08 05.10-10.10	19.60	5.36 5.71 5.70 5.59	3.85	28.90	8.94	26.80	4990.00
IV Sainfoin	15.05-20.05 30.06-04-07 15.08-25.08 05.10-10.10	17.90	4.74 4.84 4.83 4.46	3.71	28.62	8.79	27.05	4983.00
V Corn	15.05-20.05 30.06-04-07 15.08-25.08 10.10	7.90	2.29	1.90	6.53	4.00	21.00	3098.16
Barley+ vetch+rape VI Corn+soya+sorghum+amaranth Barley+vetch	25.05-30.05 05.08-10.08 30.09-05.10	25.76 12.85 8.01	4.83 3.80 2.33	3.73 2.68 1.88	28.73 11.00 7.00	8.39 5.51 4.09	23.93 23.76 22.43	4580.48 3900.33 3179.70
Rye+vetch+rape VII Corn+soya+sorghum+amaranth Barley+vetch	25.05-30.05 05.08-10.08 30.09-05.10	26.50 13.00 8.43	5.09 3.89 2.39	3.97 2.78 1.93	29.00 11.17 7.29	8.87 5.90 4.17	26.98 24.00 22.45	4687.24 3950.17 3261.52

In summer fermentative activity of invertase is high in variants VI and VII (root system after harvesting of mixed grass crop rye+vetch+rape and barley+vetch+rape for green mass is a very good energy material for microorganisms), then the variants under lucerne and sainfoin. Like in spring invertase indices are low under rye and barley. In autumn invertase activity in all variants decreases by 7.0-13.50 and 17.0-18.0 mg of glucose. Only in variants VI and VII, the autumn index of invertase is higher than that of summer by 0.50-0.60 mg of glucose. It can be explained by the better soil aeration as a result of ploughing after summer harvesting in variants VI and VII. In winter at the low temperature and adequate humidity invertase activity decreases.

Urease participates in hydrolysis of organic residues containing nitrogen and is important for the nitrogen cycle. In connection with a big number of rhizospheric microorganisms and their high biochemical functions in spring, the highest urease activity is observed in variants III, IV, VI, and VII; it is relatively low under pure rye sowing. In summer in the soil in uninterrupted variants VI and VII under mixed corn sowing, urease activity decreases (to 3.89 mg NH_3) compared to spring variants under mixed grass crop. But in the soil under lucerne and sainfoin the increase in urease activity is observed by 0.10 – 0.35 mg NH_3 than in spring. In autumn (as compared to in summer) in the soil under lucerne and sainfoin the decrease in urease activity is observed by 0.12 – 0.38 mg NH_3. In winter urease activity in the soil under all crops is 2 times as little.

Phosphotase participates in transforming phosphor-organic compounds into mobile forms. Phosphotase activity depends on cultivated cultures more than invertase and urease activity. The results reveal that phosphotase activity as well as the activity of other ferments is seasonal. High phosphotase activity under mixed grass crop (barley+ vetch+rape and rye+vetch+rape - 3.73-3.97 mg P_2O_5 in 10g of soil for 1h) owes rape (in spring roots going 1.3-1.5 m deep in soil raise nutrient substances to the upper soil layer and they are able to secrete mustard oils rich in sulfur decomposing phosphate forms difficult for vegetation). Under barley and rye (I and II variants) phosphotase indices are lower.

Dehydrogenase catalyzes the reaction of hydrogen removal of oxidizing organic substances and matters as an intermediate carrier of hydrogen. In spring high dehydrogenase activity is observed under lucerne, sainfoin, and mixed grass crops (III, IV, VI and VII variants -8.39 – 8.94 mg of thymidine triphosphate - TT in 10g of soil for 24h), it is a bit lower under rye (7.00 mg of thymidine triphosphate - TT in 10g of soil for 24h). The lowest dehydrogenase activity is observed under corn (V variant). In winter in comparison with the other seasons dehydrogenase activity is almost 2-2.5 times as little.

Catalase is the indicator of aerobic processes in soil. The researches revealed that catalase activity is seasonal. In connection with a big number of rhizospheric microorganisms and their high biochemical functions in spring the highest catalase activity is observed in variants III, IV, VI, and VII, (28.62 – 29.00 cm^3 O_2 in 1g of soil for 2 min), it is relatively low under pure rye sowing (I and II variants -16.70- 17.00 cm^3 O_2 in 1g of soil for 2 min).

The factor of mineralization

It is possible to judge the intensity of processes of mineralization by the factor of mineralization and immobilization of organic matter. The factor of mineralization in the uninterrupted variants varied from 0.17 to 0.26, in the variants with lucerne and sainfoin- 0.25-0.31. In the other variants, the factor of mineralization of an organic matter reached 0.66-0.78 where the number of bacteria and nitrogen was higher.

The physicochemical properties of the soil

It was found out that in the arable soil layer (0-27cm, uninterrupted variant III), there was a tendency to the increase in the content of humus and nitrogen both from the first level (up to 0.38-0.40%) and in relation to the other variants (up to 0.18-0.27%) and the decrease in the ratio C:N – 7-8. The appreciable difference in the content of labile phosphorus was noticed in the layer of 0-27cm (18-20 mg/100g of soil at the beginning of the experiment and 22-28 mg/100g of soil at the end). However, in the subsurface (27-55cm)the content of labile phosphorus decreased. The content of exchange potassium in the layer of 0-27 and 27-55 cm became moderate.

In the study of the process of soil formation the great consideration is given to the degree of base saturation of soil: the higher it is, the better physicochemical characteristics are, as cations Ca^{2+} and Mg^{2+},being good coagulators, improve the soil structure. The data showed that only for aggregates 10mm in the soil layer of 0-27 in uninterrupted variants (VI and VII), the degree of base saturation (Ca^{2+} and Mg^{2}) was 77-80% (above average), in the other samples (the soil layer of 27-55 and 55-77cm) it was higher(>89%). In the soil samples of the other variants (I, II, III, IV, V), the degree of Ca^{2+} and Mg^{2} saturation was lower.

Cameral treatment of the soil samples of morphometric texture in all the three variants showed that the soil in uninterrupted variants (VI and VII) was different from common variants (I, II, III, IV, V) in the well-marked plough-layer, the average thickness of humus profile (45-60cm, the grayish-brown color, the acinose cloddy texture, the mellow composition, porosity, lack of discernible carbonates and vigorous effervescence.

Correlation analysis

Microorganisms are the essential producers of ferments in soil, so it is important to know the interrelation between the number and composition of microorganisms and soil fermentative activity. The results obtained reveal the high correlative dependence between the number of the main groups of microorganisms and soil fermentative activity. The high correlative ratio between invertase activity and bacteria is established in uninterrupted variants (VI and VII). The quantity of the correlative connection between ferment activity and the number of microorganisms while cultivating sowings varies greatly during main and intermediate sowings (from 0.28 to 0.77) but it is statistically authentic.

Conclusion

It was found out that the uninterrupted sowings of fodder crops during intermediate sowings (variants VI and VII) favour the continuous and maximal accumulation of organic matter in the soil (135 centner/ha of dry mass). This favoured the increase in the showings of the biological activity of Irraqri Kastanozems by25-40%, the humus content (from76.4 to79 t/ha), nitrogen(from 5.70 to 5.94 t/ha), the amount of labile phosphorus in the layer of 0-27cm (from 22 to 28 mg/100 g of soil), the degree of base saturation Ca^{2+} and Mg^{2} (from 77 to 80%) and the decrease in the factor of mineralization (from 0.17 to 0.26).

References

Ageev, V.V., Demkin, V.I., 1990. The role of stubble and root remains of cultivated crops rotation in the accumulation of organic nutrition of plants in soil. Agrochemistry. 3, 38-50.

Babayev, M.P., 1984. The irrigated soils of Kura-Araz lowland and their producing capacity. Elservier, Baku.

Kaimakamis, I., Aggelopoulos,S., Pavloudi, A., 2013. Agricultural Production and climate change a case of Greece. Environmental Protection and Ecology. 14, 2, 693-698.

Ramazanova, F.M., Huseynova, S.M., Babayev, M.P., 2008. Biological methods of fertility reproduction of antropogene degraded irrigated soils in Azerbaijan dry subtropics. Soil-Society-Environment, 106.

Ramazanova, F.M., Babayev, M.P., 2013. The Role of the Uninterrupted Sowings of Fodder Crops in the Current Process of Soil Formation. Soil-Water Jornal, 2, 2 (1), 943-950.

Rondon, M.R., Goodman, R.M., Handelsman, J. 1999. The Earth`s bounti: assessing and accessing soil mikrobial diversity. Trend Biotechnol. 17, 403 – 409.

Salaev, M.E., Babaev, M.P., Djafarova, Ch.M, Gasanov, V., 2004. Morphogenetic profiles of Azerbaijan Soils. Baku.

Valkov, V.F., Kazeev, K.SH., Kolesnikov, S.I., 1999. The methodology of the research of soil biological activity by the North Caucasus example. The scientific idea of the Caucasus. 1, 32-37.

Zvyagintsev, D.G., 1999. Soil biological activity and scales for evaluating some of its indices. Soil Science. 6, 48-54.

Zvyagintsev, D.G. 1987. Soil and Microorganisms. Moscow.

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Effect of fertilizer treatments on early performance of two bottomland oak species in an alkaline soil

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Abstract

Many acres of once productive Missouri farmland along the Missouri River are being planted to bottomland hardwoods. However, on a number of these sites, after trees become established, most show symptoms of chlorosis due to high soil pH levels (> 7.5). Six treatments were tested for their effectiveness in ameliorating soil conditions to stimulate nutrient uptake and growth of two-year-old planted pin oak (*Quercus palustris*) and swamp white oak (*Q. bicolor)* including the following: (1) $FeSO_4$ plus water degradable S, (2) Fe chelate, (3) Fe chelate plus NH_4NO_3, (4) NH_4NO_3 alone, (5) NH_4NO_3 plus $FeSO_4$, and (6) control. Some chlorosis was still present despite two years of treatment. After two years, treatments with S had a significantly (P>0.05) lower pH. Neither Fe nor N treatments affected pH. For leaf nutrient and growth analyses, tree species were not analyzed separately. Treatments with S had lower foliar P, K, and Ca concentrations for both years, but these concentrations were not affected by Fe or N. Deer browsing continued to be a major problem to maintaining height growth. Treatments containing S had smaller basal diameters and lower tree heights than treatments without S. Height loss might have been associated with deer browsing and was greater in tree with S treatments. Sulfur containing fertilizers were effective in lowering soil pH, but the depression of pH by sulfur containing fertilizers might not necessarily coincide with favorable seedling response. Nutrients other than iron are likely involved in the seedling chlorosis. Prescriptions for nutrient management on bottomland sites such as these will need to be developed so that tree plantings can develop into healthy mast producing forests.

Key words: Chlorosis, Fe chelate, bottomland oak species, alkaline soil.

Introduction

Bottomland forests are an important part of a riparian ecosystem, which is among the most diverse type of system (Nilsson et al., 1997). Riparian ecosystems are under severe threat worldwide and considered to be key areas for the potential loss of global biodiversity (Sala et al., 2000). Historically, oaks were significant components of native floodplain forests in the Missouri and Mississippi watersheds. Cottonwood, silver maple, willow, and other flood-tolerant species dominated the low elevation, flood prone areas, while oaks, hickories, and walnuts persisted on better drained soils in the bottoms (Dey et al., 2000). These woody species growing in the floodplain increase stream bank stability, protect levees, and reduce the negative impacts of flooding by scouring, deposition, and infrastructure damage (Dwyer et al., 1997).

There is growing interest among forest and wildlife managers in the reforestation of bottomlands in the lower Missouri River and Mississippi Alluvial valleys (Dey et al., 2003). The emphasis is on reforestation of these

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lands with mast producing hardwood trees, namely oak species (*Quercus*), hickories (*Carya*), and black walnut (*Juglans nigra* L). As much as 70-90 percent of the floodplain forests in the continental United States have been lost to agriculture, river channelization improvements, and levee systems for flood protection. These alterations in river hydrology have resulted in a higher frequency of intense flooding. This fact was brought to the forefront when the Great Flood of 1993 degraded over 325,000 hectares of cropland along the lower Missouri River floodplain through scouring and the deposition of sand onto crop fields (Kabrick et al., 2005). Both professional natural resource managers and landowners now desire that these degraded or abandoned croplands be reforested by hard mast producing tree species.

A major problem on tree growth at the site is continuous browsing by white-tail deer during the growing season and damage to the stems of the trees in the dormant season from buck rubs and eastern cottontail rabbits (*Sylvilagus floridanus*) that either girdle or chew off the stems. Perhaps the biggest challenge on this site is the high soil pH, which is in the vicinity of 8.3. This high pH has caused many of the trees, especially the pinoak, to become seriously chlorotic due to the unavailability of essential micronutrients. Also, many of the young trees are stunted.

The main objective of this study was to investigate the effects of fertilization on soil pH changes and uptake of essential nutrients by the tree seedlings by evaluating the changes in total soil nutrients and foliar nutrient concentration over a growing season. It is our hope that this project will further the understanding of fertilization on bottomland oak and help natural resource managers and their efforts to develop healthy mast producing forests in bottomlands having similar soil conditions.

Materials and Methods

The study site is located on lands owned and managed by the Missouri Department of Conservation. Plowboy Bend Conservation Area is 1083.8 hectares located at latitude 38 48’ 5”N; longitude 92 24’17” W in Moniteau County, Missouri, USA. The area is a mixture of abandoned crop fields and forest remnants consisting of light seeded hardwoods such as cottonwood (*Platanus occidentalis*), silver maple (*Acer saccharinum*), and box elder (*Acer negundo*). The soils at Plowboy Bend Conservation Area are classified as Sarpy fine sand (mixed, mesic, Typic, Udipsamments). Sarpy soils are periodically saturated, ponded, or flooded during the growing season.

In 2001, a plot containing a mixture of 336 swamp white (*Quercus bicolor*) and pinoak (*Q. palustris*) seedlings was planted in eight rows, with forty-two trees in each row. The seedlings were planted in a randomized block design, with 12 swamp white and 12 pinoak seedlings per block, at a spacing of 12 m x 12 m. Half of the rows were bedded to potentially improve soil properties and drainage. Both bare root and Root Production Method™ (RPM®) seedlings (Lovelace, 1998) were planted on bedded and non-bedded soils. Five fertilizer treatments were applied to the trees on the site. Combinations of Fe, S, and N were applied in the following treatments: $FeSO_4$ + S, Chelated Fe, Chelated Fe + N, N alone, and N + $FeSO_4$. Except for the treatment of N alone, other treatments were applied according to the rates recommended by the manufacturer. Ferrous sulfate was applied at 2240 kg ha^{-1} or 336 g/tree, ammonium nitrate at 112 kg ha^{-1} actual N or 49.4 g/tree, Fe chelate (Sprint® 330) at a rate of 454 g/ 93 m^2 or 8 g/tree, and water degradable sulfur at 2240 kg ha^{-1} or 336 g/tree. These treatments were applied randomly to 20 swamp white and pinoak seedlings in the 1.3 m^2 weed mat area surrounding the base of the trees. These treatments have been applied annually since March of 2004.

Soil and plant samples were taken in June, July, August, and October 2007. During the planning of the four sampling periods, it was decided to forego sampling in the month of September to obtain data closest to the end of the growing season and leaf senescence in October. Samples were taken from the two species of trees (swamp white and pinoak), with five repetitions per treatment and six treatments (2 species x 6 treatments x 5 replicates = 60). Foliar samples of 15-20 leaves per tree were consistently taken from upper, most recently mature leaves of five trees from each species and treatment (Mills and Jones, 1996). The foliar samples from all 60 trees were placed in a labeled paper bags in cooler and transported to dry in the laboratory. A total of 120 soil samples (60 x 2 depths) were taken per sampling period at two depths, 0-10 and 10-20 cm, in each of the cardinal directions at the edge of the weed mat area. For each individual tree, the four soil samples per depth were combined into a composite sample bag to negate potentially high or low readings due to fertilizer granules moving off to one side of the weed mat area during a heavy rain event.

Basic soil analysis is shown in Table 1. Soil samples were air dried and then ground, sieved through a 2- mm sieve. Leaf samples were oven-dried at 65°C for 72 hours and ground into a fine powder. Soil samples were tested for pH using a 2:1 water to soil ratio by mixing 10 g of sieved soil into 20 ml of deionized water and testing the mixture with an Accument^{TM} AB15 pH meter. Foliar N content for the pinand swamp white oak leaves was measured using the Kjeldahl digestion method as described in Mills and Jones. Total concentration of macro and micronutrients contained in leaf and soil samples was measured using an Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) (Varian Inc., Walnut Creek, CA 94598, USA) following the method described by Ikem et al. (2007).

Table 1. Chemical properties for soil samples taken from Plowboy Bend Conservation Area experimental plots near Jamestown, MO.

Soil Location	pH	Organic Matter,%	Bray 1 P	Ca	Mg	K	CEC**
			kg/ha				cmol$_c$/kg
Plowboy Bend, CA*	8.29	0.6	13.41	514.9	51.1	36.37	8.4

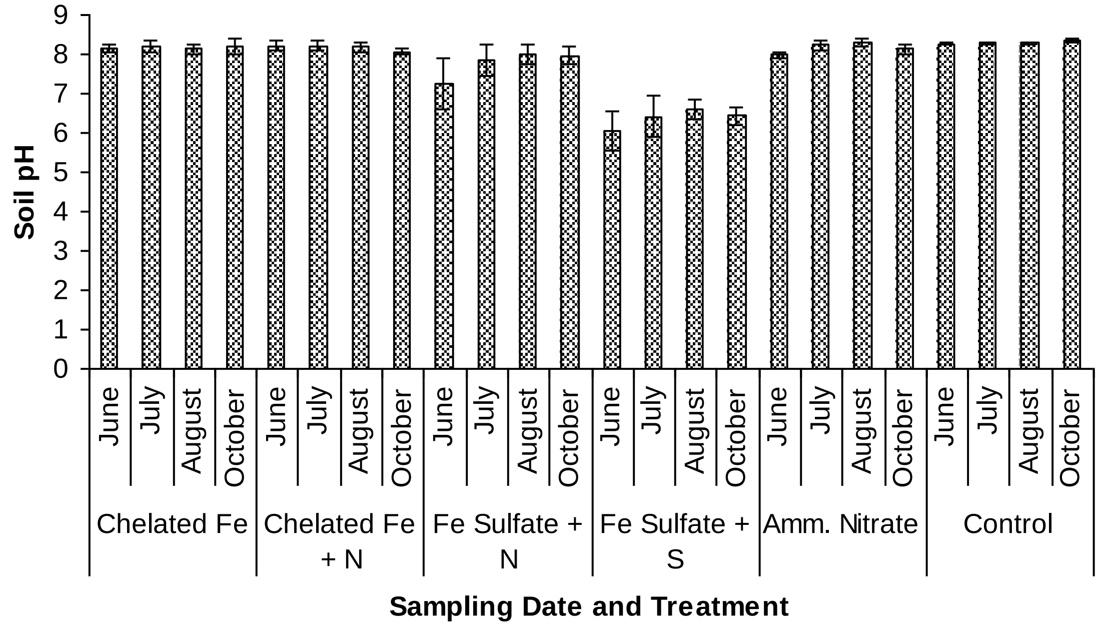
* Plowboy Bend Conservation Area experimental plots near Jamestown, MO.

**CEC = Cation Exchange Capacity;

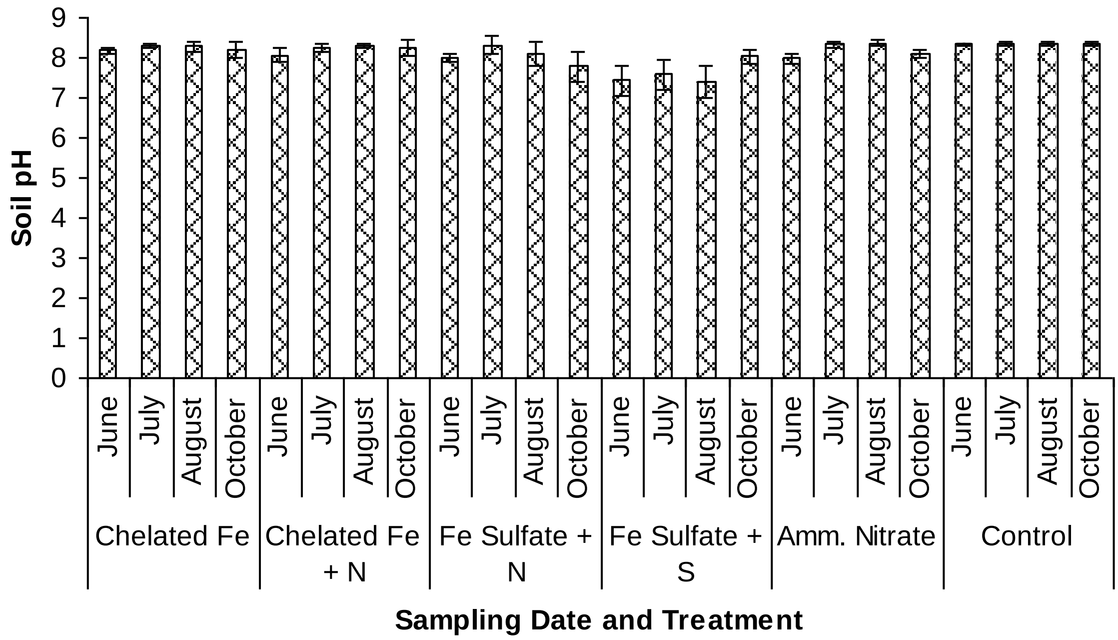
Statistical analysis was conducted using an analysis of variance (ANOVA). Foliar data was analyzed for the effects of treatment, sampling date, oak species and interactions between treatments and other study parameters. Soil data was also analyzed for the effects of treatment, sampling date, soil depth on treatment and interactions between them. The statistical software package SAS (2008) was used to complete all statistical analyses. The GLM procedure with alpha = 0.05 was used in SAS assuming a split-split plot treatment design. Least significant differences were used to separate means at the 5% probability level. The DUNCAN statement was used for the separation of means on main effects in the ANOVA.

Results and Discussion

Many of the soils on floodplain bottomlands have a high pH, high nutrient leaching, intense vegetation competition, and poor drainage all of which reduce tree performance (Stanturf et al., 2004). When these sites are planted to hardwoods, including oaks, they might exhibit leaf symptoms of Fe deficiency usually induced by poor drainage or by soils with a high Ca content and pH levels above 7.5 (Courchesne et al., 2005). These bottomland soils contain adequate amounts of mineral Fe, but as soil pH rises above 7.0, Fe changes to an insoluble form that many plants will not be able to uptake. When not corrected, Fe deficiency can cause poor root development, severe stunting, and plant death. Mineral deficiencies other than Fe such as N, P, Mg, Mn, Cu, Zn, or B may also result in chlorosis symptoms. Symptoms of Mg deficiency, in particular, may be similar to those of Fe deficiency. In this experiment, there was a significant ($p = 0.0008$) soil depth x treatment x date interaction for soil pH. Treatments containing elemental S and Fe sulfate as acidifying agents caused a drop in soil pH levels throughout the 2007 growing season (Figure 1). The $FeSO_4$ + S treatment reduced the pH by the greatest margin in the surface layer (0-10 cm) of the soil. Soil pH readings were 6.05, 6.42, 6.6, and 6.43 respectively for the sampling dates in the months of June, July, August, and October as compared to an average control treatment pH of 8.29. The addition of S treatments to the soil was intended to lower the soil pH, rather than to supply S in order to correct a deficiency. Some of the differences in pH at the sampling dates can be explained by the amount of precipitation received during the summer of 2007. Treatments containing S, $FeSO_4$ + S and $FeSO_4$ + N, caused a significant drop in pH during June, which received just slightly above average rainfall. The oxidation of elemental S (S^o) to sulfate (SO_4^{-2}), which in turn lowers soil pH, depends on soil microbial activity, the S source, and soil environmental conditions; these soil conditions include soil moisture, or in this case, rainfall (Havlin et al., 2005). As a result of decreased pH from treatments containing S, the concentrations of nine elements (P, S, Mg, Fe, Mn, Mo, Cu, Zn, and Na) increased. However, with these increases, foliar nutrient levels were still below the sufficiency levels for N, P, K, S, Ca, Mn, and Cu (Tables 2 and 3).



A.



B.

Figure 1. Soil pH (± SE) for soil depth 1 (A) and depth 2 (B) x treatment x sampling date during the 2007 growing season taken from Plowboy Bend Conservation Area experimental plots near Jamestown, MO.

Table 2 shows the treatment effects on foliar concentration of macronutrients. In this study, there were three treatments (chelated Fe + ammonium nitrate, Fe sulfate + ammonium nitrate, and ammonium nitrate alone) which contained N fertilizer. Among species, there was a significant difference in foliar N between the control and other treatments except for chelated Fe + N for pinoak and between control and all other treatments for swamp white oak (Table 6). Sampling date * treatment interaction was significant. The mean foliar nitrogen concentrations for pinoak were 1.93, 1.86, 1.79, and 1.93 percent respectively, measured at mid-month in June, July, August, and October. Swamp white oak foliar nitrogen concentrations were 1.93, 1.84, 1.79, and 1.61 percent, respectively, for the aforementioned months, following the same pattern as pinoak until the October sampling period, where the foliar N concentration in swamp white oak was significantly less than for pinoak. One explanation for the relatively low foliar N content in both species is likely associated with the fine sandy texture of Sarpy soils. The sandy nature of this soil allows nitrate from the fertilizers to leach out of the rooting zone. Furthermore, the hydric nature of these soils has the potential to create an anaerobic environment in which N would be lost as a result of denitrification and volatilization. In addition, the ammonium fertilizer in this study was broadcast applied onto a weed mat and at the surface of a high pH (8.29), calcareous soil. The fertilizer treatments were therefore exposed to elements responsible for causing atmospheric losses at the soil's surface and were totally dependent on precipitation to dissolve and incorporate them into the soil. Inherent differences among a species play an important role in the absorption and utilization of mineral nutrients from the soil (Goddard, 1984; and Hinsinger, et al., 2003) which can result in differences in foliar nutrient concentrations and in the allocation of minerals within a tree (Scherzer et al., 2003). Perhaps swamp white oak begins the translocation of foliar nutrients earlier than pinoak.

Table 2. Mean separations for treatment effects on foliar macronutrients in pinoak and swamp white oak

Treatment	N	P	K	S	Mg	Ca
	……………………………………..%..					
PinOak						
Chelated Fe	1.85ab	.13614a	.66795a	.107913c	.128737d	.306093ab
Chelated Fe + N	1.79abc	.126316abc	.62361ab	.110338c	.156824c	.308387ab
Fe Sulfate + N	1.88ab	.122621bc	.59443bc	.122677ab	.175551b	.321552a
Fe Sulfate + S	1.88a	.136917a	.52754d	.129653a	.199178a	.314613ab
Amm. Nitrate	1.83ab	.119402c	.54867cd	.117808b	.166269bc	.318209a
Control	1.72c	.132226ab	.50021d	.104726c	.140186d	.300681b
Swamp White Oak						
Chelated Fe	1.87a	.174442a	.67587a	.1161a	.15155d	.314214a
Chelated Fe + N	1.84ab	.147384bc	.59932b	.116512a	.18584c	.316141a
Fe Sulfate + N	1.85ab	.15619b	.60112b	.116537a	.19473bc	.322909a
Fe Sulfate + S	1.78b	.140775c	.53837c	.121114a	.2241ab	.326139a
Amm. Nitrate	1.80ab	.135106c	.5582bc	.118633a	.21825b	.313296a
Control	1.58c	.15434b	.59238b	.105454b	.23217a	.312779a
S x T*	0.0734	0.1934	0.2411	0.0126	0.7836	0.2473

*p-values at species x treatment interaction

Different letters denote significant ($p<0.05$) differences between treatments

Mean separations are the results of separate ANOVA by individual species

The results indicated that foliar K concentration was very low in both species of trees but foliar Na levels were high (Table 2). This data, coupled with the fact that soil K and Na levels were inversely related confirms the literature's indication that Na is likely being ued as a substitute for K in the trees for processes such as maintaining turgor pressure. Even with the addition of S to acidify the soil, did not produce the optimal pH preferred by these tree species (Gilman, 1997). Although precipitation was not part of the data collected in this study, the effects of monthly area rainfall totals were considered in the study results.

In general, total soil nutrient concentration was higher in the first 10 cm (depth 1) than in the second depth (10-20 cm) because the fertilizer treatments containing Fe, S, and N were broadcast applied. Also, the somewhat higher organic matter in the top 10 cm of soil at Plowboy Bend Conservation Area helps to retain and release soil nutrients. According to Kabrick et al. (2005), alluvial soils, such as the soil at Plowboy Bend, often do not change appreciably in organic carbon and base cation concentration with depth. Furthermore, because the Sarpy fine sand at Plowboy Bend Conservation Area is a sandy alluvium and the water table is generally more than 1.5 m below the soil surface, this soil drained excessively. The combination of the above soil conditions contributes to the fact that soil bedding had no significant effect on the soil and foliar nutrient concentrations.

Table 3. Mean separations for treatment effects on selected foliar micronutrients/heavy metals in pinoak and swamp white oak

Treatments	Fe	Mn	Mo	Cu	Zn	Na	Al
	……………………… ppm……………………………..						
PinOak							
Chelated Fe	63.65b	22.12d	.53b	6.12ab	51.31b	61.17c	60.49ab
Chelated Fe + N	55.93b	36.73cd	.76ab	4.99c	54.94b	111.93ab	54.81b
Fe Sulfate + N	88.61a	77.25b	.95a	6.76a	59.99b	101.28ab	69.26a
Fe Sulfate + S	63.15b	144.22a	.80ab	6.73a	74.6a	123.93a	64.32ab
Amm. Nitrate	66.74b	50.27c	.83ab	5.74bc	52.22b	89.73abc	62.35ab
Control	95.67a	53.68bc	.79ab	4.96c	52.8b	86.59bc	67.41a
Swamp White Oak							
Chelated Fe	101.05a	15.82d	0.93a	7.08b	33.59ab	89.39b	75.092b
Chelated Fe + N	66.98c	28.32c	0.98a	5.72c	29b	163.22a	66.331bc
Fe Sulfate + N	90.76ab	41.08b	1.02a	7.01b	31.41ab	59.05c	90.403a
Fe Sulfate+ S	72.88bc	54.16a	1.21a	6.41bc	36.93a	132.59a	63.695c
Amm. Nitrate	78.3bc	41.85b	0.92a	6.15c	35.45ab	157.55a	62.25c
Control	76.08bc	39.89b	1.12a	8.03a	29.39ab	136.35a	71.794bc
S x T*	0.2768	0.0126	0.456	0.1663	0.3932	0.7101	0.5221

*p-values at species x treatment interaction

Different letters denote significant ($p<0.05$) differences between treatments

Mean separations are the results of separate ANOVA by individual species

In main treatment effects, foliar P in pinoak leaves was significantly higher with the $FeSO_4$ + S and chelated Fe treatments than for all other treatments. Swamp white oak foliar P were highest for the chelated Fe treatment and lowest for the $FeSO_4$ + S and ammonium N treatments (Table 2). The mean foliar P values for both pinoak and swamp white oak are low or below the sufficiency ranges given for these species.

Among species, foliar S was lowest in the control and significantly different than all other treatments in swamp white oak. Furthermore, both species had the highest foliar sulfur concentration when treated with $FeSO_4$ + S (Table 2). Foliar S concentration was significant ($p = 0.0442$) for species x treatment x sampling date. In general, swamp white oak was slightly higher in foliar S than pinoak in June, July, and August of the 2007 growing season. Pinoak was significantly higher in foliar S concentration than swamp white oak in October when treated with $FeSO_4$ + S and in June when treated with $FeSO_4$ + N. For swamp white oak the foliar Mg main treatment effects were significantly different between chelated Fe and all other treatments. The results of FeSO4 + S treatment was significantly different from results of all other treatments for pinoak. In general, both species had the lowest foliar Mg levels when treated with chelated Fe and the highest foliar Mg concentrations when treated with FeSO4 + S (Table 2). Foliar Fe concentration was lowest for the chelated Fe + N treatment for both species. Foliar Fe concentration was highest for pinoak in the control treatment and highest for swamp white oak in the chelated Fe treatment (Table 3). Foliar Fe concentration had a significant ($p = 0.0003$) interaction for species x treatment x sampling date during the 2007 growing season (Figure 21). Foliar Fe content was generally higher in swamp white oak than pinoak for all months except October (treatment: Fe sulfate + N), where iron was added to the soil but the pH was not greatly reduced. This difference between the species might reflect the ability of swamp white oak to acidify its rhizosphere or release siderophores into the soil to enhance Fe uptake. The foliar Fe concentration for the Fe sulfate + elemental S treatment follows the same pattern for both species. The results for Pinoak, a pH-sensitive species with a tendency toward Fe chlorosis mirrored those of Swamp white oak, which had significantly higher foliar Fe in most treatments. This indicates the ability of iron sulfate + elemental S to lower soil pH and improve the availability of Fe for uptake to the trees of both species. Swamp white oak had the higher foliar Fe content except for a couple of spikes in June and August for the pinoak control. Foliar Mn was highest for the $FeSO_4$ + S treatment and lowest in the chelated Fe treatment for both species (Table 3). Manganese was significant (p = 0.0051) for sampling date x treatment and for species x treatment interaction (p = 0.0028). Foliar Mn increased significantly for all treatments throughout the growing season.The treatments containing sulfate and elemental S had the highest foliar Mn concentrations, with Mn values in October significantly higher than Mn values in June. Treatments containing chelated Fe were noticeably lower in foliar Mn concentration throughout the growing season. The main treatment effect of foliar Mo concentration for Pinoak was highest for $FeSO_4$ + N and lowest in the chelated Fe treatment. Treatments were not significantly different for the main effects in swamp white oak foliage (Table 3). Mean foliar Mo concentration was significant (p = 0.0003) for treatment x species x sampling date interaction (Table 3). Swamp white oak had significantly higher foliar Mo than pinoak in the months of June, July, and August when treated with chelated Fe + N; in July when treated with Fe sulfate + N; and in July and October when treated with Fe sulfate + elemental S.

Height and diameter at breast height (dbh) was recorded for trees at Plowboy Bend Conservation Area. In 2007, the mean height of swamp white oak was 2.47, 3.41, 2.3, 2.05, 2.28, and 2.74 m, respectively, for the treatments of chelated Fe, chelated Fe + N, $FeSO_4$ + N, $FeSO_4$ + S, ammonium nitrate, and the control. The mean dbh of swamp white oak was 2.65, 4.74, 2.49, 4.39, 2.01, and 3.18 cm, respectively, for the same treatments above. Pinoak mean heights were 2.23, 2.13, 1.55, 1.7, 1.26, and 1.75 m respectively for the treatments of chelated Fe, chelated Fe + N, $FeSO_4$ + N, $FeSO_4$ + S, ammonium nitrate, and control. The mean dbh of pinoak was 2.13, 2.45, 1.08, 1.73, 0.55, and 1.68 respectively for the treatments above. The mean height and diameter growth by treatment over a two- year period from 2005 through 2007showed that regardless of treatment, swamp white oak out performed pinoak on this bottomland site. This further confirms the notion that Swamps white oak is superior to pinoak at coping with the high soil pH at Plowboy Bend.

Conclusion

The availability of nutrients in general was improved, resulting in increased uptake by pinoak and swamp white oak. The lowering of soil pH to more favorable levels with the application of fertilizers containing sulfate and elemental S was responsible for much of these increases. However, many of the essential nutrients remain below sufficiency levels in the foliage. Adding chelated Fe did not alleviate Fe chlorosis, but foliar Fe levels improved when the pH was lowered. The sandy soil at Plowboy Bend did not benefit significantly from soil bedding. Overall, the growth of the trees at Plowboy Bend Conservation Area in response to fertilizers could not be accurately measured because of herbivory by rabbits and white-tailed deer. It appeared that because of herbivory damage, trees in treatments that had higher P, S, Mg, Fe, Mn, Mo, Cu, Zn, and Na levels tended to have less growth than trees with less of these nutrients. In the red oak group, Nuttall oak (*Quercus texana*) and Shumard's oak (*Quercus shumardii*) are two species that are tolerant of wide ranges of pH levels in soil and produce acorns small enough to be utilized by waterfowl. Therfore, they are recommended for reforestation of bottomlands with similar characteristics to the experimental study area. Swamp white oak can tolerate a higher pH than Pinoak but is naturally an acid soil species.

References

Courchesne, F., Cote', B., Fyles, J.W., Hendershot, W.H., Biron, P.M., Roy, A. G., Turmel, M. C. 2005. Recent changes in soil chemistry in a forested ecosystem of Southern Quebec, Canada. Soil Sci. Soc. Am. J. 69:1298-1313

Dey, D.C., Burhans. D., Kabrick, J., Root, B., Grabner, J., Gold, M. 2000. The Missouri River Floodplain: History of Oak Forests and Current Restoration Efforts. The Glade Vol. 3 No. 2. p. 2-3

Dey, D., Kabrick, J., Gold, M. 2003. Tree establishment in floodplain agroforestry practices. In: Proceedings, 8th North American agroforestry conference; June 23-25; Corvalllis, OR p. 102-115.

Dwyer, J. P., Wallace, D., Larson, D.R. 1997. Value of Woody River Corridors in Levee Protection Along the Missouri River in 1993. J. Am. Water Res. Assoc. p. 481-489.

Gilman, E. F. 1997. Trees for Urban and Suburban Landscapes. Delmar Publishing, 3 Columbia Circle, Box 15015. Albany, New York 12212-5015. 662 pp.

Goddard, R.E., Hollis, C.A. 1984. The genetic basis of forest tree nutrition. In: Bowen G.D., Nambiar, E.K.S. eds. Nutrition of Plantation Forests, Academic Press, London, UK. p. 237-258.

Havlin, J.L., Tisdale, S.L., Beaton, J.D., Nelson, W. L. 2005. Soil Fertility and Fertilizers: An Introduction to Nutrient Management. Pearson Education, Inc., Upper Saddle River, New Jersey 07458. pp. 244-254.

Hinsinger, P., Plassard, C., Tang C., Jaillard, B. 2003. Origins of root-medicated pH changes in the rhizosphere and their responses to environmental constraints: a review. Plant Soil. 248:43-59.

Ikem, A., Campbell, M., Nyirakabibi, I., Garth, J. 2007. Baseline concentrations of trace elements in residential soils from Southeastern Missouri. Environ. Monitoring and Assess. 140:69-81.

Kabrick, John M., Dey, D.C., Van Sambeek, J. W., Wallendorf, M., Gold, M.A., 2005. Soil properties and growth of swamp white and pinoak on bedded soils in the lower Missouri River floodplain. For. Ecol. Manage. 204: 315–327.

Lovelace, W. 1998. The root production method (RPM) system for producing container trees. Combined Proc. Int. Plant Propagators Soc. 48:556-557. -Wayne Lovelace is President and CEO of Forrest Keeling Nursery in Elsberry, MO and the developer of the Root Production Method®

Mills, H.A., Jones Jr., J. B. 1996. Plant Analysis Handbook II: a practical sampling, preparation, analysis, and interpretation guide. MicroMacro Publishing, Inc. 183 Paradise Blvd., Suite 104, Athens, Georgia 30607 422 pp.

Nilsson, C., Jansson, R., Zinko. U. 1997. Long term responses of river margin vegetation to water-level regulation. Science 276:798-800.

Sala, O.E., ChapinIII, F.S., Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber Sanwald, E., Huenneke, L.F., Jakson, R.B., Kinzig, A., Leemans, R., LodgeD.M., Mooney, H.A., Osterheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M., Wall, D.H. 2000. Global biodiversity scenarios for the year 2100. *Science* 287:1770-1774.

SAS Institute. 2008. SAS/STAT User's Guide: Statistics. Version 9.3. SAS Institute, Cary, NC.

Scherzer, A. J., Long, R. P., Rebbeck, J. 2003. Foliar Nutrient Concentrations of Oak, Hickory, and Red Maple. Ch. 10 in Characteristics of Mixed-Oak Forest Ecosystems in Southern Ohio Prior to the Reintroduction of Fire. USDA Forest Service, Northeastern Research Station, Deleware, OH, pp 113-121.

Stanturf, J.A., Conner, W.H., Gardiner, C.J. Schweitzer, Ezell, A.W. 2004. Recognizing and Overcoming Difficult Site Conditions for Afforestation of Bottomland Hardwoods. Ecol. Restor. 22:183-193.

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Information support of land and water productivity management models on the basis of SOTER in Uzbekistan

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Abstract

The SOTER was selected as a systematic and higher-order mapping and database development method that covers terrain and soil data serving as input for basin models. A methodology was elaborated to work with soil map on a million scale. However this methodology could be applied for larger scales used when developing national terrain and soil databases depending on task given. The SOTER database was developed for terrain of the Chirchik-Akhangaran rivers basin on an area of 14900 km2 in Uzbekistan. It serves to provide data for a set of models applied for water management in the basin. The vast area of the Chirchik-Akhangaran basin and wide range of locality elevations (220-3500 m above sea-level) explain latitudinal and altitudinal soil-climatic zonality. Under general background of vertical soil zonality, which foms the main genetic differences, the soil quality and agro-production characteristics undergo considerable changes under influence of many natural and economic factors. This made for diversity of soil-formation processes and soils in genetic and agro-production terms. The following soil varieties are identified in the basin: 1. Light-brown high-mountain grassland-steppe soils in combination with grassland, marsh-grassland and marsh soils; 2. Mountain brown soil; 3. Sierozem. Besides, intergrade zone soil is identified: meadow-sierozem, and sierozem-meadow. The SOTER database was formed on a 1:200 000 scale soil cover map of Tashkent province comprising the Chirchik-Akhangaran basin. SOTER database has the following hierarchical structure: 1. Terrain; 2. Terrain components; 3. Component data; 4. Soil components; 5. Soil profile; 6. Soil horizons; 7. Vegetation. The soil map of the basin includes 42 soil varieties transformed into SOTER unit. Based on formation principles of the SOTER database, we deem it possible to take a soil contour of soil classification for the Chirchik-Akhangaran basin as a SOTER unit. To this end, information on specific soil profiles was gathered and included morphologic description of soil profile, per genetic horizon, chemical composition of soil, and physical properties per genetic horizon. The information base can be integrated in GIS environment. The developed database contributes to such models as CROPWAT, HBV, EPIC, RZWQM, and ISAREG.

Keywords: SOTER, soil, Chirchik-Akhangaran basin, model, water, productivity, management

Introduction

According to nature-climatic classification, the Central Asian area refers to the subtropical zone of deserts and semi-deserts. The evaporation deficit is 300 to 1000 mm. Water abundant areas and quite dry areas are marked, the former corresponding to the flow formation zone, while the latter falling under the flow

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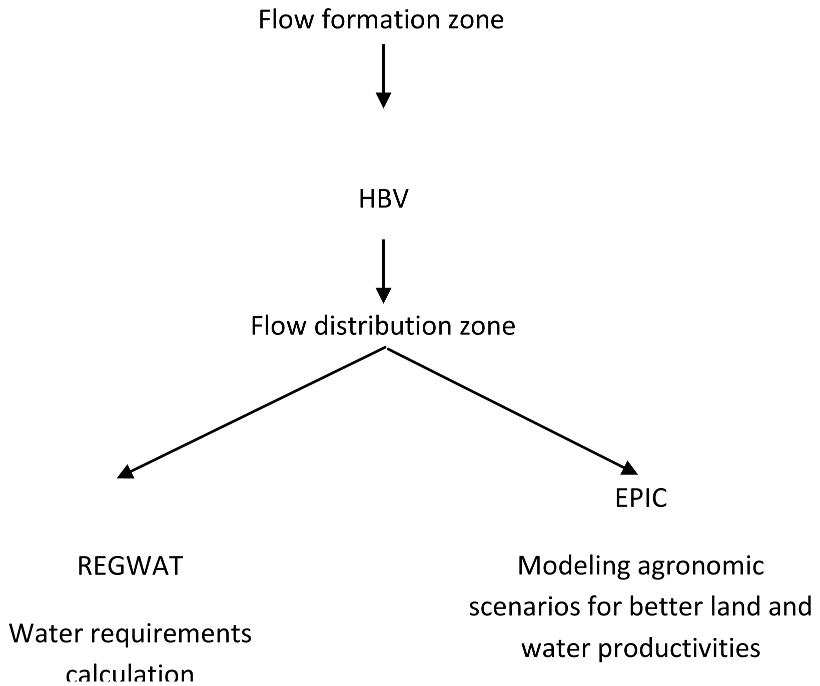
distribution zone. Water supply to downstream land fully depends on management of water distribution along the river. The Chirchik-Akhangaran basin is a representative object to study:

- flow formation zone with minimum anthropogenic impact,
- flow distribution and use (dissipation) zone, where human factor is important.

An ultimate aim is to improve productivity of land and water resources so that to ensure their effective use for sustainable meeting of nature and human society demands. The Chirchik-Akhangaran-Keles basin can be conditionally divided into two zones:

- Zone of water formation, which is described by the HBV model.
- Zone of water distribution, which is described by the REGWAT and EPIC models.

The set of models for the Chirchik-Akhangaran basin



Land in the Chirchik-Akhangaran basin has quite high bonitet, and about 40% of land refers to the land of better and good quality. However intensive use of land and growing of double crops requires that huge quantity of mineral and organic fertilizers be applied. At present, soil fertility is decreasing constantly, thus indicating to soil degradation.

Irrigation efficiency is being decreased due to unsatisfactory state of irrigation system and poor water management on fields. Under conditions of complex transition to the market economy, water saving ways must be cost-effective since construction and rehabilitation of irrigation and drainage systems will require great investments. Currently, water saving ways are oriented towards the use of farmers' experience and professionals' knowledge. International experience will be useful in this context.

The main objective of this study is to simulate crop productivity and the impact of specific cropping systems on the nitrogen dynamics under varying climate and soil conditions and different fertilization and level, to simulate crop productivity under different water levels. This would allow developing the most favorable agronomic scenarios that minimize stresses, including available water for plant development, and the soil fertility conservation scenarios.

The set of models is designed to ensure formation of "bottom-up" water demand from users and formation of sustainable top-down water supply mechanism.

A multifactor model controlling agronomic technologies is needed for this task. The model should form water requirements, based on initial properties of soil, climate, crop, and characteristics of agronomic practices.

The well-known CROPWAT model is widely applied in practice to simulate crop water requirements; however, it takes into account stresses and yield losses due to under-irrigation only. The ISAREG and HYDROS serve similar purposes. Since the CROPWAT model does not account for groundwater contribution to the water balance, it was improved and the resulting REGWAT model was developed (RIVERTVIN SIC ICWC, 2008).

The EPIC model meets the requirements of the problem set. EPIC is generally applicable, computationally efficient, and capable of computing the effects of management changes on outputs. EPIC is composed of physically based components for simulating erosion, growth, and related processes and economic components for assessing the cost of erosion, determining optimal management strategies, etc. The EPIC physical components include hydrology, weather simulation, erosion-sedimentation, nutrient cycling, plant growth, tillage.

Objectives

Geographical location

The Chirchik-Akhangaran region is located in the North-East of the Republic of Uzbekistan between the Syrdarya river and the Western Tien-Shan. In the North-West Uzbekistan borders Kazakhstan along the Keles Valley and the Kaarzhantou and Ugam ridges and in the East, Kyrgyzstan, along Talass, Pskem, and Chatkal ridges. Kuramin ridge separates Chirchik-Akhangaran Valley from Fergana Valley.

The relief of the region is quite complex. The south-western part is flat, while the north-eastern and eastern parts are mountainous. The relief gradually descends from North-East to South-West towards the Syrdarya basin. Mountain ridges of the Chirchik-Akhangaran region, referring to western ridges of Tien-Shan system, fan towards South-West. Those are divided by river valleys, wide sais and pockets.

Sources of rivers originate in Western Tien-Shan Mountains, altitude of which reaches within the basin up to 4500 meters above the sea level. Chirchik River is fed from snowmelt, precipitation and glaciers with normal annual runoff 7.2 km^3. Two main tributaries of Chirchik River are Chatkal River with the length of 223 km, catchment's area of 6870 km^2 and average watershed elevation of 2600 meters and Pskem River with the length of 70km, catchment's area of 2840 km^2 and average watershed elevation of 2740 m. Other tributaries are sufficiently small and perennial. Akhangaran and Keles rivers (Figure 1) are fed by snow melting and precipitation with normal annual runoff of 0.7 and 0.2 km^3, accordingly.

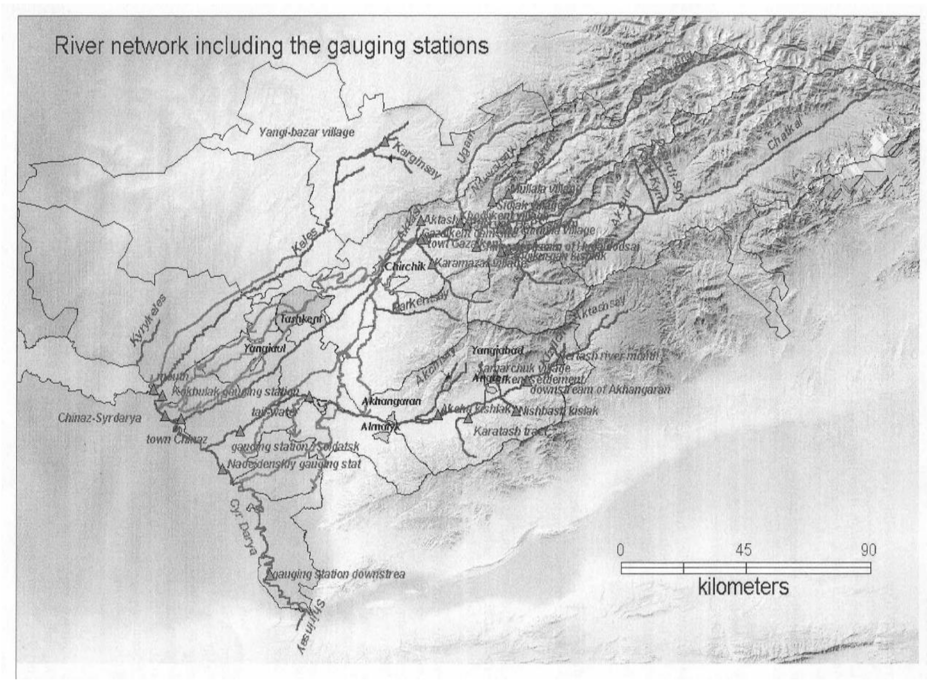


Figure 1. Location map of the study area

Climate

The region is located near the northern boundary of subtropical and moderate zones. The whole area is subjected to western transfer of air masses, including inherent processes of cyclogenesis and anticyclogenesis.

Atlantic and arctic air masses come from the north, north-west and west. Intensive rise in temperatures in winter is caused by intrusion of tropical air masses in warm sectors of cyclone, with following change by abrupt fall of temperature.

The mean air temperature is +27°C in flat area in July. The maximum summer temperature is +44°C. Winter is not so severe. The mean temperature in January is -1°C in the plain and from -6°C to -8°C in mountains. Winter is characterized by thaws. However, with intruded cold air masses, the temperature may fall to -30°C.

Two third of annual precipitation fall in winter and spring. March is precipitation-abundant month: more than 20% of annual amount. July, August, and September are the driest months. In general, precipitation is much less than evaporativitiy in the Chirchik-Akhangaran region. The mean annual precipitation is 400 mm in most part of the region, while 1000 mm of water may evaporate under given temperature conditions, i.e. precipitation-evaporation ratio is 0,4.

In the mountains, evaporation decreases as elevation increases. In elevation zone 1200-2000 m, the annual evaporation is 180 mm. Under plateau conditions at the same elevation, the evaporation is 240 mm/year.

Soils

According to standard soil-climatic zoning of Uzbekistan, its northern, north-western and western flat areas refer to the system of latitudinal zones of Eurasia and denoted as “desert (arid) zone”. Another mountainous and foothills area refers to soil belts of altitudinal zonality such as Tien-Shan and Pamiro-Alay within Turan province.

The large area of Chirchik-Akhangaran basin and wide range of locality elevations (220-3500 m above sea-level) have determined latitudinal and altitudinal soil-climatic zonality.

Under general background of vertical soil zonality, which determines the main genetic differences, the soil quality and agri-production characteristics undergo considerable changes under influence of many natural and economic factors, such as relief, parent rock nature, soil moistening conditions, soil texture, salinization and erosion processes, human activities, etc.

This made for diversity of soil-formation processes and soils in genetic and agro-production terms.

The following soil varieties are identified in the basin:

1. Brownish meadow-steppe soils;
2. Mountain brown soil;
3. Sierozem:
    a) dark,
    b) generic;

Besides, transitorial soil is identified: meadow-sierozem, sierozem-meadow.

Dark meadow, light meadow, meadow-bog and bog soils refer to hydromorphic category.

Material and Methods

Methods

SOTER system

In 1986, the International Society of Soil Science (ISSS) discussed the “Structure of a Digital International Soil Resources Map annex Data Base” called as SOTER, a World SOils and TERrain Digital Data Base (SOTER Report 1, 1986).

An international committee proposed criteria for a “universal” map legend for compilation of soil-terrain maps. The aim of the SOTER is to utilize current and emerging information technology to establish a World Soils and Terrain Database, summarize available knowledge in a single system using a common methodology. The main function of the database is to provide the necessary data for improved mapping and monitoring of changes of world soil and terrain resources.

Underlying the SOTER methodolohy is the identification of areas of land with a distinctive, ofter repetitive, pattern of landform, lithology, surface form, slope, parent material, and soil. Tracts of land distinguished in this manner are named SOTER units. Each SOTER unit thus represents one unique combination of terrain and soil characteristics. SOTER adheres to rigorous data entry formats necessary for the construction of an universal terrain and soil database.

The SOTER database has the following hierarchical structure:

1. Terrain.
2. Terrain component
3. Component data
4. Soil component
5. Soil profile
6. Soil horizon
7. Vegetation

Physiography is the first differentiating criterion to be used in the characterization of SOTER units; it describes the landforms of the earth's surface.

"Terrain" includes the following parameters: elevations, slope gradient, relief intensity, major landform, hypsometry, dissection. The second step is the identification of areas within each terrain with a particular surface form, mesorelief, parent material, drainability, erodibility, and type of soil.

The final step in the differentiation is the identification of soil components within the terrain components. Soil is characterized in soil profiles by genetic horizons for every soil variety. Soil characteristics are comprised of a significant list of chemical and water-physical properties, particularly: organic carbon (humus) content, total nitrogen, carbonates, gypsum, base exchange capacity and content of absorbed bases, soil extract composition, electrical conductivity, texture, bulk density.

The SOTER database was formed for the Chirchik-Akhangaran basin. It should provide data for a set of models designed for water resources management in the basin.

SOTER was chosen as a systematic and higher-order way of generating maps and database that contains terrain and soil data as an input to basin models.

Results and Discussion

SOTER for the Chirchik-Akhangaran basin

Soil variety is taken as a unit of SOTER for the Chirchik-Akhangaran basin. SOTER database was formed on a 1:200 000 scale soil cover map of Tashkent province, comprising the Chirchik-Akhangaran basin. The soil map of the basin contains 42 soil varieties transformed into a SOTER unit (Table 1).

Each soil component represents a single soil within a SOTER unit. The full name of soil was converted into code, using symbols showing the name of soil variety and the degree of manifestation of representative feature, one or a few of the following: erodibility, land development remoteness, groundwater level, and salinity. Each SOTER unit was characterized by the following attributes (Table 2).

Within the framework of the project, meteorological data were collected from five weather stations in Tashkent province and one weather station in Syrdarya province:

- Tashkent
- Pskem
- Dukant
- Oigaing
- Angren
- Syrdarya

Command weather station was identified for every rayon in Tashkent province:

Based on historical climatic data and one of the climate change models - ECHAM4(Germany, Max Planck Institute) and HadCM2 (UK, Hadley Centre) – climate scenarios are developed for the future as recommended by IPCC (Second country message of the Republic of Uzbekistan on the UN Framework Convention on Climate Change, 2008,)

Table 1. List of SOTER units for the Chirchik-Akhangaran basin

PROFIL_SET_ID	DESCRIPTION	SOTER unit	Profile No
UZ-BMoL_y	Brown mountain soils deeply leached on skeleton sediments, slightly eroded	47	6
UZ-BMoL_z	Brown mountain soils deeply leached on skeleton sediments, strongly eroded	48	35
UZ-BMoC	Brown mountain soils with carbonates on loess like skeleton sediments, non eroded	44	30
UZ-BMoC _y	Brown mountain soils with carbonates on loess like skeleton sediments, slightly eroded	45	36
UZ-BMoC_z	Brown mountain soils with carbonates on loess like skeleton sediments, strongly eroded	46	30 minus 30 cm topsoil
UZ-BMoT_z	Brown mountain soils typical on loess like skeleton sediments, strongly eroded	43	58
UZ-BMoT_y	Brown mountain soils typical on loess like skeleton sediments, slightly eroded	42	9
UZ-BMoF_y	Brown mountain-forest soils typical on gravelly sediments, stony,slightly to moderately eroded (S exposition)	50	5 minus topsoil
UZ-BMoF	Brown mountain-forest soils on loess sediments, non eroded	49	01
UZ-SD_2	Dark sierosem, heavy loam on loamy sediments, long-term irrigated	40	65016
UZ-SD	Dark sierosem, heavy loam on loamy sediments, non- irrigated	41	3
UZ-GRAVEL	Gravel and sands	54	
UZ-LBMo	Light-brown high mountain meadow-steppe soils	51	06
UZ-MaMeT3	Marsh-meadow soils on loess mixed with gravel, gravel at 0.5-1m, GW level<1m (T3)	32	3f
UZ-MeMaP	Meadow-peat marsh soil	31	8
UZ-MeT1	Meadow soils on alluvial sediments, heavy loam, gravel at 0.3-2m, GW level 1-2m (T1)	30	2f
UZ-MeT5	Meadow soils on heavy loam, GW level 1-2m (T5)	23 (23.24)	6f
UZ-MeT3	Meadow soils on loess mixed with gravel, heavy loam, GW level 1-2m (T3)	35 (35.36)	72003
UZ-MeMo	Meadow-high mountain soils	52	1462p
UZ-MeST5	Meadow-sierozems on loamy sediments intercalated with sands and gristle, GW level 2-2.5m (T5)	21	5f
UZ-MeST1	Meadow-sierozems soils on alluvial sediments, GW level 2-2.5m (T1)	22	5f
UZ-ROCK	Rock outcrop	53	
UZ-SmeT3	Sierozem-meadow soils on loess mixed with gravel (T3)	33(33.34)	8f
UZ-MaMeT1	Swampy marsh-meadow sierozems on alluvial sediments,GW level<1m,(T1)	38 (37.38)	9f
UZ-ST5_2	Typical sierosem on loamy loess-like and gristly sediments, long-term irrigated (T5)	15	7
UZ-ST5_2z	Typical sierosem on loamy loess-like and gristly sediments, long-term irrigated,mod.-strongly eroded (T5)	17	128m
UZ-ST5_1	Typical sierosem on loamy loess-like and gristly sediments, newly irrigated (T5)	16(16.18)	132m
UZ-ST5	Typical sierosem on loamy loess-like and gristly sediments, non irrigated (T5)	20	2
UZ-ST3_2	Typical sierosem on loamy loess-like sediments long-term irrigated (T3)	25(25.26)	7f
UZ-ST3_1	Typical sierosem on loamy loess-like sediments, newly irrigated (T3)	27(27.28)	626
UZ-ST3	Typical sierosem on loamy loess-like sediments, newly (T3), non irrigated	29	72002
UZ-ST3_01	Typical sierosem on loamy loess-like sediments, newly (T3)	19	32

Table 2. Attributes of a SOTER unit

№		Input information for the models		
		HBV	REGVAT	EPIC
	Terrain			
1.	Year of data collection	+	+	+
2.	Map ID	+	+	+
3.	Minimum elevation	+	+	+
4.	Maximum elevation	+	+	+
5.	Slope gradient	+		+
6.	Relief intensity	+		+
7.	Major landform	+		+
8.	Regional slope	+		+
9.	Hypsometry	+		+
10.	Dissection	+		+
11.	General lithology	+	+	+
12.	Permanent water surface	+	+	+
	Terrain component			
13.	Terrain component data ID	+	+	+
14.	Dominant slope	+		+
15.	Length of slope	+		+
16.	Form of slope	+		+
17.	Local surface slope	+		+
18.	Average height	+		+
19.	Coverage	+		+
20.	Surface lithology	+	+	+
21.	Texture group non-consolidated parent material	+	+	+
22.	Depth to bedrock	+	+	+
23.	Surface drainage	+	+	+
24.	Depth to groundwater	+		+
25.	Frequency of flooding			+
26.	Duration of flooding			+
27.	Start of floodoing			+
	Soil component			
28.	Profile ID	+	+	+
29.	Number of reference profiles	+	+	+
30.	Position in terrain component	+	+	+
31.	Surface rockiness	+	+	+
32.	Surface stoniness	+	+	+
33.	Types of erosion/deposition	+		+
34.	Degree of erosion	+	+	+
35.	Sensitivity to capping		+	+
36.	Rootable depth		+	+
37.	Relation with other soil components		+	+
	Profile			+
38.	Profile database ID	+	+	+
39.	Latitude	+	+	+
40.	Longitude	+	+	+
41.	Elevation	+	+	+
42.	Sampling date		+	+
43.	Lab_ID		+	+
45.	Infiltration rate	+	+	+
46.	Surface organic matter		+	+
47.	Classification FAO	+	+	+
48.	Classification version	+	+	+
49.	National classification	+	+	+
50.	Soil taxonomy		+	+

	Horizon (*=mandatory)			
51.	Profile ID*		+	+
52.	Horizon number*		+	+
53.	Diagnostic horizon*		+	+
54.	Diagnostic property*		+	+
55.	Horizon designation		+	+
56.	Lower depth*		+	+
57.	Distinctness of transition		+	+
58.	Moist color*		+	+
59.	Dry color		+	+
60.	Grade of structure		+	+
61.	Size of structure elements		+	+
62.	Type of structure*		+	+
63.	Abund. coarse fragments*		+	+
64.	Size of coarse fragments		+	+
65.	Very coarse sand		+	+
66.	Coarse sand		+	+
67.	Medium sand		+	+
68.	Fine sand		+	+
69.	Very fine sand		+	+
70.	Total sand*		+	+
71.	Silt*		+	+
72.	Clay*		+	+
73.	Particle size class		+	+
74.	Bulk density*		+	+
75.	Moisture content at various tensions		+	+
76.	Hydraulic conductivity		+	+
77.	Infiltration rate		+	+
78.	pH H_2O*			+
79.	pH KCl			+
80.	Electrical conductivity			+
81.	Exchangeable Ca^{++}			+
82.	Exchangeable Mg^{++}			+
83.	Exchangeable Na^{+}			+
84.	Exchangeable K^{+}			+
85.	Exchangeable Al^{+++}			+
86.	Exchangeable acidity			+
87.	Cation exchange capacity (CEC) of soil*			+
88.	Total carbonate equivalent			+
89.	Gypsum			+
100.	Total carbon*			+
101.	Total nitrogen			+
102.	P_2O_5			+
103.	Phosphate retention			+
104.	Fe dithionite			+
105.	Al dithionite			+
106.	Fe pyrophosphate			+
107.	Al pyrophosphate			+
108.	Clay mineralogy			+
	Climatic data			
109.	Mean minimum air temperature °C	+	+	+
110.	Mean maximum air temperature °C	+	+	+
111.	Mean air temperature °C	+	+	+
112.	Rainfall mm	+	+	+
113.	Relative air humidity %	+	+	+
114.	Wind speed at height of 2 m above the surface m/s	+	+	+
115.	Sunshine hours per day hour	+	+	+

Simulating scenarios and analyzing modeling results

This chapter describes the results of modeling of the integrated water resources management for the conditions of Chirchik-Akhangaran basin.

Simulating scenarios and analyzing results of HBV modeling

HBV-Chirchik, a surface water model of HBV-IWS version adapted to conditions of the Chirchik-Akhangaran-Keles basin realizes, on daily basis, a well-known method of mountain river runoff formation. The model is a surface water model relating to the class of conceptual models describing the relatively small amount of components, each of which is a schematized similarity of processes that take place in simulated system.

The main variables of HBV are: sub-basin and zone areas; soil characteristics. Input variables are: climate data, daily temperature and precipitation, soil moisture, mean monthly evapotranspiration, discharge in tail gauging stations (to compare simulation with actual data and to calibrate the model). Major output variables are daily and monthly flow amounts per sub-basin summation of which gives a picture of amount of flow in the whole basin. The change in river flow in the basis mainly depends on changes in climate and snow cover storage.

Figure 2 demonstrates fluctuations of flow by year. The spreading of values is determined by alternation of dry and wet years.

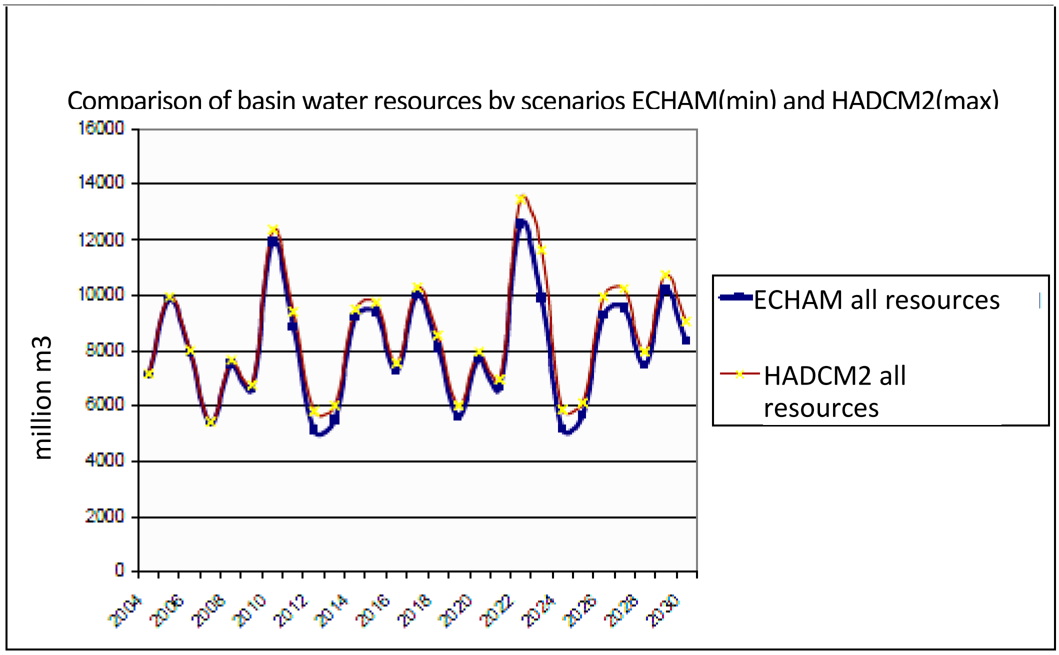


Fig.2. Comparison of basin water resources by scenarios ECHAM(min) and HADCM2(max)

Thus, the difference between average and wet year, as for example the years 2006 and 2010, reaches almost 6 Mm3. The results of river flow modeling by HBV on the basis of climatic scenarios are shown in Figure 2. The model predicts a decrease of river flow in the basin in the new thirty years. Finally, the system HBV-water distribution-Chirchik model should be adjusted for forthcoming scenario and option simulations:

- Climatic, estimating impact of future climate changes on flow volume and regime, first simulated in HBV-Chirchik and in agricultural module (climate impact on water requirements use),
- Socio-economic and agricultural, estimating future water demands, first simulated in agricultural module and in socio-economic model and transmitted to the *water distribution* model with following return (after comparison of demand with available resources).

Table 3 gives comparison of simulation results for two basin development scenarios - BAU (business as usual) and OPT (optimistic). Although the basin does not face water shortage, water demand is approaching water supply over the years and would exceed available water supply by 2030.

Table 3. Comparison of simulation results based on two climate change scenarios (Chirchik-Akhangaran-Keles basin)

Year	Total water resources		Water demand	
	BAU/ECHAM	OPT/ HadCM2	BAU/ECHAM	OPT/ HadCM2
2006	7908	8019	4778	4968
2011	8841	9404	4714	5404
2016	7263	7540	4714	5188
2021	6662	6944	5299	5258
2024	5154	5871	5362	6270

Simulating scenarios and analyzing results of REQWAT modeling

FAO methodology (FAO papers № 24 and № 56) was used as a methodical base. The reference evapotranspiration was calculated by Penman-Monteith formula, the effective precipitation was calculated using a method of US Bureau of Reclamation (documentation to CROPWAT), and groundwater contribution was estimated by Harchenko's formula adapted to FAO classification by Horst M.G. REQWAT creates text file with irrigation water requirements and computes yield damage due to under-irrigation. Agriculture is based on irrigation in this basin. In the region, like in the republic as a whole, agriculture accounts for 30% of GDP, contributes 60% of currency earnings, provides 44% of job places, and produces 90% of food. Irrigation plays an important role in social situation in the province, particularly with respect to jobs (employment). Taking into account that 60% of the total basin's population lives in the rural area, once more this indicates to the importance of water sector for stable life of the basin's residents. For forecast simulations, consider two climate change models (ECHAM and HADCM2) and set cropping pattern scenarios for rayons. Prepare the program for coupling with the general interface. Dynamics of water consumption in irrigated agriculture by four scenarios is shown in Figure 3. According to simulation results, irrigation water requirements will be growing even under the optimistic scenario of regional development.

Simulating scenarios and analyzing results EPIC modeling

EPIC model is composed of three principle structural components Soil, Climate and Landuse. They include weather simulation, hydrology, erosion/sedimentation, nutrient cycling, pesticide fate, plant growth, soil characteristics, tillage, plant environment control and economics. EPIC operates on a daily time step, considering daily weather data, soil characteristics, and farming activities like planting tillage and fertilization. Also on a daily basis, EPIC simulates water movements, the cycling of nitrogen/phosphorus/carbon and soil erosion. The SOTER database was used in the model (Table 2). The model allows creating and simulating various agronomic practices against irrigation and non-irrigation.

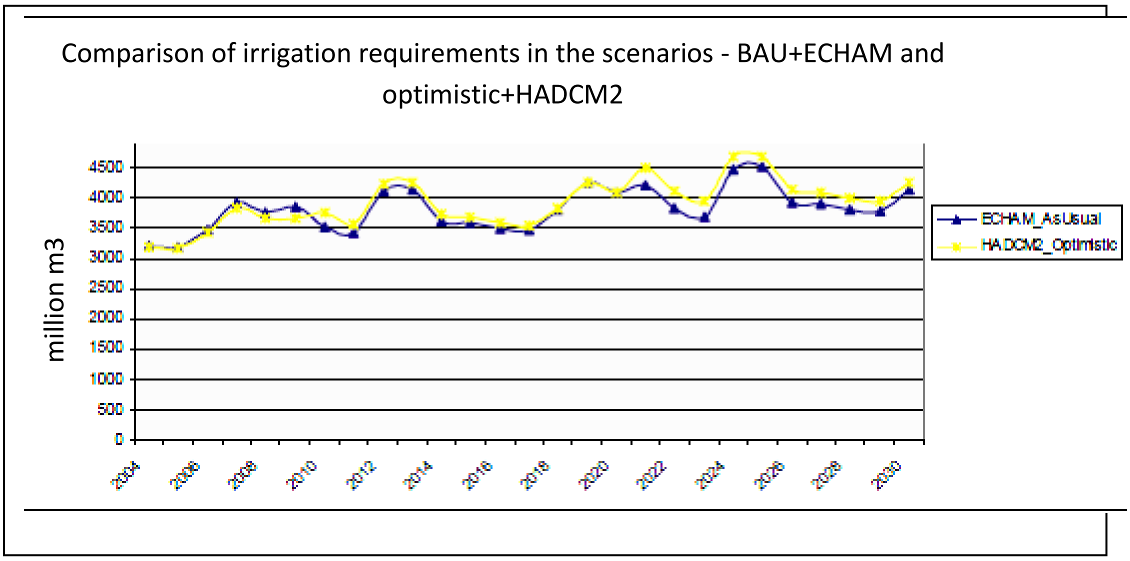


Fig. 3. Dynamics of irrigation water requirements for 2004-2030

The following tasks were set for application of EPIC model:

Simulate productivities of main crops until 2030 for the following scenarios: keeping current crop management practices; change in management practices: application of fertilizers and water; productivity forecast under climate change.

Simulation of various scenarios (4500 scenarios) has proven once again that the main limiting factor of crop productivity is irrigation water in the Chirchik-Akhangaran basin.

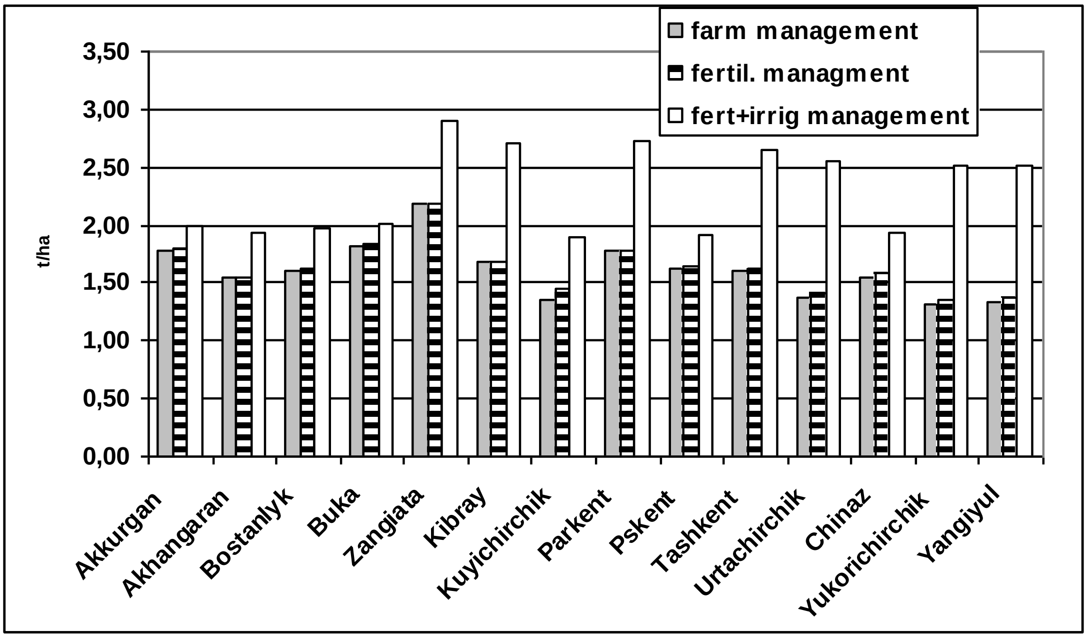


Fig. 4. Cotton yields under various irrigation regimes

The simulation results (Figure 4) show yields derived from the three scenarios: farm management (actual fertilizer application norms), fertilizer management (model optimized norms), and, fertilizer and water management (optimization) for the administrative districts of the Chirchik-Akhangaran basin.

Calculations for regime of automatic fertilization and irrigation, given the stress from these factors is 0.99 by EPIC model, allow optimization and management in such a way so that to increase yields. It follows from the analysis that almost for all districts, calculations for the water and fertilizer management and water or fertilizer management only give similar results that proves the conclusion made earlier. Under given conditions, fertilizers are less limiting factor as compared to irrigation water quantity (Figure 4).

Climate change scenarios

The climate scenarios are developed to evaluate vulnerability of agricultural, water, and socio-economic sectors in the region. Analysis of climate dynamics indicated to availability of trends towards warming. This would have effect on plant growth and development and on water consumption. Experts from Uzglavgidromet provided outputs on scenarios of temperature and precipitation changes for 20-30 years from the models: 1) HadCM2; 2) ECHAM4. The output information has monthly resolution

For more accurate calculation and evaluation of climate change on productivity, in the model EPIC we used the climate change scenarios in daily resolution. This report shows simulation results derived from the model's first version. These results are to be adjusted in the future. The calculation results indicate that while keeping current crop management practices cotton yield may considerably increase up to 80% through the effect of climate change (Figure 5). While optimizing fertilization and irrigation again temperature rise, the productivity increases up to 140% (Figure 6). The process is more visible for plain areas of the region.

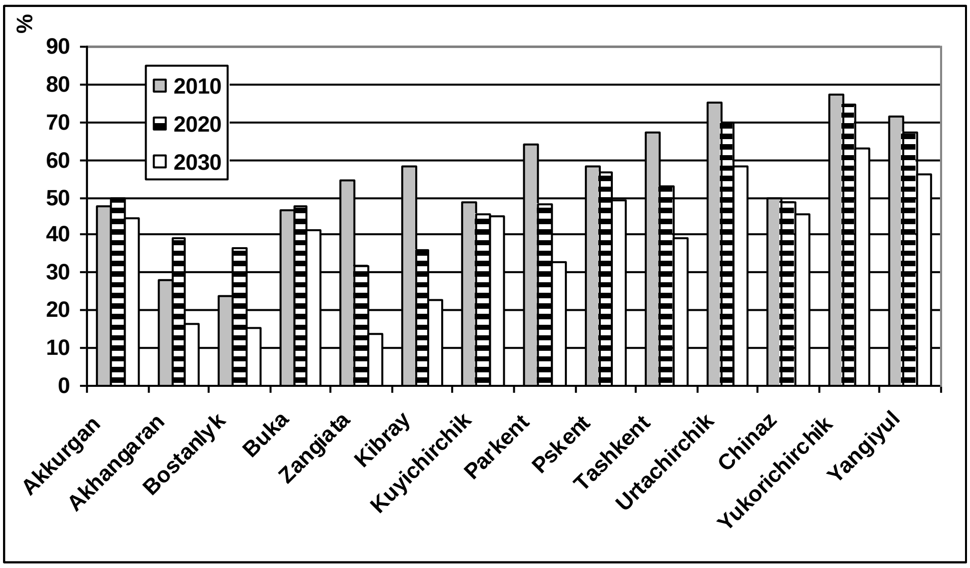


Fig. 5. Cotton yield changes in Business as usual scenario (with climate change)

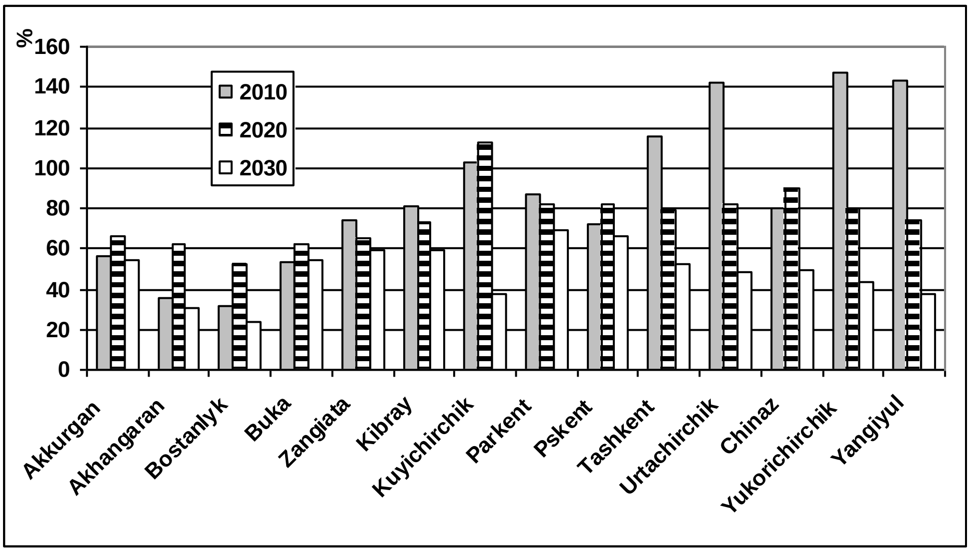


Fig. 6. Cotton yield changes in optimistic scenario (with climate change)

Conclusion

The SOTER database contains a lot of parameters and has a data capacity relevant for solving many practical tasks in agriculture and water sector: land reclamation, agronomic practices, irrigation. The research carried out within the framework of the RIVERTWIN Project demonstrated that the SOTER database served as a basis of input parameters for the developed set of models. Combination of soil database with terrain characteristics and inclusion of climatic data enlarged the database and made it more universal. Development in the direction of map digitizing and connection of GIS even more enriched this database. The work showed that SOTER at a scale of 1:1 million adapted to the soil map of the world legend (FAO 1988) can be extended to a larger scale by using the same methodology, and thus the value of this database will increase significantly since it could become possible to use it both at a regional scale and at the level of individual field for the agronomic purposes.

References

Regional Model of Integrated Water Resources Management in Twinned River Basins - RIVERTVIN //Edited by V.A.Dukhovny – Tashkent: SIC ICWC, 2008 – 188 p.

Proceedings of an International Workshop on the Structure of a Digital International Soil Resources Map annex Data Base. (20-24 January 1986, ISPIC, Wageningen). Ed. by M.F.Baumgardner and L.R.Oldeman. SOTER Report 1, ISSS, Wageningen. 138 p.

Second country message of the Republic of Uzbekistan on the UN Framework Convention on Climate Change, 2008.

9th International Soil Science Congress on
"The Soul of Soil and Civilization"
Soil Science Society of Turkey cooperation with Federation of Eurasian Soil Science Societies
14 - 16 October, 2014
Side, Antalya/ Turkey

Effect of drought stress on the growth of the *Stipa barbata*

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Abstract

Stipa barbata is known to survive under diverse soil and water conditions. In order to test its potential of aridity tolerance ability, the effect of aridity stress on the growth of the *Stipa barbata* was studied by growing plants in arid soils. The experiment was conducted in a greenhouse, with a factorial arrangement in a completely randomized design using 5 replications. Aridity levels of field capacity irrigation (as control), -6 and -10 bars were applied. The root weight, root length and chlorophyll concentration parameters in -6 bars aridity level were more than control aridity level. The water content was highest in FC aridity treatment. Our results suggest that in the soils that have -6 to -10 bars water content, *Stipa barbata* could be used for soil rehabilitation.

Keywords: *Stipa barbata*; drought; growth

Introduction

The plants that can be naturally established in drought soils called xerophytes (Richards,1954). Aridity stress cause reduced in nutrient uptake by roots and eventually plant death (Jafari, 1994). Thus, soil aridity stress can reduce rangeland production potential (Kafi and Mahdavi,2012). Drought stress has considerable adverse impacts on productivity of plants (Lauchli and Epstein, 1990). These adversely affect plant growth and development. Limited water supply is a major environmental constraint in productivity of plants. Moisture deficiency induces various physiological and metabolic responses like stomata closure and decline in growth rate and photosynthesis (Flexas and Medrano,2002). The previous research results showed that greater soil water stress decreased plant height and total fresh and dry weight of plants (Baher et al.,2002). Previous research results also showed that the number of stem per plant and plant dry weight was negatively related to water stress in plants (Colom and Vazzana, 2002). *Stipa barbata* provide vegetative cover in situations where other vegetation is unable to establish due to extremes of aridity soils (Loch, 2006).

Its root went down to 70cm and penetrating the saline soil and reaching sub surface moisture which the other plant cannot do and dissolved salt content were greatly reduced (Du and Truong, 2000). *Stipa barbata* grass has short rhizomes and massive finely structured root systems that grow very quickly. It has been reported to grow to depth as 1 meter in the first year of grows (Truong et al., 2002). This deep root system makes the *Stipa barbat* plant extreme drought tolerant. So *Stipa barbata* can establish in arid areas that receive less than 200 millimeters of rain a year so it have a high aridity tolerance (Fraser, 1993). *Stipa barbata* is well known as being a drought and salt tolerant plant (Vimala and Kataria, 2005). Aridity reduces the ability of plants to take

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up water. Hence, the ability of a plant to grow under these environmental stress conditions is a key factor to improve rangeland vegetation in saline and arid rangelands (Sharp and Davies, 1979; Sharp and Davies, 1985; Netting, 2000; Bruce et al., 2002). So aridity alters plant growth rate and nutrient uptake (Sharp and Davies, 1979; Sharp and Davies, 1985; Netting, 2000; Bruce et al., 2002). Aridity tolerance ability of *Stipa barbata* was the objects of this study.

Material and Methods

The Scions of *Stipa barbata* were taken from Research Institute of Forests and Rangelands. Plants were grown in Malayer University greenhouse at 15-40°C under a photoperiod of 16 h. Scions were planted in pots of 14 cm diameter and 25 cm depth; each pot contained 3.5 kg soil. The soil characteristics were as follows: Entisol in type, sandy clay loam in texture, sand 53.7%; silt 7.14%; clay 39.16%; pH 9.63 and organic matter 0.87%.

3 levels of aridity levels have been implemented on pots with Pressure plates. Aridity levels of field capacity irrigation (as control), -12 and -14 bars were applied. Each pot was weighed every 3 days. The decreased weight of each pot in each round of review showed the amount of water evaporated or consumed by the plants. So this weight of water is added pots by irrigation water (Alizadeh, 1999).

The plant height (cm), root system length (cm) and leaf area (cm2) were measured (after 3 months). Plants were washed with distilled water and separated into shoots and roots. The dry weight (dw) was obtained after oven drying the plants at 60 °C for 48 hours. The dry weights of the root and shoot systems were also determined.

Chlorophyll concentration was estimated spectrophotometrically (Metzner et al., 1965), after acetone extraction of the pigments from fresh leaves. Chlorophyll concentration was determined with three replicate plants. A leaf sample of 0.1 g was ground and extracted with 5 mL of 80% (v/v) acetone in the dark. The slurry was filtered and absorbencies were determined at 645 and 663 nm (Kachout et al., 2009). The pot experiment was set up in factorial arrangement in a completely randomized design using 5 replications. ANOVA was employed for statistical analysis of data. Statistical significance was defined as $P < 0.05$ (Kachout et al., 2009).

Results and Discussion

Leaf area declined significantly along decreasing soil moisture. The highest leaf area values were in lowest aridity (FC) level. Compared to the FC treatment, leaf area was reduced by 48.52% and 73.13 % in the -6 and -10 bar aridity treatments, respectively. So there was significant effect of aridity on leaf area in *Stipa barbata*. Shoot dry weights at all stages of development were reduced progressively with increasing drought stress while reversibly. Increasing drought stress in soil significantly retarded ($p < 0.05$) dry weight of stems (Figure 1). Dry weight significantly decreased ($p < 0.05$) for shoots and total biomass of plants in response to increasing concentration of salt (Figure 1). Root height and root dry weight were highest in -6 bar aridity level (Figure 1). The relative percentage of the shoot height, shoot dry weight, root length, and root weight of the under drought stress plants compared to those of the controls were computed as (salinized plants/control plants) x100 and illustrated in Figure 1.

Values of percentage relative varied from 100, 32 and 17% for shoots height, from 100, 28 and 21% for shoot weight, from 97, 100 and 53% for root height and from 95, 100 and 32% for root weight to increasing soil aridity from FC to -6 and -10 bars. In experiment, dry plant weight decreased dramatically with the increasing NaCl concentration. The greatest dry plant weight of *Stipa barbata* was obtained with the first treatment in all range of aridity treatments. The general tendency was that increasing concentrations of salt induced a progressive decline in the length of shoots and in the weight of roots, stems and leaves.

With increase in aridity level from FC to -10 bars resulted in significantly progressive decline the photosynthetic pigment. Leaf chlorophyll concentration was reduced from 48 to 27 and 16%, for FC, -6 and -10 bars aridity level (Figure 2).

Aridity stress significantly decreased water content of leaves from 7% in control treatment to 5% and 4% at -6 to -10 aridity level (Fig. 3).

Drought stress has a significant effect on growth and accumulation of organic matter in various parts of plants leaves by reducing the rate of photosynthesis (Rad et al., 2001). Results of this research showed Leaf area declined significantly as level of aridity increased from FC to -6 and -10 bars. Compared to the 4 dS/m treatment, leaf area was reduced by 48.52% and 73.13 % in the -6 and -10 bar aridity treatments, respectively.

These variations are due to different soil moistures treatments. This feature increased significantly with decreasing soil moisture.

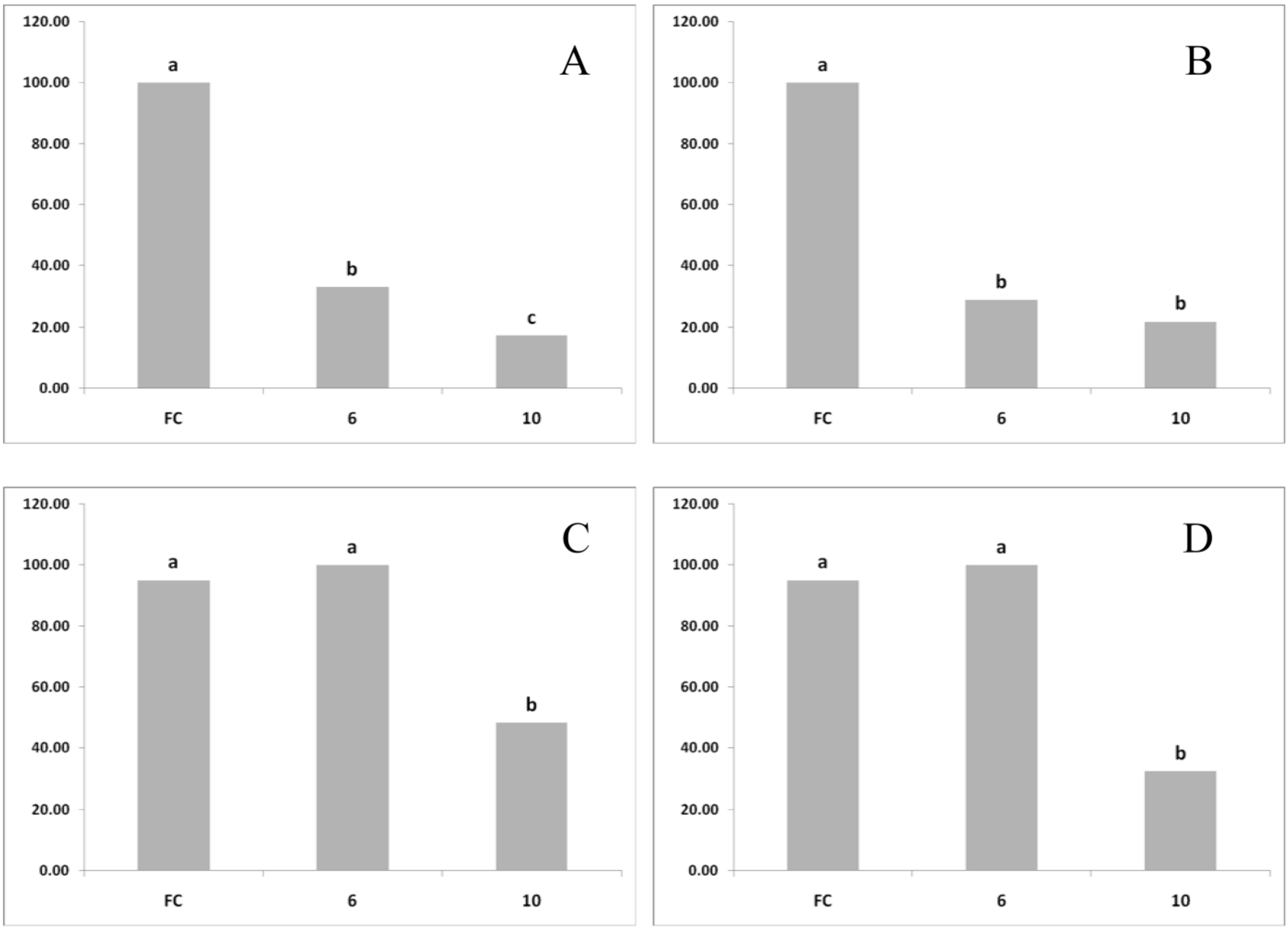

Fig. 1 Effect of aridity on root and shoot dry weights of *Stipa barbata*. Different letters represent a significant difference (P<0.05) between treatments

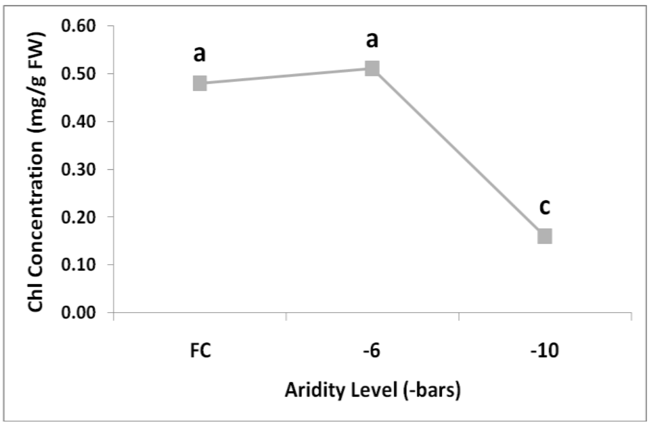

Fig. 2 Effects of various aridity levels on chlorophyll concentration. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD)

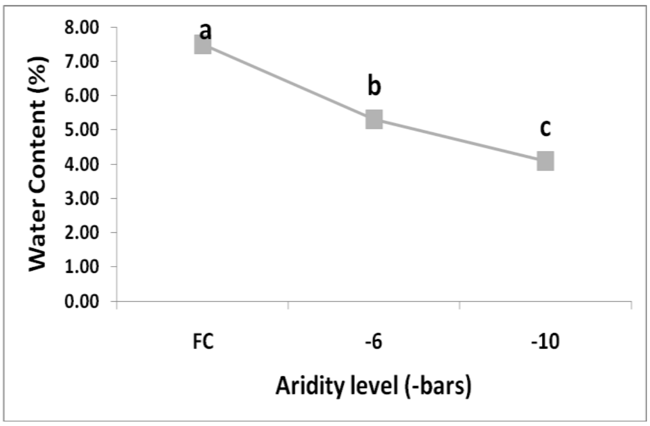

Fig. 3 Effects of various aridity levels on leaves water content. Different letter within a variable indicates significant differences at P<0.05 (ANOVA and LSD)

Results of this research showed that different aridity level had different effects on dry matter production in both shoots and roots. Many studies indicate that increasing in drought stress could decrease all plant dry weight (Omidi, 2010; Jongrungklang et al., 2008; Abdalla, M.M., and El-Khoshiban, 2007; Hamada, 1996). These were seen in shoot height and shoot weight parameters significantly reduction in different aridity level in

Stipa barbata (Fig. 1). However, previous researcher reported that drought stress may increase root weight and decrease shoot weight (Kameli and Lose, 1996). The root height and root weight increment under -6 bars aridity level has been seen in *Stipa barbata*. In other words, the plant can also produce enough roots at -6 bars of drought stress. More stress caused a reduction in root growth, water uptake, and mineral deficit and finally stop the growth. However the root height and root weight increment in -6 bars was not significant compared with the control level (Fig. 1). The absorption of nutrients from the soil depends on the availability of water to roots. It is reported that soil water deficit may reduce root growth and limit nutrient uptake by roots (Arndt et al., 2001). This significant reduction (compared with the control and -6 bars aridity levels) has been seen in -10 bars aridity level (Fig. 1). Some of reaserches consider a high root to shoot ratio as a drought tolerant parameter (Li and Wang, 2003; Gazal and Kubiske, 2004; Bargali and Tewari, 2004). They have emphasized that the first and most common feature of plant growth is increasing of root to shoot ratio in arid regions.

The chlorophyll concentration has highest value in -6bars aridity level. The lowest concentration of chlorophyll was in -10bars aridity treatment (Fig. 2). Chlorophyll content of plant under drought stress depends on stress rate and duration (Rensburg and Kruger, 1994; Kyparissis et al., 1995; Jagtap et al, 1998). By exerting severe drought stress on plant, chlorophyll content of leaf significantly decreased (Fotovat et al., 2007). with decreasing chlorophyll content due to the changing green color of the leaf into yellow, the reflectance of the incident radiation is increased (Schlemmer et al., 2005). It seems that this mechanism can protect photosynthetic system against stress (Lessani and Mojtahedi, 2005).

Water deficit can destroy the chlorophyll and prevent making it (Smirnoff, 1995). The decrease in chlorophyll under drought stress is mainly the result of damage to chloroplasts caused by active oxygen species (Bohrani and Habili, 1998). So it can be said that in -10bars aridity treatment, leaves chlorophylls have been destroyed.

Lower drought stress causes reducing the leaf area. In fact, the plants by reducing the leaf surface under the stress conditions reduce the transpiration area to prevent the wasted water. Therefore, the chlorophyll content increases per unit of leaf area (Liu et al., 2002). It was seen in -6bars aridity level. In fact, by reducing the leaf surface of the plant in stress conditions reduced the transpiration level to prevent the wasted water and therefore, despite reducing the total amount of chlorophyll in leaves the chlorophyll content increases per unit of leaf area (Liu et al., 2002).

Aridity stress significantly decreased water content of leaves from 7% in control treatment to 5% and 4% at -6 to -10 aridity level (Figure 3). Decrease in water content in plants under drought stress may depend on plant vigor reduction and have been observed in many plants (Blokhina et al., 2003). Under water deficit, cell membrane subjects to changes such as penetrability and decrease in sustainability (Meyer and Boyer, 1981). Microscopic investigations of dehydrated cells, revealed damages including cleavage in the membrane and sedimentation of cytoplasm content (Meyer and Boyer, 1981). Probably, in these conditions, ability to osmotic adjustment is reduced (Blokhina et al., 2003). It seems that concentration of appropriate solutes to preserve membrane is not sufficient in this case.

Conclusion

Stipa barbata can growth in -10 bars drought level.

References

Abdalla, M.M., and El-Khoshiban, N.H. 2007. Journal of Applied Science, 3, 2062-2074.

Alizadeh, A. 1999. Water, soil and plant relationship, Ferdowsi University Publication, Mashhad, Iran, Second Edition, 351p.

Arndt, S.K., Clifford, S.C., Wanek, W., Jones, H.G., Popp, M. 2001. Tree Physiol., 21, 705-715.

Baher, Z.F., Mirza, M., Ghorbanl,i M., Rezaii, M.B. 2002. Flavour Frag Journal, 17, 275–7.

Bargali, K., and Tewari, A. 2004. Journal of Arid Environ., 58, 505-512.

Blokhina, O., Virolainen, E., and Fagerstedt, K.V. 2003. Ann. Bot., 91, 179-194.

Bohrani, M., Habili, N. 1998. Physiology of plants and their cells, Chamran University Publication, 20-34.

Bruce, B., Gregory, W., Barker, O.E. 2002. Journal of Botany, 53, 13-25.

Colom, M.R., and Vazzana, C. 2002. Italy Journal of Agron, 6, 127–32.

Du, L., and Truong, P. 2000. Stipa barbata grass for sustainable agriculture on adverse soils and climate in South Viet Nam, Nong Lam University Publication, Thiland, , 1-13.

Flexas, J., and Medrano, H. 2002. Journal of Botany, 89, 183–9.

Fotovat, R., Valizadeh, M., and Toorehi, M. 2007. Journal of Food, Agriculture and Environ, 5, 225-227.
Fraser, B. 1993. Stipa barbata, The Hedge against Erosion, The World Bank Publication, Washington, D.C, 1-48.
Gazal, .RM., and Kubiske, M.E. 2004. Jouranl of Forest Ecology and Management, 189, 295-305.
Hamada, A.M. 1996. Biol. Plant., 38, 405-412.
Jafari, M. 1994. Journal of Iranian Institute of Rangeland and Forest Researches. 1, 28-31.
Jagtap, V., Bhargava, S., Sterb, P., Feierabend, J. 1998. Journal of Experimental Botany, 49, 1715-1721.
Jongrungklang, N., Toomsan, B., and Vorasoot, N. 2008. Asian Journal of Plant Science, 7, 628-638.
Kachout, S.S., Mansour,a A.B., Jaffel, K., Jogloy, S., Kesmala, T., Patanotha,i A. 2009. Applied Ecology and Environmental Research, 7, 319-332.
Kafi, M., and Mahdavi, A. 2012. Environmental stresses tolerance mechanisms, Ferdowsi University Publication, Mashhad, Iran. Second Edition, 466p.
Kameli, A., and Lose, D.M. 1996. New Phytol., 132, 57-62.
Kyparissis, A., Petropoulou, Y., and Manetas, Y. 1995. Journal of Plant Physiology, 23,147-152.
Lauchli, A., and Epstein, E. 1990. Plant responses to saline and sodic conditions and Agricultural Salinity Assessment and Management, ASCE, New York, 113–37.
Lessani, H., and Mojtahedi, M. 2005. Introduction to Plant Physiology (Translation). 6th Edit, Tehran University press, Iran, 726.
Li, C., and Wang, K. 2003. Journal of Forest Ecology and Management, 179, 377-385.
Liu, Y., Fiskum, G., and Schubert, D. 2002. Journal of Neurochem, 80, 780-787.
Loch, R. 2006. Stipa barbata grass. Landloch University Publication, New York, 1–2.
Metzner, R., Litwin, G., Weil, G. 1965. Psychedelic Rev Journal, 5, 3-39.
Meyer, R.F., and Boyer, J.S. 1981. Journal of Planta, 151, 482-489.
Netting, A.G. 2000. Journal of botany, 343: 147-158.
Omidi, H. 2010. American Journal of Plant Physiology, 5, 338-349.
Rad MH, Assare MH, Banakar MH, Soltani M, Asian Journal of Plant Science, 2001, 3, 132-139.
Rensburg, L.V., and Kruger, G.H. 1994. Journal of Plant Physiology, 143,730-737.
Richards L. 1954. Diagnosis and improvement of saline and alkaline soils, United States Department of Agriculture, Washington DC, 160p.
Schlemmer, M.R., francis, D.D., Shanahan, J.F., and Schepers, J.S. 2005. Agronomy Journal, 97, 106-112.
Sharp, R.E., and Davies, W.J. 1979. Journal of Planta, 147, 43-49.
Sharp, R.E., and Davies, W.J. 1985. Journal of Botany, 36, 1441-1456.
Smirnoff, N. 1995. Antioxidant systems and plant response to the environment. In: Smirnoff V (Ed.), Environment and Plant Metabolism: Flexibility and Acclimation, BIOS Scientific Publishers, Oxford, UK, 178.
Truong, N.I., Gordon, F., Armstrong, M. 2002. Productive Use and Rehabilitation of Saline Lands National Conference, Fremantle, Australia.
Vimala, Y., and Kataria, K., 2005. Journal of Botany, 3, 422-426.

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Studying of the condition of pasture territories on the basis of remote sensing

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Abstract

In article studies, methods a condition of postural territories of the Nurata district of Navoi region of the Republic of Uzbekistan on the basis of processing and the analysis of space pictures are considered. For identification and decoding of various types of pasture plants used different methods for determining the vegetation index (NDVI, VegetationIndex, DVI, RVI, ARVI, SAVI), PCA and classification methods, as well as certain types of processing, which allowed to determine the condition of vegetation cover in the investigated territory. On images distinctly is decrypted vegetation cover, piedmont plains with sparse vegetation cover and desert areas, as well as riverbed and channel etc. On the basis of the processing and analysis of remote sensing data studied vegetation cover the study area, as well as their variety and area distribution. During the field work were tested results of processing of satellite images in various ways. So in the processed satellite images are observed various phototone and texture of images, depending on density, the sizes and height of a vegetable cover. During calibration work on the ground through observation points are defined for matching specific varieties and forms of of vegetation cover and certain fototonam texture images. On the basis of processing and the analysis of a interpretation of RS materials and field the of works, is carried out the analysis of a condition of a vegetable cover of pasturable territories in different seasons.

Key words: Satellite images, pasture, processing, vegetation Index, classifications, phototonus, structure of images, monitoring

Introduction

Nowadays, in all developing countries of the world, in particular, in Uzbekistan, the big urgency is getting use of remote sensing data (RS), mainly satellite images of the medium and high resolution for carrying out of cartographical, geological, ecological, agricultural and other researches.The report discusses methods for studying the condition of grazing land based processing and analysis of satellite images.

In the report considered methods of studying of a condition of pasture territories on the basis of processing and the analysis of satellite images.

Studying of pasture territories of Nurata area was carried out with use multispectral satellite imagesLandsat 7 and 8, with the spatial resolution of 30 meters. Processing of satellite images done using of software products Erdas Imagine and Envi.

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Characteristic signature of vegetation and its condition is the spectral reflective ability characterized by the big distinctions in reflection of radiation of different wavelengths. Knowledge about relation between structure and a condition of vegetation with it spectral reflective abilities allow using satellite images for mapping and identification of types of vegetation and their condition.

The analysis of satellite images begun with improvement of visual perception of objects in the image. A combination of three bands of satellite images, received in a visible range have allowed to receive a color composition in natural colors. For identification and interpretation various kinds of pasture plants various methods of definition of an index of a vegetative cover (NDVI, Vegetation Index, DVI, RVI, ARVI, SAVI), methods PCA and classifications, and also some kinds of processing which have allowed to define a condition of a vegetation cover in investigated territory were used. Inof satellite images the vegetation cover, foothill plains with the rarefied vegetative cover and deserted territories, and also water channels are distinctly interpreted.

On the basis of processing and the analysis of RS materials were studied the condition of a vegetation cover of investigated territory, and also their types and distribution areas. During field verification works results of processing of satellite images have been approved by various methods. Therefore, in the processed satellite images are observed various phototonus and a structure of images, depending on density, size and height of the vegetation cover. At carrying out of verification, works on district conducting control points are defined conformity of certain types and forms of vegetation cover to certain phototonus and structures of images.

On the basis of processing and analysis, interpretation of RS materials and field verification works was generated a map of a condition of a vegetation cover in pasture territories.

Thus, the only constant source of water supply of settlements, floods of extensive postural territories and an irrigation of grounds, are the underground waters having within the described area universal distribution. Besides, very much natural exits of underground waters - springs have importance, small settlements, including the settlement Chuya are dated for them and Nurata.

Underground waters are important for mountain part of the area as are a natural source of flood of the territory of distant-pasture animal husbandry. A number of the factors the main of which are the climate and a hydrographic network influences conditions of formation of underground waters.

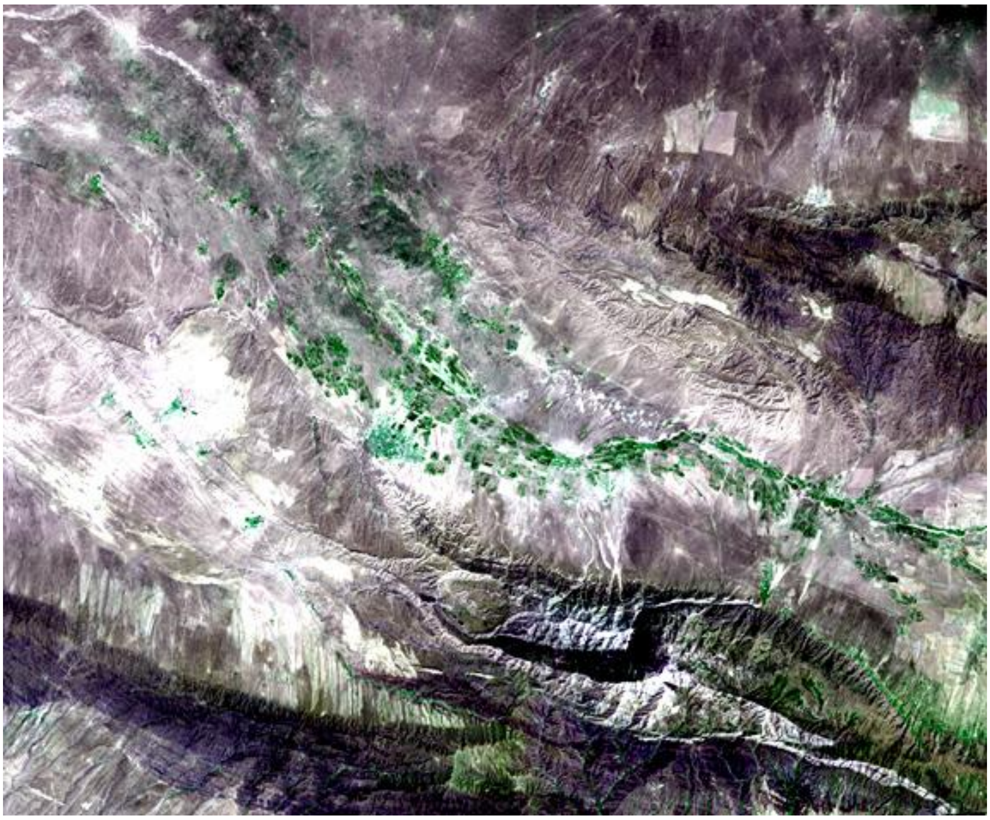

Fig. 1. Initial satellite image of the studied territory in natural colors

Spectral characteristics of plants generally are defined by ability of their foliage to pass, absorb and reflect sunlight and significantly depend on wavelength. Most distinctly, characteristics of reflective ability of plants are shown upon transition from the visible range of a range to near IR zone. In the visible range, there is quite strong absorption to a big maximum of reflective ability in green part of a range [1]. Thus only a small portion of the solar energy reflected from the sheet surface that is substantially transparent to the visible solar radiation. Absorption and reflection occur in hlorenhime.

The chlorophyll absorbs sunlight of blue and red parts of a range, and green beams generally reflects. Green color of foliage and local maximum of a spectral curve in this zone is explained by it. In a near Infrared range, the maximum of reflective ability of vegetation is observed. Reflectance value mainly depends on the type of vegetation. For this range, the surface wave and the sheet is transparent hlorenhima. Reflection occurs in another layer mesophyll - spongy parenchyma containing vacuoles air, and due to its internal structure. An important role is played by the number, size and shape of the leaf pulp cells, as these parameters determine the total surface on which the process of scattering and reflection of light. Repeated many times, they create a strong reflection of the resulting flux of solar radiation in the near infrared range.

With increasing wavelength (1.3-2.5 microns), green vegetation reflectance decreases again. Solar energy flux of this part of the spectrum is absorbed by water-containing soft cloth sheet. In this case, there are two typical low - about 1.43 and 1.93 microns, coinciding with similar absorption bands of water. In general, the water content in the leaves has a significant effect on the shape of the curve of spectral reflectance. It is lower than the stronger reflectance in the visible range and the smaller in the near IR range.

These features of the spectral characteristics of green vegetation appear as a separate sheet and plant communities as a whole, regardless of their type. It is important that the qualitative characteristics of various kinds of coincidence plants have characteristics in the spectrum of the peak position, and the overall configuration of the curve of spectral reflectance. These features, together with other features (texture, color, etc.) can identify various kinds of plants.

Spectral characteristics of the vegetation usually vary during the growing season. Moreover, different types of plants have their periods for the spectral characteristics of their images appear most clearly. It is during these periods it is advisable to use remote sensing data to recognize them.

Vegetation is the most sensitive component of natural ecosystems. The composition, development and physiological state of vegetation, and, consequently, on its spectral characteristics are heavily influenced by both long-term natural factors (climate zone, terrain, soil type, etc.), and short-term weather (precipitation, temperature fluctuations, solar radiation, etc.). The abundance of rainfall and heat fueling the rapid growth of biomass, the lack of precipitation depresses her.

For monitor the status of crops at different periods of the growing season, estimation of soil quality, biological resources of the seas and oceans, the most informative are the visible and near-infrared regions. It is here that the absorptive capacity of the majority of plant pigments [2].

For identification and decoding of various types of pasture, plants used different methods for determining the vegetation index (NDVI, Vegetation Index, DVI, RVI, ARVI, and SAVI), PSA methods and classification, as well as some types of treatment, which allowed determining the condition of vegetation in the study area. In pictures clearly deciphered vegetation, piedmont plains with sparse vegetation and desert areas, as well as rivers, etc.

NDVI (Normalized Difference Vegetation Index) - normalized relative vegetation index - a simple quantitative measure of the amount of photo-synthetically active biomass (usually called vegetation index). One of the most common and indices used to solve problems using quantitative estimates of vegetation. NDVI calculation is based on the two most stable (independent of other factors) sections of the spectral reflectance curve of vascular plants. In the red region of the spectrum (0.6-0.7 m) is the maximum solar radiation absorption by chlorophyll higher vascular plants, and in the infrared (0.7-1.0 microns) to be the region of maximum reflection worksheet cell structures [3].

In the picture (Fig. 2), dense vegetation stands a white background, flat vegetation is represented in light gray phototonus and open soil from gray to dark gray footstone, artificial materials (concrete, asphalt) - black phototonus.

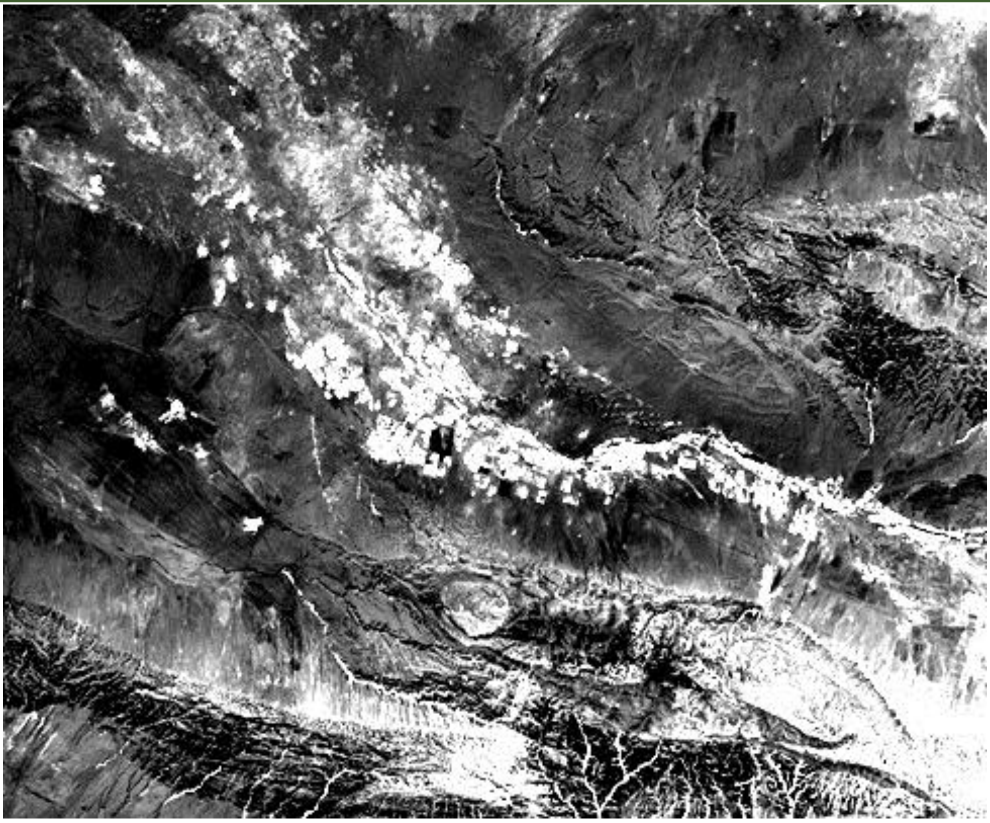

Fig.2. Result of processing the method of NDVI

Based on the result of combining NDVI channels of the original image obtained color image where vegetation cover different densities presented from bright yellow to green color (Fig. 3).

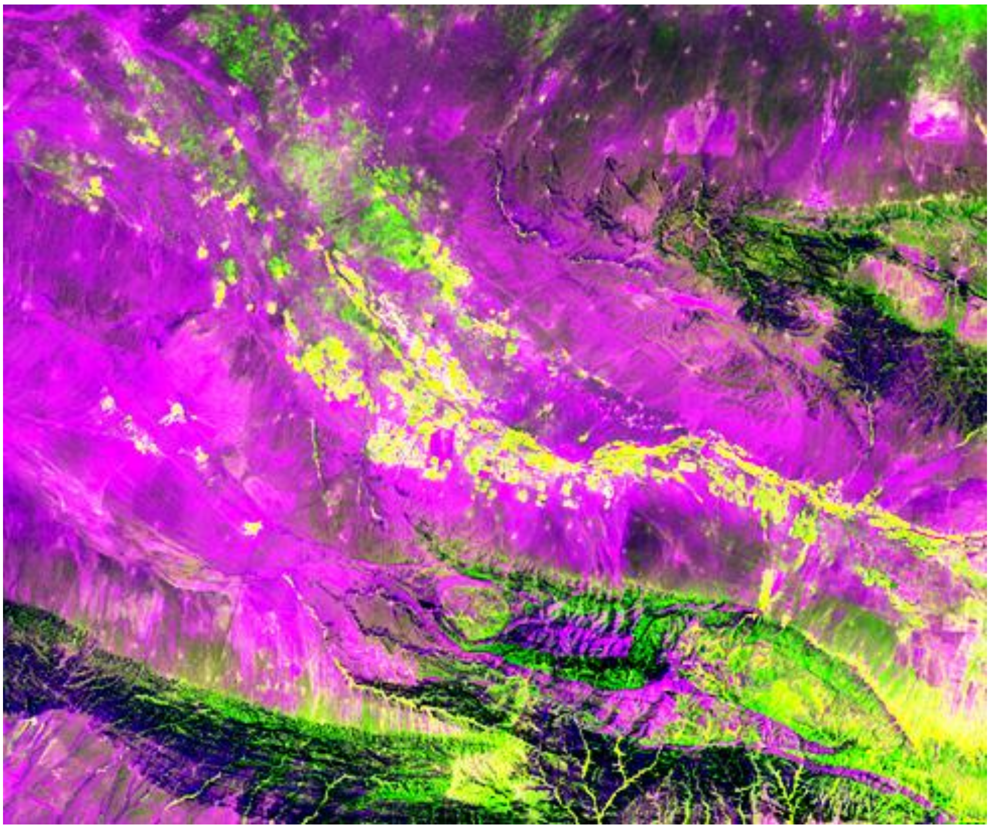

Fig. 3. Color composition obtained by combining the result of NDVI

Processed satellite image the method of ACP was the most informative in the study of the state of pastureland. In the picture (Fig. 4) is represented by dense vegetation cover bright green phototonus, sparse vegetation - dirty-green, and areas with single, sparse vegetation phototonus blue, open soil-red to burgundy footstone, hydrographical - light blue, and piedmont region - red phototonus with dirty green hues.

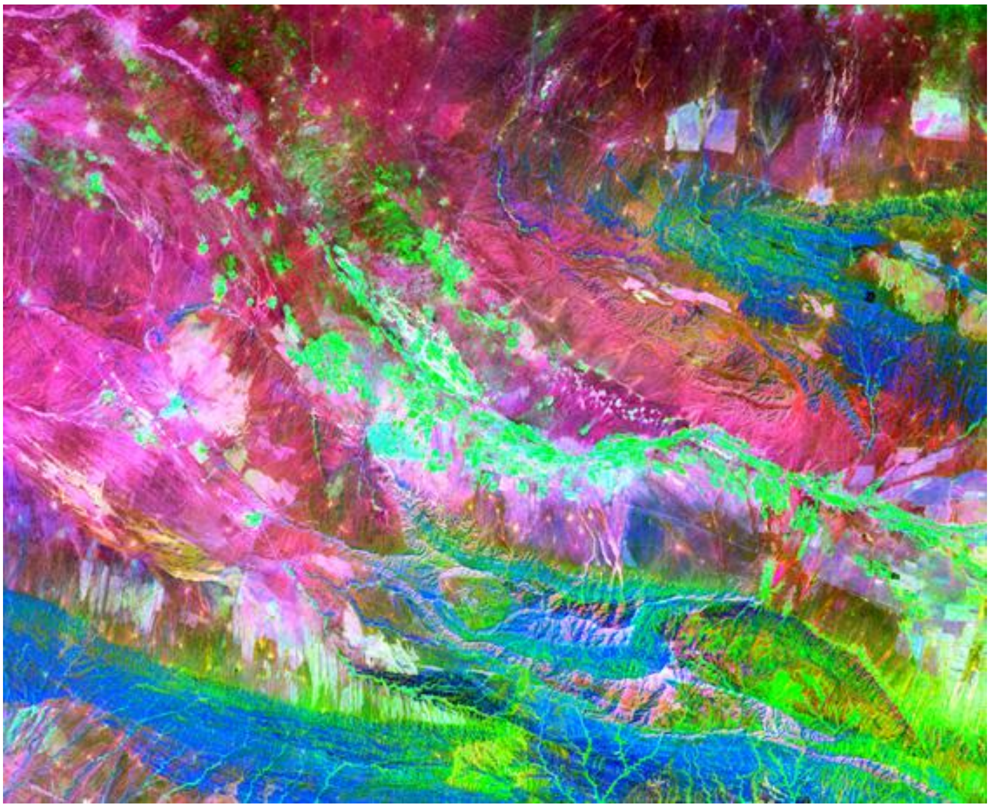

Fig. 4. The result of processing method of principal components

Satellite image of the study area treated the method of supervised classification used method of maximum likelihood. According to the results of the classification of 12 classes, including classes 8 shows vegetation of different height and density, the remaining 4 class are deserted territories (Fig. 5).

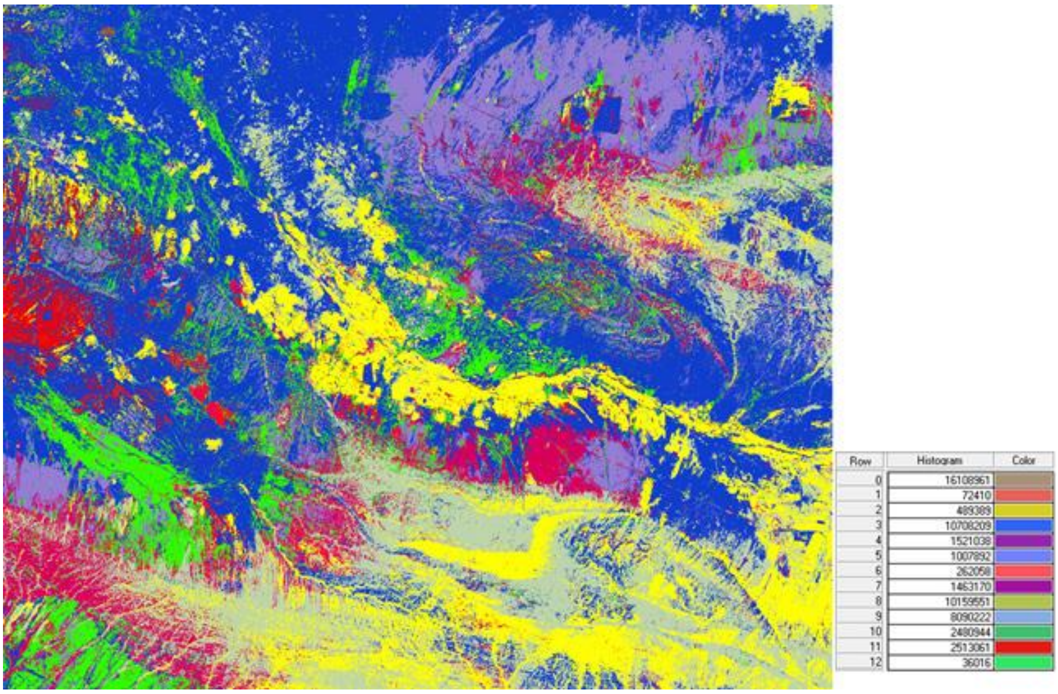

Fig. 5. Result of supervised classification

Based on the processing and analysis of remote sensing data studied vegetation cover the study area, as well as their variety and area distribution. During the fieldwork were tested the results of processing of satellite images in various ways. So on processed satellite images observed various background images and textures, depending on the density, size and height of vegetation.

When working on the ground through observation points are defined for matching specific varieties and forms of vegetation and certain phototonus texture images.

On the basis of processing and the analysis of an interpretation of RS materials and field the of works, is carried out the analysis of a condition of a vegetable cover of postural territories in different seasons.

Thus, these data served as the basis for assessing the status, types and extent of vegetation pastureland. Data can be used to monitor the state of pasture areas, as well as assessment of natural potential study area suitable for pastureland.

References

1. Geoinformatics: 2 Vol. Book. 2: A Textbook for higher educational institution/ ed. VS Tikunova. - 2nd ed. - Moscow: Publishing Center "Academy ", 2008. - 384.

2. Zhilenev M., 2009.Review of the application of multispectral remote sensing data and their combinations in digital processing.Geomatics 3, 42-48.

3. Kashkin B.B,Sukhinin A.I., 2001. Earth remote sensing from space. Digital image processing. Logos,Moscou.

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Vertical and horizontal distribution of heavy metals in a transect in sodic urban soils of Cankırı, Turkey

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Abstract

Heavy metal contents of urban soils should be monitored to avoid their potential health impact on city residents and tourists. Sodic urban soils generally exist in and around Cankırı. These soils have a high potential impact on water and air quality in residential areas due to their well known properties of low water infiltrability and poor soil structure. We evaluated vertical and horizontal distribution of common heavy metals concentrations in these soils. We determined 10 sampling sites on a transect along the highway crossing through the city in NE to SW direction. Each sampling site was sampled at five different soil depths (0-2,5; 2,5-7,5; 7,5-12,5;12,5-17,5; 17,5-30 cm). The concentrations of heavy metals in soil samples were measured using an Inductively Coupled Plasma. The rank of mean heavy metal concentrations was Fe> Mg> Mn> Ni> Cr> Zn> Cu> Ca> Co> Pb> Na>K>Cd>Hg. Concentrations of Mg and Fe were higher than critical values. Concentrations of Mg, Cr, Mn, Fe, Co, Ni, K, and Ca were gradually decreased from NE to SW. Concentration of Hg was far greater in the NE half of the study area than SW half, while concentration of Na was far greater in the SW half of the study area than NE half. Concentrations of Cd, Cu, and Pb showed patchy distribution, and greater Zn concentrations occurred at both ends of the transect compared to values closer to city center. No obvious relation was detected between pH and concentration of any studied heavy metals. In general, horizontal variations of heavy metals were greater compared to their vertical variations. That concentration of Mg was far greater than that of Ca was attributed to the parent materials of the soils, which contains considerable amount of serpentine.

Keywords: Heavy metals, serpentine, Sodic urban soils, public health, Cankırı

Introduction

Impact of heavy metal contamination in urban soils especially on crops, animals and humans is an important environmental problem worldwide. All heavy metals are toxic to these environments when their concentrations exceed the threshold values. In addition, heavy metals have a profound impact on other ecosystems. However limited number of studies have been conducted on their impact on urban soils (e.g; Luo et al. (2012a), Figueiredo et al. (2011), Wang et al. (2010), Grzetic and Ghariani (2008), and Karim and Qureshi (2014).

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Heavy metals are very useful indicators of environmental quality worldwide and are the subject of much attention because of their peculiar characteristics (Odoi et al., 2011). Wei and Yang (2010) reported that pollution sources of heavy metals in environment are mainly derived from anthropogenic sources. However, according to Jung (2001) and Park et al. (2006) heavy metals are released into the environment by both anthropogenic and natural sources. Heavy metals occur in almost all soils naturally, but their concentrations are influenced by human activities such as industry, mining, and agriculture.

The parent material largely influences heavy metals content in many soil types, with concentration sometimes exceeding the critical values (Palumbo et al., 2000; Romic & Romic, 2003; Salonen & Korkka-Niemi, 2007). Heavy metals are found in soils derived from different types of parent material. The natural amounts and compositions of the heavy metals are closely related to their concentrations and compositions in the parent materials. For instance, soils derived from serpentine, are generally rich in Mg and Ni. The ratio of concentration in soil to parent materials may be affected by soil forming factors (climate, topography, vegetation) and processes (translocation, transformation, and transportation).

The physical, chemical, and biological properties of soils affect the mobility and toxicity of these heavy metals to environment. For example, in lower soil pH, the risk of heavy metal toxicity is greater as cation exchange sites of the soil particles are invaded by H^+ (Brady and Weil, 2011) and soils, poor in organic matter content, are prone to release heavy metals as organic matter have a profound sorption capacity of the heavy metals (Sposito, 2008). The mobility of each heavy metal is specific depending on its chemistry (chemical speciation) in soil aqua system and reaction (adsorption-desorption) to soil surfaces. Adsorption isotherms are useful means to describe the adsorption-desorption behavior of heavy metals in soils (Sposito, 2008).

Sodic soils are characterized by their pH>8.5, EC< 4 dS m^{-1} and exchangeable sodium percentage<15. These soils are known with their poor soil physical properties such as extremely low water infiltration and percolation, and extremely poor soil aggregate stability. These soils become extremely hard when they are dry, and sticky and impermeable when they are wet. Soil sodicity is generally caused by irrigation of agricultural lands. However, soils derived from high sodium bearing deposits and rocks in arid, semiarid and, semi humid climates can be highly sodic depending on physical and chemical properties of parent material.

The soils of study area are derived from sodic lacustrine deposits. Their high clay content and pH may immobilize the heavy metals. However, since these soils are completely bare due to their poor physical and chemical properties, they are highly prone to be transported by wind to adjacent city parks, streets, bazaars, and so on, causing health problems. This study aimed at evaluating potential impact of sodic urban soils in Çankırı. For this purpose, vertical and horizontal distribution of common heavy metal concentrations along a transect passing through the city center were mapped. The results showed that distributions of different heavy metals were highly dissimilar in both vertical and horizontal directions.

Material and Methods

Material : The study was carried out in city of Cankırı, located at 40 ° 30' 41 ° North latitude and 32 ° 30' 34 ° East longitudes in the north of Central Anatolia Region of Turkey (Fig. 1). The climate in the region is semi-arid and annual temperature, humidity, and rainfall is 11 °C, 6 %, and 418 mm, respectively. Cankırı is covered with bare mountains and plateaus generally, and soils of city are under threat from soil erosion (Anonymous, 2011). The parent material in the study area is Sodic deposits and weathered serpentine, and soils consist gypsum, andesite, spilite, basalt, marl, clay and limestone in some degree and classified as Sodic Ustorthends.

Figure 1. Location of the study area (Anonyoumus, 2011)

Methods : Soil samples were taken from 10 sampling sites on a transect along the highway crossing the Cankırı city in NE to SW direction. Each sampling site was sampled by five different soil depths (0-2,5; 2,5-7,5; 7,5-12,5;12,5-17,5; 17,5-30 cm). Soil particle–size distribution (Gee and Bauder, 1986), aggregate stability index (Anonymous 2007a), pH and EC (Richard, 1954), soil organic matter content (Walkley and Black method, Jackson, 1967), $CaCO_3$ (Allison and Moodie, 1965), organic matter content and total nitrogen (Steubing 1965) were measured. Heavy metals were measured on extracts of 0.5 gr of the soil samples. The 0.5 g of soil samples were digested in an aqua regia with 8 ml (1:3 HNO: HCl) and dried at 120 °C. Then, HNO_3 (10 ml, 0.5 M) was added to the samples. After filtered through blue band, residue was washed with 10 ml HNO3, and then ultrapure water was added to bring the volume to 50 ml. The concentrations of heavy metals in soil extracts were measured with an Inductively Coupled Plasma. Vertical and horizontal distributions of each studied heavy metal were mapped.

Results and Discussion

The soils are clay with a Ph>8.5, EC <4 dS m^{-1}, and posses very low aggregate stability (Table 1), indicating properties of sodic soils. Contrary to clay content, sand content had a highly negatively skewed distribution. The greatest variation occurred for EC and lowest for pH. These results are compatible to majority of the data reported by others. The aggregate stability is very low and this explains the low hydraulic conductivity of these soils, which results in observed micro landslides under snowmelt and rainfalls.

Table 1. Descriptive Statistics of physical and chemical properties of the soils (N =50)

Soil Properties	Max.	Min	Mean	Std.Dev.	Skewness	Kurtosis	CV%
Sand, %	50	6	10.8	6.24	5.22	32.68	57
Silt, %	24	4	12.4	3.86	0.26	-0.31	32
Clay, %	88	42	76.82	6.98	-2.41	11.68	9.1
Total N, %	0.101	0.024	0.057	0.023	0.366	-0.75	40.2
AS (%)	0.1435	0.0038	0.064	0.040	-0.158	-1.146	62.5
Salt (%)	0.26	0.01	0.066	0.060	1.654	2.109	90.7
pH	10.1	8.9	9.8	0.27	-1.42	2.07	2.8
OM, %	2.02	0.47	1.143	0.462	0.356	-0.75	40.4
$CaCO_3$, %	22.23	4.29	13.761	2.98	-0.52	2.92	21.6
EC(dS/m)	4.53	0.271	1.17	0.98	1.92	3.50	84.1

AS; Agregatte Stability, OM; Organic Matter,EC; Electirical Conductivity

Concentrations of Mg and Fe are greater than their critical values (Table 2). According to Webster (2002), distribuiton of Mg was slighly and of Fe was strongly left skewed. Greatest variation occurred for Cu and lowest for Zn. The variations for heavy metals were generally high. Considerably high right skewed distribuiton occurred for Cu, Cd and Pb, indicating that some high values of these metals occurred in some locations. However, their maxium values indicate these metals do not pose any risks for public health as they are far below their critical tresholds. In general, those possesed greater variaiton tended to distribute nonnormally.

Table 2. Descriptive statistics of soil heavy metal contents in studied soils (N =50)

Soil Properties (mg kg^{-1})	Max.	Min	Mean	Std.Dev.	Skewness	Kurtosis	CV%
Mg	1399	308	840.7	265	-0.172	-0.415	31.5
Cr	73.134	1.60	12.14	24.41	1.60	0.715	2.0
Mn	66.104	15.52	35.75	12.25	0.61	-0.096	34.2
Fe	1511.91	452.5	1122.6	285.9	-1.07	0.44	25.4
Co	1.936	0.37	1.119	0.318	-0.160	0.227	28.4
Ni	12.887	2.91	9.03	2.62	-0.40	-0.81	29
Cu	15.173	0.46	1.938	2.1	5.47	-0.01	108.3
Zn	5.512	1.05	2.85	0.73	-0.010	3.59	25.7
Cd	0.374	0.0026	0.027	0.055	5.25	31.68	200.4
Hg	0.0372	0.0011	0.0092	0.0097	2.03	4.76	105.9
Pb	5.101	0.39	0.95	0.82	3.76	15.65	86.8
Na	0.369	0.0032	0.133	0.084	0.596	-0.219	63.3
K	0.122	0.032	0.077	0.022	-0.532	-0.045	28.3
Ca	2.194	0.62	1.44	0.39	-0.373	-0.338	27.1
Ca/Mg	2.515	1.35	1.76	0.26	0.724	0.514	14.8

The surface maps of studied heavy metals and ratio of Ca/Mg were given in Fig 2-13. Concentrations of Mg, Cr, Mn, Fe, Co, Ni, K, and Ca were gradually decreased from NE to SW. This was attributed to gradual changes in composition of parent materials from North to South. Concentration of Hg was far greater in the NE half of the study area than SW half, while concentration of Na was far greater in the SW half of the study area than NE half. Concentrations of Cd, Cu, and Pb showed patchy distribution, greater Zn concentrations occurred at both ends of the transect compared to values closer to city center. In general, horizontal variations of heavy metals were greater compared to their vertical variations. No obvious relation was detected between pH and concentration of any of studied heavy metals, which is attributed to that the pH is confined in alkalinity.

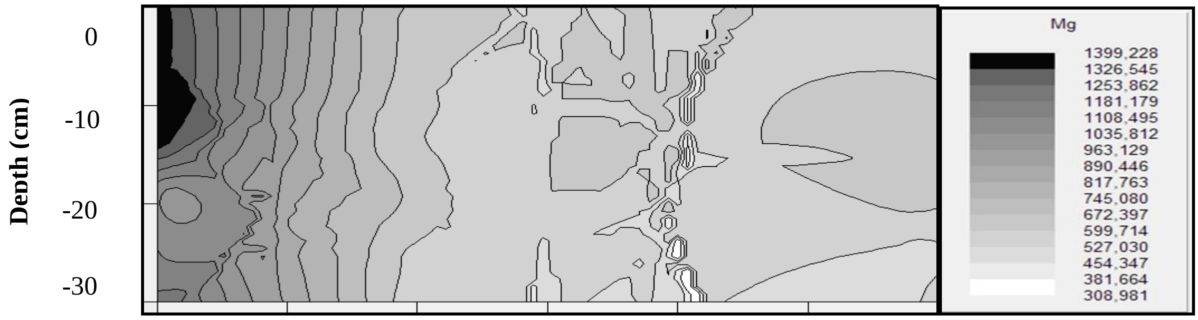

Fig. 2 Surface map of Mg

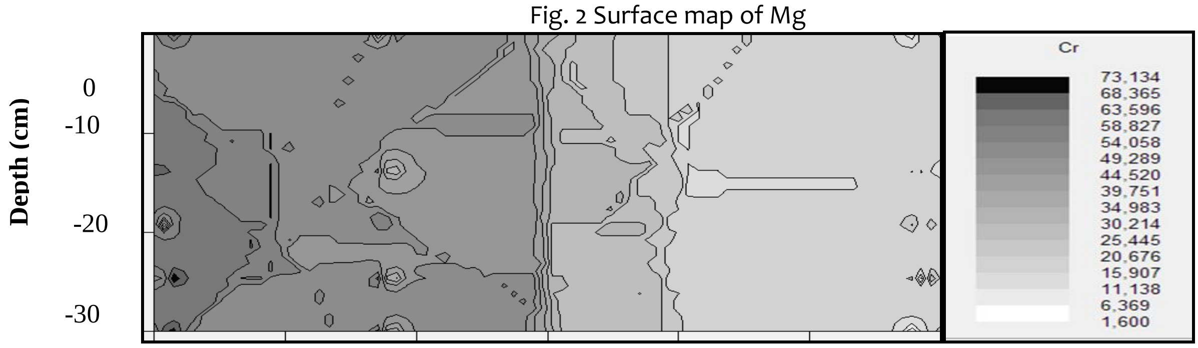

Fig. 3 Surface map of Cr

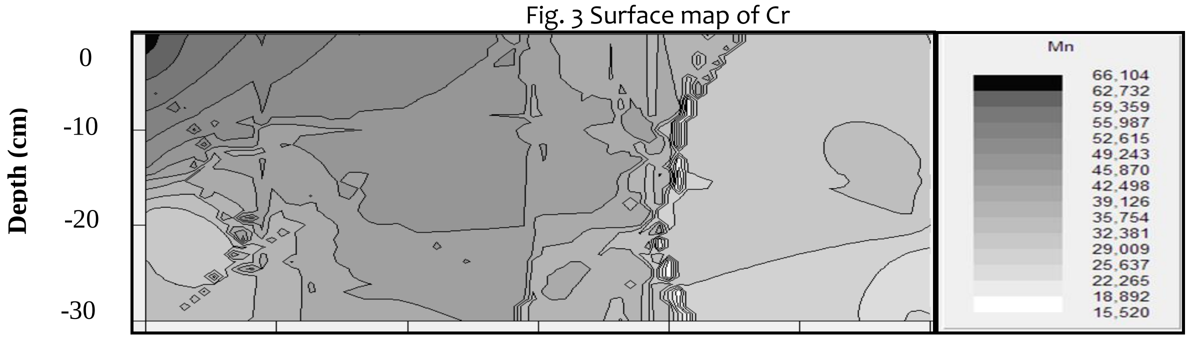

Fig. 4 Surface map of Cr

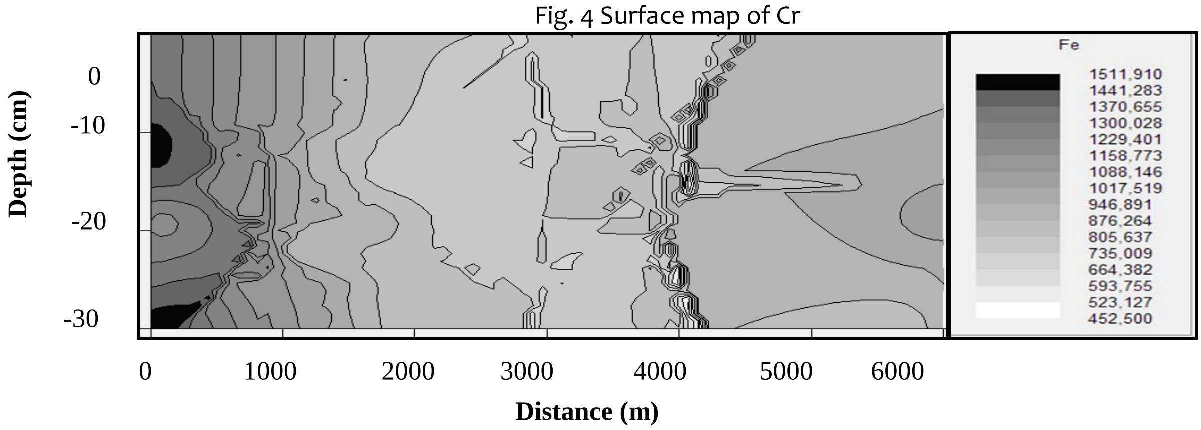

Fig. 5 Surface map of Fe

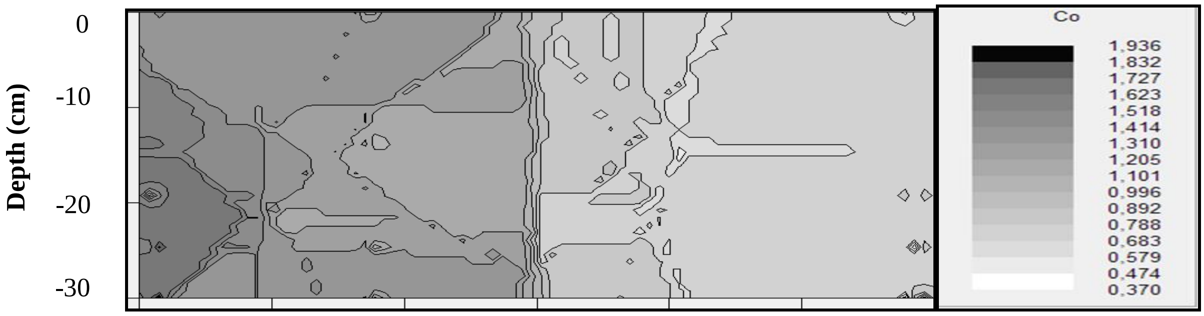

Fig. 6 Surface map of Co

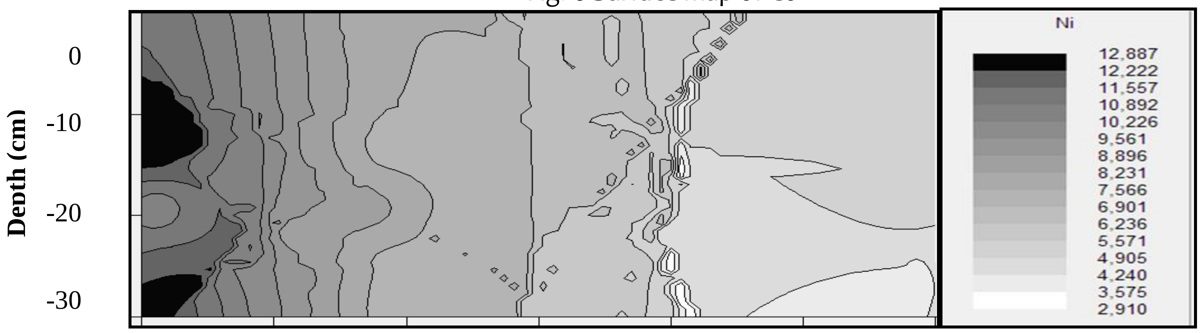

Fig. 7 Surface map of Ni

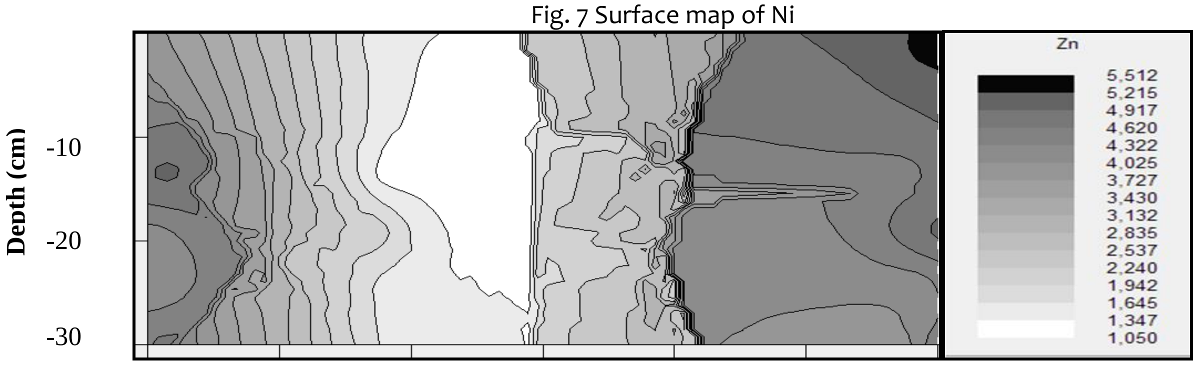

Fig. 8 Surface map of Zn

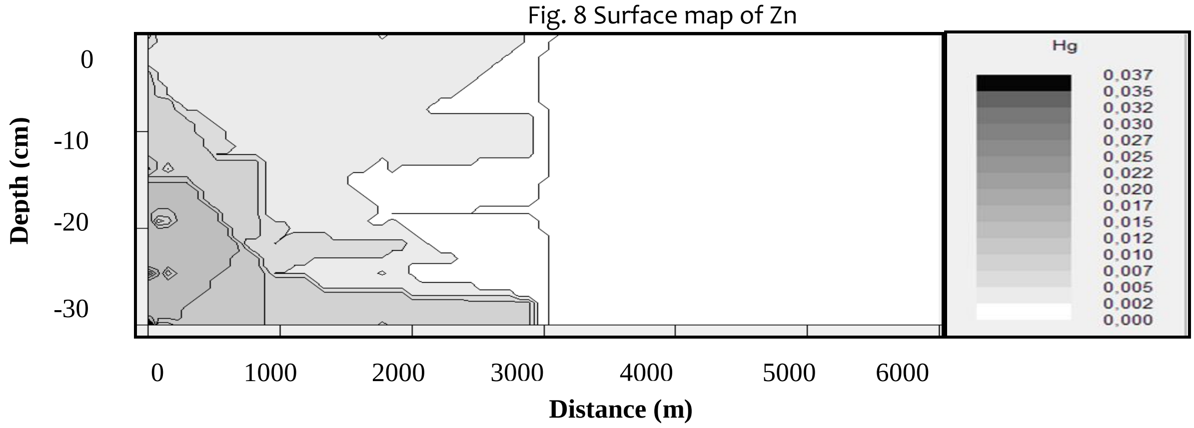

Fig. 9 Surface map of Hg

In heavy metal toxicity evaluations, mean values may be misleading. The extreme values (the maximums) should be considered. Local spatial patterns of heavy metal concentrations should be considered in urban expansion planning. The city is spreading to both sides. The excavated soils in new construction areas are transported and dumped other areas or used as sealing material in other locations of the city, causing serious contaminations of these metals. These soils are bare since those plants cannot survive in the extremely poor physical and chemical properties and this makes these soils extremely vulnerable to be transported by wind to the nearby bazaars, streets, and city parks. That is why the city experiences very high dust pollutions especially during the summer time. The topography of the studied soils is sloping, undulating, and highly irregular in slope steepens, slope type (concave, convex, linear, etc.), and slope aspect. Due to the impermeability, micro landslides are common. Material moving down slope reaches to nearby streams. Since water of these streams is used for irrigation (for irrigating rice) transported heavy metals pose a significant soil and food contamination risks in those areas.

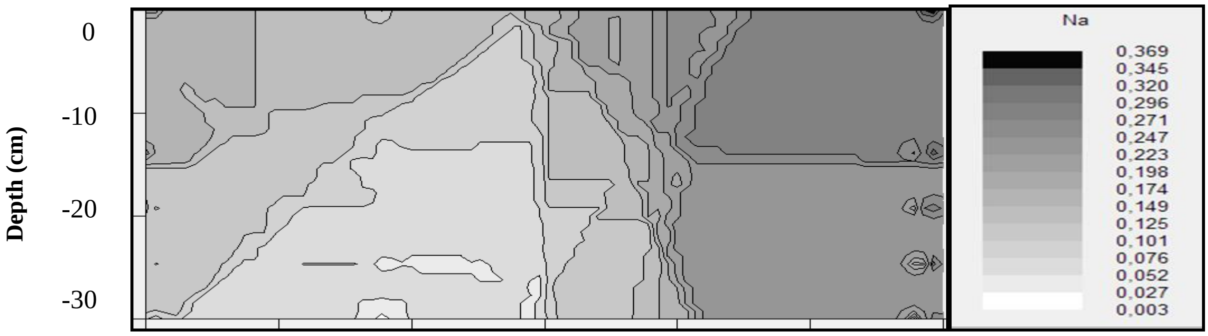

Fig. 10 Surface map of Na

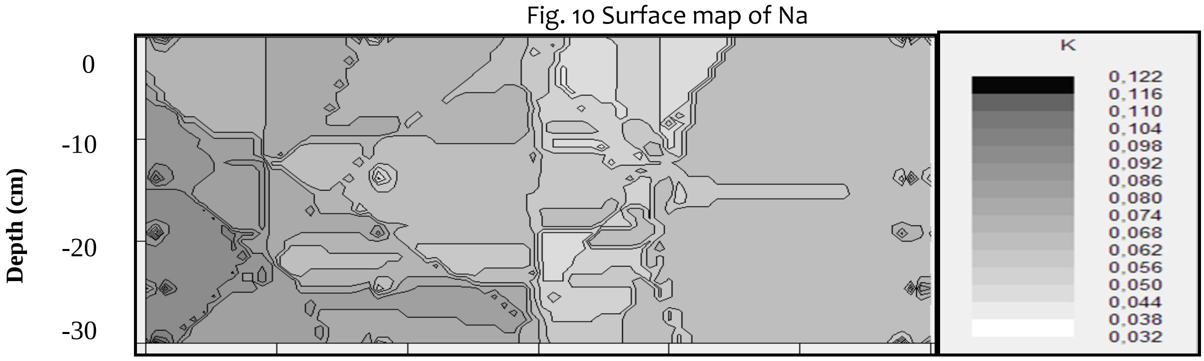

Fig. 11 Surface map of K

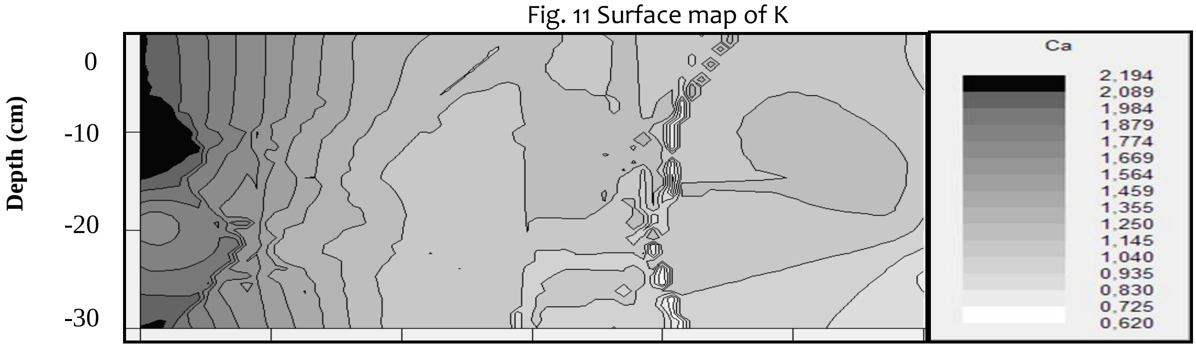

Fig. 12 Surface map of Ca

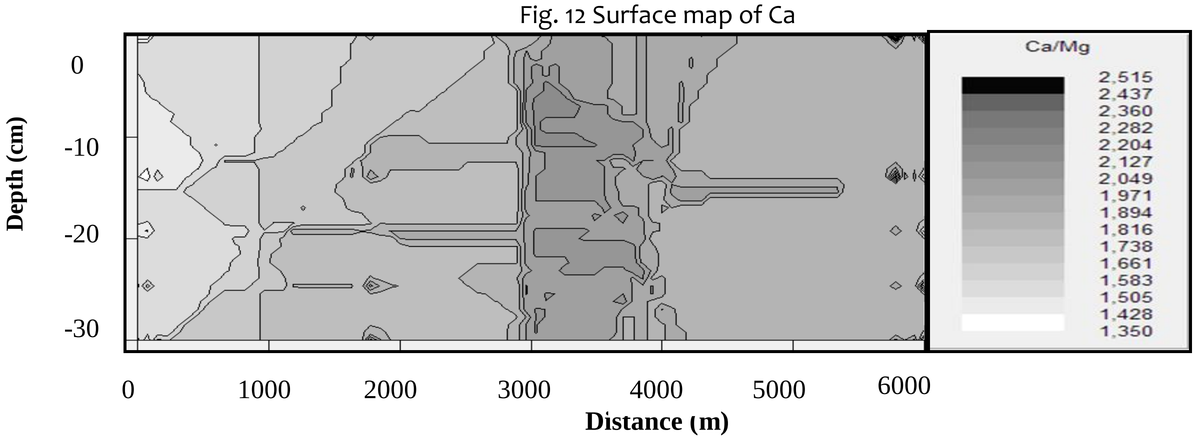

Fig. 13 Surface map of Ca/Mg

The impact of the studied heavy metals should be mitigated. Unfortunately, high soil sodicity does not allow these areas are vegetated. In the past, many attempts were made to afforest/vegetate these soils, and all these attempts were unsuccessful. Expansions of the city in all directions is inevitable, therefore, the excavated material should be handled very carefully and stored in safe areas to avoid contamination of the studied heavy metals. In other areas, the land may be left untouched or some special plantation techniques may be used to vegetate these areas. Some sodicity tolerant grasses and bushes may be used in plantations. However, the chemical, biological and physical properties of these soils should be considered carefully before any action to be taken for plantations. For example, some of these soils derived from serpentine and gypsum rocks and this may further obstruct adaptation of the plants to these localities. Since soils are considerably variable in parent material, plants species, plantations should be done site specifically. Low precipitation and high evapotranspiration result in parent materials dominate soil properties and relatively uniform accumulation of heavy metals by depth.

Low Ca/Mg ratio is typical indicator of serpentine (Schetzl and Anderson, 2005). Our low Ca/Mg ratio showed that the parent material of studied soils possesses serpentine in some degree. In general, soils derived from serpentine in arid and semi-arid regions are poor in organic matter and low in cation exchange capacity (CEC) (O'Dell and Claassen, 2009).

Conclusion

We studied horizontal and vertical distribution of Mg, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, Hg, Pb, Na, K, and Ca/Mg along a 7-km transect in Çankırı, North central Anatolia, Turkey. Their vertical and horizontal spatial distribution showed that concentrations of these heavy metals are principally controlled by their geologic origin since their spatial pattern exhibited prominent extremes and discontinuities. Surface maps showed that concentrations of Fe and Mg exceeded their critical thresholds along the transect. These soils are highly vulnerable to water and wind erosions. Care should be taken to protect city and nearby streams from pollution of these metals. The city is spreading in both directions. Therefore, the excavated material in construction areas should be handled carefully and stored in safe places to avoid environmental hazard of the heavy metals (especially Fe and Mg). Spatial distribution of these metals should be considered in planning future urbanizations.

References

Allison, L.E.A.M., C.D., 1965. Carbonate. In: Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties.

Anonim, 2007a. www.fao.org

Anonyoumus, 2011. Çankırı İl Çevre Durum Raporu. In: T.C.Ç.V.Ç.V.Ş.İ. Müdürlüğü (Editor). T.C.Çevre ve Şehircilik Bakanlığı, Çankırı.

Brady, NC. and Weil, RR., 2011. The Nature and Properties of Soils.

Figueiredo, A., Tocchini, M. Dos Santos, T., 2011. Metals in playground soils of Sao Paulo city, Brazil. Procedia Environ Sci (4): 303-9.

Gee, G.W., Bauder, J.W., 1986. Particle-size analysis. p. 383–411. In A. Klute (ed.) Methods of soil analysis. Part 1. 2nd ed. Agron. Manag. 9. ASA and SSSA, Madison, WI.

Grzetic, I.A.G., HA, R., 2008. Potential health risk assessment for soil heavy metal contamination in the central zone of Belgrade (Serbia). J Serb Chem Soc, 73: 923–34.

Jackson, M.L., 1967. Soil Chemical Analysis. Prence Hall Inc. Englewood Cliffs, N.J. USA.

Jung, M., 2001. Heavy metal contamination of soils and waters in and around the Imcheon Au-Agmine, Korea. Applied Geochem (16), 1369-1375.

Karim, Z., Qureshi, A., 2014. Health Risk Assessment of Heavy Metals in Urban Soil of Karachi, Pakistan. Human and Ecological Risk Assesment: An International Journal. Volume 20, Issue 3.

Luo, X.S., Dinga, J., Xu, B., Wang, Y.J., Li, H.B., Yu, S., 2012. Incorporating bioaccessibility into human health risk assessments of heavy metals in urban park soils. Science of the Total Environment, 424: 88-96.

O'Dell, R., & Claassen, V., 2009. Serpentine Revegetation: A Review. Soil and Biota of Serpentine: A World View Northeastern. Naturalist 16(Special Issue 5), 253-271.

Odoi , J., Armah, F., & Luginaah, I., 2011. Assessment of Spatıal Varıabılıty of Heavy Metals in Soıls Under The Influence of Industrıal Soap and Detergent Waste Water Discharge. IJRRAS 9(2).

Park, J., Lee, J., Lee, J., Chon, H., & Jung, M., 2006. Microbial effects on geochemcal behavior of arsenic in As-contaminated sediments. J. Geochem. Explo(88), 134-138.

Palumbo, M. E., Strazzulla, G., Pendleton, Y. J., & Tielens, A. G. G. M. 2000, *ApJ*, **534**, 801.

Romić M., Romić, D., 2003. Heavy metals distribution in agricultural topsoils in urban area. Environ. Geol., 43(7), 795-805.

Salonen, V., Korkka-Niemi, K., 2007. Influence of parent sediments on the concentration of heavy metals in urban and suburban soils in Turku, Finland, Applied Geochemistry, 22, 906–918.

Sposito, G., 2008. The Chemistry of Soils. Second Edition. Oxford University Press,

Stebing, L., 1965. Pflanzenökologisches Praktikum. Berlin-Hamburg: Parey 1965.

Wei, B., Yang, L., 2010. A review of heavy metal contaminations in urban soils, urban road dusts and agricultural soils from China. Microchemical Journal, 94(2): 99-107.

Wang, J., Shourong, Z., Shao, Y., Liu, J., XU, Z., Zhu, D., 2010. Amino-functionalized $Fe_3O_4Sio_2$ core-shell magnetic nanomaterial as a novel adsorbent for aqueous heavy metals removel. Journal of Colloid and Interface Science 349: 293-299.

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Predicting saturated hydraulic conductivity by soil parameters and morphological properties

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Abstract

Many studies have been conducted to predict soil saturated hydraulic conductivity (K_s) by parametric soil properties such as bulk density, particle-size distribution, porosity, and pore-size distribution. Although soil morphological properties have a strong effect on K_s, studies predicting K_s by soil morphological properties such as type, size, and strength of soil structure; type, orientation and quantity of soil pores and roots; consistency; and plasticity are rare. This study aimed at evaluating soil morphological properties to predict Ks. The study was conducted on paddy soils and adjacent grasslands on Kızılırmak Township (near the town) of Cankırı Province. Undisturbed soil samples (15 cm length and 8.0 cm id.) were collected at sixty randomly selected sampling sites from topsoil (0-15 cm) and subsoil (15-30 cm) (120 samples) with a tractor operated soil sampler. Synchronized disturbed soil samples were taken from the same sampling sites and depths for basic soil analyses. Saturated hydraulic conductivity was measured on the undisturbed soil columns using a constant-head permeameter. Following the K_s measurements, the soil columns were left to drying to field capacity and penetration resistance was measured on the columns, then the soils were disturbed and morphological properties of soil (soil structure, pores, roots, consistency, plasticity, and stickiness) were described by standard soil description charts used in soil survey studies. In addition, soil texture, percent gravel, bulk density, pH, field capacity, wilting point, cation exchange capacity, specific surface area, aggregate stability, organic matter content, and calcium carbonate were measured on the synchronized disturbed soil samples. The K_s was predicted from the soil morphological properties by stepwise multiple linear regression analysis. Contributions of soil structure class, stickiness, pore-size, root-size, and pore-quantity contributed to the Ks prediction significantly. Soil morphological properties, readily available in soil survey databases, may be used along with basic soil properties in predicting K_s.

Keywords: Saturated hydraulic conductivity, morphological properties, multiple regressions analysis, Pedotransfer Functions.

Introduction

Soil is a complex system, comprising solid, liquid and gas phases. The liquid and gas phase fill the pores which located between the solid portions. The water in these pores moves continuously by the action of evaporation, precipitation or gravitational forces even though its speed is very slow. The driving force of soil water movement is potential difference exerted from differences in water potential at different regions in soil. But, factor which determines the rate of the movement is hydraulic conductivity. Therefore we need to

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investigate the complex interactions between soil properties and K_s to correctly understand the water flow in soils.

Soil hydraulic properties vary spatially and temporally and direct measurement of these properties is both time-consuming and expensive. Therefore indirect methods such as Pedotransfer Functions (PTF's) have been used frequently to predict soil hydraulic properties.

Hydraulic conductivity is one of the most commonly used properties in PDFs. In fact, knowing the relationship between hydraulic conductivity and other soil properties are very useful for explaining movement of the water in the soil. Soil physical and chemical properties such as bulk density, organic matter content, porosity, and pore-size distribution are used quite a lot to model soil saturated and unsaturated hydraulic conductivity.

Soil morphologic properties such as soil structure features, soil pores, and roots may strongly control the saturated water flow in soils. Pachepsky et al. (2008) reported that since soil structural properties are closely related to functional hydraulic parameters, including them in the list of PTF's inputs may substantially improve the hydraulic parameter estimates. However, use of morphological properties in modeling saturated hydraulic conductivity has been ignored for a long time.

'Recent trends in PTF's research however indicate attempts to expand methods and data collections to better link hydraulic properties to morphological properties. An earlier attempt to bring structural parameters from the horizon/pedon scale to improve predictions of soil hydraulic properties at the aggregate/ped scale was generally unsuccessful' (Abbaspour and Moon, 1992; Pachepsky and Rawls, 2002)." More recently, however, Lilly et al. (2008) showed that field collected qualitative type morphological indicators can be equally good predictors of some hydraulic properties as commonly used laboratory data" (Pachepsky, et al., 2008).

Soil morphological features, particularly those pertaining to structure may explain some variations between field-measured hydraulic properties and theoretically calculated or laboratory determined values (Sharma and Uehara, 1968; Keng and Lin, 1982; Field et al., 1984; Bouma, 1992). Saturated hydraulic conductivity can also be related to soil morphological criteria based on the expert assessment (McKenzie et al., 2000). The aim of this study was predicting the saturated hydraulic conductivity by soil morphologic properties.

Material and Methods

Material

This study was carried out on a paddy soils and adjacent grasslands (total 9-ha) in Kızılırmak Township in Cankırı Province. The city of Cankırı is located 40° 30' 41° North latitude and 32° 30' 34° East longitudes in the north of Central Anatolia Region of Turkey (Fig. 1). The climate in the region is semi-arid and annual temperature, humidity, and rainfall is 11 °C, 64%, and 418 mm respectively. Cankırı is surrounded by bare mountains and plateaus (Anonymous, 2011). The parent material within the study area comprises gypsum, andesite, spilite, basalt, marl, clay, and limestone and classified as Gypsic Ustorthends.

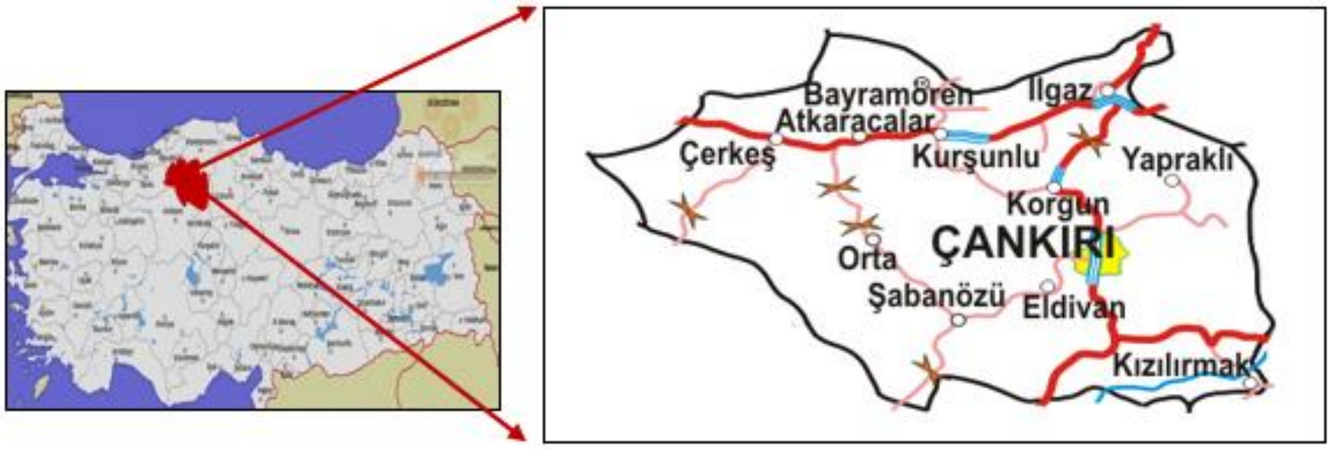

Figure 1. Location of the study area on Turkish Map (Anonyoumus, 2011)

Method

Undisturbed soil samples (15 cm length and 8.0 cm id) were taken from topsoil (0-15 cm) and subsoil (15-30 cm at randomly selected sixty sampling points) (Fig. 2) with a sampling apparatus

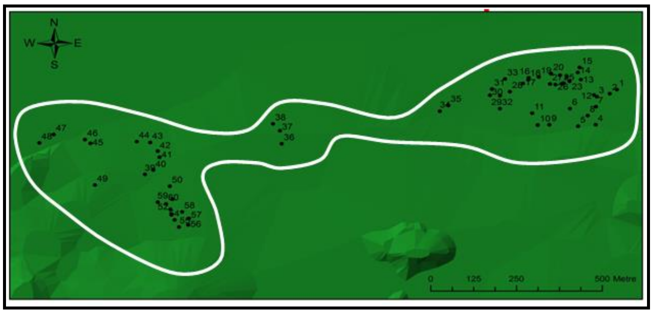

Figure 2. Soil Sampling Points

Saturated hydraulic conductivity (K_s) was measured on the soil columns using a constant-head permeameter (Klute and Dirksen, 1986). Following the K_s measurements, the undisturbed samples were left drying for three days and then were used to measure penetration resistance.

A 100 cm^3 sample was taken by a steel cylinder for bulk density measurement and the rest of the sample was disturbed and used for diagnosis of morphological properties. Basic soil properties were measured on disturbed soil samples taken concomitantly with undisturbed samples. Bulk density (Blake and Hartge, 1986), particle–size distribution (Gee and Bauder, 1986), aggregate stability index (Anonymous 2007a), field capacity and wilting point (Klute, 1986), soil skeleton (Soil Survey Staff, 1951), pH (Page et al., 1982), specific surface area (Carter et al., 1986), soil organic matter content (Page et al., 1982), cation exchange capacity (Page et al., 1982), $CaCO_3$ (Page et al., 1982), and Coefficient of Linear Extensibility; COLE (Schafer and Singer, 1976) were measured on the samples.

Soil morphological properties (structure, pores, consistence, stickiness, plasticity, roots, and mottles) were described with standard soil description charts used in soil survey studies. The morphological properties and soil colors were converted into numerical values. The strategy "greatest is the best" was applied in coding, depending on the relationship between K_s and subjected property (Tables 1-7).

Table 1. The criteria applied to soil color coding (Munsell Color Skala)

Soil Color	Code	Soil Color	Code	Soil Color	Code	Soil Color	Code
Gley	1	7.5 YR 4/2	3	7.5 YR 5/2	4	7.5 YR 6/2	5
7.5 YR 3/2	2	7.5 YR 4/3	3	7.5 YR 5/3	4	7.5 YR 6/3	5
7.5 YR 3/3	2	7.5 YR 4/4	3	7.5 YR 5/4	4		
7.5 YR 3/4	2						

Soil structure was coded according to type, size, and grade and code numbers was given (Table 2).

Table 2. Type, Grade and Size Class Criteria applied to coding soil structure (Field Book for Describing and Sampling Soils, 2002)

Type	Code	Grade	Code	Size (mm)	Code	GranularPlaty	Block-Angular Sub angular
Masive	1	Structureless	1	Very Thin	1	< 1	< 5
Platy	2	Weak	2	Thin	2	1 - <2	5 – <10
Prismatic	3	Moderate	3	Medium	3	2 – <5	10 – <20
Blocky Angular	4	Strong	4	Coarse	4	5 – <10	20 – <50
Blocky Sub-angular	5	Very Strong	5	Very Coarse	5	≥10	≥50
Granular	6			Extra Coarse	6	-	-
Single Grain	7						

Pores in soil samples were classified according to quantity, size, and type and code numbers was given (Table 3).

Table 3. Criteria applied to coding soil pores (Field Book for Describing and Sampling Soils, 2002)

Quantity	Code	(dm^2)	Size	Code	(mm)	Type	Code
Few	1	1-50	Micro	1	< 0,075	Irregular	1
Common	2	50-200	Very fine	2	0,075-1	Vesicular	2
Many	3	>200	Fine	3	1-2	Dendritic Tubular	3
			Medium	4	2-5	Tubular	4
			Coarse	5	5-10	Interstitial	5
			Very Coarse	6	≥ 10		

Resistance to breakage of soil samples were estimated for block/pad/part shaped soils. Parts of soil samples with size about 3 cm were chosen, and strength was evaluated by applying pressure to crash the aggregate and then consistency was evaluated according to Table 4.

Table 4. Consistency Classification Criteria of Soil Samples (Field Book for Describing and Sampling Soils, 2002)

Consistency	Code	Definition
Loose	5	There is no adhesion between grains.
Soft	4	Adhesion between grains is weak, it becomes powder with light pressure.
Lightweight Hard	3	Soils breakable and disintegrate with light pressure
Hard	2	It is quite resistant to pressure, crushed difficultly between the fingers, and it breakable in the palm.
Very Hard	1	It is very durable to pressure, not breakable between the fingers, and hardly breakable in the palm.

Soil stickiness was determined at soil moisture slightly above field capacity. Stickiness was observed on the sample squeezed between thumb and forefinger and classified according to degree of adhesion (Table 5). Soil plasticity was determined at field capacity; soils were formed into yarns with different diameters. The strength of yarns were evaluated according to the state to support when was standed with approximately 45 degree with vertical (Table 6).

Table 5. Criteria applied coding stickness (Field Book for Describing and Sampling Soils, 2002)

Stickiness	Code	Definition
Not sticky	1	Soil does not stick when squeezed between the fingers.
Stickiness	2	Soil sticks to a finger
Light Stickiness	3	Soil sticks to two fingers and mud elongate slightly when fingers opened
Very Stickiness	4	Soil sticks firmly to fingers and mud extend in certain ways when fingers opened

Table 6. Criteria applied coding plasticity (Field Book for Describing and Sampling Soils, 2002)

Plasticity	Code	Definition
Not Plastic	1	Soil does not form yarn.
Lightweight Plastic	2	Soil forms yarn, but easily breaks
Plastic	3	Soil forms yarn, and it resist somehow against breaking
Very Plastic	4	Soil forms yarn and it resists agains breaking

Roots in soil samples were classified according to their quantity and size, and code numbers were given (Table 7). Mottles of soil samples were evaluated according to percentage of the soil surface coating and they were coded in three classes (Table 7).

Table 7. Criteria applied to coding root and mottles in soil samples (Field Book for Describing and Sampling Soils, 2002)

Root Quantity		Code	Root Size		Code	Mottle Quantity	Code	Mottle Percentage (%)
Not or Few	<1	1	Very Thin	<1mm	1	Not or Few	3	%2
Common	1-5	2	Thin	1-2mm	2	Common	2	%2 - % 20
Many	>5	3	Medium	2-5 mm	3	Many	1	≥% 20
			Coarse	5-10 mm	4			
			Very Coarse	>10 mm	5			

Saturated hydraulic conductivity (K_s) was predicted by stepwise multiple linear regression technique. Coded values of soil morphological properties given in Tables 2-7 were used as independent variables and measured values of K_s were used as dependent variable. Independent variables, which significantly ($P<0.05$) contributed the prediction of K_s were selected as predicting variables.

Results and Discussion

Descriptive Statistics

Descriptive statistics of to the physical and chemical properties of the studied soils were presented in Table 8. Greatest variation occurred for K_s and lowest for pH. These results agreed to those reported in literature (Mulla and McBratney (2002). Most of the soil properties exhibited medium variation, and this agreed to those reported by many different authors. Unexpectedly, soil textural components exhibited somehow greater variations than commonly reported values in the literature. We attributed this to that the study area is highly variable in topography and to that soils have been derived from alluvial and colluvial parent materials.

Table 8. Statistics of some physical and chemical properties of the studied soils (N =120)

Soil Properties	Max.	Min.	Mean	Std.Dev.	CV%
K_s, cm/h	2.71	0.0036	0.834	0.66	79
Sand, %	74.17	1.49	27.91	17.31	39
Silt, %	65.54	4.89	26.25	10.50	38
Clay, %	82.7	6.18	45.83	17.89	40
ρ_b, gr/cm^3	1.62	1.06	1.25	0.09	08
PR, MPa	220.0	25.0	109.0	50.5	46
SSA, m^2/gr	284.8	82.1	204.2	47.1	23
CEC, meg/100 gr	73.8	21.8	55.1	8.36	15
COLE, %	9.8	4	8.17	1.50	18
FC, %	43	20	35.2	6.63	19
WP, %	31.0	8.0	23.1	6.52	28
pH	9.77	6.7	8.40	0.47	6
AS	0.589	0.187	0.49	0.038	8
OM, %	7.98	0.40	4.13	1.29	31
$CaCO_3$, %	24.15	5.10	15.23	4.26	28

K_s: Saturated hydraulic conductivity, ρ_b: Bulk density, PR: Penetration resistance, SSA: Spesific surface area,CEC: Cation exchange capasity, COLE: Soil expantion coefficient, FC: Field capacity, WP: Wilting point, ASI: Agregatte stability index, OM: Organic matter

Relations between soil morphological properties and Ks were analyzed by correlation analysis (Table 9). Greatest correlation occurred between Ks and Structure grade (Table 9). Stickiness consistency, and plasticity correlated to Ks negatively and others positively. Majority of studied soil morphological properties correlated to Ks with a high correlation coefficient.

Table 9. Pearson correlation coefficient between soil morphological properties

	Ks	Structure Grade	Stickiness	Pore Size	Plasticity	Pore Quantity	Consistency	Structure Size	Structure Type	Root Size
Structure Grade	0.938									
Stickiness	-0.937	-0.926								
Pore Size	0.926	0.920	-0.913							
Plasticity	-0.918	-0.918	0.963	-0.923						
Pore Quantity	0.909	0.911	-0.889	0.913	-0.921					
Consistency	-0.901	-0.894	0.928	-0.916	0.958	-0.913				
Structure Size	0.891	0.904	-0.911	0.862	-0.927	0.888	-0.894			
Structure Type	0.802	0.748	-0.857	0.759	-0.829	0.737	-0.779	0.802		
Root Size	0.485	0.417	-0.477	0.436	-0.404	0.337	-0.369	0.270	0.396	
Root Quantity	0.469	0.426	-0.488	0.423	-0.414	0.318	-0.378	0.307	0.404	0.898

Strongly correlated morphological properties were used in stepwise multiple regression analysis to predict Ks. This resulted Eq. (1). Results showed that soil structure grade, stickiness, pore size, root size, and pore quantity were contributed to the Ks prediction significantly. Structure grade described the greatest variation (88%) in Ks, followed by stickiness, pore-size, root-size and pore-quantity.

$$Ks = 0.343 + 0.200\,(\text{Structure Class}) - 0.122\,(\text{Stickiness}) + 0.0846\,(\text{Pore Size}) + 0.0802\,(\text{Root Size}) + 0.163\,(\text{Pore Quantity}) \quad (1)$$

Eq. (1) predicted Ks extremely well as indicated by high coefficient of variation ($R^2 > 0.93$, $P<0.001$). The Eq. (1) described 93% of the total variation in Ks. Soil structure grade described greatest variation in K_s, followed by stickiness and other listed variables. To evaluate the prediction success of the obtained regression equation, measured values and predicted values of Ks were correlated and related to each other by a 1:1-line (Fig. 3).

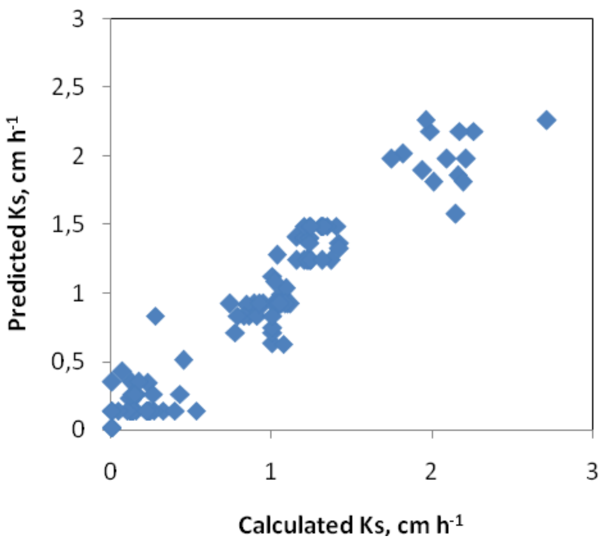

Figure 3. Relationship between measured and calculated Ks values

The resultant correlation coefficient was 0.96 with $P<0.001$ and as shown in the Fig.3, the measured and predicted values of Ks coalesced closely around the 1:1-line. This suggested that soil morphological properties may be adapted to predict Ks besides soil parametric variables.

Type, size, spatial orientation, and arrangement of soil pores have significant influence on Ks (Beven and German, 1982). Water flow is faster in inter-granular pores in granularly structured soils. Water flows easily through inter-aggregate pores in spherical features. In addition, preferential flow is common in structured saturated soils. Presence of root channels and earthworm channels easies saturated water flow in soils. Water flow in sandy soils is generally higher; however, comparable high Ks values were reported in structured clay soils due structural features such as cracks and large inter-aggregate openings. Soil clay content and clay type have considerable influence on soil structure and pore geometry, which in turn affects K_s.

When the solid phase is in the form of aggregates, pores between aggregates (inter-aggregate) is important for soil saturated hydraulic conductivity. Intra-aggregate pores are not as important as inter-aggregate pores in Ks since water flow very slowly in narrow intra-aggregate pores. In general, total porosity increases with soil clay content as there are many pores between fine soil particles. However, most of these pores are small in size and hold water very tidily. Contrary to intra-aggregate pores, inter aggregate pores, the pores which can be observed easily in soil morphology studies, amplify water flow in saturated soils. Our results showed a significant positive correlation between inter-aggregate pore quantity and Ks (Eq.1).

Water flow is very slow in swelling soils due to that the porosity decreases substantially as a response to swelling. Boivin et al. (2004) reported that shrinkage capacity of the soil increases with clay content and that this is related to clay type, pore size, and moisture content. The effect of soil clay content are very similar on the soil plasticity and soil stickiness since the point of stickiness usually lies above the upper plastic limit on the moisture scale (Baver, 1956). Stickiness is greater in soil rich in high activity clays such as montmorillonite and vermiculite. Our results showed that, expectedly, soil stickiness had a significant negative effect on Ks.

Plant roots generally amplify water flow in saturated soils since water flows rapidly in between walls of roots and soil particle surfaces. Our results revealed that root size helped significantly to predict Ks and that a positive relation occurred between root size and Ks.

Saturated hydraulic conductivity (Ks) is one of the most important soil hydraulic properties. Saturated hydraulic conductivity depends on many soils parametric (clay, sand, silt, organic matter contents; soil specific surface area, skeleton content, cation exchange capacity, soil sodicity and electrolyte concentration of soil solution; and morphological properties such as soil structure, soil porosity and pore geometry, macrospores and roots, and soil thickness and consistency. In Ks modeling studies, soil parametric variables are generally preferred. However, it's well known that a slight change in soil structure has a considerable impact on Ks since Ks is strongly controlled by soil pores and their geometry and spatial orientations in soils. Our results showed significant relations between Ks and soil morphologic properties of structure type and class, root size, pore quantity, and stickiness and that these variables predicted Ks successfully in paddy and adjacent grassland soils by stepwise multiple regression analysis. The results were highly promising, suggesting that soil morphological properties can be used besides soil parametric variables in Ks modeling studies. Further studies are needed across different soil and management conditions to adapt use of soil morphology in Ks modeling.

References

Abbaspour, K. and Moon, D., 1992. Relationships between conventional field information and some soil properties measured in the laboratory. Geoderma, 55(1-2): 119-140.

Anonim, 2007a. www.fao.org

Anonyoumus, 2011. Çankırı İl Çevre Durum Raporu. In: T.C.Ç.V.Ç.V.Ş.İ. Müdürlüğü (Editor). T.C.Çevre Ve Şehircilik Bakanlığı, Çankırı.

Baver, LD., 1956. Soil Physics. Third Edition. John Willey& Sons, Inc., New York

Beven, K. and Germann, P. 1982. 'Macropores and water flow in soils', Water Resour. Res. 18, 1311-1325.

Blake, G.R., Hartge, K.H., 1986. Bulk density. In: Methods of soil analysis. Part I, 2nd edn (ed. A.Klute), pp. 363-373. Agron. Monogr. 9. ASA, Madison, WI.

Boivin, P., P.P. Garnier and D. Tessier, 2004. Relationship between clay content, clay type and shrinkage properties of soil samples. Soil Sci. Soc. Am. J., 68: 1145-1153.

Bouma, J.1992. Effect of Soil Structure, Tillage, and Aggregation upon Soil Hydraulic Properties. Book Chapter. Interacting Processes in Soil Science (Ed; RJ Wagenet, P Baveye, BA Stewart).

Carter, D.L., Mortland, M.M., Kemper, W.D.1986. Specific Surface. Book Chapter 16. Eprints.nwisrl.ars.usda.gov.

Gee, G.W., and J.W. Bauder. 1986. Particle-size analysis. p. 383–411. In A. Klute (ed.) Methods of soil analysis. Part 1. 2nd ed. Agron. Manag. 9. ASA and SSSA, Madison, WI.

Klute, A., Dirksen, C., 1986. Hydraulic conductivity and diffusivity: laboratory methods. In. Klute A (Ed) Methods of soil analysis, Part 1. Madison, 687-734; Am Soc Agron.

Klute, A., 1986. Methods of soil analysis, part 1: physical and mineralogical methods, 2nd edn. Monogr. 9. ASA and SSSA. Madison, WI, 1188 pp.

Lilly, A, Nemes, A, Rawls, WJ, Pachepsky, YA. Probabilistic approach to the identification of input variables to estimate hydraulic conductivity. Soil Science Society of America Journal 2008; 72:16–24.

McKenzie, N.J., Jacquier, D.W., Ashton, L.J., Cresswell, H.P., 2000. Estimation of Soil Properties Using the Atlas of Australian Soils. Technical Report 11/00, CSIRO Land and Water, Canberra ACT.

Mulla, D.J., & McBratney, A.B., 2002. Soil spatial variability. In A.W. Warrick (Ed.), Soil Physics Companion (pp. 343-373). CRC Press, Boca Raton, FL.

Pachepsky, Y, Nez, DG, Lilly, A. and Nemes, A., 2008. Promises of hydropedology. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 3(40).

Page, A.L., Miller, R.H., Keeney, D.R., 1982. Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties Second Edition. SSSA Publisher, Madison, Wisconsin USA.

Rawls, WJ, Pachepsky, YA., 2002. Soil consistence and structure as predictors of water retention. Soil Science Society of America Journal 2002; 66:1115–26.

Schafer, WM. and Singer, MJ. 1976. A new method of measuring shrinks well potential using soil pastes. Soil Sci. Soc. Amer. j. 40: 805-806.

Sharma, M. and Uehara, G., 1968. Influence of soil structure on water relations in low humic latosols: I. Water retention. Soil Science Society of America Journal, 32(6): 765-770.

Staff, SS, 1951. Soil Survey Manual Agric. Handb. No.18 USDA. U.S.Government Printing Office, Wash.

USDA-NRCS, 2002. Field Book for Describing and Sampling Soils Version 2.0. National Soil Survey Center Natural Resources Conservation Service U.S. Department of Agriculture, Lincoln, Nebraska.

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The study and analysis of the factors of resource degradation in soil and water on the tray of Mostaganem

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Abstract

The plateau of Mostaganem represents a case of most affected ecosystem in Algeria by degradation of its soil and water resources. It is a sandy coastal area covering over 78 100 hectares, characterized by a significant wind activity and thus a strong erosive power. Additionally to this erosive effect, the plateau is under strong urban concentration and economic activities: agriculture, industry and port, which threaten as much its resources, that it's basic ecological balance. This work is a contribution to the diagnosis of the state of degradation of the plateau of Mostaganem subject to various agricultural and industrial constraints that affected its natural soil and water resources. One important result of this approach is that the degradation of Mostaganem plateau exists in several forms at the same time it remains undervalued because it has not benefited enough attention from scientists or even socio-economic operators. She half-opened, however, an investigation way of primary importance on ecological and environmental impacts of rapid development conducted in the region, in the medium and long term.

Keywords: Plateau, Mostaganem, Degradation, soil

Introduction

Plateau of Mostaganem is a case of an ecosystem most affected in Algeria by its resource degradation in soil and water. This plateau is part of sandy sets that are located between Mostaganem and Ténès along the western side of the country that have over fifty kilometers from coastline and where aeolian transportation is very active (Mederbal 1983; Benest, 1985). It constitutes a coastal area covering more than 78,100 ha, characterized by a strong eolian activity dominated by northwest winds. These can remain active for several months in the year. Additionally to this erosive effect, the plateau is subjected to a high urban concentration and various economic activities that threaten its resources as its fundamental ecological balances (Lorne, 1959).
To diagnose the state of degradation of the soil, it is currently made resorts to indicators of soil quality. For reliable diagnosis, this approach is based initially, on the determination of the key properties as well as the suitable processes of the soil able to constitute relevant indicators of quality. These indicators must provide a minimum of data necessary to the qualitative evaluation of the soil (Andrews and *al.* 2004). The multivariate statistical approaches, such as the principal component analysis (ACP), can be an appropriate tool for first

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identification of the most sensitive indicators or those whose impact is most important on the quality of the grounds (Pajares-Moreno et *al*., 2010).

Indeed, the ACP can provide an average objective of extraction and quantification of varied relative information to complexed whole of varied data plain (Wander and Bollero, 1999).

In the present study on degradation of the soil resources and out of water, we were confronted with the weakness of the data relating to the plateau of Mostaganem. Indeed, very few physical information exists on the area, even less recent, to allow to carry out comparisons on a temporal scale of the environmental characteristics. This leads us to adopt an approach based mainly on cartographic tools.

The use of the latter can be regarded as a space-time indicator which allows, by crossing of the eco-pedological factors of the medium, to define a set of zones spatialized according to their state of degradation but also compared to their successibility in degradation. Indeed, these two parameters: the degradation and susceptibility to degradation represent only the two faces of the same behavior of an ecosystem with respect to the agents of degradation to which its natural resources are subjected.

Material and Methods

In this approach, it is mainly the physical and agro-pedological properties of the plateau of Mostaganem which are taken into account.
For this purpose, we adopted a methodology of work that consists of five main steps:

- Acquisition of the data (maps and files).
- Data processing (Georeferencing, Rasterisation).
- Formatting the basis of geographic data.
- Formatting the basis of alphanumeric data.
- Analysis and Editing.

Zone of Study

The plateau of Mostaganem is located north-west of Algeria. It is bordered to the northwest by the solid mass of Sabkha of Arzew and north-east by the plain and wadi of Chélif south against the strengths of the plain of Relizane. It extends over an area of 110600 ha (fig.01).
The geographic coordinates delimiting the tray Mostaganem determined by MapInfo 8.5 according to the metric scale (UTM) are:
X1 = Y1 = 3958522.71 222646.08 m
X2 = Y2 = 3992014.29 294285.74 m

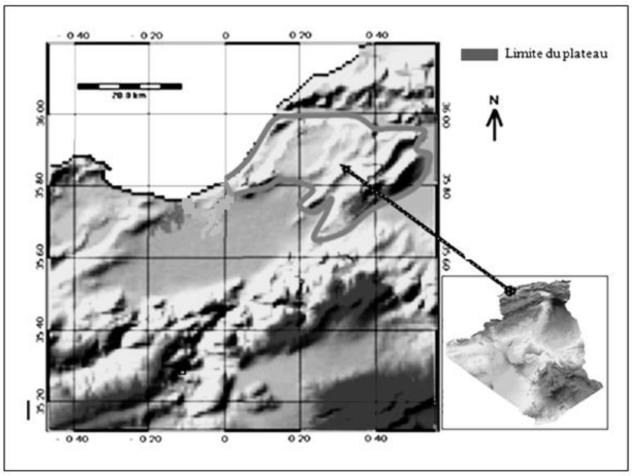

Fig. 01: Map of limitation of the plate of Mostaganem

Sampling soil

In the case of this study, soil samples were collected at several stations by the geosystemic sampling method based on taking into account the relief and land occupation (fig.02) Indeed, 26 profiles were performed in 17 stations with an average of 1 to 2 profiles per station. The horizon is the basic unit of sampling. The soil is

collected in five replicates per site at a depth of 5O cm in order to maximize the space variations, because according to Baize (1988), the carbon rate decreases with the depth;
On the field, four samples are taken using a soil auger, after two perpendicular diameters of a circle of 60 meters radius is directly mixed to obtain a composite sample by taking into account the spatial heterogeneity of the medium. The soil collected at each site, is dried in the open air in plates and in a sufficiently ventilated area; after drying, the soil was sieved to 2 mm for chemical analysis. All samples were bagged and carefully labelled; they are then put in a cardboard to prevent possible damage during transport.
For no composite soil sampling for measuring of the density and the moisture

1. The coarse litter is released and the cylinder with the volume V is inserted gently into the soil to collect the level 0-20 cm;
2. The ground is dug around the cylinder and the soil below the auger is cut.
3. Then we proceed to the removal of the soil in the cylinder with a knife and put it in a plastic bag which is immediately closed
4. On the site of conditioning, the fresh soil is weighed in order to obtain the fresh weight (W1); then the soil is dried in an oven at 105 ° C for 48 hours to obtain the dry weight (W2)
5. We then calculate the soil bulk density (Da): Da = W2 / V (g/cm3) and moisture content, is obtained by: Hp = (W1-W2) / W2 (%)

For the study of soils, the following materials were used:

- Cylinders for sampling, to measure the bulk density and moisture content.
- Auger to sample composite ground for the physico-chemical analyses in laboratory.
- Plastic bags to contain the soil samples.
- A drying oven to dry the samples of soil.
- A pH meter to measure the pH of different soils.
- A Muffle furnace

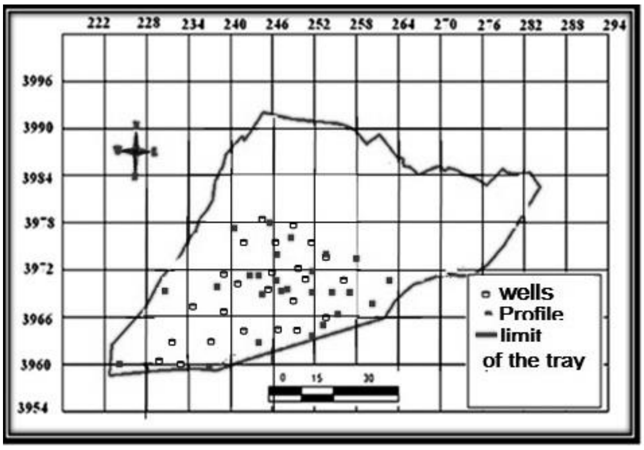

Fig. 02: Diagram of sampling of soil

Results and Discussion

Granulometric analysis

The triangles of textures make it possible to classify the soils according to their grain-size distribution reduced to three fractions (sand, silt, clay) whose sum is equal to 100%. We used the triangle of the U.S.D.A (United States Department of Agriculture) with 12 classes (Baize, 1971) to analyze our granulometric results.
The texture triangle (Fig. 03) shows that the profiles are textures distributed along the clay-sand axis and defining three classes that predominate in the study area:
- Class sandy-clay soils
- Class clay-silty soils,
- Class sandy soil.

In the tray of Mostaganem sandy fraction is more dominant compared to the clay and silt fractions; it varies between 66 and 94% with a mean of 80.42%. For the argillaceous fraction, it varies between 0.15 and 10.21% with an average rate of 6.4%. On the other side the silt fraction remains low and varies between 3.9 and 20.96% with an average of 12.77%.

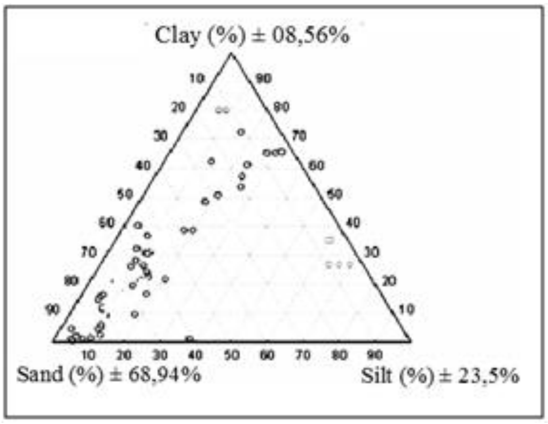

Fig.03: Results of textures in the plateau of Mostaganem

The distribution curve of the sand fraction of the studied samples (Fig. 05) shows that high frequencies are located on the side of the largest proportions of sand above 60% (right side of the histogram). In this case the cumulative occurrence is an average of 41. On the other side, the small proportions out of sands (< 30%) locate on the left histogram with a cumulated occurrence which does not exceed 13.

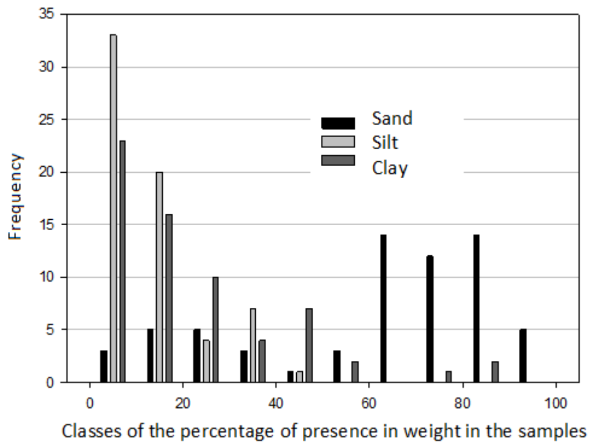

Fig.04: Distribution of particle size fractions

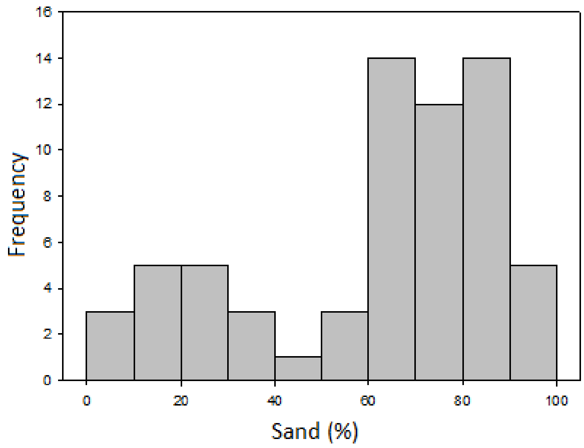

Fig.05: Distribution of the sandy fraction

The histogram of the distribution of the argillaceous fraction of the soil samples taken in the tray (fig. 06), shows a very great occurrence cumulated of almost 50 (nearly 77% of the whole of the samples) for the lower proportions out of clay 30%.

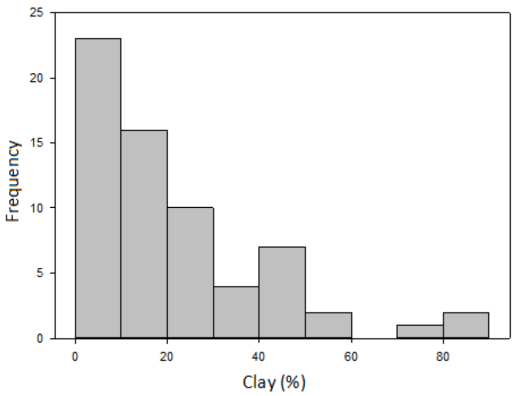

Fig.06: Distribution of the clay in the tray

Potential Hydrogen pH

On the whole (Fig. 07), the soils of the study area recorded a dominance class of pH between 7 and 8 with a cumulative occurrence of 58, which represents nearly 89% of all samples.

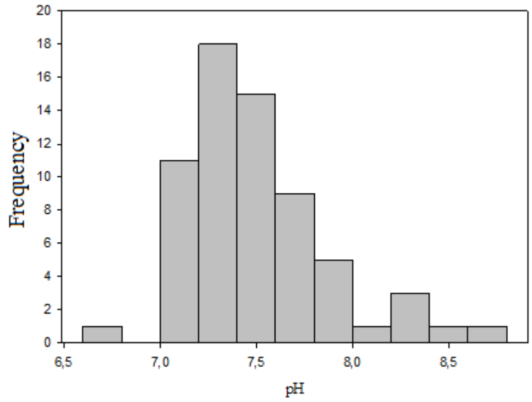

Fig.07: Distribution of the pH values of the analyzed samples

Total limestone

Results of the content of CaCO3 (fig. 08), summarizing the various classes of CaCO3 which the soil of the studied zone contain. The area is characterized by a large dispersion in values of CaCO3.

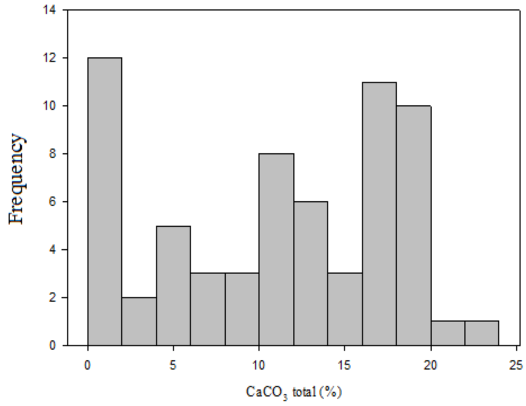

Fig. 08: Distribution of different classes of $CaCO_3$ of soil

Electric conductivity

It is noted that the soils are saline with a median value of the electric conductivity of the extract of saturated paste equal to 4.21 $mS.cm^{-1}$ (or $dS.m^{-1}$)

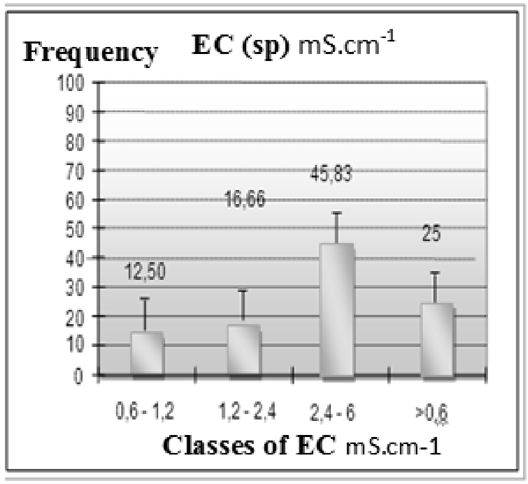

Fig.09: Classes of electric conductivity.

Organic matter

The results of the organic material (Fig. 10) shows the various classes that contain the soil of the tray, which are characterized by a high content of organic matter with the exception for some grounds.

Indeed, 40 and 54% of the samples of analyzed soils have respectively between 2 to 4% and more than 4% of organic matter.

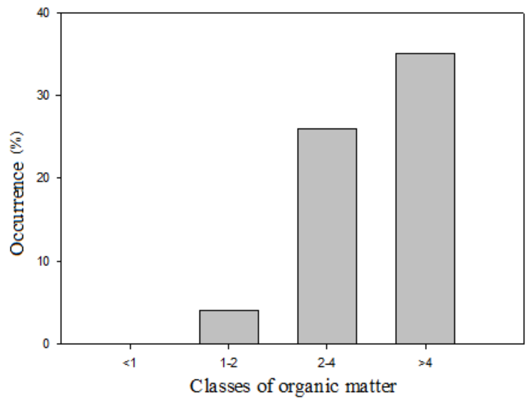

Fig.10: Class distribution of organic matter

Analysis of ions

Eigenvalues and eigenvectors

The eigenvalues are used to quantify the proportion of information explained by each axis, so it measures the degree of the highest correlation among all variables. Whereas the clean vector is the projection always perpendicular of the variable vectors to the main axis. With each eigenvalue corresponds a eigenvector. The eigenvalue is 3.70 (Table 01) and corresponds to a percentage of 17.63%, which is the ratio of the eigenvalue of the first axis to the sum of all eigenvalues multiplied by 100 and expressed from the information explained in the first axis.

Table 01: Eigenvalues of variables

	F1	F2	F3	F4	F5	F6	F7	F8	F9
eigenvalue	3,70	3,21	2,58	1,97	1,88	1,51	1,21	1,19	1,05
% **variance**	17,63	15,30	12,30	9,38	8,97	7,19	5,78	5,67	4,99
% **cumulative**	17,63	32,92	45,22	54,60	63,57	70,77	76,55	82,21	87,20

The share of information explained by the two axes is the sum of the parts explained by each axis

Axis 1 – Axis 2 : 17 ,63% + 15,30% = 32,93% for the plan 1 – 2
Axis 1 – Axis 3 : 17 ,63% + 12,30% = 29,93% for the plan 1 – 3
Axis 1 – Axis 4 : 17 ,63% + 9,38% = 27 ,01% for the plan 1 – 4
Axis 2 – Axis 3 :15,30% + 12,30% = 27,60% for the plan 2 – 3
Axis 2 – Axis 4 : 15,30% + 9,38% = 24,68% for the plan 2 – 4
Axis 3 – Axis 4: 12,30% + 9,38% = 21,68% for the plan 3 – 4

The number of factor to be retained is a purely arbitrary decision. According to the rule of Kaiser and the test of Cattell. The layout of the eigenvalues shows nine axIs which represent and synthesize as well as possible information in our study. Indeed, the share of the explained information of the first to the ninth axis is of 87, 20%.

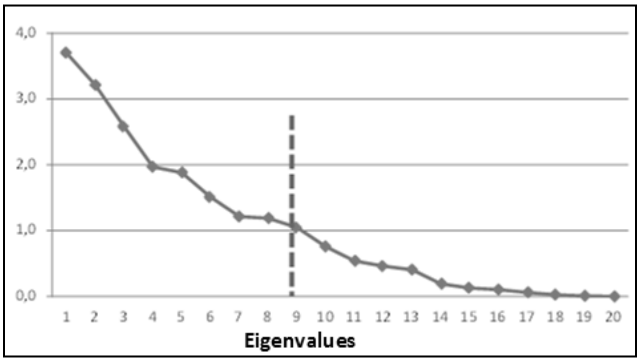

Fig. 11: Layout of eigenvalues of variables

Study of the variables

The review of contributions table variables can identify variables that have a dominant role in the formation of a factorial axis role.

Axis 1: Axis of predominantly active limestone

variables	square cosine	Contribution of the variable %
CA%	0,79	21,31
X TOTAL	0,78	21,02
TL	0,78	21,02
Chlorine	0,31	8,35

Axis 2: Axis of predominantly of Magnesium

variables	square cosine	Contribution of the variable %
Mgmg/l	0,74	22,88
Na mg/l	0,44	13,72
CL%	0,44	13,68
Sulfates	0,28	8,58

Axis 3: Axis of predominantly coarse sand

variables	square cosine	Contribution of the variable %
CS%	0,49	19,11
FS%	0,46	17,89
OC %	0,40	15,36
OM%	0,34	13,15
pH d	0,28	11,02

Axis 4: Axis of predominance of the electrical conductivity of the diluted extract

variables	square cosine	Contribution of the variable %
EC	0,42	21,08
FS%	0,25	15,73

Analysis of projections of the variables on the factorial plan

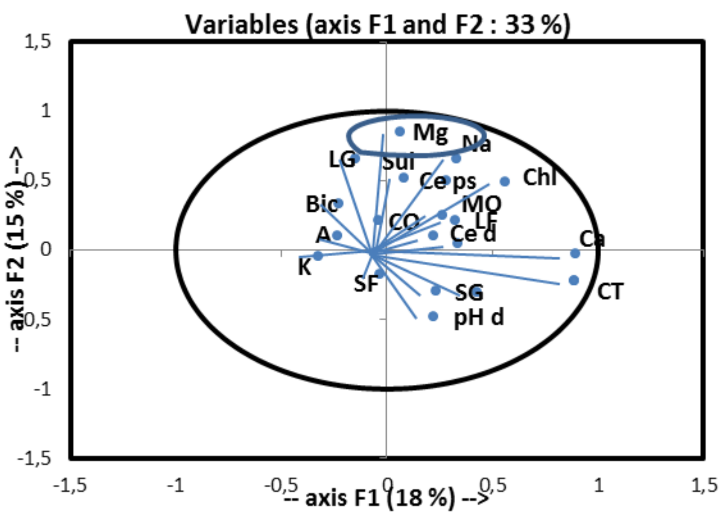

Fig 12: Projection of the variables on the Plan axis 1-2

The diagram of axis F1 and F2 alone explains 33% of the information; it includes the variables into two sets (Total limestone TL%, Ca% and chlorine) and (Mg, Na, FS% (fine silt) and Sulfate). Between the variables in the group there is a strong correlation. The vector of organic carbon and organic matter short length indicates a low correlation. The vector of organic carbon and organic matter short length indicates a low correlation, so bad considerations of the soil cover by all two axes. On the other side the vector of Mg with a great length indicates its influence in the definition of axis 2.

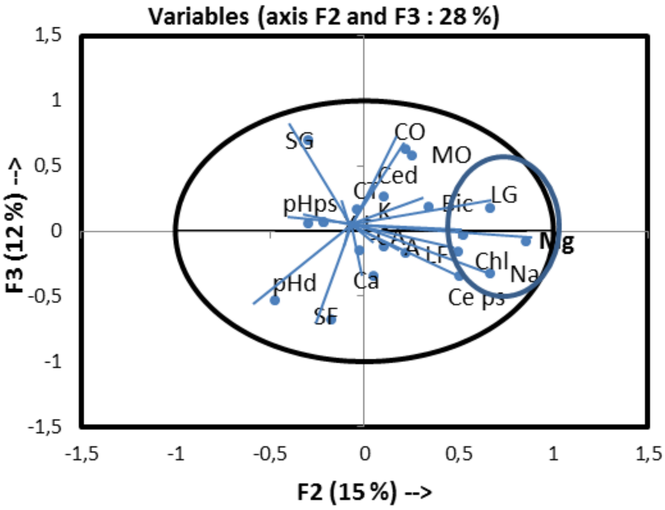

Fig 13 : Projection des variables sur le plan axe 2-3

2-3 axis Plan which explains 28% of the information shows that the axis 3 raises several variables: OC (organic carbone), OM (organic matter), CS (coarse silt), Mg, Na, CS (coarse sand), FS (fine sand), pH and EC.

To approach the discussion of the various results presented in this work, it is important to consider in terms of methodology, the fact that the soils are subject to various anthropogenic pressures related to consumption and urban development, agricultural and industrial (soil working, irrigation, fertilization, micro pollutants, construction, and industrial wastes). It is necessary particularly to add the other shapes of physical degradation of the soils of the plateau of Mostaganem generated by water and wind erosion. But in a comprehensive manner, it is possible to identify in the field a strong wind erosion activity throughout the area surrounding Mazagnan. In this case, it can be observed two areas of high wind activity the north-western part and the south-western part, In the north-western part, it is water erosion in uncultivated natural environment which is expressed in the form of centered circuses where Sheet erosion is important. The south-eastern part, on the other hand, is strongly marked by the formation of ravines and drains. Sheet erosion is less present in the naked medium compared to cultivated areas due to the influence of soil working on susceptibility to erosion. There appears the effect of anthropic action that amplifies the process of soil degradation by erosion. Similar situations affecting other cities of the plateau of Mostaganem such as: the south-western part of Mostaganem, the south-eastern zone of Ain Nouissy and Ain Sidi Cherif. It is therefore important to analyze in relation to urban and industrial development, the phenomena of water and wind erosion of soils of the plateau.

Indeed, the comparison of erosion processes and vegetation of the study areas shows a clear relationship between the degree of soil contamination and the rate of their covering plant often disturbed by the urban and industrial pressures.

To complete this discussion, it is necessary to remember that the diagnosis of the state of degradation of the plateau of Mostaganem is a complex approach in which many factors intervene. Therefore, it cannot be apprehended deeply in a study like the present work. As by the extent of field data must be grouped by the heterogeneity of the different areas that must be addressed separately.

Indeed, the case of the city of Mostaganem, cannot be approached in the same way as the city of Hassi Mameche. The first being coveted by a major urban concentration, agricultural and industrial while the second concerned only by agricultural activity

Conclusion

In perspective, it is important that the issue of the study agents of degradation of soil resources based on an integrated scheme that would involve all stakeholders in the medium. This study must be done in continuity and should lead to indicators of soil health able to allow different operators to evaluate their impact on the environment in order to maintain an ecological balance of the region in within the framework of socio-economic development.

References

Mederbal ; Benest., 1985. Evolution de la plate-forme de l'Ouest algérien et du Nord-Est ces matorrals se présentent sous différents états de dégradation p 156

Lorne, 1959. Parcourir 1959 par auteur "LORNE, R." 0-9 · (Ecole nationale du génie rural, des eaux et des forêts, Nancy (FRA), 1959).

Andrews SS., Karlen DL., Cambardella CA., 2004 - The soil management assessment framework: A quantitative soil quality evaluation method. Soil Sci. Soc. Am. J., 68: 1945-1962.

Pajares-Moreno S., Gallardo-Lancho JF., Etchevers-Barra JD., 2010 - Biochemical indicators in soils from an altitudinal ransect at the Mexican Neovolcanic belt. Agrociencia, 44: 261-274.

Wander MM., Bollero GA., 1999 - Soil quality assessment of tillage impacts in Illinois. Soil Sci. Soc. Am. J., 63: 961-971.

Baize D. et Jabiol B., 1995 – Guide pour la description des sols, édition I.N.R.A Paris. 375 p.

Baize D., 1988 – Guide des analyses courantes en pédologie édition I.N.R.A Paris. 172 P.

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Study of the attachment mechanism of potassium in soils. Application to the montmorillonites biionic Na-Ca

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Abstract

Some fifty cycles of wetting and drying (WD) were carried out on biionic Na-Ca montmorillonites samples saturated with potassium. They allowed us to highlight that the penetration of potassium in interlayer's spaces, to replace calcium or sodium, is accompanied by a connection of the sheets which confers a stable structure to them and consequently, most part of the brought in potassium passes in a nonexchangeable state. This retrogradation of potassium was confirmed by X-rays diffraction analysis. Indeed, the study of swelling to water by the measurement of d_{001} showed that the studied clays interlayer's distances evolve with the number of WD cycles, they go from 11,8 Å, for Na-Ca montmorillonites, which did not undergo WD cycles to 10,2 Å when they undergo 50 cycles. That corresponds to dehydrated montmorillonites. The study of this evolution reversibility shows that it is reversible because if we treat the Na-Ca clay submitted to a series of alternative WD and saturated by potassium, even after a high number of cycles (WD), by solutions of concentrated calcium chloride, most quantity of potassium can be extracted.

Keywords: Fixation of potassium; Na-Ca montmorillonite biionic; retrogradation

Introduction

The Potassium being a major component of plant nutrition, its availability in the roots has long been a subject of study for agronomists. In particular, issues relating to the movements of potassium, between the liquid phase in soil and mineral or organic constituents, appeared of great importance, because only the potassium content, in the solution or likely to pass easily, can be considered available to the plant [14, 16]. This dynamics of potassium is sensitive to physico-chemical characteristics changes of the soil under the influence, among other cultural practices or climatic conditions [10, 5 and 3].

More specific studies on montmorillonites made it possible to highlight the evolution of their physico-chemical properties following the blocking or retrogradation of potassium. [14, 16, 17, 6, 8 and 9]. These changes were observed on biionic K-Ca montmorillonites [11]. Yet, the exchange capacity of clay minerals in arid areas soils is always saturated by several cations [4]. It therefore seemed necessary to study the binding of potassium on biionic Na-Ca montmorillonites. Given the abundance of these elements (Na and Ca) in these soils, they have been chosen to prepare samples of biionic montmorillonite.

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Material and Methods

Sample type and preparation

The raw clay used comes from the Roussel deposit (Maghnia region, North-Western Algeria). It is purified by sedimentation. The fraction less than 2µm is exchanged with sodium, then washed several times until the disappearance of chloride ions. The prepared clay, noted Ar-Na, is dried at 80°C for 24 hours, then crushed and sieved to 0.1 mm.

The preparation of calcium clay (Ar-Ca has been carried out by dispersion of 100g of Ar-Na clay in a solution of calcium chloride then the suspension is stirred for 2 hours. The amount of salt is calculated so that it represents approximately ten times the value of the mass exchange capacity of the considered clay. After removal of excess solution, the operation is renewed twice. Several washes allow the removal of the ions excess. The resulting solid is dried at 80°C for 24 hours, then crushed and sifted to 0.1 mm.

The (Ar-Na-Ca) biionic clays are prepared by mixing suspensions of monoionic montmorillonite; for example, 25% by weight of calcium montmorillonite and 75% of sodium montmorillonite. Other proportions will be selected, to which we will add a Na-clay and a Ca-clay to cover the entire range from 0 to 100% of Ca.

The humidification is the mineral suspension in the water at the rate of 25 mL of water per gram of clay. The suspension homogenization is insured by stirring for two hours. Drying consists in one night stay in an oven at 80°C. After the first drying we agree to say that the mineral has undergone a cycle of wetting and drying (WD).

Analysis methods used

The determination of the cation exchange capacity (c. e. c.) of clay samples was performed, using the conductivity method [18]. 0,1 g of clay sample, previously saturated with barium, is placed in a (100 ml) beaker with 25 mL of distilled water. The suspension is stirred for 4 hours to allow the clay sheets to disperse. Then, we proceed to a conventional conductometric titration with a 0,025 N solution of zinc sulfate. We note, after each addition of a given volume of titrant, the value of the conductance after stabilization. We draw the graphs of the corrected conductance depending on the volume of the titration solution. The correction of the conductance value allows to compensate the dilution effects.

$$c_{(real)} = \left(\frac{V + v}{V}\right) . c_{(noted)} \tag{1}$$

Where c, is the conductance ; V, the initial volume and v, the added zinc sulphate volume.

The equivalent point (the intersection of two half-lines) is obtained graphically, by regression calculation and equalization of equations of the two linear branches of the graph. If (v) is the number of milliliters of the zinc sulphate solution ($ZnSO_4$, $7H_2O$), than

$$c.\,e.\,c._{(clay)} = (0{,}025) \times v \times 1000 \text{ meq}/100\ g_{clay}$$

The analyzes by X-rays diffraction were performed on powders with a X'Pert Pro MPD Panalytical diffractometer, (copper Kα line (λ =1,5418 Å), 45 kV, 40 mA).

Results and Discussion

Characterization of the used clay

The XRay diffractogram of our purified clay, calcium saturated and dried at 105°C (FIG 1), shows that the mineral is constituted principally of montmorillonite, characterized by lines close to 15.67, 4.46, 3.25, 2.55 and 1.69 Å [15, 2], and a small quantity of kaolinite, characterized by 7.27, 3.58, and 2.35 Å lines [15, 2].

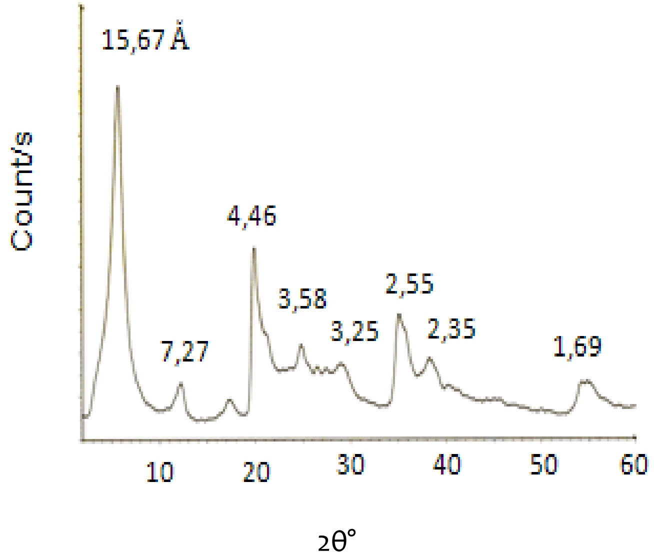

FIG 1: Diffractogram of purified clay.

It appears from the results represented in FIG 2 that cationic exchange capacity of purified clay is equal to 100 meq/100 g. The value obtained is close to that given by literature for montmorillonitic clay [1].

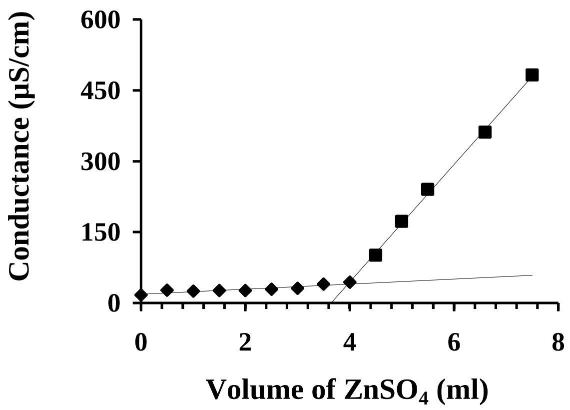

FIG 2: Variation of the conductance as a function of $ZnSO_4$volume.

Study of c. e. c. evolution of Ar-Na-Ca clay saturated with potassium and submitted to WD cycles.

Biionic Na-Ca clay samples have been saturated by the potassium ions then, submitted to WD cycle, as previously indicated.

The curves shown in FIG 3, giving the quantity of exchangeable potassium depending on the number of WD cycles, shows that, for a given calcium content, the c.e.c. is the same. It therefore seems logical to think that the biionic Na-Ca clays, saturated with K^+, behaves like a potassium pure sample. This effect was also observed by several authors [14, 16, and 12]. This suggests, in common with these authors, that when two competing ions have the same valence (in our case: K^+, Na^+), the ratio of the quantities fixed by clay is close to that of the ion concentrations in the liquid phase. And when a monovalent ion (for example K^+) is in competition with a bivalent ion (Ca^{++}), the ratio K^+/Ca^{++} of the fixed quantities depends on the K^+ ion concentration ratios in the solution to the square root of the Ca^{++} ions concentration in that solution. Let's recall that the chosen K^+ ions concentration, during the operation of the saturation of our biionic clay, was ten times greater than its c. e. c. and this operation was repeated twice. These experimental conditions allow to replace all the Na^+ and Ca^{++} ions by K^+ ions. We are also noticing the quick fixation of potassium at start of the experiment, then a slowdown and stabilization around 54 meq/100g when we reach 50 WD cycles.

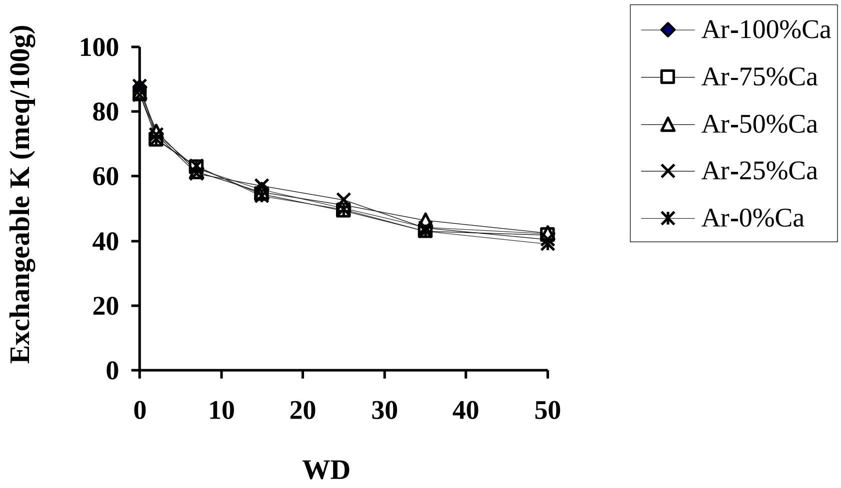

FIG 3: Variation of c. e. c. depending on the number of WD cycles.

Thus, WD cycles have the effect of locking the potassium in a proportion of up to 54% of c. e. c. Most of the experimental data published in the literature concerning the effect of WD cycles on fixing potassium in montmorillonite were obtained by drying the samples at 80°C [16, 12 and 13]. And according to these data, the potassium retention is due to a structural reorganization affecting the stacking order of sheets constituting the elementary montmorillonite crystallites. The initial disorder, which maintains the interlayer clay spacing, allows easy potassium release. The acquisition of a regular stacking order, wherein the hexagonal cavities face each other, causes a decrease of the interlayer distance, because of the localization of potassium in the volume delimited by two hexagonal cavities.

Study of swelling properties

This study is based on the determination of the position of the d_{001} lines that is to say onto the d_{001} parameter variation by the number of layers of water molecules adsorbed between the clay sheets. An inherent property in these minerals structure layer.

From the obtained results (FIG 4), we find that, for a given calcium content, the d_{001} remains constant. These results confirm those found previously, about the evolution of c. e. c. of these samples as a function of WD cycles. This confirms the hypothesis that the biionic Na-Ca montmorillonite, saturated with K^+ behaves as a pure potassium sample. We also note that the interlayer montmorillonite distance evolves with the WD cycles number. It goes from 11.8 Å, for biionic Na-Ca montmorillonite, saturated with potassium, and which did not undergo WD cycles, to 10, 20 Å when it underwent 58 WD cycles (FIG 4), corresponding to the dehydrated montmorillonite, that is to say sheets in contact; meaning that the cation which was located in the interlayer space has penetrated into the internal cavities, which would prevent the rehydration of the clay and its exchange against another cation.

Studies have shown that the reorientation of two sheets between them requires their relative displacement [3, 7]. When the mineral is hydrated, the interlayer water acts as a lubricant and the sheets can slide one over another. When dehydration occurs, the sheets get closer and a defined proportion of them are superposed exactly or with lacks by rotation. The interlayer spaces which they delimit are inaccessible to water even when the mineral is immersed, This reflects an increased stability of the crystal framework. This condition removes the montmorillonite swellability in water and consequently prevents rehydration of potassium cation, and cation exchange against another. The question raised is therefore whether if the potassium retrogradation is a reversible phenomenon or not and, if yes, under what conditions. This is an important point because the answer to this question lets know in which condition potassium can be freed without irreversible alteration of the system. This means that when there is a new potassium contribution, the phenomenon is likely to reoccur.

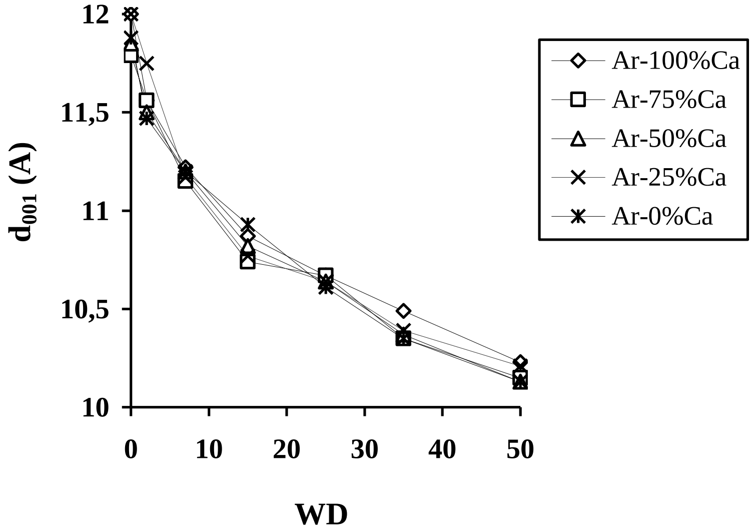

FIG 4: Evolution of the d_{001} line by the WD cycles number.

Reversibility of evolution

Completing the study of the potassium attachment, we found it necessary to study the potassium rate that can be extracted. Two factors may amend the rate of extracted potassium: the nature of the cation content in the solution and the temperature of the latter. The observed effect of these two factors is summarized in Table I. For all extractions, the total contact time and agitation is four hours. Quantities of clay mineral and solution put in contact for an exchange are of the order of 50 mg for 100 ml of 0,1N chloride solution.

Table I: quantities of extracted K^+ (meq/100g) of Na-Ca montmorillonites saturated with K ions and having undergone 50 WD cycles with chloride solutions.

Temperature of the extracting solution (°C)	25	50
cation exchanger		
NH_4^+	28	33
Ca^{2+}	68	71
Mg^{2+}	56	59

This table calls for several comments:

In the experimental conditions chosen, the temperature at which the exchange is done has no notable influence on the quantity of exchangeable potassium ;
Calcium provokes the strongest exchange;
and in all cases, a proportion of 17% of potassium remains in the not exchangeable.

Conclusion

The study of the evolution of the cation exchange capacity and swelling properties of Na-Ca montmorillonite, saturated with potassium and subject to WD cycles for different rate of Ca, allowed to highlight the specific character of the potassium fixation. The cation blocking mechanism of the K-Ca biionic montmorillonites, as it is described by other authors, was found in our biionic Na-Ca montmorillonite and shows that the presence of another cation, other than potassium, saturating the exchange capacity does not constitute an obstacle to the fixing of potassium.

Finally, however, fixing the potassium is not totally irreversible, even after a high number of cycle WD. Indeed, the Na-Ca clay treatment, who has undergone 50 WD cycles and which is saturated with potassium, by a solution of calcium chloride, allows to extract large part of the potassium.

References

[1]- A. Bakhti, , Z. Derriche, , A. Iddou, M. Larid, European Journal of Soil Science, A study of the factors controlling the adsorption of Cr(III) on modified montmorillonites, 52, 2001, 683-692.

[2]- A. Decarreau, Edition Masson, Matériaux argileux, structure, propriétés et applications, 1990, p. 215.

[3]- A. F. Ogaard, T. Krogstad, Journal of Plant Nutrition and Soil Science, Release of interlayer potassium in Norwegian grassland soils, 168, 2005,80-88.

[4]- A. Halitim, Edition O.P.U, Sols des régions arides d'Algérie, 1988, p. 371.

[5]- A. Keene, M. D. Melville, B. C. T. Macdonald, 3rd Australian New Zealand Soils Conference, Using potassium potentials to examine nutrient availability in an acid sulfate soil landscape, northern Australia, Supersoil 2004. University of Sidney, Australia.

[6]- D.Soltner, (1992). Les bases de la production végétale - le sol. Tome I, 19ème édition, Collection Sciences et Techniques Agricoles.

[7]- G. Sposito, R. Prost, Chemical Reviews, Structure of water adsorbed on smectites, 82, 1982, 554-572.

[8]- H.W. Scherer, H.E. Goldbach, J. Clemens, Plant, Soil and Environment, Potassium dynamics in the soil and yield formation in a long-term field experiment, 49, 2003, 531-535.

[9]- H. Zhu, F. Vansant, Journal of Colloid and Interface Science, The porosity and water adsorption of alumina pillared montmorillonite, 171, 1994, 377-385.

[10]- Jardine, P. N. & Sparks, D. L. (1984). Potassium-calcium exchange in a multireactive soil system. Soil Science America Journal, 48, 44-50.

[11]- J. Mamy, J.P. Gaultier, Annales Agronomiques, Les phénomènes de diffraction des rayonnements X et électroniques par des réseaux atomiques ; application à l'étude de l'ordre cristallin dans les minéraux argileux, 27, 1976, 1-16.

[12]- J.M. Zhou, P.M. Huang, Geoderma, Kinetics of potassium release from illite as influenced by different phosphates, 138, 2007, 221-228.

[13]- K.W.T Goulding, O. Talibudeen, Journal of Soil Science, Thermodynamics of K-Ca exchange in soil, 35, 1984, 397-408.

[14]- R.C. Srinivasa, M.S. Khera, Journal of the Indian Society of Soil Science, Fixation of added potassium and fertilizer K requirements of illite dominant soils as affected by K depletion, 43, 1995, 405-407.

[15]- S. Caillère, S. Hénin, M. Rautureau, Editions INRA et Masson, Minéralogie des argiles : I. Structure et propriétés physico-chimiques, 1982, p. 340.

[16]- S. Srivastava, T. Raghavareddy Rupa, , A. Swarup, D. Singh, Journal of Plant Nutrition and Soil Science, Effect of long-term fertilization and manuring on potassium release properties in a typic ustochrept, 165, 2002, 352-356.

[17]- Tessier, D. (1984). Etude expérimentale de l'organisation des matériaux argileux : Hydratation, gonflement et saturation au cours de la dessiccation et de la réhumectation. Edition Technique et documentation, Lavoisier, Paris.

[18]- Y. C. Chiu, L. N. Huang, C. M. Uang, J. F. Huang, Colloids and Surfaces, Détermination of cation exchange capacity of clay minerals by potentiometric titration using divalent cation electrodes, 46, 1990, 327-337.

Evaluation of soil quality indicators and identification of soil quality index (A case study: Konya, Turkey)

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Abstract

Sustainable agriculture greatly depends on soil quality (SQ) The definition of soil quality encompasses physical, chemical and biological characteristics, and it is related to fertility and soil health. Many indicators can be used to describe soil quality, but it is important to take into account sensitivity, required time, and related properties, than can be explained. At present, a wide variety of methods are used to evaluate soil quality using vastly different indicators. A universally accepted method of soil quality evaluation would assist agriculture managers, scientists, and policy makers to better understand the soil quality conditions of various agricultural systems.A study was carried out to investigate the soil quality attributes. This study was conducted in the Sarıcalar Research Site of Selçuk University Agricultural Faculty in Konya, Turkey to study a set of inexpensive and agronomically meaningful indicators of soil quality, i.e. aggregate stability, available water capacity, organic matter content, active carbon content, pH, available phosphorus and available potassium. This study analyzes the soil quality of soils studied, usingCornell Soil Health Assessment(CSHA) with describedindicators in same model. A total of 15soil parameters were used with the MDS method. For each soil qualityindicator, the measured value was reported as well as the associated rating score from its scoring curve. Results of the study indicated very favorable results for chemical indicators, with high rating scores for available potassium, available phosphorous and minor elements (100, 89.3, 100 respectively). The remaining indicators, i.e. the physical and biological indicators of soil quality, had unfavorable or very unfavorable results and consequently showed evidence of low physical and biological soil quality except root health. Low rating scores for aggregate stability, available water content and organic matter content (14.6, 65.7 and 11.6, respectively) were evidences of soil degradation from long-term intensive tillage and lacking use of soil-building crops or organic matter additions. Very low rating scores of penetration resistance of both surface and subsurface soils were also indicated soil degradation. Also, very low rating score for active carbon content (22.9) indicated that the soil of site wasbiologically degraded and inadequate. Finally from all evaluated indicators, especially physical degradation is most important problem for the sustainable agriculture.

Keywords: Soil quality, soil quality indicators, sustainable agriculture

Introduction

An understanding of the nature of soils in natural and human influence ecosystems is essential if progress is to be made in thedetermination and monitoring of soil quality.Doran and Parkin (1994) defined soil quality (SQ)as "thecapacity of a soil to function, within ecosystem andland use boundaries, to sustain productivity,

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maintainenvironmental quality, and promote plant and animalhealth", a definition that includes an inherent and adynamic component (Carter 2002; Larson and Pierce1991).Dynamic soil quality, on the other hand, generallyrefers to the condition of soil that is changeable in ashort period of time by human impact, including agricultural management practices (Carter 2002;Karlen et al. 1997; Magdoff and van Es2000;Mausbach and Seybold 1998; Wienhold et al. 2004).Soil quality is defined as the 'continued capacityof soil to function as a vital living system, withinecosystem and land use boundaries, sustain biologicalproductivity, to promote the quality of air and waterenvironments, and to maintain plant, animal andhuman health' (Doran and Safley, 1997).Soil quality not only effects productivity, but is also related to the health of otherresources including air, water, plants, and animals. The National Research Council (NRC,1993) in their book on soil and water quality stated "protecting soil quality, like protecting airand water quality should be a fundamental goal of national policy." They suggestenhancement of soil quality should be the first step toward increasing water quality.

The soil qualityconcept encompasses the chemical, physical and biological soil characteristics needed to maintain environmental quality and agricultural sustainability. soil qualitycan not be measured directly, but soil properties that are sensitive to changes in management can be used as soil qualityindicators. Soil qualityindicators must be inexpensive and dependent onminimal infrastructure if they are to be widely adoptedbeyond the research domain(Moebius et al. 2007, Shuklaet al., 2006). Soil qualityindicator suitability can be judged by several criteria, such as relevance, accessibility to users and measurability.

The objective of this work was to study a set of inexpensive and agronomically meaningful indicators ofas soil qualityindicators in Sarıcalar Research Site of Selçuk University Agricultural Faculty in Konya, Turkey.

Material and Methods

Site description

The study was conducted in the Sarıcalar Research Site of Selçuk University Agricultural Faculty about 30 km north of the city of Konya, at latitude of 38° 06' N and longitude of 32° 36' E, and is 1010 m above mean sea level, in semi-arid climate, where the summers are dry and hot, while winters are cool. The selected site had approximately,1200 ha and Long-term records show that the mean annualprecipitation is 379.38 mm and the total evaporationis 1226.4 mm. According to the Konya meteorologicalstation, the mean annual temperature is 11.5 °C andthe mean annual soil temperature at 50 cm is 12.5°C (DMI 1994). Soil moisture and temperatureregimes are xeric and mesic, respectively, accordingto the climate data (Soil Survey Staff 1999).

Indicators selection

The general criteria used for selecting the physical and biological indicators were previously described by Moebius (2006) and included: 1) Sensitivity to management, i.e., frequency of significant treatment effects in the controlled experiments and directional consistency of these effects., 2) Precision of measurement method, i.e., residual errors from analyses of variance, 3) relevance to important functional soil processes, 4) ease and cost of sampling and analysis. Table 1 shows the physical, chemical and biological indicators that have been selectedas a set of inexpensive and agronomically meaningfulindicators of Soil quality. These are indicators of critical soilprocesses such as aeration, infiltration, water and nutrientretention, toxicity prevention, nutrient availability, etc.,which in turn relate to soil functions such as plantproduction, landscape water partitioning and filtration andhabitat support (Idowu et al., 2008)).

Sampling and analysis

Within research site, 15 sampling plots were selected according to land use and plant plantation. Four random discrete soil samples taken from each one of them in the middle of the plots. Soil samples were collected from the 0-20 cm depth using trowels. After collection, all samples were placed in airtight polyethylene bags and transported back to the Soil and Water Laboratory of Selçuk University Agricultural Faculty. Upon their arrival to the laboratory, samples were split in two portions. One was sieved through a 2-mm mesh screen at field moist and used for biological analyses. These filed moist samples were kept at 4°C until the analyses were carried out, which took no longer than two days after sampling. The remaining was air-dried and further split in two other portions. One was sieved through a 4-mm mesh for physical analyses and other sieved through a 2-mm mesh for chemical analyses.

Soil texture was determined by the hydrometermethod after removal of organic matter usingH_2O_2 and stirring in a sodium hexametaphosphatesolution (Bouyoucos 1951). Wet aggregatestability which involved the application of simulatedrainfall of known energy (Ogden et al.1997) toaggregates on sieves (van Es et al.

2006).The unstable aggregatesslaked (fell apart) and passed through the sieve. Thefraction of soil that remained on the sieve determinedthe percent aggregate stability (Guyino et al., 2009). Bulk density (BD) wasdetermined by weighing soil cores aft er dryingfor 24 h at 105 °C (Blake and Hartge 1986). Waterretention at –33 kPa and –1500 kPa was measuredin the disturbed soil samples using a pressure plateextractor Available water content was measured using pressure chambers todetermine the difference between water stored at fieldcapacity and the permanent wilting point (Gugino, et al. 2009). Organicmatter content was determined by dumas method with LECO CN-2000. Todetermine active carbon content the soil sample was mixedwith potassium permanganate (deep purple in color) andas it oxidized the active carbon, the color changed(became less purple), which could be observed visually,but was measured very accurately using aspectrophotometer as discussed in (Weil et al., 2003). Soil pH wasmeasured potentiometrically, both in a 1:2.5 soilwater(w/v) suspension and 0.01 N KCl with a glasselectrode. Electrical conductivity (EC)was determined potentiometrically in a 1:2.5 soil-water suspension (USDA 2004). The amount of carbonate in the soil was measured with a Scheiblercalcimeter (USDA 2004).Available phosphorous was determined bythe Olsen method (Kacar, 2009). Available potassium was firstextracted with ammonium acetate (1 N NH4OAc) and thecontent of K^+ was determined by the Atomic AbsorptionEmission Spectrophotometer (AAS). The available nutrients are extracted with Morgan'ssolution, a sodium acetate/acetic acid solution, bufferedat pH 4.8. The extraction slurry is filtered andanalyzed for K, Ca, Mg, Fe, Al, Mn, and Zn on an AASTotal NH_4 and NO_3 N wad determined by Kjeldahl method (Kacar, 2009). Potential mineralizable nitrogen was measured after incubation according to the method of Gugino et al., (2009). The root health assessment involved a bioassaymethod where snap bean seeds were grown in thesampled soil and subsequently rated for symptomsand root damage caused by infection from soil-bornepathogens such as Rhizoctonia spp., Thieviopsis spp.,Fusarium spp. and Pythium spp. (Abawi et al. 2004;Abawi and Widmer 2000). Surface and subsurface Penetration resistance were measured with a cone penetrometer.

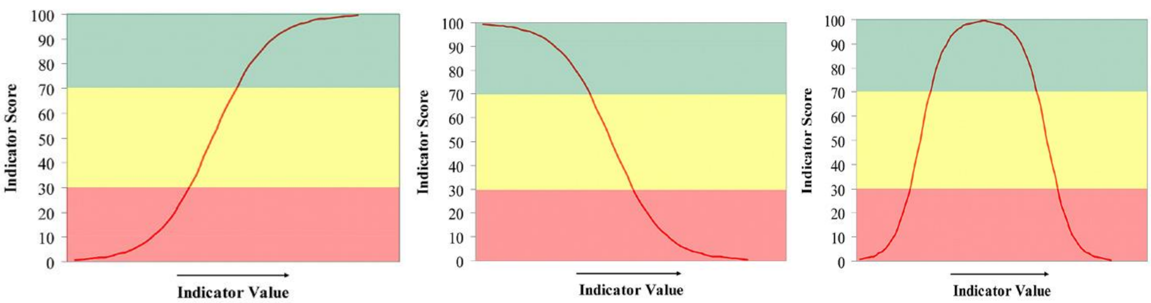
Table 1. Physical, chemical and biological soil quality indicators included in this study and associated processes

Physical indicators	Chemical indicators	Biological indicators
Available Water Capacity	pH	Root health assessment
Aggregate Stability	Available Phosphorous	Organic matter content
Surface Penetration resistance (0-20 cm)	Available Potassium	Active carbon
Subsurface Penetration resistance (20-40 cm)	Available Fe, Cu, Mn and Zn	Potential mineralizable nitrogen

Data interpretation and scoring curves

Effective use of soil health test results requires thedevelopment of an interpretive framework for themeasured data. The general approach of Andrews etal. (2004) was applied for this purpose, the three scoring curves i.e. "more is better", "less is better" and "optimum range" reported by (Karlen and Stott 1994) for the three main soil textural classes, i.e. sand, silt, and clay were used for all the selected soil qualityindicators to rate test results.

Soil qualitytest report designed (Moebius et, al 2010) was also used to facilitate soil quality indicators assessment and detection of soil constraints. This was accomplished through the combined use of quantitative data and color codingThe physical, biological and chemical indicators were grouped by blue, green and yellow colors, respectively. For each soil qualityindicator, the measured value was reported as well as the associated rating score from its scoring curve.



(a) More is better (b) Less is better (c) Optimum range

Fig. 1: Three types of scoring curves used for the interpretation of measured values of soil quality indicators;(a) More is better, (b) Less is better and (c) Optimum

In addition, the indicators were rated with color codes depending on their scores. Generally, a score of less than 30 was regarded as low and received a red color code. A score from 30 to 70 was considered medium and was color coded yellow. A score value higher than 70 was regarded as high and color coded greenThis score wasfurther rated as follows: less than 40% is regarded as verylow, 40-55% was low, 55-70% was medium, 70-85% washigh and greater than 85% was regarded as very high. The highest possible score was 100 and the least was 0.

Results and Discussion

Table 2 and table 3shows some soil quality parameters and the standard soil quality test report for theselected soil quality indicators to rate test results of the Research Site of Agricultural Faculty. The soil quality test report shows generally very favorable (49)and detection of soil constraints. This was accomplished results for chemical indicators, with high rating scores for available phosphorous, available potassium and minor elements (89.3, 100 and 100 respectively. A similar result was reported by many authors (Karlen et al., 2003, Moebiuset al., 2007,Idowuet al., 2008, Gugino et al., 2009, Rashidi et al., 2010)who concluded that based on, the measured value traditional soil testing methodology, i.e. testing the chemical indicators of soil quality, almost all soils may appear to be of good or acceptable quality.

The physical and biological indicators of soil quality, have unfavorable or adverse results and consequently show evidence of low physical and biological soil qualityexcept Root health values. Low rating scores for aggregate stability, available water content, surface and subsurface penetration resistance, organic matter, active carbon, and potential mineralizable nitrogen (14.6, 65.7, 34.6,10.2, 11.6, 22.9 and 34.3, respectively) are evidences of soil degradation from long-term intensive tillage and lacking use of soil-building crops or organic matter additions.

In addition, very low rating score for active carbon content and Penetration resistanceindicates that the soil is physically and biologically degraded and unbalanced. These results are in agreement with those of (Moebiuset al., 2007, Idowuet al., 2008, Gugino et al., 2009Andrewset al., 2004), who concluded that the lack of routine tests for physical and biological indicators of soil qualityhas resulted in inadequate attention to these aspects of the soil quality.

The overall score of 49 is low according to the Cornell Soil Health Assessment. Bu high chemical results shows that soils are improved by a long-term commitment to soilmanagement through practices such as conservation tillage, improved rotations, cover cropping and organic amendments, as discussed in (Carter , 2002, Andrewset al., 2004, Moebius et al., 2007, Idowuet al., 2008, Gugino et al., 2009 Santana et al., 2009). Long-term conservation, tillage management, maintains soil organic matter, because less physical disturbance which reduces the short-term rapid decomposition in tilled soils, leadingto aggregate stabilization and improved soil structure.

Conclusion

Soil health management requires an integrative approach that recognizes the physical, biological and chemical processes in soils. In the study area physical and biological degradation were found according the results. Results from study confirmthat farmers in the region of study can improve soil quality and agricultural sustainability by adoptingproduction systems that employ intensive cropping practices with reduced tillage management. Our experience indicates that the use of such a SQ test are effective vehicle for training in soil quality concept and for describing the importance and interaction of physical, chemical and biological components of soil. It also provides information about physical, chemical and biological aspects of soils is a more meaningful approach to monitoring SQ and provides farmers, consultants and agencies with a tool to identify soil constraints and target management practices or remediation strategies.

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Table.2. Some soil properties of Sarıcalar research area

Land use and Plantation	Sample code	Soil Properties														
		Available Water Capacity (%)	Ag. Stability (%)	Penetration resistance (PSİ)		pH 1:1	Available P mg kg^{-1}	Available K mg kg^{-1}	Available Minor Elements				Organic Matter %	Active Carbon mg C/kg soil	Potential mineralizable nitrogen µgN/g/week	Root health
				0-20 cm	20-40 cm				Fe	Cu	Mn	Zn				
Orchard	A	20.99	10.51	143.4	296.8	7,85	18,81	860	13.43	2.54	22.03	0.96	2,49	504.00	4.52	1.00
Orchard	B	19.22	7.45	186.8	277.1	7,99	20,39	816	12.49	2.69	18.33	0.91	2,26	456.00	4.03	1.00
Legumes	C	19.26	16.27	159.6	427.2	7,85	32,95	869	12.46	2.18	27.61	1.30	2,55	504.00	7.78	1.00
Legumes	D	17.91	29.00	124.8	501.1	7,94	14,47	796	13.41	2.23	25.65	0.80	2,43	528.00	4.38	1.00
Grain	E	19.06	22.76	284.8	530.6	7,94	17,67	847	12.85	2.03	20.58	0.69	2,74	576.00	10.89	1.00
Orchard	F	17.43	11.15	285.5	462.9	7,98	14,52	799	14.22	2.15	18.32	0.58	2,37	504.00	8.34	1.00
Orchard	G	20.01	31.22	240.9	342.5	8,03	16,09	852	13.11	2.31	18.00	0.68	2,18	480.00	5.69	1.33
Grain	H	22.26	26.49	253.3	521.2	7,86	30,91	921	13.59	2.03	24.04	0.94	2,95	624.00	10.61	1.00
Grain	I	20.03	24.83	235.8	303.1	7,88	15,16	810	14.00	1.92	19.60	0.68	2,77	672.00	7.49	1.00
Legumes	İ	21.41	21.01	294.7	473.5	8,03	15,69	722	14.65	1.85	19.43	0.56	2,48	624.00	9.19	1.00
Grain	J	18.95	26.71	331.5	552.3	7,96	15,02	772	13.57	1.99	21.30	0.83	2,84	648.00	10.65	1.00
Legumes	K	18.18	30.57	144.0	353.7	7,89	8,67	809	12.72	2.16	24.32	0.78	2,36	576.00	12.30	1.00
Legumes	L	17.24	38.99	195.1	482.4	7,94	12,25	783	14.57	2.35	26.45	1.36	2,92	648.00	9.76	1.00
Legumes	M	18.61	25.38	174.1	339.79	7,99	19,33	822	12.49	2.16	30.86	1.61	2,86	672.00	15.22	1.00
Grain	N	17.84	27.30	286.1	307.9	7,92	24,03	857	14.86	2.33	27.13	2.22	3,18	648.00	10.89	1.00
	Mean	19.23	23.31	222.7	411.5	7,94	18,4	822,3	13.49	2.19	22.91	0.99	2,63	577.6	8.78	1.02
	Min	17.24	7.45	124.8	277.1	7,85	8,67	722	12.46	1.85	18.00	0.56	2,18	456.00	4.03	1.00
	Max.	22.26	38.99	331.5	552.3	8,03	32,95	921	14.86	2.69	30.86	2.22	3,18	672.00	15.22	1.33
	%CV	7.71	37.16	29.58	23.67	0,77	35,67	5,79	6.08	10.31	17.48	45.67	11,09	13.09	36.42	8.34

Table 3. The standard soil qualitytest report for the Sarıcalar Research Site of Agricultural Faculty

Land use and Plantation	Sample code	Physical rating score				Biological rating score				Chemical rating score				Standard soil quality score
		ASs	AWCs	SPRs	SubPRs	OMs	ACs	PMNs	RHRs	pHs	Ps	Ks	İZ s	
Orchard	A	3	70	64	43	9	14	3	100	0	100	100	100	51
Orchard	B	2	61	44	35	6	10	0	100	0	100	100	100	47
Legumes	C	5	62	55	0	10	14	20	100	0	26	100	100	41
Legumes	D	20	58	72	0	8	17	2	100	0	100	100	100	48
Grain	E	12	63	15	0	13	22	58	100	0	100	100	100	49
Orchard	F	3	56	13	1	8	14	22	100	0	100	100	100	43
Orchard	G	24	70	22	10	5	12	3	96	0	100	100	100	45
Grain	H	16	80	21	0	17	28	46	100	0	44	100	100	46
Grain	I	14	70	25	23	13	35	7	100	0	100	100	100	49
Legumes	İ	10	82	12	0	9	28	38	100	0	100	100	100	48
Grain	J	17	64	3	0	15	31	56	100	0	100	100	100	49
Legumes	K	22	61	63	7	8	22	73	100	0	100	100	100	55
Legumes	L	39	58	40	0	16	31	40	100	0	100	100	100	52
Legumes	M	15	64	52	9	15	35	93	100	0	97	100	100	57
Grain	N	17	66	18	25	22	31	54	100	0	73	100	100	51
	Total mean.			31				42				72		49
	Mean	14.6	65.7	34.6	10.2	11.6	22.9	34.3	99.7	0	89.3	100	100	
	Min	2	56	3	0	5	10	0	96	0	26	100	100	
	Max.	39	82	72	43	22	35	93	100	0	100	100	100	
	%CV	66.75	11.58	64.52	141.06	40.80	38.67	84.66	1.04	0	26.16	0.00	0.00	

ASs: Aggregate Stability score ,AWCs: Available Water Capacity score , SPRs: Surface Penetration resistance score, SubPRs: Subsurface Penetration resistance score, OMs: Organicmatter score, ACs: Active carbon score, PMNs: Potential mineralizablescore , NRHRs:Root healthy score , Ps:Available P score , Ks:Available K score İZs :Minor Elements score

References

Abawi, G.S., Ludwig, J.W., Petzoldt, C.H., 2004.Assessing roothealth by a soil bioassay with beans as an indicator of soilhealth. Phytopathology 94:S1.

Abawi, G.S., Widmer, T.L., 2000.Impact of soil health managementpractices on soilborne pathogens, nematodes androot diseases of vegetable crops.Appl Soil Ecol 15:37–47.

Andrews, S.S., D.L. Karlen and C.A. Cambardella,2004. The soil management assessment framework: Aquantitative soil quality evaluation method. Soil Sci.Society of America J., 68: 1945-1962.

Blake, G.R., Hartge, K.H., 1986. Bulkdensity. In: Methods of SoilAnalysis, Part 1. Physical and Mineralogical Methods, Agronomy Monograph No. 9 (Ed. A Klute). SSSA, Madison.

Carter, M.R., 2002. Soil quality for sustainable land management: Organic matter and aggregation interactions that maintain soil function. Agron. J., 94: 38-47.

D.M.I. 1994 Meteorology Bulletin. Prime Ministry PrintingEstablishment, Ankara.

Doran, J.W., Parkin, T.B., 1994. Defining and assessing soil quality.In: Doran JW, Coleman DC, Bezdicek DF, Stewart BA(eds) Defining soil quality for a sustainable environment.SSSA Special Publication 35, Madison, WI, pp 3–21.

Gugino, B.K., 2007. Developing Standard Protocolsfor Soil Quality Monitoring and Assessment, http://www.hort.cornell.edu/soilhealth/research/papers/DevelopingStandarProtocols.pdf 20/01/2010.

Gugino, B.K., O.J. Idowu, R.R. Schindelbeck, H.M. van Es, B.N. Moebius, D,W. Wolfe, B.N.

Moebius-Clune, J.E. Thies and G.S. Abawi, 2009.Cornell Soil Health Assessment Training Manual, Second Edition, Cornell University, Geneva, NY.

Idowu, O.J., van Es,H.M.,Abawi, G.S., Wolfe,D.W.,Ball, J.I.,Gugino, B.K. Moebius,B.N., Schindelbeck, R.R. Bilgili, A.V., 2008. Farmerorientedassessment of soil quality using field,laboratory and VNIR spectroscopy methods. Plantand Soil, 307: 243-253.

Kacar, B., 2009. ToprakAnalizleri (genişletilmiş 2. Baskı). Nobel Yayınları No: 1387 ISBN: 978-605-395-184-1 İstanbul

Karlen, D.L,,Mausbach, M.J,, Doran, J.W., Cline, R.G., Harris ,R.F.,Schuman G.E., 1997. Soil quality: a concept, definition,and framework for evaluation. Soil SciSoc Am J 61:4–10.

Karlen, D.L., Ditzler, C.A., Andrews, S.S., 2003. Soilquality: why and how? Geoderma, 114: 145-156.

Karlen, D.L., Stott, D.E., 1994. A framework for evaluating physicaland chemical indicators of soil quality. In: Doran JW, Coleman DC, Bezdicek DF, Stewart BA (eds) Defining soilquality for a sustainable environment. SSSA SpecialPublication 35, Madison, WI, pp 3–21.

Larson, W.E., Pierce, F.J.,1991. Conservation andenhancement of soil quality. In: Proc. Vol. 2 ofEvaluation for Sustainable Land Management in theDeveloping World, Conference, International Boardfor Soil Research and Management (IBSRAM),Jatujak Thailand, Bangkok, Thailand.

Magdoff, F, van Es, H., 2000. Building soils for better crops. Sustainable Agriculture Network, Burlington, Vermont.

Majid R., Mohsen S.,R, IrajR.Mohammad G.,ISaeed A.,2010.Evaluation of Some Soil Quality Indicators in the Varamin Region, Iran.World Applied Sciences Journal 9 (1): 101-108.

Mausbach, M.J., Seybold, C.A., 1998.Assessment of soil quality.In: Lal R (ed) Soil quality and agricultural sustainability.Ann Arbor Press, Chelsea, Michigan, pp 33–43.

Moebius B.N., 2006.Evaluation of laboratory-measured soilphysical properties as indicators of soil health.M.S. thesis,Cornell University, Ithaca New York.

Moebius, B.N., Idowu,O.J.,Schindelbeck,R.R. , van Es, H.M.i, Wolfe, D.W. , Abawi, G.S.,Gugino, B.K., 2007. Developing Standard Protocols for Soil Quality Monitoring and Assessment, http://www.hort.cornell.edu/soilhealth/ research/ papers/ DevelopingStandardProtocols.pdf 20/01/2010.

Ogden, CB, van Es H.M., Schindelbeck, R.R., 1997. Miniaturerain simulator for field measurement of soil infiltration. Soil SciSoc Am J 61:1041–1043.

Schindelbeck, R.R. and Bilgili,A.V., 2008. Farmerorientedassessment of soil quality using field,laboratory and VNIR spectroscopy methods. Plantand Soil, 307: 243-253.

Bouyoucos, G.J., 1951 A recalibration of the hydrometer method formaking mechanical analysis of soils. Agron J 43: 434-438.

Santanna, S.A.C., Fernandes, M.F., IVO, W.M.P.M., Costa,J.L.S., 2009. Evaluation of soil qualityindicators in sugarcane management in sandy loamsoil.Pedosphere, 19: 312-322.

Shukla, M.K., Lal, R. and Ebinger,M., 2006.Determining soil quality indicators by factor analysis.Soil and Tillage Research, 87: 194-204.

Soil Survey Staff 1999 Soil Taxonomy.A Basic System of SoilClassification for Making and Interpreting Soil Survey.USDAAgriculture Handbook No. 436, Washington DC, USA.

USDA, 2004.Soil Survey Laboratory Methods Manual. United StatesDepartment of Agriculture - Natural Resources ConservationService, Soil Survey Investigations Report No. 42, WashingtonDC, USA.

Van Es H.M., Schindelbeck ,R.R., Melkonian, A., Moebius, B.N., Idowu, O.J., 2006. Assessment of soil aggregate stabilityusing small rainfall simulators.Department of Crop andSoil Sciences Research Series 06-01. Cornell University,Ithaca, NYWI, USA, pp. 363-375.

Wienhold, B.J., Andrews, S.S., Karlen, D.L., 2004. Soil quality: areview of the science and experiences in the USA. EnvironGeochem Heal

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A research on determining lime requirements and characteristics of Lapseki - Biga (Çanakkale) acid soils

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Abstract

The aim of this study is to determine lime requirement and characteristics of Lapseki-Biga (Gürece, Dişbudak, Beypınarı, Doğandere, Otludere, Karacaali, Karahamzalar, Çakırlı, Adliye, Yeni çiftlik and Güleç villages) in Çanakkale acidic soils. In the study, 15 acid soils were sampled and analysed for their physical and chemical properties. Samples have been incubated for 5 months and analysed for lime requirements which depend on clay type, buffer capacity and cation exchange capacity. The Woodruff and Calcium Acetate methods were used to determine lime requirements of soils. The pH values of the study soils ranged between 5.46 and 6.37. $CaCO_3$ incubation method was used to decide the most appropriate soil lime requirement method in the study area. Results showed that the most appropriate method for Çanakkale was "Calcium Acetate" method. According to the results, lime requirements of research soils were between 100-300 kg/da. Therefore lime applications are required for these acidic soils in the region.

Keywords: Acid soil, soil pH, lime requirement, Çanakkale

Introduction

The pH in soil is the minus logarithm or cologarithm of the hydrogen ions in soil solution. Soil reaction properties depend on the saturation of hydrogen ions in the soil solution. The properties of soil solutions are not uniform but may vary according to pedogenetic events and horizon depths. With regard to this, soils may have acidic, neutral or alkali reactions. When the quantity of H^+ ions in the soil solution around the colloids is equal to the quantity of OH^- ions, the soil reactions is referred to as 'neutral'. However, the reaction is acidic when the quantity of H^+ ions is more than that of OH^- ions the reaction is acidic, and alkali when vice versa [1].

The effect of the pH value of the soil is not limited to the intake of nutrient elements in the soil or fertilizer which demonstrates the productivity of the soil. The pH value generally affects the physical, chemical and microbiological properties of the soil. Therefore, to achieve a high amount of quality product yield from unit area in terms of fertilization in plant production, the pH value of the soil layer surrounding the capillary roots of the plant should match a value that supports the growth of (or is favourable by) the plant [2].

Kacar [3] suggests there is an interesting and complicated relationship between the calcification of reactive soils and the potassium in the soil. When the soil is calcified, the K^+ and Ca^{+2} in their change complex are displaced, and normally the amount of K^+ in the soil solutions is supposed to increase. However, after

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calcification of soils with acidic reaction, the amount of potassium in the soil solution decreases. The antagonistic effect of calcium on potassium intake is associated with this phenomenon.

Many researchers have associated the limiting effect of acidic soil on plant production to the fact that the intake of certain plant nutrients in the soil is significantly decreased and that the solubility of certain plant nutrients is increased to a level that is toxic for the plants. The same researchers suggest that the toxic effects of Fe, Al and Mn, as well as lack of certain plant nutrients such as P, Ca and Mg may cause decreased productivity in acidic soils [4].

The decreased productivity resulting from acidification of soil can be cured by liming. Calcium compounds such as lime stone ($CaCO_2$), unslaked lime produced by burning lime stone (CaO), slaked lime [$Ca(OH)_2$], dolomite ($CaCO_3$+$MgCO_3$) are the most commonly used liming materials. As these compounds are applied to the acidic reaction soil, H^+ which is bonded to the colloids is replaced by Ca^{+2} and removed from the soil, thus increasing the pH value [5].

A study by Özuygur et al. [6] suggests that acidic reaction of the soils in Eastern Black Sea region is the most important factor that causes low productivity for all culture plants (except for tea, which favours acidic soil), and that a significant increase in productivity is observed after the soil reaction rises above pH 6,5 with calcification.

Liming is the first step in a well-planned soil management program, and a calcification application that is fit for the needs of the soil and plants ensures highest level of benefit from other plant nutrients as well. The pH value, texture and organic material content of the soil, as well as the liming material to be used, time of liming and the frequency of application play an important role when choosing a liming program to be applied to the soil [7].

The aim of this study is to look into physical and chemical properties of 15 acidic soils that have been collected from agricultural areas in Çanakkale, and to identify their calcification needs as well as the best method for calcification.

Material and Methods

Samples of 15 soils used in the study were collected at 0-20 cm of depth from locations which represent the acidic soils in the study (Figure 1). The coordinates of sampling points were determined using a GPS.

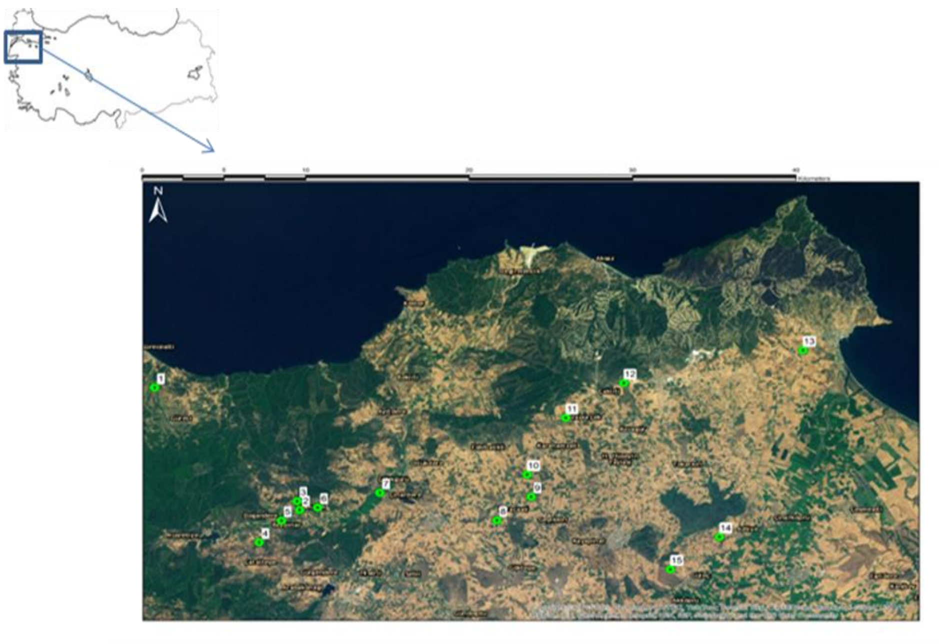

Figure 1. The studied area and sampling points.

In the soils, the pH value was identified by using pH meter in soil-water and KCl solution [8], the particle size distribution was identified by using Bouyoucos hydrometer method [9], and organic material content was identified by using Smith-Weldon method [10]. The cation exchange capacity and changeable bases were determined by Ammonium Acetate (pH 7 method) [11], and the acidity of exchange was identified by $BaCl_2$-Triethanolamine method [12]. The available phosphorus content of the soils was determined by acid-fluoride-soluble phosphorus method (Bray and Kurtz no.1); in identification of lime requirements, three different methods were used, including Calcium Carbonate Incubation Method, Woodruff Method and Calcium Acetate Method [13].

Results and Discussion

The pH values of soil samples do not vary across a wide range since samples were collected from acidic soils. Among the samples, the lowest pH value was identified as 4,50, and the highest pH value was 6,20. Most of the soil samples collected from the studied area were slight acidic, and a few samples had medium level of acidity. The organic material content of the soils in the study varied from 0,7% to 2,4%. The Cation Exchange Capacity (CEC) of the soil samples ranged between 9,95–46,32 cmol kg^{-1}, the P content favourable for the plants varied between 4,32–47,39 kg P_2O_5/da. The soil texture was frequently clay loam, sandy clay loam and clay (Table 1).

The pH value of soils no. 1 and 14 were respectively 5,82 and 5,86, which was similar, but the clay and organic matter contents of these samples were different. The soil sample no. 14, which had a clay content of 28,3% and an organic material content of 1,9%, had a higher need for lime requirement as compared to the soil sample no. 1, which had a clay content of 26,1% and an organic material content of 1,30%. The fact that these samples had similar pH values but different levels of need for lime requirement was probably due to the difference in their content of organic materials and clay.

Table 1. Some physical and chemical properties of soil samples

Samp.No	pH (1/2.5 KCl)	O.M %	CEC cmol kg^{-1}	Av.P_2O_5 (kg/da)	Clay	Silt	Sand
						%	
1	5,82	1,30	19,71	6,40	26,10	18,30	55,60
2	5,94	0,70	16,02	10,14	30,00	16,00	54,00
3	6,02	0,80	14,57	16,88	33,70	16,10	50,20
4	5,90	1,00	15,58	9,40	32,50	12,20	55,30
5	6,11	1,22	20,20	12,39	36,00	30,00	34,00
6	5,98	1,50	16,16	16,38	39,40	18,80	41,80
7	5,64	1,10	15,33	11,31	30,00	26,20	43,80
8	5,68	1,20	17.00	29,68	46,00	19,50	34,60
9	6,05	0,80	19,95	47,39	45,00	25,00	30,00
10	6,02	0,80	21,42	12,22	51,00	24,80	24,20
11	5,84	1,40	14,12	12,39	33,20	25,50	41,30
12	6,20	2,40	46,32	4,32	34,80	35,20	30,00
13	6,16	1,30	9,95	5,74	20,30	27,00	52,70
14	5,86	1,90	26,90	14,30	28,30	22,50	49,20
15	4,50	1,40	19,74	7,98	38,40	16,40	45,20

The lime requirements of the soils used in the study as identified by various methods are presented in Table 2. According to Table 2(a), the lime requirement of the soils used in this study was found to be 100 kg/da at the lowest, and 300 kg/da at the highest. The changes in the pH values of soil samples after application of various amounts of $CaCO_3$ are presented in Table 2(b). The lime requirements of the soils primarily depend on pH value and CEC. Since the soils with high content of clay and organic material have a high Cation Exchange Capacity, their lime requirement is high. Besides, the changeable acidity (changeable Al+H) content of the soils under study was above 5,1 cmol kg^{-1}. In general, there is a negative correlation between the Al+H content of the soil and its pH value. In other words, the acidity of exchange of the soil decreases as the pH value increases, and vice versa. However, the organic material content, type and amount of clay in the soil also affect the acidity of exchange [14, 4].

Table 2. Lime requirements of the soils as identified by various methods and the changes in pH values of acidic soils after application of various amounts of Calcium Carbonate ($CaCO_3$).

(a) (b)

Soil No	CaAcetat kg/da	Woodruff kg/da	$CaCO_3$ Incubation kg/da	Soil No	$CaCO_3$, kg/da applied: 0	200	300	400	500
1	120	100	180	1	6,10	7,08	7,20	7,38	7,45
2	140	100	192	2	6,14	6,70	6,98	7,26	7,76
3	200	200	198	3	6,20	6,56	6,78	6,87	7,20
4	200	200	199	4	6,09	6,54	6,69	6,85	6,98
5	160	200	193	5	6,25	6,68	6,89	7,02	7,34
6	160	200	192	6	6,21	6,72	6,87	7,09	7,22
7	200	300	204	7	6,12	6,40	6,85	7,01	7,34
8	240	300	209	8	5,84	6,33	6,68	7,12	7,58
9	140	200	190	9	6,24	6,74	7,15	7,35	7,46
10	160	200	195	10	6,29	6,61	6,83	7,12	7,44
11	180	200	199	11	6,30	6,53	6,97	7,32	7,54
12	100	100	184	12	6,33	7,02	7,68	7,72	7,98
13	120	100	181	13	6,37	7,14	7,82	7,91	8,02
14	160	200	191	14	6,06	6,80	7,22	7,47	7,69
15	220	300	215	15	5,46	6,30	6,86	6,98	7,25

In identification of the need for lime requirements of the soils in this study, Woodruff and Calcium Acetate methods were used since they are known to be yielding results in a short period of time. The results were compared to the $CaCO_3$ incubation method, which is generally accepted as a standard. The best method to identify the lime requirements in the need was determined accordingly (Figure 2).

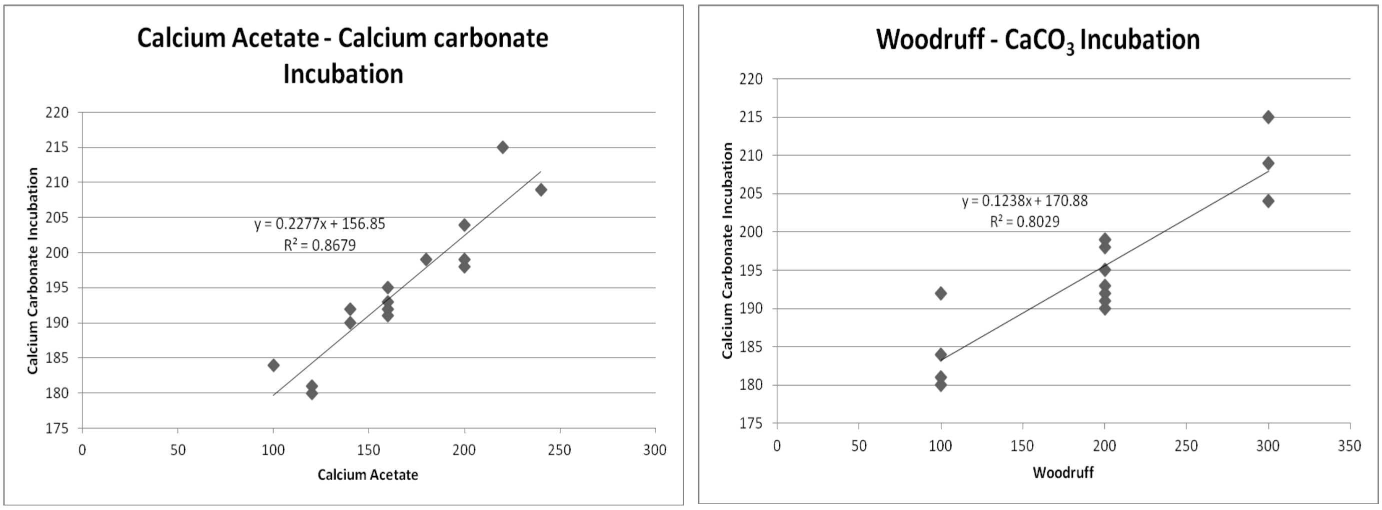

Figure 2. The correlation with Calcium Carbonate Incubation of Woodruff and Calcium Acetate Methods

A look into the graphics in Figure 2 demonstrates that the highest correlation coefficient is obtained with the Calcium Acetate method. This reveals that the best method to identify the lime requirements in the region is the Calcium Acetate method, which yields the closest results to the $CaCO_3$ incubation method. As a matter of fact, Adiloğlu [4] obtained similar results in a study conducted in the Thrace region. Since the accuracy of the method may vary according to the region and the plant species, all conditions should be taken into consideration when choosing a method.

Conclusion

As a result of the study, the shortcomings of the farmers in the region in terms of conducting analysis were identified. The soils under study were found to have very low content of organic material. The farmers should pay attention to this issue and use various organic fertilizers for the soil.

With low pH value in the soil, Al and Fe become soluble and react with the phosphorus in the soil, rendering phosphorus ineffective. Therefore, the pH adjustment in the soil should be made according to the needs of the plants. Every plant favours a different pH range to grow. Following soil analysis, a soil improver should be used according to the desired pH value. Thus, the plant will be provided with a favourable environment to grow in.

For sustainable agriculture it is important to analyse acidic soils prior to fertilization and to add required amount of lime, because insensible fertilization brings more harm than good. The farmers should be informed to add the required amount of lime to acidic soils and then move on to the fertilisation process.

As a result of the study, it has been determined that the Calcium Acetate method yields more accurate results for the calcification process to be conducted in the acidic soils in Lapseki-Biga. According to the study, the lime requirement of the soils in this regions varies between ($CaCO_3$) 100–300 kg/da. In conclusion, Calcium Acetate method can be used when the lime requirement for the region has to be identified urgently.

References

[1] Kacar, B. ve Katkat, V., (2006). *Bitki Besleme* (Dördüncü Baskı). Nobel Yayın No: 849, Fen Bilimleri No: 30, Nobel Yayın Dağıtım, Ankara.

[2] Erkoç İ., 2009. Sera Domates Yetiştiriciliğinde Kükürt ve Leonardit Uygulamalarının Fosfor Yarayışlılığına Etkileri. (Yüksek Lisans Tezi) Çukurova Üniversitesi Fen Bilimleri Enstitüsü Bahçe Bitkileri Anabilim Dalı, 127 Sayfa, Adana.

[3] Kacar B., 1983. Asit Tepkimeli Topraklarda Kireçlemenin Bitki Besin Maddelerinin Yarayışlılığı Üzerine Etkileri. Tarımda Verimlilik Paneli Barkisan, Ankara.

[4] Adiloğlu A., 1992. Trakya Bölgesi Asit Topraklarının Kireç İhtiyaçlarının Tayininde Kullanılabilecek Yöntemler Üzerinde Bir Araştırma. (Yüksek Lisans Tezi), Trakya Üniversitesi, Ziraat Fakültesi, Toprak Anabilim Dalı, 60 Sayfa Tekirdağ.

[5] Avukatoğlu G., 2009. Saray ve Çerkezköy Yöresi Asit Topraklarında Yetiştirilen Mısır Bitkisine Uygulanan Farklı Dozlardaki Kirecin Potasyum Alımına Etkisi Üzerine Bir Araştırma. (Yüksek Lisans Tezi), Namık Kemal Üniversitesi Fen Bilimleri Enstitüsü, 55 Sayfa Tekirdağ.

[6] Özuygur M., Ateşalp M., ve Börekçi M., 1974. Doğu Karadeniz Topraklarının Kireç İhtiyaçlarını Tayinde Uygulanacak Metodlar ve Kireçleme Malzemeleri Üzerinde Bir Araştırma. TÜBİTAK Yayın No: 283, TOAG Seri No:48, Ankara.

[7] Uzun F., 1994. Asit Karakterli Topraklarda Kireçleme ve Gübrelemenin Macar Fiği (Vicia Pannonica L.) Bitkisinde Kök, Gövde ve Nodül Gelişimine Etkisi. (Yüksek Lisans Tezi), Ondokuz Mayıs Üniversitesi Fen Bilimleri Enstitüsü, Sayfa 92, Samsun.

[8] Jackson, M.L.1962. Soil chemical analysis. Prentice-Hall Inc.

[9] Gee, G. W. And Bauder, J.W.1986. Particle-size Analysis. Soil Science Society of America and American society of Agronomy,677 S.Segoe Rd., Madison, WI 53711, USA. Methods of Soil Analysis Part 1,-Physical and Mineralogical Methods.SSSA Book Seies:5.

[10] Nelson, D.W. and Sommers, L.E. 1996. Total carbon, organic carbon and organic matter. Soil Science Society of America and American society of Agronomy,677 S.Segoe Rd., Madison, WI53711, USA. Methods of Soil Analysis Part 3,-Chemical Methods-SSSA Book Seies:5.

[11] Soil Survey Laboratory Staff, 1992. Soil survey laboratory methods manual.Soil Surv. Invest.Reps. 42. USDA-SCS, Washington, DC.

[12] Peech, M. 1965. Exchange Acidity. Methods of soil Analysis. Part 2. Cemical and Microbiological Properties(C.A.Black-Ed.) Madison, Wisconsin, USA.

[13] Sağlam, M.T., 2008. Toprak ve suyun kimyasal analiz yöntemleri. NKÜ Ziraat Fakültesi Yay. No:2, Ders Kitabı No: 2 Tekirdağ.

[14] Kamprath E.J ve Foy C.D., 1984. Line- Fertilizer- Plant Interactions In Acid Soils. In O.P. Engelstated

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Soil formation on terraces with different elevations in Meric catchment

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Abstract

In this research soil formations at different elevations on Meriç watershed have been investigated. Terrace number 1 has been formed on young alluvial deposits (flood plain) at 30 m elevation 0,71 km from Meriç river. Terrace number 2 (miocene-pliocene age) is about 1.5 km away from the river and at 37 m altitude. Terrace number 3 is the same age as terrace 2, and 3.4 km away from river at 61 m altitude. Physical-chemical properties and some weathering rates of these soils have been investigated. There were many buried horizons and sediment accumulations in soil profile on terrace one. On the other hand, clay illuviations were observed in other 2 terraces (argillic horizon together with medium and strong prismatic structure). The weathering progress has been evaluated by the Chemical index of alteration (CIA) - $Al_2O_3/Al_2O_3+CaO+Na_2O+K_2O$. Silt/clay ratios have also been observed. This ratio was greater in terrace 1 than other terraces. These soils were formed by fluvial sediments where there were low clay formation and young soils. Additionally, $CaO+MgO/Al_2O_3$ ratios were investigated. This ratio was lowest in terrace 2, and highest in terrace 1. Decalcification was low in terrace 1, while pretty high in terrace 2. $SiO_2/Al_2O_3+Fe_2O_3+TiO_2$ ratios were high in A horizons, and low in B horizons and sub horizons. Of the investigated soil profiles, number 1 was classified as Entisols and other profiles as Alfisols.

Keywords: Soil formation, weathering rates, Meriç catchment, soil terrace.

Introduction

Soil formation generally involves two stages or phases. The first stage involves the accumulation of the parent material and, the second involves the formation of the soil from the parent material [1]. Weathering is the chemical and physical alteration of rocks and minerals at or near the surface of the earth. The alterations occur because the rocks and minerals are not in equilibrium with the temperature, pressure, and moisture conditions of their environment [2]. Some researchers make distinction between geochemical pedo-chemical weathering [3]. Geochemical weathering is that taking place below the soil solum (A and B horizons) in C horizons, saprolite, and rocks, whereas pedo-chemical weathering is that occurring in the soil solum [4].

As is known, temperature and precipitation are the factors determining chemical, physical and biological weathering. Besides, elevation, surface runoff and vegetation affect chemical weathering. Soil genesis is based upon of leaching away of basic cations which is resulted from decomposition of silicates [5]. The intensity of chemical weathering that soils have undergone can be assessed by constructing ratios of chemical

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compounds (chemical weathering indices) or minerals (mineral weathering indices). Many of the chemical weathering indices employ the amount of silica and alumina or both in soils [6]. Chemical weathering indices are determined by the formulas which are defined by ratios of element oxides. Molecular ratio of any of the oxides can be calculated by using their weights.

Cangir and Ekinci [7], studied the genesis of the soils formed on limestones in Antalya. It was found that available Fe2O3 concentrations were high due to high degree of weathering in two soil profiles. The researchers indicated that the dominant soil forming factor is decalcification in the study area by referring SiO_2/Al_2O_3, Na_2O+K_2O/Al_2O_3 and $CaO+MgO/Al_2O_3$ ratios. Fitzpatrick [8], estimated the weathering degree by using silt-clay ratio in red tropical soils. He also pointed out that the ratios below 0.2 indicate the presence of long term weathering processes.

Nesbitt and Young [9], suggested a term called "Chemical Index of Alteration" (CIA) to be calculated from the chemical analyses of rocks and sediments and to evaluate decomposition and weathering processes. CIA is formulated as $Al_2O_3*100/(Al_2O_3+CaO+Na_2O+K_2O)$. Wagner [10], found the decomposition and weathering degree in the Bt horizon is higher than the Ap horizon. The index was found higher in high terraces and low in low level terraces.

Retallack [11], reported that $(CaO+MgO)/Al_2O_3$ ratio is decreasing correspondingly by leaching lime in soils. On the other hand, Yaalon, [12], indicated that $(CaO+MgO)/Al_2O_3$ ratio in Ap horizon increased by secondary calcium carbonates.

In another study carried in Pennsylvania, the soils formed on young alluvial material were studied and the ratio of fine clay to clay, weathering products of illite to illite and thickness of clay films were investigated. Above mentioned parametres connected by related to morphological features and pedologic developments of soils were explained [13].

In a study performed in the Netherlands, the formation of clay soils on limestone was investigated. A clay illuviation by depth was observed by taking into consideration of SiO_2/Al_2O_3 ratios. In addition, it was reported that these ratios can be used to distinguish the soils if they were old or recently formed [14].

In another study carried on the Punjab Plain in India, the uniformity of the parent material was explained by referring weathering degrees. It was reported that the sudden changes in TiO_2-ZrO_2 ratios indicated a lithological discontinuity by depth [15].

In this study, three soil profiles located on terraces on different elevations and different distances from the river within the Meric River Basin were investigated. Beside the characterization of some morphological, physical and chemical soil properties, Chemical Index of Alteration (CIA), weathering ratios as $CaO+MgO/Al_2O_3$ and $SiO_2/Al_2O_3+Fe_2O_3+TiO_2$ were determined.

Material and Methods

The study area is located in the south of Edirne Province, close to the Meriç river in Thrace Region (Figure 1).

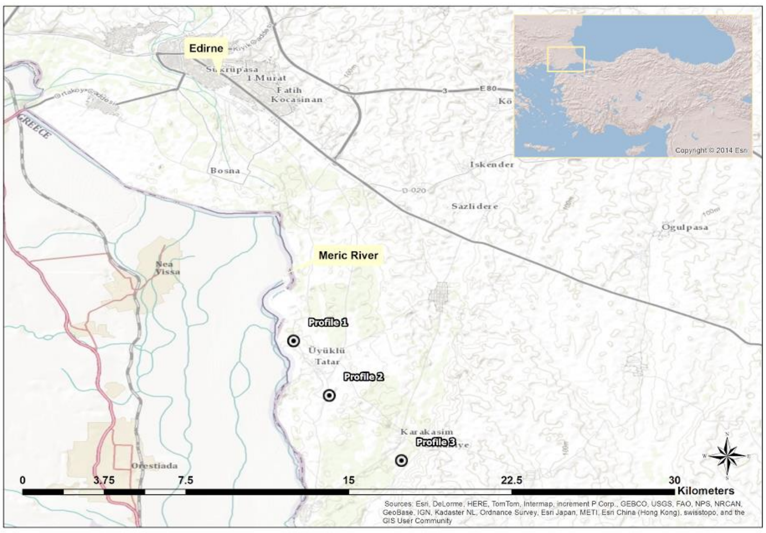

Figure 1. The study area and sites of profiles

The climate is characterised by hot, dry summers and cool, wet winters. Annual precipitation is 571.8 mm, and annual mean temperature 13.4 °C. Annual mean soil temperature at 50 cm is 15.5 °C. The soil temperature regime is thermic-mesic and the moisture regime is xeric. Annual evapotranspiration in this region is 1234.4 mm and annual water deficit is 662.6 mm. Geology of the study area is dominated by clay, sand, and gravel primarily of Quaternary (Holocene) age and lands formed on Pliocene deposits on lime rich pre-Neogene mudflows.

In this research, soil formations of three soil profiles at different elevations on Meriç watershed have been investigated. Terrace number 1 (profile 1-P1) has been formed on young alluvial terraces (Holocene age) at 30 m elevation 0.71 km from Meriç river. Terrace number 2 (profile 2-P2) (Pliocene age) is about 1.5 km away from the river and at 37 m altitude. Terrace number 3(profile 3-P3) is the Pliocene-Miocene age as terrace 2, and 3.4 km away from river at 61 m altitude.

In the soils, the pH value was identified by using pH meter in soil-water solution [16], the particle size distribution was identified by using Bouyoucos hydrometer method [17], and organic material content was analysed by using Walkley-Black method [18]. The cation exchange capacity was determined by Ammonium Acetate (pH 7 method) [19]. The calcium carbonate content of the samples was determined with a Scheibler analyser [20]. Major element compositions were determined by XRF ($Li_2B_4O_7/LiBO_2$ fusion) on air dried, ground and homogenized soil samples in ACME laboratories in Canada.

Results and Discussion

The chemical and physical analysis results of the soil profiles are spresented in Table 1. The Profile 1 (P1) has been formed on young alluvial terrace (floodplain), the Profile 2 has been formed on old graben formations and the Profile 3 has been formed on elevated horst lands. In the Profile 1, the texture, carbonate content and organic matter content are varying by depth and these soils have a buried horizon in their profile (Table 1). The depth of Profile 1 is 2m, it has an A horizon with dark colour and enriched with organic matter (2.71%). The existence of the layers which are overlaying on the buried horizon proves sediment accumulation from past to present. And these conditions are typical for young alluvial soils which have little profile development. Thus, the clay-silt ratio was found higher in Profile 1 than the other two profiles (P2 and P3).

Table 1. Some chemical and physical characteristics of the soils.

Horizon	Depth (cm)	pH H_2O	O.M (%)	$CaCO_3$ (%)	CEC cmol kg^{-1}	Sand	Silt	Clay
							%	
P1								
Ap	0-30	7,55	1,21	6,90	17,40	48,40	33,40	18,20
AC	30-56	7,63	0,71	7,85	13,90	67,70	22,50	9,80
C1	56-64	7,64	0,71	14,84	21,30	59,30	28,80	11,90
C2	64-74	7,50	0,37	11,07	13,00	71,20	23,20	5,60
2C	74-79	7,69	0,60	12,26	13,00	59,70	33,70	6,70
3C	79-85	7,71	0,75	13,52	18,30	29,10	58,90	11,90
4A	85-92	7,64	1,48	4,79	26,10	22,80	55,80	21,40
4C	92-125	7,66	0,34	6,01	13,90	74,00	18,30	7,70
5Ag1	125-172	7,36	2,31	2,77	48,30	11,50	28,10	60,30
5Ag2	172-209	7,57	1,83	12,89	87,00	12,60	39,70	47,70
P2								
Ap	0-12	6,50	2,88	0,32	5,30	71,64	24,31	4,05
E	12-26	6,10	1,22	0,20	3,17	59,41	28,42	12,17
EB	26-33	5,80	0,78	0,20	9,56	54,63	22,69	22,68
Bt	33-95	5,60	0,73	0,24	13,09	45,09	19,01	35,90
Btx1	95-127	6,10	0,83	0,16	19,02	49,44	18,96	31,60
Btx2	127-165	6,50	0,54	0,20	11,57	56,11	18,81	25,08
CB	165-179	7,60	0,19	2,83	12,17	51,92	23,00	25,08
Ck	179-198	7,80	0,54	12,14	15,58	52,27	24,90	22,83
C	198+	7,80	0,44	2,11	5,19	58,49	20,76	20,75
P3								
A1	0-12	7,14	0,99	0,87	17,45	77,21	6,64	22,15
A2	12-25	7,89	0,79	0,32	14,27	63,46	10,35	26,19
Bt1	25-42	8,35	0,74	2,37	16,50	51,37	14,40	34,22
Bt2	42-48	8,45	0,57	1,97	18,54	51,95	13,70	34,35
BC	48-52	8,48	0,46	1,62	10,30	55,39	14,72	29,90
C	52-70	8,46	0,15	1,74	2,50	60,41	22,40	17,18

Wagner et al. [10], reported that, the silt-clay ratio can be used to determine weathering degree and sudden changes of this ratio show the major effect of the parent material. Durn [21], reported that the silt-clay ratio is higher in fluvial sediments than underlying calcarentic material because of fluvial sediment's coarse texture. The P2 which is located on a graben plain has eluvial E horizon and Bt (argillic) horizon by clay illuviation. The profile has also a calcic horizon formed by decalcification. Argillic horizons are reddish in colour, have prismatic structure and cemented by clay and iron oxides. Similar situation can be also seen in the P3 which is situated at the higher elevation. However, the P3 has little profile development than the Profile 2 because of the topographical conditions.

CaO concentrations are generally above 1% in all three profiles (Table 2). Wagner et al. [10], found the CaO concentrations were below 1% in all soil profiles studied and concluded that the decalcification process was close to be completed. In this study, CaO concentrations of E and EB horizons in P2 were 1.13% and 1.07 respectively and closed to the value of 1%. It can be concluded that the decalcification process is not ended but ongoing by referring these CaO values. Besides, by referring the $(CaO+MgO)-Al_2O_3$ ratios, it is 0.04 in the E horizon and 1.42 in the Ck horizon (179 – 198 cm). This situation shows the presence of the decalcification in the profile. Retallack [11], reported that decreases in this ratio prove the existence of decalcification process in soils. The high value of this ratio is resulted from environmental conditions. Thus, Yaalon [12], reported that the high $(CaO+MgO)-Al_2O_3$ ratios are resulted from secondary carbonates. The $(CaO+MgO)-Al_2O_3$ ratio is high in the Profile1 (P1) due to its being located young alluvial plains and lack of pedogenic processes. These ratios in P3 are higher than P2 (especially in the surface horizons) because of insufficient leaching in the profile and also tectonism and erosion.

Nesbitt and Young's [9] "Chemical Index of Alteration" (CIA) ratio was found higher in Bt horizons of P2 and P3. Increase in CIA index of Bt horizons in both of the profiles shows that the alteration is higher than that of in A horizon. Wagner et al. [10] found that the alteration in the Bt horizons was higher than the Ap horizons. CIA values are higher in P2 than the P2 since the P2 is located on a flatland. This situation points out that the profile development in P2 is better than the P3. When the $SiO_2-Al_2O_3+Fe_2O_3+TiO_2$ are examined, it can be seen that the ratios of Bt in P2 and P3 are low and high in lower horizons. For the profiles P2 and P3, the ratios prove the presence of clay illuviation and the silicates has been slightly weathered in residual. The higher values in A horizons probably resulted by agricultural activities. Wagner et al. [10], studied these ratios on terraces, and they indicated that the slight changes in ratios by depth point out silicates weathering (in situ). Due to high sedimentation in P1, the ratios are fluctuating in the profile.

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Conclusion

In this study, the genesis of 3 soil profiles have been investigated which vary primarily by topography and elevation (P1, P2 and P3). In general, the age of soil is increasing by the distance from the river and by the elevation. P1 which is located close to the Meriç River and developed on fluvial deposits, 2m in depth, dark in colour, enriched by organic matter (2,71 % OM) and it has buried A horizon and overlying younger layers on it. The Profile 1 is an young Entisol (fluvents) which shows little profile development. Thus, the silt-clay ratio is higher than the Profile 2 and Profile 3 and shows sudden changes by depth as its weak profile development. The Profile 2 (P2) which has developed on a graben plain has an argillic and calcic horizons and signs of residual weathering. These characteristics show that the Profile 2 has been strongly affected by pedogenic processes. The well- developed soil profile and the pedogenic processes have been explained by weathering

Table 2. Chemical compositions of soil samples

Horizon	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	TiO_2 (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	P_2O_5 (%)	LOI (%)
P1										
Ap	63,0	14,94	4,33	0,10	1,86	3,23	2,84	2,70	0,19	5,61
AC	64,2	14,60	4,00	0,09	1,74	3,55	3,08	2,62	0,17	4,12
C1	60,8	15,70	5,01	0,12	2,28	3,74	2,78	2,72	0,13	6,41
C2	65,1	14,70	4,06	0,09	1,81	3,76	3,18	2,71	0,14	3,80
2C	64,0	14,83	4,33	0,10	1,83	3,91	3,12	2,67	0,17	4,14
3C	61,5	15,64	4,61	0,11	2,00	3,71	2,86	2,83	0,15	5,98
4A	57,7	16,08	5,52	0,13	2,28	3,31	2,29	2,78	0,16	8,63
4C	65,0	14,87	4,08	0,09	1,92	3,37	3,10	2,76	0,13	4,07
5Ag1	52,3	17,59	6,82	0,12	2,55	2,01	1,21	2,67	0,19	13,79
5Ag2	53,8	16,73	6,47	0,15	2,58	2,67	1,55	2,66	0,17	12,04
P2										
Ap	77,3	9,65	1,68	0,07	0,35	1,24	2,06	2,36	0,05	5,20
E	77,6	10,25	1,85	0,08	0,40	1,13	2,09	2,40	0,04	3,99
EB	72,6	11,98	2,91	0,07	0,66	1,07	1,80	2,29	0,04	6,10
Bt	66,6	13,87	4,01	0,06	0,92	1,18	1,48	2,12	0,03	8,98
Btx1	-	-	-	-	-	-	-	-	-	-
Btx2	69,9	12,85	3,31	0,07	0,95	1,35	1,92	2,16	0,04	6,70
CB	67,4	13,11	3,63	0,08	1,24	2,26	1,91	2,12	0,07	7,82
Ck	61,2	11,71	3,19	0,07	1,19	7,46	1,82	1,99	0,10	10,80
C	68,7	12,36	3,13	0,07	1,05	2,65	2,00	2,26	0,07	6,94
P3										
A1	76,7	10,84	1,90	0,06	0,58	1,27	1,90	2,79	0,04	4,11
A2	71,6	12,19	2,63	0,09	0,91	1,51	1,82	2,76	0,05	6,15
Bt1	66,4	13,32	3,34	0,15	1,19	2,06	1,67	2,65	0,07	8,43
Bt2	65,2	13,74	3,45	0,15	1,28	2,31	1,72	2,65	0,09	8,84
BC	66,3	13,36	3,22	0,16	1,20	2,43	1,72	2,67	0,06	8,27
C	67,5	14,15	2,57	0,08	1,10	2,37	2,47	2,79	0,10	6,05

Horizon	SiO_2 (%)	Al_2O_3(%)	Fe_2O_3(%)	TiO_2(%)	MgO(%)	CaO(%)	Na_2O(%)	K_2O(%)	P_2O_5(%)	LOI(%)
P1										
Ap	63,0	14,94	4,33	0,10	1,86	3,23	2,84	2,70	0,19	5,61
AC	64,2	14,60	4,00	0,09	1,74	3,55	3,08	2,62	0,17	4,12
C1	60,8	15,70	5,01	0,12	2,28	3,74	2,78	2,72	0,13	6,41
C2	65,1	14,70	4,06	0,09	1,81	3,76	3,18	2,71	0,14	3,80
2C	64,0	14,83	4,33	0,10	1,83	3,91	3,12	2,67	0,17	4,14
3C	61,5	15,64	4,61	0,11	2,00	3,71	2,86	2,83	0,15	5,98
4A	57,7	16,08	5,52	0,13	2,28	3,31	2,29	2,78	0,16	8,63
4C	65,0	14,87	4,08	0,09	1,92	3,37	3,10	2,76	0,13	4,07
5Ag1	52,3	17,59	6,82	0,12	2,55	2,01	1,21	2,67	0,19	13,79
5Ag2	53,8	16,73	6,47	0,15	2,58	2,67	1,55	2,66	0,17	12,04
P2										
Ap	77,3	9,65	1,68	0,07	0,35	1,24	2,06	2,36	0,05	5,20
E	77,6	10,25	1,85	0,08	0,40	1,13	2,09	2,40	0,04	3,99
EB	72,6	11,98	2,91	0,07	0,66	1,07	1,80	2,29	0,04	6,10
Bt	66,6	13,87	4,01	0,06	0,92	1,18	1,48	2,12	0,03	8,98
Btx1	-	-	-	-	-	-	-	-	-	-
Btx2	69,9	12,85	3,31	0,07	0,95	1,35	1,92	2,16	0,04	6,70
CB	67,4	13,11	3,63	0,08	1,24	2,26	1,91	2,12	0,07	7,82
Ck	61,2	11,71	3,19	0,07	1,19	7,46	1,82	1,99	0,10	10,80
C	68,7	12,36	3,13	0,07	1,05	2,65	2,00	2,26	0,07	6,94
P3										
A1	76,7	10,84	1,90	0,06	0,58	1,27	1,90	2,79	0,04	4,11
A2	71,6	12,19	2,63	0,09	0,91	1,51	1,82	2,76	0,05	6,15
Bt1	66,4	13,32	3,34	0,15	1,19	2,06	1,67	2,65	0,07	8,43
Bt2	65,2	13,74	3,45	0,15	1,28	2,31	1,72	2,65	0,09	8,84
BC	66,3	13,36	3,22	0,16	1,20	2,43	1,72	2,67	0,06	8,27
C	67,5	14,15	2,57	0,08	1,10	2,37	2,47	2,79	0,10	6,05

degree and morphological observations. As the P2 has above characteristics thus it can be classified as an Alfisol. As it has developed at higher elevation, the Profile 3 has similarities with Profile 2 but there are also differences between two. In P3, the decalcification and clay illuviation are not strong as in the Profile 2 since the P3 is located on the different topography. Therefore, the P3 can be classified as a young Alfisol by considering of its weak profile development and horizons. To determine absolute dating of soil horizons and profiles, radiocarbon dating methods must be performed. Additionally, some mineralogical and micromorphological analyses should be done to detailed genesis of the soils.

References

[1] Faniran, A. And Areola, O. 1978. Essentials of Soil Study.277 pp. Heinemann, London.

[2] Birkeland, P.W., 1974. Pedology, Weathering, and Geomorphological Research. Oxford Univ. Press, New York. 285 pp.

[3] Jackson, M.L., and Sherman, G.D.1953. Chemical Weathering of minerals in soils. Adv. Agron. 5:219-318.

[4] Buol, S. W., Hole, F. D., McCracken, R. J. and Southard, R.J. 1997. Soil genesis and classification. Iowa State Univ. Press/Ames. 527pp.

[5] Soori, M., Jafari, M., Azar Nivand, H. and Sharifani, F. 2006. A study on and comparison between soil nutrient statuses with a focus on K., P., and N. in agricultural and pasture lands of Kermanshah province: A case study. Journal of Agricultural and Horticultural Research, No 71, p. 50-41.

[6] Gerrard, J. 1995.Soil Geomorphology. Chapman and Hall. 263 pp.

[7] Cangir, C. And Ekinci, H. 1991. Kireçtaşı (Alanya) ve Denizel Kireçtaşı Konglomeraları (Antalya) Üzerinde Oluşmuş Toprakların Genesisleri ve Yeni Sınıflama Sistemindeki Yerleri. Toprak İlmi Derneği 11. Bilimsel toplantı tebliğl. Yay. No:6.

[8] Fitzpatrick, E.A. 1971. Pedology. A Systematic Approach to Soil Science: Edinburgh, Oliver and Boyd, 306 pp.

[9] Nesbitt, H.W., and Young, G.M. 1984. Early Proterozoic climates and plate motions inferred from major element chemistry of lutites. Nature 299 (5885), 715–717.

[10] Wagner,S., Costantini, Edoardo A.C., Sauer, D., and Stahr, K. 2007. Soil genesis in a marine terrace sequence of Sicily, Italy. Revista Mexicana de Ciencias Geológicas, v. 24, num. 2, p.247-260

[11] Retallack, G.J.1997. A Colour Guide to Paleosols. New York, John Wiley&Sons, P,175.

[12] Yaalon, D.H., 1997. Soils in The Mediterranean region. What Makes Them Different?, Catena, 28, 157-169.

[13] Bılzı, A. F. And Cıolkosz, E. J. 1977.Time is a Factor in the Genesis of Four Soils Developed in Recent Alluvium in Pennsylvania. Soil Sci. Soc. A. Journal, vol:41,No:1, p 122-126.

[14] Wersraten, J.M. and Sevink, J. 1978. Clay Soils on Limestone in South Limbure, The Netherlands. 2. Weathering. Geoderma 21: 269-280.

[15] Sidhu, P.S.and Sehgal, J.L. 1976. Parent Material Uniformity and Weathering Indices in the Alluvium-Derived Soils of the Indo-Gangetic Plains of Punjab in NW India. Pedologie, XXVI, 2, p.191-201. Ghent.

[16] Jackson, M.L.1962. Soil chemical analysis. Prentice-Hall Inc.

[17] Gee, G. W. And Bauder, J.W.1986. Particle-size Analysis. Soil Science Society of America and American society of Agronomy,677 S.Segoe Rd., Madison, WI 53711, USA. Methods of Soil Analysis Part 1,-Physical and Mineralogical Methods.SSSA Book Seies:5.

[18] Nelson, D.W. and Sommers, L.E. 1996. Total carbon, organic carbon and organic matter.p 961-1010. Soil Science Society of America and American society of Agronomy,677 S.Segoe Rd., Madison, WI53711, USA. Methods of Soil Analysis Part 3,-Chemical Methods-SSSA Book Seies:5.

[19] Soil Survey Laboratory Staff, 1992. Soil survey laboratory methods manual.Soil Surv. Invest.Reps. 42. USDA-SCS, Washington, DC.

[20] Anonymous, 1993. Procedures for Soil Analysis (Ed. By L.P.van Reeuwijk). ISRIC, The Netherlands.

[21] Durn, G. 2003. Terra Rossa in the Mediterranean region: Parent materials, composition and origin: Geologica Croatica, 56, 83-100.

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Magnetic susceptibility parameter in the evaluation of spatial heterogeneity of soils due to the influence of paleoecological factors

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Abstract

The objects of this study were the modern surface soils and buried soils (BS) formed on different elements paleocryogenic microrelief and under different natural areas within the center of the East European Plain. The aim was to identify the patterns and mechanisms of formation of the structure of spatial heterogeneity of soil properties and soil due to paleoenvironmental factor, based on a measure of the magnetic susceptibility (MS). Regularities of spatial variability parameter MS in soils of different elements paleocryogenic microrelief were for the first time identified. The paleocryogenic microrelief role in the formation of strong magnetic iron minerals is comparable with the effect of zonal conditions of soil formation and is expressed in water-air conditions differentiation, the nature of the variation which causes heterogeneity of soil properties at the subtype level. Variography allowed to reveal the characteristic dimensions of homogeneous structures, the presence of which was associated with paleocryogenic microrelief and its structure-forming elements. The spatial distribution of MS due paleocryogenic microrelief has the form of a circle, rhythmically repeating structures. Ideas about the formation of paleocryomorphic soils on the basis of MS parameter for the first time were succeeded to specify. Results can be used in complex paleosoil studies, modeling the factors causing spatial heterogeneity of soils, the study of soil structure and its mapping, monitoring of soil characteristics in connection with the development of technology "exact" agriculture. The results of this study should be considered at the organization of experimental research in interdisciplinary sciences.

Keywords: paleoecology, magnetic susceptibility, paleocryogenic structures, spatial heterogeneity, variography, buried soils

Introduction

It is known that the modern soil cover has the signs of severe periglacial conditions (Markov, 1959; Gerasimov et al., 1960; Velichko, 1965; Berdnikov, 1976) which cause significant spatial and profile variability of soil properties at different levels of structural organization (Alifanov, 1995; Velichko et al., 1996). The parameter of magnetic susceptibility was used to study the regularities of formation of such heterogeneity. It gives information about the course of a series of elementary soil processes (Vodyanitskiy, 2008) directly in situ and allows to express it through objectively measured physical quantity (Ivanov, 2003). The parameter of MS is defined in a field without any special sample preparation which allows to carry out massive research and receive the data corresponding to the natural (Alekseev et al., 1988).

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Material and Methods

The object of the study was soil formed on different elements paleocryogenic microrelief and under different natural areas within the center of the East European Plain. The research was conducted in the Central Russian province of soddy-podzolic soils of arable land and forest land (Vologda region), in the Vyatka-Kama province of soddy-podzolic soils (Chuvash Republic), in the Oka-Don province of gray forest soils, leached and podzolic chernozems (Tula region). Besides modern soil outcrop sections had horizons of cryomorphic buried soils and numerous paleocryogenic forms.

Soil is an object possessing high spatial heterogeneity and at the same time characterized by continuity and gradual changes of their properties (Dmitriev, 1983). The choice of approaches and methods to the study of spatial variation depends on the level of structural organization of soil on which it is viewed. In the study we used the system of large cut-trenches with an area of walls more than 20 m^2 that allow to see the nature of the boundary changes between the horizons, the number of cracks, nodules, neoformations depending on the position in the microrelief.

In the field studies the volume magnetic susceptibility values were measured using kappameter KT-6 in a regular grid with a mesh size of 20×20 cm. The regular grid covered all major morphonyl soil profiles. In the area of the soddy-podzolic soils where the distance between the elements paleocryogenic complex ranged from 50 to 200 m the small profile pits were made but the frequency of the location of sampling points in them was greater. Values of specific magnetic susceptibility, the main parameters of the biological, physical and physico-chemical conditions of the soil, the total form of Fe_2O_3 and TiO_2were measured in the laboratory conditions.

Variography was used to investigate the regulators of spatial variation of MS and assess the possible impact on the modern soil cover of paleocryogenic structures (Burgess et al., 1980; Ivannikova et al., 1988; Gummatov et al., 1992; Samsonova, 2008; Krasilnikov, 2008, and other). Experimental semivariograms were graphed for each horizontal line sampling (along the trench). The experimental semivariogram – dependency diagram of MS from the distance between sampling points (h). Approximation of the semivariograms was made in Surfer 7 and Vesper 1.6 programs, the compliance degree was estimated by the mean square error.

Results and Discussion

The detailed analysis of modern soils formed on different elements of the paleocryogenic microrelief (block elevations and interblock depressions) showed that they differ in morphological and analytical properties. As a rule the soil in interblock depression has more elongate humus profile, contains larger amounts of organic substances carbon, microbial biomass carbon, mobile form of phosphorus and at the same time contains no carbonates, characterized by a low content of exchangeable cations and has a low value of pH in contrast to the soil block. Such differences are determined by the intensity and direction of processes of leaching, gley, podzolization and humus accumulation which, in turn, alter the magnetism of iron compounds.

Soddy-podzolic soils in which iron is a typomorphic element have clearly differentiated magnetic profile that is clearly seen in the area in forest. The distribution of MS values showed that the maximum values of MS were confined to more drained block elevations, whereas in the soils of interblock depressions reducing conditions associated with long term stagnation, drop of oxidation-reduction potential and development of gley predominated. Gray forest soils and chernozems have accumulative type of magnetic profile, and a high positive correlation between the distribution of MS and C_{org} indicates the presence of strongly pedogenesis oxides Fe, profile curves of content of total forms of Fe and Ti, namely their low content of humus horizons, indicate the same.

Influence of the paleocryogenic microrelief and its structure-forming elements on the formation of magnetic iron compounds changes in the zonal direction and is expressed in differentiating of water-air conditions the nature of the variation which causes heterogeneity of soil properties at a high taxonomic level (Fig. 1).

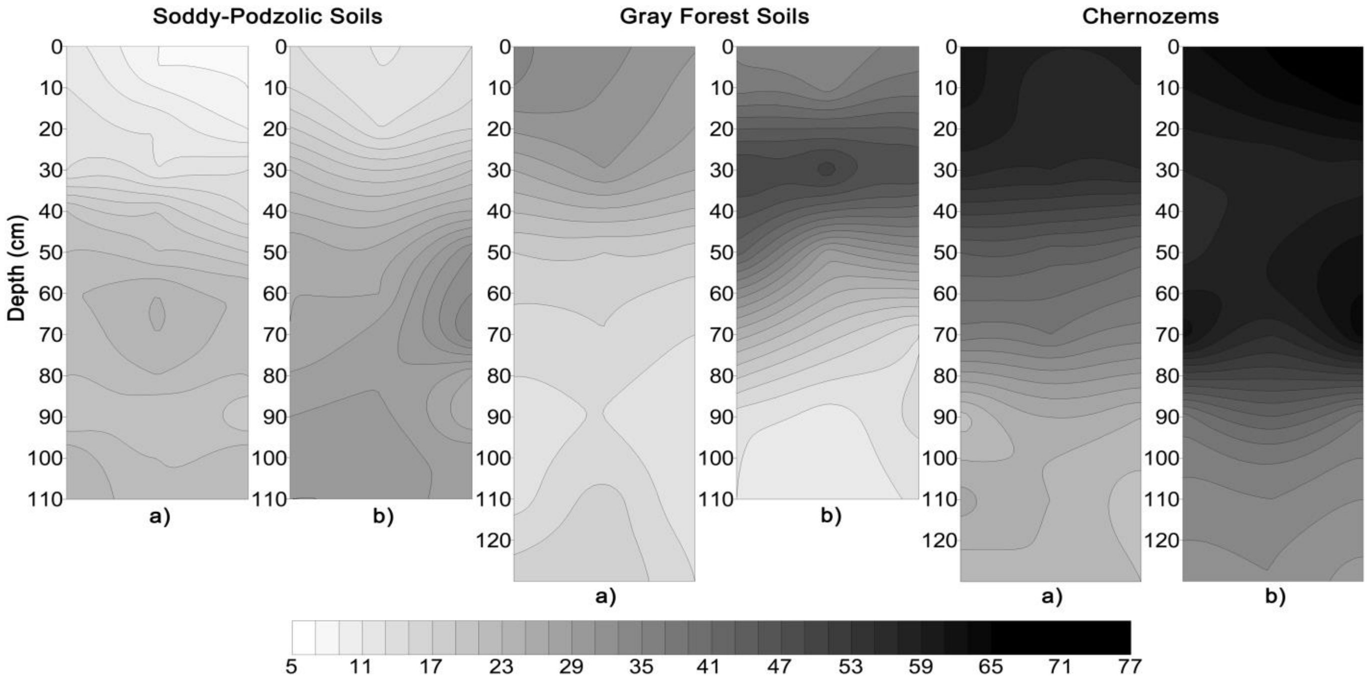

Fig. 1. Profile distribution of MS (×10^{-5} SI units) in soils formed in different elements of paleocryogenic microrelief: block elevations (a) and interblock depressions (b).

Soil cover in the area of soddy-podzolic soils (Albic Luvisols) is a complex consisting of linguiform subtypes in the blocks and gleyic subtypes in the interblocks depressions. In the gray forest soils (Grey Phaeozems) typical subtypes are associated with the blocks and subtypes with the second humus horizon are associated with the interblocks. Typical clay-illuvial chernozems (Luvic Chernozems) formed in the chernozem zone of the northern forest-steppe in the blocks but in the interblock depressions which surrounded the blocks podzolized clay-illuvial chernozems (Luvic Phaeozems) formed.

Hidden regulators were found with using variography in spatially distributed data, namely homogeneous structures were identified and their characteristic sizes were defined (Fig. 2). The structure-forming elements of the paleocryogenic microrelief (relict cryogenic wedge structures) form in the humus horizons of chernozem regions of increased content of ferrimagnetics (width of about 3-4 m) which delimit block elevations. In the gray forest soils similar regions have sizes no more than 1-2 m and are confined to the second humus horizon. In the large dishes fragments of the second humus horizon reserved mainly on the southern and gentle slopes. Thus, as the structure of the soil cover, the distribution of MS in space forms annular, rhythmically repeating structures (Vagapov, 2013).

Magnetic parameters are usually used to justify paleoclimate reconstructions (Bolshakov, 2001), diagnosis of buried soils and loess (Virina et al., 2000) and stratigraphy of loess depth and other deposits Anthropogen (Lomov et al., 1979). Generally the humus horizons of buried soils correspond to high values of MS due to the accumulation of authigenic crystals of magnetite and maghemite, the development of the crystals is a specific property of the soil formation process (Vadyunina et al., 1974).

According to coefficient of rocks transformation K (MS [A] horizon / MS [B] horizon) found by us in the north-eastern margins of the Volga Upland cryomorphic buried soil (38,710±480 yr ago) is close to cryogenic soils (Fig. 3) and Sholmskaya buried soil (~11,720–10,730 yr ago) is close to gray forest soils (Gugalinskaya et al., 2010).

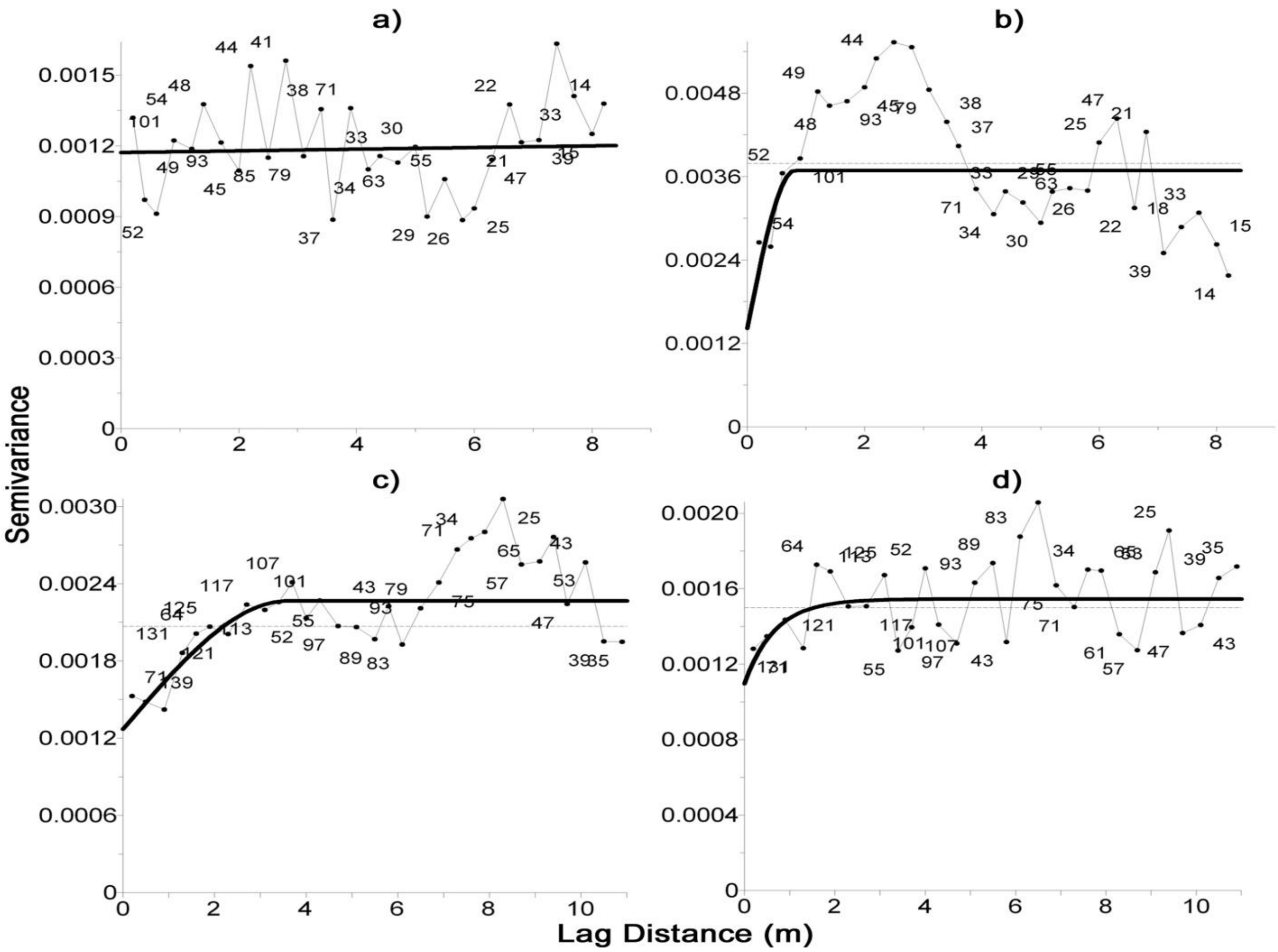

Fig. 2. Semivariograms of MS distribution for depths of 10 and 30 cm in the gray forest soil (a, b) and for the same depths in the chernozem (c, d). Points are experimental values, the figures near points indicate the number of pairs used in the analysis, the dotted line is the variance, the solid line is the result of the approximation by the model.

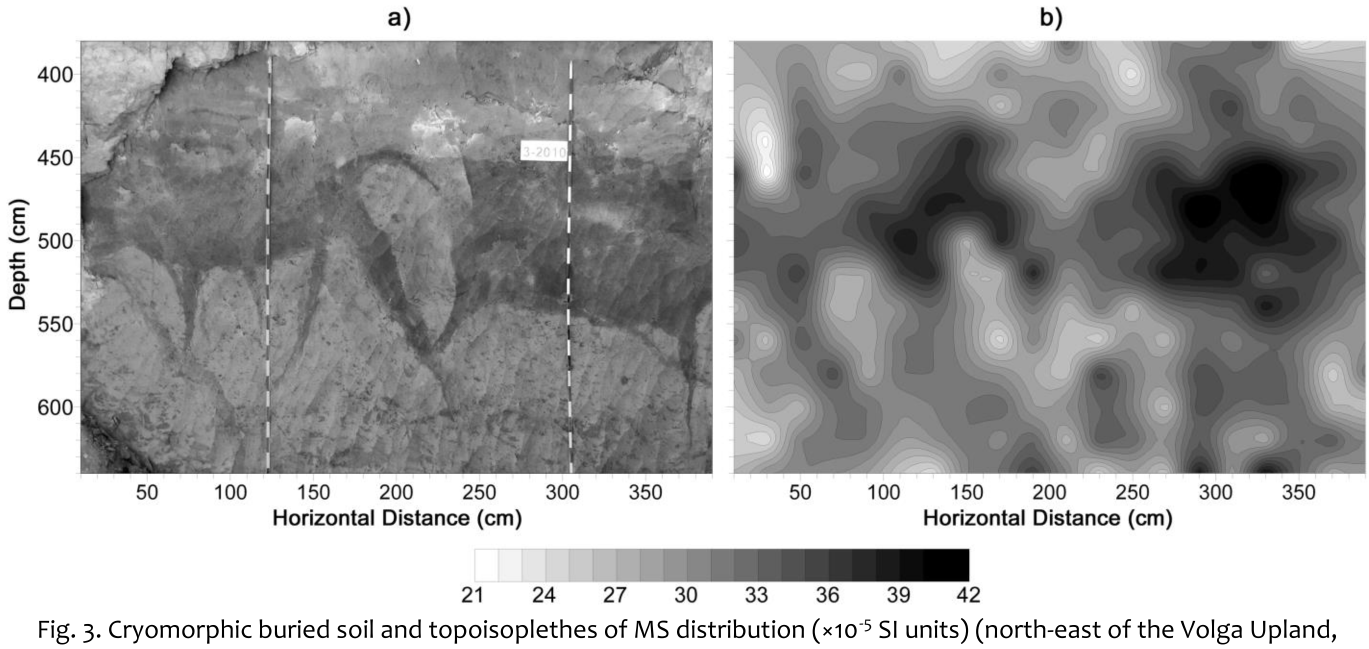

Fig. 3. Cryomorphic buried soil and topoisoplethes of MS distribution (×10^{-5} SI units) (north-east of the Volga Upland, Chuvash Republic).

Increase of parameter of MS in the horizons of buried soils can not only diagnose of the intensity of soil formation, but also be used to detect horizons of initial buried soils in morphologically homogeneous depth. The comparative morphological analysis of a profile with topoisoplethes of MS distribution allowed to reveal the presence of subhorizontal interlayer of the initial buried soils, lithological boundaries and two independent buried soils, one of which was formed in automorphic and relatively warm climatic condititions, seasonal drying up and prevalence of oxidation condititions over reduction.

Conclusion

Despite the integral parameter of MS the research has shown the prespective of using it to identify the characteristic sizes of homogeneous structures associated with the influence of the structure-forming elements of the paleocryogenic microrelief. High correlation of MS with $C_{org.}$, pH, biophile elements and physical clay causes the sensitivity of this parameter to the pedo-, litho- and cryogenesis. It allows to facilitate improvement of data obtained from complex soil research. In addition, relation of MS with grain-size distribution is of interest to study of Holocene soils formed on the lithologically heterogeneous (binomial) rocks and the complicated structure of depth. Found poor preserved buried soils and two buried soils laying each other in morphologically homogeneous depth using kappametry indicate that the late Valdai cover loess loams of center of the East European Plain are not homogeneous and monolithogenous. They are complex formed depth consisting of laying each other horizons of the buried soils.

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References

Alekseev, A.O., Kovalevskaya, I.S., Morgun, E.G., Samoilov, E.M. 1988. Magnetic susceptibility of soils of complementary landscapes. Pochvovedenie. 8. pp. 27-35.

Alifanov, V.M. 1995. Paleocryogenesis and modern soil formation. ONTI PNTs RAN, Pushchino.

Berdnikov, V.V. 1976. Paleocryogenic microrelief of center of the Russian Plain. Nauka, Moscow.

Bolshakov, V.A. 2001. Data of magnetic investigations of rocks of loess formation, their interpretations and applications. Fizika Zemli. 8, pp. 86-96.

Burgess, T.M., Webster, R. 1980. Optimal interpolation and isarithmic mapping of soil properties: I. The semi-variogram and punctual kriging. J. Soil Sci. 31, pp. 315-331.

Dmitriev, E.A. 1983. Continuity of soil and soil classifications problem object. Vestnik MGU, series 17. Soil Science. 3, pp. 10-19.

Gerasimov, I.P., Glazovskaya, M.A. 1960. Fundamentals of Soil Science and Soil Geography. Moscow.

Gugalinskaya, L.A., Alifanov, V.M., Berezina, N.S., Berezin, A.Yu., Hisyametdinova, A.A., Popov, D.A., Vagapov I.M., Ovchinnikov, A.Yu., Kondrashin, A.G. 2010. Sholmskaya buried soil on the finally paleolithic settlement Sholma-I (Volga Uplands, Chuvash plateau). In: Bulletin of the Commission for the Study of the Quaternary period. 70, pp. 45-58.

Gummatov, N.G., Zyromski, S.V., Mironenko, E.V., Pachepsky, I.A., Shcherbakov, R.A. 1992. Geostatistical analysis of spatial variability of water-holding capacity of gray forest soil. Pochvovedenie. 6, pp. 52-62.

Ivannikova, L.A., Mironenko, E.V. 1988. Theory of regionalized variables in the study of spatial variability of soil properties agrochemical indicators. Pochvovedenie. 5, pp. 113-120.

Ivanov, A.V. 2003. Magnetic and valence state of iron in the soil solid phase. Author's abstract of Dr. Sc. Moscow.

Krasilnikov, P. 2008. Variography of discrete soil properties. In: Krasilnikov, P., Carré, F. & Montanarella, L. (Eds.). Soil geography and geostatistics - Concepts and applications. Office for official publications of the European Communities, Luxembourg, pp. 12-25.

Lomov, S.P., Pen'kov, A.V. 1979. Magnetic susceptibility of some modern and fossil soils of Tajikistan. Pochvovedenie. 6, pp. 100-109.

Markov, K.K. 1959 Study of periglacial formations (review). Izvestya AN SSSR, Geographical Series. 2, pp. 113-127.

Samsonova, V.P. 2008. Spatial variability of soil properties: the case of soddy-podzolic soils. LKI, Moscow.

Vadyunina, A.F., Babanin, V.F., Kovtun, V.Y. 1974. Magnetic susceptibility of fractions of mechanical elements of some soils. Pochvovedenie. 1, pp. 116-122.

Vagapov, I.M. 2013. Magnetic susceptibility is an parameter of the formation of the spatial variability of soil due to paleoenvironmental factors. Author's abstract of Cand. Sc. Moscow.

Velichko, A.A. 1965. Cryogenic relief of Late Pleistocene periglacial zone (Cryolithozone) of Eastern Europe. In: Quaternary and its history. Nauka, Moscow, pp. 104-120.

Velichko, A.A., Morozova, T.D., Nechaev, V.P., Porozhnyakova, O.M. 1996. Paleocryogenesis, soil cover and crop farming. Nauka, Moscow.

Virina, E.I., Faustov, S.S., Heller, F. 2000. Magnetic "climate" entry in the loess-soil formation of the Russian Plain. In: Problems of stratigraphy and paleogeography of the Pleistocene. Moscow State University, Moscow, pp. 259-279.

Vodyanitskiy, Yu.N. 2008. Fe-minerals as a memory of soil-forming processes. In: Targulian, V.O., Goryachkin, S.V. (Eds.), Soil memory: soil as memory of biosphere-geosphere-antroposphere interactions. LKI, Moscow, pp. 289-313.

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The management of quality and safety of chemical fertilizers in Turkey

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Abstract

This article is focused on the defining of the system established in 2004 by the Turkish Ministry of Food Agriculture and Livestock (MoFAL) in the context of management of quality and safety of chemical fertilizers used for farming. The implementation of this system is based on two essential regulations which have been issued in line with the Regulation (EC) No 2003/2003 of the European Union dated 13 October 2003 relating to fertilisers in the context of alignment with EC acquis. The "Chemical fertiliser regulation" applies to inorganic primary nutrient fertilisers, solid or fluid, straight or compound, including those containing secondary nutrients and/or micro-nutrients. A fertiliser belonging to a type of fertilisers listed in Annex and complying with the conditions laid down in the Regulation is designated as 'EC fertiliser'. The requirements for minimum context of the fertilisers specified in Annexes of the regulation are controlled and the designation of "EC Fertiliser" is performed by the Ministry of Food Agriculture and Livestock which is the Competent Authority. The audits for EC Fertilizers which are in the markets are carried out by the provincial directorates of MoFAL in line with the "Fertiliser markets monitoring and inspection regulation". This regulation is based on the Law No 4703 which regulates the quality of products in the market, suitability analysis and auditing of the markets. In the framework of the regulation, the chemical fertiliser companies has been licensed in three ways; "Producer", "Contracted Producer" and "Importing Company". There are more than 1500 companies which have been holding the Chemical Fertiliser License. On the other hand each product has been certified in line with the "Chemical fertiliser regulation". There is more than 20 000 certified chemical fertiliser in Turkey.

Keywords: Fertiliser, inspection of fertilisers, Law No 4703.

Introduction

The plant nutrition challenges aim to maintain and increase the sustainable crop productivity to meet demands for food and raw materials and to enhance the quality of land and availability of water resources (FAO, 1998, pp. 1-13, Waraich et al., 2011, pp. 291). Fertilizers are the most important plant nutrition inputs and judicious and proper use of fertilizers can markedly increase the yields. The appropriate fertilizer input is not only used for getting high grain yield but also for attaining maximum fertility of soil and effective the plant nutrition management (White and Brown, 2010 pp. 1074, Alam et. al., 2009, pp. 90-93, YosefTabar, S., 2012, pp. 580-583).

For both commercial and environmental reasons, it is clear that fertilizers should be used with caution within the principles of sustainable fertilizer management which includes more sophisticated decision support tools, improved agronomic practices and crops or cropping systems that require less fertilizer input (White and

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Brown 2010, pp. 1073). In addition to these measures, the fertilizer markets should be controlled, monitored and guided to overcome the risks of fertilizer nutrients. As Krauss (2007) defined the 4R called guiding principles are to be applied as a part of best fertilizer management practices which are; right product(s), right rate, right time and right place.

The institutional body in Turkey making and implementing policy for plant nutrition/fertilizer management is the Ministry of Food, Agriculture and Livestock (MoFAL) reorganized in June 2011 following the abolishment of Ministry of Agriculture and Rural Affairs (MARA). The services of MoFAL are provided by the central bodies located in Ankara and local branches located in 81 provinces and more than 800 branches in district level.

This article is focused on the defining of the system established in 2004 by the Turkish Ministry of Food Agriculture and Livestock (MoFAL) in the context of management of quality and safety of chemical fertilizers used for farming. The implementation of this system is based on two essential regulations which have been issued in line with the Regulation (EC) No 2003/2003 of the European Union dated 13 October 2003 relating to fertilisers in the context of alignment with EC acquis.

Chemical Fertiliser Regulation

The regulation on the chemical fertilisers used in agriculture shortly named as "chemical fertiliser regulation" issued in 2004 by the Ministry of Agriculture and Rural Affairs (MARA) in the context of the alignment to EC acquis. In this framework the regulation is identical to Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers. This EC fertiliser regulation lays down rules relating to the placing of fertilisers on the market, i.e. the conditions for designating "EC fertilisers", as well as the provisions regarding their labelling and packaging.

The regulation on the chemical fertilisers used in agriculture applies to inorganic primary nutrient fertilisers, solid or fluid, straight or compound, including those containing secondary nutrients and/or micro-nutrients, with the minimum nutrient content established in Annexes of the Regulation.

The Regulation sets out detailed technical provisions regarding the scope, declaration, identification and packaging of four types of fertiliser:

- primary inorganic nutrient fertilisers: these are the main fertilising elements for plant growth, i.e. Nitrogen, Phosphorus and Potassium (N,P,K);
- secondary inorganic nutrient fertilisers: these are Calcium (Ca), Magnesium (Mg), Sodium (Na) and Sulphur (S);
- inorganic micro-nutrient fertilisers: these contain elements required in small quantities such as Boron (B), Cobalt (Co), Copper (Cu), Iron (Fe), Manganese (Mn) etc.;
- ammonium nitrate fertilisers of high nitrogen content: given the dangerous nature of this type of the fertiliser the regulation lays down specific provisions.

A fertiliser belonging to a type of fertilisers listed in Annex and complying with the conditions laid down in the Regulation is designated as 'EC fertiliser'. All fertilisers bearing the words "EC fertiliser" may circulate freely on the European market as well as in Turkey. The Countries may not prohibit or limit their placing on the market unless they consider that the fertiliser in question represents a danger for health or a risk to the environment. The requirements for minimum context of the fertilisers specified in Annexes of the regulation are controlled and the designation of "EC Fertiliser" is performed by the General Directorate of the Agricultural Production under the Ministry of Food Agriculture and Livestock which is the Competent Authority.

Fertiliser markets monitoring and inspection regulation

The regulation on monitoring and inspection of fertiliser markets[1] are issued in 2014 by the Ministry of Food Agriculture and Livestock in order to establish the rules and procedures for the safety and quality of fertilisers in the markets. While the designation and labelling of the EC fertilisers are carried out by the central body of MoFAL, the control and audits for EC Fertilizers which are in the markets are carried out by the provincial directorates of MoFAL in line with the "Fertiliser markets monitoring and inspection regulation". This

[1] The previous "Chemical fertilisers auditing regulation" was abolished.

regulation is based on the Law No 4703 which regulates the quality of all kind of products in the market, suitability analysis and auditing of the markets in the Turkish system generally.

The provincial directorates carry out the official controls to verify compliance of fertilisers bearing the words "EC fertiliser" with the provisions of the Regulation. The control measures are to be carried out by designated laboratories in accordance with a uniform procedure set out in the Annexes to the Regulation. The rules on penalties applicable to infringements of the provisions of the EC fertiliser are also included in this regulation.

Apart from the control and auditing provisions this regulation set up the management of the fertiliser industry in Turkey. In the framework of the regulation, the chemical fertiliser companies have been licensed in three ways; "Producer", "Contracted Producer" and "Importing Company". The Company that holds "Producer" or "Contracted Producer" licence can have their own branded products by getting a certification from the General Directorate of the Agricultural Production. The products are certified in line with the "Chemical fertiliser regulation". For inspection purposes, manufacturers should keep the records of their original Licences and Certifications as well as the approved labelling of "EC fertilisers" for as long as they are being supplied to the market.

Results and Discussion

Use of fertilizers is seen as a necessary agricultural technology for the plant nutrition and soil fertility. However, fertilization management and control measures have intensive and critical value for environmental reasons as well as economic and social point of view. The application of right and suitable fertilizer to soil is one of the principles of best fertilization management. The structure and chemical content of the soil should be identified and the most appropriate type of fertilizers should be selected as well as the most suitable method. Otherwise, the fertilization should be resulted in losses of energy and finance as well as causing environmental problems (Savci, 2012, pp. 79).

In that context there has been a system of management, control and audit of fertilisers established within the structure of the Turkish Ministry of Food Agriculture and Livestock. This system is identical to the European Union fertiliser legislation since the same provisions of the EC Fertiliser regulation has been implemented since 2004.

There are two essential regulations to manage, control and audit fertiliser companies. The chemical fertiliser regulation is mainly used for the identification, labelling and classification of fertilisers in accordance with the provisions and technical requirements defined in particularly in annexes of the regulation. The licensing of the companies and the related certification per product type and brand has been conducted by the central body of the MoFAL which is General Directorate of Plant Production by the Department of Plant Nutrition and Technology Development which is the Competent Authority.

The "Chemical fertiliser regulation" applies to inorganic primary nutrient fertilisers, solid or fluid, straight or compound, including those containing secondary nutrients and/or micro-nutrients, with the minimum nutrient content established in Annexes of the Regulation. Moreover, where the micro-nutrients are the normal ingredients of the raw materials intended to supply primary (N, P, K) and secondary (Ca, Mg, Na, S) nutrients, they should be declared, provided that these micro-nutrients are present at least in the minimum quantities specified in the Annex. A fertiliser belonging to a type of fertilisers listed in Annex and complying with the conditions laid down in the Regulation is designated as 'EC fertiliser' and a certification is issued for this fertiliser in order to be sold in the markets. The labelling standards of the fertiliser are also controlled before the certification and the Competent Authority approves the labels of the product.

Apart from the producing best quality and safe fertiliser products in the markets, the other target of the EC fertiliser regulation is to make fertilisers display certain technical characteristics and provisions which are mandatory and common in the internal market. These provisions, concerning more particularly the composition and definition types of fertilisers, the designations of these types, their identification and their packaging which differ from one Country to another are harmonised in that way.

The production of fertilisers is subject to varying degrees of fluctuation due to manufacturing techniques or basic materials. Sampling and analytical procedures may also contain variations. The "Chemical fertiliser regulation" establishes also the necessary provisions to authorise tolerances on the declared nutrient contents while designation as EC Fertiliser and gives the producers some limits of variations which makes the control of markets and punishments to be in line with regular and common standards.

The official controls and auditing of the fertiliser companies are the responsibility of provincial directorates of the MoFAL. The audits are performed via annual audit programmes periodically or complaints instantaneously. The regulation on monitoring and inspection of fertiliser markets lays down the detailed provisions for the auditing and control of a fertiliser company. On the other hand the controls of the products on the compliance of EC fertilisers with requirements of the regulation concerning quality and composition should be carried out by laboratories that are approved by the MoFAL in line with the methods described in the regulation on monitoring and inspection of fertiliser markets.

Çetindamar (2003) results show that regulations and public pressures are the main determinants in the diffusion of technologies and standards, indicating the importance of the institutional infrastructure, namely the interplay among firms, governmental and nongovernmental organisations. These two fertiliser regulations are two main determinants in the markets for standards and technical specifications of the fertilisers.

The licensing of fertiliser companies and certification of fertiliser products are not the provisions of EC fertiliser regulation and these two procedures have been implemented in line with the regulation on monitoring and inspection of fertiliser markets. These two applications are the structural results of the Turkish fertiliser industry since there is a need of a system to monitor the unregistered economy. The licensing system has been used as an efficient and effective tool for the companies engaged in fertiliser production and selling. The system enables the follow-up of the companies and their certified products in a proactive way since they should apply to MoFAL for any change regarding their dealings. The data and official records of the company are updated in the MoFAL record system. This system is also used as a resource for the statistical information. In accordance the data obtained from this system, there are more than 1500 companies which have been holding the Chemical Fertiliser License and more than 20 000 certified chemical fertiliser in Turkey.

The system of MoFAL to manage, control and audit of the fertiliser industry has been applied since 2004. Initially the regulations have been issued within the context of the alignment to EC acquis when the decision for the opening of the negotiations has been taken. During that period the legislations have been improved in line with the needs raised and any change on EC fertiliser regulation for harmonization purposes. However, there is need to exchange information and experiences with the EU Member States for the further improvement and development of the system.

Conclusion

The system established in 2004 by the Turkish Ministry of Food Agriculture and Livestock (MoFAL) in the context of management of quality and safety of chemical fertilizers used for farming are based on the Regulation (EC) No 2003/2003 of the European Union dated 13 October 2003 relating to fertilisers in the context of alignment with EC acquis. Two essential regulations are applied for this purpose, “Chemical fertiliser regulation” which is identical of EC fertiliser regulation and the regulation on monitoring and inspection of fertiliser markets. The inspection regulation is somehow different from the EC fertiliser regulation by introducing the system of licensing and certification of the fertiliser companies and their products. In addition to management and control the quality and safety of chemical fertilizers, this regulation enables the follow-up of the companies and their certified products in a proactive way by updating the record system for any change of the Company position. Although the system has been implemented since 2004, there is need to exchange information and experiences with the EU Member States in order to improve the system.

References

Alam, M. M., Hassanuzzaman, M. and Nahar K., 2009.Tiller dynamics of three irrigated rice varieties under varying phosphorus levels. American –Eurasian Journal of Agronomy, 2(2):89-94.

Cetindamar, D., 2003, The diffusion of environmental technologies: the case of the Turkish fertiliser industry, International Journal of Technology Management, Vol. 26, No. 1, pp.68-87.

Food and Agriculture Organization of the United Nations- FAO, 1998. Guide to efficient plant nutrition management, Rome, ITALY available on line: ftp://ftp.fao.org/agl/agll/docs/gepnm.pdf.

Krauss, A., 2007, Global assessment of the situation of fertilizer best management practices. Papers presented at the Industrial Fertiliser Association (IFA) International Workshop on Fertilizer Best Management Practices ,7-9 March 2007, Brussels, Belgium

MARA, 2004, The regulation on the chemical fertilisers used in agriculture. Ministry of Agriculture and Rural Affairs. Official Journal No: 25406, 18/03/2004.

MoFAL, 2014, The regulation on monitoring and inspection of fertiliser markets. Ministry of Food Agriculture and Livestock, Official Journal No: 28956, 29/03/2014.

Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers, Official Journal L 304 , 21/11/2003 P. 0001 – 0194.

Savci, S., 2012. An Agricultural Pollutant: Chemical Fertilizer. International Journal of Environmental Science and Development, Vol. 3, No. 1, 77-80.

Waraich, E.A., Rashid, A., Ashraf M. Y. , Ahmad, S.M., 2011. Improving agricultural water use efficiency by nutrient management in crop plants, Acta Agriculturae Scandinavica, Section B - Soil & Plant Science, 61:4, 291-304.

White P. J. and Brown P. H., 2010. Plant nutrition for sustainable development and global health. Annals of Botany 105: 1073–1080.

YosefTabar, S., 2012, Effect of Nitrogen and Phosphorus Fertilizer on Growth and Yield Rice (Oryza Sativa L). International journal of Agronomy and Plant Production. Vol., 3 (12), 579-584.

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Investigating of vegetation density for Sinop Province using remote sensing and geographic information system techniques

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Abstract

Remote Sensing technologies could be easily obtained many auxiliary data which was used to relating to spatial analysis such as Normalized Difference Vegetation Index (NDVI) studies. NDVI is used with remote sensing technology and Geographic Information System Techniques. This index is one of indices developed for vegetation which is accepted in worldwide. NDVI for this study using satellite image and GIS was aimed. This study belongs to Sinop Province that has been conducted in the area of about 568,464 km^2 and located between the latitudes 41° 12' 22" - 42° 04' 45" north and longitudes 34° 13' 44" - 35° 24' 39" east. In this study, spatial distribution of plant density in Sinop was mapped by using LANDSAT-7 ETM+ images and NDVI. LANDSAT-7 ETM+ images belong to 24 October 2005. Obtained NDVI map was classified as very weak, weak, moderate and intensive plant density classes for the first time by utilizing Braun Blanquet cover abundance classes (BB) and geographic information systems (GIS). The accurate assessment of the created classes was performed by utilizing ground truth data collected from 124 points throughout the study area. The accuracy of NDVI classes was found as 89.60 %. The results of the study indicated that the majority of the Sinop takes place in the very weak class (37,5 %). This was followed by intensive (28,4 %), moderate (25,7 %) and weak (8,4 %) plant density classes. The results demonstrated that the about half of classes have intense and moderate class. And also the results concretely demonstrated the high potential of Sinop province in terms of plant biological diversity and agriculture. In addition remote sensing and GIS have important role to generate accurate and fast data.

Keywords: Vegetation, Remote Sensing, Geographic Information Systems, Sinop

Introduction

The remote sensing images are very efficient for obtaining a better understanding of the earth. The remote sensing data has many application areas including: land cover classification, soil moisture measurement, forest type classification, measurement of liquid water content of vegetation, snow mapping, sea ice type classification, oceanography (Hacihaliloglu & Karta 2004). Remotely sensed data for plant studies mapping is an important subject of many studies. The normalized difference vegetation index (NDVI) is one of the simplest and most frequently used indices in plant studies (Bonneau et al. 1999, Edwards et al. 1999). NDVI is an index which is based linear relationship with spectral bands and can be calculated as (Bonneau ve ark. 1999; Edwards et al. 1999; ERDAS 2003; USGS 2006):

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$$NDVI = \frac{(B4 - B3)}{(B4 + B3)}$$

where B3 and B4 are ETM+ bands 3 and 4, respectively. The near-infrared is (Landsat Enhanced Thematic Mapper Plus (ETM +) band 4 and red (ETM+) is band 3. The NDVI produces a single band of data with values ranging from -1 to + 1, where higher values indicate more, or healthier, vegetation (Bonneau et al. 1999, Edwards et al. 1999). NDVI values can be stretched to an unsigned 8-bit image varying between 0 and 255 in ERDAS Imagine software (ERDAS 2003). Values close to 255 indicate the highest possible density of green leaves, while values close to 0 indicate the lowest possible density of green leaves or bare areas.

Numerous methods have been developed and used in mapping plant communities such as the Braun-Blanquet (BB). Researching possible relationships between the NDVI and the BB method may offer new opportunities for mapping plant classes. The aim of study is to obtain NDVI values of Sinop province using Landsat- ETM + images, to class NDVI map using BB used in plants sociology and GIS, to analyze the accuracy of classified maps, to obtain areas in different classes of NDVI, to interpretate the map of resulting.

There are several national and international publications about NDVI. Doğan et al (2014) investigated that spatial distribution of plant density of Sinop province in 2005 was mapped by using LANDSAT-7 ETM+ images and Normalized Difference Vegetation Index (NDVI). Obtained NDVI map was classified by utilizing Braun Blanquet cover abundance classes (BB) and geographic information systems (GIS). The results of the study indicated that the majority of the Sinop province takes place in the moderate class (47.56 %).

Bhandari et al (2012) noted that an improved method for the analysis of satellite image based on Normalized Difference Vegetation Index (NDVI). The results show that the NDVI is highly useful in detecting the surface features of the visible area which are extremely beneficial for municipal planning and management.

Julien et al (2006) used land surface temperature (LST) algorithms and NDVI values to estimate changes in vegetation in the European continent between 1982 and 1999 from the Pathfinder AVHRR Land (PAL) dataset. This study, realized on the Pathfinder AVHRRL and dataset has confirmed the interest of using HANTS software for the harmonic analysis of land surface temperature, in spite of its conception for NDVI images processing.

Material and Methods

Description Of The Study Area

The investigations were performed as a case study in Sinop province, which is located in north Turkey. It's geographical coordinates are the latitudes 41° 12' 22" - 42° 04' 45" north and longitudes 34° 13' 44" - 35° 24' 39" east (Fig.1). Sinop is situated on south of the Black Sea, west of Samsun, north of Çorum, east of Kastamonu.

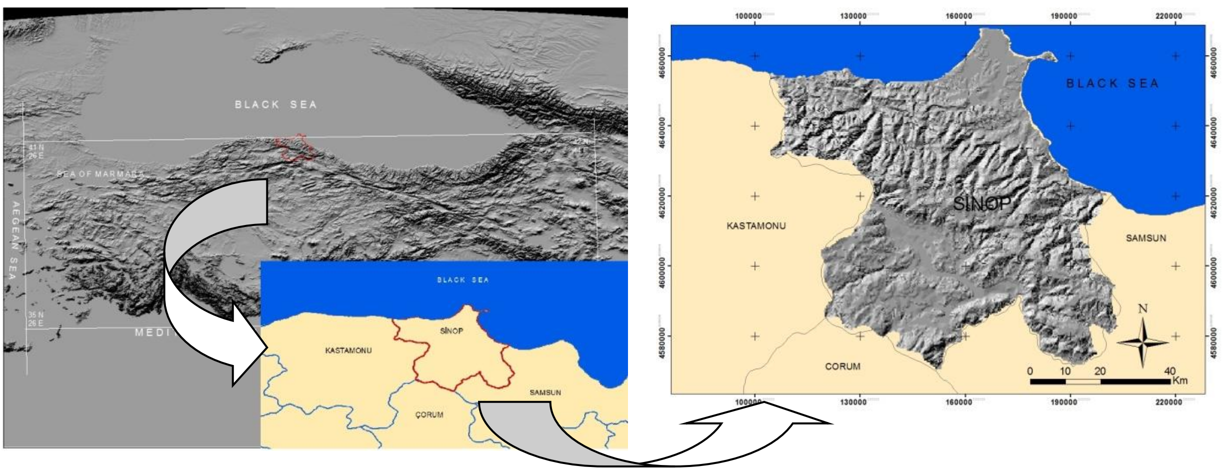

Fig. 1. Location of the study area.

According to data from meteorological stations in Sinop, climate is temperate with an average annual temperature of 13.9 °C and an average annual precipitation of 666 mm. North Anatolian Mountains is a moderate elevation in the south of Sinop Peninsula and two depression exist which separated from each other as the obvious with parallel depression (Akkan 1975). The province of Sinop covers an area of 553320 ha. Elevations vary between from 0 to 1800 metres (Fig. 2).

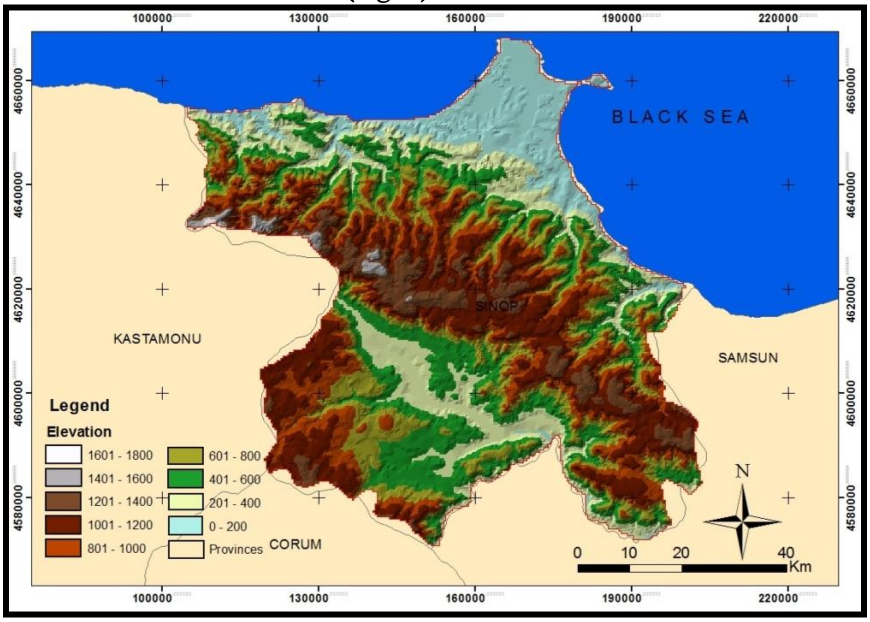

Fig. 2. Physical Map of the study area.

In this study, LANDSAT-7 ETM+ image was used for spatial distribution of plant density in Sinop province. This image belongs to 24 October 2005 (Fig. 3).

Fig. 3. Lansat image of the study area.

Landsat-7 ETM + image was cut the part of the study area. A single-band NDVI image map was converted into using NDVI functions. The NDVI is a simple numerical indicator that can be used to analyze the remote sensing measurements, from a remote platform and assess whether the target or object being observed contains live green vegetation or not (Demirel et al 2010). When creating images NDVI map, used the Landsat-7 ETM + from sensor and selected 8 bytes unsigned flex. The unsigned 8-bit NDVI model was utilized to establish NDVI classes. Thus map of NDVI was provided formation according to values between 0 and 255. Values close to 255 indicate the highest possible density of green leaves, while values close to 0 indicate the lowest possible density of green leaves or bare areas. Obtained NDVI map classified equally spaced four-class options using ArcGIS 10.1 GIS software and has been named using BB (Braun - Blanquet 1964) (Table 1).

Table 1. Braun-Blanquet (BB) cover-abundance scales (Braun-Blanquet 1964).

BB (%)	BB	NDVI Classes	NDVI classes names	NDVI Values
5<; Few individuals	1	1	very weak	0-64
5<; numerous individuals	1	1	very weak	0-64
5-25	2	1	very weak	0-64
25-50	3	2	weak	64-191
50-75	4	3	Moderate	191-128
<75-100	5	4	Intensive	128-255

Georeferenced point data (124 points) were collected to classify LANDSAT-ETM+ image and to conduct accurate assessment. These processes were made with the program of ENVI 5.0v. Also when deciding map of the study area for the determination of basic geographical features, digital contour maps of the area was produced (Fig. 4).

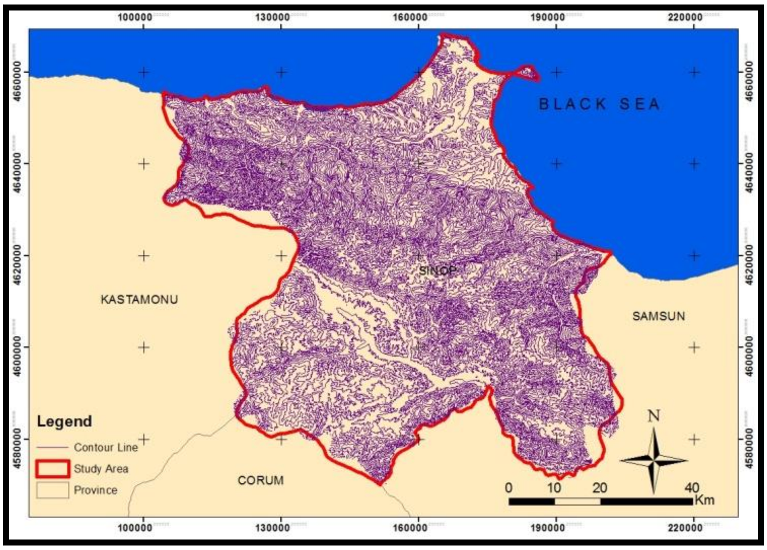

Fig. 4. Contour map of the study area.

Results and Discussion

NDVI values classified according to vegetation properties (Table 1). It was percentaged at the figure 6 that the areas one of mentioned in provincial borders of Sinop. Areas one of mentioned class demonstrated as percentage of coverage in Sinop at the Table 2. According to this the majority of the Sinop province takes place in the very weak class (37,5 %) (Fig. 6). This was followed by intensive (28,4 %), moderate (25,7 %) and weak (8,4 %) plant density classes. The results demonstrated that the about half of classes have intense and moderate class. The accuracy of NDVI classes was found as 89.60 %. Kappa (K) coefficient is 0.86 (Table 3).

Table 2. Percentage of coverage the classes of NDVI in Sinop.

	Area (Ha)	Ratio (%)
Intensive	161491,2	28,4
Moderate	145906,8	25,7
Weak	47923,2	8,4
Very weak	213142,8	37,5
Total	568464,0	100,0

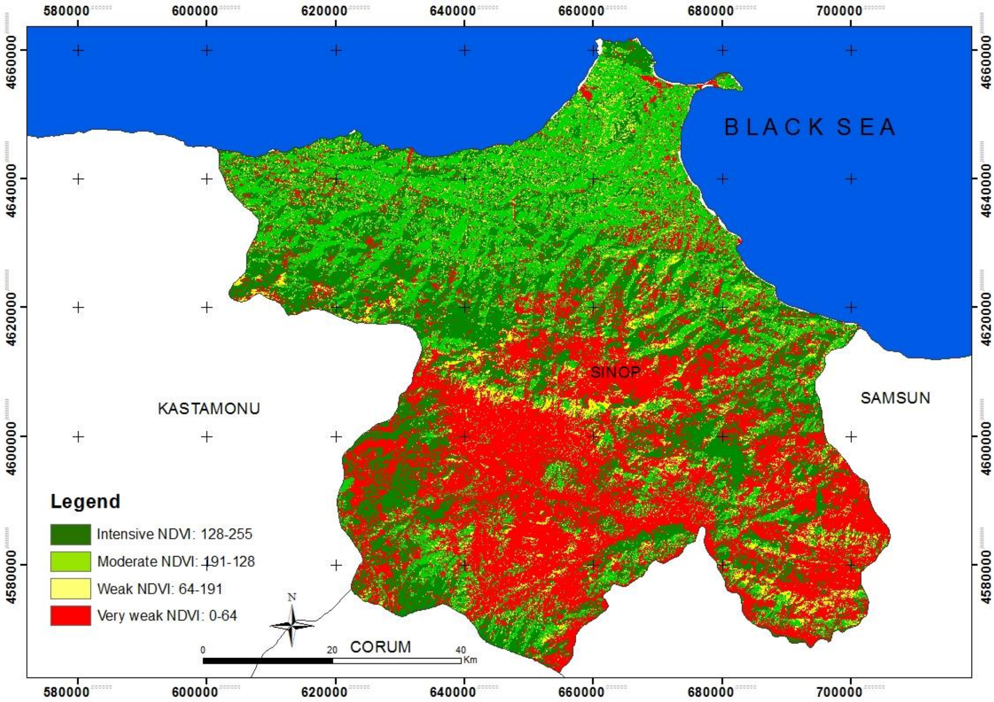

Fig. 6. Classified NDVI map

Table 3. The results of accurate analysis.

Class	Very weak	Weak	Moderate	Intensive	Column Total	Producer	User Accuracy
Very weak	29	2	0	2	33	93.55	85.29
Weak	1	23	4	4	32	82.14	71.88
Moderate	0	3	26	1	30	81.25	86.67
Intensive	1	3	1	24	29	80.00	88.89
Total	31	31	31	31	124		

Overall Accuracy = % 89,604 Kappa Coefficient = 0.8618

We therefore investigated possible relationships between NDVI and plant cover abundance, which have been indicated in many studies so far. Relationships between NDVI and various vegetation variables have been reported since the early 1980s. These variables can be summarized as: the leaf area index (Kumar and Monteith 1981, Davi et al. 2006), rangeland condition change (Minor et al. 1999), linear regression relationships between NDVI, vegetation and rainfall (du Plessis 1999), grass biomass (Schino et al. 2003), rangeland vegetation type (Geerken et al. 2005), tree rings (Jicheng and Xuemei 2006), herbaceous biomass (Wessels et al. 2006), plant biodiversity (Dogan and Dogan 2006), plant community composition (Doğan et al. 2009), Class of Plant Density (Doğan et al. 2014). This study NDVI values was classified using BB which is used plant sociology. This type of approach may contribute future studies.

Conclusion

In this study, spatial distribution of plant density was mapped by using LANDSAT-7 ETM+ images and NDVI. Obtained NDVI map is classified as very weak, weak, moderate and intensive plant density classes for the first time by utilizing Braun Blanquet cover abundance classes (BB) and geographic information systems (GIS). The majority of the Sinop province takes place in the very weak class (37,5 %). This is followed by intensive (28,4 %), moderate (25,7 %) and weak (8,4 %) plant density classes. One of the vegetation indices is the NDVI, which has been used in vegetation analysis to highlight differences that cannot be observed in the original colour band display. This study proved the relationships between the NDVI and plant density classes by using remote sensing and GIS. The results clarified that the about half of classes are intense and moderate class. And also the results concretely demonstrated the high potential of Sinop province in terms of plant biological diversity and agriculture. In addition remote sensing and GIS have important role to generate accurate and fast data.

References

Akkan, E., 1975. Sinop Yarımadasının Jeomorfolojisi. Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Yayınları. Ankara.

Bhandari, A.K., Kumar A., Singh G.K., 2012. Feature Extraction using Normalized Difference Vegetation Index (NDVI): a Case Study of Jabalpur City, Procedia Technology 6, 612 – 621.

Bonneau, L.R., Shıelds, K.S. and Cıvco, D.L., 1999. Using satellite images to classify and analyze the health of hemlock forests infested by the hemlock woolly adelgid. Biological Invasions, 1, pp. 255–267.

Braun-Blanquet J., 1964. Plant Sociology: The Study of Plant Communities, 3rd Edn. Springer-Verlag, Berlin-Wien-New York.

Davi, H., Soudani, K., Deckx, T., Dufrene, E., Le Dantec, V., François, C., 2006. Estimation of forest leaf area index from SPOT imagery using NDVI distribution over forest stands. International Journal of Remote Sensing, 27: 885–902.

Demirel, H., Ozcinar, C., Anbarjafari, G., 2010. Satellite image contrast enhancement using discrete wavelet transform and singular value decomposition. IEEE Geosciences and remote sensing letters **7** (2), 333-337.

Doğan, H.M. and Dogan, M., 2006. A new approach to diversity indices – modeling and mapping plant biodiversity of Nallihan (A3-Ankara) forest ecosystem in frame of
geographic information systems. Biodiversity and Conservation, 15, pp. 855–878.

Doğan, H. M., Celep, F., Karaer, F., 2009. Evaluation of the NDVI in plant community composition mapping: a case study of Tersakan Valley, Amasya County, Turkey, International Journal of Remote Sensing, Vol. 30, No. 14, 3769–3798.

Doğan, H.M., Kılıç, O.M., Yılmaz, D.S., 2014. Tokat İli Bitki Yoğunluk Sınıflarının LANDSAT-7 ETM+ Uydu Görüntüleri ve Coğrafi Bilgi Sistemleri ile Araştırılması, Journal of Agricultural Faculty of Gaziosmanpasa University, 31 (1), 47-53.

Du Plessis, W. P., 1999. Linear regression relationships between NDVI, vegetation and rainfall in Etosha National Park, Namibia, Journal of Arid Environments, 42: 235–260.

Edwards, M.C., Wellens, J. and Al-Eısawı, D., 1999. Monitoring the grazing resources of the Badia region, Jordan, using remote sensing. Applied Geography, 19, pp. 385–398.

Erdas, 2003. Erdas Field Guide, 7th Edn. Leica Geosystems, GIS and Mapping LLC: Atlanta, Georgia.

Geerken, R., Zaıtchık, B. and Evans, J.P., 2005. Classifying rangeland vegetation type and coverage from NDVI time series using Fourier filtered cycle similarity. International
Journal of Remote Sensing, 26, pp. 5535–5554.

Hacihaliloglu, I., Karta, M., 2004. DCT and DWT based image compression in remote sensing images. In proceeding IEEE conference on antennas and propagation society international symposium 4, 3856-3858.

Jıcheng, H. and Xuemeı, S., 2006. Relationships between tree-ring width index and NDVI of grassland in Delingha. Chinese Science Bulletin, 51, pp. 1106–1114.

Julien Y., Sobrino J.A., Verhoef W., 2006. Changes in land surface temperatures and NDVI values over Europe between 1982 and 1999, Remote Sensing of Environment 103, 43–55.

Kumar M., Monteith, JL. 1981. Remote sensing of crop growth. In H Smith (Ed.), Plants and the Daylight Spectrum, Academic Press London, pp. 134–144.

Mınor, T., Lancaster, R., Wade, T., Wıckham, J., Whıtford, W. and Jones, K., 1999. Evaluating change in rangeland condition using multitemporal AVHRR data and geographic information system analysis. Environmental Monitoring and Assessment, 59, pp. 211–223.

Schıno, G., Borfecchıa, F., De Cecco, L., Dıbarı, C., Iannetta, M., Martını, S. And Pedrottı, F., 2003. Satellite estimate of grass biomass in a mountainous range in central Italy. Agroforestry Systems, 59, pp. 157–162.

USGS, 2006. LANDSAT Project. Available: http://landsat7.usgs.gov/index.php.

Wessels, K.J., Prınce, S.D., Zambatıs, N., Macfadyen, S., Frost, P.E. and Van Zyl, D., 2006. Relationship between herbaceous biomass and 1-km2 Advanced Very High Resolution Radiometer (AVHRR) NDVI in Kruger National Park, South Africa. International Journal of Remote Sensing, 27, pp. 951–973.

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Gravelly as diagnostic indicator for soils under subalpine meadows (for example reserve "Basegi")

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Abstract

Mountain soils are of interest to researchers because of their little scrutiny and features of mountain soils. The presence of gravel in the profile is an important diagnostic indicator, especially for mountain soils. The ratio of large, medium, fine gravels affects soil formation processes, which leads to the formation of a plurality of different soils. The purpose of research is to study the distribution of rubble in the profile of mountain soils. Object of study is subalpine soils in the reserve *Basegi* at the altitude of 570-850 m above sea level. *Basegi* relates to lowlands of the Middle Urals. The morphological features under subalpine meadows formed soil divisions (organic-accumulative, litozem) which have no signs of podzolized profile and are poorly differentiated into genetic horizons. Contents of rubble varies widely in the studied soils and according to the classification of varieties by content of stones and gravel are not stony, weak-, medium- and strong gravelly. Distribution of rubble in the profile can be divided into three groups. Found that soils formed under grassland ecological communities, have different origins. Thus, the studied soil profiles are either the result of modern soil formation or consist of modern soil horizons and buried paleosoils horizons (in the lower part of the profile), or formed as a consequence of dust particles with the wind and the growth of soil on top. Aeration material fall-out leads to the formation of undifferentiated soils with the manifestation in them sod pedogenesis and burozemic pedogenesis processes. Thus, gravelly is an important diagnostic indicator for mountain soils as it helps to determine their genesis, change of environmental conditions, the intensity of weathering and pedogenesis occurring in soils. Ambiguous distribution, in profile confirms the high spatial variability of topsoil on mountainous territory, different correlation and the manifestation of weathering and pedo-genesis. Therefore, while monitoring this parameter is recommended to use.

Keywords: Sub-alpine meadows, national park, mountain soils, gravelly, genesis, soil formation.

Introduction

Currently few stationary investigations are carried out in the nature reserves of Russia and only in 20% of reserves there are certain investigations of the soil cover (Chernova, 2006). The problems of genesis and geography of mountain soils are partly studied. Thus, mountain soils are still of interest to researchers because of their little scrutiny and special features of their formation. Many researchers (Nogina, 1948; Mikhailova, Gradusov, 1969; Glavatskih, 1971) think that the formation of fine earthy matter in the mountain soils is connected with the destruction of massive-crystalline rock and its debris which are buried at the

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basement soil and make up its stony part. Other researchers (Ilina, Krinari, Karpachevskiy, Morozov, 1993; Karpachevsky, Shevchenko, 1997; Karpachevskii, 2012) claim that there are certain facts that contradict this statement. Thus, for example, often there's no or almost no gravel in the *A1* horizon and there are cases when soils on stone rivers, that have earthy matter and under layers, fill empty spaces between stones while falling through them. These facts can't be explained simply by the theory of soil formation on residual rocks. Eolian soil formation is more probable in such cases.

Fine earthy matter, formed as a result of weathering as well as the earthy matter of stony clays, is carried over by the wind and is accumulated around plants. The dust in the form of residual soil carried from the nearby slopes is mixed with a substrate. Thus, the material of aerial origin (and its mixtures) can act as soil forming materials on mountainous territories, where the rock is coated with fine earthy matter, inside of which the soil is formed.

The presence of gravel is a specific feature of mountain soils. The gravelly soils should be regarded as soils with a continuous substance supply. The smaller the weathered material is, the more intense is the supply, caused by weathering.

The gritty consistency of soils ensures their high thermal conductivity that enables quick thawing of the whole soil profile and high water permeability that prevents soils from seasonal water saturation and gleying (Molchanov, 2010).

Mountain soils of the Urals as wells as the soils of other mountain areas are gravelly soils. According to the classification of varieties of soils by the content of stones (skeleton) as of 2004, soils can range from weak to strong gravelly soils (Samofalova and collaborators, 2010; 2012a; 2012b; 2012c; 2012d; 2013).

The investigations of the mountain soils of the Middle Urals were mainly carried out to study the genesis of soils in the mountain forest zone (Ivanova, 1947; Bogatyrov, 1947; Ivanova, 1949; Kanisev, 1964; Firsova, 1968; Mikhailova, 1976, 1977; Firsova, 1991). The information about the mountain meadows of the Urals was gathered step by step (Tyflov, 1951, 1952; Ovesnov, 1952). Throughout the 20th century the investigations of the mountain meadow soils were short and occasional and were carried out only in certain areas of Perm Krai, because the mountain soils were mainly studied to extend the areas of hay fields and grazing lands.

The purpose of research is to study the distribution of rubble in the profile of mountain soils. The presence of gravel in the profile is an important diagnostic indicator (Classification and diagnosis…, 2004), especially for mountain soils. The ratio of large, medium and fine gravels affects soil formation processes, which leads to the formation of a plurality of different soils.

Material and Methods

The area of subalpine meadows in the Urals is amounted to 100 000 ha, and is more than 200 000 ha for mountain tundra meadows (Popova, Mitrofanova, Ziganshina, 2013). The object of study is subalpine soils in the reserve *Basegi* at the altitude of 570-850 m above sea level. *Basegi* is a mountain range of metamorphic rocks (Sofronitsky, 1967). This territory relates to the ridged - outlier low mountains of the Middle Urals (Voskresensky, 1980).

Subalpine meadows are not well marked altitudinal zones, representing only few shortgrass meadows in the mountain forest zones of the western and southern slopes, and taking larger areas in the intermountain saddles. The subalpine soils are characterized by the flushing type of the water regime and are developed under lowered surface moistening that is possible due to their position on the planoconvex summits, smooth and steep slopes where there is an increased surface water supply and a subsurface sidelong flow. Subalpine meadows partially border with stone rivers that are unique water collecting areas that accumulate rain water and, in dry seasons, moisture, condensed from water vapors.

The meadows of sub-goltsy altitudinal zones take the main meadow vegetation areas of Basegi. There are the following groups of grass associations: tall grass (Magno-Gramineta), short grass (Parvo- Gramineta), tall forb-rich grass (Magno-Gramineto-Herbeta), short forb-rich grass (Parvo-Gramineto-Herbeta), high forb-rich grass (Magno-Herbeta), low forb-rich grass (Parvo-Herbeta) meadows (Balandin, Ladigin, 2002).

Substantive-profile classification was used here (Classification and diagnosis…, 2004).

Results and Discussion

The conditions of soil occurrence in mountainous areas and special features of mountain soil formation define the specific morphological properties of mountain soils that serve as a guide to the orientation and degree of intensity of the soil formation. The thickness of soil profile under subalpine meadows varies between 18 and 88 cm. The thickness of humus horizon varies between 6 and 25 cm. The steeper the slope is, the less is the thickness of soil profile and humus horizon. Thus, depending on the profile thickness, under the subalpine meadows there formed such divisions of soils as litozem and organic-accumulative soils. The color of humus horizon defines the following horizon types: dark, grey and light. In general soil profiles are poorly differentiated according to the color of horizons. The morphological features have no podzolized signs. The content of rubble varies widely in the investigated soils and according to the classification of varieties of soils by content of stones and gravel these soils are not stony, weak-, medium- and strong gravelly. The distribution of rubble in the profile can be divided into three groups, depending on weathering conditions, soil formation, aeration material fall-out as well as on ratio of these processes. The first group comprises soils with an undisturbed structure during their formation that means that the formation of genetic horizons took place under the same environmental conditions. Thus, in "undisturbed" soils, where the process of soil formation runs more intensively than weathering, the content of rubble increases with the depth (Fig. 1). This type of rubble distribution can be found in soils within the zone at different altitudes above the sea level.

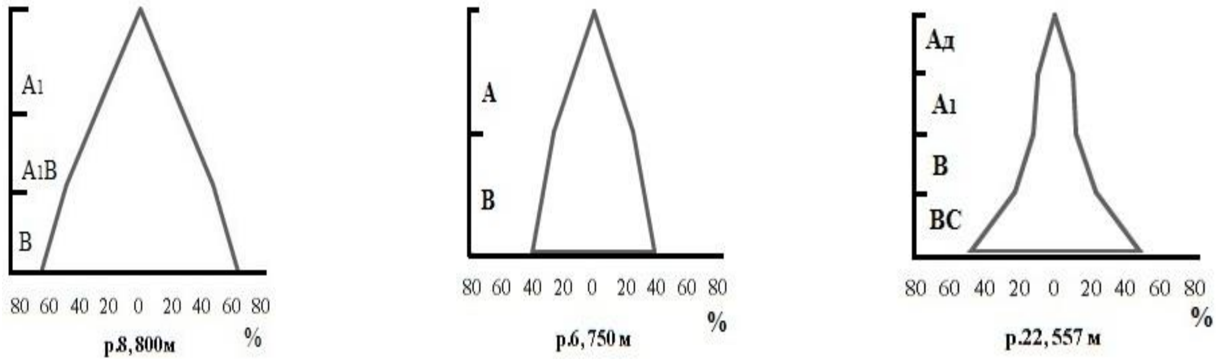

Figure 1. Rubble distribution in the profile in "undisturbed" soils

The second group comprises soils with the stone content inversion of soil profiles. In such soils the upper horizons have the biggest content of rubble, then the degree of rubble content against the content of fine earthy matter decreases (Fig. 2a), but it can increase again with the depth (Fig. 2b). There are also soils where the lower part of horizon has a decreased content of fine earthy matter and an increased content of rubble (Fig. 2c).

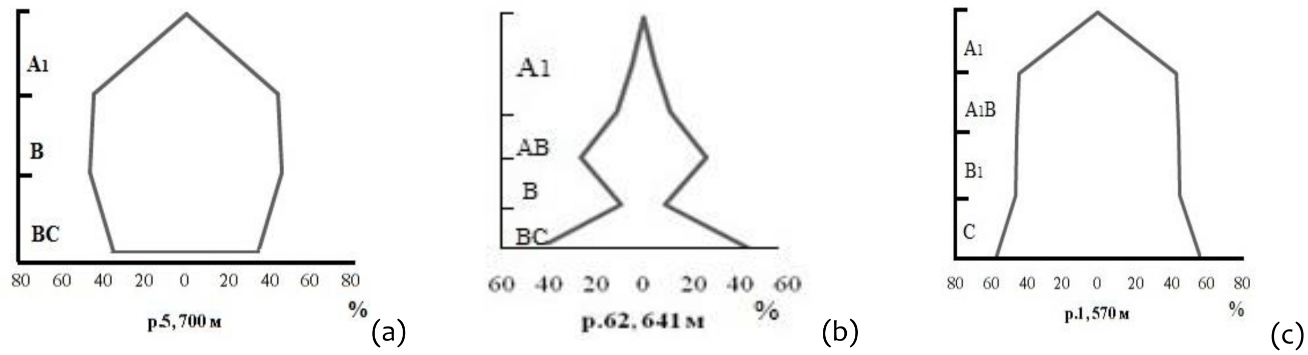

Figure 2. Stone content inversion of soil profiles

The reasons for inversion can be different.

First it may be related to the presence and active impact of the subsurface sidelong flow under mountain conditions. The atmospheric precipitations, which are easily filtered through the thickness of stones, remain in the *B* horizon and later run off along the slope in the form of a subsurface sidelong flow, carrying the fine earthy matter. Second, the inversion of stone content can point to the presence of fragments of buried horizons of soil profiles and to the change in soil formation conditions. The presence of dust on the upper surface of soils shows that it couldn't be formed out of the lower part of the surface during the process of soil formation. The presence of the horizon with an increased content of rubble in the transitional zone between two layers is indicative of their genetic independence and change in soil formation conditions. Thus, as per figures showing the distribution of rubble of soil profiles, in the area of subalpine meadows there is a frequent change of environmental conditions of soil formation. Consequently, the investigated soil profiles consist of horizons of modern soil formation and buried or paleo soils (in the lower part of the profile). The third group comprises soils, in which the upper part of the profile is often not stony or has a very low stone content (Fig. 3).

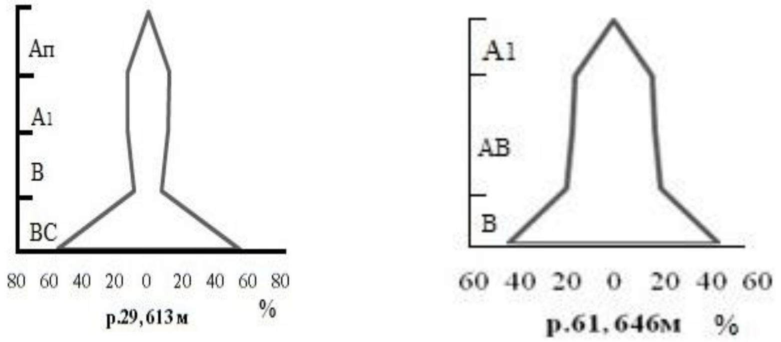

Figure 3. Rubble distribution in soils of aerial origin under subalpine meadows

The upper deposit was formed above the soliflual colluvial soil material resulting from change in environmental conditions. The glacial limit in the Urals was further to the north (Nazarov, 2011) that shows the absence of the intense water flow that is able to re-deposit the material. Thus the low content of stone in the soils relates to the fine earth supply with the wind and to the growth of soils on top. This is an important endopathic cause of the soil homogenization. Such soil origin was already proved for brown forest soils of the Southern Urals and Primorye (Karpachevsky, Shevchenko, 1997).

Aeration material fall-out leads to the formation of undifferentiated soils with the manifestation in them sod pedogenesis and burozemic pedogenesis processes. The soil formation conditions in the Urals are permanent since the middle Holocene age and so it is possible to state that braunification is a modern process. The absence of podzolized profile signs is not related to the young age of soils as they are about 10 000 years old. Thus, the formation of the upper layer of soils results from the influence of modern phytocenosis.

Conclusion

According to the morphological features, under the subalpine meadows, there formed such divisions of soils as litozem and organic-accumulative soils which, due to good drainage, have no signs of a podzolized profile as there is rubble in the profile. Based on the rubble distribution in the profile, subalpine soils can be divided into three groups. It was found out that soils formed under grassland ecological communities, have different origins. The soils at different altitudes (even in the same altitudinal vegetation belt) are in constant interaction and contact with the soils of the upper altitudinal belt and adjacent territories due to the mass movement of weathering products or aeration supply of dust particles. Thus, the distribution of rubble is an important diagnostic indicator for mountain soils as it helps to determine their genesis, change of environmental conditions, the intensity of weathering and pedogenesis that occur in soils. Ambiguous rubble distribution in the profile confirms the high spatial variability of topsoil on mountainous territories, different correlation and manifestation of weathering and soil formation processes. Therefore this parameter is recommended to use while monitoring.

References

Balandin S.V., Ladigin I.V. 2002. Flora and vegetation of the ridge Basegi (Middle Urals). Perm: publisher Bogatirev P.G. 191 p.

Bogatyrov K.P. 1947. Greensward mountain-forest soils as a special form of geographic alpine soil // Soil Science. № 12. P. 704-714.

Chernova O.V. 2006. Characteristics of soils of low mountains of the North Caucasus, formed on high-calcareous parent material (for example Abrausskogo reserve). Moscow: Reports on Environmental-th soil science, 2(2): 177-191.

Classification and diagnosis of soil Russia / Authors and contributors: L.L. Shishov, V.D. Tonkonogov, I.I. Lebedeva, M.I. Gerasimov. Smolensk: Oikumena. 2004. 342 p.

Firsova V.P. 1968. On the distribution and properties of brown forest soils in the Urals // The book: Forest and Soil: Proceedings of the All-Union Scientific Conference - Krasnoyarsk. P. 200-203.

Firsova V.P. 1991. Brown mountain-forest soils of the Urals // Soil Science. № 4. P. 47-58.

Glavatskih L.K. 1971. The mineralogical composition of the mountain taiga soils of the northern Urals // Works of Perm agricultural Academy. P. 35-42.

Ilina L.S., Krinari G.A., Karpachevskiy L.O., Morozov V.P. 1993. Aeralny brings minerals in forest soils of the Sikhote-Alin // Soil Science. № 3. P. 5-13.

Ivanova E.N. 1947. Soil of Urals // Soil Science. № 4. P. 213-227.

Ivanova E.N. 1949. Mountain forest soils of the Middle Urals // Proceedings of the Soil Institute of the USSR Academy of Sciences. V. 30. P. 168-193.

Kanisev G.N. 1964. On the mountain-forest soils primitive accumulation of the western slope of the Middle Urals // Problems of Soil Science and Agricultural Chemistry. Works of Perm agricultural Institute. Perm. V. 22. P. 175-188.

Karpachevsky M.L., Shevchenko E.M. 1997. Lithogenic ratio and caenogenetic factors in the formation of brown forest soils of the Middle Urals // Soil Science. № 1. P. 22-30.

Karpachevskii L.O. 2012. Soil formation in the Sikhote-Alin mountains. Moscow, GEOS. P.138.

Mikhailova R.P. 1976. Micromorphological and chemical properties of brown coarse humus soil central mountainous strip of the Middle Urals // Soil Science. № 6. P. 10-15.

Mikhailova R.P. 1977. Brown raw humus unsaturated soils of the Urals / R.P. Mikhailova // Proc. The soil. Inst. V.V. Dokuchaev. P. 87-142.

Mikhailova R.P., Gradusov B.P. 1969. Chemical and mineralogical composition of the clay fractions of some mountain soils of middle Urals // Soil Science. № 6. P. 96-107.

Molchanov E.N. 2010. Mountain-meadow soils of the Western Caucasus / E.N. Molchanov // Soil Science. № 12. P. 1433-1448.

Nazarov N.N. 2011. Geography of the Perm region. Part 1. Natural (physical) geography: a tutorial. Perm: Perm State. uni-t. 2nd ed., Rev. and add. Part 1. 139 p.

Nogina N.A. 1948. Influence on podzol rocks in the mountainous part of the Middle Urals // Works of the Soil Institute of the USSR Academy of Sciences, v. 28. P. 124-190.

Ovesnov A.M. 1952. Mountain meadows of Western Ural. Perm. 130 p.

Popova S.I., Mitrofanova E.M., Ziganshina F.M. 2013. Liming of acid soils in the Urals. Perm: FROM and TO. 252 p.

Samofalova I.A. 2010. Properties of bald mountain soils and mountain-forest zone of the Middle Urals (for example, reserve "Basegi") / I.A. Samofalova, O.A. Luzyanina, L.V. Kul'kova // In Sat: Proceedings of the Conference "Biosphere function of soil cover," Pushchino, Academy of Sciences, November 8-12. P. 272-274.

Samofalova I., Luzyanina O., Kul'kova L., Maulina E. 2012a. Diagnosis of soils mountain-forest belt the Middle Urals (on the example of the ridge Basegi) // Proceedings of the International Conference on "The soil of Azerbaijan: genesis, geography, land reclamation, management and ecology", National Academy of Sciences of Azerbaijan (NANA), Baku, "Elm". V. XII. Part 2. P. 970-979. ISNN 2222-7882.

Samofalova I., Luzyanina O., Maulina E., Kulkova L. 2012b. Features soil mountain-taiga zone the middle Urals // Igdir university jurnal of the institure of science and technology. 2 (2EK: A). P. 93-100.

Samofalova I.A., Kul'kova L.V., Luzyanina O.A., Kamensky P.A., Kozlova O.A., Kosozhihina Y.S., Pischalnikov D.A. 2012c. Current status and properties of brown forest soils of the mountain-forest zone in the Middle Urals // International scientific-practical conference "Sustainable use of soil resources and their environment" (15-16 November 2012), Alma-Ata, Kazakhstan. P. 243-264.

Samofalova I.A., Kul'kova L.V., Luzyanina O.A., Loskutova N.M. 2012d. Natural conditions and morphological characteristics of mountain soils in territory reserve "Basegi" Perm region // Soil reserves and national parks of the Russian Federation. Moscow: Fond "Infosfera" NIA Nature. P. 196-199.

Samofalova I.A., Luzyanina O.A. 2013. Environmental and genetic characteristics of soil Mountain-forest belt in the Middle Urals // Proceedings of the Samara Scientific Center, Russian Academy of Sciences. V. 15. № 3 (4). P. 1426-1431.

Sofronitsky P.A. 1967. Geological sketch // Proceedings of the fifth meeting of the chemical treatment and hydrogeochemistry of Geography of the Perm region. PGU, Perm Division of the USSR Geographical Society, Institute of Karst and Speleology. Vol. 4 (5). Perm. P. 26-41.

Tyflov M.A. 1951. To the knowledge of the Ural mountain meadows // Works of Perm agricultural Institute. V. 13. P. 23-40.

Tyflov M.A. 1952. Mountain meadow soils of the Western Urals: the Abstract. L., 18 p.

Voskresensky S.S. 1980. Geomorphological regionalization of the USSR and adjacent areas: a training manual / SS Resurrection, D.C. Leontiev, A.I. Spiridonov, etc. M.: Higher School. 343 p.

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Influence of atmospheric emissions of nitrogen compounds on the biochemical parameters of soils of European Russia forest

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Abstract

In recent decades much attention is paid to the problem of air pollution by nitrogen compounds. Due to the fact that nitrogen is actively involved in the natural cycle of matter, even a relatively small addition of it may lead to various environmental effects. In this article the influence of anthropogenic emissions of nitrogen compounds on soil parameters is shown on the example of forest ecosystems of European Russia. The study showed that there is a direct correlation between the levels of nitrates in the soil and atmospheric deposition of mineral nitrogen. It was also demonstrated that a high content of nitrates in the soil and its predominance over the ammonium form is typical for forest soils, which are located near major industrial centers and highways. The interaction between the respiration, microbial and the content of soil mineral nitrogen were found.

Keywords: Atmospheric pollution, ammonium, nitrates, biochemical parameters of soils, nitrogen deposition

Introduction

During the last two centuries, agriculture and the burning of fossil fuels have increased significantly the global emissions and deposition of reactive nitrogen compounds (nitric oxide [NO_x], nitrates [NO_3^-], ammonia [NH_3], ammonium [NH_4]). Currently nitrogen is a basic air pollutant and some parts of the world have its deposition of 25 or more kg N ha^{-1} yr^{-1} (Sweden, Germany, Russia) (Intergovernmental Panel ..., 2001; Bartnicki et al., 2013). Anthropogenic nitrogen compounds are relatively rapidly released from the air migration and fall in the terrestrial ecosystems through the dry deposition preferably as nitrate. The nitrates are actively involved in biotic cycle and essentially change it (Bobbink & Hettelingh, 2011; Stevens et al., 2004). In the framework of the Convention on Long-range Transboundary Air Pollution scientific programs were implemented that focus on problems associated with high emissions of nitrogen from anthropogenic sources (Bobbink et al., 2003; Sutton et al., 2011). However, the question about the impact of anthropogenic nitrogen compounds on natural ecosystems, which are characterized by relatively low levels of nitrogen emission, but have a long-term deposition of it, is poorly understood. Forest ecosystems are of significant scientific interest as an object of study because forests contribute to the flow of pollutant due to dry deposition (2-3 times higher compared to herbaceous and shrub) (Koptsik et al., 2008).

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It is known that the soil is one of the main elements of the environment, and its geochemical response to changing natural ecosystem processes under the influence of atmospheric pollutants reflects many biogeochemical processes (Mamai et al., 2013). The mineral nitrogen content in the soil and the atmosphere, the soil C/N ratio, as well as its microbiological activity, are among the main biogeochemical indexes and may be used to characterize the nitrogen cycle.

In forest ecosystems the mineral pool of nitrogen in the soil mainly consists of ammonia, due to the fact that in the process of mineralization after release from organic compounds ammonia is stabilized in substrate and therefore its water soluble form is found in small amounts (Fedorets&Bahmet, 2003). Increased nitrate in soil mineral nitrogen pool of the forests always indicates an external source of nitrogen, which is mostly anthropogenic (Dise, Gundersen, 2004). Ammonia and nitrates in natural ecosystems are mainly products of microorganisms, and in this context, changes in the structure of microbial communities indicates the processes responsible for the mineralization of organic matter (Rasgulin, 2012). There are many studies focused on the impact of different doses of nitrogen fertilizers on the microbial component in arable ecosystems (Peacock et al., 2001; Cerny et al., 2003; Marschner et al., 2003; Luo et al., 2014). However, experimental data on the influence of anthropogenic nitrogen on soil microbial status in natural ecosystems is small. So, the aim of our study was to assess the biogeochemical parameters of the soil under the impact of anthropogenic emissions of nitrogen in the forest ecosystem.

Material and Methods

Study area

The study area encompasses Moscow and Kostroma regions located in the European part of Russia. In Moscow region the annual temperatures and precipitations amounts are +5.5 °C and 670 mm, and for Kostroma region these parameters are +3.0 °C and 570 mm, respectively. The selected areas were presented by leaved, coniferous and mixed forests (age 40-60 years). In the Moscow region in the tree layer is dominated by *Picea abies (L.) H. Karst., Betula pubescens Ehrh., Abies sibirica Ledeb.,* and by *Picea obovata Ledeb., Abies sibirica Ledeb., Betula pubescens Ehrh*. in the Kostroma region. Soddy-podzolic (Umbric Albeluvisols) soil is different in texture, with pH value 4.3-5.8. The nitrogen depositions in the Moscow and Kostroma regions amount in average 10.6 kgN ha^{-1} yr^{-1} and 2-4 kgN ha^{-1} yr^{-1}, respectively (Overview of the trends.., 2009).

Snow sampling

The snow survey method was used to assess the level of the mineral nitrogen income from the atmosphere. This method allows assessing the quantity of soluble and insoluble components falling from the atmosphere to terrestrial ecosystems, including both dry and wet deposition (Glazovskii et al., 1983; Glazovskii, 2004). Snow sampling was carried out in late February and early March (the period of maximum snow accumulation and before intensive melting). The snow samples (a total of 150) at sites with different distance from the anthropogenic sources of nitrogen emissions (distance from highways with heavy traffic and stationary sources was taken into account) were collected. At each site a plot (10 m^2) was chosen where mixed samples were taken from five snow cores by the "envelope" method. The snow cores were collected with a plastic sampler (50 mm in diameter) from the snow cover (layer 0-50 cm). In respect to nitrogen deposition the studied ecosystems were ranged at three groups: less than 1 kg N ha^{-1} yr^{-1}, 1-4 kg N ha^{-1} yr^{-1} and more than 4 kg N ha^{-1} yr^{-1} (according to the classification of critical nitrogen concentrations in the soil solution by De Vries et al., 2007).

Soil sampling

The soil sampling was done at the same sites where the snow was collected. The site was a flat plot (10×10 m), where soil samples were collected from the upper (0-10 cm) layer. Bulk samples for each site were prepared, delivered to the laboratory and sieved (1 mm mesh). It has been shown that the upper mineral layer (0-10 cm) of the soil is characterized by high microbial activity and contains many roots of grass-shrub species (Umarov et al., 2007).

Nitrogen in Snow and Soil

In our study we used several methods in order to assess the impact of N deposition on soil parameters. Determination of the concentration of ammonium ($N\text{-}NH_4$) and nitrates ($N\text{-}NO_3$) in snow and soil samples was carried out using the photocolorimetric method by Kudeyarov described in detail in the publications (Kudeyarov, 1965, 1969). The C/N ratio in the soil was determined by an automated analyzer CN VARIO ELIII.

Microbial Biomass and Basal Respiration

Soil substrate-induced respiration (SIR) based on additional respiration response of soil microorganisms (initial maximum CO_2 production) enriched by the available substrate (glucose) was measured (Anderson, Domsch, 1978; Ananyeva et al., 2011). The basal (microbial) respiration (BR) was measured as described for SIR, but with the addition of water instead of glucose solution (0.1 ml g^{-1} soil), and incubated (24 h, 22°C). Prior to the estimation of SIR and BR all soil samples (0.3-0.5 kg) were sieved, moistened up to 50-60% water holding capacity and pre-incubated in aerated bags at 22°C for 7 days.

Results and Discussion

Air deposition

Air pollution by nitrogen oxides extends to large distances from the emission source and determines the increase of the geochemical background in large areas. From the data obtained the total deposition of mineral nitrogen compounds (nitrate and ammonium) from the atmosphere for the studied sites ranged from 0.4 to 15 kgN ha^{-1} yr^{-1} (on average 1-4 kgN ha^{-1} yr^{-1})(Fig. 1). In many areas nitrate forms of nitrogen dominated in atmospheric precipitations, reaching up to 10-13 kgN ha^{-1} yr^{-1}. The nitrate in atmospheric precipitation of about 4 kg N ha^{-1} yr^{-1} and higher was detected in the forests in the area of atmospheric transport of pollutants from the city of Moscow and main industrial centers (Mytishchi, Podol'sk, Voskresensk, Khimki). In forest ecosystems located relatively distant from the sources of anthropogenic nitrogen emissions (eastern, western and south-western districts of the Moscow and Kostroma regions), the deposition of nitrates was below 4 kg N ha^{-1} yr^{-1}.

The level of ammonium deposition in the study area ranged from 0.1 to 5.0 kg N ha^{-1} yr^{-1} (on average 0.4-1.0 kg N ha^{-1} yr^{-1}). In 20% studied forest ecosystems ammonium deposition forms dominated. Intensive forest fires increase the emission of ammonia to the atmosphere (Karlsson, 2009). In our opinion, this fact may explain the elevated levels of ammonium in atmospheric precipitation after forest fires which occurred in the eastern districts of the Moscow region.

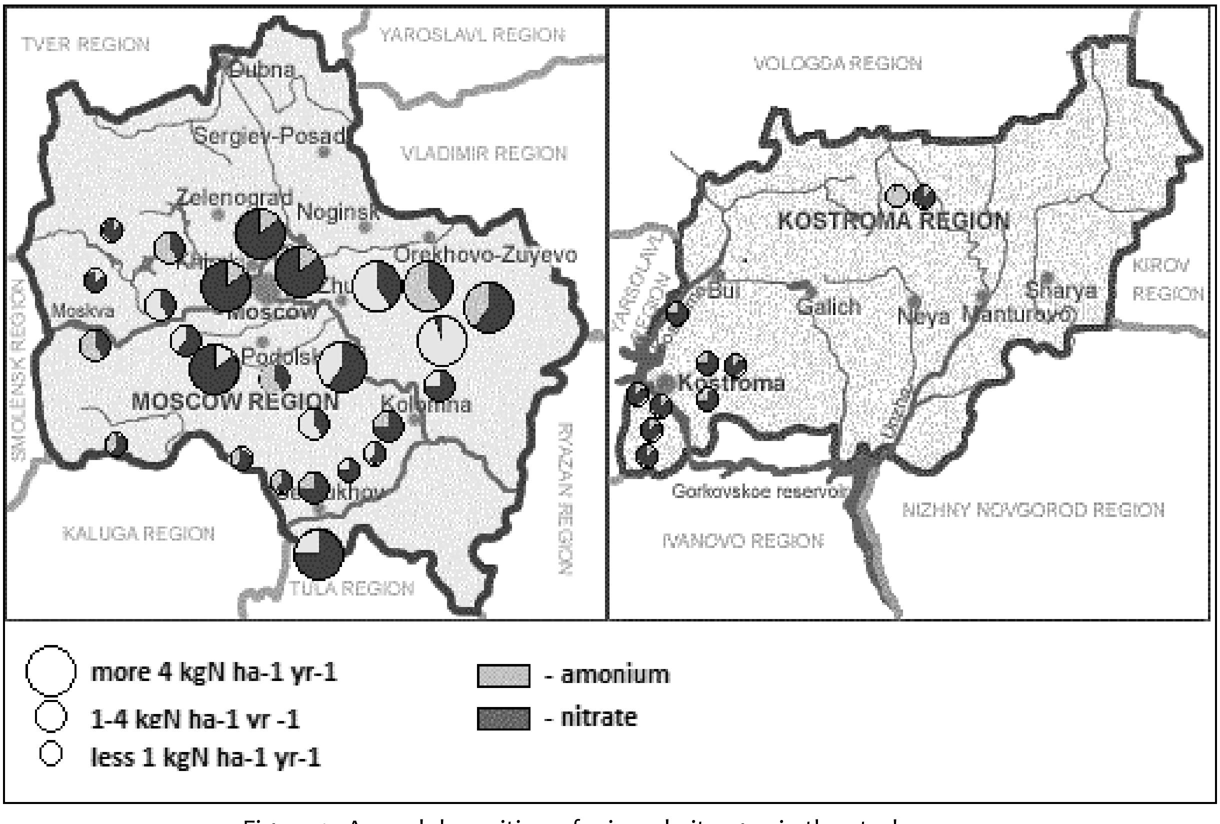

Figure 1. Annual deposition of mineral nitrogen in the study areas

Soil parameters

The content of mineral nitrogen in the soils of the studied regions was varied due to the complexity and heterogeneity of the soil (Fig. 2). In forest soils (0-10 cm) the total mineral nitrogen content was 5-23 mg N kg^{-1} (on average 9-13 mg N kg^{-1}). As described above, the pool of mineral nitrogen in the forest predominantly comprises ammonium. In the investigated forests the ammonium concentration in the soils varied up 4-11 mg N kg^{-1} (in average 5-8 mg N kg^{-1}) in the middle of the growing season (Fig. 2). Nitrate contents in the soils ranged from 0.1 to 13 mg N kg^{-1} (on average 2-6 mg N kg^{-1}) (Fig. 2).

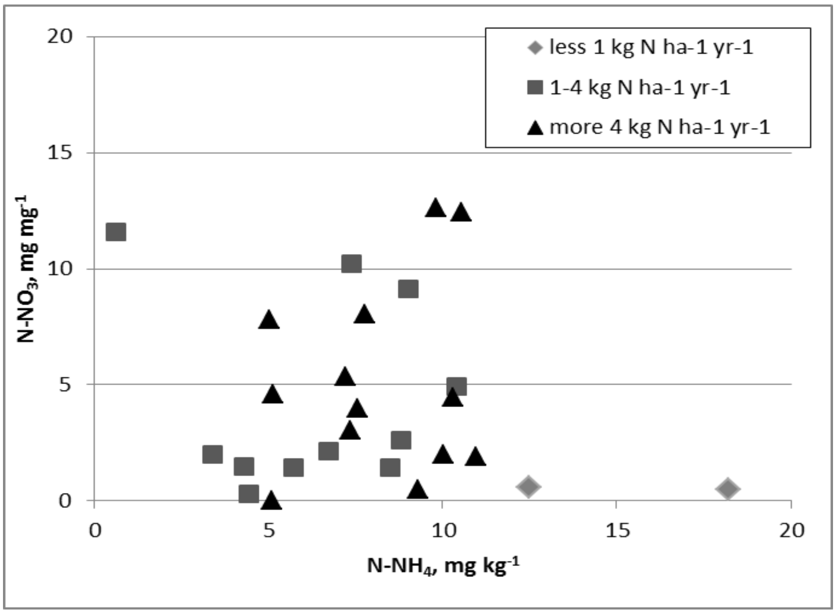

Figure 2. The ratio of ammonium and nitrate forms of nitrogen in forest soils

Nitrate dominated in the soils of several forest plots, which might be linked to an adaptation of forest ecosystems to the conditions of nitrogen limitation (Lukina et al, 2008) and the impact of anthropogenic sources (De Vries et al., 2007). High concentrations of nitrate in the soil (> 1 mg N/100 g) were registered at forest sites located in the areas subjected to forest fires and near agricultural fields. The increasing of nitrates in the soil of agricultural fields is associated with enhanced processes of organic matter mineralization and nitrification due to the changes of redox conditions (Orlov, 1992). Both the ammonia and the nitrates in the soil increase upon intensification of forest fires (Nave et al., 2011), determining the increase of their content, as compared to background conditions. Statistical analysis of the data showed that the total pool of mineral nitrogen in forest soils is largely determined by nitrate concentration ($r = 0.85$, and $r = 0.61$ for ammonium). We assume that this is due to the influence of anthropogenic emissions of nitrogen compounds. As shown above, nitrates dominate in the pool of mineral nitrogen of atmospheric deposition, which may lead to a change in the ratio of mineral nitrogen forms in the soil of the areas with the highest intensity of anthropogenic emissions of nitrogen.

The C/N ratio in the soil is a relative measure of intensity of organic matter mineralization and, therefore, the availability of mineral nitrogen (Gundersen et al., 1998; Nave et all., 2009). At low C/N ratio the mineralization is much faster. At 20 <C/N <35 the immobilization of nitrogen in soil organic matter is moderately lasting, limiting the pool of soil mineral nitrogen. Under 10 <C/N <20 the immobilization in the soil is short-term, which results to an increase in the availability of nitrogen to biota (Heikkinen, Makipaa, 2010). The C/N ratio for the studied soils ranged from 12 to 28 (on average 12-19) (Fig. 3). In our study, the C/N values above 25 were typical only for the soils of three forest sites in the Moscow region. The C/N ratio was lower for most sites, indicating the absence of long-term immobilization of nitrogen in soils.

According to the adopted classification (Orlov, 1992), the values of C/N <5 correspond to very high enrichment of soils with the available nitrogen, 5-8 is high enrichment, 8-11 – average, 11-14 – low, and C/N > 14 is very low.

Thus, according to this criterion the studied forest soils had low and very low enrichment of nitrogen, despite the relatively high levels of deposition of mineral nitrogen in some areas (8-15 kg N ha^{-1} yr^{-1}).

As shown by studies in forest ecosystems in Western Europe, there is a relationship between the deposition of nitrogen and the C/N ratio of the soil (Sutton et al, 2009). In forest soils with C/N <21 the relationship between the intensity of atmospheric nitrogen deposition and its leaching out into the soil- and groundwater is strong (R = 0.74), while at C/N> 21 this relationship is much weaker (R = 0.33) (Dise, Gundersen, 2004). However, our study did not show any correlation between the deposition of mineral nitrogen and the C/N ratio in the soil (Fig. 3). We also did not find any correlations with forest types. It can be concluded that relatively low levels of nitrogen deposition do not have a significant effect on the C/N ratio of soils.

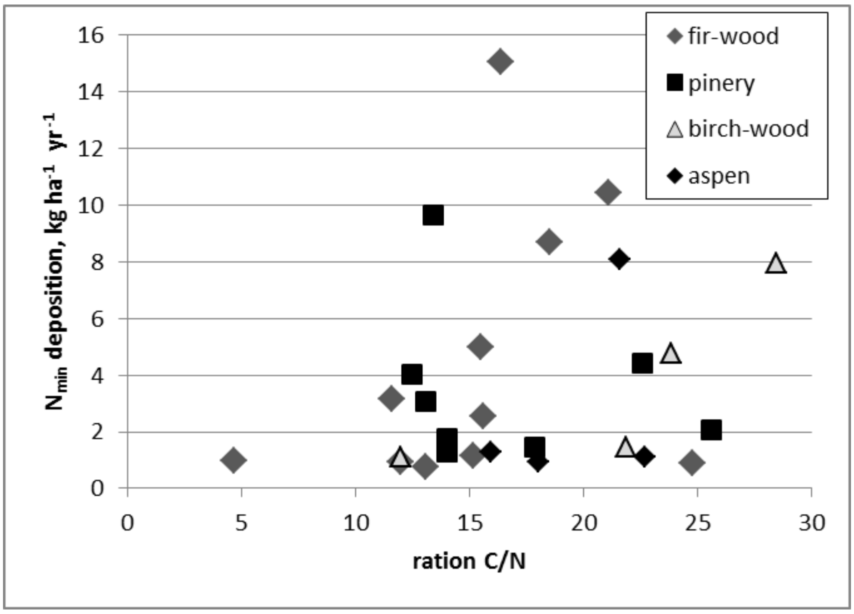

Figure 3. Interaction between deposition of mineral nitrogen and C/N ratio of soil

In forest soils the carbon of the microbial biomass (C_{mic}) and the basal (microbial) respiration (BR) values ranged from 51 to 476 μg C g^{-1} and 0.21 to 1.61 μg C-CO_2 g^{-1} h^{-1}, respectively. The soil N_{min} content was from 1 to 13 mg N kg^{-1} (in average 4.6 mg N kg^{-1}). The significant positive correlations between the soil N_{min} content and the microbial biomass (r = 0.76) and the microbial respiration rate (r = 0.62) were found. Thus, the soil C_{mic} and BR values were 69 μg C g^{-1} and 0.49 μg C-CO_2 g^{-1} h^{-1}, respectively, in the soil of aspen (Kostroma region) with N_{min} content 1.31 mg N kg^{-1}; however, the microbiological parameters were higher (by 5 and 3 times, respectively) in the soil of birch-wood (Moscow region) with N_{min} 12.7 mg N kg^{-1}. In snow samples of forest ecosystems the N_{min} values ranged from 0.9 to 8.0 kg N ha^{-1} yr^{-1} (on average 2.0 kg N ha^{-1} yr^{-1}). In the studied forests with nitrogen deposition less than 1.0 kg N ha^{-1} yr^{-1} the soil C_{mic} and BR values amounted on average 192±177 μg C g^{-1} and 0.81±0.31 μg C-CO_2 g^{-1} h^{-1}, respectively. In ecosystems with deposition values 1.5-8.0 kg N ha^{-1} yr^{-1} the microbiological indexes (C_{mic} and BR) in soil were higher (by 1.5 and 1.4 times for C, respectively). It has been demonstrated that additional input of nitrogen (3.5 kg NH_4NO_3 ha^{-1} yr^{-1}) in natural forests of North Carolina did not lead to any changes in the soil microbial biomass, though soil microbial respiration was increased from 1832 to 2005 mg C m^{-2} day^{-1} (Gallardo and Schlesinger, 1994). Compton et al. (2004) found that in Harvard forest the soil (0-10 cm) the microbial biomass don't change (horizon A) at chronic nitrogen additions of low (5 kg N ha^{-1} yr^{-1}) and high (150 kg N ha^{-1} yr^{-1}) concentrations. In soils with limited nitrogen (semi-arid environment, west Texas), its additional input (concentration 500 kg N ha^{-1}) gave an increase in the soil microbial biomass by 1.3-1.7 times (Zhang and Zak, 1998). In soils with limited nitrogen, its addition resulted in active mineralization of organic matter and an increase of microbial respiration in the soil (Lee and Jose, 2003; Yevdokimov et al., 2005). The nitrogen content in the studied ecosystems was relatively low possibly being a limiting factor for soil microorganisms, and increasing the concentration of the soil N_{min} might stimulate the biomass and activity of microorganisms.

Conclusion

Thus, our study revealed that the deposition of mineral nitrogen on the major part of the studied area is 1-4 kg N ha^{-1} yr^{-1}. This level is relatively low. However, several forest ecosystems had the deposition of mineral nitrogen higher than 10 kg N ha^{-1} yr^{-1}. It was revealed that the increase of N_{min} in the atmospheric deposition of European Russia leads to increasing soil NO_{3^-} but does not affect the C/N ratio. The relationship between the N_{min} content in the soil, microbial biomass and the rate of microbial respiration was detected. The influence of mineral nitrogen deposition on soil microbial indicators was not found.

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References

Ananyeva N.D., Susyan E.A., Gavrilenko E.G Determination of the soil microbial biomass carbon using the method of substrate-induced respiration // Eurasian Soil Science. 2011. V. 44. Issue 11. P. 1215-1221.

Anderson J.P.E., Domsch K.H. A phisiological method for the quantitative measurement of microbial biomass in soils // Soil Biol. Biochem. 1978. V. 10. N. 3. P. 215-221.

Bartnicki J., Gusev A., Aas W., Valiyaveeti S, Nyíri A. Atmospheric Supply of Nitrogen, Lead, Cadmium, Mercury and Dioxins/Furans to the Baltic Sea in 2013. OSLO. 2013. P. 159. ISSN 0332-9879

Bobbink R., Ashmore M., Braun S., Fluckiger W., Van den Wyngaert I.J.J. (2003) Empirical nitrogen critical loads for natural and semi-natural ecosystems: 2002 update. In Empirical critical loads for Nitrogen. Environmental Documentation No. 164. Air., eds. D. Achermann & R. Bobink, pp. 43-170. Swiss Agency for Environment, Forests and Landshape SAEFL, Bern.

Bobbink, R. and Hettelingh, J. P. (Eds.): Review and revision of empirical critical loads and dose-response relationships, Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM), www.rivm.nl/cce, 2011

De Vries W., Rros H., Reinds G.J. et al. (2007) Developments in deriving critical limits and modelling critical loads of nitrogen for terrestrial ecosystems in Europe. Alterra, Alterra –rapport 1382, 206 p

Dise, N.B., Gundersen, P., 2004. Forest ecosystem responses to atmospheric pollution: linking the empirical with the experimental. Water, Air and Soil Pollution: Focus 4, pp. 207 - 220.

Fedorets N., Bahmet O. Ecological settings of carbohydrate and nitrogen transformations in forest soil, (2003). Petrozavodsk.

Glazovskii N.F. Current approaches to assessing the sustainability of the biosphere and human development-M.: KMK, 2004.

Glazovskii N.F., Zlobina A.I., Uchvatov V.P. Chemical composition of snow in some areas Verhneokskogo pool // Regional Environmental Monitoring. - Moscow: Nauka, 1983. P. 67 - 86

Gundersen P., Callesen I., de Vreas W. (1998) Nitrate leaching in forest ecosystems is related to forest floor C/N ration. //Environ. Pollut. 102 (1), pp. 403-407.

Heikkinen Ju., Makipaa R. Testing hypotheses on shape and distribution of ecological response curves. //Ecological Modelling. 2010. V. 221. P. 388–399.

Intergovernmental Panel on Climate Change (2001) Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (eds Houghton JT, Ding Y et al.) Cambrige University Press, Cambrige.

Karlsson E. (2009) Extensive biomass burning in Russia during spring 2006 resulted in high deposition of ammonia in throughfall over northern Sweden // Biogeomon P.176

Koptsik S., Koptsik G., Alyabina I. Assessment of the risk of excess sulfur input into terrestrial ecosystems of the Kola peninsula // Russian Journal of Ecology. — 2008. — Vol. 39, no. 5. — P. 327–336.

Kudeyarov V.N. Calorimetric determination of ammonium nitrogen in soils and plants by phenol // Agrochemicals, 1965. № 1. - S. 146-150.

Kudeyarov V.N. Calorimetric determination of ammonium nitrogen in soils by restoring them to the ammonia // Agrochemicals, 1969, № 1. - S. 102-106.

L. E. Nave, E.D. Vance, C. W. Swanston et al. Fire effects on temperate forest soil C and N storage // Ecological Applications, 21(4), 2011, pp. 1189–1201.

Mamai A.V., Fedorets N.G., Stepanov A.L. Nitrogen fixation and denitrification processes in podzolic soils under coniferous and small-leaved forests in the Middle Taiga in Karelia// Russian Forest Science, 2013, № 1, p. 66–74

Nave L. E., Vance E.D., Swanston C.W. et al. (2009) Impacts of elevated N inputs on north temperate forest soil C storage, C/N, and net N-mineralization. //Geoderma. Vol. 153. P. 231–240.

Orlov D.S. Soil Chemistry. Moscow: Moscow State University Press, 1992. Pp. 301-311.

Overview of the trends and dynamics of environmental pollution of the Russian Federation according to the long-term monitoring Roshydromet (2009). P. 21. http://www.meteorf.ru/ .

Rasgulin S. M. Nitrogen Mineralization in Soil of a Highly Productive Southern Taiga Birch Forest/ Eurasian Soil Science, 2012, № 1, p. 65–71.

Stevens C.J., Dise N.B., Mountford J.O. et al. (2004) Impact of nitrogen deposition on the species richness of grasslands. Science 303, 1876 -1879.

Sutton M., Reis S., Baker S.M. (2009) Atmospheric Ammonia: Detecting emission changes and environmental impacts. (Eds.) Springer.

Sutton M.A., Howard C., Erisman J.W. et al. (2011). The European Nitrogen Assessment (Eds.) Cambridge University Press. 612 pp.

Umarov M.M., Kurakov A.V., Stepanov A.L. Microbiological transformation of nitrogen in the soil. Moscow: GEOS, 2007. – p.138.

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Change of fluctuations of soil properties in kashtanozem in extremely uniform conditions under agricultural impacts

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Abstract

Reliable quantitative information about changes of soils is necessary for development of projects of soil protection, engineering etcetera. Changes of soils are inevitable process under change of climate and intensive agricultural and other usages that in many cases leads to deterioration of soils properties. These changes occur simultaneously at different levels of organization of soil and soil cover. We have proposed considering three principal categories of the spatial changeability of soil properties using the concept of nesting: heterogeneity for significant changes in soil-forming factors, variability for their insignificant changes, and fluctuation for leveled soil-forming factors. We study these categories of soil changeability at example of Kashtanozem (chestnut soils), that are the most widespread soils at Kulunda steppe situated at the south of Western Siberia. In this paper we quantitatively analysing soil fluctuations. Data were the result of soil investigation in the limits of not long (6 meters) trenches of soil pedons under different usage (virgin soil, unirrigated arable soil and irrigated arable soil). Statistical comparison of soil properties at different impacts was done by comparison of statistical characteristics and probabilistic distributions (pdf) of soil properties. Pdf with high p-values was considered as probabilistic model of soil property as whole in the soil volume in space in soil horizons. Analysis of pdf regularities gives clear and stable information about difference of soil properties under agricultural impacts. Information divergences quantify these regularities. Analysis of soil fluctuation shows that they change dramatically under agricultural impact. Analysis of entropy value highlighted the main tendency – the tendency of outstanding decreasing quantity of various microconditions of soil in top horizon and growth of it in the bottom of soil profile. It is necessary to recognize that fluctuations of properties of soils, their profile distribution depend on conditions and soil formation factors, and in fact, are a genetic sign of the soil.

Keywords: soil properties, fluctuations, agricultural impact, probabilistic distribution, microconditions.

Introduction

Large-scale and detailed-scale monitoring investigations have shown that soils are characterized by essential intrinsic changeability in the space. Soil properties in soil horizons display stochasticity even in homogeneous soil objects (Dmitriyev, 1983; Mikheeva, 2001). It means that it is impossible to predict or evaluate *exactly* their values or changes in any locality.

Previously we have proposed considering three categories of the spatial changeability of soil properties using the concept of nesting: heterogeneity for significant changes in soil-forming factors, variability for their

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insignificant changes, and fluctuation for leveled soil-forming factors. All three changeability categories are observed at different organization levels of the soil and soil cover. In our opinion, the quantitative evaluation of relationships between different changeability categories of soil properties is also necessary for assessing the stability of the soil cover as a hierarchical system (Mikheeva, 2005, 2013).

In general, values of soil properties in soil horizons in any point of space are cumulative effect of various factors and processes at different scales operating mutually that is the reason of multiscale of soil variation which is differently shown at distances from several centimeters to tens and thousands of meters and kilometers. Usage of hierarchical approach allows quantitative consideration of soil cover in various scales. From the point of view of common sense, the variance of property of soil at, so called, field level of organization σ^2_{Field} can be presented in the form of the sum of variances:

$$\sigma^2_{Field} = \sigma^2_{flu} + \sigma^2_{fac} + \sigma^2_{an} + \sigma^2_{anflu} + \sigma^2_{anfac} \quad (1)$$

where

σ^2_{flu} –variance induced by stochastic fluctuations of soil property in soil individuum (pedon);

σ^2_{fac} –variance of soil property owing to micro- or meso- heterogeneity of factors of soil formation within elementary soil areal or combination of soil elementary areas, which form the field as whole object (Fridland, 1972). This heterogeneity may remove the soil, or not, outside framework of the taxonomical unit, but at the same time it permits allocation of soil contours in more detailed scales or at another criteria's of classification;

σ^2_{an} –the variance determined by heterogeneity of soil property owing to heterogeneity of an anthropogenous factor (in virgin soil it equal zero);

σ^2_{anflu} –the variance induced by different change of stochastic fluctuations of soil property as consequence of affect of anthropogenous factor;

σ^2_{anfac} –is defined by differences of the soil owing to different "lag effect" of separate sites of a soil cover in relation to anthropogenous factor.

Thus, the variability of soil property at the field level is defined by total action of elementary soil and elementary landscape processes, micro- or meso- heterogeneity of factors of soil formation, distinction of anthropogenous factor and reaction of soil to it. Each item in the equation (1) has various qualitative importance and different range of quantitative value. σ^2_{fac} and σ^2_{an} are bigger than another addends. This variability defines a structure of soil field as system. σ^2_{flu} , σ^2_{anflu} and σ^2_{anfac} are smaller by value, but they are very important for characterization of quality condition of soil and its reaction to anthropogenous factor.

Material and Methods

The fluctuations in properties of chestnut soil of the Kulunda Steppe were studied. The region is characterized by a droughty continental climate and its relief may be defined as a gently undulating plain. The soil cover consists of chestnut soils (70%), meadow-chestnut soils, meadow soils, solonetzes, and solonchaks with different degrees of hydromorphism. The chestnut soils significantly vary in texture, from loose sands to medium loams, which is a result of the ancient limnetic alluvial genesis of the territory. Loamy sandy and sandy loamy soils are predominant; they have an evenly colored humus-accumulative horizon and display deep effervescence.

The above notion of property fluctuation describes the minimum spatial changeability of soil properties occurring under conditions of practically leveled soil forming factors at a specific level of organization. In our study, the soil fluctuations were determined by the presence of coarse pores, cracks, concretions, tongues, and micro zones with different particle-size composition, moisture contents, and chemical parameters within a pedon.

The fluctuations of the soil properties were studied using the trench method. Trenches 6 m long were dug in loamy sandy chestnut soil in absolutely level conditions (in terms of the lithology, microclimate, microtopography, vegetation, and tillage) under different use (virgin soil, arable soil, and irrigated arable soil) in close vicinity to one another (within 100-300 m).

The arable soil was tilled for more than 30 years and irrigated for 20 years; corns for silage and forage grasses were the main crops. The soil was irrigated with low-mineralized water (with salt concentration of 0.7-1.0 *g per* *l)* at low irrigation norms; the water was of unfavorable salt composition with the predominance of sodium hydro-carbonate.

The trenches passed through all the genetic horizons. Samples with volumes equal 10 cm^3 were taken from each horizon in 20-22 replications (Fig. 2). The thickness of each horizon, the humus content, particle-size composition, cation exchange capacity, exchangeable cation composition, pH, salt composition, and some other parameters were determined in laboratory analysis of soil samples by standard methods in Russia.

The results of the laboratory studies were analyzed statistically. First we analyzed standard statistical parameters as average, standard deviation, coefficient of variation, asymmetry and kurtosis, range of changeability. Then we identified type and parameters of probability distribution functions (pdf) of soil properties by choosing the best approximation of pdf according to compromise statistical criterion, which equal the average of p-values of some nonparametric criteria: Kolmogorov's test, Smirnov's test and Ω^2- and ω^2- tests (Lemeshko, 2005). At the end we calculated and considered probabilistic indicators of pdf's like statistical entropy and information divergence.

Results and Discussion

The variation of soil properties appears in the shortest distances. Process of soil formation, even in absolutely leveled conditions gives these fluctuations. It is known that many processes proceeding in soils, such as formation of micro and a macro- pores, structural units, cracks and microcracks and others, are stochastic by their nature. Even the smallest representative volume of the soil represents a statistical mix of the soil particles forming complicated system of channels and surfaces. At each moment the internal state of this volume under the same repeated impact has the difference. These distinctions lead to local macroscopic effects in space - to distinctions of humidity and fluctuations of the content of substances and other characteristics of the soil.

Thus the aggregate structure of the soil has impact on a property variation in big degree, which means transition of our consideration to the lower hierarchy level. This intrinsic soil fluctuation is amplified by small fluctuations of soil forming factors, especially by variation of granulometric structure and vegetation. These factors of soil formation start acting at the lower level of hierarchy, for example, not vegetation – but separate plants, not granulometric structure – but existence of separate stones or deposits near plants at a deflation.

All these reasons, finally, lead to a variation of the quantitative values of characteristic properties of the soil quality even in very short distances in uniform conditions of soil formation. This article is devoted to quantitative studying of this phenomenon under different soil usage.

Granulometric Composition

Variation of granulometric structure in space - one of the main reasons causing a variation of properties of the soil, and, first of all, hydro-physical and physical: soil aggregate and micro aggregate structure, specific surface, main hydro-physical characteristic, moisture conductivity.

The granulometric structure of the soil generally depends on granulometric structure of initial breed, therefore, the genesis of the soil forming breeds defines generally a variation of granulometric structure of the soil, bringing to a variety of quantitative manifestation of soil properties in space even in very small territory. At the same time, the granulometric structure of a soil profile and the separate horizons can change under the influence of soil processes, such as an osolontsevaniye, an osolodeniye, lessivage, and also under the influence of contemporary water and wind erosion. As a rule, it is to some extent non-uniform in space that is reflected in a variation of the content of fractions. In this section the clay content in three studied trenches of the chestnut sandy soil of different usage is considered. It was defined by Kachinsky's method.

Low clay content - 8-12% and also in most cases weak expressiveness of texture difference of the illuvial horizon is characteristic of the profile of chestnut sandy soils of Kulunda. However, some illyuviirovannost of the horizon of B or, a so-called physical solontsevatost is sometimes noted (Fig.1).

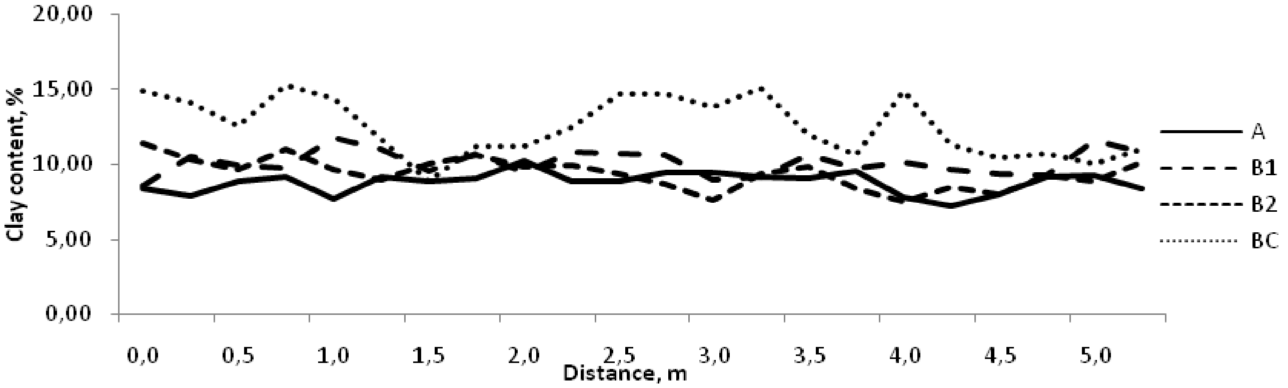

Fig.1 Fluctuations of clay content in virgin loamy sandy Kashtanozem

So, the B1 horizon of virgin option of the soil contains the clay particles more, than the A horizon and probability of the significance of distinction is 0,999. The clay content variation in these two horizons is almost identical as Fischer's coefficient for comparison of dispersions of F=1.44 doesn't exceed value of standard F-distribution. In deeper horizons the dispersion of the clay content in virgin option remains at former level, however, owing to monotonous decrease down on a profile of its average value, the variation coefficient increases from 8% to 12% (Tab. 1) a little.

In option of not irrigated arable soil the clay content in all horizons authentically exceeds the clay content in virgin option. However, if in virgin option the clay variation practically doesn't change down on a soil profile, it considerably increases in option of not irrigated arable soil, especially upon transition from the horizon A to the horizon of B1 and upon transition from B2 horizon on BC.

Table 1. Statistical characteristics of fluctuations of clay content in loamy sandy Kashtanozem of different usage

Soil horizon	Variant	m	s	CV, %	A	T	F
A	Virgin	8.8	0.7	8	-0.4	16.94*	1.37
	Arable	12.2	0.6	5	-0.6	13.2*	1.14
	Irrigation	9.6	0.6	6	0		
B1	Virgin	10.1	0.8	8	0.1	8.75*	1.53
	Arable	12.7	1	8	0.2	1.99	1.03
	Irrigation	12.1	1	8	1		
B2	Virgin	9.4	1	11	-0.1	8.56*	1.34
	Arable	12.3	1.2	10	0.3	9.22*	1.36
	Irrigation	8.6	1.4	16	0.7		
BC	Virgin	8.3	1	12	-1.2	4.54*	3.66*
	Arable	10.5	2	19	0.5	1	4.58*
	Irrigation	11.6	4.2	36	0.6		

Note. m – mean value, s - standard deviation, CV,% -coefficient of variation, A –coefficient of asymmetry, T and F – Student’s and Fisher’s criterias

The irrigation of steppe soils leads to change of nature of communications between the genetic horizons according to the clay content and profile differentiation of its main mineral components. The tendency of simplification of granulometric structure of the arable horizon of irrigated Chernozems and Kashtanozems and its some weighting in the subarable horizon, caused by transit of part of clay particles into the underlying horizons is revealed.

Kaurichev (1975) had noted that at periodic impacts of weak solutions of sodium salts on not salted soils the soil profile originally alkalinizes, and then descending water flows intensively wash out the soil and take out products of alkaline hydrolysis in deeper horizons. And V.A. Kovda (1973) wrote that alkaline solutions promote migration of compounds of silicon dioxide: to their carrying out in eluvial conditions, to inflow and accumulation in transitive and accumulative conditions. Really, in BC horizon of irrigated option of the soil more than in 25% of volume the content of silt more, than for 4% exceeds the clay content in the arable and subarable horizon, and in 10% of selection it is excess makes more, than 8% of silt. It testifies to its considerable accumulation in separate points of the BC horizon.

Thus, the clay content in the all profile of the virgin chestnut soil is stable in the space, and in A and BC horizons under the existing external conditions is close to the greatest possible value. Agricultural use of the chestnut soil leads to change of the clay content and causes processes of its intra profile redistribution that comes to light in the analysis of statistical properties of its spatial distribution. Features of spatial distribution of clay in the genetic horizons in limits of pedons reflect extent of manifestation in space of the soil processes conducting to change of its contents and intra profile distribution. For the clay content in the superficial horizon of the chestnut sandy soil the left asymmetry of its statistical distribution more strongly expressed in option of not irrigated arable land less in irrigated is characteristic.

Soil Organic Matter

The low content of humus at the small depth of the humus horizon in chestnut sandy soils is caused by climatic conditions of soil formation and easy granulometric structure (fig. 2). In the horizon A of studied virgin option of the soil the average content of humus is 1.66% (tab. 2). Its contents quite strongly vary - the coefficient of a variation is equal 16% that is obvious, connected with inhomogeneity of vegetable biomass in virgin conditions.

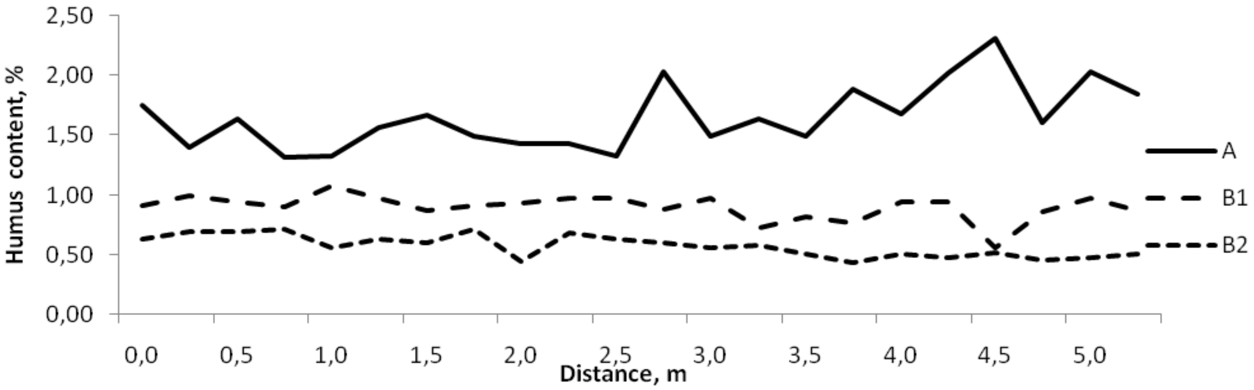

Fig.2 Fluctuations of humus content in virgin loamy sandy Kashtanozem

Strengthening of processes of a mineralization of humus substances in connection with change of physical properties, and also reduction of vegetable biomass, which income into the soil, owing to alienation with a crop of elevated biomass, in arable soils lead to decrease in the humus content in the arable horizon in comparison with the horizon A in virgin soil. It makes here 1.51%. And at the same time the variation of the humus content in the arable soil authentically decreases (Tab. 2) because of annual hashing of the superficial horizon when processing the soil and bigger uniformity of distribution of cultivated cultures in comparison with natural steppe vegetation. The coefficient of a variation of the humus content in the arable horizon of not irrigated option makes 7%.

Table 2. Statistical characteristics of fluctuations of humus content in loamy sandy Kashtanozem of different usage

Soil horizon	Variant	m	s	CV, %	A	T	F
A	Virgin	1.66	0.27	16	0.74	2.41*	6.29*
	Arable	1.51	0.11	7	0.07	2.31*	2.48*
	Irrigation	1.57	0.07	4	0.34		
B1	Virgin	0.9	0.11	12	-1.4	4.43*	1.35
	Arable	0.76	0.09	12	0.58	2.2*	1.27
	Irrigation	0.83	0.11	13	0.26		
B2	Virgin	0.57	0.09	16	0.07	1.05	2.65*
	Arable	0.6	0.06	10	0.25	0.73	4.06*
	Irrigation	0.57	0.11	19	0.69		

At irrigated soils of the steppe zone, owing to optimization of a water regime and increasing of microbiological activity, processes of humification and mineralization of organic substances amplify. At the same time, in connection with increase of efficiency of plants receipt of organic substance to the soil in the form of root weight increases, especially at cultivation of long-term herbs that finally promotes increasing of humus content at irrigated variant in comparison with not irrigated arable land.
According to our data in the horizon A of the irrigated chestnut soil the humus content is reliable above, than in not irrigated arable land and makes 1.57% (Tab. 2). However, the increase in mobility of humus substances at irrigated soil, especially by alkaline water, causes its redistribution in a soil profile that is revealed also by us. So, considerable accumulation of humus in an arable layer of the irrigated soils can't be for this reason. Besides the numerous sprinkling on a surface of the soil when watering by alkaline water by norm 300-350 m3/hectare promotes uniform distribution of humus in soil mass that sharply reduces a variation of its contents. The coefficient of its variation here is equal only 4%.

Conclusion

In summary we will note that increase of fluctuations of properties down on a soil profile - the general regularity for chestnut sandy soils and is a genetic sign of soils in dry zone of Western Siberia. It is explained by weak appearance of soilforming processes in the bottom horizons of soil profile because of sharp continentality of climate.

Machining and irrigation of the soil break the dynamic balance which has developed during natural evolution in the virgin soil. Increasing homogeneity of the superficial horizon, these influences cause processes in profile redistribution of substances and lead to sharp increase of fluctuations of properties in the bottom soil horizons, and more in the irrigated soil. Thus to statistical distributions of soil indicators the right asymmetry, testifying that considerable changes of properties happened only in small part of spatially distributed volumes of the genetic horizons is, as a rule, characteristic. Obviously, small quantity of atmospheric precipitation and small irrigating norms are the reason of it.

The variation of properties of the soil considered in elementary variation areas reveals fluctuations of soil properties which take place under almost uniform conditions of soil formation. These fluctuations at constant factors of soil formation are defined by local quantitative distinctions of elementary soil processes. Process of soil formation gives these fluctuations because of many micro processes in soils which are stochastic. Apparently from the provided data the characteristic of fluctuations of properties of the soil, its profile distribution depend on conditions and factors of soil formation and, in fact, is a genetic sign of the soil. Therefore it needs to be displayed quantitatively for the purpose of a better understanding of spatial distribution of properties in a profile and assessment of their change in time.

References

Dmitriyev Ye.A. 1983. Soil Horizons//Soviet Soil Science, Vol.15. N 4.pp. 62-70.

Fridland V.M. 1972. Structure of soil cover. Moscow. Publishing: Mysl.

Kaurichev I.S. 1975 Pochvovedenie. - Publ.: «Kolos» 1975.- 495 c.

Kovda V.A.1973 Osnovi uchenia o pochvah. - M.: Nauka-486 c.

Lemeshko, B.Yu., 2005. Statistical Analysis of Univariant Observations of a Random Variable: a Program System. Novosibirsk, Russia: Publishing Novosibirsk State Technical University.

Mikheeva, I.V., 2001. Statistical Probability Models of Soil Properties (with Chestnut Soils of the Kulunda Steppe as an Example). Novosibirsk, Russia: Publishing Rossiyskoy Akademii Nauk

Mikheeva, I.V., 2005. Statistical Probability evaluation of sustainability and variability of nature objects under modern processes (with Chestnut Soils of the Kulunda Steppe as an Example). Novosibirsk, Russia: Publishing Rossiyskoy Akademii Nauk.

Mikheeva, I.V., 2005. Spatial Fluctuations and Statistical Probability Distributions of Chestnut Soil Properties in the Kulunda Steppe. Eurasian Soil Science 38 (3), 278-288.

Mikheeva, I.V., 2009. Divergence of Probability Distributions of the Soil Properties as a Quantitative Characteristic of the Soil Cover Transformation. Contemporary Problems of Ecology 2(6), 667-670.

Mikheeva, I. 2013.Probabilistic Models of Spatial Fluctuations of Edaphic Properties in Native Soils in Steppe Zone of Western Siberia// Eurasian Journal of Soil Science. Volume: 2, Issue 2, Page: 82 – 89.

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Effect of detritus input on some soil nutrients concentrations in a Central European deciduous forest

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Abstract

The much talked-of climatic changes of nowadays are also pointed out by the results of long-term meteorological measurements of Síkfőkút Project in northeast Hungary , since climate of the forest became warmer and drier in the last three decades. Regulational and functional processes of the forest ecosystem are variously influenced by the climate change, which has an effect on the structure and species composition of the forest; and through the changes in leaf-litter production, it influences the quality and quantity of organic materials and biological activity in the soil, both directly and indirectly. Síkfőkút DIRT (Detritus Input and Removal Treatments) Project forms a part of the DIRT Project which was organized by the US-ILTER (International Long-Term Ecological Research). General purpose of the project is to reveal the connection between the modifications of leaf-litter production and the changes of climatic conditions and land use. It also studies how the modifications, decreases or increases in litter production influence the organic material content, and physical, chemical or biological processes of soils. Our detritus manipulation experiment carried out in a Quercetum petraeae-cerris community examined the effects of various detritus inputs, on soil organic carbon, nitrogen and sulfur content. We applied three detritus removal (No Litter, No Roots and No Input) and two detritus duplication treatments (Double Litter and Double Wood). Eight years after the establishment of experiment significant reductions in soil organic matter content were measured in detritus removal treatments compared to control (15,8 – 24,1%). However, the increase was of smaller extent in detritus duplication treatments (6,9 – 11%). The soil nitrogen and sulfur content showed similar tendencies.

Keywords: Detritus manipulation; DIRT; Oak forest; Carbon nitrogen and sulfur concentration

Introduction

The carbon, nitrogen, and sulfur content there are among the most important parameters in the soil. The land use change, and climate change affect soil carbon, nitrogen and sulfur contents with change the amount of litter production and decomposition processes. The carbon content of the organic matter in the upper 1 m soil layer is estimated to be 1200 – 1600 Gt by Batjes and Sombroek (1997). The upper 2 m layer supposedly contains 2376 – 2456 Gt carbon (Batjes, 1996). According to the estimations, soil contains about two and a half times as much carbon as vegetation, and about twice as much as the atmosphere (Batjes, 1998). The role of

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forests and forest soils are especially important because forests make up approximately one-third of lands; moreover, they represent about 80% of aboveground and 40% of belowground organic carbon pools in terrestrial ecosystems (FAO 2005). They also provide 72% of global net primary biomass production (Melillo et al., 1993). Humic is an important N source. The soil N stock of approx. 96-97% of the organic material is located in humic substances, detritus - mainly crop residues - and living soil biomass (Stevenson, 1994).
Soil organic matter primarily deriving from detritus (Kögel-Knabner, 2002) represents the largest mass of organic carbon and nitrogen and takes an important part in the global carbon and nitrogen cycle (Schimel, 1995; Kotroczó et al., 2008). Qualitative and quantitative detritus input manipulations may cause alterations in the accumulation or loss of soil carbon, nitrogen and sulfur content (Boone et al., 1998, Giardina and Ryan, 2000).
Detritus is a major element of forest ecosystems. Soil microorganisms consume all kinds of substrates, ranging from simple sugars contained in root exudates and fresh residues to complex humic acids in SOM (Luo and Zhou, 2006). Detritus determines microclimatic conditions, thus regulates decomposition (Vasconcelos and Lawrence, 2005; Sayer, 2006). It also influences the amount of soil available nutrients (Sayer, 2006), and these nutrients exercise considerable effects on decomposition rates as well (Rothstein et al., 2004). So aboveground detritus influences the factors of its own decomposition as well as organic matter cycle (Kotroczó et al. 2014; Veres et al., 2013). The increase of the atmospheric CO_2 level enhances litterfall (Liu et al., 2009; Kotroczó et al., 2012), while certain changes in precipitation can cause the decrease of detritus production (Sayer et al., 2006). The literature treating the effects of vegetation and detritus on soil temperature and moisture content is relatively rich (Sayer, 2006, Schaefer et al., 2009).
Deforestation and conversion of forestland to farms can reduce the amount of soil organic matter by 50% for some years or decades (Alvarez et al., 2001; Lal, 2002). This can be explained by the remarkable decrease in detritus production which entails mineralization. Mineralization reduces the amount of soil organic matter, and the decrease of organic substrates will result in the reduction of number and activity of decomposing bacteria and fungi (Tóth et al., 2007, Beni et al., 2014; Fekete et al., 2011b). These effects are also indicated by the decrease of soil respiration in a certain period of time (Steenwerth et al., 2005). However, the increase of detritus input can significantly increase the organic carbon and nitrogen content in soil (Campbell, 1978).
Several researches have already underpinned the effects of global warming on Síkfőkút forest site. The long term meteorological data have clearly indicated that the climate of the forest has become drier and warmer over the past four decades (Antal et al., 1997). The species composition and structure of the Síkfőkút forest has remarkably changed since the early 1970's (Tóth et al., 2007; 2011): more than two-thirds of the sessile oak (*Quercus petraea*) and 15.8% of Turkey oak (*Quercus cerris*) died, while the rate of Hedge maple (Acer campestre) has increased from 0% to 28% (Kotroczó et al., 2007; Kotroczó et al., 2012). This entails several changes in detritus amount and composition (Bowden et al., 2006).

Our research within Síkőkút DIRT Project constitutes an important part of a long term international project organized by USA ILTER which involves four more experimental sites in the USA (Andrews Experimental Forest, Bousson Experimental Forest, Harvard Forest, University of Michigan Biological Station) (Nadelhoffer et al., 2004) and another one in Germany (Universität Bayreuth BITÖK). The overall objective of the project is to explore how climate changes or changes in land use influence detritus production, and how soil physical, chemical and biological parameters (such as soil CO_2 release, soil temperature, soil moisture and humus contents) are modified by the changes in detritus production (Fekete et al., 2007; 2011a; 2012; Tóth et al., 2007).

Material and Methods

Site description

We carried out our researches in the Síkfőkút Forest. The study area (27 ha) is located in the southern part of the Bükk Mountains in northeast Hungary at an altitude of 325 m. GPS coordinates are as follows: 47°55`N, 20°28'E. The area has been protected and part of the Bükk National Park since 1976. According to Antal et al. (1997) the mean annual temperature was 10 °C and mean annual precipitation was 553 mm. The pH_{H2O} value of topsoil (0-15 cm) is 5.2. This forest is a semi-natural stand (*Quercetum petraeae-cerris* community) with no active management since 1976 (Jakucs 1985). In this coppiced forest the Sessile oak and Turkey oak species that make up the overstorey are a hundred years old. Based on the data from 2003 to 2005, litter production consists of the following tree species in decreasing order: sessile oak (*Quercus petraea*), Turkey oak (*Quercus* *cerris*), Hedge maple (*Acer campestre*), and Cornelian cherry (*Cornus mas*). During the same period the average dry leaf-litter production was 3326 kg ha^{-1} and the average amount of total aboveground dry detritus (including branches, twigs, fruit and buds) was 6572 kg ha^{-1} (Tóth et al., 2007). The soil type according to the WRB Soil Classification is Cambisol (Fekete et al., 2007).

The experimental plots of Síkfőkút DIRT Project were established between 13th and 18th November 2000. Following the methods of the American DIRT sites we established six kinds of treatments in three replications in 18 plots: (DL: Double Litter, C: Control, NL: No Litter, NR: No Root, DW: Double Wood, NI: No Input) (Nadelhoffer et al., 2004; Fekete et al., 2007). The plots of 7×7 m were located at random.

Table 1. The applied DIRT (Detritus Input and Removal Treatments) treatments in open-field experiment (Síkfőkút, Hungary). (Nadelhoffer et al., 2004; Fekete et al., 2007; Fekete et al., 2011a)

TREATMENTS	DESCRIPTION
CONTROL (C)	Normal litter inputs. Average litter amount typical to the given forest site
DOUBLE LITTER (DL)	Aboveground leaf inputs are doubled by adding litter removed from NL plots.
DOUBLE WOOD (DW)	Aboveground wood debris inputs are doubled by adding wood to each plot. Annual wood litter amount was measured by boxes placed to the site and its double amount of that was applied in the case of every DW plots.
NO LITTER (NL)	Aboveground inputs are excluded from plots. Leaf litter was totally removed by rake. This process was replayed continuously during the year.
NO ROOTS (NR)	Roots are excluded by inserting impervious barriers in backfilled trenches to the top of the horizon C. Root resistant plastic foil was placed into the plot in the depth of 1 m, hindering the roots developing outside of the plot. Trees and shrubs were eradicated when the plot was established, and plant roots decayed in time
NO INPUTS (NI)	Aboveground inputs are excluded from plots, the belowground inputs are provided as in NR plots. This treatment is the combination of NR+NL plots.

Soil sampling and measurements

Soil samples were collected at random from 0-15 cm depth with Oakfield soil auger (Oakfield Apparatus Company, USA). Samples were homogenized.

For detecting soil temperature an ONSET StowAway TidbiT type data logger (Onset Computer Corporation, USA) was put into the middle of each parcel at 10 cm depth. Data loggers were programmed to measure soil temperature every hour from 8th March 2001. For our comparative examinations the mean temperature values of the sampling day and the three prior days were used. Soil moisture content was determined with FieldScout TDR 300 (Spectrum Technolgies Inc, USA).

For determining total soil carbon, nitrogen and sulfur contents we applied the method of Nagy (2000) using VARIO EL CNS elemental analyzer (ELEMENTAR Analysensysteme GmbH, Germany). Soil samples were sieved, dried, ground, and pretreated with 10% hydrochloric acid to eliminate inorganic carbonate content before organic carbon analysis by dry combustion (Matejovic 1997). Carbon, nitrogen and sulfur contents were measured in 21st April 2001 and 16th June 2005.

Applied statistical methods

The statistical analyses of the data were conducted using Statistica 7.0. Random sampling and the independence of sample elements were ensured by the experimental procedure established. The homogeneity of the variances was examined by Fmax-probe. Carbon, nitrogen and sulfur contents of the plots were compared by one-way ANOVA. When groups were significantly different, ANOVA was completed with Tukey's HSD test. The value of $p \leq 0.05$ was considered to be statistically significant.

Results and Discussion

In the year of the establishment (2001) carbon content values decreased in the following order: NR, NL, DW, DL, NI and C. However, no significant differences were found between these values. After the first year the total soil carbon content of root exclusion treatments (NR, NI) decreased remarkably and in 2005 they revealed the lowest values, as the soil nitrogen and sulfur content. DL DW and Co revealed significantly higher carbon content values than the two root exclusion treatments ($F(5,12)=8.5$; $p<0.01$). The nitrogen content showed similar results ($F(5,12)=8.19$; $p<0.01$). Sulfur content was significantly lower in root exclusion treatments (NR, NI) than in the control, and it was also significantly lower in NI than in the DL and DW ($F(5,12)=5.28$; $p<0.01$).

Table 2. Soil carbon, nitrogen and sulfur concentration (means ± SE) in 2001 in the Síkfőkút DIRT treatments. The values are expressed in g kg^{1} dry soil.

	Carbon	Nitrogen	Sulfur
DL	44.1±0.8	3.5±0.01	0.41±0.04
DW	44.4±2.1	3.5±0.23	0.44±0.05
Co	41±3.5	3.3±0.15	0.45±0.02
NL	44.9±3	3.5±0.17	0.41±0.03
NR	46.7±0.7	3.8±0.11	0.42±0.03
NI	41.9±2.8	3.5±0.15	0.37±0.02

Table 3. Soil carbon, nitrogen and sulfur concentration (means ± SE) in 2005 in the Síkfőkút DIRT treatments. The values are expressed in g kg^{1} dry soil. Means with the same letter within each sampling date are not significantly different.

	Carbon	Nitrogen	Sulfur
DL	41.4^{b} ±3.1	3.4^{b} ±0.06	0.41^{bc} ±0.01
DW	41.3^{b} ±2.6	3.4^{b} ±0.17	0.40^{bc} ±0.02
Co	43.2^{b} ±2.8	3.3^{b} ±0.2	0.42^{c} ±0.02
NL	34.9^{ab} ±0.6	3^{ab} ±0.15	0.37^{abc} ±0.02
NR	32^{a} ±0.4	2.8^{a} ±0.05	0.35^{ab} ±0.01
NI	28.3^{a} ±1	2.5^{a} ±0.08	0.33^{a} ±0.01

In NR and NI plots the roots decayed after the vegetation had been cleared, they enriched the organic matter supply in soil, as well as the decomposition processes that became more intense enhanced soil respiration. Root biomass makes up 18-45% of total tree biomass and its proportion varies with the species, age and site (Santantonio et al., 1977, Makkonen and Helmisaari, 2001). That is why high carbon content values were measured in root exclusion treatments (especially in NR) in the first year. In NR it was due to the rapid decomposition of fine roots and easily decomposing plant tissues. These molecules increased the carbon content and enhanced CO_2 release of NR and NI treatments until they decomposed completely. This is shown by the high CO_2 release values of NR compared to other treatments in the first two years. The cease of transpiration due to the lack of living plants resulted in significantly higher soil moisture content, and it also enhanced the intensity of decomposition processes in root exclusion treatments. This can be explained by the fact that NR and NI had optimal moisture conditions for microbes even in drought periods. The optimal water capacity is between 50 and 70%, i. e. 25-35 %w/w, according to Gerenyu (2005). Soil moisture content values of root exclusion treatments were mostly within this range, while they were often below it in the other four treatments (Fekete et al., 2012).

The high carbon and nitrogen content values of NR measured in the first year, these values reduced remarkably for 2005. We already observed the initial increase of decomposition processes in root exclusion treatments in our previous research. After the establishment both soil enzyme activity (Fekete et al., 2007) and humus content (Varga et al., 2008) increased, but they decreased considerably already in 2002 and 2003. This phenomenon can be explained by the reduction of substrate supply due to the decomposition of roots and easily decomposing molecules of rhizosphere. As these plots did not contain any living roots, neither their biomass production nor their exudates enriched the organic matter content of soil or provided compounds with high carbon content. The primary sources of soil organic carbon are fine roots as they provide 30-80% of it. Fine roots decompose easily and turn over rapidly (Kalyn and Van Rees 2006). Soil CO_2 release is influenced by both substrate quality and quantity, and its intensity by labile carbon supply (Raich and Tufekcioglu, 2000; Fekete et al., 2012).

The two root exclusion treatments revealed even lower values than NL. On the one hand, this can be explained by the fact that root biomass plays an important role in sustaining soil organic carbon supply. (Makkonen and Helmisaari, 2001). On the other hand, it is explained by the great extent of organic matter loss in NR and NI soils, which was underpinned by our organic matter content measurements carried out by potassium bichromate method (Varga et al., 2008). Wang et al. (1999) observed similar processes in the Sierra Nevada Montain in California. They measured 30% lower soil carbon content in a nearby logged area than in an old-growth forest. This remarkable reduction in carbon and nitrogen contents were caused by intense decomposition processes in NR and NI, which is underpinned by soil respiration values (Fekete et al., 2014).

The unexpected intensity of decomposition processes in root exclusion treatments can not only be explained by the significantly higher moisture content but the soil temperature values that were 1-1.2°C higher during vegetation period than in Control (Fekete et al., 2014). As detritus input was limited in these treatments, decomposing organisms got nutrients from the soil organic matter supply and by the enhanced utilization of roots that died at the establishment of the plots. These processes resulted in a greater extent of carbon, nitrogen and sulfur content loss in root exclusion treatments.

Other processes can reduce also the soil nitrogen content in the wet period. Nitrates are highly soluble, so these compounds moves with soil water and can be easily leached through soil. Furthermore, nitrate can be chemically reduced through the process of denitrification. Denitrification, reduction of nitrate to nitrous oxide or dinitrogen gas by anaerobic bacteria, can be a important mechanism for nitrogen loss from poorly aerated soils or when soils are saturated with precipitation (Thompson, 1996.). The root exclusion treatments sometimes are saturated with water When the soil nutrients decrease the decomposing bacteria and fungi biomass also decrease in the detritus removal treatments.(Tóth et al., 2007, Beni et al., 2014).

Soil moisture and temperature are the critical climatic factors regulating soil elements (such as carbon, nitrogen) cycle, and the transformation of a number of compounds in soil. Where water is nonlimiting, biological activity may depend primarily on temperature, but as soils dry, moisture is more controlling of biological processes than is temperature (Voroney, 2007). Diffusion of substrates to microorganisms and the metabolic processes are greatly slowed by drying, so the soil microbial activity decreased.

Conclusions

The decrease in litter production has caused significant reduction in the forest soil carbon, nitrogen and sulfur content within 5 years. In contrast, the increase in litter production did not alter the soil carbon, nitrogen and sulfur content. The effect of leaf litter removal was lower than the effect of root removal to soil nutrient contents in the upper 15 cm soil layer.

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References

Alvarez, R., Alvarez, CR, Lorenzo, G. 2001. Carbon dioxide fluxes following tillage from a mollisol in the Argentine Rolling Pampa. Europen Journal of Soil Biology. 37, 161–166.

Antal, E., Berki, I., Justyák, J. et al. 1997. A síkfőkúti erdőtársulás hő- és vízháztartási viszonyainak vizsgálata az erdőpusztulás és az éghajlatváltozás tükrében. Debrecen, 83. (*in Hungarian*)

Batjes, NH. 1996. Total carbon and nitrogen in the soils of the world. European Jornal of Soil Science. 47, 151–163.

Batjes, NH. 1998. Mitigation of atmospheric CO_2 concentrations by increased carbon sequestration in the soil. Biology and Fertility of Soils. 27, 230–235.

Batjes, N.H., Sombroek, WG. 1997. Possibilities for carbon sequestration in tropical and subtropical soils. Global Change Biology. 3, 161–173.

Beni A., Soki E., Lajtha K., Fekete I., 2014. An optimized HPLCmethod for soil fungal biomass determination and its application to a detritus manipulation study. Journal of Microbiological Methods. 103, 124–130

Boone, RD., Nadelhoffer, KJ., Canary, JD. 1998. Roots exert a strong influence on the temperature sensitivity of soil respiration. Nature. 396, 570–572.

Bowden, RD., Nagel, L., Kotroczó, Zs. et al. 2006. Long-term change in vegetation composition and biomass in a Central European oak forest at the Síkfőkút International Long-Term Ecological Research (ILTER) Site, Hungary. Mid-Atlantic Ecology Conference. Ecology in the Field. New Jersey School of Conservation. Branchville, New Jersey. Mid-Atlantic Chapter of the Ecological Society of America (MAESA) 2-3.

Campbell, CA. 1978. Soil organic carbon, nitrogen and fertility. (eds. Schnitzer M, Khan SU) Soil Organic Matter. Developments in Soil Science 8. Elsevier, Amsterdam, 173.

FAO 2005. Global forest resource assessment: Progress towards sustainable forest management. In: FAO (ed). FAO Forestry Paper. Rome, 147.

Fekete, I., Varga, Cs., Kotroczó, Zs. et al. 2007. The effect of temperature and moisture on enzyme activity in Síkfőkút Site. Cereal Research Communications. 35, 381–385.

Fekete, I., Varga, Cs., Kotroczó, Zs. et al. 2011a. The relation between various detritus inputs and soil enzyme activities in a Central European deciduous forest. Geoderma. 167–168, 15–21.

Fekete I, Kotroczó, Zs., Varga, Cs., Veres, Zs., Tóth. J. A. 2011b. The effects of detritus inputs on soil organic matter content and carbon-dioxide emission in a Central European deciduous forest. Acta Silvatica et Lignaria Hungarica. 7, 87–96.

Fekete, I., Kotroczó, Zs., Varga, Cs. et al. 2012. Variability of organic matter inputs affects soil moisture and soil biological parameters in a European detritus manipulation experiment. Ecosystems. 15, 792–803.

Fekete, I., Kotroczó, Zs., Varga, Cs., Nagy, PT., Várbíró, G., Bowden, RD., Tóth, JA., Lajtha, K. 2014. Alterations in forest detritus inputs influence soil carbon concentration and soil respiration in a Central-European deciduous forest. Soil Biology and Biochemistry. 74, 106–114.

Gerenyu, LVO., Kurganova, IN., Rozanova, LN. et al. 2005. Effect of soil temperature and moisture on CO_2 evolution rate of cultivated Phaeozem: analysis of a long-term field experiment. Plant Soil and Environment. 51, 213–219.

Giardina, CP., Ryan, MG. 2000. Evidence, that decomposition rates of organic carbon in mineral soil do not vary with temperature. Nature. 404, 858–861.

Jakucs, P. (ed.) 1985 Ecology of an Oak Forest in Hungary I. - Akadémiai Kiadó, Budapest, p. 23.

Kalyn, AL., van Rees, KCJ. 2006. Contribution of fine roots to ecosystem biomass and net primary production in black spruce, aspen, and jack pine forests in Saskatchewan. Agricultural and Forest Meteorology. 140, 236–243.

Kotroczó, Zs., Krakomperger, Zs., Papp, M., Bowden, RD., Tóth, JA., 2007. Long-term change in the composition and structure of an oak forest at Síkf}okút, North Hungary. Természetvédelmi Közlemények 13, 93–100 (with English abstract).

Kotroczó, Zs., Fekete, I., Tóth, J.A., Tóthmérész, B., Balázsy, S. 2008. Effect of leaf- and root-litter manipulation for carbon-dioxide efflux in forest soil. Cereal Res Commun 36, 663–666.

Kotroczó, Zs., Veres, Zs., Fekete, I., Papp, M., Tóth, J.A. 2012. Effects of Climate Change on Litter Production in a *Quercetum petraeae-cerris* Forest in Hungary. Acta Silvatica et Lignaria Hungarica. 8, 31–38.

Kotroczó, Zs., Zs. Veres, I. Fekete, Zs. Krakomperger, J. A. Tóth, K. Lajtha, B. Tóthmérész 2014. Soil enzyme activity in response to long-term organic matter manipulation. Soil Biology and Biochemistry. 70, 237–243.

Kögel-Knabner, I. 2002. The macromolecular organic composition of plant and microbial residues as inputs to soil organic matter. Soil Biology and Biochemistry. 34, 139–162.

Lal, R. 2002. Soil carbon dynamics in cropland and rangeland. Environmental Pollution. 116, 353–362.

Liu, LL., King, JS., Fitzgerald. LB. et al. 2009. Enhanced litter input rather than changes in litter chemistry drive soil carbon and nitrogen cycles under elevated CO_2: a microcosm study. Global Change Biology. 15, 441–453.

Luo, Y., Zhou, X. 2006. Soil Respiration and environment. Academic Press is an imprint of Elsevier, San Diego, 149.

Makkonen, K., Helmisaari, HS. 2001. Fine root biomass and production in Scots pine stands in relation to stand age. Tree Physiology. 21, 193–198.

Matejovic, I., 1997. Determination of carbon and nitrogen in samples of various soils by dry combustion. Communications in Soil Science and Plant Analysis. 28, 1499–1511.

Melillo, JM., McGuire, AD., Kicklighter, DW. et al. 1993. Global climate change and terrestrial net primary production. Nature. 363, 234–240.

Nadelhoffer, K., Boone, R., Bowden, RD. et al. 2004. The DIRT experiment. In: Foster, DR., Aber, DJ. (eds.) Forests in Time. Yale University Press: Michigan.

Raich, JW., Tufekcioglu, A. 2000. Vegetation and soil respiration: correlations and controls. Biogeochemistry, 48, 71–90.

Rothstein, DE., Vitousek, PM., Simmons, BL. 2004. An exotic tree alters decomposition and nutrient cycling in a Hawaiian montane forest. Ecosystems. **7**, 805–814.

Santantonio, D., Hermann, RK., Overton, WS. 1977. Root biomass studies in forest ecosystems. Pedobiologia. 17, 1–31.

Sayer, EJ. 2006. Using experimental manipulation to assess the roles of leaf litter in the functioning of forest ecosystems. Biological Reviews. 81, 1–31.

Sayer, EJ., Tanner, EVJ., Cheesman, AW. 2006. Increased litterfall changes fine root distribution in a moist tropical forest. Plant and Soil. 281, 5.

Schaefer, DA., Feng, W., Zou, X. 2009. Plant carbon inputs and environmental factors strongly affect soil respiration in a subtropical forest of southwestern China. Soil Biology and Biochemistry. 41, 1000–1007.

Schimel, D. 1995. Terrestrial ecosystems in the carbon cycle. Global Change Biology. 1, 77–91.

Steenwerth, KL., Jackson, LE., Calderon, FJ. et al. 2005. Response of microbial community composition and activity in agricultural and grassland soils after a simulated rainfall. Soil Biol. Biochemistry. 37, 2249–2262.

Stevenson, FJ. 1994. Humus Chemistry: Genesis, Composition, Reactions. John Wiley & Sons, New York.

Thompson, T. 1996. Agricultural Fertilizers as a Source of Pollution. In I.L. Pepper, C.P.Gerba, and M.L. Brusseau (eds) Pollution Science pp. 211–223. Academic Press, San Diego, CA.

Tóth, JA., Lajtha, K., Kotroczó, Zs. et al. 2007. The effect of climate change on soil organic matter decomposition. Acta Silvatica et Lignaria Hungarica. 3, 75–85.

Tóth J. A., Nagy, P. T., Krakomperger Zs, Veres Zs., Kotroczó Zs., Kincses S., Fekete I., Papp M., Mészáros I. and Viktor O. 2013. The Effects of Climate Change on Element Content and Soil pH (Síkfőkút DIRT Project, Northern Hungary). *In:* J. Kozak et al. (eds.), The Carpathians: Integrating Nature and Society Towards Sustainability, Environmental Science and Engineering, Springer-Verlag Berlin Heidelberg pp. 77–88.

Tóth, J. A., Nagy P. T., Krakomperger Zs., Veres Zs., Kotroczó, Zs., Kincses, S., Fekete, I., Papp, M., Lajtha, K. 2011. Effect of litter fall on soil nutrient content and pH, and its consequences in view of climate change (Síkfőkút DIRT Project). Acta Silvatica et Lignaria Hungarica. 7, 75–86.

Varga, Cs., Fekete, I., Kotroczó, Zs. et al. 2008. Effect of litter amount on soil organic matter (SOM) turnover in Síkfőkút site. Cereal Research Communications. 36, 547–550.

Vasconcelos, HL., Lawrence, WF. 2005. Influence of habitat, litter type, and soil invertebrates on leaf-litter decomposition in a fragmented Amazonian landscape. Oecologia. 144, 456–462.

Veres, Zs., Zs. Kotroczó, K. Magyaros, J. A. Tóth, B. Tóthmérész. 2013. Dehydrogenase Activity in a Litter Manipulation Experiment in Temperate Forest Soil. Acta Silv. Lign. Hung. 9, 25–33.

Voroney, RP. 2007. Soil water content, in: Soil microbiology, ecology, and biochemistry (ed. Paul EA), Burlington, Oxford, 47 pp.

Wang, Y., Amundson, R., Trumbore, S. 1999. The impact of land use change on C turnover in soils. Global Biogeochemical Cycles. 13(1), 47–57.

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The use of soil methods in archeology in Mikulcice

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Abstract

Currently, Mikulčice is one of the most significant archaeological sites not only in the Czech Republic but also in the Central Europe. One of the auxiliary sciences of archeology is pedoarcheology. This paper presents the results of pedoarcheological research at the site located in Mikulčice - Valy. The aim was to assess the usefulness of pedoarcheological methods to distinguish filling of cultural pits. The paper aims to differentiate individual sections of the settlement based on results of laboratory analyzes of different amounts of phosphorus, carbon, humus and humus quality. The test pit S1 MAP was 130 cm deep. However, the first 30 cm were made up of rock walls of the palace. Another 30 to 70 cm consisted of sandy dark colored sediments that were homogeneous throughout this part. At 80 cm, there is a sudden change of almost all the monitored characteristics. Granularity is changed, clay content increases and the amount of sand decreases. At this depth, there is also an increase in the amount of phosphorus, Cox, humus and total carbon. There is also a large amount of carbon and bones. This is probably the beginning of the waste pit. S2 MAP test pit is also considered as the waste pit. The total depth of the pit was 100 cm. Waste pit ranged from 10 cm to 60 cm. This pit comes from the Great Moravian period. It has been surprisingly found that two distinct peaks of phosphorus content were present in the layer forming the filling of the waste pit (10 - 60 cm). The same trend was detected at other characteristics. This may indicate a certain discontinuity of settlement at this place. Period of intense utilization was substituted by period of less intense settlement that was immediately followed by more intensive use of the surrounding. Below the layer of waste pit, from about 60 cm to the bottom of the pit, sandy aluvial soil was found. It is interesting that there is alternation of gain and loss of sand. This phenomenon is probably due to the activities of the Morava River floodplain. The increased sand content is refered to running water which was more powerful causing floods of greater intensity.

Keywords: Pedoarchaeology, Mikulčice, Cultural filling, Phosphorus

Introduction

Currently, Mikulčice belongs to one of the most important archaeological sites not only in our country but also in the Central Europe. This fact is reflected in the number of archaeological research at the location. However, the research does not rely solely on classical archeology. Interdisciplinary cooperation, especially of scientific fields, is becoming increasingly important there as on one of the few sites in the Czech Republic. One of the auxiliary sciences of archaeology is pedoarcheology. This paper presents the pedoarcheologic results of the location Mikulčice - Valy. The aim was to assess the usefulness of pedoarcheological methods in distinguishing filling of cultural pits and in differentiating individual sections of the settlement based on the results of laboratory analyzes. Settlement should be reflected in different amounts of phosphorus, carbon, humus and

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humus quality. Another equally important task was to distinguish the pits from different cultural periods and finally to determine the calm period of sedimentation and periods of increased flood activity on the basis of grain-size analysis and to compare these results with the references, in particular, with the work of E. Opravil.

Short Introduction to Pedoarcheology

It had been almost a hundred years, when Olaf Arrhenius realized that the soil located at archaeological sites shows increased amounts of phosphorus (1931). This discovery very slowly induced the development of a scientific discipline that is now commonly known as pedoarcheology (sometimes as archeopedology). This term was firstly published by Russian researcher C.C. Nikiforoff in 1943. Nikiforoff focused on paleopedology and was also interested in the soils associated with the occurrence of archaeological sites. Nikiforoff realized these soils cannot be regarded as fossil soils. He suggested that the scientist, dealing with soils occurring on site of archaeological findings, with their changes and transformations, should have not been called paleopedologists but archeopedologists (Nikiforoff, 1943).

Pedoarcheology is based on a simple but many times verified fact that each human activity causes changes in soil. The result of these changes is different properties of soil compared to soil that has not been affected by human activity. Such activities include agricultural activities, waste disposal, handicraft, ritualistic activities and even common activities such as preparing and eating food. Archaeologists, with the help of knowledge of pedologist, can get more accurate information on the use of the settled area, its internal organization, organization of agriculture, handicraft production, the form of a functional purpose of buildings and other spaces. In addition, important objective of pedoarcheology is to understand the processes taking place in soil at particular site and to determine period of depositing artifacts (Walkington, 2010). WALKINGTON (2010) consider soil as a unique archive of information:

- At the site of discovery, soil represents the unique interaction between factors, which have shaped it, and this location. In other words, the soil is an archive depositing information related to the development of the field on and near location.
- Soil is seen as a three-dimensional body where soil processes occur both vertically and horizontally. If we can recognize these processes and determine the cause of the process, we will understand the entire archaeological site better.
- Soils can store paleoecological indicators such as pollen, phytoliths, the remains of animals and plants. Such data help to get an idea of the conditions under which the site of research has been formed and the conditions inhabitants lived in. Information about the influence of the soil on these paleoecological indicators is equally important.

The soil keeps a record of past use, landscape management and use of space at the site discovery. The soil deposits the artifacts and remains of buildings.

Material and Methods

Sampling was conducted on the 17 of August 2010 in area of the Royal Palace. The sites were selected by archaeologists. There sediments are very dark colored with carbon residues probably forming filling of the waste pits. Three sampling sites were selected in total. The test pit No. 1 with a depth of 100 cm, marked as S1 – MAP, is a likely waste pit from the time of settlement before the Great Moravian period. The second test pit was labeled as S2 - MAP and represents also a waste pit probably from the Great Moravian Empire. The depth of the pit was about 100 cm as well. The test pit No. 3, marked as 31-MAP, is a waste pit from the time of the Great Moravian Empire with the depth of 100 cm as well. The aim of this paper is to compare the chemical and physical properties of the sediments of three pits and to confirm or disprove that the waste pits from different cultural period will vary in chemical properties. Physical analysis was carried out to determine grain-size and color of the intact sample. These chemical analyzes were conducted: analysis of phosphorus (SULLIVAN, K.A. - KEALHOFER, L., 2006; Oonk, S. - Slomp, C.P. - HUISMAN, D.J., 2009), organic carbon and humus (ENTWISTLE, J.A., 2000), loss on ignition (STEIN, K.J., 1984). Dating of soil, in accordance with OCR method (Frink, D.S., 1994), was carried out as well.

Characteristics of Nature

Location belongs to the Thaya-Moravian bioregion. Bioregion is formed by river floodplains belonging to the first zone of altitudinal zonation with a clear relation to the Pannonian province.

Geomorphology is characterized as the floodplain, i.e. loose meanders of rivers embedded in depth of 2-4 m, arms of river in various stages of ground cover, mounds. The typical height of the bioregion is 155-185 cm.

The substrate of the bioregion is mostly sand and gravel sand. The surface is formed by alluvial soil 2-5 m thick.

Soil, present in the area, consists mostly of gleyic fluvisols on non-carbonate sediments. Typical fluvisols dominate in the upper parts. In the floodplain of the Morava River, there is abundance of gleyic phaeozem. In depressed floodplains, there is sometimes trophic peat soil. In oxbows, there are typical gley and gyttja. In the mounds, little arenic cambisol or rankers prevail.

The entire bioregion is located in the warmest region of the Czech Republic - T4. The average annual temperature is 9.5 °C and the average annual rainfall is 585 mm according to weather station Hodonín.

Results and Discussion

The test pit S1 – MAP

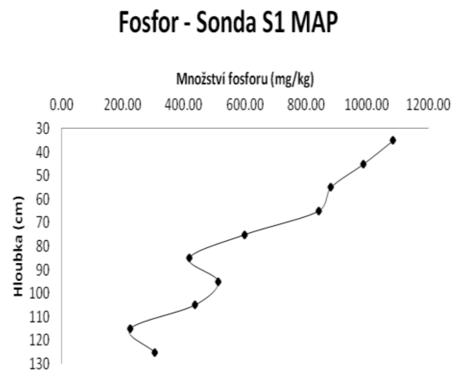

Figure 1. Phosphorus - S1 MAP

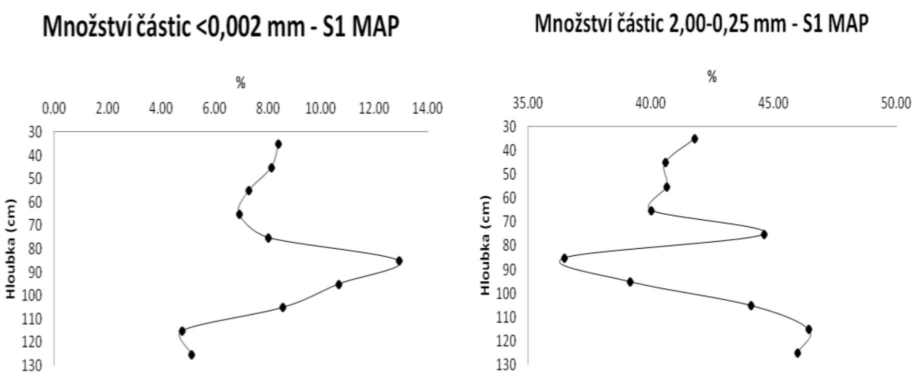

Figure 2: The course of the grain composition – S1 MAP

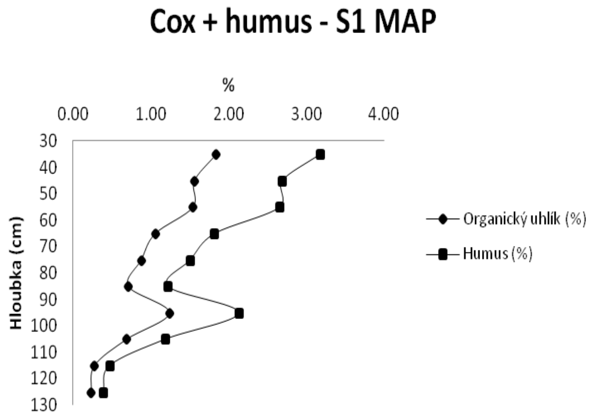

Figure 3: Cox + humus - S1 MAP

S1 MAP is a filling of the waste pit which was built on sandy alluvium of the river Morava. According to the findings, archaeological dating was carried out resulting in ranking the pit in period before the Great Moravian Empire. The actual test pit was 130 cm deep. The first 30 cm were made of rocky walls of the palace. Another 30 to 70 cm consisted of sandy sediments of dark color with homogeneous properties throughout this part. At the depth of 80 cm, there is a sudden change in almost all of the observed characteristics. The grain-size composition is changing resulting in increasing clay content and decreasing the amount of sand. At this depth, there is also an increase in the amount of phosphorus, Cox, humus and total carbon. There is also a large amount of carbon and bones. This is probably the beginning of the real waste pit which have been covered was by a layer of sand with homogenous properties due to the floods (JOYCE, A.A. - MUELLER, R.G., 1992).

The test pit S2 – MAP

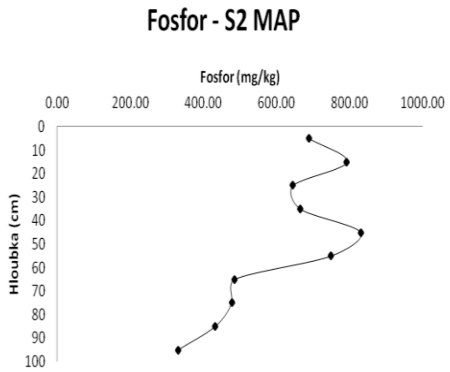

Figure 4: Phosphorus - S2 MAP

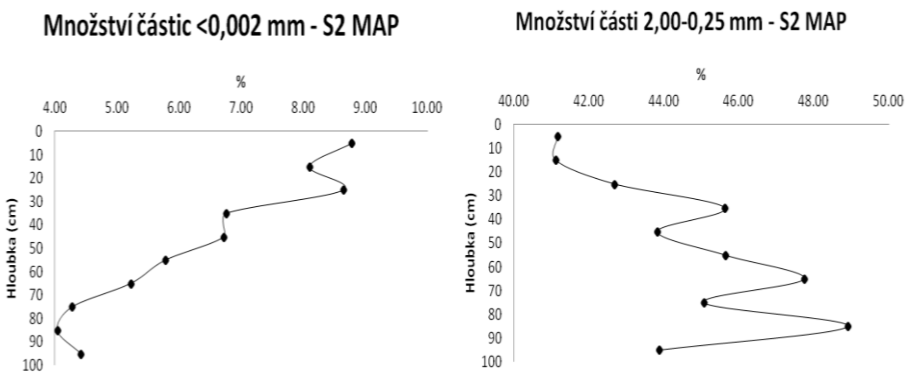

Figure 5: Course of the grain-size composition - S2 MAP

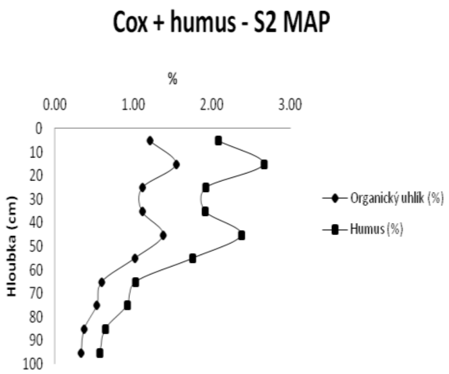

Figure 6: Cox + humus - S2 MAP

The test pit MAP S2 also represents the filling of the waste pit. The total depth of the test pit was 100 cm. The waste pit ranged from about 10 cm to about 60 cm. This waste pit comes from the Great Moravian period. It was surprising to find that the layer forming the filling of the waste pit (10 - 60 cm) shows two distinct peaks of phosphorus content. The same trend is observed also in other monitored characteristics. This may indicate a certain discontinuity in settling this location. Period of intense utilization was substitued by period of less intensive settlement, which was immediately followed by another intensive use of the surrounding areas (KUDRNÁČ, J., 1962). Below the layer of waste pit, from about 60 cm to the bottom of the test pit, there is sandy alluvium. It is interesting that there is an alternation of gain and loss of sand. This phenomenon is probably due to the activities of the Morava River floodplain (FOSS, J.E. - LEWIS, R.J. - Timpson, M.E., 1995). The increase of the sand content indicates that running water was more powerful and floods were of greater intensity.

The test pit S3 – MAP

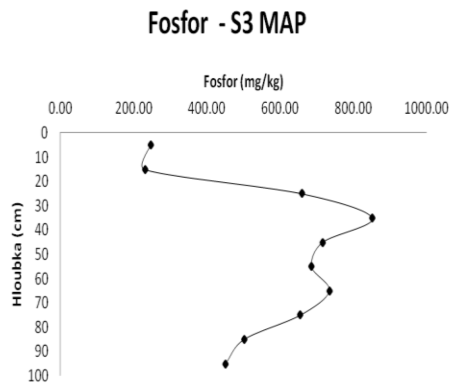

Figure 7: Phosphorus - S3 MAP

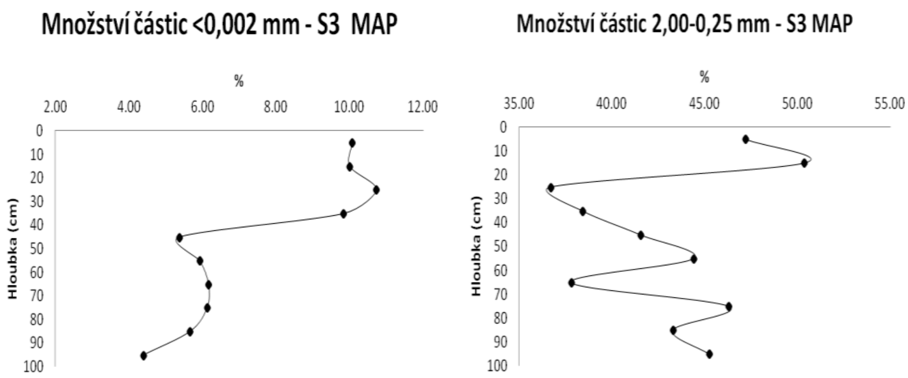

Figure 8: Course of the grain-size composition - S3 MAP

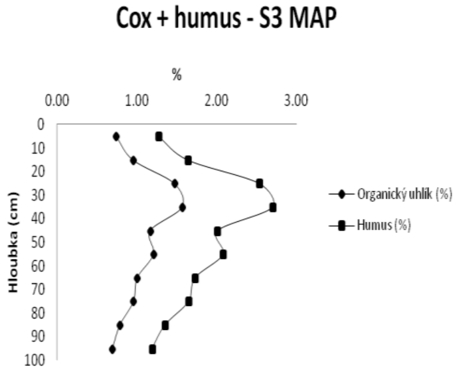

Figure 9: Cox + humus - S3 MAP

The last test pit is a waste pit dated in the Great Moravian period. The total depth of the test pit was 100 cm. Extend of the waste pit was up to the depth of approximately 60 cm. Even in this test pit, surprising fact of two peaks in the course of the development was found out. Very similar results were found at other studied characteristics. This investigation suggests that calm period of sedimentation took place in the floodplain at the time of Great Moravian Empire as well. In particular, characteristics of the grain-size do not show any pronounced anomaly at the depth of 0-10 cm. Different situation is at the depth of 60-100 cm. Again, there is probable discontinuity of the development due to increased activity of the Morava River floodplain (FOSS, J.E. - LEWIS, R.J. - Timpson, M.E., 1995).

Conclusion

Using pedoarcheological methods managed distinguishing the waste pit from the period before the Great Moravian Empire from the waste pits dated in the period of the Great Moravian Empire. The difference was mainly in the grain-size composition, the amount of phosphorus, humus, and especially in the quality of humus. Phosphorus analysis has indicated that it is possible to use phosphorus to distinguish two stages in one location. The results have great potential for further work. They will be used for the preparation of the project devoted to distinction of waste pits from different cultural epochs.

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References

Arrhenius, O. (1931), Die Bodenanalyse im Dienst der Archäologie. Zeitschrift fűr Pflanzenernährung, Dűngung, and Bodenkunde Tiel B 10

Conry, M. J., 1972: Pedological Evidence of Man´s Role in Soil Profile Modification in Ireland. *Geoderma* 8, 139-146

Entwistle, J. A., 2000: The geoarchaeological signifikance and spatial variability of a range of physical and chemici soil properties from a former habitation site, Isle of Skye. *Journal of Archaeological Science* 27, 287-303

Foss, J. E. – Lewis, R. J. – Timpson, M. E., 1995: Soils in Alluvial Sequences: Some Archaeological Implications. In: COLLINS, M.: E.Pedological Perspectives in Archaeological Research. Proceedings of two symposia sponsored by Division S-5 of the Soil Science Society of America in Cincinnati, OH, 8. Nov. 1993. SSSA Special Publication Number 44. Soil Science Society of America, Inc. Madison, Wisconsin, USA, 170 p.

Frink, D. S., 1994: The Oxidizable Carbon Ratio (OCR): a Proposed Solution to some of the Problems Encountered with Radiocarbon Data. *North American Archaeologist* 15 (1), 17-29

Joyce, A. A. – Mueller, R. G., 1992: The Social Impact of Anthropogenic Landscape Modification in the Río Verde Drainage Basin, Oaxaca, Mexico. Geoarchaeology: An International Journal 7 (6), 503-526,

Kudrnáč, J., 1962: Otázka velikosti zázemí k výživě člověka v době hradištní. *Archeologické rozhledy* 14, 693-697

Nikiforoff, C. C., 1943: Introduction to paleopedology. American Journal of Science 3, 194-201

Oonk, S. – Slomp, C. P. – Huisman, D. J., 2009: Geochemistry as an aid in archaeological prospection and site interpretation: Curren issues and research directions. *Archaeological Prospection* 16, 35-51

Puri, A. N. – Swarnakar, R. D., 1969: Determining Available Phosphoric Acid in Soils. *Geoderma* 2 (2), 85-93

Stein, K. J., 1984: Organic matter and carbonates in archaeological sites. *Journal of Field Archaeology* 11 (2), 239-246, Sullivan, K. A. – Kealhofer, L., 2004: Identifying aktivity areas in archaeological soils from a colonial Virginia house lot using phytolith analysis and soil chemismy. *Journal of Archaeological Science* 31, 1659-1673

Van Moort, J. C. – De Vries, D., 1970: Rapid Carbon Determination by Dry Combustion in Soil Science and Geochemistry. *Geoderma* 4, 109-118

Walkington, H., 2010: Soil Science Applications in Archaeological Contexts: A Review of Key Challenges. *Earth-Science Reviews* 103, 122-134

Watson, J. P., 1969: Some Contributions of Archaeology to Pedology in Central Africa. *Geoderma* 2 (4), 291-296

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Influence of grain size on the chemical composition of soil

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Abstract

In 2012, pedological samples were taken from 5 plots with the incidence of water erosion. At first sight, selected areas were apparently damaged by erosion. On each plot, three soil pits in total were uncovered. The first soil pit was uncovered in the upper side where the least disruption of water erosion was assumed. The second soil pit was uncovered in the central part of the plot where the highest degree of soil damage due to water erosion was assumed. The last soil pit of each plot was uncovered at the bottom of the plot. Accumulation of soil washed down from the higher parts of the land was assumed there. In this manuscript, we bring you a brief overview of the changes of chemical elements content and granularity of the plot. Particles of size less than 0.01 mm were used for the evaluation of grain size. In the Czech Republic, these particles are commonly used for grain size classification. Chemical elements were measured using a handheld XRF analyzer. For this paper, following elements were selected: Si, P, Ca, Mn, Mg, S, Ti, Fe and Hg. This paper deals with the effect of erosion on the changes of the chemical soil composition. The samples of topsoil from the upper part of the land and samples from the lower part of the land were compared. The results show the bottom part of the land contains increased amount of chemical elements often up to 50%. For example, P has increased from 0.0348% to 0.06968%, in the case of Ca from 0.68984% to 0.79112%, Mn from 0.06278% to 0.22236%, Mg from 0.77456 % to 0.80426%, S from 0.0219% to 0.08122%, Ti from 0.26006% to 0.30882%, Fe from 1.87544% to 2.32032% and Hg has increased from 0,00106% to 0.00122%. In the topsoil, the strongest correlation between elements and granularity was observed at the following elements: Mg ($r = 0.92$), S ($r = 0.97$) and Fe ($r = 0.69$). Therefore, it is evident water erosion affects altering the soil chemical composition in the cumulative part of the slope. Heavy metals or rare earth metals were not detected in the case of these five sites of interest. However in other locations, this may be different.

Keywords: chernozem, granularity, soil, gran size

Introduction

Soil erosion is a major worldwide problem. In the Czech Republic, according to the Ministry of Environment, 4 2279 391 hectares of land are affected by erosion. It represents more than 50% of the territory of the Czech Republic. This leads to significant physical, chemical and biological soil degradation. Soil represents an essential part of the biosphere. It enables food production, building our homes and cities; it filters water, store carbon, and represents chronicle of human history. Soil is facing to tremendous anthropogenic pressures not only in the industrial part of the world. However, the most significant causes of land degradation include agriculture and cultivation systems. There are loss of organic matter, biodiversity, loss of nutrients and the subsequent negative impact on cultivated plants. As a result of using the inconvenient machines, soil is compacted and its structure is disrupted. All the above mentioned functions may be significantly damaged or completely destroyed by erosion. Even though the problem of soil erosion is

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receiving increasing attention, all the possible causes or consequences of erosion are not known yet. Soil erosion is a complex process most often caused by wind or by precipitation. The subject of research in relation to soil erosion is represented most frequently by temporal and spatial comparisons of erosion intensity (Zhu, 2011) comparing the state after and before rain while watching the physical principles and processes related to erosion. These data are of course very important and help us to understand the functioning of erosion and to establish reliable methods to prevent erosion events.

However, monitoring the practical effects of erosion is equally important. It includes especially the effects on crop yields, damage caused by disrupting of roads and buildings, and sedimentation and pollution of watercourses and lakes. Little attention is devoted to physical and chemical changes in the soil caused by soil erosion. It is not only a reduction in the amount of nutrients occurring due to erosion of topsoil, but it is also a transport and subsequent accumulation of hazardous elements. In many regions, there is a release of great amount of heavy metals into the environment caused by the influence of anthropogenic activities. The most significant issue is especially mining and processing of ores and heavy industry. These substances are then easily bound to soil particles. However, their concentration in the soil is very low in most cases. In most cases, health limits are exceeded close to the source of pollution (Alloway, 1995). Wind and water erosion represents the serious risks to the environment, to the health of animals and humans (Bačeva et al., 2014). Dust particles of soil drift due to wind erosion. Afterwards, they are inhaled together with heavy metals bound to the particles and cause various health problems (Pakkanen, 2003). Water erosion leads to a transfer of fine soil particles binding the greatest number of elements and other substances (particles of size <0.01 mm) and leads to subsequent accumulation in the bottom sites of the land. Heavy metals or other hazardous substances are gradually accumulated resulting in their concentration reaching critical values (Zhang et al., 1998). The soil is often washed off into watercourses and reservoirs and there is an accumulation of hazardous substances in sediments. These substances then also enter food chains.

A number of papers devoting to the bioavailability of heavy metals in the soil was published such as: Alvarenga et al., 2004, Concas et al., 2004, Lee et al., 2001 and Merrington et Alloway, 1994. All studies agree that the bioavailability of a range of heavy metals is high (naturally, it varies depending on the current pH, humidity and other parameters). Therefore, exceeding concentrations of elements, occurring due to water erosion in bottom positions of the slope, is extremely dangerous.

The aim of this study was to assess the accumulation of some elements in bottom positions on chernozem soils which are located on the slopes threatened by water erosion. Five slopes in South Moravia were selected. This is the hottest area in the Czech Republic (average annual temperature of this region is 9.5 °C, average annual rainfall is 519 mm). It is a region which is characteristic by a considerable area of the individual fields. As a result of consolidation, which took place in the 50’s – 80’s of the 20th century in the Czechoslovakia, area of individual fields has reached up to 5000 ha. Thus, water and wind erosion is very intense there. The focus was paid to the following elements: Si, P, Ca, Mn, Mg, S, Ti, Fe and Hg. These elements correlated with the content of particles of size <0.01 mm.

Material and Methods

The samples were collected during the autumn 2012, air dried and then sieved through a sieve with a grid size of 2 mm. Grain composition was investigated using the pipette method. Particles of size <0.01 mm were selected for statistical analysis. In the Czech soil science, particles smaller than 0,01 mm are used to classify class of grain size in soil. The chemical composition of the soil was investigated using XRF analyzer.

Results and Discussion

Table 1: Overview of plots and soil classification

Locality	Soil classification
Hustopeče	Chernozem
Horní Bojanovice	Chernozem
Němčičky	Chernozem
Krumvíř I	Chernozem
Krumvíř II	Chernozem

Table 2: Content of chemical elements and particles of size <0,01 mm

Topsoil – top of the slope	Si (%)	P (%)	Ca (%)	Mn (%)	Mg (%)	S (%)	Ti (%)	Fe (%)	Hg (%)	0.01 (%)
Hustopeče	27.3500	0.0486	0.8947	0.0304	0.7356	0.0430	0.2444	2.1050	0.0017	39.92
Horní Bojanovice	25.9000	0.0423	0.8105	0.0971	0.7443	0.0233	0.2433	2.0679	0.0010	54.14
Němčičky	29.2500	0.0352	0.4960	0.0618	0.8230	0.0241	0.2426	1.9874	0.0010	36.06
Krumvíř I	27.5600	0.0271	0.5073	0.0517	0.7963	0.0118	0.3030	1.5569	0.0009	43.98
Krumvíř II	27.6000	0.0208	0.7407	0.0729	0.7736	0.0073	0.2670	1.6600	0.0007	39.82
Mean values	27.5320	0.0348	0.6898	0.0628	0.7746	0.0219	0.2601	1.8754	0.0011	42.784
Topsoil – bottom of the slope	Si (%)	P (%)	Ca (%)	Mn (%)	Mg (%)	S (%)	Ti (%)	Fe (%)	Hg (%)	0.01 (%)
Hustopeče	25.3600	0.0488	0.8516	0.0676	0.8123	0.0354	0.2940	1.6946	0.0009	16.50
Horní Bojanovice	25.4600	0.0645	0.6365	0.0515	0.8923	0.3150	0.2781	2.8642	0.0011	32.06
Němčičky	22.9600	0.0688	0.9536	0.0710	0.7782	0.0209	0.3242	2.1655	0.0012	18.30
Krumvíř I	25.4500	0.1000	0.7675	0.0797	0.7653	0.0119	0.3273	2.2028	0.0017	14.34
Krumvíř II	23.1600	0.0663	0.7464	0.8420	0.7732	0.0229	0.3205	2.6745	0.0012	17.94
Mean values	24.4780	0.0697	0.7911	0.2224	0.8043	0.0812	0.3088	2.3203	0.0012	19.828

Table No. 2 shows the concentration of elements in the top and bottom of the slope. As evident from Table No. 2, elements P, Ca, Mg, S, Fe and Hg have increased their concentration in bottom of the slope. Therefore, water erosion significantly affects the chemical properties of the soil causing uneven distribution of chemical elements on the plot. This finding is corresponding to the conclusions of Fullen (1995). He found that due to water erosion, the concentration of chemical elements will increase in the areas with the washed soil sediment. It is also clear the grain size of the fine soil fraction (particles of size <0.01 mm) has reduced at the bottom of the slope, consider the table No. 2. This fact is confirmed in the conclusions of Fullen (1995). The effect of water erosion on the concentration of chemical elements in the locations of sedimented washed soil was confirmed in other papers such as Santis et al. (2010). Table No. 3 shows correlation between individual elements and content of soil particles of size < 0,01 mm.

Table 3: The correlation coefficient

Top of the Slope		Zone of Accumulation	
Element	correlation coefficient	Element	correlation coefficient
Si	0.901	Si	0.235
P	0.241	P	-0.291
Ca	0.648	Ca	-0.637
Mn	-0.525	Mn	-0.178
Mg	-0.524	Mg	0.927
S	-0.731	S	0.978
Ti	0.003	Ti	-0.779
Fe	0.14	Fe	0.691
Hg	-0.117	Hg	-0.358

At the bottom position of the slope, where washed soil is accumulated, high correlation between the content of particles of size <0.01 mm and these elements (Ca, Mg, S, Ti, Fe) has been found, consider the table No. 3. It is interesting that the correlation between the content of elements and content of particles of size <0.01 mm was not detected at the top part of the slope. Therefore, it can be assumed particles binding chemical elements are relocated as the result of erosion. Similar conclusions were reached by Zhou et al. (2010).

Conclusion

The plots were monitored for the accumulation of certain chemical elements due to water erosion. These elements may have been bound to the particles of size < 0.01 mm. Strong correlations were found between the content of soil particles and these chemical elements: Ca, Mg, S, Ti and Fe.

The effect of water erosion leads to the accumulation of harmful elements in areas of accumulated washed soil. This represents a significant environmental risk. Concentration of chemical elements is being multiplied and these elements can subsequently enter the food chain with a greater extent.

This issue is very complex and there is a need to carry out further detailed research. Attention shall be paid not only to heavy elements but also to other hazardous substances and to their fate not only in the soil located on the slope but also their behavior in the wider area, and to the possibility of their entry into the food chain.

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References

Alloway, B. J., 1995: Heavy metals in soil. Blackie Academic, London

Alvarenga, P. M., Araújo, M. F., Silva, J. A. L., 2004: Elemental uptake and root-leaves transfer in Cistus ladanifer L. growing in a contaminated pyrite mining area (Aljustrel–Portugal). Water, Air and soil pollution 152, 81-96

Bačeva, K., Stafilov, T., Šajn, R., Makreski, P., 2014: Distribution of chemici elements in soils and stream sediments in the area of abandones Sb-As-Ti Allchar mine, Republic of Macedonia. Environmental Research 133, 77-89

Concas, A., Patteri, C., Cincotti, A., Cao, G., 2004: Metal contamination from abandoned mining sites: experimental investigation on possible remediation techniques. Land Contamination and Reclamation 12, 9-20

De Santis, F., Giannossi, M. L., Medici, L., Summa, F., Tateo, F., 2010: Impact of physico-chemical soil properties on erosion features in the Aliano area (Southern Italy). Catena 81 (2), 172-181

Fullen, M. A., Brandsma, R. T., 1995: property chnges by erosion of loamy sand soils in east Shropshire, UK. Soil Technology 8 (1), 1-15

Lee, C. G., Chon , H. T., Jung, M. C., 2001: Heavy metal contamination in the vicinity of the Daduk Au–Ag–Pb–Zn mine in Korea. Applied Geochemistry 16, 1377-1386

Merrington, G., Alloway, B. J., 1994: The transfer and fate of Cd, Cu, Pb and Zn from two historic metalliferous mine sites in the UK. Applied Geochemistry 9, 67-77

Pakkanen, T. A., 2003: Size distributions of mass and chemici componets in street-leve. And roztop PM1 particles in Helsinky. Atmospheric Environment 37 (12), 1673-1690

Zhang, C., Selinus, O., Schedin, J., 1998: Statistical analyses for heavy metal contents in till and root samples in an area of southern Sweden. Science of the Total Environment 212, 217-232

Zhou, Z. C., gan, Z. T., Shangguan, Z. P., Dong, Z. B., 2010: Effects of grazing on soil physical properties and soil erodibility in semiarid grassland of the Northern Loess Plateau (China). Catena 82 (2), 87-91

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Alterations of fungal metabolism under decreasing oxygen level

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Abstract

In specific environments such as cattle overwintering areas, both dung and urine excretions onto soil surface often results in microaerobic or even anaerobic conditions in the underlying soil. Soil fungi have to cope with that by changing their metabolism. Therefore, the aim of the work was to study changes in growth, functionality as well as in membrane composition of soil fungi under decreased oxygen level. Soil samples were collected at the Borová farm (South Bohemia, Czech Republic) from six different sections with various intensity of cattle impact. Soil fungi were isolated by serial dilution and plating on Sabouraud dextrose-, Potato dextrose-, and Chloramphenicol glucose agar. The effect of decreasing oxygen level in fungal isolates was assessed in flasks with three treatments for each isolate: Aerobic – cellulosic stopper; Microaerobic – butyl rubber stopper, screw cap, headspace atmosphere unchanged; Anaerobic – butyl rubber stopper, screw cap, headspace atmosphere replaced by argon. After 7 days in a horizontal shaker at 28 °C, fatty acids composition as well as N_2O production capability was examined on GC-FID and GC-ECD, respectively. In total, 164 fungal isolates were analysed. Results confirmed the dependence of fungal metabolism on the environmental conditions. Decreased oxygen level caused significant increase in saturated (14:0, 18:0, 20:0) as well as some monounsaturated fatty acids (18:1ω9, 20:1ω9), but decrease in polyunsaturated and hydroxy (18:2ω6,9, 18:1 2OH) fatty acids. Decreasing oxygen level also altered the capability of fungi to produce nitrous oxide. On average, a half of isolates (50.6 and 49.7 %) of fungi were producing > 0.2 µg N_2O-N per day under microaerobic and anaerobic conditions, respectively. Considering different parameter (proportion of initial nitrite concentration in the medium transformed into N_2O-N), more N_2O-producing fungi was observed under microaerobic than anaerobic conditions (36.0 and 32.5%, respectively). Additional result showed an inability of colorant-producing fungi to complete the metabolic pathway in colorant synthesis under oxygen depletion.

Keywords: Soil fungi; Nitrous oxide; Fatty acids; Colorants; Cattle overwintering; Oxygen depletion

Introduction

Fungi were for a long time thought to play only a minor role in the ecosystem processes of anoxic environments [1]. However, many fungal taxa were shown to possess metabolic adaptations for anaerobic environments such as ability to utilize nitrate and/or nitrite as an alternative for oxygen [2] or response to environmental disturbances by changes in membrane constitution [3]. That allows them to respond to changes in environment conditions [4]. Moreover, it is known that both yeasts and microscopic fungi have the capacity for fermentation. They can therefore remain active under conditions of limited oxygen supply [5-8]. Molecular ecological studies of anoxic environments have also shown a vast diversity of microeukaryotes having unique physiological adaptations to survive in the adverse conditions [9].

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The aim of this work was to describe changes in two branches of metabolism of soil fungi: i) nitrous oxide productivity; and ii) fungal cell membrane composition under conditions of oxygen depletion. Soil is a habitat where reductive conditions are often present and may predominate for a long period of time [8]. Such conditions can become predominant in natural terrestrial environments where surface flooding appears [10]. Moreover, anthropogenic ecosystems were influenced in past decades with the consequence of substantially affected nutrient cycling and increasing N2O emissions [11]. Particularly, cattle overwintering areas are suggested significant sources of N2O [12]. Three main factors have been identified in those areas: (i) inputs of dung and urine released into soil, leading to extraordinary amounts of organic carbon and nitrogen; (ii) compaction of soil by animal trampling and other changes reducing soil aeration; and (iii) grazing and defoliation resulting in reduced plant N uptake [13].

Material and Methods

Soil Sampling

Soil fungi were isolated from soils of upland pasture used for overwintering cattle, located on the Borová farm in South Bohemia, Czech Republic (latitude 48°52’41” N, longitude 14°13’14” E), described in previous studies [12-15]. Six sites, differing in the management history and intensity of animal impact, were selected. Each sampling site was represented by three composite samples, each consisting of three random single samples of thoroughly homogenised soil from the top 15 cm soil layer. Soil samples were collected in May 2013, several days after cattle left the winter pasture.

Isolation and Identification of Soil Micromycetes

Soil micromycetes were isolated as previously described [15] using the plate dilution method from 2 g of fresh soil. Sabouraud dextrose-, Potato dextrose-, and Chloramphenicol glucose agar were used. To record as many as possible of different fungal species, morphologically different colonies from each soil were chosen. One isolate from each morphologically distinct colony was transferred onto fresh agar plate to obtain pure fungal isolates.

The identification of isolates was provided by sequencing of the ITS rDNA. DNA from fungal mycelium was extracted using NucleoSpin® Soil kit (Macherey-Nagel, Germany). PCR was performed with primers ITS1F-ITS4 [16, 17]. After purification, PCR products were commercially sequenced with ITS1F as sequencing primer. Sequence similarity search was performed using nucleotide BLAST algorithm [18]. For a purpose of this study, only genera of fungi were assigned based on the maximum query coverage and identities of nucleotides.

Incubation Experiment

Fungal cultures were directly inoculated into 100 mL flasks with either cellulosic or butyl rubber stopper and screw cap. Flasks were filled with 20 mL of sterile modified Czapek broth at pH 6.7. Sodium nitrite (10 mM) was selected as the nitrogen source, according to previous experiments [19]. The effect of decreasing oxygen level on fungal isolates was assessed in three treatments: *Aerobic* – cellulosic stopper; *Microaerobic* – butyl rubber stopper, screw cap, headspace air unchanged; *Anaerobic* – butyl rubber stopper, screw cap, headspace air replaced by argon. After 7 days in a horizontal shaker at 28°C, fatty acids were extracted using Instant FAME protocol (MIDI Inc., USA).

N_2O Measurement

N_2O production was measured after 7 days using a gas chromatograph equipped with a 3 m, 0.318 cm i.d. stainless steel Porapak Q column and electron capture detector (GC-ECD, Agilent HP 5890, Agilent Corp., USA). The temperature of the column and detector were 80°C and 300°C, respectively. Peak areas were estimated using an HP integrator and results were computed from detector responses to N_2O standards [12]. Control flasks (blanks) were filled only with a sterile medium. The rate of N_2O production was expressed as a proportion of NO_2^-–N transformed from initial amount in the medium into N_2O–N during incubation period as well as nmol N_2O–N d^{-1} $flask^{-1}$ regardless the biomass.

FAME Profiles

The whole cell FAME profiles were identified by gas chromatography (Agilent 7980A, Agilent Technologies, USA) with a flame ionization detector on a capillary column (Ultra 2, 25 m x 0.20 mm x 0.33 um, Agilent Technologies, USA). The samples (2 µl) were injected in split mode (1:30) at an injection temperature of 250°C using hydrogen as carrier gas. The GC-temperature regime was 170°C – 5°C min^{-1} – 260°C – 40°C min^{-1} – 310°C –

1.5 min. Individual peaks were identified using an automatic identification system (MIDI Inc., USA). The RTSBA6 library (MIS Sherlock System, ver. 6.2) was used for identification of the FAME.

Statistical Analyses

Differences in fatty acids composition in three levels of oxygen were analyzed using multivariate ordination analyses (software CANOCO for Windows, ver. 4.5).

Results and Discussion

Fungal Cultivable Community

In total, 164 strains of soil microscopic fungi were isolated from the soils of overwintering pasture. Community of cultivable soil fungi comprised of Basidiomycetes (2 isolates), Zygomycetes (32 isolates) and Ascomycetes (130 isolates). Isolated fungi were assigned to 32 genera, of which *Aspergillus*, *Clonostachys*, *Fusarium*, *Gibberella, Mortierella*, *Mucor*, *Metarhizium Paraphaeosphaeria*, *Penicillium* and *Trichoderma* were predominant (each genera represents between 3 and 10 % of the fungal community). These fungi represents relatively typical species composition of soils in temperate region consisting of several species of *Aspergillus*, *Mucor* and *Penicillium*, together with *Trichoderma*, C*ladosporium*, *Alternaria*, *Rhizopus*, and *Fusarium* [20].

Table 1. List of N_2O-producing fungal genera isolated at the cattle overwintering pasture, number of productive species and average N_2O-producing capability determined in nitrite-containing liquid medium under microaerobic and anaerobic conditions; dash symbol (–) indicates N_2O production below positive acceptance level.

	Taxonomic assignment to the genus level	No. of N_2O productive species	Microaerobic nmol N_2O d^{-1} $flask^{-1}$	Anaerobic nmol N_2O d^{-1} $flask^{-1}$
Zygomycetes	*Absidia*	1	15.54	–
	Lichtheimia	1	17.55	–
	Mortierella	1	10.00	–
	Mucor	2	15.02	10.78
Ascomycetes	*Arthopyreniaceae*	1	154.01	–
	Arthrinium	2	88.48	31.85
	Aspergillus	4	188.51	142.78
	Chaetomium	1	35.27	–
	Cladosporium	1	–	8.43
	Clonostachys	1	98.39	96.96
	Fusarium	4	317.23	713.44
	Gibberella	2	499.33	1723.62
	Gibellulopsis	1	–	42.26
	Haematonectria	1	208.08	2411.09
	Ilyonectria	1	–	19.61
	Metarhizium	2	268.70	88.64
	Paraphaeosphaeria	1	494.83	264.57
	Penicillium	3	25.34	–
	Purpureocillium	1	191.54	61.06
	Tolypocladium	1	7.28	9.64
	Trichoderma	3	61.98	63.76
	Westerdykella	1	106.90	84.22

N_2O Measurement

The overall ratio of N_2O-producing fungi, regardless the level of oxygen depletion reached 49%. That number is in good accordance with numbers reported in other recent studies, i.e. from 34% [21] or 45% [22] to 62% [23]. The spectrum of N_2O-producing fungal genera (Table 1) is, moreover, very similar to that reported in recent studies, which described this ability in fungi belonging to the genera *Fusarium*, *Paecilomyces*, *Penicillium*, *Talaromyces*, *Gliocladium*, *Chaetomium*, *Aspergillus*, *Rhizomucor*, etc. [21-23].

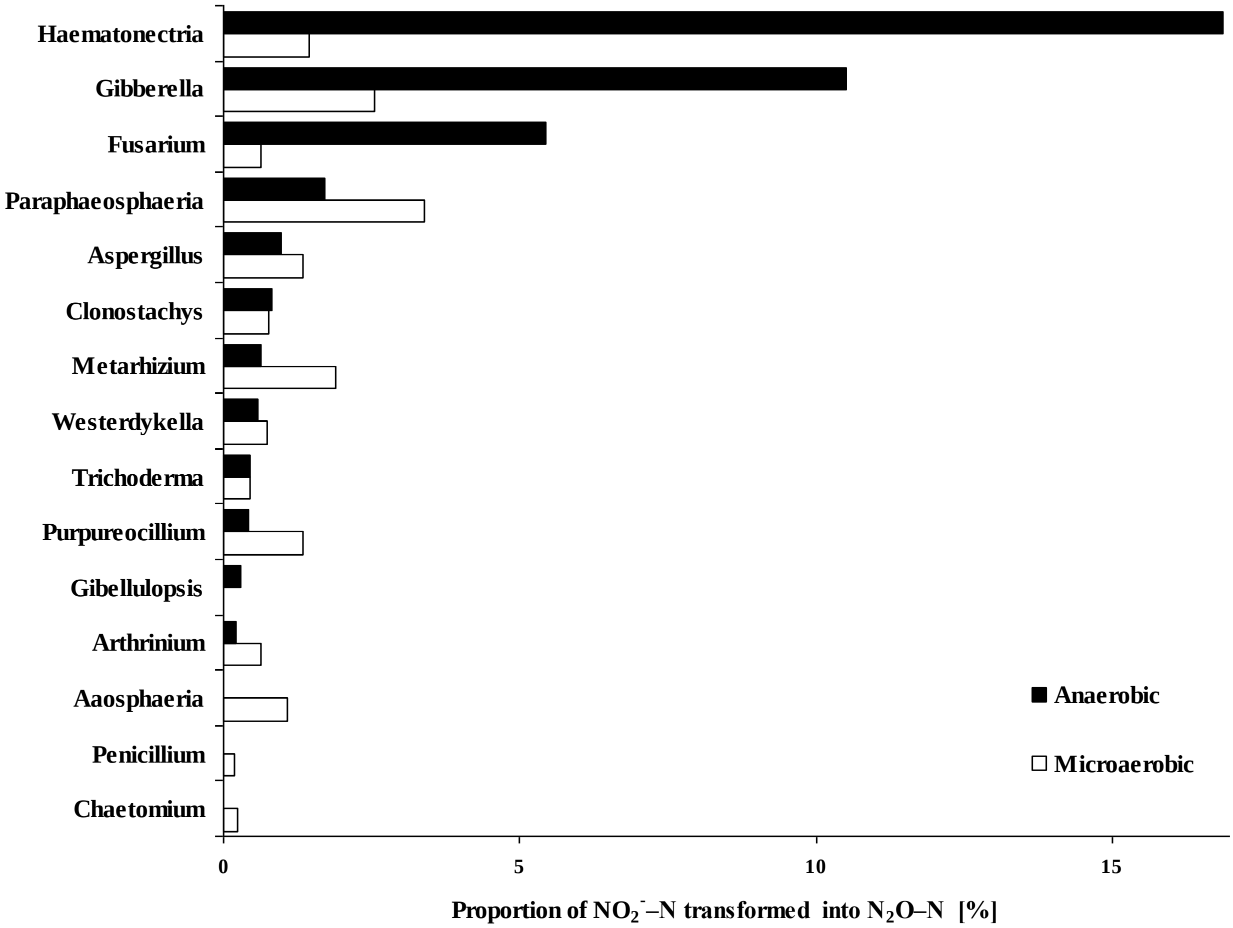

Fig. 1. The relative proportion of NO_2^-–N transformed from an initial concentration in cultivation medium into N_2O–N during seven days of incubation under microaerobic (empty) and anaerobic conditions (black).

Fungi formerly included in *Fusarium* genus (*Gibberella*, *Haematonectria*) as well as *Fusarium* itself were considered as the main producers of N_2O in soils of overwintering pasture. These fungi were able to transform up to 17.0 % of initial concentration of nitrite–N into N_2O–N under anaerobic conditions (Fig. 1); under microaerobic conditions, the ratio was substantially lower (up to 2.9 %). Other fungi showed N_2O-producing levels to be higher under microaerobic than anaerobic conditions (Fig. 1). These findings partly correspond to the recent findings which reported that the N2O production is enhanced, when the conditions are aerobic at the beginning of the experiment, contrary to the continuously anaerobic ones [23].

FAME Profiles Analyses

The principal component analysis (PCA) of the fatty acids in whole-cell FA profiles (Fig. 2) revealed shift in FA composition as a result of decreasing oxygen level. The anaerobic treatment was separated from aerobic along first canonical axis, as well as from microaerobic treatment separated along second canonical axis. In detail, decreased oxygen level caused significant increase in saturated (12:0, 14:0, 18:0, 20:0) as well as some monounsaturated fatty acids (16:1ω7; 18:1ω9; 20:1ω9), but decrease in polyunsaturated and hydroxy-fatty acids (18:2ω6,9; 20:2ω6,9; 10:0 3OH; 18:1 2OH) (Fig. 2).

The decrease in main fungal biomarker FA 18:2ω6,9 [24] is in accordance with other study dealing with the effect of low oxygen levels on FA profiles in flooded soils [25]. However, that study reported the decrease in the amount of FA 18:1ω9 [25], which is also used as fungal biomarker [24]. Using pure fungal cultures, the data indicated the opposite trend for this FA (Fig. 2). The discrepancy between laboratory and field data can be explained by possible utilization of FA 18:1ω9 as a source by various microorganisms under anaerobic conditions [26]. Surprisingly, the amount of other FA (17:0 cyclo and 16:1ω7) showed completely opposite trends, contrary to previously published data about the effect of oxygen depletion on FA profiles of anaerobically incubated soils or cultures [27, 28].

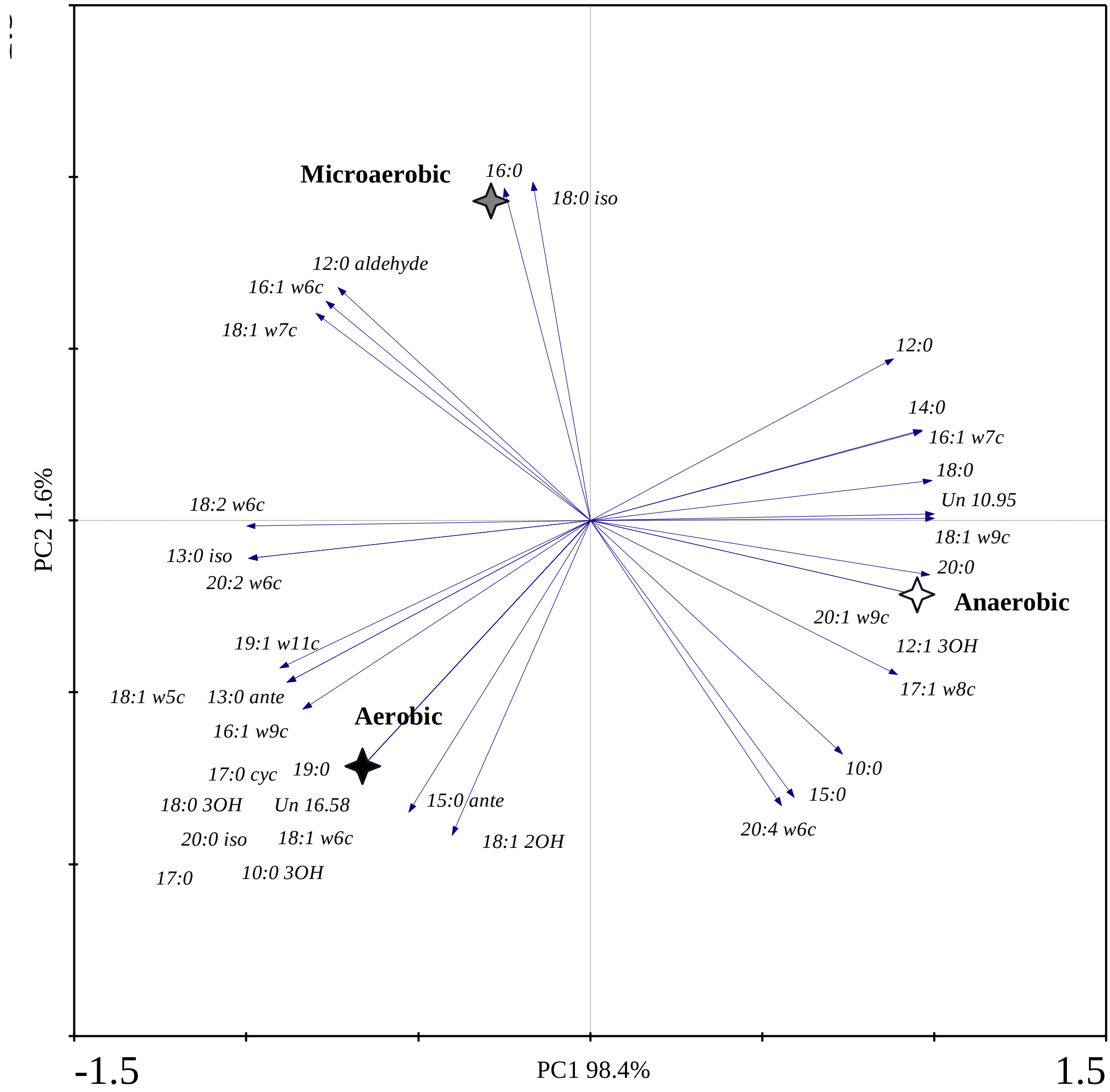

Fig. 2. Principal component analysis (PCA) of the 35 most frequent fatty acids in whole-cell FA profiles of 164 fungal isolates indicated substantial shift in FA composition in the conditions of oxygen depletion. Treatments: Anaerobic – empty; Microaerobic – grey; Aerobic – black.

Colorant Production

An additional result was observed during incubation of fungi under conditions of oxygen depletion. Some fungi, which have been described in the literature as colorants producers (*Aspergillus* sp., *Eurotium* sp., *Fusarium* sp., *Penicillium* sp. and *Talaromyces* sp.) [29-32] were not able to produce colorants under anaerobic conditions; under microaerobic conditions, the production of colorants was visible in lower extent than under aerobic one (Fig. 3). Such lack of final product was observed in case of e.g. *Monascus* sp. This fungus secretes pigments depending on environmental factors and/or nutritional factors [33]. In oxic conditions, orange-colored molecules are oxidized into yellow-colored pigment and after complexation with L-glutamate the red pigments are released [34]. Similar metabolic pathways can not be finished under decreasing oxygen levels.

Fig. 3. The inability of fungi (*Aspergillus nidulans*) to produce colorants under anaerobic conditions (-); under microaerobic conditions (+/-) the production of colorants was visible in lower extent than under aerobic one (+).

Conclusion

Simulated decreased oxygen level substantially affected selected branches of fungal metabolism. Fungi had to change the composition of their cell membrane to cope with anaerobic conditions. Several fungi were observed to produce substantial amount of nitrous oxide under both anaerobic and microaerobic conditions. Colorant-producing fungi were limited by low-oxygen levels and were unable to produce or produced only limited amounts of colorants.

Acknowledgements

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References

Dighton, J., 2003. Fungi in Ecosystem Processes. Marcel Dekker Inc., New York.

Shoun, H., Fushinobu, S., Jiang, L., Kim, S.W., Wakagi, T., 2012. Fungal denitrification and nitric oxide reductase cytochrome P450nor. Phil. Trans. R. Soc. B 367, 1186-1194.

Pupin, A.M., Messias, C.L., Piedrabuena, A.E., Roberts, D.W., 2000. Total lipids and fatty acids of strains of *Metarhizium anisopliae*. Braz. J. Microbiol. 31, 121-128.

Kaur A., Chaudhary, A., Kaur, A., Choudhary, R., Kaushik R., 2005. Phospholipid fatty acid – A bioindicator of environment monitoring and assessment in soil ecosystem. Curr. Sci. 89, 1103-1112.

Gunner, H.B., Alexander, M., 1964. Anaerobic growth of *Fusarium oxysporum*, J. Bacteriol. 87, 1309-1316.

Tabak, H.H., Cooke, W.B., 1968. Growth and metabolism of fungi in an atmosphere of nitrogen. Mycologia 69, 115-140.

Curtis, P.J., 1969. Anaerobic growth of fungi. Trans. Br. Mycol. Soc. 53, 299-302.

Kurakov, A.V., Lavrent'ev, R.B., Nechitailo, T.Yu., Golyshin, P.N., Zvyagintsev, D.G., 2008. Diversity of facultatively anaerobic microscopic mycelial fungi in soils. Microbiology 77, 90-98.

Manohar, C.S., Raghukumar, C. 2009. Anaerobic denitrification in fungi from the coastal marine sediments off Goa, India. Mycol. Res. 113, 100-109.

Inglett, P.W., Reddy, K.R., Corstanje, R., 2005. Anaerobic Soils. In: Hillel, D. (Ed.) Encyclopedia of Soils in the Environment. Academic Press, London, pp. 72-78.

Nevison, C.D., Esser, G., Holland, E.A., 1996. A global model of changing N_2O emissions from natural and perturbed soils. Clim. Change 32, 327-378.

Hynšt, J., Šimek, M., Brůček, P., Petersen, S.O., 2007. High fluxes but different patterns of nitrous oxide and carbon dioxide emissions from soil in a cattle overwintering area. Agric. Ecosyst. Environ. 120, 269-279.

Chroňáková, A., Radl, V., Čuhel, J., Šimek, M., Elhottová, D., Engel, M., Schloter, M., 2009. Overwintering management on upland pasture causes shifts in an abundance of denitrifying microbial communities, their activity and N_2O-reducing ability. Soil Biol. Biochem. 41, 1132-1138.

Šimek, M., Brůček, P., Hynšt, J., Uhlířová, E., Petersen, S.O., 2006. Effect of excretal returns and soil compaction on nitrous oxide emissions from a cattle overwintering area. Agric. Ecosyst. Environ. 112, 186-191.

Jirout, J., Šimek, M., Elhottová, D., 2013. Fungal contribution to nitrous oxide emissions from cattle impacted soils. Chemosphere 90, 565-572.

White, T.J., Bruns, T., Lee, S., Taylor, J.W., 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis, M.A., Gelfand, D.H., Sninsky, J.J., White. T.J. (Eds.) PCR protocols: A guide to methods and applications. Academic Press, New York, pp. 315-322.

Gardes, M., Bruns, T.D., 1993. ITS primers with enhanced specificity for basidiomycetes –application to the identification of mycorrhizae and rusts. Mol. Ecol. 2, 113-118.

Altschul, S.F., Gish, W., Miller, W., Myers, E.W., Lipman, D.J., 1990. Basic local alignment search tool. J. Mol. Biol. 215, 403-410.

Kurakov, A.V., Nosikov, A.N., Skrynnikova, E.V., L'vov, N.P., 2000. Nitrate reductase and nitrous oxide production by *Fusarium oxysporum* 11dn1 under aerobic and anaerobic conditions. Curr. Microbiol. 41, 114-119.

Pugh, G.J.F., 1974. Terrestrial Fungi. In: Dickinson, C.H., Pugh, G.J.F. (Eds.), Biology of Plant Litter Decomposition. Volume 2. Academic Press, London, pp. 303-336.

Kurakov, A.V., Pakhnenko, O.A., Kostina, N.V, Umarov, M.M., 1998. Nitrous oxide production by soil microscopic fungi. In: Proceedings of the 16th World Congress of Soil Science on CD-ROM, Papers List of Symposium 26, 833-t, pp. 1-6.

Mothapo, N.V., Chen, H., Cubeta, M.A., Shi, W., 2013. Nitrous oxide producing activity of diverse fungi from distinct agroecosystems. Soil Biol. Biochem. 66, 94-101.

Wei, W., Isobe, K., Shiratori, Y., Nishizawa, T., Ohte, N., Otsuka, S., Senoo, K., 2014. N_2O emission from cropland field soil through fungal denitrification after surface applications of organic fertiliser. Soil Biol. Biochem. 69, 157-167.

Joergensen, R.G., Wichern, F., 2008. Quantitative assessment of the fungal contribution to microbial tissue in soil. Soil Biol. Biochem. 40, 2977-2991.

Song, Y., Deng, S.P., Acosta-Martínez, V., Katsalirou, E. 2008. Characterization of redox-related soil microbial communities along a river floodplain continuum by fatty acid methyl ester (FAME) and 16S rRNA genes. Appl. Soil Ecol. 40, 499-509.

Hudson, J.A., Cai., Y., Corner, R.J., Morvan, B., Joblin, K.N. 2000. Identification and enumeration of oleic acid and linoleic acid hydrating bacteria in the rumen of sheep and cows. J. Appl. Microbiol. 88, 286-292.

Guckert, J.B., Antworth, C.P., Nichols, P.D., White, D.C., 1985. Phospholipid ester-linked fatty acid profiles as reproducible assays for changes in prokaryotic community structure of estuarine sediments. FEMS Microbiol. Ecol. 31, 147-158.

Petersen, S.O., Klug, M.J., 1994. Profile of a soil microbial community temperature on the phospholipid fatty acid effects of sieving, storage, and incubation, Appl. Environ. Microbiol 60, 2421-2430.

Duran, N., Tixeira, M.F.S., de Conti, R., Esposito, E., 2002. Ecological-friendly pigments from fungi. Crit. Rev. Food Sci. Nutr. 42, 53-66.

Mapari, S.A.S., Hansen, M.E., Meyer, A.S., Thrane, U. 2008. Computerized screening for novel producers of *Monascus*–like pigments in *Penicillium* species. J. Agric. Food Chem. 56, 9981-9989.

Mapari, S.A.S., Meyer, A.S., Thrane, U., Frisvad, J.C. 2009. Identification of potentially safe promising fungal cell factories for the production of polyketide natural food colorants using chemotaxonomic rationale. Microb. Cell Fact. 8, 24.

Mabrouk, A.M., El-Khrisy, E.A.M., Youssef, Y.A., Asem, M.A. 2011. Production of textile reddish brown dyes by fungi. Malays. J. Microbiol. 7, 33-40.

Hajjaj, H., Blanc, P. J., Groussac, E., Goma, G., Uribelarrea, J. L., Loubiere, P., 2000. Improvement of red pigment/citrinin production ratio as a function of environmental conditions by *Monascus ruber*. Biotechnol. Bioeng. 64, 497-501.

Lin, T.F., Demain, A.L., 1991. Effect of nutrition of *Monascus* sp. on formation of red pigments, Appl. Microbiol. Biotechnol. 36, 70-75.

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The actualities of soils classification improvement in Lithuania

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Abstract

The new tendencies of soil classification have appeared in Lithuanian soil school since 1999. Since then the soils in Lithuania were classify according to the WRB 1998 soil classification diagnostic principles. There was created the new LTDK-99 soil classification. Despite the fact that this classification expanded the limits of Lithuanian soil knowledge, this classification also highlighted some of the relevant soil knowledge and classification problems. The discussions are held not only about the newly created terms but also about the several newly distinguished first-level groups of soil diagnostic characteristics. Mostly the discussions are held about the identification and diagnostics of cambisols, planosols, arenosols, regosols. Also, there is an idea to impose one more group to this classification – stagnosols. The origin of the secondary clay minerals is linked to the glaciogenic territory formation peculiarities. However, there is no proof that the clay minerals in the soils of territory of Lithuania might appear due to brownification. Also, there are no scientific surveys proving that in Lithuania identified cambisols are specific due to brownification formed nontronite. Due to the intensively appearing lesivelation in these soils the discussion is held whether the soils are identified in the right way. Due to the complicated glaciogenesis of Lithuanian soil deposits, appears a problem to identify planasols. In edition WRB 2007 planosols were identified according to the pedogenesis in old, strongly weathered binomial deposits. The examples are usually connected with South America, southern and eastern Africa subtropical zone's old, strongly weathered plateaus. Meanwhile, according to the WRB 2007 classification the planosols that are identified in Lithuania are assigned to stagnosols. It means it is assigned to the soils that are originated due to the territorial soil forming deposits binomial genesis and stagnification. The problem of arenosols and regosols classification appears due to the peculiarities of diagnostics. The diagnostic features are similar in both groups of soils and are connected with the primitive pedogenesis in them. The existing problems of Lithuanian soil diagnostics underline the questions of classification of soils in Lithuania. Apart from that, the question about the soil diagnostics allows to think about the classification evolution tendencies. The report points out the possible ways to solve the discussed problems.

Keywords: soils of Lithuania, actuality of classification, cambisols, planosols, stagnosols, arenosols, regosols.

Introduction

The history of Lithuanian soil sciences has been closely related with the evolution of social economic system of the country. After restoration of Lithuania's independence in 1990, the trends of Lithuanian soil sciences changed. The Russian school of soils classification, which had been dominant until 1996, was supplanted by the western ones. The former genetic classification of soils (TDV-96) (Buivydaitė, et al., 1996, Buivydaitė, 1997) was replaced by LTDK-99 soil classification based on FAO principles and WRB diagnostics. V.V. Buivydaitė, M.

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Vaičys, J. Juodis, A. Motuzas were the main architects of this classification (Buivydaitė, et al., 2001; Lietuvos dirvožemiai, 2001). The authors of the new classification (Buivydaitė, 1997) were fully aware of the awaiting challenges in coining new terms and transforming the hierarchic soil system.

In recent years, soil classification LTDK-99 has been constantly improved. Based on new data, the list of soils has been supplemented with new entries and the internal structure of typological groups has been elaborated (Mažvila, et. al., 2006, Lietuvos dirvožemių našumas, 2011, Volungevičius, et al., 2013), indices of typological units of soils optimised, and diagnostic features specified. Forest scientists (Vaičys et al., 2005) have put efforts to harmonise the LTDK-99 soil classification with the types of forest habitats by working out methodical principles. A system of solutions has been suggested for classification of anthropogenic impacts on soils (Volungevičius et al., 2011).

In spite of all efforts, the improvement of LTDK-99 classification posed a number of serious problems. A representative of the Lithuanian school of soil classification D. Galvydytė (Galvydytė, 1996, 1999, 2001, 2006) was the main critic of the new classification. She constructively pointed out the weaknesses of the new classification and suggested possible solutions. D. Galvydytė maintained that improvement of soil classification should be based on the experience gained by other countries of the world (Galvydytė, 1996) and urged to preserve the genetic principle of the former classification in the new classification of Lithuanian soils (LTDK-99) (Galvydytė, 2001). She was the first to point out the intrinsic systemic and diagnostic problems of the new classification (Galvydytė, 1999).

In the last 15 years, the new classification of Lithuanian soils (LTDK-99) has been intensively applied in research and educational works and in production. This time span in the Lithuanian history of soil sciences, the persistent development of science and the ever improving soil classification (WRB, 2006. 2007) serve as a basis for evaluation of functionality of LTDK-99 soil classification and for generalisation of the main problematic issues and fields to be improved. There are three main problematic fields of the new classification: systemic, terminological and diagnostic. This presentation addresses the third – diagnostic – field because its analysis can partly contribute to improvement of the system itself and solution of terminological issues. Though LTDK-99 classification expanded the limits of knowledge about the soils of Lithuania it also exposed some problems of identification and grouping of soils. Not only have the disputes occurred over new terminology but also over the diagnostic features of the newly distinguished soil groups of the first level. Controversies commonly occur as concerns identification and diagnostic of cambisols, planosols, arenosols and regosols. Also a possibility to introduce a new group of soils – stagnosols – has been considered.

The existing problems of soil diagnostic in Lithuania increase the relevance of soil classification issues and reveal the development trends of classification. The presentation contains suggestion as to the possible solutions of the mentioned issues.

The presentation explicates the ideas about the soil genetics promoted by the Lithuanian school of soil geography. Also an attempt is made to measure the diagnostic features of soils and geographical factors responsible for their formation.

Material and Methods

The presentation encourages a discussion and contains the insights based on the material collected in 15 years by the Lithuanian Soil Science Society during expeditions (Vaisvalavičius, et al., 2013, Motuzas, et al., 2012, 2011) and on the works devoted to development and improvement of soil classification LTDK-99 carried out in the territory of Lithuania (Fig. 1). During the mentioned time span, the Lithuanian Soil Science Society organised and took part in 30 scientific and educational soil expeditions.

The expeditions have been organised in different regions of Lithuania's territory seeking to gain knowledge about the Lithuanian soils in the context of LTDK-99 classification and to argue out their diagnostic features in the context of WRB 2006 diagnostic principles. The itineraries of expeditions were designed to provide material about the all 12 typological groups of Lithuanian soils. The last five years were devoted to the issues of diagnostic and classification of cambisols, planosols and arenosols discussed in the presentation.

Figure 1. Object of investigation – the territory of Lithuania and East Europe

The presented insights are based not only on the expedition material but also on the principal documentation representing the LTDK-99 classification – Classification of Lithuanian Soils (2001) (Buivydaitė et al., 2001), New Lithuanian soil classification (LTDK-99) adapting to forest site types and forest types of classifications (2005)(Vaičys et al., 2005), Macromorphological Diagnostics of Lithuanian Soils (2006) (Mažvila et al., 2006), and Lithuanian Agricultural Productivity (2011) (Mažvila, 2011) – and critical articles by a representative of soil geography D. Galvydytė (Galvydytė, 1996, 1999, 2001, 2006).

Results and Discussion

Problems of Cambisols Diagnostic

The distribution and genesis of clay particles are among the key diagnostic features allowing distinguishing between typological groups of soils. Chemical degradation and leaching of clay particles (Fig. 2) allow diagnostic of Podsols. Leaching of chemically not degraded clay particles to deeper illuvial diagnostic soil horizons is the main morphological diagnostic feature of luvisols. Accumulation of clay particles and specific clay minerals (Lietuvos dirvožemiai, 2001) *in situ* in the middle part of soil profile is a diagnostic feature of cambisols.

The higher amount of clay particles in the middle of soil profile (except lessivage) may be predetermined by the genesis of Lithuanian surface deposits. This is especially obvious in the deposits of ground moraine (Galvydytė, 1993) distinguished for the content of clay particles ranging within 3–10 %. In the loam of terminal moraine this range is considerably wider even reaching 30 %. The wide range is related with the genesis of deposits. Meanwhile, the range of clay particles in the loam of ground moraine may be interpreted in two ways and when their content does not exceed 5 % they may be regarded as a result of pedogenesis, i.e. brownification, produced by weathering of the middle part of the profile.

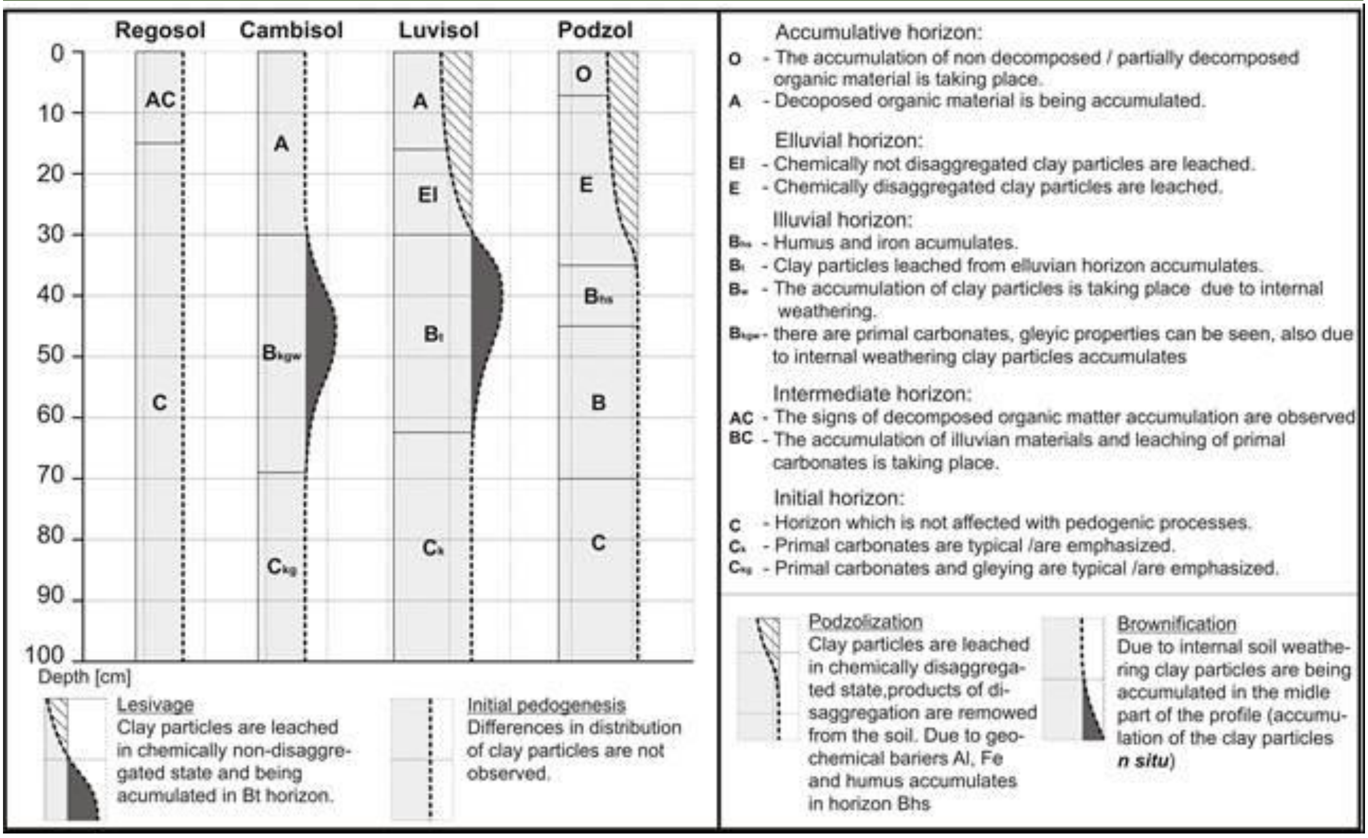

Figure 2. Distribution types of clay particles in the soil profile in the process of pedogenesis.

The deposits composing the surface of the territory of Lithuania are relatively young (their dominant age, except in South Lithuania, is 5 000–20 000 years). They are of glacial genesis. The activity of the Pleistocene glaciers and material composition of exarated pre-Quaternary surface enriched the morainic deposits with secondary clay minerals. This is why the genesis of the secondary clay particles contained in the Lithuanian soils cannot be associated with pedogenesis. Their content and chemical composition has been predetermined by glacigenetic features of formation of the territory. Therefore, even small oscillations of the content of clay particles (not exceeding 5 %) should be interpreted as a consequence of glaciogenesis of the territory. For interpreting the oscillations of the content of soil particles in a different way, i.e. for possibility of relating them with brownification, it is necessary to perform thorough chemical and mineralogical analyses. So far analyses of this kind are lacking in Lithuania therefore the influence of brownification can be neither proved for certain nor disposed of.

Investigations proving that Lithuanian cambisols contain specific iron minerals resulting brownification (beidellite and nontronite) (Fig. 3) also are lacking. As lessivage in these soils is very intensive there are doubts as to the validity of distinguishing soils of this type.

By WRB 2006 (edited in 2007)	By LTDK-99
The soil profile forms at a low or medium atmospheric humidity conditions. This influences the anbscence of concentration of illuvial clay, Al and Fe. Degradation is reflected in changes of color, quantity of clay and carbonates.	The brownification is characterized by chemical weathering of silicates and formation of clay minerals (beidellite and nontronite). I.e.it is formation of cambic horizon in which **in situ** process is taking place.

Figure 3. Specific features of cambisols diagnostic within WRB 2006 and LTDK-99 systems. Cambic B horizon.

Problems Related with Planosols and Stagnosols

The issue of planosols is among the most debatable issues in the Lithuania classification of soils. In the WRB 2007 version (WRB, 2007), planosols encompass soils which formed in old strongly weathered binary deposits whose binary character developed in the long-lasting pedogenetic process (Fig. 4). These soils are not only distinguished for multi-layer granulometric composition of soil profile but also for stagnancy. The soils of this kind commonly are associated with old strongly weathered plateaus of South America and subtropical plateaus of South and East Africa.

	By WRB 2006 (edited in 2007)	By LTDK-99
Planosols	Characteristic features are stagnation of water and sudden geologic or pedogenetic changes in granulometric composition of sediments, these changes can be found in depth to 100 cm. Albic horizon without albeluvic tonguing properties can be found. Forms in periodically or seasonally humid climate, generally in the subtropical and tropical climate zones.(Brazil, Paraguay, Argentina, Africa, Bangladesh, Thailand, Australia).	Characteristic features are binomiallity of sediments, The depth of which can be to 100 cm. The stagnation in this depth can occur. Do not have albic and illuvial humic ferrous horizon. Lithuanian climate: cool climate of middle latitudes.
Stagnosols	Charactersitic features are water stagnation, structural changes and medium sized changes in texture of parent material.These changes can occure till 50 cm of depth. Albic horizon without albeluvic tonguing properties can be found. Prevalent in humid and subhumid climate, in West and Central Europe, North America, Southeast Australia, Argentina. Forms in friable glacial genesis deposits, in alluvial and culluvial deposits , also in weathered silstone. Forms complexes with Luvisols, Cambisols and Umbrisols.	?!

Figure 4. Problems of planosols and stagnosols diagnostic.

Features characteristic of planosols also have been identified in the soils of Lithuania. The occurrence of these soils in Lithuania is associated with the occurrence of multi-layer deposits in the process of formation of the surface cover in the glacial and post glacial periods under the influence of aquaglacial processes. The mentioned specific features of territorial glaciogenesis also are responsible for stagnic features occurring in the granulometric interfaces of soils. Thus, all evidence suggests that soils of this kind can be classified as planosols. Yet in the WRB classification, pedogenesis and the predetermined diagnostic features are emphasised in the genesis of planosols. Meanwhile, the diagnostic features of planosols distinguished in the territory of Lithuania have been predetermined by specific features of territorial glaciogenesis and geomorphology.

Climate is another important factor which predetermined the development of Lithuanian soils and preconditioned formation of soil zones. Climate in Lithuania is mild and humid of mid-latitudinal transitory type. It is favourable for formation of leaching cryogenic soil moisture regime which, in its turn, is responsible for lessivage and podzolization processes dominant in Lithuanian soils and conditioning respective diagnostic features of soils. The planosols in the territory of Lithuania commonly have albic diagnostic horizon. These features strengthen doubts as to the validity of distinguishing planosols in the territory of Lithuania even more.

Planosols distinguished in the territory of Lithuania on the ground of the mentioned features and pedogenesis factors in the WRB 2007 classification (WRB 2007) should be classified as stagnosols because they agree with the glacigenic origin of the territory, climate and other factors and diagnostic features of stagnosols.

Diagnostic of Arenosols and Regosols

Distinguishing of arenosols and regosols also is debatable (Fig. 5). There are no questions as to the validity of diagnostic of these soils yet it is uncertain when the soils formed in the sandy environment should be classified as arenosols or regosols the more especially that in some cases attribution of soil to regosols is based on its granulometric composition and in other cases it is based on the degree of its development. Diagnostic features of both groups of soils are comparable and related with the initial soil formation. Solution of this issue requires a thorough analysis of specific features of formation of arenosols and regosols individually.

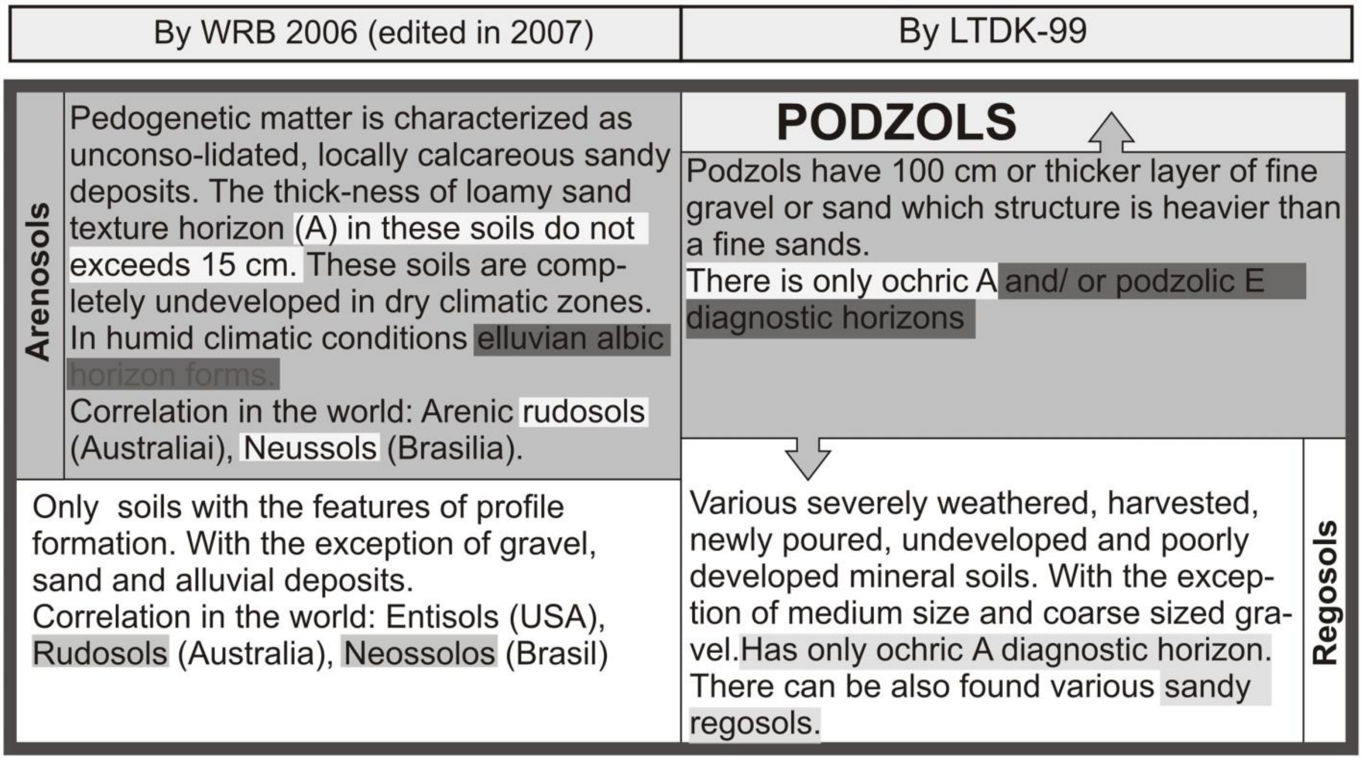

Figure 5. Diagnostic of arenosols.

In the WRB 2006 (WRB, 2007) classifier it is pointed out that arenosols may develop under the conditions of arid and humid climate. Under the conditions of arid climate, arenosols form due to slow pedogenesis whereas under the conditions of humid climate the permanently renewing surface is the key factor of arenosols formation, for example in continental and coastal blown sand dunes.

In the first case, diagnostic of arenosols is valid and undeniable because in the arid and sub-arid regions slow pedogenesis and climate factors are unfavourable for formation of other types of soil zones. Meanwhile, distinguishing arenosols in humid climate zones strikes as debatable due to the presence of albic horizon and regic properties of permanently renewing surface developed under the impact of aeolian processes.

Thus under the climate conditions of Lithuania, arenosols are distinguished in the continental and coastal sand dune areas where they are formed by aeolian (geomorphological) processes and podzolization (pedogenic) processes occurring due to surplus precipitation (in some regions 550–850 mm on the average). Podzolization processes in these regions are strengthened even more by coniferous forests.

Due to microclimatic features of dunes their southern slopes are exposed to solar radiation and receive greater amounts of heat whereas the northern slopes receive greater amounts of precipitation. These microclimatic features predetermine that soil formation in the southern slopes markedly slows down due to the lack of moisture whereas in the northern slopes this process intensifies. Nevertheless podzolization features, i.e. formation of albic horizon, can be observed in the ochric A horizon of arenosols in the southern slopes of dunes. This allows presuming that in the long term the arenosols of the southern slopes will evolve into Podzol characteristic of the northern slopes.

Typological units of poorly developed soils	Short description	New possible terms
Regosols	Severely weathered , harvested, newly poured, undeveloped and poorly developed mineral soils, AC-C profiles are found. These soils (except........) forms in friable sediment matter and have only ohric A horizon.	
Arenosols	Soils with AC-C profiles (thickness of AC horizon is up to 10 cm), poorly developed and hardly weathered. Regosols formed in various genesis friable sandy and/ or sceletic sediments.	*Arenic Regosols*
Pelosols	Poorly developed, hardly weathered or deluvial soils that have AC-C profiles. Regosols formed in silty, clayey or loamy deposits.	*Pelic Regosols*
Lithosols	Poorly developed, hardly weathered soils with AC-R profiles (thickness of AC is up to 10 cm) . Regosols formed in rocky parent matter.	*Lithic Regosols*

Figure 6. Suggestion for reclassification of of regosols and integration of arenosols
(by Soils of Poland/Systematics of Polish Soils/ https://sites.google.com/site/galeriagleb).

Yet until then these soils will preserve the dominant diagnostic features of regosols – ochric A horizon – whose thickness does not exceed 10 cm. They represent the initial stage of podzols formation.

As a matter of fact, in the WRB (WRB 2007) and LTDK-99 classifications (Lietuvos dirvožemiai, 2001) the soils formed in the loamy and clayey deposits with the initial soil profile formation properties are included in the group of regosols. Under the Lithuanian conditions they are associated with the surfaces renewed by natural or anthropogenic erosion. Nevertheless, the scientific community agrees that in the long term these soils will develop into zonal soils characteristic of the territory of Lithuania (cambisols aor luvisols).

Bearing in mind that the sand soils of Lithuania form as a result of erosion processes (aeolian, anthropogenic transformations of the surface, etc.) and slow soil formation is unable to conceal the podzolization properties perhaps it would be more logical to classify them as regosols rather than arenoslos as is the case at present?!

Perhaps it is expedient to revise and distinguish a typological group of regosols (Fig. 6) with sub-groups of arenic regosols, lithic regosols, loamic regosols and pelic regosols ?! Only sand soils forming under arid climate in sandy deposits could be classified as arenosols.

Conclusions

Soil classifications are dynamic systems and their changes are closely related with the latitude of thought of soil researchers and the level of knowledge about soils. Yet soil classification principles should remain consistent with the geographical features of territory evolution.

1. Improvement of the Lithuanian LTDK-99 soil classification and solutions of related problems require new thorough investigations of soil evolution. Especially relevant are investigations of the chemical

composition and genesis of secondary clay minerals in the Lithuanian soils and their distribution in the soil profile.
2. Amendment of LTDK-99 soil classification not only should be based on diagnostic features consentaneous with WRB 2006 (2007 version) but also should take into consideration the specific genesis and epigenesis of the surface of Lithuania's territory. This is especially relevant for solution of diagnostic problem of planosols and stagnosols.
3. Diagnostic problems related with arenosols should be solved taking into consideration their development level and dominant zonal soil formation processes in a territory.

References

Buivydaitė V., Vaičys M., 1996. Lietuvos dirvožemių klasifikacijos derinimas su Pasaulio dirvožemių žemėlapių legenda. Geografija, T 32, 43-57.

Buivydaitė V., 1997. Peržiūrėta ir papildyta Lietuvos dirvožemių klasifikacija (naudota iki 1996m.). Kaunas.

Buivydaitė V., 1997. Problems of Soil Classification in Lithuania. The Role of Education and Research for Economic and Sustainable Agriculture and Forestry: Proceedings III International Conference of Agricultural Scientists from the Nordic and Baltic Countries, Jelgala, October 11-12, 1996., Tartu, 127-129.

Buivydaitė V.V., Vaičys M., Juodis J., Motuzas A., 2001. Lietuvos dirvožemių klasifikacija, Vilnius, pp. 137.

Galvydytė D., 1993. Moreninio priemolio struktūros atspindys dirvožemyje. Geografija T 29, 27-34.

Galvydytė D., 1996. Kitų šalių, tarptautinė ir Lietuvos dirvožemių klasifikacijos. Geografija 32, 58–65.

Galvydytė D., 1999. Naujoji dirvožemių klasifikacija ir su ja susijusios problemos. Geografija Nr. 35, 5–9.

Galvydytė D., 2001. Senosios Lietuvos dirvožemių klasifikacijos papildymai ir pataisymai. Geografija, Nr. 37(1), 5–16.

Galvydėtė D., 2006. Nauja Lietuvos dirvožemių klasifikacija: lyginamoji kritinė analizė. Annales Geographicae 39 (1) t, 53-59.

Lietuvos dirvožemiai, 2001. In: Eidukevičienė M., Vasiliauskienė V. (Eds.), Vilnius, pp. 1244.

Lietuvos žemių našumas, 2011. In: J. Mažvila (Eds.), Akademija, pp. 279.

Mažvila J., Vaičys M., Buivydaitė V. V., 2006. Lietuvos dirvožemių makromorfologinė diagnostika. Akademija, pp. 283.

Motuzas A., Vaisvalavičius R., Pranskietienė I., Zakarauskaitė D., Volungevičius J., Marcinkevičius A., Brazienė Z., Petkevičienė B., Lukšienė L., Meškėnaitė G., 2011. Dirvožemio danga Nemuno žemupio Lygumoje. Mokslinės konferencijos ekspedicijos vadovas. Akademija, pp.18.

Motuzas A., Vaisvalavičius R., Eidukevičienė M., Volungevičius J., Lukšienė L., Meškėnaitė G., 2012. Rudžemių ir balkšvažemių diagnozavimo ypatumai. Mokslinės konferencijos ekspedicijos vadovas. Akademija, pp. 18.

Vaičys M., Karazija S., Beniušis R., 2005. Naujosios Lietuvos dirvožemių klasifikacijos (LTDK-99) derinimas su miško augaviečių tipų ir miško tipų klasifikacijomis. Žemės ūkio mokslai. Nr. 2, 56-61.

Vaisvalavičius R., Volungevičius J., Eidukevičienė M., Motuzas A., 2013. Dirvožemio dangos ypatumai Dainavos Lygumoje. Mokslinės konferencijos ekspedicijos vadovas. Akademija, pp. 32.

Volungevičius J., Kavaliauskas P., 2009. Lietuvos pedologinio rajonavimo problema. Žemės ūkio mokslai. T.16. Nr. 1-2, 1-13.

Volungevičius J., Skorupskas R., 2011. Classification of anthropogenic soil transformation. Geologija, Vol. 53. No. 4(76), 165–177.

Volungevičius J., Šimanauskienė Š., Kažys J., Bukantis A., Baškytė R., Baltrūnas V., Česnulevičius A., Kavoliutė F., 2013 In: Eidukevičienė M. (Eds.), Lietuvos gamtinė geografija, Klaipėda, pp. 331.

World reference base for soil resources, 2006, FAO, pp. 145.

World reference base for soil resources, First update 2007, World Soil Resources Reports No. 103. IUSS, ISRIC, FAO, pp. 128.

9th International Soil Science Congress on
"The Soul of Soil and Civilization"
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The effect of *Melia volkensii* Aagroforestry system on soil – water dynamics, maize performance and biomass

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Abstract

Melia volkensii is a deciduous, open crowned tree with a grey, fairly smooth bark; Leaves light, bright green, with (sub) opposite leaflets up, and densely hairy when young. *Melia volkensii* (Gurke) is in the family *meliaceae* and is indigenous to Eastern Africa at altitudes of 350-1700m above sea level, normally found in sandy soils. *Melia volkensii* is a multipurpose tree producing a wide range of useful product. This study was conducted in Gachoka division of Mbeere District, Kenya, some 200 km north of Nairobi, altitude 1155 masl, AEZ LM4, rainfall 600-800 mm, temperature 20-32^{o}C. The objective of the study was to determine the effect of distance and lopping *Melia volkensii* on Soil water balance, performance and biomass yield of maize within an agro forestry land use system in Mbeere district. The experimental treatments were 7 thus: Lopped trees 0.5 m, lopped trees 1.5m, and lopped trees 2.5 m; unlopped trees 0.5m, unlopped trees 1.5 m and unlopped trees 2.5 m; and No trees with 3 distances thus: 0.5, 1.5 and 2.5 meters from the tree. The treatments were in a randomized split-plot design with Lopped and unlopped trees as the main plots and distances as the sub-plots. Results indicated that soils were alkaline with low N, K, C and Na, but high in P; textural class, Sandy clay loam, with low CEC and EC; soil classification, Nitorhodic Ferralsols and Cambisols. Maize height increased in the lopped and unlopped sites, effects of drought affected height growth and height was higher in the lopped sites due to increased light penetration and photosynthetic activity, there was no effect of distance on crop performance in all the sites, Biomass production was highest in the lopped site (second seasons of 2008/2009 and 2009/2010); soil hydraulic conductivity increased with distance (1.5 m and 2.5 m); Soil moisture content was higher in the unlopped site (both periods 2008/2009 and 2009/2010); distance did not affect soil moisture content; Soil bulk density increased with distance in the lopped site and was low in all the sites. In conclusion, nutrient replenishment initiatives like inorganic and organic fertilizer application and lopping are appropriate tree management options within an agro forestry system. Further, distances affects soil water storage and tree-crop interactions; while soil moisture content is enhanced at sites with adequate undergrowth/ tree cover.

Keywords: *Melia volkensii*, Agro forestry, Soil water dynamics, Maize performance and Biomass Production

Introduction

Importance of Melia Volkensii (Gurke)

Botanic Description : Melia volkensii is a deciduous, open crowned tree, bark grey and smooth, Leaves are light, bright green, bipinnate with (sub) opposite leaflets, and are densely hairy when young. Flowers are small, white and fragrant, with male and female flowers on the same tree (andromonoecious). The fruit is drupe-like and oval; colour changing from green to pale grey as the fruit matures. Fruit size is normally 4 cm long with a very thick, bony endocarp.

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Taxonomy, Requirements and Geographic Distribution in Kenya : Melia volkensii (Gurke) is in the family meliaceae and is indigenous to Eastern Africa altitudes of 350-1700m above sea level,normally found in sandy soils, a multipurpose tree producing a range of useful products.

Agroforestry : Agroforestry is a science whereby trees and agricultural / horticultural crops are grown on the same piece of land, designed to provide tree and crop products and also protect, conserve, diversify and sustain vital economic, environmental, human and natural resources. Agroforestry focuses on interactions among components, is biologically productive, profitable, and sustainable than conventional forestry or traditional agriculture (monoculture). Success of agroforestry is determined by integrated individual forest and agricultural components, choice of tree and crop species combinations.. The main agroforestry types are: 1) Silvopasture (Wood-pasture) - mixing trees and pasture/forage; 2) Silvoarable (Wood/field crop, intercropping or alley cropping) - mixing trees and arable or horticultural crops; 3) Forest farming - cultivating high-value products within forested areas; 4) Forest gardening - imitating complex forest ecosystems to produce many products.

Soil physical properties

Soil water relations: Soil moisture flow is an essential process in our environment because i) crops need soil moisture to grow, ii) determines the workability of a soil, iii) it is the main transport medium for solutes, plant nutrition, pesticides and pollutants, iv) it influences surface runoff and flooding, and v) provide drinking water (groundwater) (soil moisture flow and solute transport simulation models, both in the unsaturated and saturated part of the soil, using laboratory and field studies).

Moisture in soil is present in three forms: Liquid, Solid (ice), or Gaseous (vapor), the most common form being liquid. As the water content of soil changes, many of the soil properties change accordingly, such as energy level and permeability of the soil. Soil permeability is a measure of the ability of air and water to move through the soil. The soil permeability decreases rapidly with decreasing moisture content since the flow of water is restricted to smaller pores and thinner films (De Jong, 1976). Soil moisture is expressed on a weight basis (g/100g oven dry soil) or on a volume basis ($cm^3/100cm^3$ bulk soil).

Types of soil water numerical models: Up to the 1990's, the majority of numerical models simulated one-dimensional (i.e. vertical) moisture flow only. These one-dimensional models can be divided into two main categories (Bastiaansen et al., 2009): bucket models (Droogers et al., 2001), and models based upon the Richards' equation (Van Dam et al., 2008). Generally, these types of models are data input demanding and not always applicable in practice. When using either 1-, 2- or 3-dimensional models,, boundary conditions need to be described, in addition to Meteorological data (e.g. precipitation and evaporation drainage data (e.g. distance, depth, and resistance), and regional data (seepage or percolation) at the required temporal scale.

Knowledge of soil hydraulic properties is essential for proper understanding and evaluation of the physical and chemical processes involved in water flow and transport of dissolved salts, plant nutrients and pollutants through soil systems (Al-Jabri et al., 2002).

The most-widely used method is the one where the relationships are described by the Mualem-Van Genuchten equations (Van Genuchten, 1980). The Mualem – Van Genuchten equations describe both the soil moisture retention curve and the hydraulic characteristics with six parameters: a fitted matching point for the hydraulic conductivity at saturation (K_o, [L.T-1]), the saturated moisture content qs [L3L-3], the residual moisture content qr [L3L-3], a parameter α [L-1] which is related to the inverse of the air entry suction value; a parameter n which is a measure of the pore-size distribution; and l, a pore connectivity factor that is normally assumed to be 0.5. To obtain the parameters of the Mualem-Van Genuchten equations from laboratory data, the curves should be fitted through a number of measured points of the soil moisture retention and hydraulic conductivity relationships.

Soil physical characteristics can be obtained in the field by application of infiltrometer measurements and a numerical model in combination with optimization techniques as described by Lazarovitch et al. (2007).Soil physical relationships can be derived on the basis of other related soil properties using pedotransfer functions, e.g. using particle size distribution, bulk density and/or organic matter content data. Pedotransfer functions can be categorized into two main groups: i) Class pedotransfer functions and ii) Continuous pedotransfer functions. Class pedotransfer functions calculate hydraulic properties for a textural class (e.g. sand) by assuming that similar soils have similar hydraulic properties. Continuous pedotransfer functions use measured grain size distributions to provide continuously varying hydraulic properties across the textural triangle (Wösten et al., 2001a).

Although pedotransfer functions are sometimes seen as the bridge between pedology and hydrology and are gaining in popularity, it has been shown that pedotransfer functions developed for one location are not always applicable for other locations (Li et al., 2007). It should be recognized that the usefulness of any statistical function is limited to the data population used in the development of this function.

Infiltration: The vadose zone is an integral component of the hydrological cycle, directly influencing infiltration, storm runoff, evapotranspiration, interflow, and aquifer recharge. Understanding the nature of water movement in the vadose zone and its quantification is essential to solving a variety of problems. Examples of such problems are: prediction of runoff from given precipitation events for purposes of erosion control; sediment transport and flood control; estimation of water availability for plant growth; estimation of water recharge to the underlying aquifer; and assessment of the potential for aquifer contamination due to migration of water soluble chemicals present in the vadose zone.

Estimation Methods for Infiltration Rate: There are numerous techniques available for the estimation of water infiltration rate through the vadose zone. Such techniques include: 1) soil-water balance, 2) lysimeter measurements, 3) Darcy flux method, 4) soil temperature methods and 5) electromagnetic methods amongst others. However, none of these methods offers a quick and easy way to obtain an estimate of infiltration rate for purposes of preliminary analysis and decision-making. These estimation methods are easy-to-use and yield scientifically based estimates using soil-hydraulic and climatic parameters representative of the prevailing site conditions. The compiled methods can be divided into three broad categories of: a) empirical models, b) Green-Ampt models, and c) Richards equation models. Before discussing these models, a brief introduction to the processes involved in soil-water movement will be presented.

Empirical Models: Empirical methods are usually in the form of simple equations, the parameters of which are derived by means of curve-fitting the equation to actual measurements of cumulative water infiltration. These equations only provide estimates of cumulative infiltration and infiltration rates, and do not provide information regarding water content distribution. Most are derived on the basis of a constant water content being available at the surface.

Kostiakov's Equation

Kostiakov (1932) proposed the following equation for estimating infiltration,

$$i(t) = at^{-}b \qquad (1)$$

where i is the infiltration rate at time t, $a=(\alpha >0)$ and $b=(0< \beta <1)$ are empirical constants. Upon integration from 0 to t, Eq. 1 yields Eq. 2, which is the expression for cumulative infiltration, $I(t)$.

$$I(t) = \frac{a}{1-b} t^{(1-b)} \qquad (2)$$

The constants a and b can be determined by curve-fitting Eq. 2 to experimental data for cumulative infiltration, $I(t)$. Since infiltration rate, i, becomes zero as $t \rightarrow \infty$, rather than approach a constant non-zero value, Kostiakov proposed that the Eqs. 1 and 2 be used only for $t < t_{max}$ where t_{max} is equal to $(a/K_s)^{(1-b)}$, and K is the saturated hydraulic conductivity of the soil.

Green-Ampt Models

Basic Concepts: Green and Ampt (1911) derived the first physically based equation describing the infiltration of water into a soil. The Green-Ampt model has been the subject of considerable developments in applied soil physics and hydrology owing to its simplicity and satisfactory performance for a great variety of hydrological problems. Green and Ampt assumed a piston-type water content profile with a well-defined wetting front. The piston-type profile assumes the soil is saturated at volumetric water content of θs (except for entrapped air) down to the wetting front. At the wetting front, the water content s drops abruptly to an antecedent value of θ_o, which is the initial water content. The soil-water pressure head at the wetting front is assumed to be h_f (negative). Soil-water pressure at the surface, h_s, is assumed to be equal to the depth of the ponded water.

At any time, t, the penetration of the infiltrating wetting front will be Z. Darcy's law can be stated as follows:

$$q= \frac{dI}{dt} = -K_s \left\{ \frac{hf-(hs+Z}{Z} \right\} \quad (3)$$

where K_s is the hydraulic conductivity corresponding to the surface water content, and *I(t)* is the *s* cumulative infiltration at time *t*, and is equal to $Z(\theta s\text{-}\theta_o)$. Using this relation for *I(t)* to eliminate *Z* from Eq. 3, and performing the integration yields,

$$I=K_s t-(hf-hs)(\theta s-\theta_o)\mathrm{Log}_e \left\{ 1-\frac{I}{(hf-hs)(Os-Oo)} \right\} \ldots.(4)$$

Equation 4 is precisely the statement of the Green-Ampt model.

Hydraulic conductivity and Soil moisture content: The water movements in the unsaturated zone, together with its water holding capacity are very important for assessing the water demand of the vegetation, as well as for the recharge of the ground water storage. A fair description of the flow in the unsaturated zone is also crucial for predictions of the movement of pollutants into ground water aquifers. The controlling factors of soil moisture may be classified under two main groups' viz. climatic factors and soil factors. Climatic factors include rainfall intensity, storm duration, inter-storm period, temperature of soil surface, relative humidity, radiation, evaporation, and evapotranspiration. The soil factors include soil matric potential and water content relationship, hydraulic conductivity and water content relationship of the soil, saturated hydraulic conductivity and effective porosity. Saturated and unsaturated hydraulic conductivity are related to the degree of resistance from soil particles when water flows through soil pores. In addition, the volumetric water content of soil affects unsaturated hydraulic conductivity markedly.

Saturated Hydraulic Conductivity*:* The hydraulic conductivity depends on the attributes of the soil and the fluid together. The soil characteristics, which have bearing on the hydraulic conductivity, are the total porosity, the distribution of pore sizes and the tortuosity – in short, the pore geometry of the soil. The fluid attributes, which affect the hydraulic conductivity, are fluid density and viscosity. The simplest technique to measure the saturated hydraulic conductivity (K_s) in the laboratory is to take an 'undisturbed' cylindrical sample of the soil, saturate it, and let water flow through it. From the rate of outflow, the hydraulic gradient and the cross-sectional area observed on the sample, K_s could be calculated with Darcy's equation. Because truly undisturbed samples are difficult to obtain and the sample size is relatively small, laboratory methods have limited usefulness and direct measurement of K_s in the field is usually preferred.

Soil water and storage: Saturated and unsaturated hydraulic conductivity are related to the degree of resistance from soil particles when water flows through soil pores. In addition, the volumetric water content of soil affects unsaturated hydraulic conductivity markedly. Soil hydraulic properties i.e., soil water retention curve SWRC and hydraulic conductivity function K [θ (h)], are the main soil properties for determining the water retention and movement in soils.

Material and Methods

Study area : This study was conducted in Gachoka division of Mbeere District, eastern Kenya, approximately 200 km north of Nairobi, altitude 1155 m above sea level, agroecological zone LM_4, rainfall between 600 to 1100 mm and bimodal, unpredictable and erratic, (Kassam et al., 1991); temperature between 20 and 32°C, potential evapotranspiration (P/PET) 35%. (Jaetzold et al., 2006).

Topography and Climate*:* The District slopes in a Northwest to Southeast direction with an altitude of 1200 metres above sea level sloping down to 500 metres on the Tana River basin. Mwea plains cover the Southern part of the District. Temperature ranges from 20°C to 32°C depending on altitude. August is usually the coldest month (average monthly minimum temperature of 15°C) while the warmest month occurs in March average monthly maximum temperatures rising to 30°C).

General Soil Characteristics of the District*:* The soils are variable, generally low in fertility; well drained, very deep to dark red friable clay (nito-rhodic Ferralsols, Rhodic Ferralsols), shallow to very deep, dark reddish brown to yellowish brown, loose to friable, loamy sand to sandy clay loam, in places rocky (Ferralic Arenosols; with Orthic Ferralsols and Acrisols), (Sombroek et al., 1982; Jaetzold and Schmidt, 1982) and in the Mwea plains, are covered with black cotton soils of low to moderate fertility (Pellic Vertisols).

Farming systems: The district has three main Agro-Ecological Zones (AEZ) (Jaetzold et al 1982): Lower midlands, LM 4, Lower Midlands, LM 5 and Lowlands, L5), and is largely an agriculturally potential zone under rain-fed conditions. Food crops include maize, millet, sorghum, beans, cowpeas, green grams cassava and bananas (mainly for subsistence), while cash crops are cotton, tobacco and sunflower. Livestock in the District are mainly indigenous breeds, kept under free-range system and include cattle, sheep, goats and poultry, dairy cattle, dairy goats and exotic poultry.

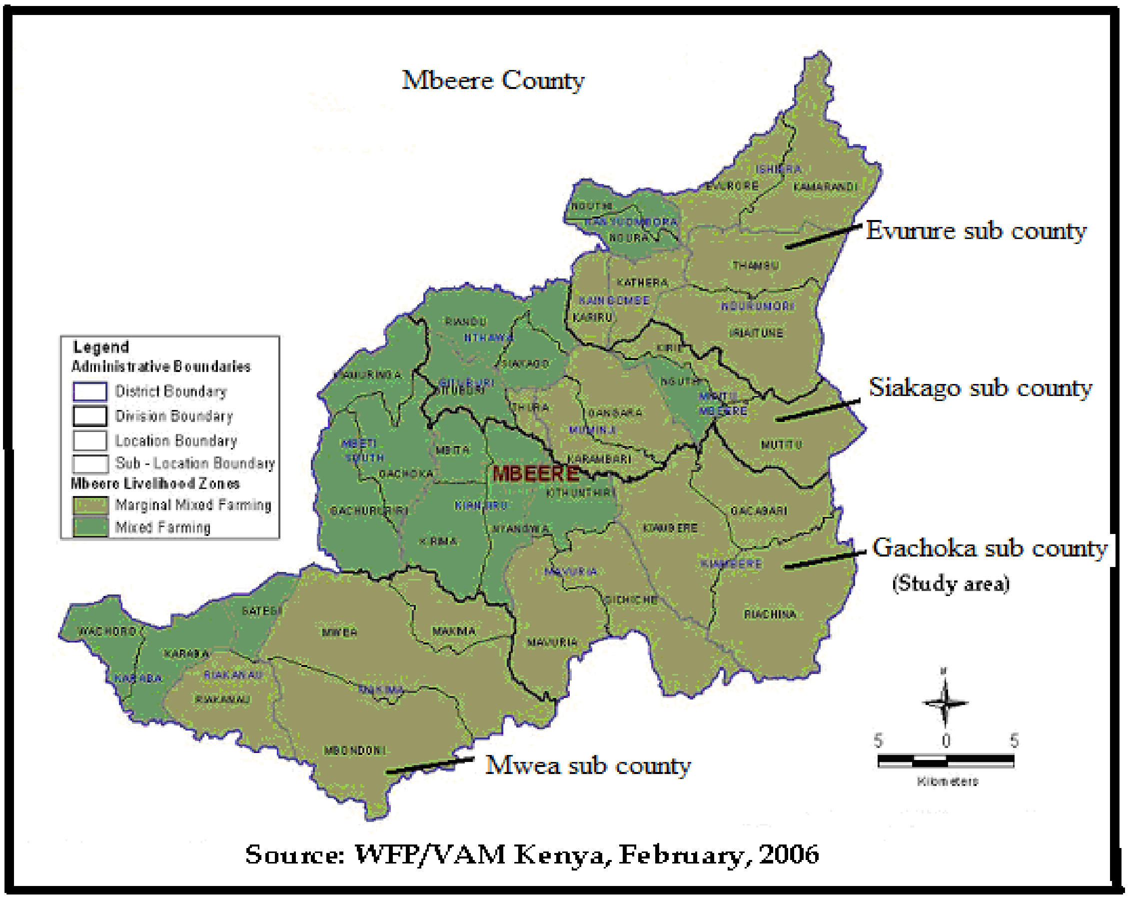

Figure 1: Map showing Mbeere County with Gachoka sub-county as study area

Experimental treatments and design: The experimental treatments were 7 thus: Lopped trees 0.5 m, lopped trees 1.5m, and lopped trees 2.5 m; unlopped trees 0.5m, unlopped trees 1.5 m and unlopped trees 2.5 m; and No trees with 3 distances thus: 0.5, 1.5 and 2.5 meters from the tree. The treatments were arranged in a randomized split-plot design with Lopped and unlopped trees as the main plots and distances as the sub-plots.

Experimental design: The experimental design was a randomized Complete Block Design (CBD) of 9 treatments with five replicates in lopped and unlopped main plots, with 3 sub-plots at 0.5m, 1.5m and 2.5m in each. Each experimental plot measured 10 x 5 m, and there were 3 plots plus the control, all measuring 15 m x 10 m.

Land preparation: Land was prepared using manual labour, the main activities being vegetation slashing, ground digging, levelling and site staking to conform to actual field measurements in the experimental layout.

Planting: Maize (Nduma 43 variety) seeds were planted at 30 cm (along maize rows) by 90 cm (between maize rows) between Melia volkensii trees spaced at 5 meters apart, thus making 4 maize rows between each tree row. Within the maize rows, holes were spaced 30 cm apart and three seeds were placed in each hole, about 40 mm deep and covered with soil. Upon emergence, one seedling was thinned leaving two seedlings per hole. The Mbeere experiments were conducted for two seasons: (short rains between October and December 2008 and long rains between March to June 2009.

Fertilizer application: Spot application of Nitrogen fertilizer as CAN was applied to the maize planting holes at rates of 194.4 grams per planting hole equivalent to 50 kg N ha^{-1}.

Other agronomic practices

Weed control: Weeding of the plots was done manually once every two weeks and stopped at tussling stage of maize.

Pest and disease control: *Upon emergence, the bean seedlings were sprayed with Diazinon (to control Maize blight (Pseudomonas syringe pv. phaseolicola) (10 mls to 20 litres of water) regularly at intervals of two weeks. Spraying was stopped when the seedlings had developed four leaves, but the same was continued using Dithane M 45 (15 g to 20 litres of water) to control fungal diseases like Anthracnose (Colletrotricum lindermuthianum) and halo blight (Pseudomonas syringe pv. phaseolicola).*

Tagging of plants for height assessment: One plant, randomly selected, was tagged per row of 20 maize plants, followed a grid system from the first row and ending with the fourth in the plot.

Soil sampling and analysis: Soil classification (at 0-15 cm, 16-30 cm, 31-45 cm and 46-60 cm soil depth), Soil pH, N, C, P, SOM, Ca, Mg, for site characterization was done in all the sites as described by Okalebo et al., 1993.

Soil water balance (flow and storage) (infiltration and hydraulic properties): This was assessed in all the sites at 0-15 cm, 16-30 cm, 31-45 cm and 46-60 cm soil depth respectively at 0.5m, 1.5 m and 2,5 m distances from the trees in each replicate.

Saturated hydraulic conductivity (Ks) (Klute and Dirksen, 1986): Saturated hydraulic conductivity determinations were done in the laboratory using the constant head method as described by Klute and Dirkesn (1986). K_s was calculated using the following formulae:

$K_s = Q\ L/\ At\ \Delta H$

Where Q = volume of percolate (cm3), t = time of water flow (min), A = cross-section area of the soil-core (cm3), L = length of the soil core (cm), ΔH = hydraulic head difference (cm): which is the sum of length of the core sample (L) and water column above the soil sample (6h).

Infiltration rates measurement: Field infiltration measurements were done using a disc permeameter as described by Perroux and White (1988). Measurements were taken at planting, mid season and at harvest. Infiltration results were fitted into the infiltration equation of Phillip (1957), thus:

$$I = S\sqrt{t} + Kt$$

Where I is cumulative infiltration; t is time; S is sorptivity and K is the ability of soil to transmit water (Collis-George, 1980).

Determination of crop growth: Heights were measured using a ruler and tape measure placed along the stem of the plant from the base level to the tip of the growing shoot. This was done at regular intervals of two weeks from plant emergence. However, measurements could not proceed due to the server effect of drought that impeded development to tussling stage.

Determination of biomass: Due to the effect of drought, all maize plants in the plots (lopped and unlopped) were cut at the ground level before tussling, tied together and weighed on site using a portable weighing machine to give an estimate of the total plant fresh weight per plot (Biomass).

Lopping height determination: The lopping height was determined from the actual crown height. Crown height (C.H) was obtained using the following formulae:

[(Top reading to Crown - minus Bottom reading to Crown base)/ Horizontal distance (Distance of instrument observer from the tree base)]*100

Lopping height (L.H) obtained using the formulae: L.H = 1/3 Crown height (C.H) (Suunto)

Data analysis: The data was entered in Excel spreadsheet, transferred onto SPSS spreadsheet, subjected to Analysis of Variance (ANOVA) using SPSS computer analysis programme (SPSS, 1999) and means separated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Site characterization

Soil pH was obtained using 1:2.5 H_2O soil: water ratio for the sites indicating that the soils had high alkalinity (7.38-7.52), Organic carbon was very low (0.45-0.47%) indicating very low organic matter in the soils, due to low organic matter materialization in these soils as a result of aridity conditions (low soil moisture content), nitrogen was low (0.06-0.1%), potassium (1.00 ppm), phosphorus (17.50-22.50 ppm) and sodium (0.25 ppm) was very high, low-medium and medium respectively implying that the soils had adequate quantities of these elements.

The soil textural classification of the soils was sandy clay loam and the soil class Nitorhodic Ferralsols and Cambisols, generally poor in soil moisture retention due to low clay and high sand contents. The Electrical conductivity (EC 0.2 DSm^{-1}) and Cation Exchange Capacity (CEC) of the soils were low indicating that exchange of cations was low within the soil structure hence limited availability of plant nutrients. Generally the soils were of low nutrient status

Effect of *Melia volkensii* agroforestry system on Maize performance

There was a general increase in maize height between the lopped, unlopped and control sites during the 1st and 2nd rainfall seasons (Figures 1a and 1b below). The unlopped and control sites had appropriate vegetation cover which promoted mineralization of soil organic matter hence availability of nutrients.

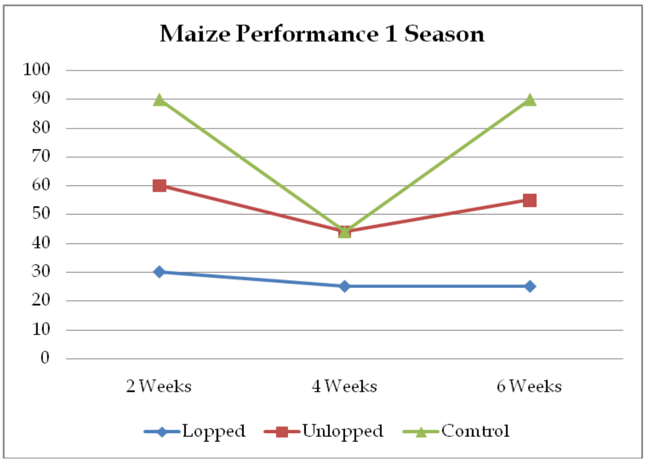

Figure 1a. Maize crop performance 1st season 2008/09

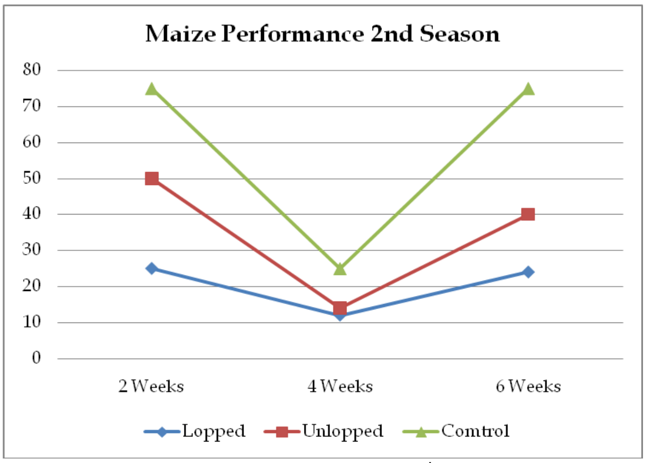

Figure 1b. Maize crop performance 2nd season 2009/10

Effect of *Melia volkensii* agroforestry system on Biomass production

There was a general increase in biomass production in the lopped sites during both 1st and 2nd seasons (Figures 4a and b). However, biomass production for the 2nd season was higher compared with the 1st season during 2008/9 and 2009/10(Figures 2).

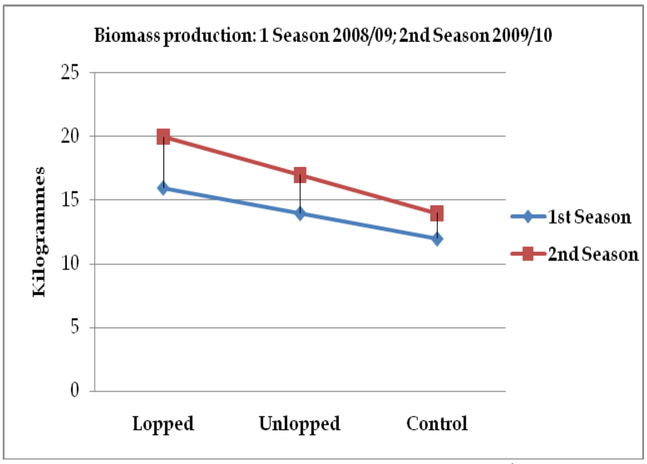

Figure 2. Biomass production: 1st Season 2008/09; 2nd Season 2009/2010

In the lopped site, light penetration was enhanced and this promoted photosynthesis, increased carbohydrate production, and increased biomass production, compared to the unlopped site. The control had the lowest biomass production probably caused by reduced litter availability for eventual decomposition into organic manure for crop production. It also had no moderating influence that trees enhanced on crop production like improved microclimate (increased soil moisture availability to crops through organic matter production, appropriate growth temperatures occasioned by shading effect on crops and protection from adverse wind effects that increase evapotranspiration on leaves thereby reducing photosynthetic activity).

Effect of *Melia volkensii* agroforestry system on Soil water dynamics

The hydraulic conductivity (0.168-0.508 cm/hr) was found to be low in all the sites and this was probably due to the effect of temperature on soil water viscosity that lowered infiltration rate. The effect of distance on soil hydraulic conductivity was not significant in all the sites. However, effect of roots on soil texture and permeability significantly affect hydraulic conductivity especially when tree distance is considered. Roots further away from the tree trunk do not affect soil texture and infiltration.

Generally soil hydraulic conductivity tended to increase with distance, especially between distances 1.5-2.5 m from the tree to the sample spots in all the seasons of 2008-2010. However, a decline in conductivity was also note between distances 0.5-1.5 m. Soils near trees have a relatively high root content and the influence on roots on soil is such that they tend to promote solid adherence of soil particles thus reducing the soil micro and macro pores. This has the effect of reducing soil infiltration and percolation, and hence soil hydraulic conductivity. As distance from the tree is increased, this influence of roots on soil structure is reduced and most soils increase in permeability occasioned by reduced root density, reduction in soil organic matter and increase in soil pore density that enhances soil hydraulic conductivity.

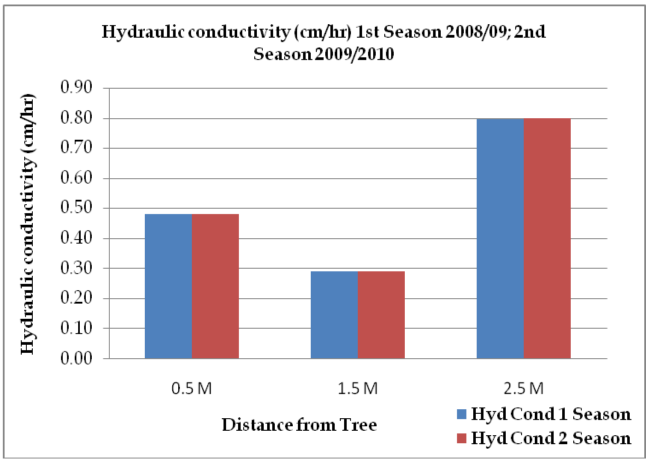

Figure 3. Hydraulic conductivity (cm/hr) 1st Season 2008/09; 2nd Season 2009/10

Conclusions

The soils in the sites were found to be alkaline, low N, K, C and Na content, but with high P levels, low CEC and EC and Sandy clay loam.. The textural class was Nitorhodic Ferralsols and Cambisols.

Maize height increased in the lopped and unlopped sites. However, the effects of drought and reduced rainfall significantly reduced height growth. However, it was higher in the lopped sites. Distance did not have any effect on crop performance

Biomass production was highest in the lopped site. However, the effect of tree distance on biomass production was not significant. Biomass production was highest during the second seasons due to enhanced rainfall.

Soil hydraulic conductivity increased with distance, indicating that distance significantly affected hydraulic conductivity.

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References

Al-Jabri, S.A., R. Horton, and D.B. Jaynes. (2002). A point-source method for rapid simultaneous estimation of soil hydraulic and chemical transport properties. Soil Science Society of America Journal, 66: 12-18.

Bastiaansen, W.G.M., R.G. Allen, P. Droogers, G. D'Urso, and P. Steduto. (2009). Twenty-five years modeling irrigated and drained soils: State of the art.Agricultural Water Management, In Press, doi:10.1016/j.agwat.2007.05.013: 15 pp.

De Jong, E. 1976. Agriculture and soil moisture: Paper presented at the Workshop of Remote sensing of Soil Moisture and Ground Water, Toronto. Ontario, pp. 3-9.

Droogers, P., M. Tobari, M. Akbari, and E. Pazira. (2001). Field-scale modeling to explore salinity problems in irrigated agriculture. Irrigation Drainage, 50 (1):77-90.

Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research*, 2nd Edition, John Wiley and Sons, Inc. 605 Third Avenue, New York, New York 10158.

Jaetzold, R. and Schimidt, H.(1982). Farm management handbook of Kenya.

Volume II. Natural conditions and farm management information. Ministry of Agriculture, Kenya

Kassam, A.H., Velthuizen, H.T., Fischer, G.W. and Shah, M.M. (1991). Agroecological land resources assessment for agricultural development planning. A case study of Kenya. Resources database and land productivity, Technical Annex 1, land resources, Land and Water development Division, FAO and IIASA.

Lazarovitch, N., A. Ben-Gal, J. Simunek, and U. Shani. (2007). Uniqueness of soil hydraulic parameters determined by a combined Wooding inverse approach.Soil Science Society of America Journal, 71 (3): 860-865.

Li, Y., D. Chen, R.E. White, A. Zhu, and J. Zhang. (2007). Estimating soil hydraulic properties of Fengqiu County soils in the North China Plain using pedo-transfer functions. Geoderma, 138 (3-4): 261-271.

Okalebo, J.R., Gathua, K.W. and Woomer, P.L. (1993). Laboratory Methods of Soil and Plant Analysis. A Working manual. Marvel EPZ (Kenya) Ltd; Nairobi, pp. 88.

Singh, Alam (1958). Jodhpur Pattern (J.P.) Permeameter, Current Engg. Practice, Vol. 1, No. 3, Sept. 1958, Bombay, pp. 19-21

Sombroek, W.G., Braun, H.M.H and van der Pouw, B.J.A. (1982). Exploratory Soil Map and Agro-climatic zone map of Kenya, scale 1: 1,000,000. Kenya Soil Survey, National Agricultural research Laboratories, Ministry of Agriculture, Kenya

SPSS (1999). *Statistical package for Social Sciences (SPSS PC+):* SPSS for Windows Version 11.0 Chicago, Ilinois: SPSS Inc.

Van Dam, J.C., P. Groenendijk, R.F.A. Hendriks, and J.G. Kroes. (2008). Advances of modeling water flow in variably saturated soils with SWAP. Vadose Zone Journal, 7 (2): 640-653.

Van Genuchten, M.T. (1980). A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Science Society of America Journal, 44 (3): 892-898.

Wösten, J.H.M., Y. Pachepsky, and W.J. Rawls. (2001a). Pedotransfer functions: bridging the gap between available basic soil data and missing soil hydraulic characteristics. Journal of Hydrology, 251: 123-150.

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$CaCl_2$ activation and reaction mechanism of the yellow river sediment

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Abstract

This paper is to explore the way of improving the Yellow River sediment pozzolanic activity and stability, which aims at propelling the application in stabilized earth-based materials of the Yellow River sediment, so as to achieve its large-scale utilization and alleviate its massive deposition in downstream river channel of the Yellow River. The influence of ratio and dosage of $CaCl_2$ and $CaCl_2$+$Na_2O{\cdot}nSiO_2$ on the activation of the Yellow River sediment was discussed. Reaction mechanism of $CaCl_2$ with sediment was preliminarily explored through X-ray Diffraction and Fourier Transform Infrared Reflectance. The results show that Pozzolanic Activity Index (PAI) and reactive rate of 4% $CaCl_2$ activated sediment are 1.2 and 3.9 times of the original respectively. When the sediment is activated by compound activator ($Na_2O{\cdot}nSiO_2/CaCl_2$ =1/1) of 6 wt. %, the PAI is 0.63, increasing 24%. XRD and FTIR analysis indicates that $CaCl_2$ promotes the hydrolyzetion of albite, which explains the increased amount of soluble Si^{4+}.

Keywords: The Yellow River sediment; pozzolanic activity index; hydrolyzetion

Introduction

The Yellow River is one of the most famous high silt-laden rivers; its average sand content is 37kg/m^3. The average annual sediment discharge is 1.6 billion tons and about 400 million tons of sediment deposits in downstream channel, which led to the riverbed raise about 10cm each year. And now the riverbed is 15 meters higher than farmland in Henan and Shandong province, which undoubtedly become a serious hidden danger to residents living on both sides of the lower Yellow River [1].

The sediment, scoured by the Yellow River water, mainly composes of silica, feldspar, calcite and small amount of clay. Mineral composition directly determines the poor reactivity with hydraulic binders of sediment, which has become a barrier for the use of sediment in situ in road construction. It also can't meet the requirements of raw soil material or stabilized earth concrete until its reactivity is improved through activation. Therefore, how to activate the potential activity are becoming the key problems in implementation of the resources utilization of the Yellow River sediment.

Effects of soil reaction activity and geotechnical properties mainly focus on the influence of ions, such as H^+, OH^+, SO_4^{2-}, PO_4^{3-}, Cl^-, NO_3^-,Ca^{2+}, and et.al. Acidic and alkaline environment promotes the release of Al^{3+} and Si^{4+}, and therefore improves the reactivity of soil. Several authors have recognized this action. Yang et.al [2], by

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analysis the effluence of sodium hydroxide (NaOH) concentration, reaction temperature and time on the reactivity of saline soil, proposed the ideal processing conditions of improving reactivity of soil in presence of OH^-. Liu et.al [3] activated the Yellow River by phosphoric acid, and observed the formation of filamentous calcium phosphoric crystal through the reaction of phosphoric acid with calcium carbonate on the surface of clay particles. Spectrum analysis of Fourier Transform Infrared Reflectance (FT-IR) showed that —OH group content of activated sediment was increased.

The relevant research institutions comprehensively analyze the influence of ions on the geotechnical properties of soil. The France technical guide for soil treatment [4] indicated that phosphate and nitrate ions as retarders, even inhibitors, of setting; and suggested sulfates have a harmful at 10g kg^{-1}. Yilmaz and Civelekoglu [5] noted a beneficial action of Ca^{2+} by blending gypsum as an agent for solidification of soil. According to the observations of Xing et.al [6], they react with C_3A to form Friedel's salt (calcium chloroaluminate) and delay the development of the calcium compounds (calcium aluminate hydrate (CAH) and calcium silicate hydrate (CSH)). Lucile Saussaye et.al [7] explored the concentration thresholds for each anionic disruptive element beyond which the soil stabilization could be altered. Crannell et al. [8], during the stabilization of incineration waste by soluble phosphates, indicated the formation of $Ca_3(PO_4)_2$ and of $Ca_5(PO_4)_3OH$, with a stabilization of approximately 50% of the water soluble calcium. The stabilization of the phosphate ions would thus take place before the treatment of the soil.

The researches have recognized that Acid, alkali, metal cations and anions have an influence on the properties soil reaction activity and geotechnical properties. However, no reaction mechanism has been defined until now to explaining the effect. In this paper, the results associated with effect of $CaCl_2$ on reactivity are characterized by the test of PAI and reactive rate (K_α). The reaction mechanism is observed by X-ray Diffraction (XRD) and FT-IR.

Material and Methods

Materials

The Yellow River sediment comes from Huayuankou at the lower reaches of the Yellow River; its moisture content is between 41-47%, the chemical composition is given in Table 1. Ordinary Portland cement 42.5 and lime were purchased as commercial products. The performance index of P.O 42.5 cement is listed in Table 2. Effective component of lime is no less than 70%. Modulus of sodium silicate ($Na_2O{\cdot}nSiO_2$) is 1.8. Calcium chloride ($CaCl_2$) is analytical reagents.

Table 1 Chemical composition of the Yellow River silt

Composition	SiO_2	Al_2O_3	CaO	Fe_2O_3	K_2O	Na_2O	MgO	others
Content (%)	70.9	9.1	6.1	3.0	2.1	2.1	1.3	5.4

Table 2 Performance index of cement

Compressive Strength /MPa		Flexural strength /MPa	
3 d	28 d	3 d	28 d
29.0	53.4	5.9	8.8

Sample preparation and test approach

PAI test

Mass ratio of compound activator $Na_2O{\cdot}nSiO_2/CaCl_2$ (or N/C, for short) is 0/1, 0.5/1, 1/1 and 2/1, mass fraction varies from 2 to 8 wt.%. $CaCl_2$ solution was added into the soil samples and hermetically placed for 24h after evenly stirred. Then, $Na_2O{\cdot}nSiO_2$ was incorporate into the above samples and placed in the same way. At last, according to Chinese standard GB/T17671-1999, cement with a level of replacement of 30% activated sediment (dry weigh) was made into mortar specimens. The specimens were placed in standard curing box at 19-21°C and 90%RH.

Test of reactive rate (K_α)

Conical flask with 8.0g sediment and 4.0±0.1g 4 wt.% $CaCl_2$ solution were hermetically put into constant temperature water bath cabinet for 48h at 80°C. The specimen boiled for 2h through refluxing method after adding 200ml saturated $Ca(OH)_2$ solution. Then mixed 8 ml HCl and continued to boil 5 min. Extract solution was constant volume to 250 ml. ICP-AES analysis is used for detection the concentration of Si^{4+} and Al^{3+} content in the extract solution. The content of soluble SiO_2 and Al_2O_3 were derived by calculation. K_α was gotten by the formula (1).

$$K_\alpha = \frac{Slouble\ SiO_2 + Slouble\ Al_2O_3}{Total\ (SiO_2 + Al_2O_3)} \qquad (1)$$

Test of XRD and FT-IR

The mineral composition of sediment was determined by Panalytical X'Pert PRO MPD XRD using Cu Ka radiation in a 2θ range between 10 and 80 at room temperature. Differentia of ionic groups was observed IRPrestige-21 spectrometer manufactured by Shimadzu Corporation.

Results and Discussion

The Yellow River sediment in clay particles content is 6.21 wt.%, total active iron , aluminum and silica gel is less than 10 mg/g and cation exchange capacity(CEC) is only 0.27 mmol/kg. Plastic limit is 17.3% and plasticity index is 8.9, obviously lower than the average of the ordinary clay. The inter-particle adhesiveness is too weak to form a stable aggregate structure. The ion exchange, ash reaction and chemical activation rarely occurs between inorganic binder and sediment that seriously influences the formation of strengthen structure so as to restrict the application of sediment in road construction and raw soil materials.

Activation effect

PAI is defined as the compressive strength ratio of blending 30% activated sediment mortar and cement specimen at 28 days. It is usually used for evaluating the potential activity of mineral admixture. In this study, PAI is applied to compare activation effect with different mixing ratios compound activator.

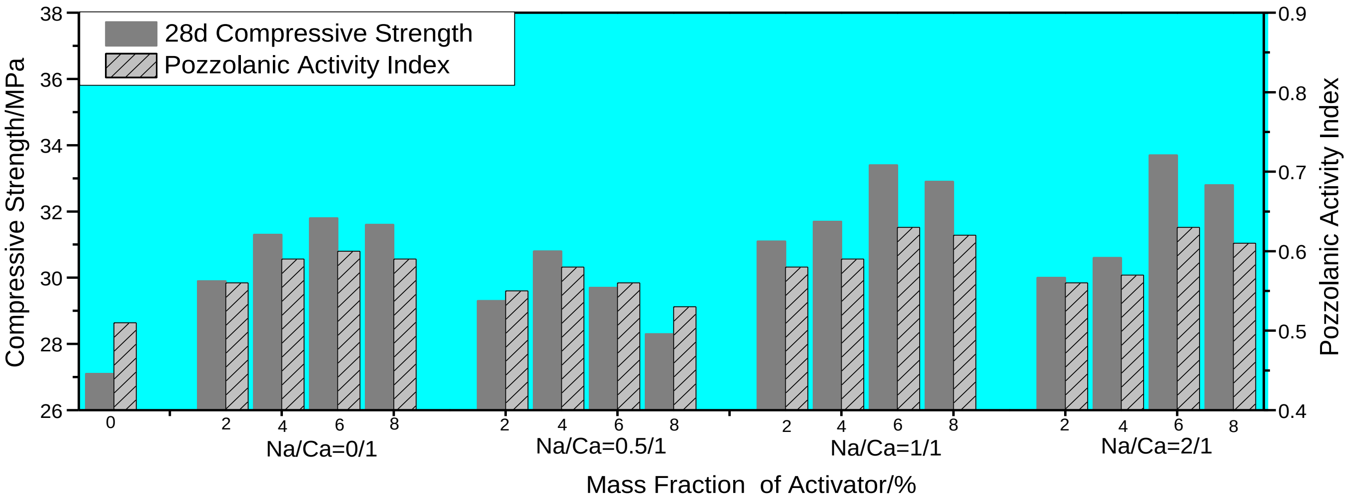

Fig.1 Compressive strength and PAI of mortar specimens at 28days

Compressive strength and PAI of modified sediment with $CaCl_2$ increased with dosage before it reached 6 %, and then slightly decreased (Fig.1), which is due to a few CEC of the Yellow River sediment. One of the roles of $CaCl_2$ is ion-exchange action between Ca^{2+} and low valence metal ions adsorbed by clay particles so as to reduce its' electro-negativity and improve inter-particle cohesion. The other reason is that $CaCl_2$ reacts with C_3A generating insoluble double salt $C_3A{\cdot}CaCl_2{\cdot}10H_2O$, and thus, it plays the role of improvement mortar strength.

Compressive strength and PAI results reached peak value when mass ratio of N/C was 1/1(Fig.1). The results of the activated sediment mortar at 28d increased 23% compared with the nature, respectively reached to 33.1MPa and 0.63 when the activator dosage was 6%. This is because $Na_2O{\cdot}nSiO_2$ precipitates silica gel and calcium silicate gel from solution in the role $CaCl_2$ of and CO_2. During the cement hydration and hardening, it wraps around the sediment particles and bonds them together forming a whole [9,10]. $Ca(OH)_2$, the reaction product of $Na_2O{\cdot}nSiO_2$ with $CaCl_2$, fills in the pores of silica gel after dehydration and increases the density and strength of specimen.

Primary exploration of activation mechanism

Soluble Si^{4+} and Al^{3+} of activated sediment with 4 wt.% $CaCl_2$ increased obviously (Table 4), K_α is 3.9 times of the original. Kaolinite XRD diffraction peak enhanced and albite weakened compared with nature sediment (Fig.2), which suggested that $CaCl_2$ promote hydrolyzetion of albite and contribute to release soluble Si^{4+}. But the increase of soluble Al^{3+} can't be interpreted reasonably.

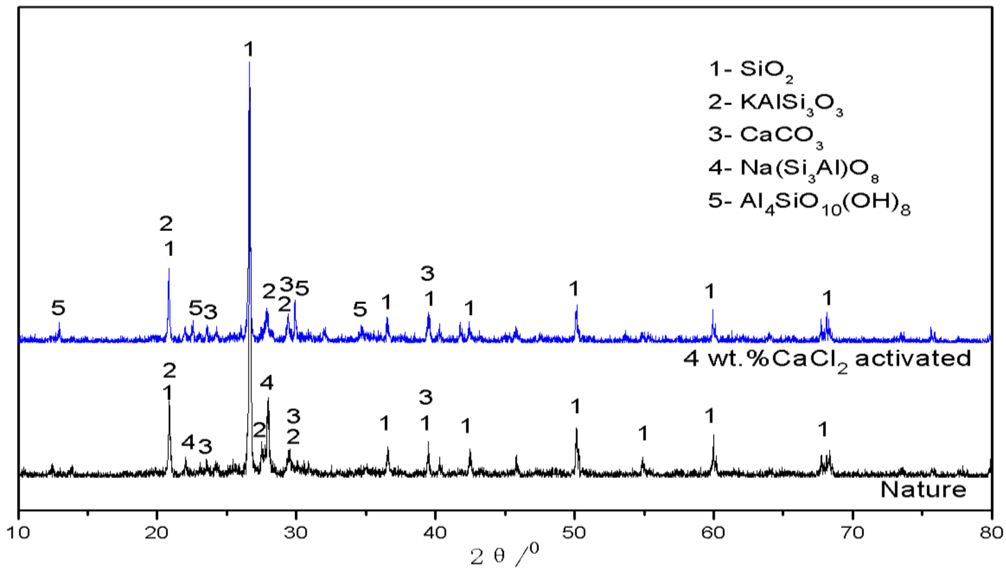

Fig.2 XRD spectrum of sediment

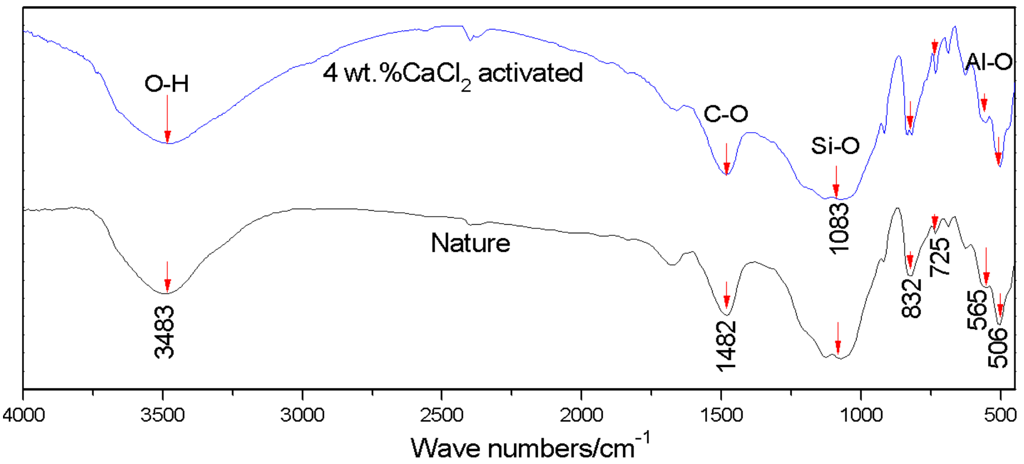

Fig.3 FT-IR spectrum of sediment

Table 4 Content of soluble Si^{4+} and Al^{3+}

Code	Si^{4+} (mg/ml)	Al^{3+} (mg/ml)	Soluble SiO_2 (mg/g)	Soluble Al_2O_3 (mg/g)	**K_α**
Nature sediment	0.08	0.07	5.22	4.19	1.18
4 wt.% $CaCl_2$ activated	0.26	0.31	17.42	19.00	4.55

A little variation occurred in FT-IR spectrum of sediment specimens (Fig.3). Symmetric stretching vibration of Si-O and Al-O (725cm^{-1}) relatively enhanced that implied the increase of structure confusion and probability of formation new network. Because of the complexity of composition and structure, activation mechanism of the Yellow River needs further discussion.

Conclusion

The continuous increasing of the Yellow River sediment has led to many environmental and social problems. Therefore, it is essential to develop research and technology of resource utilization of the sediment. In order to promote the use of the sediment in road engineering and soil materials, this experimental study focus on the influence of $CaCl_2$ on the activation effect and reaction mechanism.

- Four different mixing ratios of compound activator are used to stimulate the Yellow River sediment at various dosages. The results prove the positive effects on PAI of sediment of $CaCl_2$ and its' compound activator.
- XRD and FT-IR analysis show that $CaCl_2$ promote the hydrolyzetion of albite and release of soluble Si^{4+}.

Acknowledgements

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References

[1] Wang Z.Y., Lin B.N.. Sedimentation studies in China – review and prospect. Chinese Journal of Sediment Research 2003; 4:73-81.
[2] Yang J.J., He C.S., Zhang L., Zhao S.N. Study on Effect of Alkali Chemical Activating Reactivity for Saline Soil. Bulletin of the Chinese Ceramic Society 2010; 29:1284-1289.
[3] Liu J.X., Zhang L., Yang J.J., Xiao Y.L. Activation Effect and Mechanism of Phosphoric on the Yellow River Sediment Limes Soil. Chinese Journal of Building Materials 2013; 16:898-902.
[4] LCPC-SETRA. Traitement des sols à la chaux et/ou aux liants hydrauliques – Assises de chaussées (GTS) – guide technique; 2007.
[5] Yilmaz I, Civelekoglu B. Gypsum: An additive for stabilization of swelling claysoils. Appl Clay Sci 2009;44:166–72.
[6] Xing H, Yang X, Xu C, Ye G. Strength characteristics and mechanisms of salt-rich soil-cement. Eng Geol 2009; 103:33–8.
[7] Lucile Saussaye, Mohamed Boutouil, Fabienne Baraud, Lydia Leleyter. Influence of anions on the geotechnical properties of soils treated with hydraulic binders: Individual and coupling effects. Construction and Building Materials 2014; 65:303-309.
[8] Crannell BS, Eighmy TT, Krzanowski JE, Dyksta Eusden Jr J, Shaw EL, Francis CA. Heavy metal stabilization in municipal solid waste combustion bottom ash using soluble phosphate. Waste Manage 2000; 20:135-148.
[9] E. Acevedo-Martinez, L.Y. Gomez-Zamorano, J.I. Escalante-Garcia.Portland cement-blast furnace slag mortars activated using waterglass: – Part 1: Effect of slag replacement and alkali concentration[J].Construction and Building Materials 2012, 37: 462-469.
[10] Ding Rui. Experimental study of the surface reactions between clay minerals and water-glass[J]. Chinese Journal of Geotechnical Engineering 1999; 5: 334-337.

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Determination of sorption characteristics of Zn (II) ions onto natural and physically modified zeolites

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Abstract

The purpose of this study was to characterize the zinc (Zn) sorption properties of the natural (NZ) and physically modified zeolites (PMZ) for agricultural and environmental treatments. Experiments were carried out using batch method as a function of solution pH, contact time, adsorbent dosage, and temperature. All these factors affected Zn ions sorption from aqueous solution. The sorption efficiencies in the optimised conditions for natural and physically modified zeolites were found to be 95.9 and 99.7 % for the Zn ion concentration of 100 mg L^{-1}, respectively. Equilibrium modelling data were evaluated using linear Langmiur, Freundlich and Dubinin-Redushckevich (D-R) isotherms. Maximum Zn sorption capacities (b) for the NZ and PMZ were found to be 20.87 mgg^{-1} and 15.75 mgg^{-1}, respectively. Thermodynamic parameters, Gibbs free energy change (ΔG), enthalpy change (ΔH) and entropy change (ΔS), were calculated at different temperatures. From the obtained results, it could be concluded that the natural zeolite is more effective than physically modified zeolites in terms of the maximum sorption capacity. Therefore, natural zeolite could be used for the adsorption of Zn ions in agriculture and environmental treatments.

Keywords: Zinc, zeolite, sorption, thermodynamic parameters

Introduction

Natural zeolite is porous material with high cation exchange capacity (CEC), cation selectivity, void volume and great affinity for positive charge ions such as zinc (Zn^{++}) (Ming and Mumpton, 1989). In several studies, authors have also reported the use of natural zeolite as a sorbent for trace metals and cations (Chlopecka and Andriano, 1997, He et al., 2002). Natural zeolite reserves occur most frequently in Japan, USA, Russia, Hungary (Amonette et al., 2002) and Turkey (Ataman, 1977; Sarioglu, 2005).

Physical and chemical adsorption or ion exchange processes are used in various fields for ions adsorption in recent years. However, ion exchange proceses, which used organic resins, are very expensive. Hence, cheaper materials such as zeolite and sepiolite are needed. The use of zeolite for removal of Zn^{++} from aqueous solution and wastewater is especially promising and very competitive compared to other processes such as biological and chemical treatments (Sarioglu, 2005).

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Results of the present study will accommodate evaluation of the NZ and physically modified zeolite (PMZ) as an adsorbent in the removal of Zn^{++} from wastewater, and reducing Zn^{++} sorption by soil components. The objectives of this study were to determine the effects of the pHs, dosage of the adsorbent, contact time and the sorption properties of the Zn^{++} ions onto the NZ and PMZ from aqueous solution. Morover, sorption properties and capacity of the NZ and PMZ are to compared in terms of environmental and agricultural.

Material and Methods

The natural Turkish zeolite (Sivas,Yıldızeli) used as an adsorbent in this study which supplied from Rota A.Ş. Mining Company. Its mineralogical and chemical properties were given at table 1.

Table 1. Chemical and mineralogical analyses of the natural zeolite

Constituent	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	SrO	BaO	CaO	Na_2O	K_2O	ZnO
Value (%)	58.7	0.32	11.59	2.12	1.40	0.51	0.25	4.66	0.38	0.77	0.64
XRD-Mineralogical Analysis; Clinoptilolite/Heulandite+Mordenit : % 95, Quartz : % 5											

The natural zeolite samples were powdered in a mortar and sieved using 328, 154 and 75µm sieve. The surface area of particles of different sizes is determined by the BET-N_2 method and ethylene glycol monoethyl ether (EGME) (Chiou et al., 1993). Zeolites held at different temperatures (200,400 and 600 °C), and the highest sorption (%) was obtained for 77 µ size at 600 °C. Therefore, the treated zeolite that 77 µ in size and at 600 °C chosen as physically modified zeolite (PMZ).

Sorption (%) of Zn ions using the NZ and PMZ were conducted depending on the some experimental parameters as: (i) pH of solution (i.e. 4, 5, 6, 7 and 8); (ii) adsorbent dosage (5, 10, 20, 30 g/L); (iii) contact time (i.e. 0.5, 1, 2,8, 12 and 24 hours); (iv) temperature (20, 30, 40, and 50 °C).

The dried zeolite samples (0.4 g.) were placed in polyethylene tubes and were mixed with 40 ml of Zn aqueous solution at the initial concentration with different pH levels. The tubes were shaken for 1 h. at room temperature (21°C). The samples were centrifuged at 200 rpm and the clear supernatant was carefully taken to determine Zn^{++} ions concentration of the solution phase and then filtered with filter paper. Zinc contents in the filtrates were analysed by AAS method. This procedure was repeated to determine the optimum experimental conditions mentioned above. The mean values of the duplicate analysis were used to calculate the amount of Zn in solution, and the limit of error of duplicate samples was lower than 5%.

Sorption (%) and the amounts of exchanged Zn^{++} ions (qe) by the zeolite were computed using Eqs. (1) and (2), respectively.

$$q_e = \frac{(C_o - C_e)V}{m} \quad (1)$$

$$\text{Sorption (\%)} = \frac{(C_o - C_e)}{C_o} x100 \quad (2)$$

where qe is the amount of exchanged Zn ions (mg g−1), C_o and Ce are the initial and equilibrium concentrations of Zn ions in solution (mg L^{-1}), respectively. V is the solution volume (L) and m is the adsorbent weight (g). The mean value of the duplicate analysis was used to calculate the amount of Zn^{++} ions in solution.

Results and Discussion

Effect of Solution pH on Zn Sorption

Sorption (%) of Zn ions from aqueous solution using the natural (NZ) and physically modified zeolite (PMZ) were studied at pH values 4–8 and the data obtained were given in figure 1. The pH of the aqueous solution was found to be an important factor for the exchange of Zn ions by zeolites. Sorption (%) generally increased by raising the pH from 4 to 8 and reached a maximum value at pH 8. Ören ve Kaya reported (2006) that depending on the pH and metal concentration, zinc may form complexes with OH^- such as $Zn(OH)_2$, $Zn(OH)_3$, $Zn(OH)_4$, at higher pH>6 values. Therefore, zinc hidroxyle species may adsorbate and participate onto the zeolite structure, or inner sites of zeolite. For this reason, subsequent experiments were conducted on solutions with an initial pH 6. Because, adsorption mechanisms are more important compare with participate mechanisms in this study.

Effect of Adsorbent Dosage on Zn Sorption

The adsorbent dosage is an important parameter, because it determines the capacity of an adsorbent for a given initial concentration of the adsorbate (Saltali and Sarı, 2006). The effect of the dosage on the adsorption of Zn ions was studied using adsorbent dosage 5, 10, 20, 30 gr/L. The adsorption of Zn ions increased with increased amounts of the adsorbent, and became nearly constant over 0.4 g of adsorbent (Fig. 2).
Moreover, the Zn ions adsorption was negligible at dosages higher than 0.4 g. The similar results related with the amount of zeolite were reported by Ören and Kaya (2006). Therefore, 0.4 g of adsorbent dosage was used for further experiments.

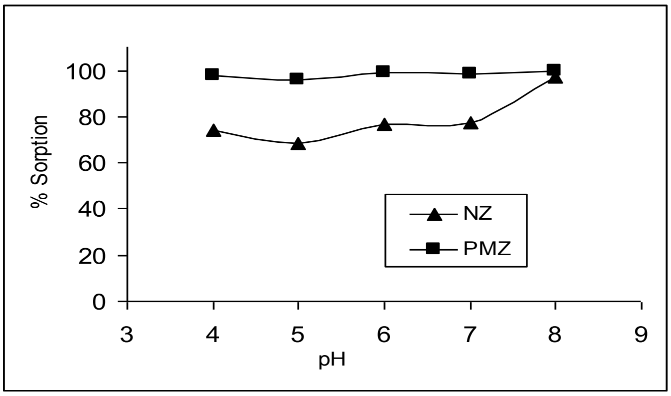

Figure 1. Effect of pH on Zn sorption by the NZ and PMZ

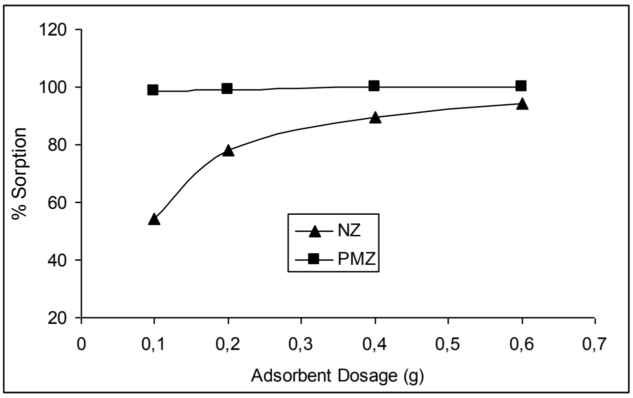

Figure 2. The effect of adsorbent dosage on % Zn sorption

Effect of the Shaking Time on Zn Sorption

The effect of shaking time on the sorption of Zn ions using the NZ and PMZ are shown Fig. 3. Sorption (%) of Zn ions increased with increasing shaking time and it reached up 80% within 24 h and became very slow with increasing of shaking time. This may be ascribed to the utilization of readily available adsorbing sites of the zeolite (Karadag et al., 2006). After shaking time of 12 h, sorption (%) of Zn ions were seen to be very slow (Fig. 3).
On the basis on these results, 24 h shaking period was selected for all further studies.

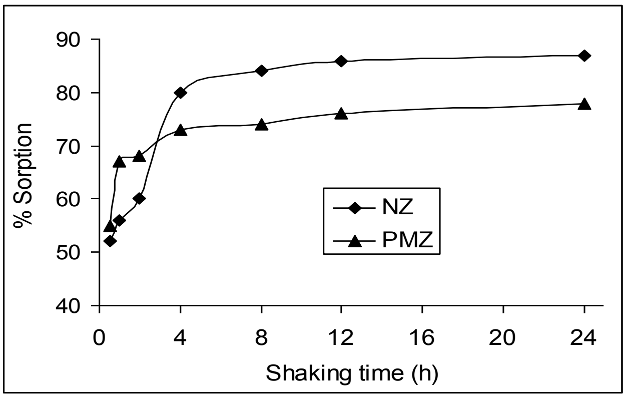

Fig. 3. The effect of shaking time (h) on % Zn sorption

Effect of Temperature on Zn Sorption

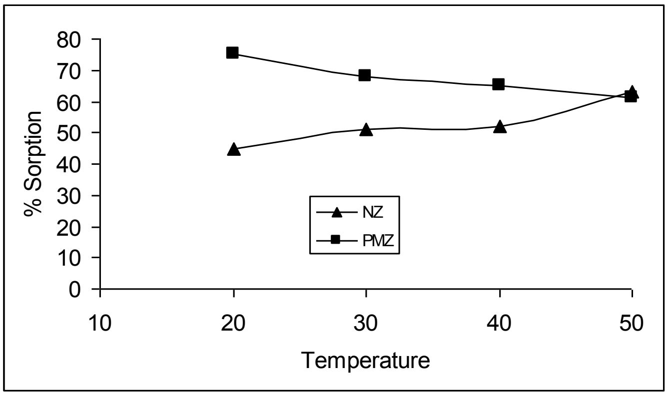

Figure 4. Effect of temperature (°C) on % Zn sorption

The effect of the temperature (20, 30, 40, and 50 ◦C) on sorption of Zn ions are presented at figure 4. The amount of Zn ions removed from aqueous solution for the NZ increased with rising temperature from 20 to 50 ◦C, but decreased for the PMZ.
The highest sorptions (%) were found to be 75 % at 20 ◦C for the PMZ, and 63 % at 50 ◦C for the NZ. A decrease in the soprtion (%) of Zn ions with the rise in temperature may be attributed to the increasing tendency to desorb from the interface to the solution (Karadag et al., 2006). On the basis on these results, 50 °C for the NZ, 20 °C for the PMZ were selected for all further studies.

Adsorption Isotherms

Several adsorption models such as Langmiur, Freundlich and Dubinin-Redushkevich (D-R) have been applied to describe the experimental isotherms data of Zn ions (Freundlich, 1906; Langmuir, 1918; Banat et al., 2000). The data were also modelled by D-R isotherm to determine the type of adsorption (physical or chemical) (Dubinin et al., 1947). The experimental data conformed to the linear form of Langmiur model (Eq. 3).

$$\frac{C_e}{q_e} = \frac{1}{kb} + \frac{C_e}{b} \tag{3}$$

Where C_e is the concentration of Zn ions in equilibrium solution (mg L^{-1}), q_e is the amount of Zn ions adsorbed (mg) by per unit mass of adsorbent (g), and the value of *b* (mg g^{-1}) and *k* (L mg^{-1}) are maximum sorption capacity of adsorbent and the adsorption energy coefficient, respectively. Fig. 5 indicates the linear plot of Langmuir isotherm over the entire concentration ranges. The correlation coefficient value was found satisfying (r^2=0.99). The maximum sorption capacity (*b*) for Zn ions were found 20.87 mgg^{-1} for NZ and 15.75 mgg^{-1} for PMZ. The obtained results were higher than in the ranges of cited values in the lireratures. For example Ören and Kaya (2006) found that b values of Gördes and Bigadic zeolites were determined 6 and 3 mg g^{-1}, respectively. Elsewhere, Trgo and Peric (2003) reported that *b* value 12 mg g^{-1} for zeolitic tuff. The higher b values in our experiment may be attributed to the easy the penetration of Zn ions into the zeolite channels and pourous as reported by Ören and Kaya (2006).

The experimental data applied to linear Freundlich isotherm, and the correlation coefficient (r^2) value of the linear plot of Freundlich isotherm for the NZ and PMZ were found 0.786 and 0.701, respectively. For the correlation coefficient (r^2) values of the linear plots were lower than 0.965, sorption data for Freundlich isotherms were not calculated.

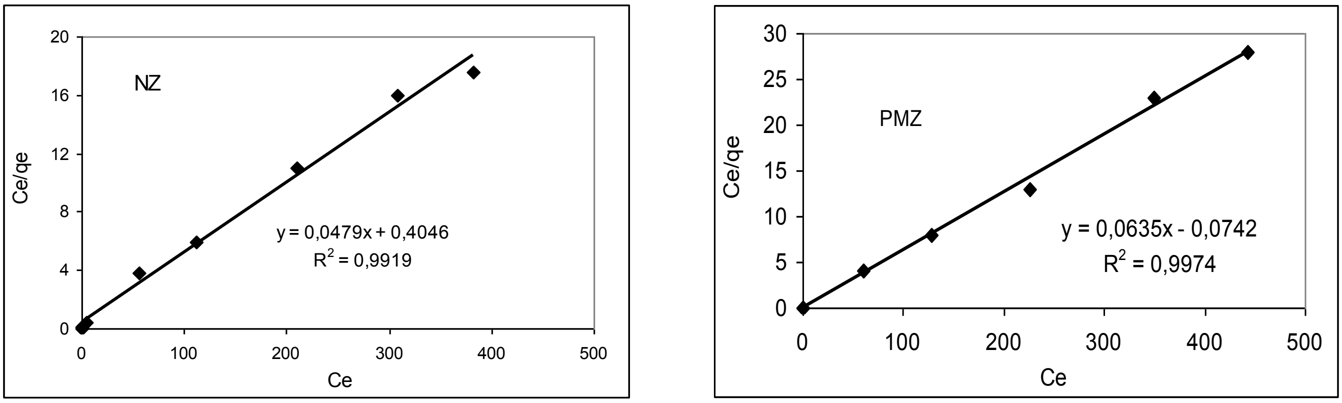

Figure 5. Langmuir isotherms of the NZ and PMZ data

The equilibrium data were also applied to the Dubinin-Redushckevich (D-R) model to determine physical or chemical processes (Dubinin et al., 1947). The linearized form of the D-R isotherm is as follows:

$$\ln q_e = \ln q_m - \beta \varepsilon^2 \tag{4}$$

where q_e is the amount of adsorbate adsorbed on per unit weight of adsorbent (mol L^{-1}), q_m represent the maximum adsorption capacity (mol g^{-1}), β is the activity coefficient related to mean adsorption energy ($mol^2 J^{-2}$) and ε is the Polanyi potential. The Polanyi potential was described using eq. 5. The mean adsorption energy (*E*; kJ mol^{-1}) was found using eq.6.

$$\varepsilon = RT \ln(1 + 1/C_e) \tag{5}$$

$$E = \frac{1}{\sqrt{-2\beta}} \tag{6}$$

Where *R* is the gas constant (J mol^{-1} K^{-1}), *T* is temperature (K), and C_e is the equilibrium concentration of the Zn ions (mol L^{-1}).

The *E* value provide information about the nature of adsorption process; chemical or physical, and its value ranges from 1 to 8 kJ mol^{-1} for physical sorption and from 9 to 16 kJ mol^{-1} for chemical sorption (Donat et al., 2005; Saltali et al., 2007). As seen in Fig. 6, the slope of the D-R plot (ln q_e vs ε^2) gives β constant and intercept of the plot yields q_m value.

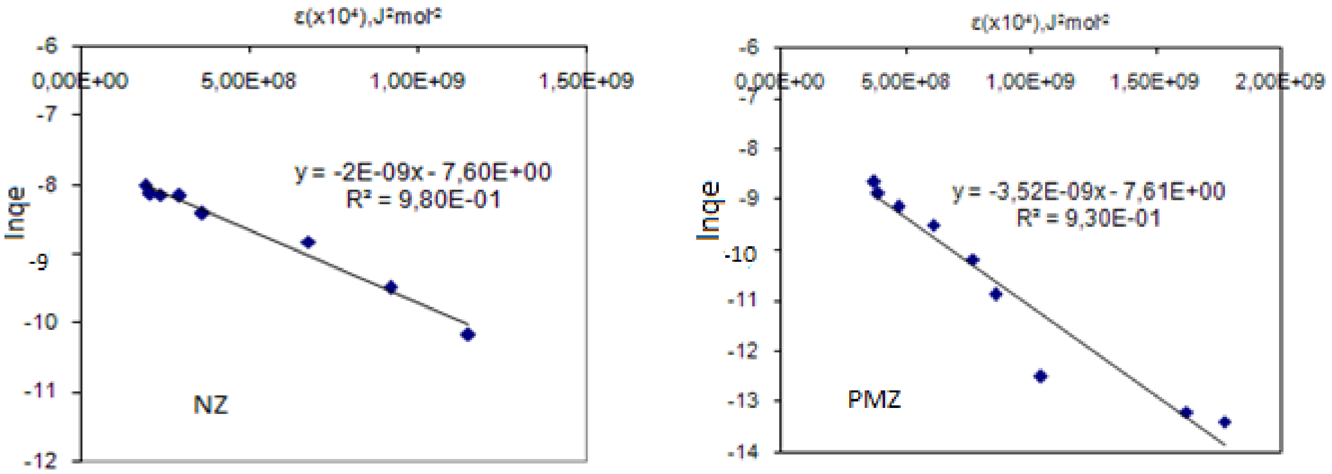

Figure 6. D-R plot of Zn ions sorption by the NZ and PMZ

E values were calculated as 15.82 kJ mol^{-1}, 11.91 kJmol^{-1} for the NZ, PMZ, respectively. The obtained values indicated that chemical sorption tendency is higher compared with physical sorption since it was in the range of 9-16 kJ mol^{-1}. This may be due to the sorbed Zn ions at inner surface of pores and channels of zeolite, and limited transfere to solution phase at normal conditions because the contribution of the external surface area to the total surface area of zeolite materials is limited (Ming ve Mumpton, 1989; Ören ve Kaya, 2006).

Thermodynamic parameters

In order to investigate the effect of temperature on the adsorption of Zn ions onto zeolite, the distribution coefficient, K_d (mL g^{-1}), was calculated at the temperature of 293, 303, 313 and 323 K by using Eq. (7) (Ho and Huang, 2002; Nibou et al., 2010).

$$K_d = \frac{q_e}{C_e} \tag{7}$$

Thermodynamic parameter, the enthalpy change ΔH^o, and the entropy change ΔS^o, was calculated from the slope and intercept of the plot of lnK_d against 1/*T*, respectively (Gonzales-Pradas et al.,1994; Demirbas et al., 2005; Nibou et al., 2010). The other thermodynamic parameter, Gibbs free energy change (ΔG^o) was calculated by using Eq (9).

$$\ln K_d = \frac{\Delta S^o}{R} - \frac{\Delta H^o}{RT} \tag{8}$$

$$\Delta G^o = -RT \ln K_d \tag{9}$$

Table 2. Thermodynamic parameters of the NZ and PMZ

Zeolite	ΔH^o (kJ/mol K)	ΔS^o (J/mol K)	ΔG^o kJ/mol			
			293°K	303°K	313°K	323°K
NZ	+11.97	83.30	-12.43	-13.26	-14.10	-14.93
PMZ	-11.48	13.32	-15.38	-15.51	-15.64	-15.78

The enthalpy (ΔH^o) value for the NZ was +11.97 kJ mol^{-1}, for the PMZ was -11.48. The pozitive ΔH^o exhibited that the adsorption of the Zn ions on the NZ was endothermic, and heat was used to transfere the Zn ions from aqueous solution onto the NZ (Sarı et al.,2007, Nibou et al., 2010, Dikici et al., 2010) as seen at figure 4. The negative ΔH^o value indicated that sorption of Zn ions by the PMZ was exothermic. The exothermic nature of the proceses showed that sorption of Zn ions onto the PMZ was favoured at low temperature (Nibou et al., 2010)

The entropy (ΔS^o) values were found to be 83.30 J mol^{-1} K^{-1} for the NZ, and 13.32 J mol^{-1} K^{-1} for the PMZ. This results implied that Zn ions in solid phase (surface of adsorbent) were in a much more chaotic distribution compared to the relatively ordered state of bulk phase (aqueous solution) (Sarı et al., 2007). The pozitive ΔS^o values suggested that complexation and stability of the sorption proceses increased, and being some structural changes at the solid-liquid interface (Donat et al., 2005)

Gibbs free energy change (ΔG^o) were calculated between -12.43 and -14. 93 -15.38 and -15.78 for the adsorption of Zn ions onto the NZ and PMZ at the temperature range of 293, 303,313 and 323 Kelvin (K), respectively. The negative ΔG^o values indicated that thermodynamically favourable and spontaneous nature for the adsorption of Zn ions onto the NZ and PMZ (Sarı et al., 2007). The ΔG^o values become high negative with increasing temperature, indicating that sorption is more favourable at high temperature, and sorption tendency of the Zn ions by the NZ increased with increasing temperature (Nibou et al., 2010), especially for the NZ as can be seen from figure 4.

Conclusion

The optimum sorption characteristics of the natural (NZ), physically modified zeolite (PMZ) were also determined using batch type adsorption experiments. The maximum adsorption capacities (*b*) of the Langmuir model were calculated as 20.87 and 15.75 mgg^{-1} for the NZ and the PMZ, respectively. Dubinin-Redushkevich (D-R) isotherms showed that the chemical sorption tendency is higher compared with physical sorption. Thermodynamic parameter, the change of Gibbs free energy (ΔG^o), ranged between -12.43 and -14.93 kJ/mol for the NZ, between -15.38 and -15.78 kJ/mol for the PMZ, for the studied temperatures. The negative values of ΔG^o indicate that the sorption of Zn onto the studied adsorbents was feasable and spantaneous. However, it was found that maximum sorption capacity of zeolitic material decreased with physical modification. From the obtained data, the NZ may be recommended for using as environmental and agricultural purposes.

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References

Amonette, J.E., Bleam, W.F., Schulze, D.G., Dixon, J.B. (Eds.) 2002. Soil Mineralogy with Environmental Applications, SSSA Book Series:7, Madison, WI, pp. 585–610

Ataman, G. 1977. Batı Anadolu Zeolit Oluşumları, Yerbilimleri, 3, 85–95.

Banat, F.A., Al-Bachir, B., Al-Asheh, S., Hayaajneb, O. 2000. Adsorption of phenol by Bentonite. Environmental Pollution 107,391-398.

Chiou, C. T.; Rutherford, D. W.; Manes, M. 1993. Sorption of N_2 and EGME vapors on some soils, clays, and mineral oxides and determination of sample surface areas by use of sorption data. Environ. Sci. and Tech. 27,1587 - 1594

Chlopecka, A., Adriano, D.C. 1997. Influence of zeolite, apatite and Fe-oxide on Cd and Pb uptake by crops, Sci. Total Environ. 207, 195–206.

Demirbas, A., Pehlivan, E., Gode, F., Altun, T., Arslan, G. 2005. Adsorption of Cu(II), Zn(II), Ni(II), Pb(II), and Cd(II) from aqueous solution on Amberlite IR-120 synthetic resin, J. Colloid Interface Sci. 282,20–25.

Dikici,H., Saltali, K., Bingölbalı, S. 2010. Equilibrium and kinetics characterisrics of copper (II9 sorption onto gyttja. Bull Environ Contam Toxicol. 84,147-151

Donat, R., Akdogan, A., Erdem, E., Cetisli, H. 2005. Thermodynamics of Pb and Ni adsorption onto natural bentonite from aqueous solution, J. Col. Int. Sci. 286, 43–52.

Dubinin, M.M., Zaverina, E.D., Radushkevich, L.V. 1947. Sorption and structure of active carbons. I. Adsorption of organic vapors, Zhurnal Fizicheskoi Khimii, 21, 1351–1362.

Freundlich, H.M.F. 1906. Uber die adsorption in losungen, Zeitschrift fur Physikalische Chemie (Leipzig) 57A 385–470.

Gonzales-Pradas, E., Villafranca-Sanchez, M., Canton-Cruz, F., Socias- Viciana, M., Fernandez-Perez, M. 1994. Adsorption of cadmium and zinc from aqueous solution on natural and activated bentonite, J. Chem. Tech. Biotech. 59, 289–295.

He, Z.L., Calvert, D.V., Alva, A.K., Li, Y.C., Banks, D.J. 2002. Clinoptilolite zeolite and cellulose amendments to reduce ammonia volatilisation in a calcareous sandy soil, Plant Soil 247, 253–260

Ho, Y.S., Huang, C.T., Huang, H.W. 2002. Equilibrium sorption isotherm for metal ions on tree fern, Process. Biochem. 37, 1421–1430.

Karadag, D., Koc, Y., Turan, M., Armagan, B. 2006. Removal of ammonium ion from aqueous solution using natural Turkish clinoptilolite, J. Haz. Mat., 136, 604-609

Langmuir, I. 1918. The adsorption of gases on plane surfaces of glass, mica and platinium. J. American Chemical Society, 40,1361-1403.

Ming, D.W., Mumpton, F.A. 1989. Zeolites in Soils. In Dixon, J.B.and.Weed, S.B (Co-Eds.), Mineral Soil Environment, SSSA Pub. Inc., Madison,WI.

Nibou, D., Mekatel, H., Amokrane, S., Barkat, M., Trari, M. 2010. Adsorption of Zn^{2+} ions onto NaA and NaX zeolites: kinetic, equilibrium and thermodynamic studies. J. Haz. Mat. **173**, 637–646

Ören, A.H., Kaya, A.. 2006. Factors affecting adsorption characteristics of Zn on two natural zeolites. Journal of Hazardous Materials B 131, 59-65.

Saltali, K., Sarı A., Aydın, M. 2007. Removal of ammonium ion from aqueous solution by natural Turkish (Yildizeli) zeolite for environmental quality. Journal of Hazardous Materials B 141(1), 258-63.

Sarı, A., Tuzen, M., Demirhan, C., Soylak, M. 2007. Adsorption characteristics of Cu and Pb onto expanded perlite from aqueous solution. J.Haz. Mat.148, 387-394

Sarioglu, M. 2005. Removal ammonium from municipalwastewater using natural Turkish (Dogantepe) zeolite, Sep. Purif. Technol. 41, 1–11.

Trgo, M., Peric, J. 2003. Interaction of the zeolitic tuff with Zn-containing simulated pollutant solutions. Journal of Colloid and Interface Science 260(1), 166-175.

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The effect of soil hysteresis and compaction on calibration curve of gypsum block

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Abstract

The content and soil moisture capacity depends upon various factors such as soil compaction. On the other hand, moisture hysteresis has great effect on moisture behavior of soil. In the current study, the effect of hysteresis and soil compaction on calibration curve of gypsum block was investigated. To do this, calibration curve of a gypsum block in one heavy soil (Silty Clay) in three bulk density (natural in the farm and plus 10% and minus 10%) for two phases of wetting and drying were provided. The results showed that block calibration curve was different in two phases of wetting and drying in different densities. The effect of moisture hysteresis on calibration curve of gypsum block is increased by reducing soil compaction (reducing of bulk density). This is due to the fact that by reducing soil compaction and because of heavy texture of soil, the fine pores - reduced and distribution of soil pores will be more non-uniform. Thus, considering the effect of ink bottle, hysteresis -increased. The effect of soil compaction on gypsum block calibration curve is reverse during drying and wetting such that for specific soil moisture during drying phase, with increasing soil compaction, the electric resistance of the block - reduced. While, increasing of soil compaction during wetting phase increased the electrical resistance of the block.

Keywords: Gypsum Block, Hysteresis, Soil Compaction, Soil Moisture, Bulk Density

Introduction

The relations between soil and water are complex. Being informed of these relations is of great importance in various issues of irrigation and drainage (Abasi, 2008). For example, soil moisture characteristic curve is the most important physical characteristics of soil. It shows the relationship between suction (matric potential) and soil moisture. Some of the effective factors on soil moisture characteristic curve are hysteresis, soil structure, porosity, form of soil pores, soil compaction, temperature and the soil mineral materials (Abasi, 2008). The slope of soil moisture characteristic curve is mild because in heavy soils, the distribution of soil pores is more uniform and most of the moisture is absorbed by soil particles surface but in coarse soils due to coarse pores, great part of moisture is emptied in a specific suction suddenly and the characteristic slope is getting steep (Mirzakhani, 2004; Baybordi, 2005; Abasi, 2008). Moisture characteristic curve in low suctions is greatly dependent upon soil structure but in strong suctions due to the increase of adsorption is mostly affected by soil texture (Mirzakhani, 2004, Baybordi, 2005; Abasi, 2008). Hysteresis defines that soil behavior is not equal during the advance of a process with its behavior during the return of the same process (Alizadeh, 2011). In equilibrium state in definite suction, soil moisture during the dryness is more than the wetting phase

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and then, soil characteristic curve in dryness is above the related curve in wetting phase. This means that during drainage, water is kept in soil with more force. Generally, hysteresis reasons are as follows (Hillel; 1981; Bayboridi, 2004; Mirzakhani, 2004; Barzegar, 2004; Baybordi, 2005; Alizadeh, 2011):

1- Heterogeneity of soil pores is called ink bottle. Matric potential (suction) of soil during dryness is compatible with the fine pores of soil and during wetting phase is compatible with the radius of coarse pores and as these two values are different, dewatering process is not compatible.
2- The influence of water contact angle with soil, in which contact angle during water adsorption is greater than contact angle during dryness.
3- Retained air reducing the soil water capacity.
4- Expansion and contraction of clay particles affecting the soil structure and the deformation of soil pores.

It can be said that among the above factors, the first factor has great importance in creating hysteresis (Baybordi, 2005). Prunty and Bell (2007) showed that in low moistures that little change in the moisture leads into considerable change of soil matric potential, moisture hysteresis is of great importance and then, it should be considered in soil physics issues. Ball and Robertson (1994) showed that moisture hysteresis is more observed in ploughed soils than natural soil. Baybordi (2005) believed that hysteresis is effective on moisture amount measured by gypsum block.

One of the effective factors on the content and soil moisture capacity is soil compaction being evaluated in agricultural land with bulk density index. Soil compaction can be effective on soil structure and soil matrix potential (for a specific moisture). In other words, soil compaction can affect intensity of hysteresis.

There are various methods and tools to measure the moisture and potential of soil matrix. One of the easiest methods is gypsum block (Durner and Or, 2006). Qanadzadeh et al (2009) in a study evaluated five kinds of gypsum blocks. The blocks were different based on the type of gypsum and the composition of various values of gypsum and cement. The results showed that the blocks made of the composition of gypsum and cement had significant correlation with the moisture of soil.

Ghahreman et al (2009) by calibration of gypsum block in three textures of soil (sandy loam, loam and clay loam) and in five levels of salinity of soil saturation extract (ignorable, 2, 6, 10, 18 dS/m) presented some equations to correct the read of gypsum block and removing the effect of salinity.

Malazian et al. (2011) evaluated the performance of the MPS-1 sensor by testing for a wide range of varying soil conditions, including temperature and hysteresis. The results showed that hysteresis had little influence on the performance of sensor in measuring the soil matric potential.

Alizadeh et al (2009) evaluated the effect of soil compaction and texture (sand, loam and clay) on the accuracy of Teta probe. The results showed the device in sand soil had the highest accuracy and by increasing the amount of clay, the accuracy of the device is reduced. The effect of soil compaction on the accuracy of the measurements in sand soil was ignorable and by heavy soil texture, the effect of soil compaction on the accuracy of device is increased.

This study was done for investigation of the soil compaction on hysteresis and effect of hysteresis and soil compaction on the performance of gypsum blocks.

Material and Methods

In this study, the experiment was done in a heavy texture soil in three bulk density (natural in the farm and plus 10% and minus 10%) and for two phases of wetting and drying. To do this, bulk density of natural soil was measured in farm (sampling location) with the value 1.2 gr/cm^3. Soil texture (Silty Clay) was determined by hydrometer method (Anonymous, 2009).

Based on the soil bulk density, the moisture of soil and vase volume, soil mass being poured in the vase was calculated. This soil mass was poured as 5 cm layers inside the vase such that specific bulk density was obtained.

After putting the gypsum block in the vase, the measurement of soil moisture by weighting method and block reading was done consecutively. At first, the test was carried out during drying phase and then without taking the soil and block out of the vase, it was done wetting process. During drying process, in the interval of both consecutive readings, the vase was put for 24 to 48 hours exposed to in the open atmosphere (to reduce moisture) and by putting the plastic cover on soil surface, it was put in the shade (to make the moisture distribution in vase more uniform). Also, during wetting process, after adding water to vase, besides putting the plastic cover on soil surface, the vase was put for 24 hours in the shade.

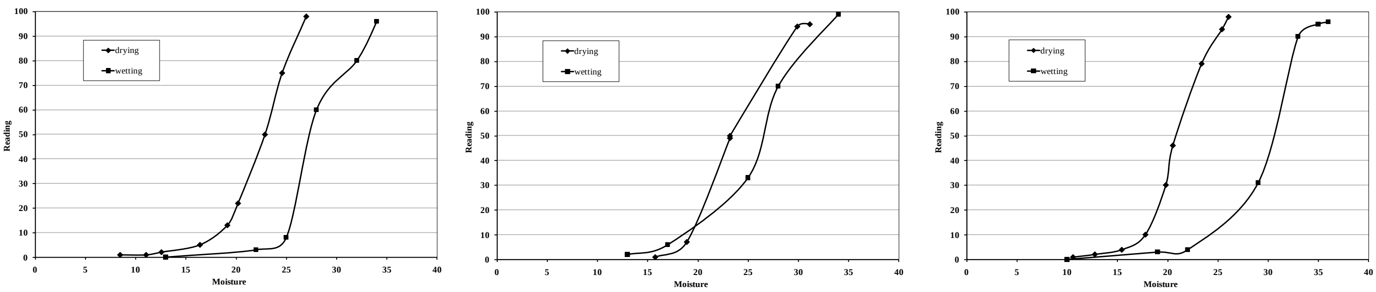
The experiment was carried out in three bulk density including natural bulk density in the soil and plus 10% and minus 10%. In this study, gypsum block model 5201F1L and reader model 5910F1 were applied. This reader showed the value of electric resistance of the block as zero to 100 indexes (zero for dry block with the maximum electric resistance and 100 for saturation block with the minimum electrical resistance).

Results and Discussion

Calibration curve of gypsum block is shown in two stages of drying and wetting in various compactions in Fig 1. As is shown in this figure, hysteresis has considerable effect on calibration curve of gypsum block. Like the moisture characteristic curve, calibration curve of the block during drying is above the related curve in wetting phase and its reason is explained in the previous section.

The effect of hysteresis on calibration curve of gypsum block is increased by decreasing soil compaction (the reduction of soil bulk density). This is due to the fact that by reducing soil compaction and because of soil heavy texture, the fine pores are reduced and in other words, soil pores distribution gets non-uniform. Thus, considering the effect of ink bottle, hysteresis is increased. Because of this, by increasing soil bulk density, due to the uniform distribution of the pores, calibration curve of gypsum curve in two phases of drying and wetting gets closers.

Calibration curve of gypsum block in various bulk densities during drying and wetting is shown in figures 2 and 3, respectively. The results show that the effect of soil compaction on calibration curve of gypsum block during drying inverse is in wetting stage and this is due to moisture hysteresis. As is shown in figure 2, during drying as a definite soil moisture by increasing soil bulk density (soil compaction), the electrical resistance of the block is reduced while in accordance with figure 3, during wetting, as a definite soil moisture, by increasing soil bulk density (soil compaction), electrical resistance of the block is increased. It can be said that in equilibrium conditions, matric potential of gypsum block and the surrounding soil are equal. According to the effect of ink bottle, matric potential of soil during moisture removing is in conformity with the radius of fine pores of soil and during dewatering is in conformity with the radius of coarse pores of soil. As by increasing soil compaction, the volume of coarse pores of soil is reduced and volume of fine pores of soil are increased, increasing soil compaction causes that during drying process, soil matric potential is decreased less. Thus, gypsum block absorbs more moisture and shows less electrical resistance. While increasing soil compaction caused that during wetting, soil matric potential is reduced considerably. Thus, gypsum block absorbed less moisture from the soil and showed more electrical resistance.



(a) (b) (c)

Fig 1: The block calibration curves in the natural soil (a) and compacted soils: 10% plus (b) and 10% minus (c)

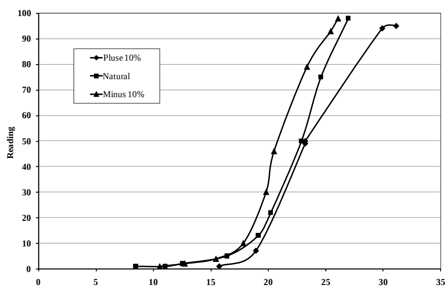


Fig 2: Calibration curve of block in various compactions during drying stage

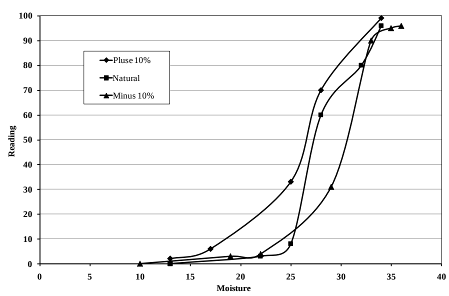


Fig 3: Calibration curve of block in various compactions during wetting stage

Conclusion

In the current study, the effect of hysteresis and soil compaction on calibration curve of gypsum block was investigated. The results showed that block calibration curve was different in two phases of wetting and drying in different densities. The effect of moisture hysteresis on calibration curve of gypsum block is increased by reducing soil compaction (reducing of bulk density). This is due to the fact that by reducing soil compaction and because of heavy texture of soil, the fine pores are reduced and distribution of soil pores will be more non-uniform. Thus, considering the effect of ink bottle, hysteresis is increased. The effect of soil compaction on gypsum block calibration curve is reverse during drying and wetting such that for specific soil moisture during drying phase, with increasing soil compaction, the electric resistance of the block is reduced. While, during wetting phase by increase of soil compaction, the electrical resistance of the block is increased.

References

[1] Abbasi F. 2008. Advanced Soil Physics. *University of Tehran Press*, 1th Edition. (In Persian)

[2] Alizadeh A. 2011. Soil, Water, Plant Relationship. *Ferdowsi University of Mashhad*. 10h Edition. (In Persian)

[3] Alizadeh, H.A.; M. Nouri Mohammadieh and A. Liaqhat. 2009. The investigation of the effect of compaction and soil texture on the accuracy of measuring the moisture by Teta probe device. *Iranian water research journal*. No. 4, Pages 19-29.

[4] Anonymous. 2009. Guidelines for Laboratory Analysis of Soil and Water Samples. *Vice Presidency for Planning and Supervision*, No. 467. (In Persian)

[5] Ball B.C. and E.A.G. Robertson. 1994. Effects of soil water hysteresis and the direction of sampling on aeration and pore function in relation to soil compaction and tillage. *Soil and Tillage Research*, Volume 32, Issue 1, Pages 51-60.

[6] Barzegar A.R. 2004. Advanced Soil Physics. *Shahid Chamran University Press*, 2th Edition. (In Persian)

[7] Baybordi M. 2004. Soil Physics. *University of Tehran Press*, 7th Edition. (In Persian)

[8] Baybordi M. 2005. Principles of Irrigation Engineering (Vol. 1: Soil- Water Relationship). *University of Tehran Press*, 8th Edition. (In Persian)

[9] Durner W. and D. Or. 2006. Soil Water Potential Measurement. DOI: 10.1002/0470848944.hsa077a, Book Title: *Encyclopedia of Hydrological Science*s, John Wiley & Sons, Ltd.

[10] Ghahraman B., K. Davary, A.R. Astaraii, M. Majidi and S. Tamssoki. 2009. Correction of Gypsum blocks readings due to salinity effects for soil moisture content measurements. *Journal of Water and Soil*, Vol. 23, No. 1, Pages 69-78.

[11] Ghanadzadeh, M.A.; K. Davary and B. Ghahraman. 2009. The evaluation of various buildings of gypsum block to determine soil moistsure. *Iranian water research journal*. No. 3, Pages 23-32.

[12] Hillel D. 1981. Introduction to Soil Physics. *Academic Press*, INC.

[13] Malazian A., P. Hartsough, T. Kamai, G.S. Campbell, D.R. Cobos, J.W. Hopmans. 2011. Evaluation of MPS-1 soil water potential sensor. *Journal of Hydrology*, Volume 402, Issues 1–2, Pages 126-134.

[14] Mirzakhani R. 2004. Introduction to Soil Physics. *Academic Press Center*, 1th Edition. (In Persian)

[15] Prunty L. and J. Bell. 2007. Soil Water Hysteresis at Low Potential. *Pedosphere*, Volume 17, Issue 4, Pages 436-444.

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Mineralogy, geochemistry and microorganism biodiversity of anthroposoils and the application of selected autochthonous species of microorganisms in bioleaching processes of contaminated substrates (ashy soils)

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Abstract

Soils and buried coal-combustion ashes on the model contaminated site contain high concentrations of arsenic, that is present mainly in the finest fraction of the studied samples. Amorphous aluminosilicate glasses represent dominant component of solid samples and are a major As-binding phase. Arsenic is incorporated in aggregates of nanoparticles composed by Al, Si, Ca, Fe. In case of static and dynamic leaching with aqueous solutions, arsenic extractability from solid matrix is relatively low (approximately 4,8 %). Significantly higher proportion of As was released by fungal bioleaching using *Aspergillus niger* (17 %). For the study of bioleaching processes, species diversity of contaminated soils with focus on microscopic filamentous fungi and bacteria was defined. Identified species of microscopic fungi of soil substrates were *Alternaria* sp., *Aspergillus niger*, *Cladosporium* sp., *Mucor* sp., *Mycocladus* sp., *Paecilomyces* sp., *Penicillium* sp., *Rhizopus stolonifer* var. *stolonifer*, several species of the genus *Trichoderma* and bacterial strains of the genus *Pseudomonas*, *Rhodococcus*, *Bacillus* and *Streptomyces*.

Keywords: Contamination, arsenic, mineralogy, microorganisms, bioleaching, remediation

Introduction

Model locality, Zemianske Kostoľany (region of Upper Nitra), belongs to the one of the most contaminated sites in Slovakia because of negative influence of mining and industrial activities. In 1965, the dam of one of the ponds failed and 3 million of As-rich ash material were released onto the surrounding environment of the Nitra river and thus contaminating up to 20 km of mostly agricultural land. In the 1970s, instead of remediation polluted area was covered by a 40 - 60 cm thick layer of agricultural soil. Polluted area has been used since then as fields or meadows. During the annual plowing of the agricultural soils, the latter resulting in regular mixing of the uppermost portions of the 1965 ashes with the soils. From the long-term point of view, Zemianske Kostoľany represents model locality with the potential source of contaminants in the environment - particularly arsenic. In some sampling sites, total arsenic content is higher than 1500 ppm[1, 2, 3, 4]. The major

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goals of this study were mineralogical characterization of selected samples of coal-combustion ash buried under agricultural soil, evaluation of arsenic solubility in water, isolation and identification of bacterial and fungal diversity from As-rich soil for the purpose of their potential use in soil remediation and assessment of arsenic bioleaching potential of the selected species..

Material and Methods

Different kinds of samples for mineralogical and microbiological study were collected from several various agricultural sites treated with arsenic-rich anthropogenic sediments in the vicinity of Zemianske Kostoľany during period 2008 - 2012. Coal-combustion ashes buried under agricultural soil as well as agricultural soils were taken from an area of approximately 2 km^2 below the active ash pond, about 500 m downstreams from current dam. Combination of methods, including scanning electron microscopy (SEM), backscattered electron microscopy (BSE), energy dispersive spectroscopy (EDS), wavelength dispersive spectroscopy (WDS), transmission electron microscopy (TEM) and X-ray powder diffraction analysis were used to characterize the main mineral phases in ash samples. Water extractable percentages of As was determined by single extraction with water from the first step of sequential extraction procedure by Shiowatana et al.[5] and from the column experiment that lasted 3 days. For microbiological study a serial dilution of the representative samples (10 g of fresh ashy-soil substrate) was made using sterile distilled water until a dilution of 10^{-10} was obtained. 1 ml of this dilution was inoculated on different types of nutrient agar (SAB, MEA, PDA, MPA1, MPA2, PSA, TSA). Morphologically and color different bacterial and fungal colonies were picked and isolated after purification process on the same medium and maintained as pure culture for a further study. Twenty-four bacterial isolates were chosen for further identification by 16S rDNA sequence analysis. Isolated microscopic fungi species were identified on the basis of macro and micromorphological structures. Species *A. niger*, *P. putida* and *P. chlororaphis* were chosen for further study of bioleaching. It was weighed 1 g of soil substrates in five replicates into the Erlenmeyer flasks. It was added 95 ml of liquid medium (SAB, TSM or B1) and 5 ml of inoculum. Biomass was filtered after 29 days of cultivation.

Results and Discussion

Mineralogical study

Selected studied samples consist mainly of Si, Fe, Al and Ca. Also concentration of Mg, K, Na, Ti and S is high. Content of As is in the range from 714 to 1859 $mg.kg^{-1}$ and is highest in fraction under 25 µm. Amorphous aluminosilicate glasses are the most common phases present in the sample (74 % in average), also common are quartz, calcite, mullite, plagioclases, hematite and magnetite. Cristobalite, rutile, white micas, pyrrothite, pyrite, montmorillonite and perovskite were also identified. Amorphous aluminosilicate glasses are characteristic by highly variable content of Si, Al, Ca and Fe and are able to accumulate wide range of elements and are the main phases accommodating As. Less commonly occurring unburned coal particles are the second phase with the ability to absorb As. According to transmission electron microscopy with EDS in the finest fraction is As incorporated in aggregates of nanoparticles composed by Al, Si, Ca, Fe, less commonly in Fe, Ca phases. The dominant primary As carriers are the Si-rich glasses, simply because their proportion (up to 86.0 vol. %) greatly exceeds the proportion of the Ca- or Fe-dominant glasses. Quantitative analysis of the abundance of glasses has been carried out previously[3]. Results from static and dynamic system of arsenic leaching with water showed that As is released after a short contact with water (under 5 % of total As content). Thus the water-soluble As reservoir has not been exhausted and there is potential to contaminate the surrounding environment. This reservoir is slowly replenished as the glasses devitrify and decompose. Although proportions of water-soluble arsenic were relative low, they exceeded the maximum permissible level in drinking water (10 $µg.l^{-1}$)[6].

Microbiological study

Relative abundance of bacterial taxonomic groups based on PCR analysis was: majority (62.50 %) of the identified bacteria belonged to the *γ-Proteobacteria* followed by *Firmicutes* (20.80 %), *Actinobacteria* (8.30 %) and *Bacteroidetes* (8.30 %). There were identified 12 species: *Pseudomonas* sp., *P. chlororaphis*, *P. putida*, *P. baetica*, *P. reinekei*, *B. cereus*, *B. pumilus, Rhodococcus erythropolis* and *Streptomyces* sp. Three out of 24 identified isolates were hard culturable microorganisms belonging to the genera *γ-Proteobacteria* and *Firmicutes.* In some cases it was found more bacterial species in substrates with a higher arsenic content than in the samples with a lower arsenic content. Some species of fungi were identified from the selected soil substrates, e.g. *Alternaria sp.*, *Aspergillus niger*, *Cladosporium* sp., *Mucor* sp., *Mycocladus* sp., *Paecilomyces* sp., *Penicillium* sp., *Rhizopus stolonifer* var. *stolonifer* and several species of genus *Trichoderma.*

Fungal diversity of the Upper Nitra region was also studied by Beňová[7]. In the studied substrates (coal dust from mine in Nováky and sedimentation basin in Zemianske Kostoľany) dominated mainly species of the genus *Aspergillus*, *Paecilomyces*, *Penicillium* and *Trichoderma.* In the coal dust there were also identified *Alternaria* sp., *Cladosporium cladosporioides*, *Doratomyces* sp., *Scopulariopsis brevicaulis*, *Stachybotrys chartarum*, *Trichurus* sp.. From sedimentation basin were isolated *Absidia* sp., *Aureobasidium* sp., *Umbelopsis nana*, *Mucor* sp., *Mycelia sterilia* and *Zygorhynchus heterogamus*.

Bioleaching and comparison of leaching efficiencies of arsenic by selected strains of bacteria (*P. chlororaphis, P. putida*) and microscopic filamentous fungus (*A. niger*) were examined in this study [8, 9, 10]. Selected species of microorganisms were isolated from the upper horizont of the studied contaminated soils. Total arsenic content in the studied samples was in range from 93 to 634 ppm. Concentrations exceed limit values for agricultural land several times. Aplicating *A. niger* to the substrates 17,04 % of As was removed by autochthonous microflora together with the strain *A. niger*. Leaching by *P. putida* and autochthonous microflora was removed 9,23 % of total As content and 5,62 % of As was released through application of *P. chlororaphis*. Results showed that bioleaching by *A. niger* had the highest leaching efficiencies of arsenic in comparison with bacterial species (**Fig. 1**).

In some cases were the amounts of released arsenic higher in control samples (samples contained only solid substrate and liquid medium) than in the leachates that were enriched in the inoculated strain. Growth phase of indigenous strains was supported by adding nutrients in the form of nutrient medium. Due to their abundance and adaptation abilities in the presence of arsenic and its toxic effect they were more efficient in arsenic leaching.

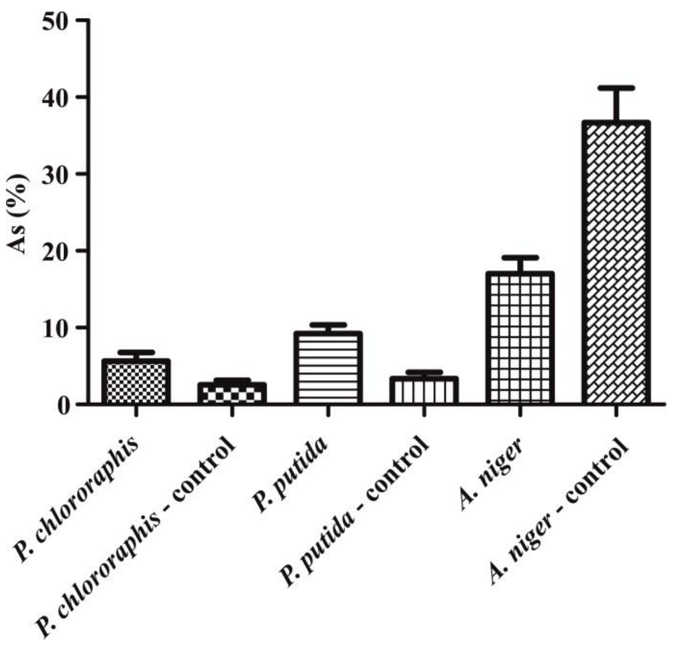

Fig. 1 Efficiences of arsenic bioleaching (%) by selected species of microorganisms (average values).

Conclusion

Soil microorganisms (bacteria and fungi) play key role in the environmental fate of arsenic by mechanisms affecting transformations between soluble and insoluble, as well as toxic and nontoxic forms. Experiments carried out under laboratory conditions showed that it was released 5,62 – 17,40 % of total arsenic content through bioleaching by selected species of microorganisms. Since contaminated site Zemianske Kostoľany is an old burden, long-term exposure and selective pressure of high concentrations of arsenic induced the formation of the adapted autochthonous microflora. Soil biodiversity of culturable microorganisms from soil samples is favourable finding with respect to the possibility of the application of biological processes in the remediation. Proven ability of selected microorganism strains predetermine their using in modern biotechnological process for remediation of As-contamination sites.

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References

1) Jurkovič, Ľ., Hiller, E., Veselská, V., Peťková, K., 2011. Arsenic Concentrations in Soils Impacted by Dam Failure of Coal-Ash Pond in Zemianske Kostolany, Slovakia. Bulletin of Environmental Contamination and Toxicology. 86,4, 433-437.

2) Peťková, K., Lalinská-Voleková, B., Jurkovič, Ľ., Veselská, V., 2011. Chemické a minerálne zloženie elektrárenských popolov (lokalita Zemianske Kostoľany). Mineralia Slovaca. 43, 4, 377-386.

3) Bolanz, R.M., Majzlan, J., Jurkovič, Ľ., Göttlicher, J., 2012. Mineralogy, geochemistry, and arsenic speciation in coal combustion waste from Nováky, Slovakia. Fuel. 94, 125-136.

4) Veselská, V., Majzlan, J., Hiller, E., Peťková, K., Jurkovič, Ľ., Ďurža, O., Voleková-Lalinská, B., 2013. Geochemical characterization of arsenic-rich coal-combustion ashes buried under agricultural soils and the release of arsenic. Applied Geochemistry. 33, 153-164.

5) Shiowatana, J., McLaren, R.G., Chanmekha, N., Samphao, A., 2001. Fractionation of arsenic in soil by a continuous-flow sequential extraction method. J. Environ. Qual. 30, 1940-1949.

6) Governmental Order No. 296/2005 Coll. which sets up requirements on quality and qualitative objectives of surface waters and limit values of pollution from waste waters and special waters.

7) Beňová, A., 2004. Mycologic analysis of selected localities in Horná Nitra region affected by mining industry. Phytopedon. 1, 3, 49-52.

8) Vojtková, H., Janulková, R., Švanová, P., 2012. Physiological aspects of metal tolerance in *Pseudomonas* bacteria isolated from polluted sites in Ostrava, Czech Republic. 12th International Multidisciplinary Scientific GeoConference SGEM 2012 – volume IV: 17. – 23. 6. 2012. Bulgaria: Albena, 2012, 177-183.

9) Peťková, K., Šimonovičová, A., Jurkovič, Ľ., Čerňanský, S., Molnárová, M., 2012. Experimentálna aplikácia identifikovaných mikroskopických húb v procese biolúhovania pochovaných sedimentov (Zemianske Kostoľany). Geochémia 2012, ŠGÚDŠ, 135-138.

10) Peťková, K., Jurkovič, Ľ., Šimonovičová, A., Čerňanský, S., 2013. Potential of *Aspergillus niger* in bioremediation of contaminated soils. 13th International Multidisciplinary Scientific GeoConference SGEM 2013 – vol. 1, Bulgaria: Albena, 757-763.

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Arbuscular mycorrhizal fungal communities associated with roots of wheat (*Triticum aestivum* L.) under long-term organic and chemical fertilization regimes in Mediterranean Turkey

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Abstract

Arbuscular mycorrhizal (AM) fungi are major members of soil fungi symbiosis with most of plants and could promote their nutrient absorption. However, little information has been available regarding AM fungal association with crops in semi-arid areas such as southern Mediterranean Turkey where soil productivity is low due to unfavorable climatic effects and soil characteristics. We, therefore, investigated AM fungal community structures under different fertilizer managements (chemical fertilization [CF], farmyard manure [FM], plant compost [PC] and mycorrhiza-inoculated compost [PCMy], no fertilizaztion [CO]) examined with crop rotation of wheat (*Triticum aestivum L.*) and maize (*Zea mays L.*) in a long-term field experiment established in , Adana Region, Mediterranean Turkey, in 1996. Soil samples were collected in June 2009 during a wheat cropping season. To elucidate AM fungal flora, total DNA were extracted from fine wheat roots and 257 partial sequences of the nuclear ribosomal large subunit (LSU) RNA genes were determined. CO had the highest AM fungal diversity, recording the lowest diversity in FM plot. Although AM fungal diversity varied with treatments, AM fungal communities under organic treatments (FM, PC and PCMy) were relatively similar. AM fungal diversity under CO and CF tended to be different from those of organic treatments. PC and PCMy induced higher AM fungal diversities and richness than the FM treatment, although the AM fungal communities of organic treatments them were similar. It was suggested that plant compost can contribute the AM fungal diversity better than chemical fertilizers and farmyard manure do. The AM fungal species applied with PCMy were not dominant in PCMy treated plot except for genus *Rhizophagus*. These results strongly suggest that the inoculated AM fungal species could easily be replaced by endogenous ones which are well-adapted to the environments.

Keywords: Arbuscular mycorrhizal fungi, Entisols, Long-term organic and inorganic fertilization effect, Molecular diversity, Southern Mediterranean Turkey, *Triticum aestivum* L.

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Fertilization systems impact on crop rotation productivity and heavy metals content in shallow sod-podzolic loamy soil and winter rye grain

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Abstract

Field study of organic, mineral and complex fertilization systems was fulfilled on experimental plots of Perm Agricultural Scientific Research Institute in 2002-2010 years. Average yields in fifth rotation varied from 2831 to 3859 FU as influenced by fertilization systems. All studied systems provided yields raising compared with control treatment (no fertilizers). Essential advantage of complex fertilization systems, guaranteed humus, mobile phosphorus and potassium content raise, was determined. The maximum yields, but minimum crop returns were obtained from combination of manure total rate 160 t ha^{-1} within rotation and equivalent mineral fertilizers application (fertilizers rates are defined according the nutrients quantity in FYM). The highest crop returns were gained after mineral fertilizers application. Mineral fertilizers and FYM may be the sources of heavy metals soil contamination. The essential pollution by heavy metals of agricultural product and soil was not noted in given studies after long-term (about forty years) manure and mineral fertilization.

Keywords: fertilization system, FYM, crop rotation productivity, heavy metals content.

Introduction

The main problem of modern husbandry is the preservation and increasing of soil fertility, as well-being base of any country and whole of mankind on our planet (Mineev, 2008). Dominant part of arable lands in Perm Region (69 %) set on sod-podsolic soils defining by poor natural fertility. Systematic and complex fertilization of these soils proved to be the compulsory condition of any crop high yields (Petuchov, et al., 1964; Nydin , et al, 1967) . Even on the cultivated sod-podsolic soils considerable decline of grain yields and phosphorus and potassium available forms in soil were observed without fertilizers application (Voytovich, et al., 1990).

Long application of fertilizers together with their positive impact on agricultural crops productivity and soil fertility has also negative influence on the agricaltural biocenoses, caused by heavy metals accumulation in soils and vegetative production (Ramad, 1981; Alexeev, 1987; Obuchov et al, 1992; Ladonin, 1997; Mineev, et al., 1999). However, such fears are not always justified. Results of long-term field experiments in Leningrad Research Institute (Nebolsin et al., 2005; Yakovleva, 2009) show that farming impact in soils pollution by heavy metals is insignificant (1 - 2 %).

The objective of given experimental work is to compare the influence of long-term application of various fertilizers systems on arable crops yields, fertility of sod-podsolic heavy loam soil, and heavy metals content in grain and soil.

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Material and Methods

Experimental work was fulfilled in 2002-2010 in long-term stationary field experiment on the experimental farm of Perm Scientific Research Institute. The experimental plots located on sod shallow- podsolic heavy loam soil with humus content 2,1 - 2,2 %, pH 5,4 - 5,5, P_2O_5 content 125 and K_2O - 170 mg kg^{-1}. (1969, before experiment foundation). Field trials were executed in fallow grain grass rotation with following rotation scheme: clean fallow, winter rye, spring wheat as shelter crop for meadow clover, first year clover, second year clover, spring barley, potato, oat. Certified seeds were used for sowing.

The following fertilization systems were studied in the experiment: organic (farm yard manure FYM total rates 40; 80; 160 t ha^{-1} within rotation); mineral, (fertilizers rates are defined according the nutrients quantity in FYM; complex (FYM total rates 40; 80; 160 t ha^{-1} within rotation with equivalent rates of mineral fertilizers).

Experimental scheme: [1] No fertilizers; [2] FYM 80 t ha^{-1}; [3] FYM 160 t ha^{-1}; [4] NPK rates equivalent manure 80 t ha^{-1}; [5] NPK rates equivalent manure 160 t ha^{-1}; [6] FYM 40 t ha^{-1} + NPK rates equivalent manure 40 t ha^{-1}; [7] FYM 80 t ha^{-1} + NPK rates equivalent manure 80 t ha^{-1}; [8] FYM 160 t ha^{-1} + NPK rates equivalent manure 160 t ha^{-1}.

FYM was applied two times during crop rotation: for winter rye and potato (20, 40, 80 t ha^{-1} before plowing). The mineral fertilizers rates, defined according the nutrients quantity in FYM, were distributed between winter rye, wheat, barley, potato and oat. Meadow clover was not fertilized. Treatment placing is randomized, each treatment has four replications on field area and two replications in time. In 2008-2009 the fifth rotation ended for both according replications. Soil and plant chemical analyses were fulfilled in analytical laboratory of Perm Agricultural Research Institute according national standarts: humus content - GOST 26213-84; pH_{KCl} - GOST 26483-85; hydrolytic acidity - GOST 26212-91; exchange bases sum - GOST 27821-88); mobile phosphorus and exchange potassium - GOST 26207-91. Heavy metals soil content - defined in Perm agrochemical service center. Data processing included analysis of variance and correlation coefficients determination.

Results and Discussion

Long-term application of fertilizers, within 40 years, had essential impact on change of soil agrochemical properties (table 1). So, arable land treatment without fertilizers led to considerable decrease of humus and potassium content, then, to some increase of soil acidity. Mineral fertilization systems, especially high fertilizers rates, caused base saturation decreasing and, vice versa, exchange and hydrolytic acidity raising. Humus content was relatively stable.

FYM application provided humus content preservation or moderate increasing, up to 2,43% from highest rate 160 t ha^{-1}. Soil pH_{KCl} reached 5,3. The tendency of hydrolytic acidity decline was noted under organic and complex fertilization systems treatment. The most favourable soil conditions were worked out from application of FYM highest rate - 160 t ha^{-1}. NPK high doses caused acidity raising and base saturation decreasing in spite of manure high rates using.

Table 1. The influence of fertilization systems on soil chemical properties. The end of fifth rotation (2008-2009), average for two replications in time.

Treatment	Humus,%	pH_{KCl}	S	Ha	V,%	P_2O_5	K_2O
			mmol/100 g			mg/kg	
1.No fertilizers	2,12	4,9	19,2	3,07	86	173	163
2. FYM 80 t ha^{-1}	2,22	5,0	20,1	2,83	88	208	222
3. FYM 160 t ha^{-1}	2,43	5,3	20,0	2,54	89	210	262
4. NPK rates equivalent manure 80 t ha^{-1}	2,23	4,8	18,8	3,81	83	197	251
5. NPK rates equivalent manure 160 t ha^{-1}	2,31	4,4	17,2	4,43	80	256	316
6. FYM 40 t ha^{-1} +NPK rates equivalent manure 40 t ha^{-1}	2,35	4,9	18,5	3,26	85	201	268
7. FYM 80 t ha^{-1}+ NPK equivalent rates	2,46	5,1	19,6	2,95	87	248	339
8. FYM 160 t ha^{-1} + NPK equivalent rates	2,70	5,1	17,9	3,70	83	333	433
LSD_{05} *	0,23	0,3	1,3	0,71		60	41

Notes: * LSD - least significant difference

All fertilization systems have led to essential increase of exchange potassium content, especially high mineral fertilizers rates and complex systems (up to 433 mg/kg of soil). Situation with mobile phosphorus content was not so evident. Only combination of FYM at least 80 t ha^{-1} with NPK and, also highest NPK rates promoted significant P_2O_5 increasing, in other treatments only the raising tendency was noted. All studied systems of fertilizers have raised productivity of agricultural cultures compared with control treatment (no fertilizers). The most essential supplements of winter rye grain yield were obtained from organic fertilization systems and NPK rates equivalent manure 160 t ha^{-1} - 0,46-0,54 t ha^{-1} (table 2). Application of 80 t ha^{-1} FYM guaranteed winter rye yield equal to the one from higher fertilizers rates. Mineral and complex fertilization systems, en bloc conceded the organic system. The difference between these treatments has not exceeded LSD $_{05}$ value. The supplements of winter rye grain yield were due to raising individual ear productivity, correlation coefficients (r) between total yield and grain quantity; grain mass from one ear were 0,6 and 0,64, accordingly. Spring grain crops have also positively responded on all studied systems of fertilizers. Spring wheat grain yield raised from 2,30 to 3,85 t ha^{-1}. The greatest supplements 1,17-1,55 t ha^{-1} of grain yield were gained from combination of FYM and mineral fertilizers (treatments 7,8). The field raising may be explained by increase of 1000 grains mass (r = 0,91). All studied treatments have provided essential increase of clover hay yields compared with control. The maximum total (for two years) gain of clover hay 1,35 t ha^{-1} was received from FYM 160 t ha^{-1} application , but the variances between treatments were insignificant, within LSD $_{05}$. Complex fertilization systems with medium and high fertilizers rates showed some benefits for barley yields. Grain supplements were about 0,45-0,56 t ha^{-1} without significant difference between treatments 7 and 8 (table 2). Grain yield rise was provided by stem thickness increase (r = 0,8) and 1000 grains mass (r = 0,79). Potato like all tuber cultures positively responds on FYM application, yield gain were about 4,9 t ha^{-1} , but effect from mineral fertilizers was just the same. Combination of FYM and mineral fertilizers provided father raising of tubers yield, up to 29,35 t ha^{-1}. This may be explained by high offtake of nutrients by potato tubers yields and heavy nutrients demand of this culture. Application of FYM 80 t ha^{-1}+ NPK in equivalent rates provided getting yield approximately equal to those from fertilizers rates two times greater compared with this treatment. Yield raising was provided by tubers mass and quantity in the clone (r=0,72 and 0,56 accordingly).

Table 2. The influence of fertilization systems on crop yields in fifth rotation, average for two replications in time.

Treatment	Crop yields, t ha^{-1}					
	Winter rye 2002- 2003	Spring wheat 2003- 2004	Clover	Barley 2006-2007	Potato 2007-2008	Oat 2008-2009
1.No fertilizers	3,12	2,30	8,28	2,26	19,40	2,46
2. FYM 80 t ha^{-1}	3,60	2,77	9,03	2,42	24,11	3,00
3. FYM 160 t ha^{-1}	3,66	2,76	9,63	2,52	24,31	3,21
4. NPK rates equivalent manure 80 t ha^{-1}	3,36	2,89	9,41	2,42	24,96	3,25
5. NPK rates equivalent manure 160 t ha^{-1}	3,56	3,48	9,09	2,55	25,04	3,22
6. FYM 40 t ha^{-1}+NPK rates equivalent manure 40 t ha^{-1}	3,31	3,13	9,31	2,47	26,62	3,15
7. FYM 80 t ha^{-1}+ NPK equivalent rates	3,39	3,47	9,41	2,71	28,10	3,48
8. FYM 160 t ha^{-1} + NPK equivalent rates	3,26	3,85	9,31	2,81	29,35	3,44
LSD $_{05}$	0,24	0,25	0,69	0,22	2,61	0,31

Significant supplements of oat grain were noted in all studied fertilization systems – from 0,54 to 1,02 t ha^{-1}. The efficiency of organic and mineral fertilization systems was roundly equal. Yield gains obtained in these treatments were within LSD $_{05}$. Formation of the highest oat grain yield 3,44-3,48 t ha^{-1} was provided by complex fertilization system with fertilizers rates no less than FYM 80 t ha^{-1}+ NPK. Average crops productivity in fifth rotation varied from 2831 to 3859 FU as influenced by fertilization systems. The maximum yields, but minimum crop returns were obtained from combination of manure total rate 160 t ha^{-1} within rotation and equivalent mineral fertilizers application. The highest crop returns were obtained after mineral fertilizers application.

Mineral fertilizers and FYM may be the sources of heavy metals soil contamination. So, heavy metals content evaluation was one of the aims of given experimental work. All studied fertilization systems have not led to soil pollution by mobile forms of heavy metals (Cu, Zn, Pb, Cd). Their content in soil was far from maximum permissible concentration (table 3). Fertilizers application caused small raising of Zn content – from 1,20 to 2,38 mg/kg. Some decreasing of copper content was noted: from 0,33 mg/kg (control) to 0,20-0,25 mg/kg, without express tendency according the treatment. Probably, it was caused by Cu offtake with greater yields. Variations of Pb and Cd concentration were insignificant .

Table 3. The influence of fertilization systems on the soil content of heavy metals mobile forms in the end of fifth rotation, 2009 (mg/kg).

Treatments	Cu	Zn	Pb	Cd
1.No fertilizers	0,33	1,20	0,32	0,05
2. FYM 80 t ha^{-1}	0,23	1,29	0,24	0,04
3. FYM 160 t ha^{-1}	0,29	1,35	0,43	0,03
4. NPK rates equivalent manure 80 t ha^{-1}	0,20	0,95	0,35	0,02
5. NPK rates equivalent manure 160 t ha^{-1}	0,22	1,43	0,28	0,04
6. FYM 40 t ha^{-1} + NPK rates equivalent manure 40 t ha^{-1}	0,24	2,25	0,34	0,05
7. FYM 80 t ha^{-1}+ NPK equivalent rates	0,24	2,25	0,34	0,05
8. FYM 160 t ha^{-1} + NPK equivalent rates	0,25	2,38	0,25	0,05
LSD_{05}	0,04	0,80	Fф<Fт	0,01
MPC*	3,0	23,0	6,0	-

Notes: * MPC- maximum permissible concentration

Heavy metals concentration is very important parameter of agricultural product quality. It is known that character of heavy metals accumulation in crops depends on many factors: content level of heavy metals in soil, soil properties, forms and doses of applied fertilizers, plants biological features, weather conditions during vegetative season, etc. Copper and zinc are important elements for plants metabolism, without them many enzymatic biochemical reactions in plants are impossible. The copper concentration in studied treatments was varying from 3,48 to 4,50 mg/kg (table 3). The essential increase - up to 4,50 mg/kg, was observed only from high NPK rates equivalent manure 160 t ha^{-1}, but it was essentially lower MPL – 30 mg/kg. Joint application of manure with mineral fertilizers essentially decreased zinc content in winter rye grain. Some authors (Gomonova, 1994; Chernych et al., 1995; Nosovskaya et al., 2000) noted that some heavy metals metals, for example, zinc and copper, forming organic-mineral complexes with soil organic substance, became less available to plants. Long-term application of manure single and together with mineral fertilizers caused Pb accumulation in grain, but, its concentration was below MPC and MPL. All studied fertilization systems have no effect for Cd accumulation in winter rye grain. The gained harvest may be used, both for food, and for the fodder purposes.

One additional indicator - biological accumulation coefficient C_b (Titova, 2005) has been calculated for estimation of production pollution level.

$$C_b = C_p/C_s, \text{ where} \quad (1)$$

C_p - concentration of an element in plant;
C_s - concentration of an element in soil.

High biological accumulation coefficients for winter rye plants were noted for Zn and Cu that may be explained by participation of these elements in the vital functions of plant organism (table 4). All systems of fertilizers have raised biological accumulation coefficient for copper, especially high NPK rates. Complex fertilization systems promoted decrease of biological accumulation coefficient for Zn from 24,7 up to 10,6 in last treatment (FYM 160 t ha^{-1} + NPK in equivalent rates). Varying of C_b for lead did't represent evident picture of its dependence from fertilization systems. Mineral fertilizers application affected raising of C_b for cadmium. Thw lowest C_b for cadmium was noted from complex fertilization systems. Hence, in general, joint application of FYM and mineral fertilizers promotes decrease of heavy metals accumulation in agricultural product and its quality improvement.

Table 4. The influence of fertilization systems on heavy metals content and biological accumulation coefficients in winter rye grain, 2010.

Treatment	Content, мg/кg				Biological accumulation coefficients			
	Cu	Zn	Pb	Cd	Cu	Zn	Pb	Cd
1.No fertilizers	3,73	29,6	0,29	0,04	11,3	24,7	0,9	0,8
2. FYM 80 t ha^{-1}	3,93	26,9	0,38	0,04	17,1	20,9	1,6	1,0
3. FYM 160 t ha^{-1}	4,08	25,8	0,36	0,05	14,1	19,1	0,8	1,7
4. NPK rates equivalent manure 80 t ha^{-1}	3,93	28,3	0,35	0,05	19,7	29,8	1,0	2,5
5. NPK rates equivalent manure 160 t ha^{-1}	4,50	29,7	0,30	0,04	20,5	20,8	1,1	1,0
6. FYM 40 t ha^{-1} + NPK rates equivalent manure 40 t ha^{-1}	3,55	25,0	0,35	0,03	14,8	11,1	1,0	0,6
7. FYM 80 t ha^{-1}+ NPK equivalent rates	3,48	25,3	0,38	0,03	14,5	11,2	1,1	0,6
8. FYM 160 t ha^{-1} + NPK equivalent rates	3,55	25,3	0,38	0,04	14,2	10,6	1,5	0,8
LSD_{05}	0,76	3,42	0,05	Fф<Fт				
MPC*	10,00	50,0	0,50	0,1				
MPL**	30,00	50,0	5,00	0,3				

Notes: *MPC - maximum permissible concentration ; ** MPL - maximum permissible level

Conclusion

Joint application of manure and mineral fertilizers in rates nor less than FYM 40 t ha^{-1} + NPK in doses equivalent manure 40 t ha^{-1} promoted humus accumulation in soil, guaranteed mobile phosphorus and exchange potassuim content raise, soil status quo in regard to acidity and base saturation. All studied fertilization systems have increased crops yields in field eight-course rotation, but the highest supplements were obtained by application of complex fertilization systems with FYM rates 80 t ha^{-1} and more. Average crops productivity in fifth rotation varied from 2831 to 3859 FU as influenced by fertilization systems. The maximum yields, but minimum crop returns were obtained from combination of manure total rate 160 t ha^{-1} within rotation and equivalent mineral fertilizers application. The highest crop returns were gained after mineral fertilizers application. Long-term application of organic and mineral fertilizers has not caused soil and agricultural product pollution by heavy metals above MPC and MPL. Complex fertilization systems possess some advantage in this position compared with mineral fertilizers and promote the improvement of agricultural product quality.

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References

Alexeev, Y..V., 1987. Heavy metals in soils and plants. Agropromizdat. Leningrad.

Vojtovich N.V., Kirdin V. F., Polev N.A., 1990. How to rescue fertility of soils of Non-Black Earth Region. Husbandry, 5, 20-21.

Gomonova, N.F., 1994. Influence of agrochemical preparations long application on sod-podsolic soils on transformation of heavy metals in system soil-plant. In: Heavy metals and radioactive nuclides in agroecological systems. Proceeding of scientific conference:. Moscow, 180-186

Ladonin, V.F., 1995. Influence of complex chemicals application on heavy metals accumulation in soil and plants. Chemistry in agriculture 4, 32-34.

Mineev, V.G., Gomonova N.F., Zenova G. M, Skvortsova I.N., 1999. Properties change of sod-podsolic soil and its bacterium coenosis from intensive cultivation. Soil science 4, 455-460 .

Mineev V.G., 2008. Agrochemistry and environmental problems of modern agriculture. In: Proceeding of Russian meeting of the Geographical experiments network with fertilizers. Moscow, 5-8 .

Najdin P.G., 1967. Geographical distribution of mineral fertilizers efficiency in the USSR. Agrochemistry, 1, 24-40.

Nebolsin A.N., Nebolsina Z.P., 2005. Theoretical bases of soils liming. Agr. Inst. St.-Petersburg.

Nosovskaya I.I., Soloviev G.A, Egorov V. S, 2000. The influence of long-term systematic application of mineral fertilizers and manure on copper and zinc accumulation in soil. Agrochemistry, 9, 50-56.

Obuhov A.I., Popova A.A., 1992, Balance of heavy metals in sod-podsolic soils coenoses and monitoring problems. Annals of Moscow State University. Part. 17, Soil science, 3, 31-39.

Petuchov M.P., Prokoshev V.N. 1964. Application of fertilizers in the Ural Region. Perm.

Ramad F., 1981. Bases of applied ecology. Gidrometeoizdat. Leningrad.

Titova V.I. Dabachov M. B, Dabahova E.V., 2005. Practical works on agroecology. Education manual. N.Novgorod

Chernych N.A. LadoninV.F., 1995. Problems of heavy metals rationing in soil. Chemistry in agriculture 5, 10-13.

Yakovleva L.V., 2009. Ecological aspects of sod-podsolic soils liming in the Northwest of Russia. DSc Agr. thesis abstract. St.-Petersburg - Pushkin.

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Effects of Humic liquid fertilizer on six wheat bread varieties at the end of drought condition

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Abstract

Wheat bread is one of the most valuable plants on the earth which is occupied near one-eighth of the overall surface and also it is clearly important to human nutrition, and anything that affects wheat management and production has the potential for significant worldwide impact. In Iran wheat bread is one of the most important crops and can be affected by salinity tension in many areas. In order to investigate the effect of Humic liquid fertilizer (Potassium Humat) on quantitative and qualitative traits of six wheat varieties (Gascogne, Sabalan, 4057, Rozi -84, Gobustan and Saratovskaya-29) an experiment by factorial split plot method has been done based on randomized complete block design in three replications in the research station of Ardabil islamic azad university, Iran. Results showed the number of grains per spike, grain weight per spike, grain yield and protein content was meaningful for each variety. Genotype 4057 with 2.98 tons per hectare had the highest grain yield. The most grain protein with a mean 14.80 belonged to Saratovskaya-29 variety and grain yield was increased around 31.36 percent. So Humic liquid fertilizer (i. e; Potassium Humat) as miraculous natural substance can be used for increasing the quantity and quality of organic wheat bread cultivation.

Keywords: Wheat Bread, drought stress, Potassium Humat

Introduction

Wheat bread production is so important primarily for human nutrition and then to feed the birds and animals and also industrial uses. The importance of wheat bread is mainly because of physical and chemical properties of materials such as corn starch and gluten. But Crop production such as wheat can be effected by drought conditions. Main part of Iran is located in arid and semi-arid areas which makes difficult to predict rainfall according to low precipitation and different frequencies. Under this kind of situation, grain yield reacts lot of fluctuations during period of connective years. Water deficiency at the end of the growing season in the Mediterranean areas is so common. Water stress is coincident to pollination and grain filling stages of wheat. Most areas under wheat crop production in Iran is affected by drought condition.

According to the strong role of Humic materials in increasing crop quality, it can enhance plant tolerance against the living and non-living stresses factors (Shahryari, 2009). Yang et al., (2004) showed that Humic acid can effects directly and indirectly on physiological processes on plant growth. The direct effects includes

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increasing cell membrane permeability, respiration, biosynthesis of nucleic acids, ion absorption and the enzymatic activity. Humic acid decrease application of manure fertilizers and increase the total plant production (Beninati, 1993).

Gonzalez et al., (1999) concluded that under drought stress conditions, among all parts of plant function, the number of spikes per square meter is more effected by drought stress than other properties.

Also, Seed weight and number of seeds per spikes will be decreased the productivity. In some experiments the relationships between productivity and the weight of seed was confirmed and drought conditions can effects on grain weight more than other parts of plant.

Wheat bread is the main food for many countries and it supplies 70 percent of calorie and 80 percent of protein intake of human body.

Due to growing world population and current shortage of food in the world, it is necessary to find some ways to increase production and the optimum use of production of wheat bread.

The main aim of this experiment is determining and comparing the quality and quantity of six varieties in four different environmental conditions and make a decision to find an appropriate and positive reaction to a stressful condition for different varieties of bread wheat.

Material and Methods

In order to evaluate the efficacy of Humic acid on some quantitative and qualitative traits, six bread wheat (Gascogne, Sabalan, 4057, Rozi-84, Gobustan and Saratovskaya-29) were selected and an experimental research has been done on the farm of Islamic Azad University, Ardabil branch, Iran by factorial split-plot randomized complete block design with three replications.

The main factor levels included normal irrigation, spray irrigation with Humic acid fertilizer, drought stress + spray irrigation with Humic acid fertilizer. Each plot consisted of three rows with three meters length and each rows had 20 cm apart from each other. Seeding rate determined for each variety based on 450 seeds per square meter and based on the weight of seeds they were planted on early November.

Customized Irrigation has been done twice in autumn and three times in the spring season. Foliar application in different growth stages to produce one hectare of wheat was supplied based on 400 ml in 50 liter of water

Spray irrigation at tillage, germination and grain filling stage was done on the aerial part of the plant. To deal with weed grasses at all stages from tillage stage to stage of grain filling stage, hand and mechanical tools was used without any chemical fertilizers. Cultivated lands with wheat bread was under rotation with wheat and fallow. Land preparation operations was done including plowing after harvesting the previous crop, two times of disk and creation two vertical leveler and farrow operation.

Studied traits was included number of spikes per square meter, number of grains per spike, grain's weight per spike, grain yield and protein. After harvesting operation, random sampling was done on the seeds for each plot to estimate the quality of wheat production. All flour of grains was prepared by Laboratory Mill 3100 instrument and protein content was measured based on dry samples by Inframatic 8600 device. Finally statistical analysis carried out by using statistical software of MSTAT-C and SPSS-16.

Results and Discussion

Number of spikes per square meter: According to the variance analysis results in table 1 it was shown that there is no significant difference between genotypes. In drought conditions, number of spikes per square meter reduced around 23.83 percent.

Number of grains per spike: the results was indicated that there was a significant difference at 1% level between irrigation levels and number of grains per spike. Drought Stress was caused 42.8% reduction in number of grains per spikes in comparison with normal irrigation. Also, effects of irrigation level with level of applied Humat had significance difference at 1% level (Table 1).

The mean Comparison of irrigation levels and applied Humat (Table 2) was indicated irrigation level with potassium Humat and drought stress with a mean 34.88 and 33.47 respectively had maximum number of grains per spikes and drought stress with a mean 25.07 had minimum number of grains per spikes. Also a significant difference at 1% level was observed between the studied genotypes (Table 1). The number of grains per spike in Sabalan variety had maximum grain with 37.52 significant difference in comparison to other genotypes and Saratovskaya-29 with 24.55 had minimum grain per spike (Table 3).

Table 1. Results of variance analysis in genotypes of wheat bread crop under drought condition and potassium Humat

Mean of Square					Freedom degree	variables
Protein content	Grain function	Weight of grain per spike (mg)	No. grains per spikes	No. spikes per square meter		
0/22	1/315*	0/226	154/425*	17868/77*	2	replication
3/264**	82/317**	13/846**	130/411*	111406/89**	1	Level of drought stress (A)
2/251**	1/1983*	0/206	29/517	12272/22	1	Level of Humat (B)
0/0036	38/609**	3/179**	910/93**	8978	1	(A) × (B)
0/284	0/435	0/265	56/944	8100/37	6	First error
2/259**	1/351**	0/724**	221/127**	5355/07	5	Genotypes (G)
0/259	1/089**	0/159	45/818	3677/56	5	(G) × (A)
0/593*	0/334	0/055	4/25	4666/36	5	(G) × (B)
0/253	0/226	0/42**	153/011**	1774/27	5	(G)×(A)x (B)
0/185	0/302	0/096	34/035	5965/38	40	Second error
3/1	22/26	20/76	19/06	26/53	Coefficient of Variability	

* Significant difference at 1% level
** Significant difference at 5% level

Grain's weight per spike: It was observed that grain's weight per spike in different level of irrigation had significant differences at 1% level. Drought stress was effected on grain's weight in spike with 16.59 percent in comparison with normal irrigation. Also it was observed that the effects of irrigation level with application of Humat had significant difference at 1% level (Table 1).

Results of irrigation level with Humat usage level indicated irrigation level with potassium Humat and drought stress had maximum weight of grain per spike with averages 1.78 and 1.62 gram respectively and drought stress with potassium Humat with mean 1.09 gram had minimum weight of grain per spike. Also, it was included that there was a significant difference among all studied genotypes at 1% level.

Table 2. Results of Comparison the wheat bread properties for irrigation level and potassium Humat

Grain function (ton/ha)	Weight of grain per spike (mg)	No. of grains per spike	Condition
b2/489	ab1/471	ab29/04	normal
a3/626	a1/784	a34/88	Normal+Potassium Humat
bc2/118	a1/621	a33/47	Drought stress
c1/645	b1/094	b25/07	Drought stress+ Potassium Humat

Differences between means in each column with the same words has no significant difference at 5% level

In Sabalan variety based on grain's weight per spike with mean 1.76 gram had highest value but there was no significant differences with Gascogne, 4057, rozi-84 and Gobustan. Saratovskaya-29 with 1.02 gram had lowest weight of grains per spike (Table 3).

Grain's Yield: Statistical analysis was shown that in terms of grain's yield among genotypes, irrigation level, Humat level, irrigation level with Humat level and effects of irrigation level with genotypes had significant difference at 1 and 5 percent level.

Results of table 2 was shown that irrigation level with potassium Humat with a mean 3.62 ton per hectare had maximum grain's yield and drought stress with possium Humat with a mean 1.64 ton per hectare had minimum grain's yield. These results indicate that the absence of potassium Humat can reduce grain's yield by 31.36 percent.

The 4057 variety with a mean 2.98 ton per hectare had highest grain's yield but there was no significant difference with Sabalan and Saratovskaya-29 which had lowest grain's yield with 1.99 ton per hectare (table 3). Shahryari et al., 2009 indicated that potassium Humat in a good situation of irrigation can increase wheat yield from 2.49 to 3.91 ton per hectare.

Table 3. Mean comparison of measured properties for studied genotypes of wheat bread

Protein (%)	Grain function (ton/ha)	Weight of grain per spike (mg)	No. of grains per spike	Genotypes
b14/01	bc2/412	a1/584	bc29/27	Gascogne
b13/94	ab2/689	a1/761	a37/52	Sabalan
c13/09	a2/987	a1/532	b32/39	4057
b14/12	bc2/350	a1/545	b30/68	Rozi-84
c13/17	bc2/382	a1/506	bc29/38	Gobustan
a14/80	c1/998	b1/027	c24/45	Saratovskaya-29

Differences between means in each column with the same words has no significant difference at 5% level

Protein percent: statistical analysis in table 1 was shown that among genotypes, irrigation level, level of Humat application, Humat's level application × genotypes had a significance difference in terms of protein in grains at 1 and 5 percent level. Drought stress increases protein content with 3.03 percent in comparison with normal irrigation.

Comparison of irrigation levels with levels of humat application (Table 2) was shown that drought stress with a mean 14.25% had maximum protein content which is no significant difference with potassium Humat and normal irrigation which had minimum protein content with a mean 13.47 percent. Saratovskaya-29 with a mean 14.80 percent had maximum protein content. Gobustan and 4057 genotypes wit 13.09 and 13.17 percent respectively had minimum protein content among other varieties (Table 3). Shahryari et al., 2009 indicated potassium Humat as a miraculous natural substance can increase the quality and quantity of wheat crop and can be used for producing organic wheat crop. Also, for increasing protein content in wheat crop, potassium Humat can be used particularly in face of drought condition.

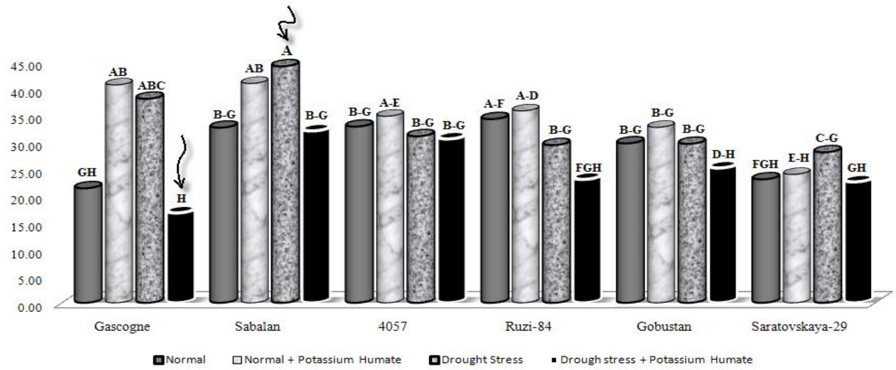

Fig 1. Three side effects of irrigation level* potassium Humat level* genotypes for numbers of grains per spike

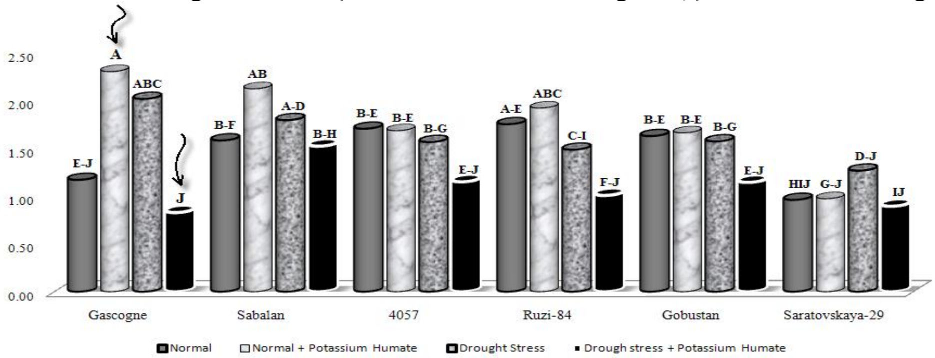

Fig 2. Three side effects of irrigation level* potassium humat level* genotypes for grain's weight per spike

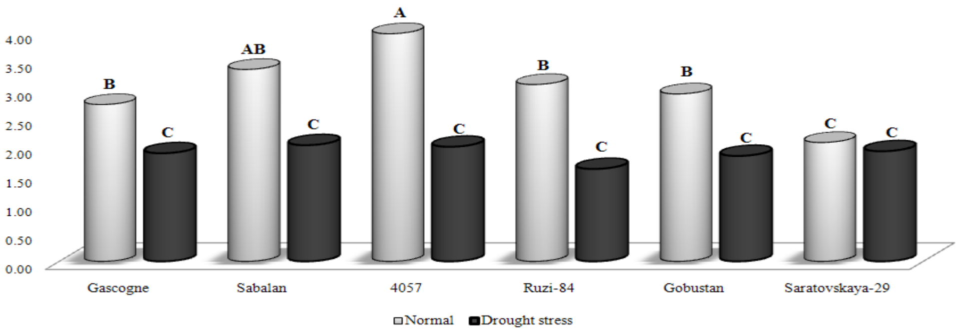

Fig 3. Two side effects of irrigation level* genotypes for grain's function

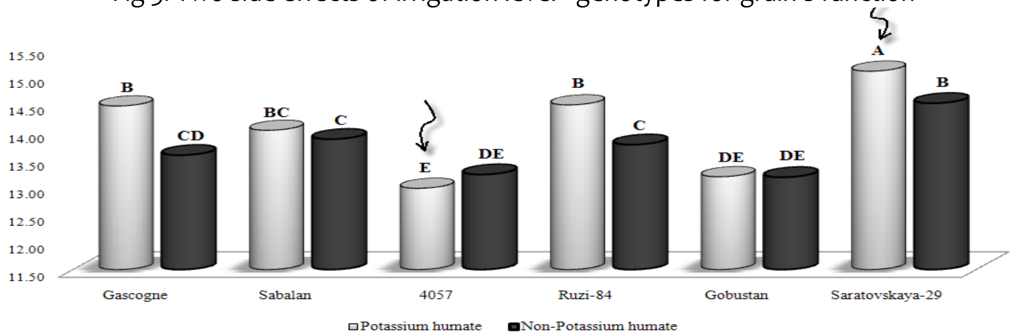

Fig 4. Two side effects of potassium Humat* genotypes for percent of protein

Conclusion

In drought stress condition Gascogne genotype had largest number of spikes per square meter and Saratovskaya-29 has the lowest number of spikes. These results indicated that the absence of potassium Humat can reduce 16.74 percent of grains per spike. Protein content in grains is so important properties which genetic characteristic can effect on it more than environmental factors. These results was incompatible with Beninati which protein content of wheat bread is influenced by environmental factors. Generally potassium Humat in normal irrigation is able to increase the number of spikes, but it cannot be useful for drought stress condition. These results indicate that absence of potassium Humat reduce weight of grains per spike around 17.54 percent. Because of extensive genetic variation among varieties was studied in this research, there was a significant difference between different types of genotypes. Therefore there is the possibility to use the existing diversity to produce high yielding varieties.

References

1. Beninati, N.F and Busch, R. H., 1993. Grain Protein inheritance and nitrogen uptake and redistribution in a spring wheat. Crop Sci. 32: 1471-1475.
2. Gadimov, A., Ahmaedova, N. and. Alieva, R. C., 2007. Symbiosis nodules bacteria Rhizobium legominosarum with peas (*Pisum sativum*) nitrate reductase, salinification and potassium humate. Azerbaijan National Academy of Sciences, pp. 52-59.
3. Gonzalez, A., I. Martin and L. Ayerve, 1999. Barley yield in water stress conditions. The influence of osmotic adjustment and stomatal conductance. Field Crop Res. 62: 23-34.
4. Shahryari, R., Gadimov, A., Gurbanov, E. and Valizade, M., 2009. Application of potassium humate in wheat for organic agriculture in Iran. Abstracts Book of Go Organic International Symposium. The Approach of Organic Agriculture: New Market, Food Security and a Clean Environment. Bangkok, Thailand.
5. Yang, C. M., Wang, M. H., Lu, Y. F., Chang, I. F. and Chou, C. H. 2004. Humic substances affect the activity of chlorophyllase. J. Chem. Ecol. 30(5): 1057-1065.

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The complex of mathematical models of micromycete sprouting in anthropogenically impacted soils

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Abstract

Soil microscopic fungi (micromycetes) represent a group of microorganisms, which generally benefit soil fertility. Some species take part in cellulose, humus, minerals, biostimulators, toxins and other matters transformations in soil. Many authors believe that the rate of micromycetes fruiting and alteration in population in anthropogenically impacted soils is closely related to microbiota alteration caused by pollutants. Thus, the study of micromycetes colonies growing patterns and their mathematical modeling, as well as changes of the model parameters under anthropogenic impact, is of significant importance. The studies carried out over the years resulted in mathematical models of propagule sprouting and showed the effect of crude oil pollution of soil on the model parameters. The colonies radius alteration patterns in anthropogenically impacted soil were studied. It has been shown that the diffusion processes might be one of the reasons of the radius alteration rate deviation from the linear growth law, as well as formation of ring structures in colonies. The created mathematical models and their changes under the crude oil pollution demonstrate a significant capacity increase in environmental niche regarding opportunistic fungi. This evidence clearly indicates that there has been a significant shift in the structure of the soil fungi compounds in contaminated soil towards dramatic increase in opportunistic fungi. The computational experiments performed using derived mathematical models and their comparison with natural/real experiments provided good correlation between the calculations and experimental data.

Keywords: Anthropogenically impacted soil, micromycetes, a mathematical model.

Introduction

One of the characteristics of soils is that they are inhabited by microscopic fungi. Some species take part in cellulose, humus, minerals, biostimulators, toxins and other matter transformations in soil. Under technogenesis conditions, there are matters getting into soil that can only be decomposed in the presence of micromycetes. According to a number of authors (Ilarionov et al., 2003; Marfenina, 2005; Lebedeva, 2000) the total population of toxin-generating fungi greatly depends on the alterations in microbocenosis caused by pollutants impact. Such alterations resulted in acute toxin-generating elements gaining dominant positions in crude oil polluted soils. Research results published over the last few years indicate that the possibility for plant, animal, and human pathogenic species to spread in anthropogenically impacted soils (urban soils primarily) is very high.

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The study of micromycetes colonies patterns of growth and its mathematical modeling is of significant importance. An often stated assumption is the one suggested by D. Pert (Panikov et al., 1981) about consistency of micromycetes colonies growth rate:

$$\frac{dR(t)}{dt} = K_r \text{ or } R(t) = R_0 + K_r t, \quad (1)$$

where R_0 – initial colony size, and K_r – radial colonies growth rate. Within a certain period of time when the colony size is increasing only on account of the cells located along the colony peripheries, this assumption is justified. In the early 20th century, M.A. Egunov noticed that over the time the colonies growth rate decreased and offered the following equation to describe fungal colonies growth on agricultural media (Panikov, 1995):

$$\frac{dR(t)}{dt} = K_0 - kR(t). \quad (2)$$

In this equation: $R(t)$ – is a colony radius, k – is a constant of colony growth inhibition by metabolism products. Substituting $t = 0$ in the equation, and taking into account that $R(0) = 0$, we get

$$\frac{dR(t)}{dt}\Big|_{t=0} = K_0 \quad (3)$$

Thus, K_0 – is the initial radial colony growth rate, i.e. colony growth rate at the beginning of the observations when the following fluctuations of the environmental conditions haven't affected the colony growth yet. This differentiates initial radial rate from the average radial rate. On the other hand, the solution to the differential equation is the function $R(t) = K_0(1 - e^{-kt})$ and K_0 – is a maximum of possible colony size (unachievable though). So, we suppose that the value of K_0 is a more precise description of the soil condition at the time of the research. There is information available in the literature regarding the impact of energy substrate concentration, nitrogen nutrition, and organic matter on the radial colonies growth rate being an indicator of fungal growth kinetics. The inhibition of the radial growth rate has been also observed to occur by soil biosystem components.

Material and Methods

To understand the processes, going on in soils, and to estimate the soil pollution consequences, a mathematical modeling of propagule sprouting dynamics was carried out. When building our model, we followed these assumptions: in practice it doesn't take long for a fungi propagule to sprout, and the growth is limited in time. Bukhenen assumed that micromycetes have a resting period and to re-commence their growth they need an external impulse, with the shift from resting cells going active being randomised and following the Pirson's law. In this case the total number of the sprouted fungi at the moment of t can be calculated using the formula:

$$S(t) = \begin{cases} 0, & t \le t_1 \\ kS_0 \int_{t_1}^{t} (z - t_1)^p (t_2 - z)^n dz, & t_1 \le t \le t_2 \\ S_0, & t \ge t_2 \end{cases} \quad (4)$$

In the given formula t_1 and t_2 are the moments of the beginning and the end of the fungal propagules sprouting, and S_0 is the maximum number of fungi sprouting in the given soil under the given conditions, respectively. This model, however, has a number of drawbacks. Firstly, there are too many parameters. Secondly, it doesn't presume that fungal propagules can sprout during later periods of time, other than t_2. Despite the propagules sprouting period being limited in time, only a certain number of them does sprout at a specified time. In particular, for a long while the propagules population keeps growing in a linear way in polluted soil.

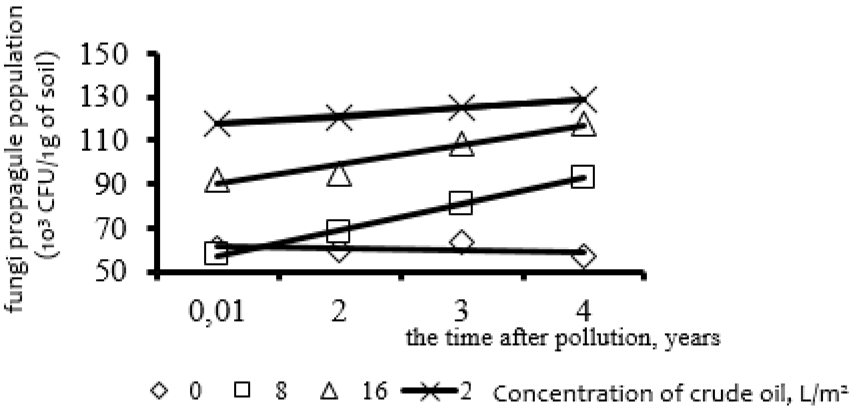

Fig. 1. Crude oil pollution impact on the number of fungi buds

With the alterations in the fungal propagule population being non-linear, and the intensive growth at the initial stage virtually reaching a lack of growth moment, the following equation has been considered as a model:

$$\frac{dS(t)}{dt} = \frac{\lambda S^2(t)}{t^{n+1}}, \qquad n > 0, \tag{5}$$

on condition that $t \to +\infty$, $S(t) \to kS_m$. Here, S_m – is a maximum number of fungi that can sprout in the tested amount of soil with all the necessary growth conditions available; the k index indicates the share of the maximum fungal number that can sprout in soil under given environmental conditions ($0 \le k \le 1$). Distinguishing between the variables, we come to the general solution to the equation (5):

$$S = \frac{nt^n}{Ct^n + \lambda} \tag{6}$$

Taking into account the term of $t \to +\infty$, $S(t) \to kS_m$, we find the C constant from the above equation. As a result, the solution to the equation is as follows:

$$S(t) = \frac{kS_m t^n}{T^n + t^n}, \quad \lambda = \frac{nT^n}{kS_m} \tag{7}$$

where T – is the moment when the propagule population reaches the half of kS_m. The power n is determined depending on the fungal growth period: the shorter the interval, the bigger the value of n. In this case, 90% of fungal propagules sprout by the time $\sqrt[n]{9}T$. The graph in Fig.2 is given as an example of model (5) with the following values of the parameters: k = 0,8, S_m =50, T = 8, n = 8. In this case, 90% of propagules sprout by the 11th day.

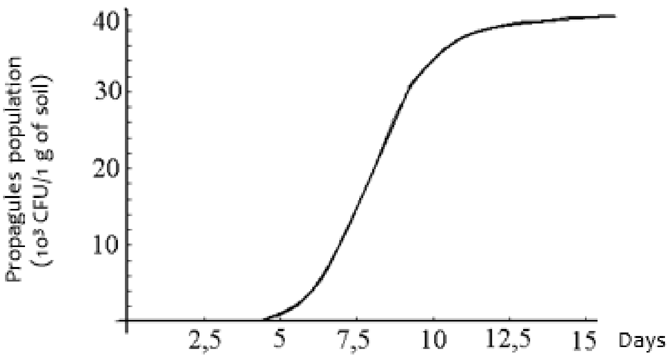

Fig. 2 Alteration dynamics of propagules population

The derived model is very much similar to Bukhenen's one: the function has the same type of distribution. What makes it different is the fact it doesn't have any strict time limits, and is one parameter less. It is also worth noting that the derived formula for S(t) is quite similar in its structure to Mozer's formula.

Assuming that under the experiment conditions we used the same soil and chose the same moment to count fungal propagule, it can be considered that external factors impact only *k* index. Thus, there will be two models in different conditions:

$$S_1(t) = \frac{k_1 S_m t^n}{T^n + t^n} \qquad S_2(t) = \frac{k_2 S_m t^n}{T^n + t^n} \tag{8}$$

If the t_0 moment chosen to count is $S_1(t_0) = S_1$, $S_2(t_0) = S_2$, then

$$\frac{S_1}{S_2} = \frac{k_1}{k_2} \tag{9}$$

The latter means that to estimate the impact of the external environmental factors, it is more appropriate to calculate the ratio of the sprouted fungal propagules number under the simulated conditions to the control variant.

As the concentrations of crude oil were increased, the number of fungi increased in both types of soil. The obtained results are well correlated with the mathematical model (5). It is established that *k* index is in a linear dependence on the pollution concentration:

$$k_{leached} = (0{,}09d + 1)k_{control};$$
$$k_{dark-gray} = (0{,}05d + 1)k_{control}, \tag{10}$$

where *d* - pollution concentration in % (Fig.3). Determination coefficient for both types of soil has proved to be very high and equaled 0, 87.

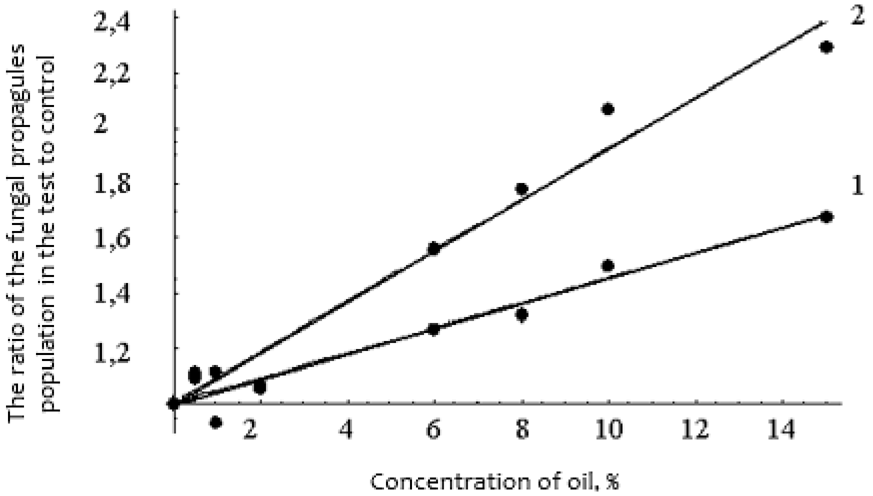

Fig.3 The impact of the commercial oil polluted soil on the ratio of the fungal propagules population in the test to the control 6 months after the pollution: 1- forest dark-gray, 2 – leached chernozem (soil)

In the natural environmental conditions when the soil has a certain pool of fungal propagules, the introduction of pollutants causes changes in their living conditions. As it has been found above, crude oil promotes micromycetes growth. In this regards, we can assume that before pollutans were added the fungal propagules growth had complied with the model (5), and then, as the conditions changed, the growth rate changed as well. The following equation has been offered as a mathematical model:

$$\frac{dS}{dt} = \begin{cases} \dfrac{nT^n S^2}{k_1 S_m t^{n+1}}, & 0 < t < t_0, \\ \dfrac{nT^n (S - S_0)^2}{(k_2 - k_1) S_m (t - t_0)^{n+1}}, & t > t_0. \end{cases} \tag{11}$$

Here, t_0 – is the moment when the pollutants enter into the soil; S_0 – the number of propagules at the t_0 moment; k_1, k_2 – are the indexes characterising environmental conditions before and after pollution. In case of adding pollutants at the moment when the fungal population has almost settled down, i.e. when $t_o > \sqrt[n]{9}T$, the equation solution is as follows:

$$S(t) = \begin{cases} \frac{k_1 S_m t^n}{T^n + t^n}, & 0 < t < t_0 \\ S_0 + \frac{(k_2 - k_1) S_m (t - t_0)^{n+1}}{T^n + (t - t_0)^n}, & t > t_0. \end{cases} \quad (12)$$

Results and Discussion

As in case with model (5), the direct calculations left no doubts that the most informative characteristic of changes in soil conditions is the calculation of the ratio of the propagules population in the tested soil to the propagules population in the control variant (in this case we mean S_o). The derived mathematical model allows us to quantitatively estimate the effect of the soil polluted by different oil compounds on the propagules sprouting dynamics (Vodopyanov et al., 2003).

The upward trend in human diseases caused by opportunistic mycoses due to pathogenic fungi has gained a significant attention among health experts and mycologists in recent years. A number of authors have shown that in anthropogenically impacted soils there are groups of micromycetes potentially dangerous to humans. However, we haven't found any reports about oil and oil products effect on the concentration of opportunistic fungi as well as a mathematical description of this process.

In soils polluted by crude oil and oil products the dominant position is occupied by species which are atypical and rare in background soils and belong to group BSL2 (potential inducers of deep mycoses). One of the important reasons of the increase in allergic diseases and opportunistic mycoses might be environmental pollution, and oil products being one of them. From the environmental positions the identification of mycoses risks should involve the study of environmental factors leading to accumulation or reduction in the incidence of the potentially dangerous species. Along with the natural factors effect, an important focus of studies should also be on anthropogenic impacts leading to the increase or decrease in the incidence of the potentially dangerous microscopic fungi.

When studying the soils, it has been observed that the population of opportunistic fungi in the oil-polluted soil increases significantly faster than the total population of fungi in general does (table).

Table 1. The population of opportunistic fungi in leached chernozem polluted by different concentrations of oil (thousands. KOE/1g of soil)

Oil concentration, %	days			
	3	30	90	180
0	39,0	37,5	38,1	38,6
0,5	38,3	43,2	49,7	51,3
2	39,3	50,1	68,2	70,2
4	54,8	380,5	754,0	628,3
6	56,6	355,0	522,0	647,3
10	60,1	475,1	673,4	728,1

The calculating experiment carried out using the model (11) for the population of opportunistic fungi in the crude oil polluted soil showed that it adequately described the ongoing propagule growth (Fig. 4). The values of *n* and *T* fluctuated in calculations insignificantly and averaged out at: *n*=1,83; *T*=32,55. The calculation of the k_2/k_1 ratio has provided results shown in Fig.5. The Fig.5 illustrates that with the increase in concentration, the k_2 index in relation to k_1 for opportunistic fungi went up in non-linear way. Furthermore, this ratio is several times higher in comparison with its increase when defining the general fungal population (Fig. 5). This indicates that there has been a great shift in the fungi compound's structure towards a sharp increase in the number of opportunistic fungi.

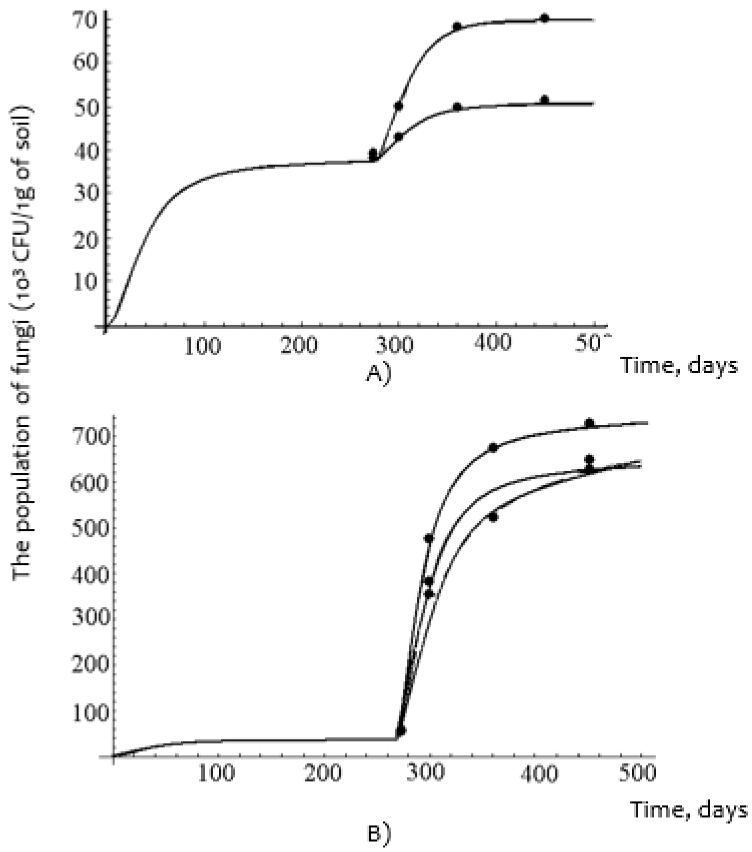

Fig. 4 The alteration in opportunistic fungi population in the crude of a pollution
A)low concentrations of a pollution, B) high concentrations of a pollution

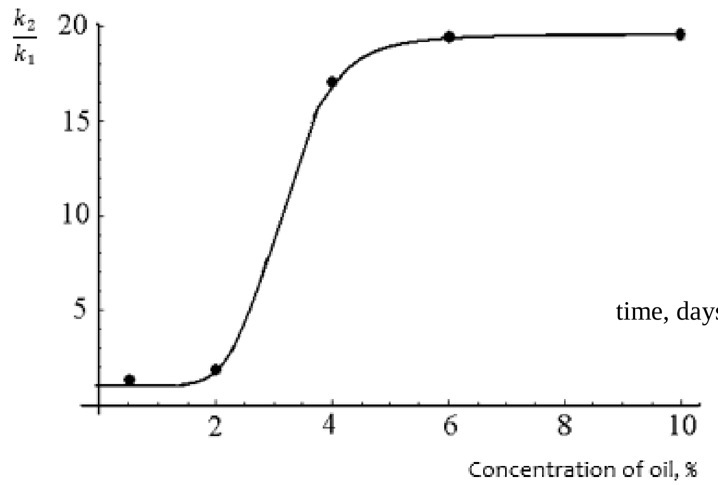

Fig. 5. k_2/k_1 ratio value depending on the concentration of a pollution and a curve built using the model (13)

Depending on the level of pollution, various levels of steady states have been recorded that are determined by the value of *k* in models (11), (12). Taking into account the k_2/k_1 ratio dependence on the law of limited growth, we come to the following equation:

$$k_2 = k_1 + \frac{k_{max} S^r}{K_m + S^r} k_1 \tag{13}$$

where *S* – is a concentration of oil, k_{max} – is the maximum value of the k_2/k_1 ratio, acceptable in the given ecological niche.

Conclusion

Thus, crude oil and oil products getting into soil and containing hydrocarbons decomposable by micromycetes cause functional changes in microbial community and its interactions with other organisms, and form microscopic fungi groups with increased content of human pathogenic species. The derived mathematical models allow us to quantitatively estimate the effect of soil pollution with various materials on the dynamics of fungi propagules sprouting and accumulation of opportunistic micromycetes. The reclamation of such soils requires the development of special measures to prevent the accumulation of potentially dangerous species in the first place.

References

Ilarionov, S. A., Nazarov, A. V., Kalachnikova, I. G., 2003. The Role of Micromycetes in the Phytotoxicity of Crude Oil-Polluted Soils. *Russian Journal of Ecology,* 34(5):303–308

Marfenina, O.E., 2005. Anthropogenic ecology of soil fungi. Health for All, 196 p

Lebedeva, E.V., 2000. Micromycetes – indicators of anthropogenic pollution of soils // Mycology and cryptogamic botany in Russia: Traditions and Modernity: Proc. Conf. – SPb.: SPbHFA, p. 173-176.

Kireeva, N.A., Vodopyanov, V.V., Bakaeva, M.D., 2003.Features of microfungi in oil-polluted soils//Abstracts XIV Congress of Europian Mycologists. Katsively, Yalta, Crimea, Ukraine 22-27 September 2003, p.46

Panikov, N.S, Afremova, V.D., Aseeva, I.V., 1981. Kinetics of the growth of colonies of Mucor plumbeus and Mortierella ramanniana fungi on agarized media with glucose. Mikrobiologiia. 50(1), 55-61. [Article in Russian]

Panikov, N.S., 1995. Microbial Growth Kinetics. Springer, Science – pp.378

Vodopyanov, V.V., Kireeva, N.A Tarasenko, E.M., 2003. Mathematic model of microbiological processes the oil–contaminated soil//1st FEMS Congress of European Microbiologists. Abstract Book. June 29–July 3, 2003. Slovenia, Ljubljana, Cankarjev Dom, p. 188.

Svistova, I.D., Sherbakov, A.P., Koretskaia, I.I., 2003. Talalaiko N.N. Accumulation of toxic types of microscopic fungi in urban soils. Gigiena i Sanitariia, 5:22-25

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Responsiveness of potato varieties on mineral nutrition

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Abstract

In the experiment were studied 4 methods for calculating doses of nutrients: the recommended doses of nutrients, taking into account the soil fertility (for early ripening variety Fresco - $N_{50}P_{50}K_{57}$, medium early variety Nevskii - $N_{100}P_{100}K_{114}$, middle - Lugovskoi - $N_{150}P_{150}K_{171}$); for additional tubers yield increase ($N_{108}P_{54}K_{36}$, $N_{135}P_{90}K_{54}$, $N_{135}P_{90}K_{54}$); to compensation for takeout nutrients with the planned harvest ($N_{75}P_{30}K_{120}$, $N_{100}P_{40}K_{160}$, $N_{125}P_{50}K_{200}$); to compensation for takeout the planned harvest, basing on the soil fertility ($N_{67.5}P_{18}K_{36}$, $N_{90}P_{24}K_{48}$, $N_{112.5}P_{30}K_{60}$). The soddy shallow clay loam podzolic soil is characterized by agrochemical properties: humus – 2,3%, pH_{KCl} – 5,5, H and Sum were at 3.3 and 18.8 $mmol_{(+)}$ 100 g^{-1} soil, respectively, exchangeable P_2O_5 - 94 mg $kg^{-1}$and K_2O - 131 mg kg^{-1}. There was a significant increase in the productivity of potato in the varietal sequence: early ripening < middle early < intermediate. Tuber yield was increased when for calculating doses nutrients used method for additional increase tuber yield (yield of potato are 25.6, 34.2, 48.5 t ha^{-1}, respectively) and for compensation for takeout nutrients (yield of potato are 21.3, 32.0, 51.5 tones/ha respectively). Data on weight fraction of dry matter and of starch in the tuber were ranged from 18.3% to 26.4% and from 14.6% to 18.2%, respectively. The highest dry matter content in the tubers of the test plants has accumulated the Lugovskoi variety, smallest – the Nevskii. The maximum values the indicator for each variety was obtained on variants without mineral fertilizer. Most recoupment of fertilizer application is marked on early ripening variety and was 253.5 kg. Least responsive turned the middle (from 3.8 to 98.7 kg). Maximum return nutrients on all varieties obtained by introducing doses calculated by taking into account the compensation removal of soil fertility, the yield ranged from 45.6 to 51.5 t ha^{-1}.

Keywords: Cultivation of potatoes, a group of precocity, methods for calculating doses of elements of potato nutrition, plant productivity.

Introduction

The potato is the third most important food crop in the world after rice and wheat in terms of human consumption (Mahmudpur and Norov, 2013). The potato is important in the agriculture because not only the great food value of the crop, but also forage and technical (Marcelo and Paulo, 2011). In this regard, the role of research becomes relevant into the development of more efficient technologies for growing cultures, allowing to increase the productivity of the potato fields (Shpaar, 1999). Production of potato (Solanum tuberosum L.) takes a very important place in world agriculture, with a production potential of more than 320 million ton harvested and more than 19 million ha planted area (Alaa et al., 2012). Potato is grown world wide as source of carbohydrates, and its commercial production requires high input of chemical fertilizers which is high cost (Egamberdiyeva and Hoflich, 2004). Moreover, fertilization is considered one of the most important factors affecting the growth and yield of potato. Many researchers recorded an increase of potato tubers

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yield as a result of increasing the levels of potassium (K) fertilization (El-Gamal, 1985; Humadi, 1986. Tisdale et al., 1985). Such increases in the yield of potato tubers was either due to the formation of large sized tubers or increasing of the number of tubers per plant or both (El-Gamal, 1985). In recent years, the average yield of potatoes in the Russian Federation amounted to 10-11 t/ha, but in the world of 14.6 t ha^{-1}. In this regard, the role of research into the development of more efficient technologies for growing cultures, allowing to increase the productivity of the potato fields (Safin, 2002). Potato yield is largely dependent on soil and climatic conditions, characteristics of the genotype of plants, agricultural machinery, as well as mineral nutrition conditions (Kuzyakin, 2003).
Dose of fertilizer for potatoes studied in different areas of Russia and Permskii krai. However, the data are inconsistent because of the large differences of soil and climatic conditions, agrochemical soil properties, precursors and other factors.

Material and Methods

Mineral fertilizer doses were studied in different parts of Russia and in Permskii krai. However, the data found out are contradictory due to significant difference of soil and climate conditions, soil agrochemical properties, forecrop and other factors. The purpose of research is to identify the most effective method of doses calculation of nutrients at potato cultivation. Studies conducted in the Permskii krai in 2012 in the experimental field of the Perm State Agricultural Academy. For cultivation were used 3 varieties of potato: Fresco, Nevskii, Lugovskoi.

The scheme of the 2-factor experiment was applied as follows:
Factor A – variety of potato:
A_1 –Fresco (early ripening);
A_2 –Nevskii (medium early);
A_3 – Lugovskoi (middle).
Factor B – Doses of nutrients calculated with different methods:
B_1 – without fertilizers (control);
B_2 – doses for additional tubers yield increase ($N_{108}P_{54}K_{36}$, $N_{135}P_{90}K_{54}$, $N_{135}P_{90}K_{54}$);
B_3 – the recommended of nutrients with taking into account the soil fertility ($N_{50}P_{50}K_{57}$, $N_{100}P_{100}K_{114}$, $N_{150}P_{150}K_{171}$);
B_4 – doses for compensation of takeout with nutrients with the planned harvest ($N_{75}P_{30}K_{120}$, $N_{100}P_{40}K_{160}$, $N_{125}P_{50}K_{200}$) ;
B_5 – doses for compensation of takeout with nutrients with the planned harvest basing on the soil fertility ($N_{67.5}P_{18}K_{36}$, $N_{90}P_{24}K_{48}$, $N_{112.5}P_{30}K_{60}$).

The soddy shallow clay loam podzolic soil is characterized by agrochemical properties: humus – 2.3%, pH_{KCl} – 5.5, H and Sum were at 3.3 and 18.8 $mmol_{(+)}$ 100 g^{-1} soil, respectively, exchangeable (extract of 0,2 M HCl) P_2O_5 - 94 mg kg^{-1} and K_2O - 131 mg kg^{-1}.
Meteorological conditions (precipitations and temperature) were favorable for crops. Total plot area taken into consideration is 7.3 m^2. Total square of the experiment was 882 m^2. The repetitiveness of variants was three-time. From mineral fertilizers were used carbamide (46.2% N), superphosphate (26% P_2O_5) and potassium chloride (60% K_2O). Potatoes were planted into crests with a scheme 70 x 30 cm. Determination of quality indicators were conducted according to standard methods in Russia. For statistic processing we used the variance analysis method (Dospekhov, 2011).

Results and Discussion

Observations showed that plant tops grew more intensively in variants with higher doses of nitrogen and tubers grew in variants with higher doses of potassium, then nitrogen. Results of the experiment with varietals productivity of potatoes depending from nutrients doses is presented in Table 1.

Table 1. Influence of nutrients doses on crop yield of potatoes (t ha^{-1})

Doses of nutrients (factor B)	Variety of potato (factor A)			Average (factor B)
	Fresco	Nevskii	Lugovskoi	
B_1	17.7	27.2	46.6	30.6
B_2	18.8	31.2	48.1	32.7
B_3	25.6	34.2	48.5	36.1
B_4	21.3	32.0	51.5	34.9
B_5	21.9	32.8	45.6	33.4
Average (factor A)	21.1	31.5	48.1	
Minimal difference (P=95%) for particular differences factor A = 6.3; for factor B = 5.5				
Minimal difference (P=95%) for main effects factor A = 2.8; for factor B = 3.2				

According to main effects factor A maximal crop yield was obtained in variant with Lugovskoi variety and minimal crop yield was with variety Fresco. According to particular differences there is accurate increase of potato productivity in varietal sequence as follows: early ripping < medium early < middle, regardless of doses of nutrients.

In the experiment in general taking into account the main effect factor B accurate increase of tuber crop was obtained with applying the recommended of nutrients with taking into account the soil fertility (B_3) and doses for compensation of takeout with nutrients with the planned harvest (B_4). While growing Nevskii variety the accurate increase of yield was obtained with applying the recommended of nutrients with taking into account the soil fertility (B_3) and also doses for compensation of takeout with nutrients with the planned harvest basing on the soil fertility (B_5). The increase of yield due to doses of nutrients was not obtained in middle Lugovskoi variety, which has a long vegetative period and ability to use the soil nutrients to the greater extent.

According to International Organization for Economic Cooperation and Development (OECD) content of main nutrients in tubers varies depending from variety, soil and weather conditions, growing technology and other factors. The data of content of dry substance and starch obtained in the experiment vary within 18.3 % (Nevskii, B_2) and 26.4 % (Lugovskoi, B_1), 14.6 % (Fresco, B_2) and 18.2 % (Fresco, B_1) respectively.

Table 2. Influence of nutrients doses on dry substance/starch content in tubers* (%)

Doses of nutrients (factor B)	Variety of potato (factor A)						Average (factor B)	
	Fresco		Nevskii		Lugovskoi			
	1	2	1	2	1	2	1	2
B_1	23.4	18.2	21.4	17.5	26.4	19.6	23.7	18.4
B_2	21.0	14.6	18.3	16.2	21.1	15.9	20.1	15.6
B_3	19.9	16.9	20.8	15.1	26.1	16.8	22.2	16.3
B_4	21.5	17.3	18.3	17.2	24.2	18.0	21.3	17.5
B_5	21.7	15.3	18.3	17.5	25.8	17.3	21.9	16.7
Average (factor A)	21.5	16.5	19.4	16.7	24.7	17.5		
Minimal difference (P=95%) for particular differences factor A = 1.5/4.5; for factor B = 1.4/2.8								
Minimal difference (P=95%) for main effects factor A = 0.7/2.0; for factor B = 0.8/1.6								

* – 1 – content dry substance; 2 - content starch.

Lugovskoi variety has accumulated the highest dry substance in the tubers of the test plants, Nevskii varieties has had the smallest content. The decrease of dry substance in tubers has been observed due to the use of nutrients in fertilizers. Maximum indicators for each variety were obtained in the control variant (B_1).

When cultivating potato starch is about 70-80 % of the dry substance and 95 ... 98 % of the total amount of the polysaccharides. The starch content is directly related to the dry substance content and therefore, the highest figures for each of the varieties have been obtained in control variants (B_1). Regardless of potato varieties the use of mineral fertilizers leads to a systematic reduction of this indicator. It can be clearly observed especially when applying doses for additional tubers yield increase (B_2).

An important indicator of the safety of products is the content of nitrates. Data on the content of nitrates in potato tubers are presented in Table 3.

Table 3. Influence of nutrients doses on the content of nitrates in potato tubers (mg kg^{-1})

Doses of nutrients (factor B)	Variety of potato (factor A)			Average (factor B)
	Fresco	Nevskii	Lugovskoi	
B_1	462	99	655	405
B_2	625	566	226	472
B_3	397	427	502	442
B_4	251	329	427	336
B_5	504	408	235	382
Average (factor A)	448	366	409	
Minimal difference (P=95%) for particular differences factor A = 107; for factor B = 71				
Minimal difference (P=95%) for main effects factor A = 48; for factor B = 41				

Use of fertilizers along with favorable weather conditions and early harvest resulted in accumulation of quite high amount of nitrate compounds in the tubers, regardless of potato varieties.
An important moment when assessing the efficiency of fertilization in the experiment is the determination of crop increases due to fertilization or the actual return of fertilizers expressed by crop increase of one hectare per unit of reactant in fertilizers (Table 4).

Table 4. Agronomical assessment of fertilization of potato cultivation

Variant	Variety of potato	Doses of nutrients (kg ha^{-1})	Yield (t ha^{-1})	Crop increase (t ha^{-1})	Return of kg of fertilizer reactant due to crop increase
1	Fresco	$N_0P_0K_0$	17.7	-	-
	Nevskii	$N_0P_0K_0$	18.8	-	-
	Lugovskoi	$N_0P_0K_0$	25.6	-	-
2	Fresco	$N_{50}P_{50}K_{57}$	21.3	3.6	17.3
	Nevskii	$N_{100}P_{100}K_{114}$	21.9	3.2	10.2
	Lugovskoi	$N_{150}P_{150}K_{171}$	27.4	1.8	3.8
3	Fresco	$N_{108}P_{54}K_{36}$	31.2	13.5	68.0
	Nevskii	$N_{135}P_{90}K_{54}$	34.2	15.5	55.4
	Lugovskoi	$N_{135}P_{90}K_{54}$	32.0	6.3	22.7
4	Fresco	$N_{75}P_{30}K_{120}$	32.8	15.0	66.9
	Nevskii	$N_{100}P_{40}K_{160}$	46.6	27.8	92.7
	Lugovskoi	$N_{125}P_{50}K_{200}$	48.1	22.5	59.9
5	Fresco	$N_{67.5}P_{18}K_{36}$	48.5	30.8	253.5
	Nevskii	$N_{90}P_{24}K_{48}$	51.5	32.8	202.3
	Lugovskoi	$N_{112.5}P_{30}K_{60}$	45.6	20.0	98.7

Basing on the data presented in Table 4, it can be noticed that early ripening variety Fresco showed the highest crop increase (from 17.3 to 253.5 kg) due to amount of nutrients used among the majority of the variants studied. Lugovskoi variety was less responsive to fertilization in the experiment. Level of return was from 3.8 to 98.7 kg. Nevskii variety was characterized with intermediate values. Regardless of potato varieties higher return of nutrients was obtained after the use of doses for compensation of takeout with nutrients with the planned harvest basing on the soil fertility (B_5).

Conclusion

The results of our experiment of the cultivation of potato in conditions of soddy shallow clay loam podzolic soil in Permskii krai allow to make some conclusions:

• the use of doses of nutrients for additional tubers yield increase (B_2; early ripening and medium early variety) and for compensation of takeout with nutrients with the planned harvest basing on the soil fertility (B_5) (middle variety) was more effective with high content in the soil of exchangeable phosphorus and potassium;

• increased ability of the root system for assimilation of middle and late potato varieties to make greater use of nutrients from the soil and resulted increase of yield of Lugovskoi;

• the use of main nutrients doses for compensation of takeout with nutrients with the planned harvest basing on the soil fertility (B_5) allowed us to obtain the maximum return of nutrients in mineral fertilizers (98.7-253.5 kg) and tuber yield at 45.6 - 51.5 t ha^{-1} regardless of the variety .

References

Alaa, S.A., Ammar, D.I., Salah, M.N., 2012. Water use efficiency of potato (Solanum tuberosum L.) under different irrigation methods and potassium fertilizer rates. *Annals of Agricultural Sciences* 2, 99-103.

Dospekhov, B.A., 2011. Methodology of field experience. Agroprpmizdat, Moscow. 351 p.

Egamberdiyeva, D., Hoflich, G., 2004. Effect of plant growth-promoting bacteria on growth and nutrient uptake of cotton and pea on a semi-arid region of Uzbekistan. *Journal of Arid Environment* 56, 293–301.

El-Gamal, A.M.,1985. Effect of potassium level on potato yield and quality. *Journal of Agricultural Science Mansoura University* 10, 1473–1476.

Humadi, F.M., 1986. Influence of potassium rates on growth and yield of potato. *Iraq Journal of Agricultural Science "Zanco"*. 4 (2), 69–75.

Kuzyakin, DV., 2003. Regeneration of mid potato genotypes for mineral fertilizers in the Urals: Author. diss . Perm, p. 25 .

Mahmudpur, A.R., Norov, M.S., 2013. Effects of selection on seed potatoes quality and yield. Kishovarz (Farmer), Tajik Agrarian University (Dushanbe). 1, 67-68.

Marcelo, S.B., Paulo, I.F., 2011. Modelling of drying kinetic of potatoes taking into account shrinkage. Procedia Food Science, pp. 713-721.

Safin, R.I., 2002 Optimization of mineral nutrition and plant protection in the adaptive technology of potato cultivation in forest-steppe of the Volga region. Author. diss . Kazan. 24 p.

Shpaar, D.V., 1999 . Potatoes. FUAinform, Moscow. 272 p.

Tisdale, S.L., Nelson, W.L., Beaton, J.D., 1985. Soil Fertility and Fertilizers. Macmillan Pub. Co., New York.

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Estimation of dynamic equilibrium in a polydisperse soil system

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Abstract

During analysis of a polydisperse soil system (PSS), the count of specific particles alone is insufficient. What is more important, is to estimate their dynamic ratio via constants — $k_1/k_2=K$. These "constants" are always calculated relatively to the reference silt content thus acting as relevant values for the given physical clay weight. This approach allows universal and standardized PSS analysis. A PSS balance constant functions as a universal coefficient indicating the proportion between the "humus content per 100 g of soil" value and "humus content per 100 g of physical clay".

Keywords: balance, polydisperse system, fractions, physical clay, dust, dynamic balance constants, humus content

Introduction

The study of polydisperse soil system is currently an actual problem in soil science because granulometric composition affects multiple soil properties, such as physicochemical, physical and mechanical characteristics, thermal and water conditions, etc. In general system theory, soil is regarded as a bio-inert four-phase polydisperse heterogeneous self-regulating open ecological system tending to reach in its development the state of dynamic sustainable balance. This opens the path to mathematic modelling of the system.

Stability, buffering, integrity and sustainability of a PSS are "guarded" by the internal laws of the system: existence of a backup mechanism and feedback mechanism, and the course of mutually antithetic processes of aggregation and dispersion of soil matter ultra- and microaggregates according to their own life cycle.

Only particles smaller than 0,01 mm take part in colloid-chemical reactions occurring in soil. Particles larger than 0,01 mm do not participate in these reactions acting as soil ballast in that respect. Therefore, some authors [Tiulin, 1958; Markovskiy, Ponomareva, 1958] suggest calculating the agrochemical characteristics during soil analysis per 100 g of physical clay (the number of particles <0,01 mm), instead of the typical calculation method per 100 g of soil, because the ballast part of soil matter — physical sand (>0,01 mm) — varies in different soils considerably causing serious mess in the data obtained during comparative study of soils with dissimilar granulometric composition.

Material and Methods

Solid phase of soils exhibits irregular distribution of nutrients. 85-95% of humus, nigrogen, phosphorus, exchange capacity and adsorbed water are associated with particles smaller than 0,01 mm (*z*). Fractions

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larger than 0,01 mm (γ) are inert; they act as mechanical "diluent" for the substances concentrated mostly in physical clay. Thus it is necessary to take this dilution effect into account. To do that, the ratio between the masses has to be introduced using the coefficient $k_1=100/z=1+\gamma/z$.

However, physical clay mass is also heterogeneous. It splits into two groups: hydrophilic particles smaller than 0,001 mm ($\alpha\phi$) and hydrophobic particles — 0,01-0,001 mm dust ($\beta\phi$). Particles of the first group are enriched with fulvate humus and superfine minerals with labile lattice while the second group is characterized by humate humus type and illite minerals with rigid lattice. The ratio between these groups in physical clay varies depending on the season and year and that variability has to be considered during soil analysis.

To take into account the dynamics of heterogeneous masses, we introduce the silt-to-dust coefficient for physical clay — $k_2=z/\alpha\phi=1+\beta\phi/\alpha\phi$. Since the physical clay content in soil varieties is a variable, too, in comparative dispersity analysis it is practical to assign to it a constant value — z=100. In that case the silt and dust content will always be evaluated per 100 g of physical clay. This PSS parameter is defined as physical clay saturation with silt ($V_\alpha=100\alpha\phi/z$,%) or dust ($V_\beta=100\beta\phi/z$,%). Each of the values can vary from 50 to 100%. Thus, it is insufficient to consider just the number of specific particles during PSS analysis. Their dynamic ratio expressed via k_1 and k_2 is more important.

Results and Discussion

The ratio of coefficients ($k_1/k_2=K$) in soils takes up three values: K>1, K<1, and K=1. We define the balance state with K=1 as ideal dynamic balance in PSS because the system elements (z, γ, $\alpha\phi$, k_1, k_2 and V) exist in determined (dt) relations with each other and can be described with mathematic precision. E.g., $k_1=k_2$, z=V, $\alpha\phi=\alpha dt$, etc. If K≠1, nothing can be predicted or simulated.

If a system exists in ideal dynamic balance, its dispersity is predictable: it is possible to calculate for any physical clay value the amount of silt (αdt) and dust component in it using the following equation:

$$k_1/k_2=(100/z):(z/\alpha dt)=1{,}0$$

Hence the following is true —$100\alpha dt=z^2$,

then – $\alpha dt=0{,}01z^2$ silt amount is equal to the squared weight of physical clay divided by 100.

$$\text{Dust value — } \beta dt=0{,}01\gamma z=z-\alpha dt$$

Examples of these calculations are provided in columns 5 and 6 of the table 1.

The αdt values thus obtained are called base (determinant) values as the values most probable for the given physical clay value. Base silt content values (column 5 of the table 1) play decisive role in PSS analysis. They act as a model (colloid reference). Real dynamic balance states where K≠1 can be evaluated relatively to the model. Each time the actual (real) dust content values ($\alpha\phi$) of a specific soil sample are compared against its base $K=\alpha\phi/\alpha dt$.

If the pulverescent component ($\beta\phi>\alpha\phi$) is prevailing in physical clay, then $K=\beta\phi/\alpha dt$. Thus the PSS dynamic constants are calculated (column 8 of the table). To do that, just the z and $\alpha\phi$ values of the soil sample are sufficient.

The title of "constants" is justified by the fact that their calculation is always based on the reference value of silt content, which is constant for the given physical clay. This approach allows universal and standardized PSS analysis. Real dynamic balance states of soil samples are measured (compared) against an ideal reference.

The above dispersity analysis model has been tested experimentally. A fragment of the research is provided in the table. Granulometric soil composition was determined in combined analysis with pyrophosphate sample preparation and selection of a physical clay sample from the same kern. Then general humus content (y) was determined in soil and in physical clay (x). At the same time we calculated humus content in physical clay using the formula: $x_p=yK$ for K>1, and $x_p=y/K_1$ for K<1. The coeffcient of correlation between x and x_p is close to 1 when п=200. The PSS balance constant acts as a universal coefficient indicating the proportion between the "humus content per 100 g of soil" and "humus content per 100 g of physical clay". In other words, we can state that general humus content in soil is the humus content in physical clay diluted according to the value of the dynamic balance constant. All values of "humus content per 100 g of physical clay" have K=1 being therefore absolutely comparable to each other. They are reduced to a common denominator. However, the "humus content per 100 g of soil" values are not comparable with each other because each individual soil sample has its own K value. The most objective assessment of the soil humus status is based on the saturation of physical clay with humus (column 12 of the table). Here humus content in physical clay is correlated with its content in soil and multiplied by 100.

$$W=100x/z, \%$$

The suggested mathematic model ($x=K_y$ for $K>1$ and $x=y/K$ for $K<1$) has restrictions. The equation works in the physical clay content range from 70-75 to 25-30%. The degree of physical clay saturation with silt or dust varies from 50 to 70-75%. Dynamic balance constants in clay, heavy, medium or light loamy soils vary from 2 to 1 for $K>1$ and from 1 to 0,5 for $K<1$.

In light soils (z=25% or less) analytical and calculated values of humus content in physical clay do not always coincide.

Table 1. Correlation between the constants of PSS dynamic balance (K) and humus content in soil (y) and physical clay (x, x_p)

Sample level and depth, cm	Particles content, %			Base (reference) values, %		Physical clay saturation with silt or dust, %	Dynamic balance constants	Humus content, %			Physical clay saturation with humus
	<0,01 mm	<0,001 mm	0,001-0,01 mm	<0,001 mm	0,001-0,01 mm			Per 100 g of soil	Per 100 g of physical clay: Analytical	Per 100 g of physical clay: Calculated	
	z	α_{ϕ}	$\beta_{\hat{o}}$	α_{dt}	β_{dt}	V	K	y	x	x_p	W
1	2	3	4	5	6	7	8	9	10	11	12
Yellow and brown clay based southern black soil											
Апах 0-20	53,9	31,0	22,9	29,0	24,9	57,5	1,068	3,88	4,17	4,14	7,7
C120-130	61,8	39,1	22,7	38,2	23,7	63,2	1,024	0,46	0,50	0,47	0,7
Loess-like loam based light chestnut saline soil											
A 0-12	42,3	25,1	17,2	17,9	24,4	59,4	1,402	2,82	3,57	3,95	8,2
B_1 5-15	61,3	44,1	17,2	37,6	23,7	71,9	1,172	1,68	2,10	1,97	3,4
B_2 35-45	60,8	45,5	15,3	37,0	23,8	74,8	1,229	1,30	1,63	1,60	2,7
Loess-like clay based crusty solonetz soil											
A 0-3	37,1	21,8	15,3	13,7	23,3	58,7	1,591	2,08	3,34	3,31	9,0
B_1 5-15	65,3	49,6	15,7	42,6	22,7	75,9	1,164	1,40	1,71	1,63	2,6
B_2 17-27	63,9	48,1	15,8	40,8	23,0	75,3	1,178	0,80	1,00	0,94	1,4

Conclusion

1. Granulometric composition has to be interpreted based on the correlation between the elements of a PSS in its functional environment.
2. Soils exhibit the ideal state of dynamic balance, *which can be described mathematically*. It can be simulated for each physical clay value. Then the model silt content acts as a reference value (colloid reference) used to calculate the dynamic balance constants of real soil samples.
3. Dynamic balance constants have twofold nature. On the one part, they are unique: any soil sample has its own values of the constant. On the other part, they act as a universal coefficient of the proportion between the "humus content per 100 g of soil" and "humus content per 100 g of physical clay". Knowledge of the K and "humus content per 100 g of soil" values allows predicting the humus content in physical clay with high probability (95-98%).
4. Objective evaluation of soil humus status can be accomplished using two indicators: "humus content per 100 g of physical clay" and "physical clay saturation with humus". These indicators are absolutely comparable with each other because their K=1. At the same time, the "humus content per 100 g of soil" are incomparable. Each of them has its own K≠1, and its own dilution effect.

References

1. A.G. Markovskiy, V.A. Ponomareva. Group composition of soil particles smaller than 0,01 mm and its role in phosphoric acid absorption in soils / Pochvovedenie, No.8. 1955.– pp. 49-60.
2. A.F. Tiulin. Humus-clay colloids in soil, their genesis and role in the root nutrition of higher plants. – Nauka Publ., 1958, 51 p.

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Physical and chemical soil indicators of arid ecosystems in Azerbaijan

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Abstract

Some of the physical and chemical characteristics of gray-brown and gray-meadow soils under natural phytocenosis of the arid ecosystems of Azerbaijan have been studied. Gray-brown soils (Siyazan-Sumgait massif) covered with halophytic vegetation have a small amount of humus - 0.53-0.85% (7.63-12 tons/ha^{-1}) and weakly saturated with nitrogen 0.029-0.046% (0.41-0.65 t ha^{-1}). The vegetation formation change is accompanied by changes in the humus content of soils. Thus, under deciduous trees of the forest belt humus increases to 1.3-1.7% (18.5-23.8 t ha^{-1}), and the amount of nitrogen reaches 0.072-0.093% (1.0-1.4 t ha^{-1}), which is associated with the activities of humus forming saprophages. Under coniferous plantations content of humus and nitrogen reduces to 0.46% (6.9 t ha-1) and 0.026 (0.36 t ha^{-1}). The soils are heavy and contain up to 52-90% of the physical clay. The soils are saline (1.5-1.8%) with chloride, chloride-sulphate composition of salts, and the underground waters overlain at the depth of 5-7 m with mineralization of 10.8-16.8 g l-1. The sum of the absorbed bases is 18.9-20.1 meq 100g-1 soil and of carbonate is 9-23%. The humification corresponds to the fulvate type (Cr. C. / Cf. K = 0.65). Gray-meadow soils (Salyan region), forming under the saltwort vegetation, are characterized by minimal content of humus (0.54-0.63%), nitrogen (0.030-0.035%) and their reserves (7.02-8.19 t ha^{-1}and 0,390-0.455 m ha^{-1}). Under the wormwood ephemeral vegetation a quantity of humus and nitrogen increases to 0.71 - 1.10% (9.23-14.30 t ha^{-1}) and 0.036-0.055% (0.468-0.715 t ha^{-1}). Total absorbed bases vary on cenoses between 54.3-62.3 and 43.0 - 51.1 meq 100g^{-1}. The total carbonate level is high: 13.7-18.9%. Reaction (pH) of alkaline soil solution varies between 7.9 and 8.2. The underground waters are at a depth of 1.7-3.0m with salinity 5-15 g/l. The soils are saline (1.7-3.0%) with chloride and sulfate-chloride salt composition. Humification develops on fulvate and fulvate-humate type - Cr. C. / Cf. K = 0.45-0.91. The soils are medium loamy and heavy loamy with a physical clay content of 45-65%. Meadow-gray soils (Shirvan steppe), developing under a wormwood-ephemeral vegetation are characterized by the high value of the sum of exchangeable bases mg.ekv./100 20-30 g soil.

Keywords: Humus, salinization, absorbed bases.

Introduction

Physical and chemical indicators of grey-brown, grey-meadow and meadow-grey soils developing in arid environmental conditions under different plant formations were comparatively studied. Environmental conditions are known to determine the nature of physical, chemical and biological processes occurring in the soils and particularly affecting the biochemical reactions and humification.The research of the pattern of intensity changes of biological, physical and chemical processes of soils developing in arid environmental conditions where the major dominant elements of the environment are abiotic factors is very important. Similar studies should be conducted in other natural areas and cover a large variety of soil and climatic

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conditions such as hydro-thermal regime, pH reaction, salt composition, depth of groundwater salinity, dynamics of biological and humification processes. It should be noted that certain stationary integrated researches were conducted in the main types of soils of Azerbaijan in developing arid and humid environmental conditions and the natural connections between biotic and abiotic factors were indentified (Aliyev, 1978; Djafarova, 2005). However, the research of the dynamics of soil processes under the influence of complex ecological and genetic factors of soil formation remains the prior problem requiring systematic study and subsequent generalization of the results. In this direction Azerbaijani scientists conducted comprehensive studies of physical and chemical properties of soil and humus condition of arid ecosystems (Zahidova, 2003; Sadikhova, 2004; Djafarova, 2005; Samedov et al., 2013).

Gray-brown, gray-meadow and meadow-gray soils of natural cenoses developing in arid environmental conditions have been selected as the object of the research. The researches revealed some regularities of changes in humus condition and physicochemical properties of these soils characterized by different stages of soil-forming process such as semi-desert steppe, meadow, meadow-steppe.

Material and Methods

Physicochemical analysis and determination of qualitative and quantitative indicators of humus soils were carried out by conventional methods in soil science (Arinushkina, 1970; Kononova and Belchikova, 1961).

Results and Discussion

Gray-brown soils (Siyazan-Sumgayit massif, Azerbaijan) of natural phytocenosis covered with halophytic vegetation contain a small amount of humus (0,53% - 0,85%), which stocks (0-30 cm layer) are only 7.63 - 12 t / ha and are weakly saturated with nitrogen 0.029 - 0.046% (0,41-0,65 t / ha). The researches have established that a change in plant formations accompanied by a change of quantitative and qualitative indicators of humus.öThus, in the soil under deciduous trees (artificial afforestation) amount of humus increases to 1.3-1.7% (18,5-23,8 t / ha), and the amount of nitrogen reaches 0,072-0,093% (1.0 - 1.4 t / ha), which is associated with active soil humification saprophages recession. Under coniferous vegetation (pine, cypress) the content of humus and nitrogen decreases to 0.46% (6.9 t / ha) and 0.026% (0.36 t / ha) respectively. Apparently, the acidic degradation products of recession conifers limited biological processes of humification. Humification on virgin soils develops on fulvic type (Sg.k / Sf.k = 0.65) with a predominance of fulvic acids. The soils of studied habitats are saline (1.5 - 1.6%) with chloride, chloride-sulphate type of salinity. Ground waters occur at a depth of 5-7 m with a salinity of 10.8 - 16.8 g / l. Total absorbed bases is 18,9-20,1 mmol/100 g. of soils, and the amount of carbonates varies between 9-23%.

Gray-meadow soils are common in Salyan steppe, which occupies 149 hectares of territory of Kura-Araz lowland. Gray-meadow soils of natural cenoses formed under saltwort vegetation are characterized by minimal content of humus (0.54 - 0.63%), nitrogen (0,030-0,35%) and stocks respectively 7,02-8,19 t / ha and 0,390-0,455 t / ha which is similar to the previous saline soils. Under sagebrush ephemeral vegetation the amount of humus and nitrogen increases to 0,71-1,10% and 0,036-0,055% with larger reserves respectively 9.23 - 14.30 t / ha and 0,468-0,715 t / ha. Total absorbed bases on cenoses varies between 54,3-62,3 and 43,0-51,1 mmol /100 g of soils.

The total carbonate content is high reaching 13.7 - 18.9%. The pH reaction of the soil solution is alkaline which is equal to 7.9 - 8.2. Ground water occurs at a depth of 1.6 - 2.3 m with a salinity of 5-15 g / l.

The soils are salinized (1.7-3.0) with chloride and sulfate-chloride salt composition. Humification develops on fulvic humate and fulvic type (Sg.k / Sf.k = 0,45-0,91) with predominance of fulvic and humic acids gradual increase. Meadow gray soils are the dominant soils of Shirvan steppe which occupies 687 470 hectares territory of Kura-Araz lowland. Gray-meadow soils developing under sagebrush ephemeral vegetation characterized by a high value of the sum of exchangeable bases (20-30 mmol/100 g. of soils). Calcium predominates in the base of composition (50-70%). The soils are clay and the content of physical clay comes to 60-70%. The amount of salts in the profile varies between 0.1-0.9% which is prevalent in the composition of sulfates. pH reaction of the soil solution is alkaline (8.0-8.2). The development of these soils occurs in soil moisture conditions. Ground water is at a depth of 5-10 m. The content of humus and nitrogen varies between 1.6-2.1% and 0,088-0,115% respectively. Reserves of humus and nitrogen constitute 22,4-29,4 t/ha and 1,32-1,72 t/ha. Humification develops on fulvic humate and fulvic type (Sg.k / Sf.k = 0,9-1,1) with predominance of humic acids.

- It was established that gray-brown, gray-meadow and meadow-gray soils developing in arid environmental conditions under different plant forms differ from each other not only on the type of salinity and composition of salts but also in some physicochemical parameters.
- Quantitative and qualitative changes of humus condition reflect general characteristics of the various stages of soil-forming process of the studied soils.

Conclusion

On the basis of comprehensive studies it was found that the gray-brown, gray-meadow and meadow- gray soils of arid ecosystems of Azerbaijan formed under different plant communities differ on certain physico-chemical parameters, quantitative and qualitative composition of humus. The results indicate different stages of soil-forming processes related to each type of soil and so this data should be used during morphologic diagnostics and biodiagnostics of soils of arid ecosystems.

References

Aliyev, S. A., 1978, Ecology and energy of biochemical conversion processes of soil organic matter. "Elm", Baku, Azerbaijan.

Arinushkina, E. V., 1970. Guidance on chemical analysis of soils. MSU, Moscow, Russia.

Volobuyev, V. R., 1963, Soil ecology. Academy of Science of Az. SSR, Baku, Azerbaijan.

Djafarova, S. Z., 2005. Some physico-chemical and biological indicators of gray-brown and meadow gray soils. Proceedings of the Soil Science Society of Azerbaijan. XI. Baku, Azerbaijan, pp. 221-225.

Zahidova, B. B., 2003. The effect of salinity on the humus status of gray-brown soils of individual phytocenoses. In: St. Petersburg, Russia. «Humic substances in the biosphere» II International Conference, p. 145.

Kononova, M. M., Belchikova N. P., 1961. Rapid methods for determining the composition of humus in mineral soils. For «Soil science» magazine, № 10, 228 pages.

Sadikhova, M. E., 2004. Changes in the ecological status of anthropogenically-degraded gray-brown soils of dry subtropics Azerbaijan. In: Rostov-on-Don, Russia. International Science Conference, pp. 17-19.

Samedov, P. A., Bababekova, L.A., Aliyeva, B.B., Mamedzade, V. T., Sadikhova, M. E., Aliyeva, M.E., 2013. Biological indicators and their importance in the diagnosis of saline soils of arid biogeocenoses of Azerbaijan. For magazine «Vestnik» of Ryazan State University named after P. A. Kosticheva. № 4 (20), 52-57.

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Establishment of recommendation fertilization guide of vegetable crops in Algeria

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Abstract

The goal of fertilization is to meet the nutritional needs of plants by completing the supply of soil nutrients in an economically profitable and environmentally friendly. Achieving on-farm optimum economic crop yields of marketable quality with minimum adverse environmental impact requires close attention to fertilization guide. The recommendations seek to do this by ensuring that the available supply of plant nutrients in soil is judiciously supplemented by additions of nutrients in fertilizers. The objective is that crops must have an adequate supply of nutrients, and many crops show large and very profitable increases in yield from the correct use of fertilizers to supply nutrients. The main objective of this work is to establishing a reference guide of fertilization of vegetable crops and cereal in Algeria. To meet this objective, we have processes in two steps: 1) Establishment of theoretical fertilizer recommendation from international guide of crop fertilization; 2) Validation of these developed theoretical fertilizer recommendation by trials in the fields. Sixteen fertilization guides of vegetable crops from the Canadian provinces (5 guides), USA (10 guides) and countries of northern Europe England (1 guide). Generally, the rating of these recommendation is ranging from poor soil to soil exceedingly rich; however, the numbers of fertility classes are very different. Indeed, Quebec Ontario, Minnesota, Wisconsin New England, Maryland and Kentucky and Florida guides are subdivided into 5 fertility classes, ranging from poor soil to soil exceedingly rich. The recommendation of New Brunswick and Manitoba contain six classes. The recommendation of Michigan, Nova Scotia and England contain 10 and 7 fertility classes respectively. The recommendation fertilizer of New York and New Jersey have 3classes. Unlike the systems of fertilization recommendation mentioned above, the recommendation fertilizer of Pennsylvania is based on continuous models of P, K and contains 34 classes for P and 22 classes K. Then we standardized the P soil analysis with conversion equations (Olsen method) and units of measurement (kg/ha, mg/kg…).Following this procedure we transformed discontinued systems of fertility classes in to continuous models to facilitate comparison between the different fertilization recommendation models in one hand, in other hand to obtain critical value (CV).Finally, we used statistics of the conditional expectation in order to generate the theoretical recommendation fertilization guide of fertilization with 7 *fertility classes* (VL, L, M, MH, OP, H and VH). The next step was calibrating soil tests against yield responses to applied nutrient in field experiments. A database (not published data) from agriculture and agri-food Canada, were used. Production of pumpkin responded positively and significantly to P or K soil fertility levels, increases being observed with P more often than with K. According to the Cate-Nelson methods, the critical value of Olsen-P in the top 20 cm of soil was about 25 mg/kg: at values of greater than or equal to 25 mg/kg, crops achieved about 80% of their maximal yield in the absence of fertilizer application. The CV of K in soil for this crop was about 140 mg/kg. The CV found was very close to this generated by the theoretical method for recommendation of fertilization guide. Finally, we used the procedure of Cope

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and Rouse in both sides of the CV in order to make subdivisions of different groups of soil fertility. One calibrates the soil-test value against yield response to tile nutrient to predict fertilizer requirement.

Keywords: Fertilization recommendation, NPK-fertilization, critical value, vegetable crops.

Introduction

According to FAO, over the past 50 years, the increase in world agricultural production was 1.6 times greater than 10000 years of agricultural history. This shows the importance of the contribution of science to the development of agriculture. Nutrient management is a key factor in the success or failure of cropping systems in Algeria. Insufficient nutrient levels can decrease yield and quality by creating a stressed environment where plants are more susceptible to disease and weed infestation. However, excessive nutrient levels can also reduce crop productivity, quality and farmers profitability (Tindall et al.,1997).Proper nutrition is essential for satisfactory crop growth and production. Crop Fertilizer recommendations based on soil tests take into consideration the fertility level of individual fields. If the soil in a particular field is already high in a nutrient, as determined by soil test, a low application will be recommended and vice versa. In this way limited capital or resources can be used on fields where they will do the most good. Excessive fertilizer use, especially nitrogen and phosphorus, has potential to degrade ground and surface water quality (Dahnke et al., 1992).The use of soil tests can help to determine the status of plant available nutrients to develop fertilizer recommendations to achieve optimum crop production. The profit potential for farmers depends on producing enough crops per hectare to keep production costs below the selling price. Efficient application of the correct types and amounts of fertilizers for the supply of the nutrients is an important part of achieving profitable yields.

The fertilizer industry supports applying nutrients at the right rate, right time, and in the right place as a best management practice for achieving optimum nutrient efficiency (Roberts, 2008). Determining the optimal fertilizer rate for each vegetable crop and cereal can be challenging. Currently, many farmers in Algeria use NPK fertilizers but have little information on which to base their decisions on how much to apply. The result is that many of the soils receive more fertilizer than can be used by the crop, and the unused portion is either lost or accumulated in the soil. For example, in some soils that have been fertilized yearly at rates recommended by agricultural ministries, the available phosphorus determined by the Olsen test has risen to about two or three times the amount needed for maximal yields of wheat, according to studies to date. Bringing the application rates more in line with crop requirements could save hundreds of thousands of tons of fertilizer each year.Thus, for instance, Algerian ministry of agricultural suggest simple recommendation for cereal whatever soil-test value; 100kg P_2O_5/ha are available, 100kg N-sulphate/ha or 80kg urea/ha). However, for vegetablecrops fertilization no data are available, thecrop fertilization is left for farmers. However, FERTIAL Spa, Algeria have launched a very good initiative which is to make free soil testing for farmers.

The most economical means of determining the fertilizer needs of cereal and vegetable soils is to have soil analysis. This means that productive agriculture should first solve the problem of under/over fertilization. This implies a profound reflection on the different farming practices and development of fertilization recommendation. Soil testing remains one of the most powerful tools available for determining the nutrient supplying capacity of the soil, but to be useful for making appropriate fertilizer recommendations good calibration data is also necessary. One of the efficiency approaches to making fertilizer recommendations which is based on the concept that a nutrient should be applied only if there is a reasonable expectation of a crop response. Under this approach, fertilizers should be applied only if they increase yields, and then only at optimum rates. The soil test will provide the basis for fertilizer application rates. One of the main problems hindering the development of Algerian agriculture and his economic success is the slightly-use of fertilizers. So far Algeria has neither the scientific tools (suchas diagnostic and analytical) or fertilizer recommendation guide for vegetable and cereal. Therefore the development of fertilization recommendation is the best options for optimize vegetables and grain production for Algerian market. The only references (recommendations) in fertilizing crops available to the Algerian agriculture are given by the company FERTIAL as only an indicative tool. The target of fertilization recommendation is to guideextension educators to provide help for farmers to interpret the soil test results. In addition to helpthem to decide how much fertilizer to apply. A controlled fertilization program of this nature also minimizes the potential for soil damage and water pollution. In other hand, the reduced nutrient use efficiency or losses in yield and crop quality by over- or under-application of fertilizer will be minimized. Good nutrient management is essential to helping farmers grow the food we want to buy without harm to the environment or health: farming can produce food and other crops profitably, sustainably and with high environmental standards.

The objectives of this work include:

1. An inventory and synthesis of recommender systems for N, P and K available for vegetable nationally and internationally.
2. A proposed recommendation models for some vegetable crops (theoretical model).
3. Validation of proposed fertilizer recommendation by Field Trials preparation and fertilization final recommendation for vegetable crops.
4. Produce a manual in order to help farmers and land managers better assess the fertilizer required for the range of crops they plan to grow, by suggesting what level of nutrients are required to provide the best financial return for the farm business. The manual will help ensure that proper account is taken of both mineral fertilizers.

Material and Methods

Establishment of theoretical recommendation of fertilization

For the development of fertilization recommendation guide, two approaches are possible:

1. The development of theoretical recommendation of fertilization followed by field validation and soil calibration;
2. Conduct large scale of NPK fertilization experiments after soil calibration.

According to Dr.Tremblay researcher at Agriculture and Agri-food Canada (personal communication) the first approach allows the gain time and cost of experimentation, so we consider the first procedure, since it will allow us to develop a theoretical framework followed by field trials for validation. And also allow us to define the intervals of nutritional adequacy of different cultures. A schema 1 summarize all steps of procedure to elaborate theoretical of fertilization recommendation guide.

Validation of these developed theoretical fertilizer recommendation by trials in the fields.

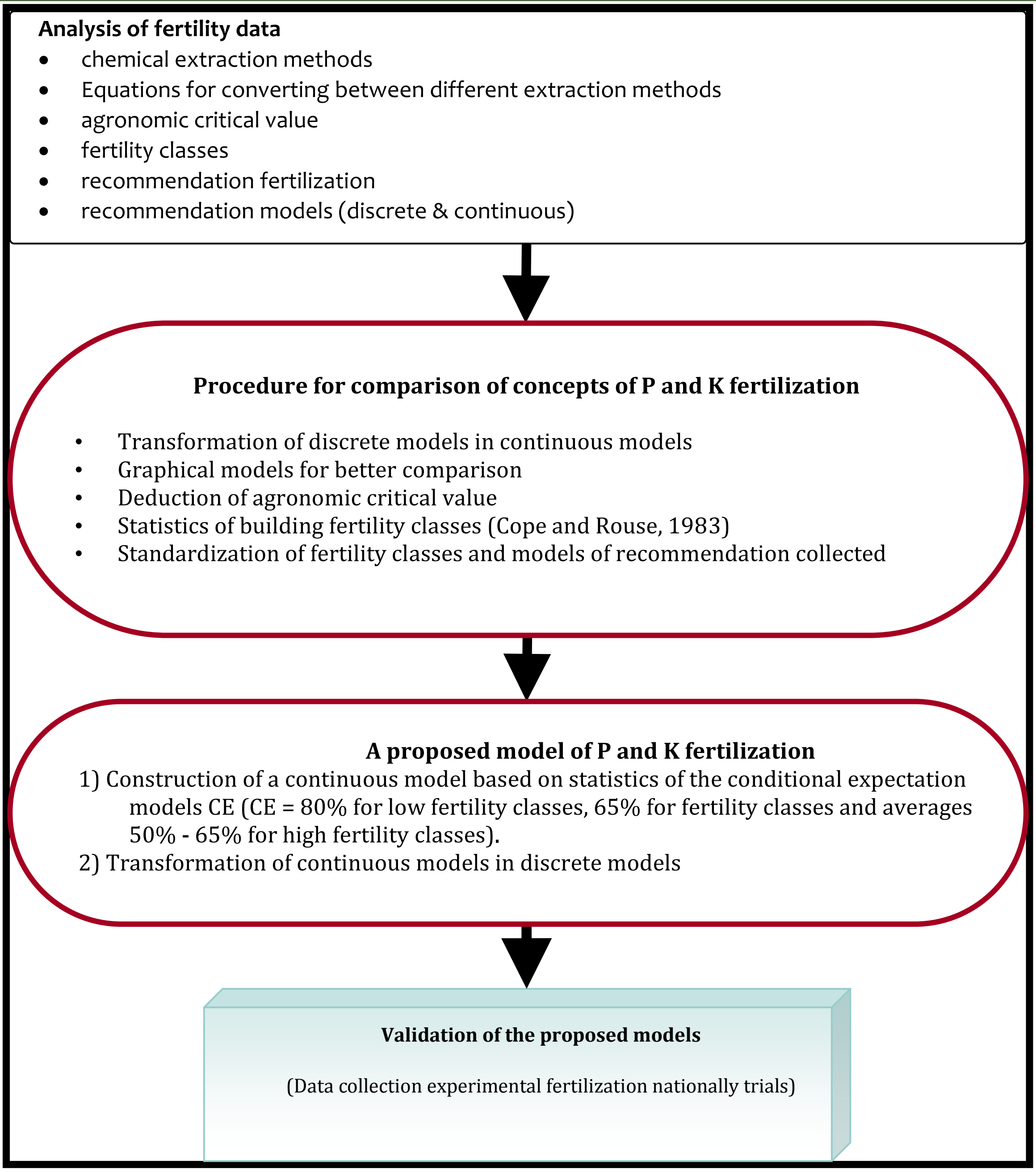
The research base is developed from research projects in which measured yields are related to soil test values for the nutrient of interest and the rate of that nutrient that has been applied. We used a database from Agriculture and Agri-food Canada (AAC) and Ministère de l'Agriculture, des Pêcheries et de l'Alimentation Québec (MAPAQ)derived from a large fertilization trials of vegetable crops (pumpkins; *Cucurbita maxima*) and soils calibration across Quebec province (Canada) from 2001 to 2003. We received this data as part of our study on: ⋘the changes made on the fertilization recommendation guide of vegetable crops of Quebec⋙ (Sbih and Khiari, 2005).

The soil samples collected before planting in fall 2001 Soil samples were collected in a systematic grid at 27 sites to a depth of 0-20 cm, The A composite soil sample was taken for each location. The soil samples were packed into plastic bags, then the soil samples were air dried and ground to pass through a 2-mm sieve, and analyzed for total N (Bremner and Mulvaney, 1982)., available P,K, Ca, Mg, Al, B, Cu, Fe, Mn, Zn, and Na was determined Mehlich III (Mehlich, 1984). The soil texture of surface layers ranged from clay loam to sandy soil.

Statistics

The Cate-Nelson method is to plot the relative yield (0-100%) of pumpkin against the level of available P or K in the soil. The relative yield for each location is the total dry matter obtained in the treatments without fertilizer as a ratio of maximum yields obtained when fertilizer is added.

One incorporated the responses to P for treatment combinations that provided adequate N nutrition of the crop and one incorporated the responses to N when adequate P was available in the treatment. Soils were divided according to the probability (high or low) that pumpkin will respond to fertilization. The diagram of the results is divided into quadrants that maximize the number of points in the positive quadrants and minimize the number in the negative quadrants.



Schema 1: general procedure to elaborate theoretical fertilization recommendation guide.

Table 1: soil mineral analysis and pumpkins yield

	Soil Test												Pumpkin yield
	N Total	P Olsen	K	Ca	Mg	Al	B	Cu	Fe	Mn	Zn	Na	
	(%)	mg/kg											T/ha
Number	27	27	27	27	27	27	27	27	27	27	27	27	27
mean	2,56	28	70	4697	3058	168	28	12	155	17	33	265	23,7
min	1,68	1,4	24	1323	1682	28	19	6	42	8	9	67	39,0
max	3,52	77,8	160	42160	7024	1714	45	19	1659	33	52	669	1,716
SD	0,50	21,2	32	3079	674	142	7	3	128	5	8	100	11,92
VC	0,19	0,75	0,44	0,66	0,22	0,85	0,26	0,29	0,83	0,28	0,24	0,38	0,49

Results and Discussion

Data analysis of international recommendation guide

In the first step we analyzed 16 fertilization guides of vegetable crops from the Canadian provinces (Quebec, Manitoba, Ontario, New Brunswick and Nova Scotia), of American States (New England, New York, New Jersey, Pennsylvania, Maryland, Michigan, Minnesota, Kentucky, Wisconsin and Florida) and countries of northern Europe (England). Generally, the fertilization guide of Quebec, Ontario, Minnesota, Wisconsin and Florida have five fertility classes, ranging from poor soil to soil exceedingly rich. The recommendation of New Brunswick and Manitoba contain six classes. The recommendationguide of Michigan, Nova Scotia and England contain 10 and 7 fertility classes. The states of New England, Maryland and Kentucky have four recommendation fertility classes, the recommendationguide of New York and New Jersey hasonly 3 classes. Unlike the systems mentioned above recommendations, the recommendation guide of Pennsylvania is based on continuous models of recommendation of P and K and contains 34 classes for P and 22 classes K, this is why we took the Pennsylvania model as reference. The above tables illustrate the different types of Pa and K recommendations guide.

Example of Phosphorus and potassium recommendation for potatoes (Minnesota, USA)

Table 19. Phosphate recommendations for potatoes.[1]

Yield Goal	Bray-P1 / Olsen-P	0-5 / 0-3	6-10 / 4-7	11-15 / 8-11	16-20 / 12-15	21-25 / 16-18	26-30 / 19-22	31-50 / 23-41	51+ / 42+
		Soil Test P Level (ppm)							
cwt/A		P_2O_5 to apply (lb/A)[2]							
less than 200		75	50	25	0	0	0	0	0
200 - 299		100	75	50	25	0	0	0	0
300 - 399		125	100	75	50	50	50	50	50
400 - 499		150	125	100	75	75	75	75	75
500 or more		175	150	125	100	100	100	100	75

[1] For acid irrigated sands, responses up to 150 lb/A P_2O_5 have been observed on very high (41+ ppm) P soils.
[2] For most efficient application, apply phosphate fertilizer in a band 2-3 inches below and to each side of the tuber planting.

Table 20. Potash recommendations for potatoes.

Yield Goal	0-40	40-80	81-120	121-160	161-200	201+
	Soil Test K Level (ppm)					
cwt/A	K_2O to apply (lb/A)[1]					
less than 200	150	75	50	25	0	0
200 - 299	200	100	75	50	25	20
300 - 399	300	200	100	75	50	25
400 - 499	400	300	200	100	75	50
500 or more	500	400	300	150	100	75

[1] Do not apply more than 200 lb K_2O/A in the band at planting.

Example of Phosphorus and potassium recommendation for potatoes (N. Brunswick, Canada)

PHOSPHORUS

Rating	Soil P level	Soil P content (ppm P)	Recommendations (kg P_2O_5/ha) Group I [(1)]	Group II
L-	Very low	< 10	280	335
L	Low	11–19	280	335
M	Medium	20–39	220	270
M+	Medium high	40–58	160	210
H	High	59–78	110	140
H+	Very High	> 78	97	114

Group I includes all varieties mentioned for nitrogen, except for Netted Gem Russet Burbank that belong to Group II.

POTASSIUM

Rating	Soil K level	Soil K content (ppm K)	Recommendations (kg K_2O /ha)	
			Group I	Group II
L-	Very low	< 18	280	335
L	Low	19-37	280	335
M	Medium	38-74	220	270
M+	Medium high	75-112	160	210
H	High	113-148	110	140
H+	Very High	> 148	60	90

Group I includes all varieties mentioned for nitrogen, except for Netted Gem and Russet Burbank that belong to Group II.

Example of Phosphorus and potassium recommendation for Onions and Peppers (Kentucky, USA)

FERTILIZER: *Onions*

Soil Test Results *(lb/A)*		Fertilizer Needed *(lb/A)*
Phosphorus		**Phosphate** *(P_2O_5)*
Low	<31	181-240
Medium	31-60	61-180
High	61-80	1-60
Very High	>81	0
Potassium		**Potash** *(K_2O)*
Low	<201	176-250
Medium	201-300	101-175
High	301-450	1-100
Very High	>450	0
Nitrogen		**N**
Apply 90 to 100 lb of nitrogen (N)/A to soils of relatively low fertility; broadcast and disk before planting. Decrease nitrogen application according to soil fertility. On heavily fertilized soils, apply 50 to 60 lb N/A. Once bulbing starts sidedress with 25 lb N/A every two weeks for a total of four applications.		

FERTILIZER: *Peppers*

Soil Test Results *(lb/A)*		Fertilizer Needed *(lb/A)*
Phosphorus		**Phosphate** *(P_2O_5)*
Low	<31	81-100
Medium	31-60	61-80
High	61-80	1-60
Very High	>80	0
Potassium		**Potash** *(K_2O)*
Low	<201	81-100
Medium	201-300	61-80
High	301-450	1-60
Very High	>450	0
Nitrogen		**N**
Peppers use approximately 100 to 150 lb of N/A. Apply 25 to 50 lb of N/A preplant. Rate to use will vary depending on previous crop and general fertility of the soil. Following sod, apply 50 lb of N prior to planting. After fruit begin setting, sidedress with another 30 to 50 lb of N/A. Two weeks later, make an additional application of 30 to 50 lb of N/A. For N fertigation, see comments in text and specific recommendations in the fertigation table.		

Tool for P and K analysis standardization

Methods of chemical extraction of P and K and their conversion equations to make comparable fertility classes, we used a data conversion mining models with P conversions proposed by Tran and Giroux (1989) and Mallarino (1995) (Table 1). These conversions will redefine the fertility classes for each crop, taking into account the conversion of the unit of measurement. For potassium, the extraction with ammonium acetate is equivalent to MehlichIII, therefore, the fertility classes of K remains unchanged regardless of the method of extraction of potassium. The table 1 summarizes the conversion equations for phosphorus analysis

Table 1: Equations of conversion

Equations	Authors
Mehlich-3 P = 2,63P-Olsen+4,3	Tran et Giroux 1989
P-Olsen = 0,46 Mehlich-3 P + 1,5	Mallarino, 1995
P-Olsen = 0,42 P-BrayI + 3,5	Mallarino, 1995
Mehlich-3 P = 14.8 + 1.54 P-Olsen	Kleinman et al., 2001
P-Olsen = 5.69 + 0.46 Mehlich-3 P	Kleinman et al., 2001
Bray-1 P = 13.5 + 1.34 Olsen P	Kleinman et al., 2001

Mehlich-3 P: P extraction methodMehlich-3;Mehlich-1 P: P extraction methodMehlich 1; P-BrayI: P extraction method (BrayI)

Critical value

Following the standardization procedure of recommendation fertilization, we transformed recommender systems in continuous models to facilitate comparison between the different fertilization recommendation models (U.S. states, Canadian provinces, England). The critical value is defined as the point marking the change of rate of the recommended dose based on the richness of the soil P or K (slope change) of the continuous model or the median of the class of medium fertility for models of constant slope like Quebec recommendation fertilization. The figure 1 is an illustration of this stage of the procedure.

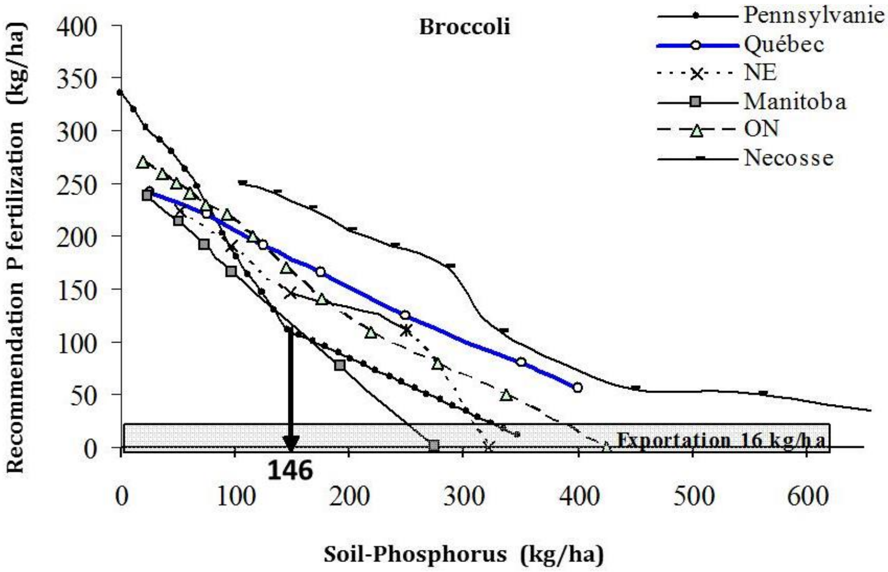


Figure1: Graphical representation of the different models of P Recommendation fertilization of broccoli crop

This figure shows the evolution of optimal doses of P_2O_5 for growing broccoli according to the richness of the soil P (continuous model).It shows a critical point of the model of Pennsylvania abscissa soil-P = 146 kg ha^{-1} marking the change in the rate of change in the recommended dose of 16 to 5 kg ha^{-1} of P_2O_5 per change of 10 kg ha^{-1} of soil-P. According to the model ofMitscherlich Bray,this point is the critical value beyond which there is a stable yield. This value is very close to 150 kg ha^{-1}soil-P, the median of phosphate soil fertility in Quebec (CRAAQ, 2003). However, the Quebec model keeps the same rate of change of 5 kg ha^{-1} of P_2O_5 per change of 10 kg ha^{-1} of soil-P whatever the class of phosphate fertility of soils. This trend does not subscribe to the principles of less than proportional decrease of recommendation fertilizer in the category of high fertility class. As the definition of fertility classes varies from one to anothersystem, we opted for uniform intervals of fertility by a graphical approach to the transformation of discrete models in continuous models.

This graphical approach has allowed us to develop equations with which it became possible to create new recommendations in phosphorus and potassium (Table 2). Previously, we have divided into intervals of indices of available P in both sides of the critical value, dividing this value by 2 and 4 for the very poor class and poor, and then multiplying by 2 and by 4 for the medium and rich by the procedure of Cope and Rouse (1983). Thus the obtained values are: 37.5 - 75 - 150 - 300 - 600 kg ha^{-1}soil-P (Table 2) we have inserted the value of 450, which is an intermediate value between 300 and 600 kg P/ha and represent value in which the Pennsylvania model recommendation is equal to zero. We recalculated the corresponding recommendations of P_2O_5in these subdivisions. The results obtained with the new recommendations are given in Table 2. Subsequently, we computed descriptive statistics such as, mean, standard deviation, maximum, minimum and coefficient of variation on all the recommendations by fertility class.

Table 2: Equations of different continue models of Phosphorus recommendation fertilization

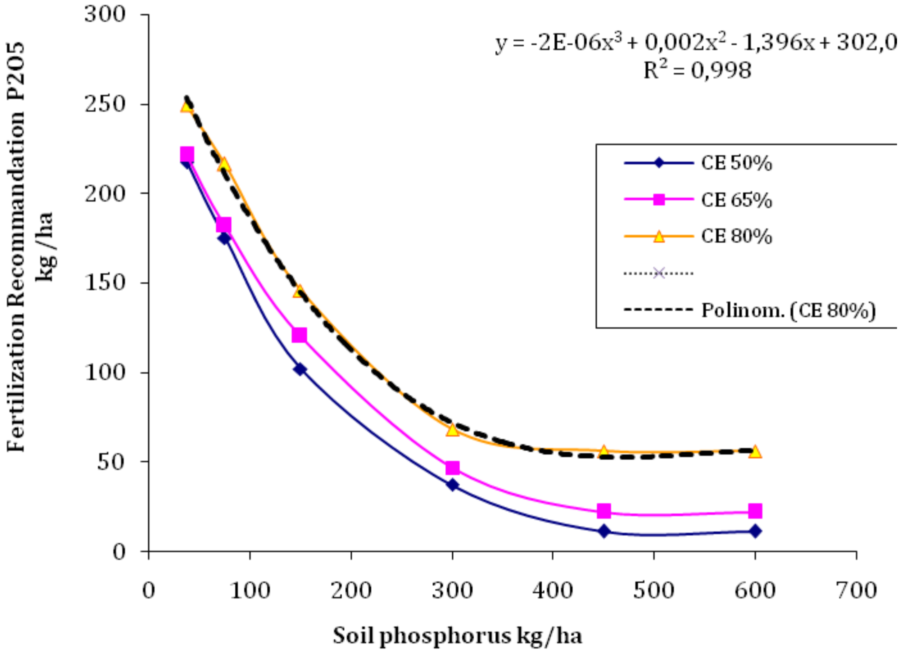
	Equations of recommandation models				Formulation					
	Y = a x3 + bx2 + cx + d				(C1) 37.5	(C2) 75	(C3) **150**	(C4) 300	(C5) 450	(C6) 600
États	a	b	c	D	P_2O_5 kg ha^{-1}					
Pennsylvania	-4.00E-06	0.0048	-2.1294	351.61	**278**	**217**	**127**	**37**	**11**	**11**
Québec		8.00E-05	-0.5333	255.71	236	216	178	103	55	55
New York			-0.4001	157.16	142	127	97	37	0	0
N. Jersey		0.0008	-1.3067	252.97	205	159	56	56	56	56
N. England	-3.00E-05	0.0138	-2.6223	329.79	249	198	146	0	0	0
Kentucky		-0.0035	-1.6555	196.64	130	53	17	17	17	17
Michigan		0.0005	-1.0901	254.19	214	175	102	0	0	0
Minnesota		-0.0095	-1.5346	288.38	217	120	56	56	56	56
Florida		-0.0047	-0.4668	194.6	170	133	19	0	0	0
Manitoba		0.0002	-1.0002	262.52	225	189	117	0	0	0
Ontario		0.0006	-0.9305	293.25	259	227	167	68	0	0
N. Brunswick			-0.9481	233.39	198	162	91	90	90	90
N. Scotia		0.0001	-0.3924	340.78	326	312	284	232	184	141
Great Britain										
Maryland			-0.603	213.99	191	169	124	33	27	27
Wisconsin	-3.00E-05	0.0151	-2.3544	130.22	62	26	16	0	0	0
Min					62	26	16	0	0	0
Max					326	312	284	232	184	141
standard deviation					64	70	72	61	51	42
Mean					207	166	106	49	33	30
CV					31	42	67	126	153	139
conditional expectation at 50 %					***217***	***175***	***102***	***37***	***11***	***11***
conditional expectation at 65 %					***222***	***182***	***120***	***47***	***22***	***22***
conditional expectation at 80 %					***249***	***216***	***146***	***68***	***56***	***56***

C1 : classe 1 =(C3)/4; C2 : classe 2 = (C3)/2; C3 : classe 3; C4 : classe 4 = (C3) x 2 ; C5 classe 5 = (C4) +150; C6 : classe 6 = (C3) x 4. C3 : Represent the critical value in the recommended dose according to the model Mitscherlich and Bray (Pennsylvania recommendation guide)

As recommended doses vary from one to anothersystem, we proposed a dose recommendations representative of a chance to cover the cases identified in each fertility class through the recommendation systems used in this study. A conservative approach, covering 50% of cases identified in each fertility class (the class average) and a more liberal approach, covering 80% of cases in a class of fertility, these approaches can be used as decision aid to determine the dose of P_2O_5 and K_2O to recommend as agronomic indicators for P and K (Fig. 2). The difference between the approaches should demonstrate the importance of considering the variation of agronomic criteria (yield potential, planting density, cultural practices, cultivar ...) soil (soil sorbtion capacity, type of colloidal matter ...) climate (rainfall, temperature, irrigation ...) from one system to another.

Elaboration of new P recommendation fertilization

Then the obtained value with Conditional Expectation at 80% were used in order to elaborate a continue model as showed in figure 2. The parameters of the equation generated by this value are used to elaborate the new fertilization recommendation



CE: Conditional Expectation

Figure 2: Probabilistic models to help change the recommendation of P fertilizer for growing broccoli

Table3: Equations of conditional expectation at 80%of phosphorus recommendation fertilization of broccoli

	Equations of conditional expectation at 80 %				**elaborate new P fertilization recommendation for Broccoli**		
	Y = a x3 + bx2 + cx + d						
Classe (x)	**a**	**b**	**c**	**d**	**∑**	**mean**	**New girds**
0	-2,00E-06	0,0026	-1,396	302,05	302	302	
50	-2,00E-06	0,0026	-1,396	302,05	239	(302+239)/2=270	**270**
100	-2,00E-06	0,0026	-1,396	302,05	186	(239+186)/2=212	**210**
150	-2,00E-06	0,0026	-1,396	302,05	144	(186+144)/2=165	**165**
200	-2,00E-06	0,0026	-1,396	302,05	111	(144+111)/2=128	**130**
300	-2,00E-06	0,0026	-1,396	302,05	63	(111+63)/2=87	**90**
400	-2,00E-06	0,0026	-1,396	302,05	32	(63+32)/2=47	**50**
450	-2,00E-06	0,0026	-1,396	302,05	18	(32+18)/2=25	**25**

Table 4: Phosphorus recommendations for broccoli (theoretical model of fertilization recommendation)

		Soil Test P level (mg/ha)						
	Olsen-P(ppm)	≤ 0-4	4-12	12-22	22-30	30-46	46-62	≥62
	Olsen-P (kg/ha)	≤0-10	10-28	28-50	50-68	68-104	104-144	≥144
		P_2O_5 to apply (kg/ha)						
Rating		*VL*	*L*	*M*	*MH*	*OP*	*H*	*VH*
Broccoli		**270**	**210**	**165**	**130**	**90**	**50**	**25**

Fertility classes: VL: very low; L: low; M: medium; MH: medium high; OP: optimum; H: high; VH: very high

Phosphorus recommendations for vegetable (theoretical model of fertilization recommendation guide)							
	Soil Test P level						
Olsen-P(ppm)	≤ 0-4	4-12	12-22	***22-30***	30-46	46-62	≥62
Olsen-P (kg/ha)	≤0-10	10-28	28-50	50-68	68-104	104-144	≥144
Mehlich3-P(ppm)	≤22	23-45	46-67	68-89	90-134	135-179	≥180
Mehlich3-P(kg/ha)	≤50	51-100	101-150	151-200	201-300	301-400	≥401
	P_2O_5 to apply (kg/ha)						
Rating	*VL*	*L*	*M*	*MH*	*H*	*VH*	*EH*
Pumpkin	220	180	140	***110***	70	40	20
broccoli	270	210	165	130	90	50	25
onion	280	215	165	125	85	55	40
Garlic	250	190	140	105	70	40	20
leek	255	200	150	110	70	40	25
beet	200	170	135	110	75	45	35
Lettuce	220	180	150	120	85	50	35
cucumber	255	190	140	105	75	50	40
melon	235	185	145	110	80	65	50
peas	165	130	105	85	65	40	25
green bean	130	100	75	60	50	30	15
Lima-beans	150	120	100	75	55	35	25
cabbage	245	205	170	135	100	61	45
Cauliflower	250	205	165	135	100	70	60
radish	180	145	120	95	70	50	40
rutabaga	195	160	130	105	80	50	40
Carrot	180	150	125	100	75	50	45
Peppers	260	210	165	130	100	60	40
tomato	235	195	160	130	95	65	50
Eggplant	245	200	160	125	90	60	50

Fertility classes: VL: very low; L: low; M: medium; MH: medium high; OP: optimum; H: high; VH: very high

Model recommendation of potassium

We followed the same approach as for P. Figure 3 shows the evolution of optimal doses K_2O for growing broccoli according to the richness of soil K (continuous model recommendation of potassium). It shows a critical point of the model of Pennsylvania abscissa K = 292 kg / ha marking the change in the pace of change in the recommended dose of 31 to 10 kg K_2O per 10 kg of variation K_2O/ha. However, the Quebec model keeps the same rate of change, 36 kg K_2O per 10 kg of variation K_2O/ha whatever the class of potassium fertility of soils. The results for the different models are shown in Table 5.

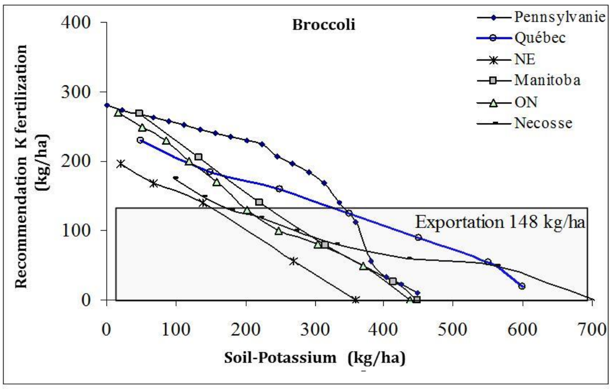
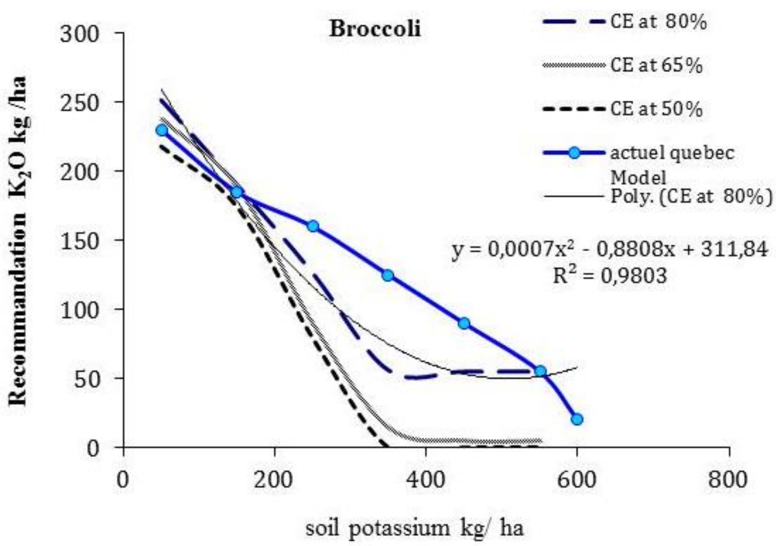


Figure 3: Graphical representation of the different models of K recommendation fertilization of broccoli crop

Table5: Equations of different continue models of potassium recommendation fertilization

	Equations of recommandation models				Formulation					
	Y = a x3 + bx2 + cx + d				(C1) 75	(C2) 150	(C3) **300**	(C4) 450	(C5) 600	(C6) 1200
States	a	b	c	D	K_2O kg ha^{-1}					
Pennsylvania	-3.00E-06	5.00E-05	-0.1392	275.43	**264**	**246**	**157**	**11**	**11**	**11**
Quebec	-1.00E-06	1.00E-03	-0.5727	255.75	218	189	147	109	56	55
New York			-0.6578	221.73	172	123	24	67	67	67
N. Jersey			-0.9347	265.37	195	125	56	56	56	56
N. England		-0.0004	-0.4392	203.29	168	128	36	0	0	0
Kentucky		-0.0001	-0.2855	173.96	152	129	79	0	0	0
Michigan		-0.0003	-0.7485	309.34	252	190	58	0	0	0
Minnesota		-0.0003	-0.4952	300.26	261	219	125	0	0	0
Florida		-0.0039	0.6287	132.46	158	139	0	0	0	0
Manitoba	-3.00E-07	0.0005	-0.8722	310.25	248	190	85	0	0	0
Ontario	-1.00E-07	0.0005	-0.8446	290.14	230	174	79	0	0	0
N. Brunswick	-2.00E-05	0.0133	-3.2553	446.06	268	190	126	70	70	70
N. Scotia		0.0002	-0.4315	205.79	175	146	94	52	19	0
Great Britain										
Maryland			-0.531	156.64	117	77	0	28	28	28
Wisconsin		-0.0006	-0.1795	264.75	248	224	157	0	0	0
								0		
Min					117	77	0	0	0	0
Max					268	246	157	106	70	70
standard deviation					49	46	53	26	28	28
Mean					208	166	82	26	20	19
CV					23	28	65	136	135	146
conditional expectation at 50 %					***218***	***174***	***79***	***0***	***0***	***0***
conditional expectation at 65 %					***239***	***189***	***90***	***26***	***15***	***6***
conditional expectation at 80 %					***252***	***190***	***126***	***56***	***56***	***55***

C1 : classe 1 = (C3)/4; C2 : classe 2 = (C3)/2; C3 : classe 3; C4 : classe 4 = (C3) x 2 ; C5 classe 5 = (C4) +150; C6 : classe 6 = (C3) x 4.C3 : Represent the critical value in the recommended dose according to the model Mitscherlich and Bray (Pennsylvania recommendation guide)



CE: Conditional Expectation

Figure 4: Probabilistic models to help change the recommendation of K fertilizer for growing broccoli

Table 6: Equations of conditional expectation at 80%of potassium recommendation fertilization of broccoli

	Equations of conditional expectation at 80 %				**elaborate new K fertilization recommendation for Broccoli**		
	Y = a x3 + bx2 + cx + d						
Classe (x)	**a**	**b**	**c**	**d**	**∑**	**mean**	
0	0,00E+00	0,0007	-0,8808	312	312	312	New girds
100	0,00E+00	0,0007	-0,8808	312	231	(312+231)/2=271	**270**
200	0,00E+00	0,0007	-0,8808	312	164	(231+164)/2=197	**200**
300	0,00E+00	0,0007	-0,8808	312	111	(164+111)/2=137	**140**
400	0,00E+00	0,0007	-0,8808	312	72	(111+72)/2=91	**90**
500	0,00E+00	0,0007	-0,8808	312	46	(72+46)/2=59	**60**
600	0,00E+00	0,0007	-0,8808	312	35	(46+35)/2=41	**40**
650	0,00E+00	0,0007	-0,8808	312	35	(35+35)/2=35	**35**

Table 7: Potassium recommendations for broccoli (theoretical model of fertilization recommendation)

		Soil Test K level (ppm)						
		≤45	46-89	90-134	135-179	190-223	224-268	≥269
		K_2O to apply (kg/ha)						
Rating		*VL*	*L*	*M*	*MH*	*OP*	*H*	*VH*
broccoli		270	200	140	90	60	40	35

Fertility classes: VL: very low; L: low; M: medium; MH: medium high; OP: optimum; H: high; VH: very high

Potassium recommendations for vegetable (theoretical model of fertilization recommendation)

		Soil Test K level (ppm)						
		≤45	46-89	90-134	135-179	190-223	224-268	≥269
		K_2O to apply (kg/ha)						
Rating		*VL*	*L*	*M*	*MH*	*OP*	*H*	*VH*
Pumpkin		220	180	140	80	50	40	35
broccoli		270	200	140	90	60	40	35
onion		260	200	145	105	80	60	55
Garlic		220	150	100	55	25	10	10
leek		230	175	125	80	45	20	10
beet		280	200	130	80	40	20	10
Lettuce		225	165	115	80	60	55	45
cucumber		230	200	140	90	60	45	40
melon		240	180	130	90	60	40	30
peas		165	120	80	55	35	30	30
green bean		165	115	75	45	25	10	10
Lima-beans		150	120	90	65	50	45	40
cabbage		275	200	145	105	80	65	55
Cauliflower		280	210	155	115	85	60	55
radish		200	140	100	70	50	40	35
rutabaga		230	200	140	95	60	40	35
Carrot		225	195	150	110	80	70	60
Peppers		285	190	120	80	55	45	40
tomato		230	180	130	95	65	45	30
Eggplant		295	210	150	100	65	40	30

Fertility classes: VL: very low; L: low; M: medium; MH: medium high; OP: optimum; H: high; VH: very high

Nitrogen fertilization

One of the major challenges related to vegetable production today is the adverse environmental impacts associated with the large amounts of N fertilizer applied to these crops. Nitrogen fertilizer recovered in the above-ground plant biomass is less than 40% of the amount applied in the same year as the crop grown (Cassman et al., 2002). Nitrogen fertilizer in excess of the amount required by crops can be readily leached through soil as NO_3 and adversely impacts ground and surface waters (Hong et al., 2007). The goal of N management for crops should be to apply enough N fertilizer for the producer to receive maximum return on N fertilizer inputs without unduly increasing N losses to the environment, usually as NO_3 leaching to groundwater (Schmidt et al., 2009).

The examination of the different fertilizer recommendation guides shows the existence of three types of models of nitrogen fertilization:

1. model (I) based on the content of soil organic matter;
2. model (II) based on the nitrate content of soils;
3. model(III) based on the addition of a single dose of N for each crop (no soil testing).

We took as reference the model III being the most widely used compared to other models, then we used the conditional expectationstatistics (EC)in order to determine nitrogen dose for different vegetables crops.

In the first step we classified the recommended doses in descending order, and then we applied the ECto deduce the percentile ranking of the recommended fertilizer dose.The results in the table 8 showed that for example the dose of applied N to broccoli crop varied from 140kg N/ha at CE 50% to 193kg N/ha at CE 80%, this represent 38% of added N. This approach indicates that there is a large interval to find the adequate dose for this crop, in addition to this interval can be a guide for optimum fertilizer.

Table 8: Theological nitrogen fertilization dose of vegetable crops in mineral soils

Crops	conditional expectation		
	50%	65%	80%
	kg N ha^{-1}		
Pumpkin	100	114	118
broccoli	140	168	193
onion	112	119	133
Garlic	110	111	112
leek	112	123	129
beet	110	112	120
Lettuce	112	129	134
cucumber	114	119	123
melon	111	114	119
peas	50	56	58
green bean	45	51	62
Lima-beans	45	67	81
cabbage	140	148	174
Cauliflower	140	148	174
radish	56	60	84
rutabaga	50	50	69
Carrot	82	103	111
Peppers	129	137	140
tomato	111	134	135
Eggplant	118	143	148

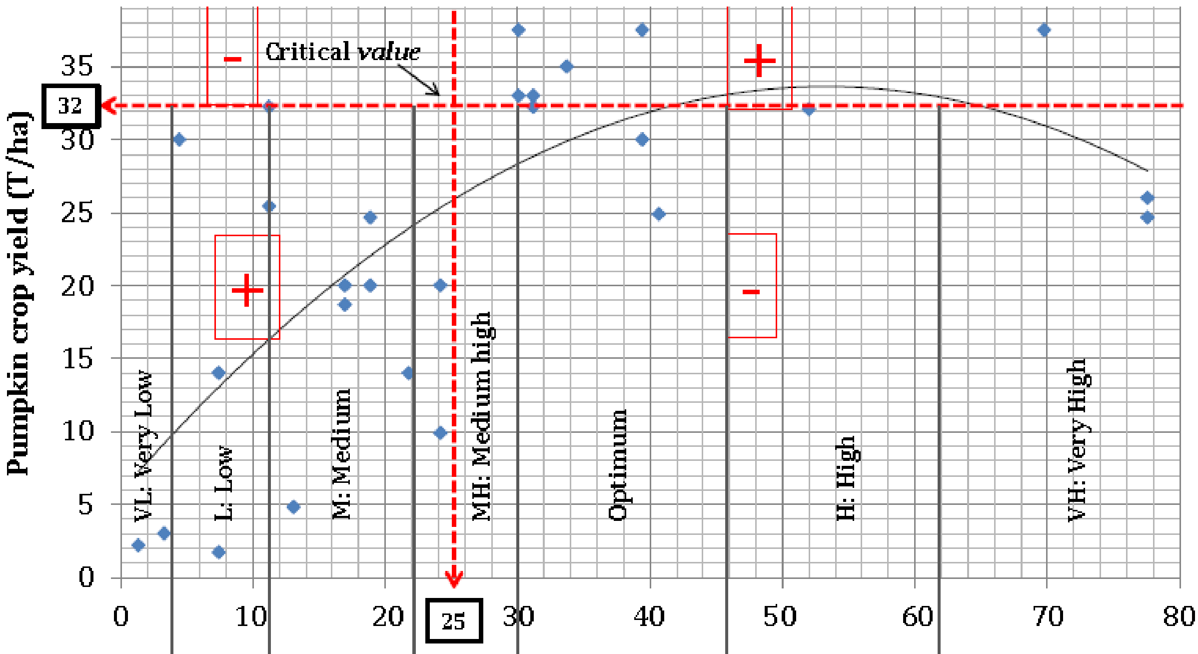
Calibration and validatıon

Phosphorus test calibration

The research base is developed from research projects in which measured yields are related to soil test values for the nutrient of interest and the rate of that nutrient that has been applied. Generally the pH of the Algerian soil varied from neutral to alkaline, this why we used the conversion equation of the amounts of P extracted the method MehlichIII (Mehlich, 1984) to P-Olsen. The original 27 soil sample dataset covered an extensive range of P that varied 1.4 to 76 ppm with variation coefficientof 75% (Table 1). The corresponding pumpkin harvest yield varied between 2 to 37 t/ha with variation coefficient of 49%. The difference between these variation coefficientsis due generally, that relative plant yield was better indicator of soil P availability than relative P extraction of all method of STP.TheFigure5 traduce this relation.

As showed by Figure 5 there is a good response of pumpkin crop response to the soil phosphorus fertility ($R^2 = 0.50$). The purpose of calibration of soil analysis is to determine the critical value (CV) of different major nutrients for each crop. In order to determine the critical value of pumpkin crop, we adopted *Crop Sufficiencyphilosophy,* this approach is focused the crop response to fertilization: That mean the expected response of the crop at any given soil test level is what determines the recommended level of each nutrient.

A CV for phosphorus is determined by using graphical techniques of empirical method of Cate and Nelson (1971). So the CV of pumpkin crop is 25ppm P which corresponds to 32Tha^{-1} representing 83% of maximum crop yield. According to the Cate-Nelson methods, the critical level of Olsen-P in the top 20 cm of soil was about 25 ppm: at values of greater than or equal to 25 ppm, crops achieved about 80% of their maximal yield in the absence of fertilizer application. These mean that for soil test values above this CV, there is no or less expected increase in yield when phosphate fertilizer is applied. Below this value, some increase in yield is expected when phosphate fertilizer is applied.



	Soil Test Phosphorus (mg/kg)						
Olsen-P(ppm)	≤ 0-4	4-14	14-22	***22-30***	30-46	46-62	≥62
Olsen-P (kg/ha)	≤0-10	10-28	28-50	50-68	68-104	104-144	≥144
	P_2O_5 to apply (kg/ha)						
Rating	*VL*	*L*	*M*	*MH*	*OP*	*H*	*VH*
Pumpkin	*220*	*180*	*140*	*110*	*70*	*40*	*30*

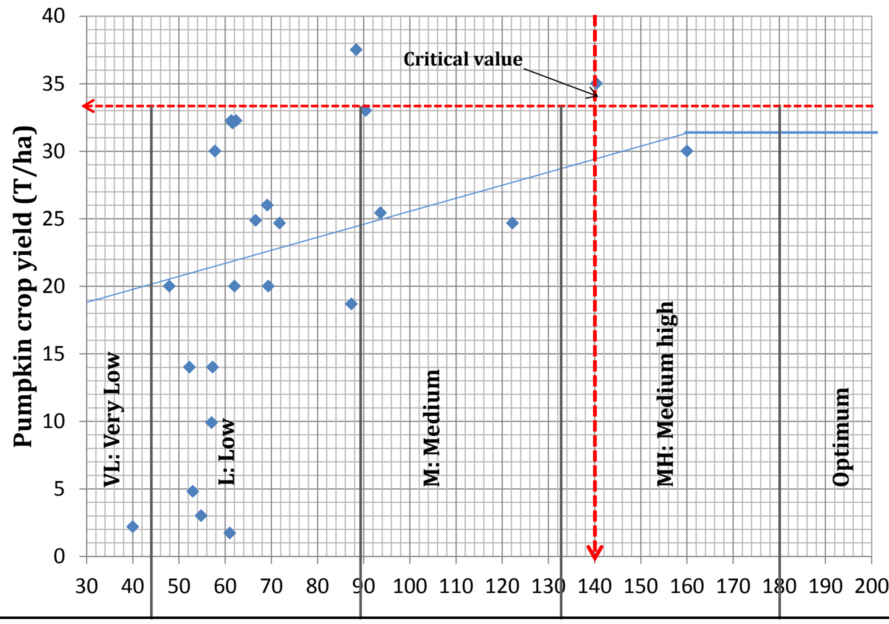
Figure 5: pumpkin crop response to different phosphorus soil fertility level

The agreement between the values of field trials and the values calculated by the theoretical recommendation fertilization guide model is generally satisfactory. Indeed, the deduced medium high fertility interval(MH) contains the obtained CV for pumpkin crop. The lower pumpkin harvest yield is associated with low P levels <25 ppm, but for practical purposes ≤20 ppm can be used to define low P soils. The middle category was associated with soil P levels between 20 to 46 ppm. Values above 46 ppm were well correlated with the highest relative yields in most fields and was selected as the level at which sufficient P is available for a good pumpkin yield.

Potassium test calibration

The 27 soil sample dataset covered an extensive range of K test soil that varied 24 to 160ppm with variation coefficient of 44% (Table 1). The corresponding pumpkin harvest yield varied between 2 to 37 t/ha with variation coefficient of 49%.

Pumpkin harvest yield responded positively and significantly to Ksoil fertility levelas showed by Figure 6, a good response of pumpkin crop response to the soil K fertility. However, the soil K fertility has not exceeded the optimum class fertility (135-179 ppm). A CV for K is determined by using graphical techniques of empirical method of Cate and Nelson (1971). So the CV of pumpkin crop is 140ppm K which corresponds to 33.5Tha^{-1} representing 90% of maximum crop yield. According to the Cate-Nelson methods, the critical level of Olsen-K in the top 20 cm of soil was about 140ppm: at values of greater than or equal to 140ppm, crops achieved about 90% of their maximal yield in the absence of fertilizer application. These mean that for soil test values above this CV, there is no or less expected increase in yield when phosphate fertilizer is applied. Below this value, some increase in yield is expected when potassium fertilizer is applied. The obtaining CV of K was more difficult and not evident because soil test K have not exceeded 160ppm, this value is included in MH class fertility, therefore the others fertility lasses (OP, H and VH) as determined by theological recommendation fertilization guide are not represented. This why More research emphasis should be spent on including sites with optimum soil K levels in order to fill a data gap.



	Soil Test K level (ppm)							
		≤45	45-89	89-134	134-179	179-223	....	≥267
	K_2O to apply (kg/ha)							
Rating		*VL*	*L*	*M*	*MH*	*OP*	*H*	*VH*
Pumpkin		220	180	140	80	50	40	35

Figure 6: pumpkin crop response to different potassium soil fertility level

Conclusion

Theological recommendation fertilization guide generated by using 16 international fertilizer guides show the adequacy with soil P and K test calibration. Indeed, 7 categories of soil P fertility were established: 1) Very Low (0-4ppm), Low (4-14ppm) Medium (14-22 ppm) Medium High (22-30ppm), Optimum (30-46ppm), High (46-62ppm) and Very High (>62ppm). The same K classes rating with potassium levels are generated: VL (0-45ppm), L (45-89ppm), M (89-134ppm), MH (134-179ppm), OP (179-223ppm), H (223-267ppm) and VH (>267ppm). Research is conducted to determine crop yields at different soil test levels for a given nutrient (correlation).The uses of dataset show that soil calibration generate a CV of soil test P and K of 25 and 140ppm respectively. The used*Crop Sufficiency Philosophy*method called *"fertilizing the crop"*denote more advantages than do *the maintenance approach*which emphasizes maintaining the soil fertility level at or above the point of the economic maximum yield:

1. This method is both economical and environmentally sound;
2. the only fertilizers applied will be those that increase yields, and these will be applied at optimum rates.

The next step determines how much fertilizer is required for optimum yields at different soil test levels (calibration).New field experiments are currently under way and are comparing split NPK applications vs. one full NPK application in each crop cycle in one hand, in another to determine the CV for each crop. This work will help to understand the precise N, P and K needs of vegetable and cerealcrops and the optimum economic doses for Algerian soils.

References

Cassman, K.G., Doberman, A., Walters, D.T., 2002. Agroecosystems, nitrogen-use efficiency, and nitrogen management. Ambio 31, 132–140.

Cate, R.B. and L.A. Nelson. 1971. A simple statistical procedure for partitioning soil test correlation data into two classes. Soil Science Society of America Proceedings 35:658-659.

Commercial Vegetable Production Recommendations New Jersey (2004).S. A. Garrison editor, Rutgers Cooperative Extension provides information and educational services.

Commercial Vegetable Production Recommendations Maryland (1992). Cooperative extension service, University of Maryland System.

Cornell Vegetables Resources for commercial growers (2004). Cornell Cooperative Extension, Natural Resource, Agriculture and Engineering Service or Cornell University Press.

Cope, J.T and R. D. Rouse (1983). Interpretation of soil test results p35-54 in L.M. Walsh and J.D. Beaton (ed.) soil testing and plant analysis. Rev. ed. SSSA, Madison, WI.

CRAAQ (Centre de référence en agriculture et agroalimentaire du Québec) (2003). Guide de référence en fertilisation. 1er édition.

Dahnke, W.C. C. Fanning, A. Cattanach. (1992): Fertilizing potato. North Dakota State Univ., SF-715.

Fertilizer Recommendations for Vegetable Crops in Michigan (1992).Extension Bulletin E-550B • Cooperative Extension Service • Michigan State University

Hochmuth, G.J. and E.A. Hanlon(2000). IFAS Standardized Fertilization Recommendations for Vegetable Crops Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

Hong, N., Scharf, P.C., Davis, J.G., Kitchen, N.R., Sudduth, K.A., 2007. Economically optimal nitrogen rate reduces soil residual nitrate. J. Environ. Qual. 36, 354–362.

Horton, M. L. (1995). Recommended soil testing procedures for the northeasternunated states Northeastern Regional Publication No. 493 Agricultural Experiment Stations of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia.USDA Cooperative State Research, Education and Extension Service 2nd Edition.

Jones T., J. Masabni, B. Rowell, and J. Strang.(2004-05).Vegetable Production Guide for Commercial Growers Kentucky.R. Bessin, Extension Editor.

Jones M.J. 1987. Interpreting Data from On-farm Fertilizer Trials for Use Where Soil-test Values Are Not Available.*in*Soil Test Calibration inWest Asia and North AfricaProceedings of the Second Regional Workshop. Ankara, Turkey, 1-6 September 1987.eds A. Matar, P. N. Soltanpour& A. Chouinard. viii + 118 pp. Aleppo, Syria: International Center for Agricultural Research in Dry Areas ICARDA-120.

Kelling K. A., L. G. Bundy, S. M. Combs, and J. B. Peters (1998) Soil Test Recommendations for field, Vegetables and fruit crop. University of Wisconsin-Extension.A 2809.

Ketterings, Q.M., K.J. Czymmek, W.S. Reid and R.F. Wildman(2002). Conversion of modified Morgan and Mehlich-III soil tests to Morgan soil test values. Soil Science 167(12): 830-837.

Khiari, L. et coll. (2000). An agri-environmental phosphorus saturation index for acid coarse-textured soil.J. Environ. Qual. 29: 1561-1567.

Kleinman, P., J.A.; Sharpley, A. N.; Gartley, K.; Jarrell, W. M.; Kuo, S.; Menon, R. G.; Myers, R.; Reddy, K. R.; and Skogley, E. O: (2001). interlaboratory comparison of soil phosphorus extracted by various soil test methods. COMMUN. SOIL SCI. PLANT ANAL., 32(15&16), 2325–2345

Manitoba Agriculture (1989-90) Vegetable crop production guide.Agdex 250-30

Mehlich, A. 1984. Mehlich-3 soil test extractant: a modification of Mehlich-2 extractant. Commun. SoilSci. Plant Anal. 15(12): 1409-1416.

Odet, J (1989). Memento fertilisation des cultures légumières. Centre technique interprofessionnel des fruits et légumes, France.

Olson, R.A, K.D. Frank, P.H. Grabouski, and G.W. Rehm. 1982. Economic and agronomic impacts of varied pholosophies of soil testing. Agr. J. 74:492-499.

Ministère de l'agriculture et de l'alimentation de l'Ontario (2003). Recommandations pour les cultures légumières Publication 363F

Ministry of Agriculture, Fisheries and Food (2000).Fertiliser Recommendations for Agricultural and Horticultural Crops (RB209) *Reference Book 209* 7th ed. London: HMSO.

New Brunswick Agriculture, Fisheries and Aquacultures (2001).Crop fertilization guide. The Land Development Branch,

New England Vegetable Management Guide (2004-05). Universities of Maine, New Hampshire, Vermont, Connecticut, and Massachusetts.

Nova Scotia Department of Agriculture &Fisheries (2004).Soil test report.

Rosen C. J., and R. Eliaso (2002).Nutrient Management for Commercial Fruit & Vegetable Crops in Minnesota. University of Minnesota Extension Service.

Soil Test Recommendations for Commercial Vegetables (2004).Agricultural Analytical Services Laboratory Penn State University.

Schmidt, J. P, Dellinger A. E., and Beegle D. B. 2009: Nitrogen Recommendations for Corn: An On-The-Go Sensor Compared with Current Recommendation Methods Agronomy Journal • Volume 101, Issue 4 •

Tran, T. S et M. Giroux (1989).Évaluation de la méthode Mehlich-III pour déterminer les éléments nutritifs (P, K, Ca, Mg, Na) des sols du Québec. Agrisol, Vol. 2, No 1 : 27-33.

Tindall, T.A., Stark, J.C., Falen, C.L., and Bywater, L.D. (1997). Idaho's Cooperative Fertilizer Evaluation Program Potato Nutrient Management.Presented at the Idaho Potato Schools January 22, 1997.

Tremblay, N. Scharpf. H-C. Weier, U. Laurence, H. et Owen, J (2001): Régie de l'azote chez les cultures maraîchères : Guide pour une fertilisation raisonnée. AAC,No. de cat. A42-92/2001F

Vilain, L. 1999. De l'exploitation agricole à l'agriculture durable. Aide méthodologique à la mise en place de systèmes agricoles durables. Paris. 155 pages.

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Migration of organic substances in rice-swamp soils and scientific bases of stabilizing their humus status

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Abstract

It is known that in arid conditions in periodically flooded paddy soils due to the predominance of downward flow of irrigation water and alkaline reaction of medium, soluble form of organic substance is exposed to vertical migration.
In this regard, the aim of our study was to investigate the intensity of vertical migration of water soluble form of humus during growing season under flooding.The obtained research results on migration of humus showed that during one growing season from 1 ha in the layer 0-20 cm capacity, 4,56 ±1,3 kg/ha of water soluble humus migrate, in layer 0-50 cm 11,9 ± 1,7 and in layer with capacity 85 cm as a result of hydrostatical pressure of groundwater , which is characteristic for almost all irrigated areas, especially for rice areas, there is a sharp decrease in the intensity of migration (4,9 ± 1,3 kg/ha). Study of seasonal dynamics of humus under rice showed that humates and fulvates of alkali metals are easy soluble in water and in the presence of the downward flow of water, they can easily move deeper into the soil profile. In this regard, in soils under rice there is a sharp decrease of total humus by fall. The same pattern is typical for total nitrogen. In rice- alfalfa crop rotation with two fields of alfalfa (green mass is separated) the original level of humus concentration is retained. Organic substance in the soil under wheat is most rich in active components. Concentration of C_{trans} in it was 0.88 % of carbon. Minimum amount of it was determined in rice soil which is equal to 0,03 % carbon. Level of humus concentration in investigated soil was 1,51 ÷ 1,96 %. This level of humus can be assumed as optimal for rice- marsh soils in Akdala irrigation area. Solubility of humus is higher under rice, which by the end of the season has increased almost twice, and under alfalfa of 1st and 2nd year of life, this figure decreased by the end of the season. Research has established that there is a constant transformation of organic residues observed, depending on soil biological activity. Deficit of biomass balance under rice is 99,3 c/ha, wheat 66.8 and alfalfa 41,6 c/ha, which is 2 times lower than under the previous crops. Humification coefficients of crop and root residues of alfalfa (0,24 ± 0,02) and rice (0,26±0,016) differ in statistical stability and can be used for assessment of current state of soil surface of rice- marsh soils. Carbon balance calculation shows that in decomposition of residues of alfalfa, the balance is even, while in decomposition of root and rice stubble – it is negative. Based on the foregoing, to maintain a stable balance of humus it is necessary to perform certain agrotechnical methods, including mandatory use of organic fertilizers, crop rotation with alfalfa and leaving crop straw, etc. The research results showed that the distribution of humus in rice-humus marsh soil is regulated by normal function rule. In the rice-swamp soils, rice yield capacity has a maximum quantitative dependence, among the studied factors of total soil humus status on general humus concentration and nitrogen concentration in it.

Keywords: organic farming, migration humus, rice-swamp soils

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Introduction

Currently, due to the extensive development of soil surface there is a decrease of global reserves of humus (Dobrovolsky et al, 1986, 121 p.). Per year they decrease by 1,2 – 1,4 billion tons, and for the last 100 years, about 400 billion tons of humus have been lost. Also a slowdown of the paces of humus new formation is observed due to the decrease of incoming litter by more than 40 % due to agricultural activities. According to S.P. Gorshkov et al (Gorshkov, 1980, pp. 34-55), neoplasm of humus in the biosphere in prehistoric times was 1,8 – 3,6 billion tons per year.

Thus, as scientists believe (Dobrovolsky et al, 1986, 121 p.), along with the issue of rational use of various mineral resources, mankind faces another acute problem of rational use and protection of humus sphere of the Earth.

As we know, one of the most important functions of the soil – is soil source of nutrients and compounds. As the significant part or most of the biomass goes away with harvest, as well as cultivation of many plants on soils, on which they did not originally grow , results in the fact that arable land in the absence of special agronomic techniques on maintaining their fertility, no longer cope with the supply of crops with necessary elements. Therefore, for the effective use of agricultural lands, constant regulation of soil fertility and optimization of mineral nutrition of plants is needed.

The issue of soil organic substance is at one of the central places in soil science. Organic substance can be defined as a leading factor in soil fertility, reflecting the state of the ecosystem, especially in terms of intensive human impact. Soil use in agrocenosis has a great influence on all groups of organic substance, in conservative part, as well as labile, which plays a very important role in the fertility of paddy soils.

Works by K.V. Dyakonova (Dyakonova, 1992, pp.143-147), R. Tate (Tate, 1991, 400 p.) and others are devoted to the study of humus composition and properties which offer a variety of methods and approaches to the study of humus status, which gives an idea of agronomic significance of particular components of organic matter. It is very relevant for irrigated soils with in the same type of soil to identify the most agronomically valuable humus components that are qualitatively and quantitatively sensitive to the conditions of agrotechnique and have substantial impact on soil productivity. The obtained data and conclusion on critical minimum level of humus concentration and diagnostic parameters of humus status of irrigated soils can be used for conducting monitoring studies. And the results of these studies will provide an opportunity to develop the concept of conservation and enhancing soil fertility, to give recommendations for the effective application of various fertilizer systems.

Among the negative soil processes causing soil degradation, one of the main processes is dehumification process, which reduces the valuable qualities of arable soils, including their resistance to adverse anthropogenic factors (Sheudzhen et al, 1998, pp. 28-32).

In the system of humus substances the water-soluble part is the most dynamic. This position is confirmed by the nature of profile and seasonal dynamics of water-soluble forms of humus in paddy soils. The water soluble humus as well as general, migrates into the underlying horizons in significant quantities. Since the easy degradable organic matter is the most dynamic component of soil organic matter, it plays a significant part in many functions of soil and biosphere: plant and soil animals nutrition; soil biological activity; fixation of atmospheric nitrogen; regulation of soil and atmosphere air composition; formation of soil structure and physical properties; sorption and accumulation of heavy metals and radionuclides and other pollutants. Concentration of easy degradable organic matter in topsoil fluctuates quite widely - from 0.1% to 1.5-2 % from soil weight (Ganzhara et al, 1990, pp. 53-55). Easy degradable soil organic matter is an important source of plant nutrients.

Concentration of easy degradable organic matter in soils is characterized by clearly defined seasonal dynamics associated with the processes of its decomposition, which are most manifested in the first half of vegetation and in the process of plant root mass accumulation.

In this aspect, rice- marsh soils can be considered as the most suitable object for studying humus degradation aimed at early indication of signs and identification of reliable criteria of their evaluation at different levels of degradation. It should be avoided, that the amount of humus in soil is decreased below a critical level beyond which the increase of negative effects caused by this decline begin.

Our studies carried out in 2001-2005, also showed that humus profile of paddy soils, despite their overall low concentration is pretty stretched. At depth of 0,5-1,0 meters their concentration is commensurable with concentration in arable horizons. Apparently, mobilization and migration processes in periodically flooded rice soils contribute to this process, which will be described below. The data obtained in Akdala area (Otarov et al, 2007, pp. 73-105) also show that there have been substantial loss of humus in soils, used for rice growing, as compared to their virgin analogues. In Takyr soils used for rice cultivation in 1976 and 1984 to date, as compared to their virgin analogues there occurred statistically reliable ($t_{fact} \pm t_{tabl}$) losses of humus, respectively, to 19,3±4,37 and 24,7±3,07 percent. In our opinion, this was caused by deterioration of soil-reclamation and environmental conditions Akdala area as a whole.

According to the "Guidelines for the implementation of state control over protection and use of land resources " RND 03.7.0.6.06-96 (Instructions on implementation of state control over protection and use of land resources, 1958) soils in Akdala area according to total humus concentration refer to "weak" and "medium degraded".

Current humus condition in rice soils is also characterized by degradation of soil humus system with increasing of its solubility, eluviation and removal to drainage and waste and river network, that leads to dehumification and degradation of soils.

In this regard, management and optimization of humus status of paddy soils is of priority importance, which in turn, guarantees environmentally friendly and stable yields and is relevant for Akdala area.

Priority task in addressing the above problems is the need of profound study of main components of humus balance. Conducting of these studies includes assessment of basic flow of organic matter in soils, in which there occur losses of humus and its reproduction in view of optimizing and stabilization of humus regime in conditions of prolonged flooding of soils.

Material and Methods

Studies were carried out on ancient delta part of Akdala irrigation area. Farm territory is located within well *separated geomorphological region - ancient Akdala Bakanass delta* , which is part of a major geomorphological region - Balkhash Alakul depression or South Balkhash area. Within Almaty region the Balkhash Alakul depression is divided into well separated areas of modern delta and Ili river valley, ancient Akdala Bakanass delta, sand area Taukum and tarry-sandy area in Sary- Isik - Otrau (its western part). Object of research is included in a very dry moderately hot Ia of agroclimatic area – which occupies the most dry northern part of the area. Soil surface is diverse. Takyr type, partly saline marsh soil prevail; in depressions - takyrs. Salt marsh soils are very largely spread (Soil map of Almaty, 1958).

The soil surface of the object before growing of rice was mainly represented by takyr soils of various degrees of salinity. These soils had a low humus concentration which was not exceeding 1,0-1,2. On soil texture these soils have various layers and they are very changeable, and a sharp change of mechanical texture in particular horizons is observed.

Currently these soils under the influence of rice crop have transformed in irrigated (rice) marsh soils. Rice is a specific crop which requires a constant layer of water in plots during the whole growing period. In conditions of periodic flooding, a specific situation is formed which is defined by characteristics of soil-forming process taking place in conditions of changing flooding and subsequent drying of soils. Constant alternation of cycles of increased watering and drying of soils, the development of contrasting modes inevitably causes loosening of certain systems existing in soil. Especially sharp changes occur in the redox regime of soils, which largely determines the nature of soil formation process, in particular, migration of elements in soil mass, processes of humus formation, nutrient regime, etc.

Thus, after the flooding as a result of domination of the restored conditions, in paddy soils begin to develop basically two groups of processes which result in the formation of specific profile of paddy soils.

The first of them – is mobilization processes, leading to the increase of the mobility of organic matter and some chemical elements (Fe, Mn, S, N, etc.), their transition to low-valence forms. These processes are accompanied by relatively rapid degradation of organic matter, loss of nitrogen and other easy restorable compounds. Second - migration processes leading to removal of the mobile forms of organic and chemical elements from the upper soil horizons to the underlying or inter-horizon redistribution. In particular, many researchers have note quite stretched humus profile. Significant amount of humus (about 1%) can be detected at a depth of 1 m and below, which is not typical for other varieties of delta soils.

In performing the work, we used a wide complex of soil study methods, adequate to its specificity as a natural body. Profile method, comparative geographic method, soil key method, soil- regime observations method, method of soil extracts, field soil studies included expeditionary and stationary methods .

To analyze the substance composition of soils were used the following analytical methods: humus by Tyurin I.V. method (GOST 26213-91), water-soluble humus from water extracts by Kubel method, preparation of water extracts from soil by K.K.Gedroits, CO_2 carbonates – by by Golubeva's gasometrical method, gross nitrogen – by Kjeldahl, easy hydrolyzable nitrogen by Turin – Kononova's method (Arinushkina, 1977, 489 p.), P_2O_5 and K_2O - by Machigin in modification CINAO (OST 46-42-76). Statistical data processing will be carried out by method of variational statistics described (Dmitriev, 1995, 320 p.) using the software analyzes package «Excel – 97».

Results and Discussion

It is known that organic matter is the basis for formation and maintaining of soil status and quality, and largely determines its physical, chemical and biological properties, and is one of the important factors of soil fertility and a prerequisite for resistance to degradation. At the same time it is an important component in the global carbon and nitrogen cycle, influencing on their flow and emission in the whole ecosystem, including the soil, plant, water and atmosphere. Therefore, the correct regulation of stocks and ensuring of the optimal quality of organic matter is one of the foundations of not only maintaining sustainable land cultivation but also sustainable development of biosphere as a whole (Soil Science, 2000, 5 p.).

Before interpreting the data on humus dynamics and its components under different crops in rice-alfalfa crop rotation, we calculated their variational statistical indicators (table 6). The calculated values of Student t-test show that on these soils at the level of 0,05 %, which are adopted for the study of such significance, value t_{act} is significantly higher than ttab .. Variability analysis shows that under alfalfa of the 2nd year of life, general humus in spring and autumn, the coefficients of variation on group scale according to the degree of variation do not exceed the average value , and nitrogen has insignificant degree of variation, in water soluble humus it is insignificant, whereas in solubility in spring it is little, and in autumn it is insignificant, but in such indicator as nitrogen concentration in humus the degree of variation is very high.

Table 1 - Dynamics of the basic elements of soil fertility underalfalfa of 2nd year of life (n=6, $t_{0,95}$=2,45)

Fertility indices	Indices of statistical processing				
	M±m,%	σ	V, %	Fluctuation ranges, mg/kg	t-criteria of reliability, $t_{act.}$
Total humus, spring	1,53±0,2	0,57	37,3	1÷2,33	7,7
Total humus, fall	2,76±0,14	0,36	23,5	2,21÷3,04	19,7
Total nitrogen, spring	0,086±0,019	0,046	3,0	0,014÷0,14	4,5
Total nitrogen, fall	0,107±0,016	0,04	2,6	0,056÷0,154	6,7
Water soluble humus, spring	0,006±0,0003	0,0007	12,5	0,005÷0,007	20,0
Water soluble humus, fall	0,008±0,0004	0,001	12,5	0,006÷0,009	20,0
Solubility of humus, spring	0,6±0,08	0,2	13,1	0,36÷0,9	7,5
Solubility of humus, fall	0,4±0,036	0,09	5,9	0,3÷0,54	11,1
Nitrogen concentration in humus, spring	5,1±0,86	2,13	139,2	1,4÷7,7	5,9
Nitrogen concentration in humus, fall	4,2±0,78	1,92	125,5	2,3÷6,6	5,4

The table shows that soil under alfalfa of 2nd year of life in the spring the total humus concentration is higher than in the soil under alfalfa of the 1st year of life under the cover of wheat. This is natural. A large number of works are devoted to the question of influence of perennial grasses on irrigated soils on the accumulation of organic matter and the rate of its decomposition in plowing grass field. In these studies it is shown that planting of perennial grasses is a factor of increasing soil fertility. Similar data were obtained in our previous works. Crop and root residues of alfalfa at the moment are the main source of organic matter for paddy soils. In autumn alfalfa of 2nd year of life and alfalfa under the cover of wheat there occurs the increase of humus concentration to 2,76 % and 2,22 % respectively, which is ensured by the products of intensive decomposition of root and crop residues of alfalfa under the influence of high temperature and activity of soil organisms.

Table 2 – Dynamics of main soil fertility elements under alfalfa of the 1st year of life under the cover of wheat (n=6)

Fertility indices	Statistical processing indices				
	M±m,%	σ	V, %	Fluctuation ranges, mg/kg	t-reliability criteria, $t_{act.}$
Total humus, spring	1,25±0,25	0,6	48,0	0,62÷2,15	5,0
Total humus, fall	2,22±0,5	1,2	54,1	0,74÷3,44	4,4
Total nitrogen, spring	0,07±0,017	0,04	57,1	0,028÷0,14	4,1
Total nitrogen, fall	0,077±0,015	0,036	46,8	0,042÷0,126	5,1
Water soluble humus, spring	0,003±0,0002	0,0005	16,7	0,003÷0,004	15,0
Water soluble humus, fall	0,005±0,0004	0,0009	18,0	0,004÷0,006	13,9
Solubility of humus, spring	0,3±0,05	0,12	40,0	0,17÷0,48	6,0
Solubility of humus, fall	0,3±0,07	0,17	56,7	0,15÷0,54	4,3
Nitrogen concentration in humus, spring	5,1±0,37	0,92	18,0	3,9÷6,5	13,8
Nitrogen concentration in humus, fall	4,1±0,65	1,6	39,0	1,6÷5,7	6,3

In rice soils a sharp decrease occurs in total humus concentration in autumn, and it is related to the fact that mobilization and migration processes are intensive in terms of irrigation method of constant flooding. As major mobilization processes we can indicate the dominance of reductive conditions and alkalinity of medium, and as migrant - a permanent downward flow of irrigation water, contributing to removal of the products of mobilization process (humus) deep into the soil profile and drainage waters. The same pattern is also typical for total nitrogen, i.e. the best nitrogen regime is in soils under alfalfa of 2nd year of life (table 1), and no worse under alfalfa under cover of wheat (table 2) , but under rice (table 3), total nitrogen concentration is lower than in the above mentioned soils and also by autumn its concentration decreases. Amount of water soluble humus in soil under alfalfa of 2nd year of life, from spring to autumn, increases from 0,006 to 0,008 %, the same pattern is typical for soils under alfalfa crop under cover of wheat, although their relative concentration is lower than in the previous soil (0,003 in spring and 0.005 in autumn).

Table 3 – Dynamics of main elements of soil fertility under rice (n=6)

Fertility indices	Statistical processing indices				
	M±m,%	σ	V, %	Fluctuation ranges, mg/kg	t-reliability criteria, t_{act}
Total humus, spring	1,22±0,21	0,5	41,0	0,49÷1,93	5,8
Total humus, fall	0,92±0,15	0,37	40,2	0,31÷1,44	6,1
Total nitrogen, spring	0,084±0,013	0,03	35,7	0,042÷0,126	6,5
Total nitrogen, fall	0,072±0,013	0,03	41,7	0,042÷0,112	5,5
Water soluble humus, spring	0,009±0,0006	0,0015	0,1	0,007÷0,011	15,0
Water soluble humus, fall	0,012±0,0009	0,002	0,1	0,009÷0,015	13,3
Solubility of humus, spring	0,56±0,1	0,25	44,6	0,36÷1,02	5,6
Solubility of humus, fall	0,98±0,2	0,48	49,0	0,6÷1,9	4,9
Nitrogen concentration in humus, spring	8,03±1,97	4,84	60,3	4,2÷17,1	4,1
Nitrogen concentration in humus, fall	9,4±2,8	6,9	73,4	4÷22,6	3,4

To assess humus status in paddy soils, an important indicator is humus solubility. Study of its dynamics under different crops of rice- alfalfa crop rotation has revealed that the solubility of humus under rice in spring was 0,56 %, and by the end of the season it has increased almost twice, which is explained by processes taking place in flooded rice soils, which have been mentioned above. In soils under alfalfa of the 1st and 2nd year of life, this is not happening, even, on the contrary, in the latter, this indicator decreased by the end of the season from 0,6 to 0,4 %.

In this regard, we have to study how humus substances migrates in soil horizons which are under flooding during the growing season.

To study the migration of humus in soil profile and its loss value per season we have conducted experiments during 3 years (figure 1) in 5 replicates which had the following options:

1. Migration and loss value from arable horizon (0-20 cm);

2. Migration and loss value from subsurface horizon (20-58 cm);

3. Migration and loss value from 58-100 cm horizon (see figure 1)

In natural conditions into soil profile at different depths (under specific genetic horizons) chromatographic columns with sorbent have been set in steps, which have a certain cross-sectional area (25x25 cm), which allows to make calculation of the vertical migration of water-soluble humus per hectare. Step settling of lysimetric columns in depths in soil profile gives us an idea about the amount of humus, coming with a solution from upper soil horizon to the underlying. At the end of the season chromatographic columns with sorbent have been gently removed from the soil. Sorbed organic matter was extracted with 2% ammonia solution, and from the obtained extracts the total carbon was determined by common methods of Dyakonov. (Recommendations on the study of balance and transformation of organic matter in agricultural use and intensive soil cultivation, 1984, 96 p.).

Figure 1 – experiment on studying humus migration in soil profile

Table 4 - Variation- statistical indices of loss (migration) of humus from different layers of rice-marsh soils (t_{tabl} = 2.8 in n = 5 and P = 0.95)

Horizon см	Statistical indices					
	n	M±m, kg/ha	[illegible]	V, %	Fluctuation ranges, kg/ha	t-reliability criteria T_{act}
0-25	5	4,56±1,3	2,7	59,2	1,4[illegible]	3,5
0 -50	5	11,9±1,7	3,9	32,8	5[illegible]	7,0
0 -85	5	4,9±1	1,7	34,7	3[illegible]	4,9

The results of statistical processing of the available data on migration of humus show that from 1 hectare of arable horizon of capacity 20 cm, 4,56 kg of humus migrates per 1 growing season. The next layer of capacity 0-50cm, a reliable and regular increase of the amount of migrated humus has been observed. And in the layer of capacity 85 cm, a sharp decrease of the intensity of migration is observed, which we attribute to hydro statistical pressure of groundwater, which is characteristic for almost all irrigated areas, especially rice plots.

The data obtained are completely consistent with the findings obtained in studies of past years that in rice growing, humus in these soils is distributed according accumulative-eluvial-illuvial type, ie at different depths there are formed horizons of secondary accumulation of humus.

In accordance with modern concepts (Körschens et al, 2002, pp. 195-211, Titova et al, 2000, pp. 369-384), soil humus consists of two main pools: labile (transformable) and stable (inert), which role in soil fertility varies. Transformable (active) part of humus is the most accessible source of plant nutrition, determines biological activity and other agrochemical properties of soils and is significantly changed under the influence of different agro-techniques. Active part of humus is involved in carbon cycle and other elements, forms basic functions of organic matter and determines effective soil fertility. Inert humus is a kind of "organic skeleton" of the soil. In the long-term extensive use of soil, humus active part may be supplemented by an inert part, which is causing soil degradation. Pool of so-called inert humus soil is scientists is identified as the value of minimal humus concentration by the researchers of the Institute V.V. Dokuchaev and Germany. Thus, total humus concentration in soil, expressed in terms of carbon, can be represented by the formula: $C_{total} = C_{min} + C_{trans}$. Ctrans – transformable part of organic matter, allowing to obtain the maximum yield with efficient use of fertilizers;

The minimum amount of the active humus components has been determined in soil under rice, which is equal to 0,03 %.

Table 5 - Impact of rotation crops on concentration of active components in humus in arable layer

Crop rotation	C_{opr}, %	C_{min}, %	C_{trans}, %
Alfalfa layer	1,45	1,27	0,18
Alfalfa of 2-d year	1,27	1,27	0,00
Wheat	2,15	1,27	0,88
Rice	1,30	1,27	0,03

S.L. Travnikova and colleagues believe that the level C_{trans} is considered to be sufficient for obtaining maximal yield which corresponds to natural or fallow soil. According to our researches, carried out in previous years, the level of humus in studied soils is 1,3 ± 0,013 %. This level of humus can be conditionally assumed as optimal for rice-marsh soils in Akdala irrigation area. Action of active components in humus should be sufficient for creating favorable conditions for growth and development of plants in these soil and climatic conditions and ensure soil ecological functions.

Conclusion

Study of seasonal dynamics of humus under rice showed that due to the fact that humates and fulvates of alkali metals are easily soluble in water and in the presence of downward flow of water can easily move deeper into the soil profile. In soil under alfalfa of 2^{nd} year of life in the spring total humus content is higher than in the soil under alfalfa of 1st year of life under the cover of wheat, ie planting perennial grasses is a factor to increase soil fertility. Crop and root residues of alfalfa at the moment are the main source of organic matter for paddy soils. In autumn alfalfa of 2^{nd} year of life and alfalfa under wheat cover there is the increase of humus content to 2,76 % and 2,22 %, respectively, which is provided by the products of intensive decomposition of alfalfa root and stubble. In soils used for rice growing there is a sharp decrease in total content of humus in autumn, it is attributed to the fact that mobilization and migration processes occur quite intensively under irrigation method of constant flooding. The same pattern is typical for total nitrogen. The regulation which was identified in our previous works, is confirmed, that in the rice soils humus migration is towards the underlying horizons. Solubility of humus is higher under rice, and by the end of the season it has increased almost twice, which is explained by processes which occur in flooded rice soils. In soils under alfalfa of 1st and 2nd year of life, this indicator has decreased by the end of the season.

The data obtained on the study of migration humus showed that during 1 vegetative season, from 1 ha of arable horizon of capacity of 20 cm, 4,56±1,3 kg/ha migrate from the layer of capacity 0 -50 cm 11, 9 ± 1,7 kg/ha, and in the layer of capacity of 85 cm as a result of hydro-statistical groundwater pressure, which is characteristic for almost all irrigated areas, especially for rice, there is a sharp decrease in the intensity of migration (4,9±1,3 kg/ha). Most rich in active components is the soil organic matter under wheat. Concentration of Ctrans in it was 0.88% C. The minimum amount of active humus components was defined in humus soil under rice, which is equal to 0,03 %. C. It was found that there is a constant transformation of organic residues, plant residues are intensively decomposed in the initial period, and by the end of vegetation the decomposition process is reduced, the direct dependence on biological activity of soils is observed. Deficit of biomass balance under the crop of rice is 99,3 c / ha, under wheat 66.8 c / ha, under alfalfa 41.6 kg / ha, which is 2 times lower than under the previous crops. To keep at least a zero balance, certain agrotechniques are needed, including mandatory use of organic fertilizers, crop rotations with alfalfa, increasing of the amount of crop residues by increasing crop yield capacity, etc.

The coefficients of humification of alfalfa stubble and root residues ($0{,}24 \pm 0{,}02$) and rice ($0{,}26 \pm 0{,}016$) differ in statistical stability and can be used to assess current state of soil surface in the studied areas of rice cultivation. Resolution of existing problems is possible only due to conducting systematic studies in the field and pot experiments, which are the fundamental basis for exploring the impacts of agricultural land use on soil fertility, crop yields stability, and the environment. Findings and conclusions on critical minimum level of humus content and diagnostic parameters of humus status of irrigated soils can be used for conducting monitoring studies and development of the concept of preserving and enhancing fertility of these soils, recommendations on effective application of various fertilizer systems. In recent years there has been observed an increase in the extent of agrogenic degradation of humus in irrigated soils due to the decline of the volumes of using of mineral and organic fertilizers, violation of land cultivation systems, deterioration of reclamation state, use of agricultural activities which are not adapted to zonal conditions of humus formation.

References

1. Dobrovolsky, G.V., Nikitin, E.D., 1986. Ecological functions of soil. Publishing House of Moscow University. 121.
2. Gorshkov, S.P., 1980. Circulation of products of land denudation. In the book: Circulation of matter in nature and its changing due to human activities. Moscow. Moscow State University, 34-55.
3. Dyakonova K.V., 1992. The changing nature of humic substances in agricultural use and intensive land cultivation. Soil science. 1, 143-147.
4. Tate R.III., 1991. Soil organic matter. (trans. from English). Moscow. 400 p.
5. Sheudzhen A.H., Bochco T.V., Trahov E.M., 1998. Humus as an integral component of soil fertility and its changing in rice growing. Bulletin of Krasnodar Scientific Center Adyghe (Cherkess) International Academy of Sciences. Agriculture 2, P. 28-32.
6. Ganzhara N.F., Borisov B.A., 1990. Easy decomposed organic matter in soils. Chemicals in agriculture. 1. 53-55.
7. Otarov A. Ibrayeva M.A., A.S. Saparov., 2007. Degradation processes and current soil ecological condition of rice areas of the republic. Col. "Ecological basis for the formation of soil conditions in Kazakhstan in terms of anthropogenes and development of a theoretical framework of reproduction of fertility ", Almaty. 73-105
8. "Guidelines on implementation of state control over protection and use of land resources," 1996. RND 03.7.0.6.06-96 6. Almaty.
9. Soil map of Almaty region. 1958. Scale 1:300000, 10 sheets, Alma –Ata.
10. GOST 26213-91, the determination of humus according to Tyurin.
11. Arinushkina E.P., 1977Guidance on chemical analysis of soils. Moscow State University Press, Moscow. 489.
12. OST 46-42-76 1.7.104. Determination of P_2O_5 and K_2O according to Machigin (CINAO)
13. Dmitriev E.A., 1995 .Mathematical Statistics in Soil Science. Moscow State University Press, Moscow. 320.
14. Soil Science at the turn of the century (from the editorial board). 2000. Soil Science.1, 5.
15. Recommendations on studying of balance and transformation of organic matter in agricultural use and intensive soil cultivation. 1984. Soil Institute V.V. Dokuchaev, 96.
16. Körschens M. Howitz H., Hein H.O., 2002. Untersuchungenübereineleistungsfähige, nachhaltigesowieökonomisch und ökologischorientierteLandwirtschaft. Arch. Acker-Pfl. Boden, 48. 195-211.
17. Titova N.A., Travnikova L.S., Kogut B.M., Kershens M., 2000Organic matter and soil stability in the XXI century: correlation and composition of active and inert parts of organic matter of black soils in long-term experiments. Research papers. Soil Inst. Dokuchaev. "Modern Issues of Soil Science." M. RAAS. 369-384.

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Agroecological and agrochemical status of technosols due to opencast mining in Bulgaria

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Abstract

The power industry as a major sector in the economy of Bulgaria is associated with coal mining. The open coal mining damages the land and an environment as a whole in the industrial areas. These are damages refunded legally a certain way (Regulation 26, 2002). The reclaimed land in the coal mining area recovered first by filling of geological materials with suitable physicochemical properties and surface deposition with natural soil at least 40 cm. sometimes due to deficiency of natural soil materials, recultivation of soils is humus free with direct biological reclamation. The study presents two mining area, technogenetic areas constructed - by two methods of reclamation – humus and humus free direct. Evaluated is the availability of nitrogen, phosphorus, and potassium as essential nutrients in Technosols of both reclaimed areas. Compared are the contents of heavy metals in reclaimed Technosols reference to the maximum allowable concentrations normed by the Bulgarian legislation. This research conclude that the studied Technosols irrespective of the method of reclamation have significant deficiency of nutrients, but some of them was found and a load with heavy metals.

Keywords: open cast mining, Technosols, supply of nitrogen, phosphorus, and potassium, maximum allowable concentration of heavy metals.

Introduction

The extraction and processing of minerals most dramatically change the Earth's surface. In Bulgaria the damaged areas of mining are also not less by the end of 2009 are 25 514 ha, with more than 16 000 ha were destroyed by the application of coal open cast mining. In our country, the reclamation of damaged areas takes place by Regulation №26 for "Land restoration, improvement of low lands, removal, and recovery of the humus layer." In the field of science and practice recovered reclaimed land called Technosols. These are technically designed areas with soil forming materials resulting from human activity (IUSS Working Group WRB, 2006).

The scientific research works for the reclamation show that the newly Technosols, the content of primary nutrients are in short supply. There are mining areas of Technosols, which contain sulfides materials with a high degree of oxidation, as a result of that there is dynamic in the removal of chemical elements from the soil to the environment. The National monitoring network in Bulgaria does not include Technosols for monitoring of essential soil indicators. The specialized researches of the properties of Technosols give insufficient

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information about their impact on the environment and human health. The nutrient supply and the content of pollutants are to date questions in Technosols to prevent local anomalies in the environment.

This paper aims to show the new representative data for Technosols formed after open cast coal mining. Agroecological status is comparison of the actual content of pollutants in Technosols for assessment of environmental risk and human health and agrochemical status compare content of basic nutrients - nitrogen, phosphorus, and potassium with limits of their supply.

Material and Methods

Studied are variations of Technosols with soil representative profiles. They positioned in the GIS. Table (1) shows the differences between the variations of Technosols. The Technosols are different by type of soil forming materials, geographic and climatic conditions, land use and post reclamation period.

Table 1. Geographical coordinates, type reclamation, post reclamation period, land use

Profile №	Objects	h (m)	Geographical coordinates	type and post reclamation period	Land Use
1	„Maritza-east“,	170	N42.17683°; EO 25.94943°	Humus type – 45 years	Cultivated use
2	„Maritza-east“,	209	N 42.16847°; EO 25.94539°	Direct biological reclamation 45 years	Forest use
3	„Chukurovo“,	788	N 42.53939°; EO 23.60056°	Direct biological reclamation 45 years	Forest use
4	„Chukurovo“,	800	N 42.53940°; EO 23.60083°	Direct biological reclamation 25 years	Forest use

The soil samples have been collected two twice a year. The analyzed soil parameters are pH (ISO 10390: 2005); Sorption capacity and exchange cations (ISO 11260&14254); Mechanical structure of the soil - (Kachinski, 1958); Content of SOM (Kononova, 1963, Filcheva and Tsadilas, 2002); Total content of heavy metals (ISO 114 66:1995 и ISO 11047:1998); Bioavailable forms of nitrogen, phosphorus, and potassium (Banov et al.,2013).
The assessment of nitrogen, phosphorus, and potassium supply is according to limits (Atanasov et al, 2009). Assessment limits are also use by the National Agriculture Advisory Service (NAAS).
The contents of heavy metals and metalloids are compared with background of naturally soils is in Bulgaria and limits for the dangerous substances according to Regulation № 3 (2008).

Results and Discussion

Physical and Chemical Characteristics of Technosols

The scientific papers show that the basic physical and chemical soil parameters may assess the suitability of materials for biological reclamation (Treikyashki et.al, 1982). The subsequent studies say that basic physical and chemical soil parameters might group the reclaimed soils in classification (Banov, 1996; Hristov, 2001).

According to this author's classification, the studied Technosols are two subtypes: humus (profile 1) and direct biological reclaimed subtypes (profile 2, profile3 and profile 4) as they are indicated in Table 2.

The classification of Technosols divides on the lowest level of variations by physical clay (Atanasov et al, 1970). Shown subtypes vary in different degrees, but the varieties are medium sandy loam variation (profile 3) to heavy clay variation (profile 2). Profile 1 and Profile 4 are heavy sandy loam to light clay varieties. The content of physical clay is proportional to the sorption capacity at all studied profiles of Technosols.

Depending on the type and time of post-reclaimed period, it had formed three types of soil profiles: in humus-reclaimed subtype, the profile is A-C1-Cn; in the directly biological reclaimed subtypes the profile are AC-C1-Cn and C1-Cn. AC-horizons are a positive trend in the development of soil formatting processes in Technosols presented by profiles 2 and 3. It is in connection with accumulation of biogenic substances and mostly the SOM is 1% more in AC-horizons than the layers in the lower part of the profiles. A specific for profile 2 and 4 is high SOM in layers in depth (C1-Cn) is the result of high coal content.

All are studied profiles are in pH range from 6 to 8, which is favorable for the development and growth of plants. Only in profile 4 which is strongly acidic can be expected to processes associated with leaching of substances outside the soil profile.

Conclusion of the analysis of physical and chemical parameters in different Technosols is that the soil formatting changes are in the early stages of development and their properties result from the properties of the building materials.

Table 2. Basic physical and chemical soil parameters

Depth (cm)	pH H_2O	Physical clay content %	Sorbionen capacity cmol(+)/kg	SOM %
Humus reclaimed type of Technosols - profile 1 "Maritza-East"				
A 0-30	7,25	64,0	43,9	2,04
C1 30-50	7,75	51,5	33,1	0,75
C2 50-70	7,25	58,8	27,9	0,34
Direct biological reclaimed type of Technosols – profile 2 "Maritza-East"				
AC 0-25	6,10	86,9	40,3	2,54
C1 25-70	5,95	90,3	37,9	1,46
C2 70-100	5,80	80,5	38,8	1,28
Direct biological reclaimed type of Technosols – profile 3 "Chukurovo"				
AC 0-5	6,25	37,0	12,9	1,69
C1 5-22	6,45	38,3	10,0	0,62
C2 22-52	7,55	55,0	16,0	0,69
C3 52-74	7,70	39,5	11,5	0,64
Direct biological reclaimed type of Technosols – profile 4 "Chukurovo"				
C1 0-35	4,50	47,9	13,0	2,28
C2 35-60	4,40	63,2	18,2	4,57
C3 60-90	4,40	64,6	17,0	5,21

Content of Heavy Metals in Technosols

The toxicity of pollutions as Pb, Cu, Zn, Cd, Cr, Co, Ni, As, Hg is estimated at values higher than background concentrations with the following limits. Preventive concentration (PC) is the content of pollutants in soil (mg/kg), does not affect soil functions, and is not dangerous for the environment and human health. Maximum allowable concentration (MAC) is the content of pollutants in soil mg/kg, above which there is disturbance of the soil functions under certain conditions and can leads to danger for the environment and human health. Intervention concentration (IC) is the content of pollutants in soil mg/kg, above which there is disturbance of the soil functions and is dangerous for the environment and human health.

First the content of different heavy metals compare with background values in the natural soil. Table 3 gives background values and preventive pollutant concentration of heavy metals and this part of Ordinance 3 (2008) for dangerous substances.

Table 3. Background and preventive pollutant concentration (mg/kg)

Soils = f(mechanical composition)	Cd	Cu	Cr	Ni	Pb	Zn	Co
Background							
Standard soil with pH 6	0,4	34	65	46	26	88	20
Preventive pollutant concentration							
Loamy sand and sandy	0,6	50	90	60	40	110	30
Sandy clay	0,6	60	110	65	45	160	35
Clay	1,0	70	130	70	50	180	40

Notes: 1. At pH <6.0 preventive values for soils with sandy-clay mechanical composition is applied to clay soils and the values of loam-sandy and sandy soils, soils with sandy-clay mechanical composition.

2. In the pH range of lead is <5.0.

According to background, PC, MAC, and IC have been estimated thee basic groups of heavy metal spices in Technosols:

The first group - the content of Cr, Ni and Co in studied Technosols is below background values of these elements in natural Bulgarian soils. By this fact, we may conclude that Technosols building after open coal mining have different and imbalance chemical content of these elements talking about their deficit (fig.1).

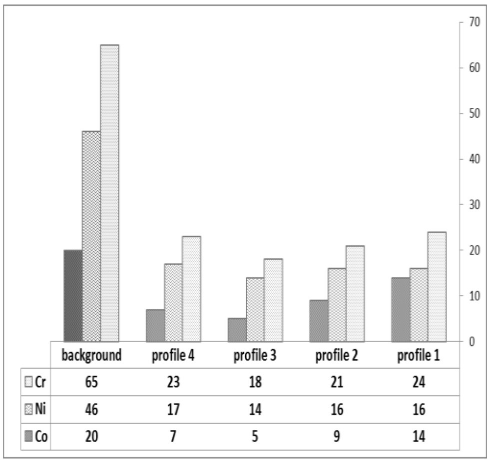

Fig. 1 Comparison between average content of **Cr, Ni, Co** in different Technosols with background values of elements in natural Bulgarian soils– mg/kg

In the second group - the content of Pb, Cu, and Zn in Technosols from the both investigated mining areas has also different spies from natural Bulgarian soils. The comparison between average content of Pb, Cu, and Zn in fourth Technosols with preventive pollution concentration shows that only in profile 2 have limited concentration for copper (fig.2). The third group is for cadmium concentration in Technosols. Cadmium concentration is high in all Technosols (fig.3). It concentration has compared with MAC which is given in Table 4.

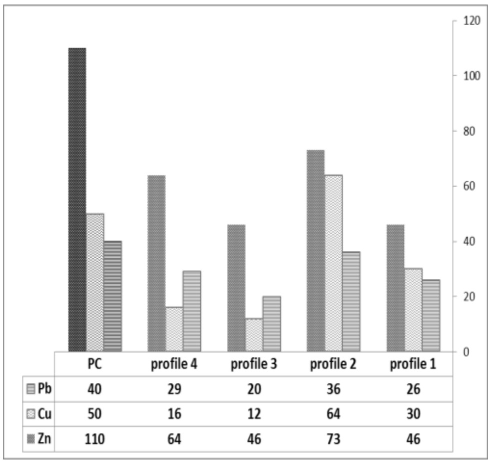

Fig.2 Comparison between average content of Pb, Cu, and Zn in different Technosols with Technosols with PC

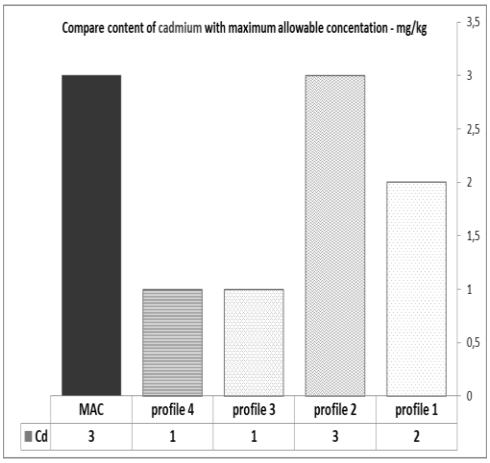

Fig.3 Comparison between average content of Cd in different Technosols with MAC

Table 4. Maximum allowable concentration and Intervention concentration (mg/kg)

Pollutants	pH (H_2O)	MAC		IC
		Arable land	Grass land	
Cd	<6.0	1,5	2,0	
	6.0 – 7.4	2,0	2,5	12
	>7.4	3,0	3,0	

*Note – the table is part of Ordiance 3 (2008), which inclued concetration about more elements Pb, Cu, Zn, Co, Ni, Cr

In conclusion, the content of heavy metals in Technosols has different species compare with their content in the natural soils. The content of heavy metals in Technosols is in function with chemical content of reclaimed materials. Nevertheless, there are the following similar tendentious in both mining areas: the concentrations of **Cr, Ni**, and **Co** are in deficit; the concentrations of **Pb, Cu,** and **Zn** are higher up to preventive concentration in profiles with high coal content; the concentration of **Cd** is MAC in all the profile but more dangerous with environment risk in acid Technosol.

Supply of Nitrogen, Phosphorus, and Potassium

The supply of nitrogen, phosphorus and potassium has been estimated by limited values (Table 5) The data shows that humus reclaimed profile have higher content of nitrogen but supply of element in unsufficient in all the difference Technosols. The phosphorus supply is bad in all the types of studied Technsols. It doesn't matter the genesis and content of different geological materials.

Table 5. Content of N, P, K in Technosols

Depth (cm)	$NO_4^{+}+NH_3^{-}$ mg/kg	P_2O_5 mg/100g	K_2O mg/100g
Humus reclaimed type of Technosols - profile 1 "Maritza-East"			
A 0-30	15,1	6,2	46,5
C1 30-50	12,3	2,3	17,0
C2 50-70	8,4	2,7	16,0
Direct biological reclaimed type of Technosols – profile 2 "Maritza-East"			
AC 0-25	13,1	2,7	51,5
C1 25-70	15,4	2,1	39,0
C2 70-100	11,9	2,9	44,0
Direct biological reclaimed type of Technosols – profile 3 "Chukurovo"			
AC 0-5	8,4	2,5	23,0
C1 5-22	8,7	3,9	12,5
C2 22-52	12,6	1,1	22,0
C3 52-74	12,5	0,9	13,5
Direct biological reclaimed type of Technosols – profile 4 "Chukurovo"			
C1 0-35	10,6	1,8	12,5
C2 35-60	15,6	2,6	15,0
C3 60-90	17,4	1,9	14,0
Limited supply			
sufficient	20-40	13-20	15-20
unsufficient	<20	7-13	10-15

* Note - the limit values are summarized reference values for all soils, soils of different types, they may be different in the soil types.

Only supply of potassium is sufficient in all the type of Technosols. In profile 2, content of potassium is higher than humus reclaimed type – profile 1. The potassium supply in profile 2 may to be explaining with high coal content, but there is not the same correlation for profile 4 from Chukurovo mining area, which also has high coal content.

The survey show than in agrochemical aspect the supply of basic nutrients in Technosols is again function of chemical characteristic of building reclaimed materials. There are similarities and differences between the two mining areas. The main similarity is that the Technosols differences have positive potassium supply, but negative phosphorous and nitrogen supply independent of the type of reclamation.

Conclusion

New constructed Technosols after open cast coal mining have genetic low level of nutrient supply. The nutrient supply in Technosols is better, when the reclamation is humus type instead of direct biological reclamation. The reclamation in Bulgaria is humus type from 1992 that is why the future quality of Technosols will be without dangerous elements and lower nutrients deficits.

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References

Atanasov I., T. Raichev, Sv. Ruseva. 2009. Glossary of soil science, 191 p.

Banov, M., Bl. Hristov. 1996 Some principles of classification, nomenclature and diagnosis of reclaimed soils without humus cover the area of the "Maritsa Iztok". *Soil Science, Agrochemistry and Ecology*, №3, 26-29p.

Banov, M., C. Tzolova L. Totev, Pl. Ivanov. 2013 Guide for testing and reclamation of degraded lands and Technosols and technical liquidation and conservation of mining sites. Publ. *Ambrosia* HT Ltd, ISBN 978-95492592-7-8,

Filcheva E., Tsadilas, 2002. Influence of Cliniptilolite and Compost on Soil Properties. *Commun. of Soil Sci. and Plant Analysis*, 33, 3&4, 595-607p.

Hristov, Bl. 2001 Contribution to the classification of reclaimed soils in Bulgaria magazine. *Soil Science, Agrochemistry and Ecology*, №1, 2-7p;

ISO 10390: 2005. Determination of pH (H_2O; 1 mol/l KCl; 0,01 M $CaCl_2$)

ISO 110 47:1998. Soil quality - Determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc - Flame and electro thermal atomic absorption spectrometric methods.

ISO 11260:2011. Soil Quality. Determining the actual capacity of cation exchange and base saturation with a solution of barium chloride

ISO 114 66:1995. Extraction of trace elements soluble in aqua regia.

IUSS Working Group. WRB. 2006. 2nd edition. World Soil Resources Reports №103, FAO. Rome.

Kaczynski, A. 1958. Mechanical and micro-soil composition, methods of its study. Publisher *Academy of Sciences of the USSR*. Moscow. 191 p.

Kononov, M. 1963 Soil organic matter. Its nature, properties and methods of the study. ANSSSR. Moscow. 314 p.

Ordinance № 26. 2002. The Land restoration, improvement of low lands, removal and recovery of the humus layer.

Ordinance № 3 on the admissible content of harmful substances in soil from 01.08.2008.

Treykyashki, P., Bl. Hristov. 1982. The grouping of geological materials suitability for biological reclamation. *Proceeding of III National Conference of Soil Science*. S.

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Data manipulation of correlations between soil properties and GHG emission

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Abstract

Apart from the water vapours, carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) are important greenhouse gases (GHG) contributing 60, 20 and 6% towards global warming, respectively (IPCC, 2007). Researches of greenhouse gases emission and climate change require relatively huge amount of data. The objective of the present study was to develop input correlations between attributes of soils and their GHG production potential. Generally, these data can be inducted from measuring devices directly or from different systems like geographical information systems and some other specific systems which are used for experimental data storage and management. A software development which store and manage these different data under one platform can be useful for research and development projects. In the present study, one physical data table was generated for data manipulation and data storage using a web- developed platform. Data storage with only three columns usage assures possibility for continuous refinement during the researching processes, because new variables could be determined after the entities identification process. One of the most important benefits from such development will be that researchers could be able to store and manage data from different systems under one platform using one physical data table.

Keywords: -manipulation, non-relational data storage, greenhouse gases, physical data table.

Introduction

The global temperatures have increased 0.8°C over the past century and are predicted to increase another 1.1-6.4 degrees over the next century (Peters et al., 2013). The concentration of CH_4 and N_2O is much lesser than CO_2, both gases have 25 and 298 times higher global warming potential than CO_2, respectively (IPCC, 2007). Ravishankara et al. (2009) reported that N_2O can also lead to depletion of the stratospheric ozone layer. Agricultural soil is a major source of N_2O (Hayakawa et al., 2009; Singla et al., 2013; Singla & Inubushi, 2014c). Several reports are available in the published literature which studied the emissions of these GHG under various soil types, cropping, irrigation and fertilizer management (Cabrera et al., 1994; Glatzel et al., 2004; Kong et al., 2013; Singla & Inubushi, 2014a, b; Singla et al., 2014).

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One of the main problem with systems that use huge amount of measuring or any identifier data is Big data management. It will be useful if such large amount of data (more than 10 million dataline) could be stored in one project with one web developed platform usage.

The development of data-manipulation model could meet such requirement and provide a useful platform for data storage. Generally, databasing projects consist of three essential tasks: data collection, data preparation, and data modelling (Pyle, 1999; Westerman, 2001). The integrated mechanisms of such models ensure that the system stores input data into one physical data table (non-virtual) (Mátyás et al, 2014).

The main objective of the present study was to develop input correlations between soil attributes, their GHG production potential, and geographical information system (GIS) data of sampling parameters under one platform with three columns datastoring structure.

Material and Methods

Data sites used in the study

The eight sites from eastern Hungary (47°55'~48°12' N, 21°23'~67' E) and seven sampling sites from central Japan (34° 49'~36°36' N, 139°00'~54' E) were selected for data storage. Chemical and microbial properties are shown in Table 1. Equations in multiple regression models for the relationship between GHG production/consumption potential and the soil properties were stored in the database (Table 2). Statistcal analyses were completed using SPSS Statistics 20 (IBM, New York, USA).

Database

Oracle Application Express (Apex) was used for experimental data storage. Apex provided opportunity to easy access because users could share works (by hierarchical levels) in same web platform without any software installation (Mátyás et al., 2014). Data of both countries were stored in Apex data tables using Oracle servers. The structure of entity identification was determined with key usage.

Data-manipulation model

The first registered version of Joker Tao was led by EU project supporting (INNO-1-2008-0015 MFB-00897/2008) in 2008. The developed datastorage and datamanipulation model provides opportunities to every input data could be stored and managed using even 3 columns, while integrated mechanisms ensure the interoperability of multi table usage.

After the data entry processes in Apex data tables, data of CO_2, N_2O and CH_4 production/consumption potentials and the soil properties under different land-use types in central Japan and eastern Hungary (Kong et al., 2013) were stored in one physical data table with three columns usage. Cognitive attribute of this system model prevails on many levels. Different data with attributes and correlations were stored in uniform storage format. Each attributes were key indexed. Multitude of huge amount of data lines generated a qualitative leap in this system model. When data lines were created, it was done automatically which could be logical. Attributes of data storage, data maintenance and properties function both as cognitive and feature. At the same time, the above explanatory properties monitor and enforce the feedback environment.

Results and Discussion

Every data which were stored in four columns structure are recorded in three columns physical data table now. Structure of data storage was determined with attributes of conceptual-functional name, functional logic and physical functionality. Tables of sampling country, sampling land use, sampling location and sampling sites were created to input attributes of sampling. Tables of measurements, measurement unit, types of measurement and types of soil properties were created to input measured data (Figure 1). Actual query determines how the system interprets the data, because every stored data could be entity and attribute in this model.

Associated attribute of this system model means that the system could initiate the search with a parallel processing mode to complete queries. Every single A and B search path is further engraved (marked) and path number increases.

Table 1. Chemical and microbial properties of Japanese and Hungarian soils

Sampling code*	pH (H_2O)	EC (d S m^{-1})	Total C (mg g^{-1} ds)	Total N (mg g^{-1} ds)	C/N	MBC (mg g^{-1} d.s.)	MBN (mg g^{-1} d.s.)	SOC (mg g^{-1} d.s.)	NO_3^--N (mg g^{-1} d.s.)	NH_4^+-N (mg g^{-1} d.s.)	NO_2^--N (mg g^{-1} d.s.)
JA-F	5.6	0.13	133 a	9.0 a	14.8 b	1862 a	188 a	454 b	25.1 a	1.24 a	0.71
JN-F	5.8	0.08	94 b	7.2 b	13.1 d	625 c	26 cdefg	371 c	5.36 d	0.85 abcd	0.56
JN-G	5.8	0.1	91 c	7.3 b	12.5 e	594 c	91 b	125 e	10.16 c	0.59 de	0.71
JA-O	5.9	0.11	70 d	5.5 c	12.6 e	807 b	89 b	206 d	2.31 e	0.82 bcd	0.94
JN-O	5.4	0.08	63 e	5.1 d	12.3 e	207 ef	9 fg	228 d	7.09 d	0.65 cde	0.32
JK-C	5.9	0.07	9 i	0.9 j	10.1 j	291de	37 cde	49 f	6.61 d	0.45 de	0.21
JM-C	5.2	0.13	40 f	3.8 e	10.7 i	252 de	27 cdefg	697 a	16.4 b	1.00 abc	0.36
HT-F	6.3	0.07	61 e	5.3 d	11.7 f	305 d	39 cd	150 e	5.79 d	1.21 ab	-
HH-G	8.2	0.55	17 h	1.6 i	10.7 hi	132 fg	45 c	55 f	14.26 b	0.50 de	1.51
HD-G	7.4	0.19	69 d	3.5 f	20.0 a	129 fg	47 c	225 d	7.78 cd	0.55 de	-
HP-O	8.6	0.06	6 j	0.6 k	9.5 k	84 gh	14 efg	47 f	1.79 e	0.37 e	0.1
HL-C1	6.3	0.04	18 h	1.6 i	11.1 gh	79 gh	16 defg	40 f	0.85 e	0.47 de	0.08
HL-C2	6.4	0.03	16 h	1.4 i	11.1 g	26 h	4 g	58 f	0.84 e	0.39 e	-
HG-C1	7.5	0.08	39 f	2.9 g	13.6 c	121 fg	19 defg	64 f	0.67 e	0.39 e	0.45
HG-C2	7.4	0.17	35 g	2.5 h	13.9 c	85 gh	29 cdef	132 e	1.37 e	0.48 de	0.24

Means within the same column followed by the same letter fo not differ significantly by Tukey's HSD test ($p<0.05$, n=3). EC: electrical conductivity; C: carbon; N: nitrogen; ds: dry soil; MBC: microbial biomass carbon; MBN: microbial biomass nitrogen; SOC: soluble organic carbon; $NO3^-$-N: nitrate nitrogen; $NH4^+$-N: ammonium nitrogen; $NO2^-$-N: nitrite nitrogen; - : not detected; *: site abbreviations are the same with Table 1.

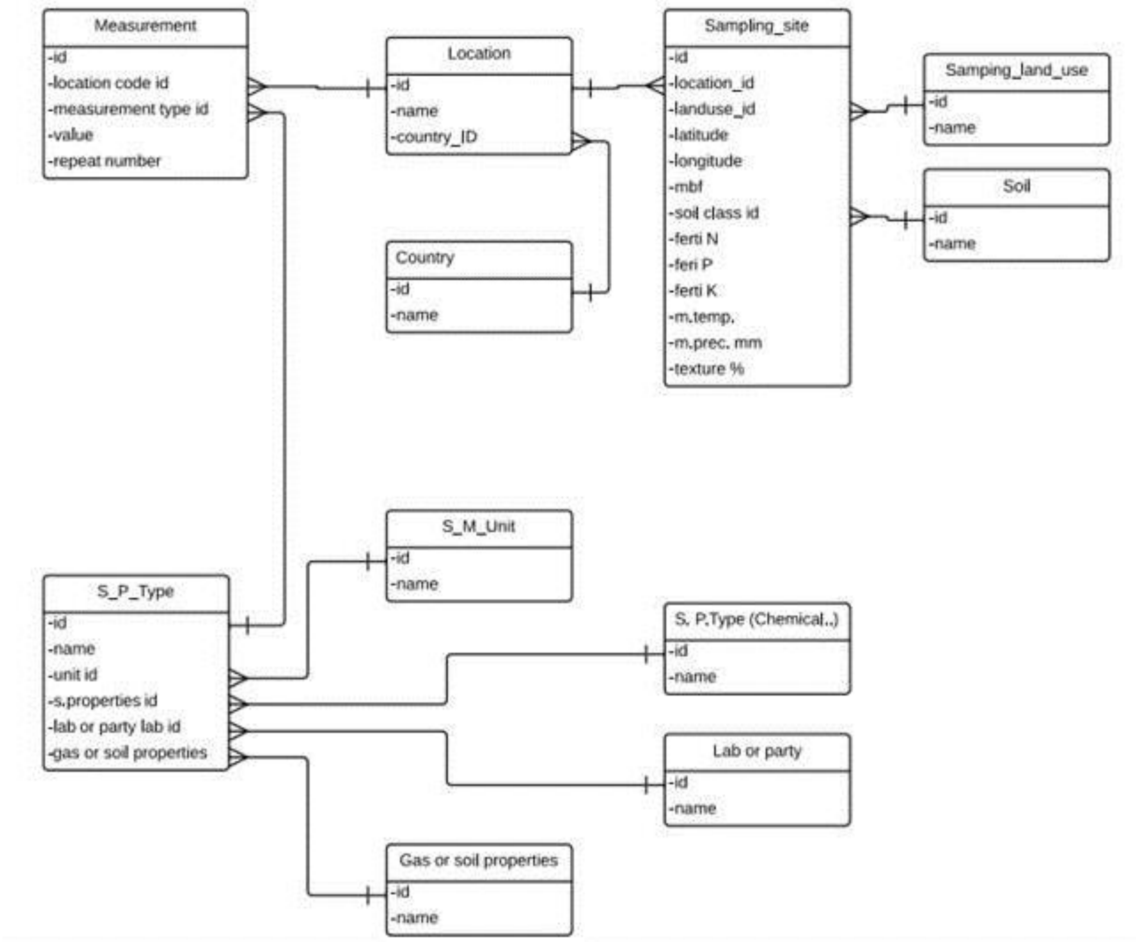

Figure 1. Apex data-tables

Table 2. Multiple regression models for the relationship between the cumulative greenhouse gas (GHG) production/consumption (Y) and the soil properties (X)

Country	#	Equations	Adjusted R^2	p
Japan (n = 7)	#1	Y1 = 1130.0 X1 – 32.0	0.86	0.002
	#2	Y1 = 4.3 X4 + 298.2	0.666	0.016
	#3	Y1 = 0.435 X3 + 296.9	0.548	0.035
	#4	Y3 = 31.48 X10 – 355.8	0.51	0.043
Hungary (n = 8)	#5	Y1 = 1750.3 X2 – 574.0	0.942	< 0.001
	#6	Y1 = 291.0 X7 – 321.1	0.699	0.006
	#7	Y1 = 5.663 X3 – 301	0.877	< 0.001
	#8	Y2 = 32.7 X2 – 7.4	0.936	< 0.001
	#9	Y2 = 0.102 X3 – 1.9	0.803	0.002
	#10	Y2 = 5.1 X7 – 2.0	0.605	0.014
	#11	Y2 = 0.018 Y1 + 3.4	0.958	< 0.001
	#12	Y3 = 6.262 X10 – 44.98	0.609	0.014
	#13	Y3 = 3.3 X8 – 31.2	0.477	0.035
Japan and Hugary (n = 15)	#14	Y1 = 108.9 X7 + 55.01	0.408	0.006
	#15	Y2 = 13.64X2 + 0.867	0.255	0.032
	#16	Y3 = 1.137 X6 – 0.169 X5 – 22 X9 + 26.2	0.811	< 0.001

Y1: cumulative carbon dioxide (CO_2) production; Y2: cumulative nitrous oxide (N_2O) production; Y3: cumulative methane (CH_4) consumption; X1: nitrite nitrogen (NO_2^--N); X2: ammonium nitrogen (NH_4^+-N); X3: microbial biomass carbon (MBC); X4: microbial biomass nitrogen (MBN); X5: soluble organic carbon (SOC); X6: total carbon (TC); X7: total nitrogen (TN); X8: soil water content; X9: the ratio of MBC to TC; X10: soil carbon: nitrogen (C:N) ratio. #1 to #13 were analyzed by single regression method. #14, #15, and #16 were analyzed by stepwise regression method.

Differently, the relational data storage models with multi-table using (Imhoff et al., 2003), only one physical data table was used for data-manipulation. In this case, there is no need to create relationships between data tables or use horizontally column expanding which could slow down the time of the query (Mátyás et al, 2014).

More data rows were used in this model than in relational multi-level database systems, but path number usage could shorten the searching line during the time in which query is completed. It offers a tool and opportunity for the researchers and developers to coordinate parallel teamwork and continuous data entry processes.

Conclusion

Data storing with three columns usage assures possibility for continuous refinement during the researching processes, because new variables could be determined after the entities identification process. A software development which store and manage different data under one platform can be useful for research and development projects. In the present study one physical data table was generated for data-manipulation and data storage using a web-developed platform. Data storage with three columns usage assures possibility for continuous refinement during researching processes.

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References

Cabrera, M. L., Chiang, S. C., Merka, W. C., Pancorbo, O. C., & Thompson, S. (1994). Nitrous oxide and carbon dioxide emissions from pelletized and nonpelletized poultry litter incorporated into soil. Plant and Soil, 163, 189-195.

Cheng, W., Sakai, H., Hartley, A., Yagi, K., & Hasegawa, T. (2008). Increased night temperature reduces the stimulatory effect of elevated carbon dioxide concentration on methane emission from rice paddy soil. Global Change Biology, 14, 644-656.

Glatzel, S., Basiliko, N., & Moore, T. (2004). Carbon dioxide and methane production potentials of peats from natural, harvested and restored sites, Eastern Quebec, Canada. Wetlands, 24, 261-267.

Hayakawa, A., Akiyama, H., Sudo, S., & Yagi, K. (2009). N_2O and NO emissions from an Andisol field as influenced by pelleted poultry manure. Soil Biology and Biochemistry, 41, 521-529.

Imhoff, C., Galemm, N., & Geiger, J. G. (2003). Mastering data warehouse design: relational and dimensional techniques. Indianapolis, Indiana: Wiley Publishing, Inc..

IPCC (2007). Changes in atmospheric constituents and in radiative forcing. In Climate change, the physical science basis, contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge, UK.

Kong, Y., Nagano, H., Katai, J., Vago, I., Olah, A. Z., Yashima, M., & Inubushi, K. (2013). CO_2, N_2O and CH_4 production/consumption potentials of soils under different land-use types in central Japan and eastern Hungary. Soil Science and Plant Nutrition, 59, 455-462.

Mátyás, B., Mátyás, Gy., Szendrei, M., Singla, A., Kong, Y., Kátai, J., Oláh, Á. Zs., & Inubushi, K. (2014). Development of four columns data storage model for data-manipulation of greenhouse gases and soil properties. Sustainable Agriculture Research – in reviewing

Menon, R.M. (2005). Expert Oracle JDBC Programming. New York: Springer-Verlag.

Peters, G. P., Andrew, R. A., Boden, T., Canadell, J. G., Ciais, P., Quéré, C. L., Marland, G., Raupach, M. R., & Wilson, C. (2013). The challenge to keep global warming below 2 °C. Nature Climate Change, 3, 4-6.

Pyle, D. (1999). Data preparation for data mining. San Francisco, CA: Morgan Kaufmann, Inc..

Raich, J. W., & Schlesinger, W. H. (1992). The global carbon dioxide flux in soil respiration and its relationship to vegetation and climate. Tellus, 44B, 81-99.

Ravishankara, A. R., Daniel, J. S., & Portmann, R. W. (2009). Nitrous oxide (N_2O): the dominant ozone depleting substance emitted in the 21st century. Science, 326, 123-125.

Sadalage, P. J., & Fowler, M. (2013). NoSQL Distilled: A brief guide to the emerging world of polyglot persistence. Addison-Wesley: Pearson Education, Inc..

Singla, A., Dubey, S. K., Iwasa, H., & Inubushi, K. (2013). Nitrous oxide flux from Komatsuna (Brassica rapa) vegetated soil: A comparison between biogas digested liquid and chemical fertilizer. Biology and Fertility of Soils, 49, 971-976.

Singla, A., & Inubushi, K. (2013). CO_2, CH_4 and N_2O production potential of paddy soil after biogas byproducts application under waterlogged condition. International Journal of Agriculture Environment and Biotechnology, 6, 233-239.

Singla, A., & Inubushi, K. (2014a). Effect of biochar on CH_4 and N_2O emission from soils vegetated with paddy. Paddy and Water Environment, 12, 239-243.

Singla, A., & Inubushi, K. (2014b). Effect of biogas digested liquid on CH_4 and N_2O flux in paddy ecosystem. Journal of Integrative Agriculture, 13, 635-640.

Singla, A., & Inubushi, K. (2014c). Effect of slag-type fertilizer on N_2O flux from komatsuna vegetated soil and CH_4 flux from paddy vegetated soil. Paddy and Water Environment, (DOI 10.1007/s10333-013-0405-z) (in press).

Singla, A., Sakata, R., Hanazawa, S., & Inubushi, K. (2014). Methane production/oxidation potential and methanogenic archaeal diversity in two paddy soils of Japan. International Journal of Ecology and Environmental Sciences, 40, 49-55.

Westerman, P. (2001). Data warehousing: using the Wal-Mart model. San Diego, CA: Academic Press.

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Determination of infiltration models parameters using adaptive neuro-fuzzy inference system

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Abstract

Infiltration process is one of the most important components of the hydrological cycle. The direct measurement of infiltration is laborious, time consuming, expensive, and often involves large spatial and temporal variability. Thus, any indirect estimation of this process is quite helpful. The main objective of this study was to predict the cumulative infiltration at specific time steps, using readily available soil data and adaptive neuro-fuzzy inference system (ANFIS). 63 double ring infiltration data were collected from different land uses of Kojor region. Basic soil properties including bulk density, particle-size distributions, organic carbon, gravel content (>2 mm size), and $CaCO_3$ content were determined. Infiltration models of American soil conservation service (SCS), Philip, Kostiakov, Green-Ampt and Horton were used and thus evaluated by Pearson correlation coefficient (r), root mean squared error (RMSE) and mean error (ME). The results showed that Kostiakov model had the best fitness to experimental data with maximum of r and minimum of RMSE in all land uses. The ANFIS model was used to predict the parameters of Kostiakov model. The basic soil properties were hierarchically used as inputs to develop ANFIS models. Results of the reliability test for the developed ANFIS models indicated that ANFIS models can be successfully used for the estimate of parameters of Kostiakov model.

Keywords: ANFIS, Infiltration models, Soil infiltration.

Introduction

Infiltration is a vital component of the hydrological cycle, and its accurate quantification is a fundamental step in effective soil, water, and crop management (Parchami-Araghi et al., 2013). Infiltration can be either measured in the field or estimated using mathematical models. The direct measurement of infiltration is laborious, time consuming and expensive. Throughout the past century, several infiltration models have been developed. The infiltration models can be categorized from entirely physically-based to empirical. Table 1 shows a summary of these models.

Fuzzy logic can easily incorporate expert knowledge into standard mathematical models in the form of a fuzzy inference system (FIS). A FIS is a nonlinear mapping of a given input vector to a scalar output vector by using fuzzy logic. A FIS simulates the process of human reasoning by allowing the computer to behave less precisely than conventional computing. It is suitable for approximate reasoning using a collection of membership functions and rules and is very powerful for modeling systems that are difficult to represent by an accurate

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mathematical model. The fields of hydrology and water resources commonly involve a system of concepts, principles, and methods for dealing with modes of reasoning that are approximate rather than exact. The capability of dealing with imprecision gives fuzzy logic great potential for hydrological analysis and water resources decision making (Bárdossy and Disse, 1993; Bardossy et al., 2007; Bogardi et al., 2004).

Table 1. Approximate theory-based and empirical infiltration equations.

Model		Model parameters	Equation
Empirical models	Kostiakov (1932)	c>0 and 0<a<1 are dimensionless empirical constants.	$I = ct^a$
	USDA-NRCS (1974)	k and b are dimensionless empirical constants.	$I = kt^b + 0.6985$
	Horton(1940)	C(mm min^{-1}) is the basic infiltration rate, m = (i_o - i_c)/a, where i_o (mm min^{-1}) is the initial infiltration rate at t = 0, a > 0 is a constant that determines the rate at which i_o, approaches i_c.	$I = Ct + m(1 - e^{-at})$
Theory based models	Green-Ampt (1911)	K_{fs} is the field- saturated hydraulic conductivity in mm min^{-1}, H is the ponding depth at the ground surface in mm; ψ_f is the constant effective suction head at the wetting front in mm; θ_{fs} is the field-saturated soil water content in fraction; and θ_a is the initial soil-water content in fraction.	$I = K_{fs}t + (\theta_{fs} - \theta a)(H + \psi_f) \times \ln(1 + \frac{I}{(\theta_{fs} - \theta a)(H + \psi_f)}$
	Philip(1957)	S is sorptivity (mm min$^{-0.5}$) and A is transmissivity factor (mm min^{-1}).	$I = st^{0.5} + kt$

I: cumulative infiltration (cm); t: infiltration time (min).

Sy (2006) employed artificial neural network (ANN) to model infiltration using data derived from plot-scale rainfall simulator experiments conducted in Cebu, the Philippines. The ANN resulted in a satisfactory network with an average R^2 of 0.9110. Sensitivity analysis showed that soil moisture and hydraulic conductivity are the influencing factors in modelling infiltration using ANN. When compared with the traditional Philip and Green-Ampt models, ANNs provided the highest accuracy in terms of cumulative infiltration.

Ghorbani Dashtaki (2009) collected 123 double ring infiltration data from different sites of Iran. The parameters of some infiltration models were then obtained using sum squares error optimization method. Basic soil properties of the two upper pedogenic layers such as initial water content, bulk density, particle-size distributions, organic carbon, gravel content, $CaCO_3$ percent and soil water contents at field capacity and permanent wilting point were obtained for each sampling point. The developed ANNs were categorized into two groups; type 1 and type 2 ANNs. For developing type 1 ANNs, the basic soil properties of the first upper soil horizon were used as inputs, hierarchically. While for developing type 2 ANNs the basic soil properties of the two upper soil horizons were used as inputs, using principal component analysis technique. Evaluation results of these two types ANNs showed the better performance of type 1 ANNs in predicting the infiltration parameters.

Gholami and Darbandi (2011) applied ANNs to estimate cumulative infiltration using 170 double ring infiltration data from different area of Iran. The essential properties includes: the percentage of silt and clay, Electrical Conductivity (EC), Saturation Percentage (SP), Field Capacity moisture and Wilting Point moisture (WP) was extracted by excavating profile near those points for organizing ANNs. Forth propagation artificial neural networks were used for estimating the cumulative infiltration after 30, 60 and 90 minutes from the beginning of water infiltration to soil and also basic infiltration. Results of this research show the validity of estimating infiltration by ANNs.

Parchami-Araghi et al. (2013) predicted the cumulative infiltration at specific time steps, using readily available soil data and 210 double ring infiltration data from different regions of Iran using ANNs. Results indicated that at the 1% probability level, ANNs-derived cumulative infiltration curve can be accepted as one of the replications of a reliable infiltration experiment. It was also concluded that compared to the Horton, Kostiakov, revised USDA-NRCS, Philip, and Green and Ampt infiltration models, the Kostiakov–Lewis model performed better to quantify the infiltration process.

In this study, Infiltration models of American soil conservation service (SCS), Philip, Kostiakov, Green-Ampt and Horton were applied to the observed infiltration data and the best-fit infiltration model for the study area was identified and evaluated. In addition, the ANFIS was used to model the infiltration parameters using readily available soil data and 63 double ring infiltration data collected from different land uses of Kojor region. The sensitivity of the ANFIS model was evaluated to determine which input parameters affected the output.

Material and Methods

Study area

The Kojor forest watershed (36° 13′ 30"~36° 33′ 00" N latitude, 51° 35′ 00"~51° 51′ 00"E longitude) is located at east of Nowshahr city in hyrcanin forest was selected. The basin area is about 130 km^2 and mainly consisting of forest lands in mid and downstream and rangelands in upstream areas. The average slope of the study watershed is some 45%. The highest and the lowest altitude of the watershed are 2650 and 150 m above mean sea level, respectively. The length of the main stream which drains into the Caspian sea is almost 20 km. Mean annual precipitation is 1308.8 mm at plain meteorological station, which reversibly decrease as elevation increases so that the mean annual precipitation at upland station declines to some 330 mm. Around 75% of the lower part of the watershed area is covered by native deciduous species of Fagus orientalis, Alnus sp, Acer valetinum, *Tillia begonifolia*, *Acer cappadocicum*, *Parrotia persica and Diospyrus lotus* with average density cover of some 75% (Vafakhah, 2013). The infiltration data were obtained by double ring method from 63 points from different land uses of Kojor region. Fig. 1 shows the distribution of the infiltration experiment points. Each infiltration experiment was conducted on three replications, using double ring infiltrometer with inner and outer diameters of 30 cm and 70 cm, respectively. The replications were conducted at the vertices of a 5 m unilateral triangle, and the soil samples were collected from the center of the triangle. The infiltration experiments were conducted until infiltration rate reached a constant value.

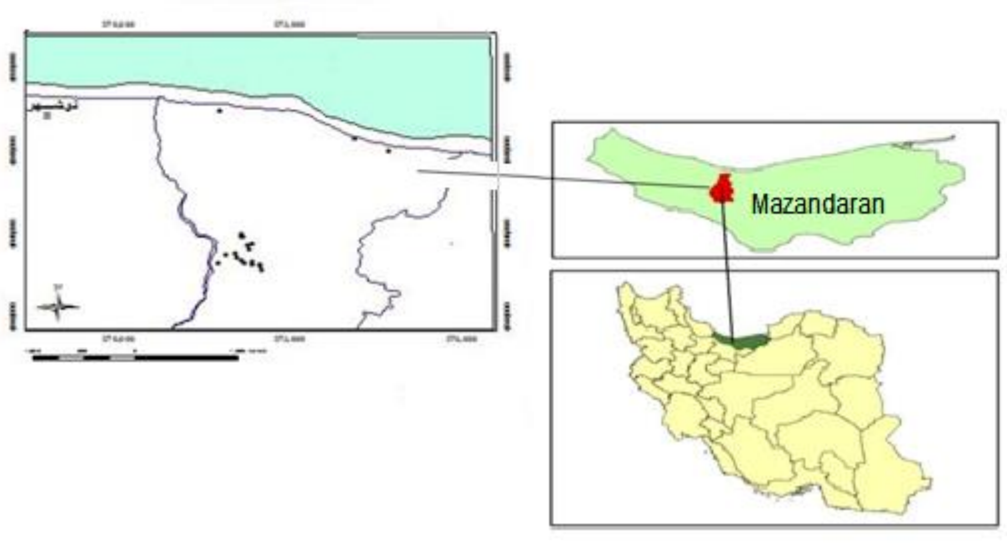

Fig.1. The general feature of the study area and the infiltration sampling points

Measurement of soil properties

Some soil properties of topsoil (0-30 cm horizon) were determined by standard methods. The initial water content, particle-size distributions, bulk density, organic carbon, gravel content (>2 mm size), and $CaCO_3$ content were determined, using gravimetric method, hydrometer method, (Gee and Bauder, 1986), core method (Blake and Hartge, 1986), Walkley and Black method (Walkley and Black, 1934), and calcimeter method (Nelson, 1982), respectively.

Estimation of infiltration model parameters

In the present study, five infiltration models viz. Kostiakov, USDA-NRCS, Horton, Green–Ampt and Philip were selected. These five infiltration models were chosen based on their practical utility and their frequent use in past studies. The infiltration rate and cumulative infiltration data obtained from 63 sampling points over the study area were fitted to these five infiltration models. The optimal model parameters were determined by the least square technique using Infilt package. The method suggests that, for the best fits, the sum of the squares of differences between the observed and the corresponding estimated values is minimum (Parhi et al. 2007). The following objective function was used to determine the parameters:

$$Min\ O(p) = \sum_{j=1}^{n}(I(m)_i - I(p)_i)^2 \quad (1)$$

where $I(m)_i$is the measured cumulative infiltration for soil (i) and $I(p)_i$is the predicted cumulative infiltration for soil(i), where (j)=1, 2, . . . n, with n the total number of j determinations for each soil i. Subscript j indicates the number of times which cumulative infiltration was measured or estimated.

2.4.Evaluation of the infiltration models

The accuracy of the infiltration models was evaluated by comparing the measured and predicted infiltration values. The statistic Pearson correlation coefficient r (–), root of the mean square error RMSE (cm) and the mean Error ME (cm) were used to evaluate the models (Ghorbani Dashtaki et al., 2009).

$$RMSE_i = \sqrt{\frac{\sum_{j=1}^{n}(I(p)_j - I(m)_j)^2}{n}} \quad (2)$$

$$r = \frac{\sum_{i=0}^{n}(I(p)_j - \overline{I(p)_j})(I(m)_j - \overline{I(m)_j})}{\sqrt{\sum_{i=1}^{n}(I(p)_j - \overline{I(p)_j})^2 \sum_{i=1}^{n}(I(m)_j - \overline{I(m)_j})^2}} \quad (3)$$

$$ME_i = \frac{\sum_{j=1}^{n} I(p)_j - I(m)_j}{n} \quad (4)$$

The RMSE is always positive; it equals zero only if all measured cumulative infiltration at different times equal the predicted values. The Pearson correlation coefficient is a measure of linear association between two variables (measured and predicted). The values of correlation coefficients range from −1 (a perfect negative relationship) to +1 (a perfect positive relationship). The sign of the coefficient indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships. In order to facilitate the comparison between different models, the mean absolute values of ME (Mean AME), the mean RMSE values (Mean RMSE), and the mean r values (Mean r-Pearson) over n soil samples were determined for each model. It is obvious that the smaller the 'Mean AME' and 'Mean RMSE' values, and the more the mean of r values approaches 1, the better performance will be achieved for the model. The validation indices that have been described above can be used to facilitate to rank the infiltration models. A final ranking was based on the mean of the ranking given to the models for each separate validation index.

Development of ANFIS models

The first step in developing ANFIS models is the selection of input data. The measured soil properties and the parameters of the best-fit infiltration model in the study area were used as input and output variables for developed ANFIS models, respectively. The most readily available soil data as inputs were applied for developed ANFIS models. A hierarchical approach then was followed for the development of this type of ANFIS models (Ghorbani Dashtaki et al., 2009). These models were introduced as $ANFIS_i$. The subscript i indicates the type of hierarchical ANFIS model and the number of its input variables minus two so that in the first hierarchical model ($ANFIS_1$), uses sand, silt, and clay as input variables (Table 2).

Table 2. Input parameters of the hierarchical ANFIS models.

Hierarchical ANFIS models	ANFIS input
$ANFIS_1$	percentages sand, silt, and clay (SSC) (%)
$ANFIS_2$	$ANFIS_1$ inputs + bulk density (ρ_b) (gr cm^{-3})
$ANFIS_3$	$ANFIS_2$ inputs + gravel content (%)
$ANFIS_4$	$ANFIS_3$ inputs + initial water content (%)
$ANFIS_5$	$ANFIS_4$ inputs + organic carbon content (%)
$ANFIS_6$	$ANFIS_5$ inputs + $CaCO_3$ (%)

Data normalization, as one of the frequently standard data preprocesses in progress of the ANFIS models were used due to issues caused by large attribute values. The measured soil properties and the parmeters of the best-fit infiltration model were scaled to the range between 0.1 and 0.9 as follows:

$$X_n = 0.1 + 0.8\left(\frac{X - X_{min}}{X_{max} - X_{min}}\right) \quad (5)$$

where $X_n$is the normalized value, x_i is the original data, x_{min} and x_{max} are, respectively, the minimum and maximum of data. The ANFIS used in the study is a fuzzy inference model of Sugeno type, and is a composition of ANN and fuzzy logic approaches. In this study, five different types of membership functions (MFs) namely gaussian (gaussMF), generalized bell-shaped (gbellMF), trapezoidal (trapMF), triangular (triMF), spline-based (piMf) were used (Jang, 1993). A detail of the ANFIS used in this study can be found in the Vafakhah (2012). Then, the network with the best generalization property (according to RMSE statistic value in testing phase) was chosen among the networks developed for each hierarchical $ANFIS_i$.

Results and Discussion

Soil properties of the experimental soils

The physical properties of the experimental soils are given in Table 3. As can be seen in Table 1, the minimum and maximum soil CaCO3 contents are varied from 1.67 to 36.67 percent, respectively. The organic carbon (OC) contents of the soil samples were between 2.17 to 2.17 percent having mean and standard deviation of 3.34% and 1.21%, respectively.

Table 3. Some physical properties of the experimental soils.

Soil property	Max	Min	Mean	Standard deviation
Clay(%)	48	13	33.57	8.90
Silt(%)	45	1	33..38	10.18
Sand(%)	86	17	33.04	16.50
Bulk density(gr cm^{-3})	1.86	1.22	1.50	0.17
Gravel (%)	51.13	0.18	7.76	12.18
Intial water content (%)	0.28	0.04	0.21	0.05
Organic carbon content (%)	4.99	2.17	3.34	1.21
CaCo3(%)	36.67	1.67	9.37	9.42

Evaluation of the infiltration models

The parameters of the selected infiltration models given in Table 4 were obtained by non-linear least squares optimization method.

Table 4 The ranges of parameter values of infiltration models by land use type.

Land use			Forest	Coastal land	Farmland	Orchards
Kostiakov	c	Min	0.283	0.806	2.005	1.845
		Max	10.793	1.922	12.343	8.963
	a	Min	0.46	0.648	0.31	0.366
		Max	0.97	0.94	0.66	0.70
Green-Ampt	a	Min	-0.012	0.538	4.099	3.278
		Max	81.02	2.562	53.545	59.183
	b	Min	-0.636	0.123	-1.674	-1.040
		Max	2.268	0.997	2.60	0.410
Horton	ib	Min	0.01	0.068	0.010	0.12
		Max	0.997	0.85	0.408	0.307
	fo	Min	0.056	0.26	0.355	0.905
		Max	11.88	1.864	12.03	6.284
	k	Min	0	-0.007	0.047	0.047
		Max	0.097	0.045	0.098	0.104
USDA-NRCS	a	Min	0.006	0.324	1.377	1.317
		Max	11.514	1.367	11.679	8.353
	b	Min	0.423	0.766	0.324	0.352
		Max	1.952	1.030	0.677	0.779
Philip	S	Min	-0.087	0.655	2.124	1.650
		Max	9.152	1.659	8.290	8.080
	K	Min	0.022	0.132	-0.442	0.026
		Max	2.436	0.946	2.346	0.449

The infiltration models were evaluated using different validation indices (Table 5).

Table 5. Validation indices for the infiltration models for different land uses

Land use		Forest	Coastal land	Farmland	Orchards
Kostiakov	Mean R^2	0.99(1)[a]	0.99(1)	0.95(3)	0.99(1)
	RMSE	2.59(1)	2.78(1)	14.77(2)	1.80(1)
	SD RMSE	4.75(2)	1.58(1)	18.13(2)	1.87(2)
	Mean ME	-0.45(1)	0.39(1)	-2.24(1)	-0.14(1)
	Mean AME	0.99(2)	0.99(1)	2.25(1)	0.99(2)
Green-Ampt	Mean R^2	0.93(4)	0.98(2)	0.78(1)	0.94(4)
	RMSE	8.16(4)	3.45(3)	37.88(4)	3.78(3)
	SD RMSE	15.96(4)	3.38(3)	48.58(4)	1.65(1)
	Mean ME	-3.11(4)	-0.66(3)	-13.17(4)	-0.26(2)
	Mean AME	2.17(3)	1.03(2)	13.38(4)	1.10(3)
Horton	Mean R^2	0.99(1)	0.99(1)	0.97(4)	0.98(2)
	RMSE	2.85(2)	4.19(4)	11.02(1)	3.87(4)
	SD RMSE	4.55(1)	2.24(2)	12.50(1)	2.31(4)
	Mean ME	0.65(2)	2.58(5)	-6.14(3)	-2.12(5)
	Mean AME	2.32(4)	2.81(4)	8.17(3)	2.62(4)
USDA-NRCS	Mean R^2	0.97(2)	0.98(2)	0.95(3)	0.99(1)
	RMSE	3.34(3)	2.84(3)	15.58(3)	2.16(2)
	SD RMSE	5.22(3)	2.93(2)	18.85(3)	2.01(3)
	Mean ME	-0.73(3)	-0.59(2)	-2.52(2)	-0.33(3)
	Mean AME	0.74(1)	0.99(1)	2.52(2)	0.33(1)
Philip	Mean R^2	0.96(3)	0.95(3)	0.81(2)	0.97(3)
	RMSE	9.37(5)	14.77(5)	48.43(5)	4.72(5)
	SD RMSE	17.76(5)	18.13(4)	57.41(5)	4.55(5)
	Mean ME	-4.23(5)	-2.24(4)	-19.99(5)	-1.61(4)
	Mean AME	4.23(5)	2.25(3)	20.55(5)	0.99(2)

[a]Rank of each model based on the calculated statistic is given in the parenthesis.

Comparing SD RMSE values given in Table 3 show the Kostiakov and Horton models have similar performance, but performance of the Philip model is more variable than other models in estimating infiltration. According to the obtained mean RMSE, the lowest RMSE values were obtained with the Kostiakov in forest, coastal and orchards land uses and the Horton in farmland. Also, the Philip model proiveded highest mean RMSE in all land uses except coastal land use that Horton model had highest mean RMSE in this land use. Based on the obtained mean R^2 values, the Kostiakov model have the highest mean R^2 in forest, coastal and orchards land uses and the Horton in farmland. The calculated validation indices (Table 3) indicate that the goodness of cumulative infiltration can be estimated by the Kostiakov in forest, coastal and orchards land uses and the Horton in farmland. The Green-Ampt and Philip models obtained the lowest ranking among the evaluated models.Althought, the SCS model have underestimated and overestimated similar the Kostiakov and Horton models. The mean RMSE values of the evaluated infiltration models for different soil texture classes are given in Table 6.

Table 6. The mean RMSE values for different soil textures of the evaluated models

Texture	Kostiakov	Green-Ampt	Horton	USDA-NRCS	Philip
Clay	16.59	42.04	2.52	54.87	17.58
Sandy Clay Loam	0.43	0.70	12.07	0.50	0.64
Clay Loam	2.10	4.38	0.21	6.75	3.19
Loam	4.02	17.54	3.92	14.27	2.48
Loamy Sand	3.03	1.34	6.36	1.94	1.57
Sandy Loam	3.20	6.13	4.26	4.75	4.25
Mean	4.36	11.73	4.61	6.54	5.22

As can be seen in Table 4, it was found that the Kostiakov and Horton models perform best for all soil textures except loamy sand texture. For loamy sand texture, the lowest mean RMSE values are obtained for the Green-Ampt model. Overall, the Kostiakov model had the lowest prediction error in the studied textural classes.

Evaluation of ANFIS models performance to estimate the parameters of Kostiakov model

The properties of hierarchical ANFIS selected for estimating the parameters of Kostiakov model are presented in Tables 7 and 8.

Table 7. Selected ANFIS models for the estimation of a empirical constant in Kostiakov model

Model	Membership function type	RMSE	
		Train	Test
ANFIS1	Trapezoidal	0.088	0.20
ANFIS2	Triangular	0.0009	0.30
ANFIS3	Spline-based	0.00002	0.276
ANFIS4	Generalized bell-shaped	0.00002	0.179
ANFIS5	Triangular	0.0004	0.23
ANFIS6	Triangular	0.003	0.23

Table 8. Selected ANFIS models for the estimation of c empirical constant in Kostiakov model

Model	Membership function type	RMSE	
		Train	Test
ANFIS1	Triangular	1.393	3.34
ANFIS2	Gaussian	0.001	3.36
ANFIS3	Gaussian	0.001	3.35
ANFIS4	Trapezoidal	0.0009	6.53
ANFIS5	Trapezoidal	0.00002	0.5
ANFIS6	Generalized bell-shaped	0.00004	0.47

As can be seen in Tables 7 and 8, a general decreasing trend is visible from ANFIS1 to ANFIS6. This implies that in general, the more number of inputs were used, the more accurate the estimations became. The RMSE values at the test period are always less than those at the training phase indicating good generalization ability of the developed ANFIS models.

Conclusion

Infiltration process is one of the most important components of the hydrologic cycle. In order to quantify this process, several models are developed by different researchers. In this study, the performance of Kostiakov, Green-Ampt, USDA-NRCS, Horton and Philip models were quantitatively evaluated, using 63 sets of experimental infiltration data obtained from different land uses and soil types of Kojor region. The results indicated that the Kostiakov model can be regarded as a more reasonable predictor model. This model provided highest ranking for the four statistical validation indices. It also performed a very high applicability to different soil textural classes. The second best infiltration model appeared to be the Horton model. The Philip, USDA-NRCS, and Green-Ampt models obtained ranks 3, 4, and 5 among others, respectively. It can be then concluded that the Kostiakov infiltration model is the most reasonable model to estimate the water infiltration with minimum relative error.

The results of this study showed that selected ANFIS models were able to estimate the parameters of Kostiakov model and in general, the performance of developed ANFIS models improved through the more number of inputs.

References

Bárdossy, A., Disse, M., 1993. Fuzzy rule-based models for infiltration. *Water Resour. Res.*, 373-382.

Bardossy, A., Duckstein, L., Bogardi, I., 2007. Fuzzy rule-based classification of atmospheric circulation patterns. Int. J. Climatol., 15(10), 1087-1097.

Blake, G.R., Hartge, K.H., 1986. Bulk density. In: Klute, A. (Ed.), Methods of Soil Analysis: Part I – Physical and Mineralogical Methods, second ed. ASA/SSSA, Monograph 9, Madison, WI, pp. 374–380.

Bogardi, I., Bardossy, A., Duckstein, L., Pongracz, R., Demicco, R., Klir, G., 2004. Fuzzy logic in hydrology and water resources. Fuzzy Logic in Geol., 153-190.

Gee, G.W., Bauder, J.W., 1986. Particles size analysis. In: Klute, A. (Ed.), Methods of Soil Analysis: Part 1 – Physical and Mineralogical Methods, second ed. ASA/ SSSA, Monograph 9, 383–411.

Ghorbani Dashtaki, Sh., Homaee, M., Mahdian, M.H., 2009. Estimating soil water infiltration parameters using Artificial Neural Networks, J. Water Soil, 23(1),185-198. (In Persian)

Ghorbani Dashtaki, Sh., Homaee, M., Mahdian, M.H., Kouchakzadeh, M., 2009. Site-Dependence Performance of Infiltration Models, Water Resour. Manage., 23,2777–2790.

Green, W.H., Ampt, G., 1911. Studies of soil physics, Part 1. The flow of air and water through soils. J. Agric. Sci. 4, 1–24.

Horton, R.E., 1940. Approach toward a physical interpretation of infiltration capacity. Soil Sci. Soc. of Am. J., 5,339-417.

Jang, J. S. R., 1993. ANFIS: Adaptive-network-based fuzzy inference system. IEEE Transactions on, Systems, Man and Cybernetics, 23(3), 665-685.

Kostiakov, A.V., 1932. On the dynamics of the coefficient of water percolation in soils and on the necessity for studying it from a dynamics point of view for purposes of amelioration. Transactions of the Sixth Commission of International Society of Soil Science, part A, pp. 17-21.

Nelson, R.E., 1982. Carbonate and gypsum. In: Page, A.L., Miller, R.H., Keeney, D.R. (Eds.), Methods of Soil Analysis. Part 2, second ed. Agron. Monogr. 9. ASA, Madison, WI, pp. 181–197.

Parchami-Araghi F., Mirlatifi S.M., Ghorbani Dashtaki Sh., Mahdian, M.H., 2013. Point estimation of soil water infiltration process using artificial neural networks for some calcareous soils, J. Hydro., 481, 35-47.

Parhi, P.K., Mishra, S.K., Singh, R., 2007. A modification to Kostiakov and modified Kostiakov infiltration models. Water Resour. Manage., 21, 1973–1989.

Philip, J.R., 1957. The theory of infiltration: 1. The infiltration equation and its solution. Soil Sci. 83, 345–357.

US Department of Agriculture, Natural Resources and Conservation Service, 1974. National Engineering Handbook. Section 15. Border Irrigation. National Technical Information Service, Washington, DC (Chapter 4).

Vafakhah, M., 2012. Application of artificial neural networks and adaptive neuro-fuzzy inference system models to short-term streamflow forecasting. Can. J.Civil Eng., 39(4), 402-414

Vafakhah, M., 2013. Comparison of cokriging and adaptive neuro-fuzzy inference system models for suspended sediment load forecasting. Arab. J. Geosci., 6(8), 3003-3018.

Walkley, A., Black, I.A., 1934. An examination of the digestion method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci. 37, 29–38.

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Research of the applicability of Mehlich-3 multinutrient extraction method in Thrace region soils

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Abstract

This research was carried out to extract available soil macro (K, P, Ca, Mg) and micro (Fe,Cu, Zn, Mn, B) nutrients by using single extraction solution (multinutrient extract solution) and analysis by ICP –OES equipment and determination of correlation coefficient between this method and other classical analysis methods. Total of 107 acidic and 123 neutral and alkaline soils were sampled from Thrace region. Soil available macro (P, K, Ca, Mg, S) and micro (Fe, Cu, Zn, Mn, B) nutrients were determined by ICP-OES after extractions of samples by Mehlich-III and other routine extraction methods. According to correlation test results of classical macro and micro nutrients extraction methods used in soil analysis laboratory and Mehlich-3 extraction method, high and very high correlation is determined for B and Mn in acidic soils. For other nutrients (K, Ca, Mg, S, Fe, Cu, Zn) ,except B, Mn and P, high and very high correlation is determined in neutral and alkaline soils. Regardless of soil reaction, correlation test results indicated intermediate correlation for B and P except Mn.

Keywords: Soil analysis, Mehlich-3, extraction method.

Introduction

In the middle of the last century, because of chemical analysis techniques is limited, different extraction and analysis techniques were used for each of the nutrients. Advances in techniques of chemical analysis led to the determination of a large number of elements with the same solution(multi nutrient elements extraction). Macro and micro nutrients, except nitrogen can be analysed by using universal or multi nutrient extraction methods and ICP-OES device.

Jones and Benton (1998) evaluated soil extract methods which starting in USA from the early 1940s to today in their article that is about soil analysis methods and soil extraction. In particular, Mehlich-3 and Ammonium Bicarbonate DTPA extraction methods have to be adopted which led to analyze many of the elements simultaneously.

Many researches have been conducted about available nutrient extraction and analysis. Bray (1949) stated that to conduct the studies with discipline and to obtain successful results, studies should give answers to the followings; a.With the extraction method, all or large portion of available nutrients able to determine b. The release of plant nutrients into solution must be correctly identified. This order doesn't work if the order mentioned in the first substance cannot be fulfilled c.The method should be cheap, quick and easy to implement. But this situation should not preclude the accuracy of the results.

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According to Schroder et al., (2009) The Mehlich-3 extraction method is widely used to extract plant-available phosphorus from soil over a wide range of pH values. The method is also used by many laboratories to determine multiple plant-available nutrients simultaneously. However, except for P, this method has not been statistically validated within and among laboratories. The objective of the study was to determine the repeatability (within-laboratory performance) and reproducibility (among-laboratories performance) of the Mehlich-3 method for several different nutrients by using a wide variety of soils. An in-house homogeneity test was conducted for 11 soils. Three replicates of each of the 11 soils were sent to 23 domestic and international laboratories for analyses primarily for K, Ca, Mg, Zn, Mn, Fe, and Cu. Samples were scooped, weighed, or both scooped and weighed for extraction. The various nutrients in the extracts were quantified by the participating laboratories by using inductively coupled plasmaatomic emission spectrometry. The Horwitz ratios were also used to evaluate the repeatability and the reproducibility. The method has been proven to be suitable for use as a reference method for testing soil materials for extractable P, K, Mg, Zn, Mn, and Cu. Further study may be needed to confirm the suitability of the Mehlich-3 method for Ca and Fe.

Matula (2009) tested the universality of three multi-nutrient soil tests after a radical intervention in soil chemistry by gypsum treatment on a variable set of 36 soils. Pot experiments with barley in a growth chamber were conducted to determine the bioavailability of K, Mg, P, Mn and B from soils. Three soil tests were employed to evaluate the nutrient status of soils: Mehlich-3,water extraction of soils and extraction with 0.5M ammonium acetate with addition of ammonium fluoride (Matula 2009). The ICP-OES technique was used to detect the nutrients in extracts. There were no marked differences in correlations between soil tests and the plant in K, Mg and P. But in the case of Mn and B Mehlich-3 test was not in appropriate agreement with the plant. Shortcoming of water extraction is missing information of capacity character for the derivation of the fertilizer recommendations on heterogeneous soils. The highest universality of Ammonium-acetate soil test was proved in all studied nutrients (K, Mg, P, Mn, B) in relation to the plant. Determination of the cation exchange capacity value that extends the information of capacity character is a part of this soil test. The cation exchange capacity value contributes to a more sophisticated approach to interpretation for the fertilizer recommendations.

Gürbüz and Günay (2013) conducted a study in Thrace region. Total of 107 acidic and 123 neutral and alkaline soils were sampled from Thrace region. Soil available macro (P, K, Ca, Mg, S) and micro (Fe, Cu, Zn, Mn, B) nutrients were determined by ICP-OES after extractions of samples by Mehlich-3 and other extraction methods. According to correlation test results; Mehlich-3 and ammonium asetate EDTA extraction methods can be used for acidic soils, Mehlich-3 and ammonium bicarbonate DTPA extraction methods can bu used for neutral and alkaline soils. Mehlich-3 and ammonium acetate methods had a high correlation coefficient and can be used for all soils (acidic, neutral and alkaline) after necessary calibration studies.

In this study, routine extraction methods that is performed field trials and calibrations and accepted the most appropriate method about half a century ago will be compared with multi nutrients extraction methods that reduce the workload of soil laboratories by using time and resources economical. The aim of the study is to determine the suitability of the Mehlich-3 extraction method for soil conditions in Thrace region.

Material and Methods

Most of the soil samples, located in Edirne, Kırklareli and Tekirdağ, are determined by considering large soil groups and areas that are covered by these groups. Total of 107 acidic, 123 neutral and alkaline soils were sampled from Thrace region. 154 samples are determined by considering soil groups and other 76 samples are obtained from 5 soil laboratories in Edirne and Tekirdağ. Samples, obtained from soil laboratories, were selected from soils which is analyzed by using routine methods and contain inadequate or less amount of nutrients. Soil samples were taken from a depth of 0-20 cm before sowing of summer crops during the months of March, April and May. The spatial distribution of acid and alkaline soils in three provinces can be seen in Table 1 (Eyüboğlu 1999). Soil samples were dried in the shade and passed through a 2.0 mm sieve.

Study were conducted with 107 acidic, 123 neutral and alkaline soils and total of 230 soils received from the region of Thrace. In order to test the accuracy of analysis, certified reference soil samples were used; Red soil (GBW07416) as acid soil and the Moist soil (GBW07413) as alkaline soil. In the extraction process in soil analysis, ultra pure blue band filter paper, ultra pure water and Gerhardt Laboshake shaker was used. Extraction process was conducted in three replicates. Samples were analysed by ICP-OES device (Spectro Arcos SOP).

Figure 1. Representation of the sample points on the map

Table 1. Amounts of acid soils in Thrace region and Turkey

Provinces	Acid soil areas, ha (pH < 6,5)	Total agricultural areas, ha	Ratio of acid soils %
Kırklareli	77.957	324.122	24,05
Edirne	152.217	446.115	34,12
Tekirdağ	127.108	468.865	27,10
Total	357.282	1.239.102	28,83
Overall in Turkey	2.414.398	32.813.541	7,36

Standard Soil Analysis Methods

Soil reaction (pH) was measured in saturated soil paste using combined electrode pH meter as mentioned by Richards (1954). Soil available phosphorus was determined according to Olsen (1954). Available potassium, calcium and magnesium are determined using ammonium acetate extraction method (Kacar,2009). Available iron, zinc, copper and manganese were extracted using DTPA method (Lindsay and Norvell, 1978) and measured using ICP. Available boron was determine with ICP according to Berger and Troug (1939). Available sulfur was extracted using $CaCl_2$ and determined using ICP-OES.

Mehlich-3 Extraction Method

The Mehlich-3 extractant has been adapted by many laboratories as a near-universal extractant (Mehlich 1984). The Mehlich 3 extraction of macro and micro elements is applicable for a wide range of soil properties. In this method, originally, dilution ratio was 1:10 (sample amount was 2.5 ml volume of the soil and 25 mL extract solution). This part of the method is calibrated by Baker et al, (2002) with a 1:7 dilution rate (2 g soil and 14 mL extract solution).

Mehlich-3 stock solution: (3,75 M NH_4F + 0,25 M EDTA). 277,8 g amonium flouride is dissolved in 1200 mL distilled water. 146,1 g EDTA is added and mixed. Distilled water is added to bring volume to 2L. This solution is enough for 10 samples.

Mehlich-3 extracting solution: (0,2N CH_3COOH + 0,25 NNH_4NO_3 + 0,015 NNH_4F + 0,013N HNO_3 + 0,001 M EDTA). 1000 g of ammonium nitrate is dissolved in 40 L distilled water. 200 mL Meclich 3 stock solution is added and mixed. 575 mL acetic acid and 41 mL nitric acid is added and mixed. Distilled water is added to bring volume to 50 L. pH of the solution should be 2,5 +/-0,1.

Standard calibration solution: In order to measure elements in linear range, Mehlich-3 extraction solution is used as matrix to prepare calibration standards for each element to be measured in the soil.

Analysis Process : 2.0± 0.05 g of air dried soil (passed through a 2-mm sieve) is put in a 70-mL glass or plastic Erlenmeyer flask. 14 ml Meclich 3 extraction solution is added. Extraction flasks are placed on mechanical shaker for five (5) minutes. Samples are filtered with Whatman no:2 filter paper. The concentrations of the elements is determined using ICP that is calibrated with calibration standarts.

Statistical Analysis

Results of Mehlich-3 extraction method and other routine analysis methods are evaluated by statistical analysis. Correlation coefficients between the methods are calculated with SPSS package programmes. Significance level of the correlation coefficients were evaluated according to Table 2 (Atan, 2010).

Table 2. Significance level of the correlation coefficients

Correlation coefficients	Significance level
0.00-0.25	Very low
0.26-0.49	low
0.50-0.69	moderate
0.70-0.89	High
0.90-1.00	Very high

Results and Discussion

Determined with Mehlich-3 and routine extraction methods, P, K, Ca, Mg, S, Fe, Cu, Zn, Mn and B contents of soil samples are given in Table 3, 4, 5.

Table 3. Minimum, maximum and average P, K, Mg, Ca contents of samples

Elements		P, ppm			K, ppm			Mg, ppm			Ca, ppm		
Methods	Soil	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Standart methods	Acid	2.44	145.2	32.5	22.6	1783	140	1.12	1224	338	111	8500	2311
	Neutral alkaline	0.40	43.0	13.3	15.4	1341	247	43.9	1043	393	1673	9297	5642
Mehlich-3 extraction method	Acid	0.92	139.1	44.6	22.0	381	138	8.09	464	264	23.3	26356	2733
	Neutral alkaline	0.02	189.8	26.6	55.2	1083	237	76.7	466	368	8.41	24269	7545

Table 4. Minimum, maximum and average iron, copper, zinc contents of soil samples

Elements		Fe, ppm			Cu, ppm			Zn, ppm		
Methods	Soil	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Standart methods	Acid	1.18	144	35.0	0.15	6.92	1.10	0.07	10.0	0.87
	Neutral alkaline	2.41	67.8	13.9	0.34	5.06	1.35	0.02	2.69	0.40
Mehlich-3 extraction method	Acid	1.10	438	155	0.00	10.4	1.52	0.07	20.8	1.95
	Neutral alkaline	6.27	430	98	0.12	12.5	3.11	0.15	7.07	1.29

Table 5. Minimum, maximum and average manganese, sulfur, boron contents of soil samples

Elements		Mn, ppm			S, ppm			B, ppm		
Methods	Soil	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Standart methods	Acid	0.70	186	54.6	1.18	203	9.50	0.10	1.27	0.48
	Neutral alkaline	2.00	84.4	16.0	1.96	164	12.6	0.25	1.36	0.70
Mehlich-3 extraction method	Acid	1.91	354	264	8.25	272	23.7	0.04	2.12	1.46
	Neutral alkaline	16.9	295	163	3.47	170	21.3	0.25	2.31	1.36

All of the acid, neutral and alkaline soils were analyzed with Mehlich-3 and routine analysis methods. Correlation coefficients between the methods were calculated and given below Table 6. The graphic that is generated according to these coefficients is shown in Figure 2.

Table 6. Mehlich-3 extraction method correlation coefficients

Soil pH	Fe	Cu	Zn	Mn	K	Mg	Ca	P	S	B
Acid	0.86**	0.87**	0.74**	0.70**	0.99**	0.86**	0.72**	0.75**	0.81**	0.39**
Neutral alkaline	0.92**	0.78**	0.86**	0.18*	0.96**	0.75**	0.76**	0.41**	0.88**	0,39**
All	0.85**	0.78**	0.75**	0.44**	0.98**	0.79**	0.81**	0.65**	0.84**	0,53**

**:%1 significance level

As seen in the Table 6, in acidic, neutral and alkaline soils without distinction, for all identified nutrients, significant relationship at 1% significance level was found between Mehlich-3 extraction method and the standard methods. Significant relationship at 5% significance level was found only for manganese in neutral and alkaline soils.

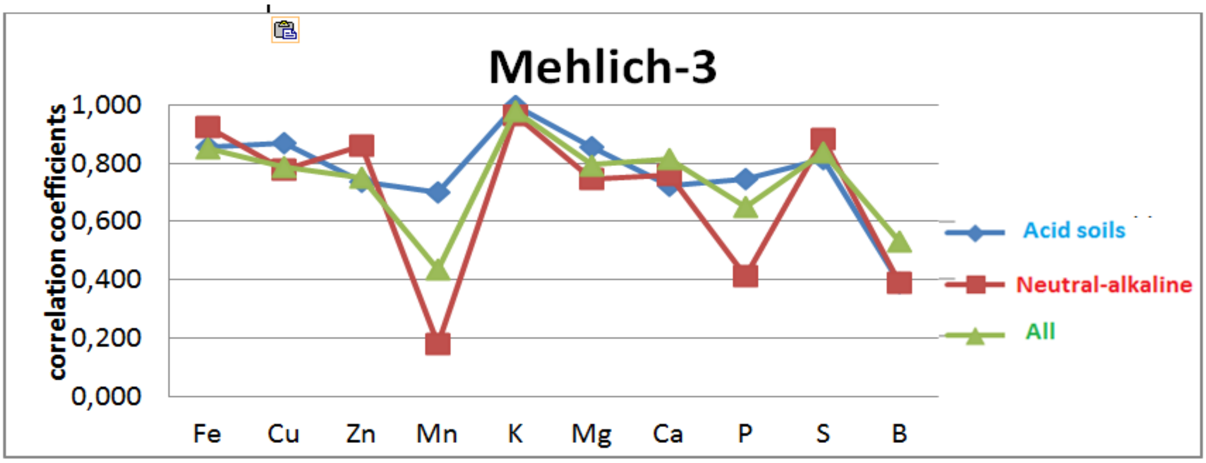

Figure 2. Distrubution of Mehlich-III extraction method correlation coefficients

For all soils, very highly significant relationships (0,9-1,0) is determined for K, highly significant relationships (0.70-0.89) is determined for Fe, Cu, Zn, Mg, Ca, S and moderately significant relationships (0.50-0.69) is determined for P, B. As seen in the Table 3 in acidic, neutral and alkaline soils without distintion, for all identified nutrients, significant relationship at 1% significance level was found between Mehlich-3 extraction method and the standard methods. Only for manganese siginificant relationship at 5% significance level was found in neutral and alkaline soils.

Conclusion

For all nutrients in acid soils relationship is determined between correlation coefficeints obtained by using Mehlich-3 extraction method and standard methods, these methods can be used in acid soils as multiple extraction method. Similar results have also been obtained by Rodriquez-Suarez et al., (2008). In alkaline soils low significant relationship is determined for Mn extracting with Mehlich-3. In terms of the region's soil is largely insufficient for Mn nutritional element, the low correlation coefficient can be ignored.

For all soils and elements relationships was determined by Mehlich -3 and ammonium acetate methods. For sulfur, low significant relationship was determined between ammonium acetate method and standard methods. In this respect, these two methods can be used in these types of soils. These results were similar with Elrashi et al., (2003), Rodriquez-Suarez et al., (2008) and Schroder, et al., (2009).

References

Atan, 2010. Sosyal Bilimlerde Araştırma Yöntemleri Dersi. Gazi Üniv. Sosyal Bilimler Enst. İşletme Anabilim Dalı. Yönetim Organizasyon Y.Lisans Programı.

Baker, W.H., Herron, C.G., Carroll, S.D., Henslee, M.A., Lafex, D.C. and Evans, E.E., 2002. A Comparative Summary of the Standard Mehlich 3 Soil Test with a Modified Mehlich 3 Dilution Ratio Procedure. http://arkansasagnews.uark.edu/205.pdf.

Berger, K. C. and Truog, E., 1939. Boron determination in soils and plants using the quinalizarin reaction. Industrial and Engineering Chemistry. Analytical Edition.Vol. 11, pp. 540-545.

Bray, R.H., 1949. Correlation of soil tests with crop response to added fertilizers and with fertilizer requirement. Diagnostic techniques for soil and crops. The American Potash Institute, pp. 53-56.

Eyüpoğlu, F., 1999. Türkiye Topraklarının Verimlilik Durumu. Köy Hizmetleri Genel Müd. Toprak ve Gübre Arş Enst. Yay. Genel Yayın no:220, Teknik Yayın No: T-67. Ankara.

Gürbüz, M.A., Günay, E., 2013. Makro ve Mikro Besin Elementlerinin Birlikte Ekstraksiyonunda Kullanılabilecek Metodların Trakya Yöresi Örneğinde Araştırılması. 6. Ulusal Bitki Besleme ve Gübre Kongresi 03-07 Haziran 2013. Kapadokya, Nevşehir.

Houba, V.J.G., Temminghoff, E. J. M., Gaikhorst, G. A., van Vark, W., 2000. Soil analysis procedures using 0.01 M calcium chloride as extraction . Communications in Soil Science and Plant Analysis - L , vol. 31, no. 9-10, pp. 1299-1396.

Jones Jr., Benton, J., 1998. Soil test methods: Past, present and future of soil extractants, Comminication in Soil Science and Plant Analysis, Vol:29 İssue:11-14, pages: 1543-1552. Department of Horticulture, University of Georgia, Athens, Georgia.

Kacar, B., 2009. Toprak Analizleri. Genişletilmiş II. Baskı, S: 165-166. 2. Baskı. Nobel Yayın Dağıtım Tic. Lim. Şti. Ostim. Ankara.

Lindsay, W.L., Norvell, W.A., 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. Soil. Sci. Soc. Am. J. 42:421-428.

Matula J., 2009. A relationsip between multi-nutrient soil tests (Mehlich-3, ammonium acetate, and water extraction) and bioavalibility of nutrients from soils for barley. Plant Soil Environ.,55, pp:173-180.

Mehlich, A., 1984. Mehlich-3 soil test extractant: A modification Mehlich-2 extractant. Communication Soil Science Plant Analyisis. 15(12):1409-1416.

Olsen, S.R., Cole, C.V., Watanale, F.S. and Dean, L.A., 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA Circular No:939, Washington DC.

Richards, L.A.,1954. Diagnosis and Improvement of Saline and Alkali Soils. United States Department of Agriculture Handbook 60:94.

Schroder, JL., Zhang, H., Richards, J.R., Payton, ME., 2009. İnterlaboratory validation of the Mehlich-3 method and as a universal extractant for plant nutrients .J AOAC İnt. Jul-Aug:92 (4): 995-1008.

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Minimum data set analysis in hazelnut areas using multivariate statistics and geostatistics methods

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Abstract

Hazelnut is one of the most important industrial agricultural products for the Blacksea region in Turkey. The main aim of this research is to form minimum data set in Ordu and Giresun in where hazelnut has been intensively cultivated. In the result of factor analysis performed using 13 soil physical and chemical parameters, it was determined five factors that have more than 1 eigenvalue and these factors explained variation of data set from about 77%. Factor 1 was called as micronutrient factor in determined factors. It was found that this factor was the most identifying for variation of data set from about 19%, whereas Factor 5 called as available boron factor explained the lowest variation (approxiamately 13%) in data set.

Keywords: Hazelnut areas, minimum data set, physical and chemical analysis, principal component analysis, spatial variability.

Introduction

Turkey which is the most important producer of hazelnut meets nearly 70%-80% of the world production and exportation (Akova, 2005). Blacksea region has the most suitable factors for the production of nuts in the world, and it also has the highest quality nuts in the world. As well as getting rain throughout the year that will satisfy the climatic requirements of nut, it is grown in the region on steep sloped lands in order to protect the land against erosion. It is cultivated in 12 provinces including Ordu, Giresun and Trabzon.

When the agricultural structure of Anatolia is examined, it can be seen that the Blacksea region has a leading position in terms of growing maize, tobacco, tea, and nuts for trade. The fact that the climatic and soil characteristics of the region meet most of the requirements of these crops to a great extent is the most important reason for the cultivation of these crops. It is also the reason why, especially, nuts among these products were cultivated in the region for the first time. Because when hazel tree is examined in terms of the conditions in which it grows well, it can be seen that especially humid climate is necessary to ensure a good growing and high yields. It is also possible to grow nuts in arid and semiarid climates, but it requires regular

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irrigation. The lands with an average temperature of 13 °C-16 °C are the most suitable places for nut cultivation. However, in these areas the lowest temperature should not be below -8 °C – -10 °C, and the highest temperature should not be over 36 °C-37 °C, total rainfall should not be over 700 mm, and the precipitations should be evenly distributed to seasons. Moreover, the rate of the humidity in June and July should not be below 60%.

For the last fifty years nuts have contributed significantly to the economy of Turkey thanks to both employment provided and as an added value. They have become an important regional product which is spreading from eastern part of Blacksea region to the west part and other provinces, thanks to the factors such as emigration from the region, and the fact that it is relatively easier to cultivate nuts compared to other products, and that, from the 1970s, it was guaranteed that it would be bought at a price higher than its cost price. Ordu and Giresun, where the study was carried out, are the regions that have the highest share total production with the rates between 58% and 60% (Tanrıvermiş et al., 2006). As for the distribution of the fields of nuts, with 201 000 ha, Ordu has 30% of the total fields of nuts, and Giresun is second to Ordu with an area of 118 000 ha nut fields and it has 18% of total fields of nut cultivation (Anonymous, 2010).

The objective of this study, which was carried out in Ordu and Giresun, which cover nearly 50% of the total fields of nuts in Turkey, is to generate minimum data set about the lands under nut cultivation using some soil physical and chemical characteristics. Factor analysis was used in order to reduce data connected with physical and chemical characteristics of the soil, and the distribution of the new variables, according to the fields, obtained after factor analysis was mapped by geostatistical approach. Thus, we aimed to create a spatial distribution map both to determine primary soil factors for nut fields in two provinces which have the highest capacity of nut production, and to find out the areas where these factors are sufficient or insufficient.

Material and Methods

Study Area

This study was performed in Ordu and Giresun provinces that located on central and east part of the Black Sea Region (Figure 1). Coverage of Ordu is about 6 756 km^2 while Giresun province has about 6 934 km^2. Lands of the Ordu have been generally used as agriculture (397 248 ha), forest (157 583 ha), pasture (80 395 ha) and non-agricultural areas (40 382 ha) (Anonymous, 2008). In addition, according to the Anonymous (2010) distribution of land use for Giresun province, only 165 503 ha has been used for agricultural applications. The maximum and minimum average temperatures of Ordu province is between 6.4 °C and 22.7 °C, annual average value is 14.0 °C. In addition, average annual precipitation for Ordu is 1 029.2 mm. As far Giresun, maximum and minimum average temperatures of it are 7.0 °C and 22.7 °C, annual average value is 14.3 °C. Average annual precipitation for Giresun is 1 236.7 mm.

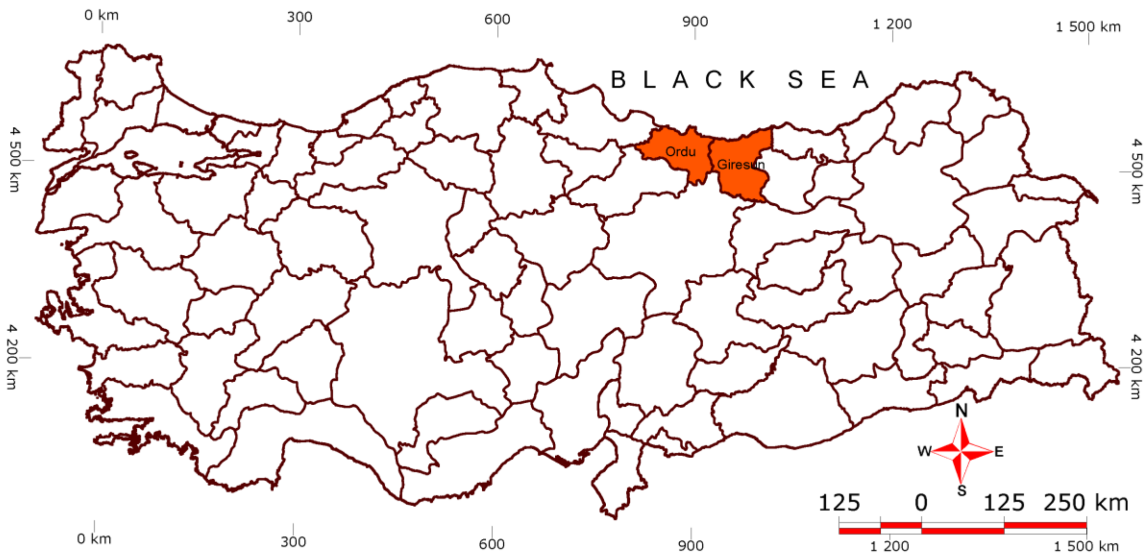

Figure 1. Location map of the the study area (Ordu and Giresun provinces)

Soil Sampling and Analyses

In the lands chosen for soil sampling, the distance between the two sampling points was determined by Global Possitioning System (GPS) in a way that the distance between the two points is 2 500 m. Disturbed soil samples were taken at a depth of 0-30 cm.

On the soil samples the following analyses were carried out; texture analysis by Bouyoucos hydrometer (Gee and Bauder, 1986), volumetric lime analysis by Scheibler calcimeter (Nelson, 1982), organic matter analysis by Smith-Weldon method (Nelson and Sommers, 1982), pH in 1:2 soil-water mixture (Hendershot et al., 1993) and electrical conductivity (EC) in 1:2 soil-water mixture (Rhoades, 1986), total nitrogen analysis by Kjeldahl method (Bremner and Mulvaney, 1982), available phosphorus (Av.P) by Bray and Kurtz No.1 method (Bray and Kurtz, 1945), extractable potassium (K), calcium (Ca), magnessium (Mg) and sodium (Na) (Soil Survey Staff, 1992), available zinc (Av.Zn), copper (Av.Cu), iron (Av.Fe) and manganese (Av.Mn) analyses by reading the solution obtained after the extraction by Diethylenetriaminpenta-aceticacid (DTPA) on the atomic absorption spectrofotometer (Anonymous, 1990) and available boron (Av.B) by azometin-H method (Wolf, 1971).

Multivariable Statistical and Geostatistical Analyses

While factor analysis, which is one of the multivariable statistical methods, was used in order to form minimum data set with new variables related to the 18 physico-chemical soil characteristics examined in this study, spatial distribution maps of the variables in the minimum data set called factors were prepared using geostatistical method.

Although factor analysis caused dimensional reduction and helped to remove a dependence structure, its aim was to find several new independent variables bringing together interrelated variables in a situation with the variable P (Tatlıdil, 2002). As the soil characteristics used as variables in factor analysis had different units, standardized values of the soil characteristics measured were used in factor analysis to eleminate the effects of the units. The variables to be included in the analysis were determined taking coefficients in correlation matrix and communalities into consideration. As a result of this analysis, while the groups with eigenvalues ≥ 1 were accepted as factors, the critical factor loading was taken as 0.5.

Geostatistical method was used to generate distribution maps of factors determined in the study area. To be able to generate distribution maps, first, semivariogram models and parameters of these semivariograms such as nugget, sill and range were determined using factor score values concerning the factors established after factor analysis. The following equality was used for estimating semivariogram models.

$$\gamma(h)=\frac{1}{2N(h)}\sum_{i=1}^{n}(Z_{(xi)}-Z_{(xi+h)})^2 \qquad (1)$$

Where γ (h) is the semivariance for the interval distance class h, N(h) is the number of pairs of the lag interval, $Z_{(xi)}$ is the measured sample value at point i, and $Z_{(xi+h)}$ is the measured sample value at position (i+h). To determine spatial variability of the factors established, the isotropic semivariogram models such as spherical, and exponential were used.

Geostatistical software (GS^+ 7.0 2007) was used to construct semivariograms and spatial structure analysis of determined factor score values. In addition, maps of factor score values in the study area were produced by kriging technique (Isaaks and Srivastava, 1989) using ArcGIS 9.3v geography information system program.

Results and Discussion

Descriptive statistics of soil properties

Related to measured soil properties, some descriptive statistical properties such as average, maximum, minimum values, standard deviation, coefficients of variation and so on were given in Table 1. According to Table 1, it seems that all properties except for sand, silt and pH are far away from normal distribution. In this research carried out on hazelnut cultivated soils, it was determined that exchangeable sodium (Exc.Na) has the highest skewnees followed by calcium carbonate ($CaCO_3$), Av.Zn, Av.Cu and Av.P, respectively.

Some researchers indicated that soil properties can show skew distributions under degradated ecosystems (Nael et al., 2004; Wang et al., 2003). In addition, as investigated coefficients of variation of soil properties in the study area, most of the soil properties have high coefficient of variation; that case is similar with skewness coefficient. Wilding (1985) classified coefficient of variation, which is an important indicator for explaination of soil properties' variations, as low (15%), medium (15-30%) and high (>35%) according to its value. Whereas it was determined that sand, silt and pH belong to medium class according to coefficient of variation, all other soil properties have high variation (Table 1). The most important reasons of the high skewnees and variation of soil properties in data set can be explained with varying topographical and climatical conditions in Central and Eastern Black Sea regions. Besides, the values of pH in soil samples widely ranged between 3.44 and 8.07, that means from strong acid to moderately alkaline soil reaction, whereas EC had a minimum value of 0.09 dS m^{-1} and a maximum value of 2.96 dS m^{-1}. The mean values of organic matter and $CaCO_3$ content (%) were 3.87 and 1.93.

Table 1. Descriptive statistics of soil properties

Variables	Unit	Mean	Min	Max	S.D.	C.V. (%)	Skewness	Kurtosis	N
Sand	%	51.72	16.83	85.70	13.23	25.58	-0.18	-0.53	795
Clay	%	22.34	4.15	60.81	11.47	51.35	0.82	0.33	795
Silt	%	25.93	2.09	49.65	6.38	24.60	0.32	1.06	795
pH		5.37	3.44	8.07	1.07	19.88	0.56	-0.59	795
EC	dS m^{-1}	0.43	0.09	2.96	0.31	70.52	2.93	12.86	795
$CaCO_3$	%	1.93	0.12	58.84	6.79	352.66	5.83	36.64	795
SOM	%	3.87	0.64	12.64	1.77	45.65	1.44	3.40	795
Av.P	mg kg^{-1}	9.38	0.07	124.22	15.00	159.86	3.57	16.98	795
TN	%	0.21	0.05	0.65	0.09	40.86	1.30	2.79	795
Exc.K	cmol kg^{-1}	0.50	0.07	4.28	0.46	91.48	2.95	13.16	795
Exc.Ca	cmol kg^{-1}	10.21	0.10	42.99	7.31	71.60	0.99	1.05	795
Exc.Mg	cmol kg^{-1}	1.25	0.08	8.20	1.24	99.20	2.37	6.63	795
Exc.Na	cmol kg^{-1}	0.40	0.13	7.76	0.44	110.00	10.52	145.27	795
Av.B	mg kg^{-1}	1.47	0.18	8.69	0.97	65.64	2.49	10.94	795
Av.Fe	mg kg^{-1}	49.70	1.04	266.71	35.70	71.82	1.84	5.49	795
Av.Cu	mg kg^{-1}	2.64	0.07	29.31	2.61	99.09	3.67	24.55	795
Av.Zn	mg kg^{-1}	1.62	0.03	24.80	2.55	157.84	4.56	26.75	795
Av.Mn	mg kg^{-1}	41.64	0.70	227.98	40.89	98.21	1.78	3.22	795

S.D.: Standard Deviation; C.V.: Coefficient of Variation; EC: Electrical Conductivity; $CaCO_3$: Calcium Carbonate; SOM: Soil Organic Matter; Av.P: Available Phosphorus; TN: Total Nitrogen; Exc:K: Exchangeable Potassium; Exc.Ca: Exchangeable Calcium; Exc.Mg: Exchangeable Magnessium; Exc.Na: Exchangeable Sodium; Av.B: Available Boron; Av.Fe: Available Iron; Av.Cu: Available Copper; Av.Zn: Available Zinc; Av.Mn: Available Manganese

Factor analysis of soil properties

Factor analysis was used to generate new and meaningful factor structures by gathering variations that have high correlation between each other. Hair et al. (1995) indicated that variation that has no relation to other variations and is found to be statistically insignificant can be ignored by checking correlation matrix. It is necessary that variations must have normal distribution in factor analysis. This hypotesis is valid for all variations and for all linear combinations of variations. In correlation matrix, relationships between variations should be over threshold. For example; if relationships between variations is below the 0.30, it is not possible to get suitable factor or factors from these variations. On the other hand, high correlation coefficients between variation don't give guaranty for making suitable factor, too. High dual correlation between two variations can decrease when other variations are constant. To be suitable, correlations between variations should be between 0.30 and 0.90. In this present study, it was determined statistically important ($p<0.05$: $p<0.01$) for 116 from 153 correlation relationships that were investigated for 17 selected soil characteristics (Table 2). Whereas the highest positive and negative correlation relationships between soil properties were found for TN x SOM (0.80, $p<0.01$) and Clay x Sand (-0.88; $p<0.01$), then Av.Mn x Sand (0.07, $p<0.05$) and Exc.Ca x TN (-0.07; $p<0.05$) were found as the lowest positive and negative correlation relationships between soil properties. Sand generally showed significantly negative correlation with other soil properties. On the other hand, it was determined that Av.P, Cu, Zn and Mn have significantly positive correlation with investigated soil properties. It seems that these correlation relationships calculated between soil properties were suitable for factor analyses of investigated data set.

In addition, another indicator is also Kaiser-Mayer-Olkin (KMO) coefficient in order to evaluate the suitability of dataset for factor analysis. KMO is an index which compares magnitute of observed correlation coefficients with magnitute of partially correlation coefficients. To make factor analysis, KMO value must be bigger than 0.5 (Kalaycı, 2010). In this study KMO coefficient value was found as 0.574.

After giving decision for suitability of dataset to factor analysis, normalized dataset was used to calculate factor analysis and result of it was given in Table 3. In result of factor analysis five factors that have eigenvalue more than 1 were determined. Eigenvalue that has been used as an indicator for factor selection has been used as a criterion when doing evaluation between factors and soil properties. In this case, soil properties have been assigned to factor that has the highest eigenvalue (Shukla et al., 2006). On the other hand, when variances of soil properties of selected 5 factors were investigate factors can explain variances of (>85 %) caly, sand , TN and SOM as the highest ration whereas, they can explain variances of (>50 %) Av. Mn as the lowest ratio. Factor 1 explained with 18.36% of variability belonging to dataset by taking high value (>0.80) for Av.Cu and Av. Zn. This factor was called as micronutrients. Average pH values of soils in the study area have acidic soil reaction, so there is high availability of most of the micronutrient elements for plants. Thus, it seems that average values of micronutrient elements assigned as factor component are sufficient; however, it was determined insufficient by taking into consideration of minimum values in some part of the study area (Table 1). Texture components were assigned as sand and clay as component for Factor 2 explained with 16.39% of variability belonging to dataset by taking high value (>0.95) for clay and sand fractions. Not only both factor components got high values, as it was expected textural components were assigned by taking as positive and negative for factor. That's why this factor can be described as texture by means of components of factor.

Table 2. Spearman's correlation coefficients between soil properties

	Sand	Clay	Silt	pH	EC	$CaCO_3$	SOM	Av.P	TN
Clay	-0.88**								
Silt	-0.50**	0.09**							
pH	-0.21**	0.32**	-0.18**						
EC	-0.11**	0.17**	-0.10**	0.54**					
$CaCO_3$	-0.15**	0.19**	-0.03	0.34**	0.09**				
SOM	0.06	-0.16**	0.11**	-0.19**	0.14**	0.02			
Av.P	0.13**	-0.14**	-0.05	0.06	0.24**	-0.03	0.21**		
TN	-0.04	-0.03	0.09**	-0.08*	0.23**	0.01	0.80**	0.25**	
Exc.K	-0.01	0.08*	-0.11**	0.24**	0.30**	0.11**	0.19**	0.39**	0.25**
Exc.Ca	-0.30**	0.40**	-0.11**	0.68**	0.32**	0.23**	-0.25**	0.02	-0.07*
Exc.Mg	-0.04	0.04	0.08*	0.13**	-0.15**	-0.05	-0.30**	-0.07	-0.26**
Exc.Na	0.09*	-0.04	-0.15**	0.17**	0.14**	-0.06	-0.06	0.16**	0.13**
Av.B	-0.06	0.05	0.11**	-0.21**	-0.23**	-0.17**	-0.16**	0.04	-0.19**
Av.Fe	0.05	-0.12**	0.14**	-0.29**	-0.10**	-0.24**	0.23**	0.14**	0.09**
Av.Cu	-0.16**	0.18**	0.03	0.41**	0.25**	0.04	-0.02	0.16**	0.01
Av.Zn	-0.15**	0.15**	0.05	0.28**	0.34**	0.11**	0.18**	0.37**	0.15**
Av.Mn	-0.25**	0.29**	0.04	0.23**	0.27**	-0.10**	-0.09*	0.11**	-0.08*

	Exc.K	Exc.Ca	Exc.Mg	Exc.Na	Av.B	Av.Fe	Av.Cu	Av.Zn
Exc.Ca	0.24**							
Exc.Mg	0.06	0.40**						
Exc.Na	0.24**	0.35**	0.25**					
Av.B	0.04	-0.13**	0.28**	0.02				
Av.Fe	-0.13**	-0.27**	0.09**	-0.13**	0.25**			
Av.Cu	0.07	0.24**	0.16**	0.01	0.09**	0.40**		
Av.Zn	0.25**	0.05	-0.04	-0.08*	0.07	0.38**	0.53**	
Av.Mn	0.07*	0.14**	0.13**	-0.01	0.11**	0.35**	0.45**	0.45**

EC: Electrical Conductivity; $CaCO_3$: Calcium Carbonate; SOM: Soil Organic Matter; TN: Total Nitrogen; Av.P: Available Phosphorus; Exc:K: Exchangeable Potassium; Exc.Ca: Exchangeable Calcium; Exc.Mg: Exchangeable Magnessium; Exc.Na: Exchangeable Sodium; Av.B: Available Boron; Av.Fe: Available Iron; Av.Cu: Available Copper; Av.Zn: Available Zinc; Av.Mn: Available Manganese; *: p<0.05; **: p<0.01

Factor 3 explained with 16.27% of variability belonging to dataset by taking high value (>0.80) for SOM and TN. It seems that average values of both factor components are sufficient according to Table 1; however, it was determined insufficient level of these two elements by taking into consideration of minimum values in small part of the study area. Horuz (1996) indicated that on 56.9 and 29.4% of the hazelnut areas of the Terme and Ünye districts located at Ordu province were found low levels of SOM and TN, respectively.

Exchangeable basic cations were assigned to Factor 4 as variables. Factor 4 explained with 13.56% of variability belonging to dataset. Exc.Na was found to be the highest value in factor components so, it has the biggest variability. On the other hand, mean values of Exc.Na in soils were found at low level for plants in Table 1. In addition, Exc. Na is a soil property that has the highest skewness value in dataset, and its maximum values in some parts of the study area passed threshold values which are very important for sensitive cultivated plants. These maximum values can be explained by resulting from parent material including high Na^+ content. While assessment of other factor components that are Exc.Ca and Exc.Mg, Exc.Ca and Exc.Mg were found at sufficient and low level for plants, respectively.

Table 3. Proportion of variance, initial eigenvalues and communality estimates of factors calculated by using soil properties

Soil properties	Factors					Communality estimates
	Factor 1 Micronutrients	Factor 2 Texture	Factor 3 Organic Matter	Factor 4 Basic Cations	Factor 5 Available Boron	
Sand	-0.099	-0.958	-0.049	0.008	-0.025	0.931
Clay[a]	0.115	0.953	-0.067	0.047	-0.080	0.934
pH[c]	0.390	0.214	-0.198	0.393	-0.654	0.819
SOM[b]	0.053	-0.073	0.911	-0.141	0.051	0.861
TN[b]	-0.007	0.048	0.942	0.087	-0.037	0.898
Exc.Ca[a]	0.159	0.364	-0.168	0.643	-0.470	0.820
Exc.Mg[b]	0.094	0.057	-0.398	0.667	0.223	0.665
Exc.Na[b]	-0.103	-0.106	0.205	0.798	-0.024	0.702
Av.B[b]	0.106	0.093	-0.168	0.187	0.811	0.741
Av.Fe[a]	0.602	-0.139	0.207	-0.149	0.514	0.712
Av.Cu[b]	0.813	0.047	-0.034	0.117	-0.032	0.679
Av.Zn[b]	0.833	0.053	0.148	-0.091	-0.029	0.727
Av.Mn[b]	0.660	0.266	-0.173	0.070	-0.004	0.542
Initial Eigenvalues	3.19	2.31	1.83	1.49	1.21	-
Variance %	18.36	16.39	16.27	13.56	12.57	-
Cumulative Variance %	18.36	34.75	51.02	64.57	77.15	-

[a]: Square root transformation; [b]: Logarithm transformation; [c]: inverse tangent transformation; Av.Cu: Available Copper; Av.Zn: Available Zinc; Av.Mn: Available Manganese; SOM: Soil Organic Matter; TN: Total Nitrogen; Exc.Na: Exchangeable Sodium; Exc:K: Exchangeable Potassium; Av.B: Available Boron.

Av.B and pH were assigned to Factor 5 as variables of soil properties and this factor was called "Available Boron". This factor explained with 12.57% of variability belonging to dataset. As well known, Av.B is very important plant nutrition element and has vital effect on hazelnut yield. Tarakçıoğlu et al. (2003) reported that 93.8% of the hazelnut cultivated areas in Ordu province has insufficient content of boron. In addition, Sillanpaa (1982) indicated that content of boron in soils of Turkey range between 0.06-9.99 mg kg^{-1} and its level is insufficient in Black Sea, Marmara and Aegean Sea regions.

Spatial variability of determined factors

After factor analysis, in order to determine the spatial distribution of the five factors indicated in minimum dataset, results of semivariograms related to geostatistical analysis and their kriging maps were given in Table 4 and in Figure 1. According to Table 4, it was seen that texture and basic cations that were modelled with spherical model have medium spatial dependence, whereas micronutrients, organic matter and available boron that were modelled with exponential model have strong spatial dependence.

If the ratio of nugget/sill is less than or equal to 25%, the variable was considered strongly spatially dependent; if it is higher than 75% the spatial dependence is weak and if the ratio is between 25-75%, the variable is called medium spatially dependent (Cambardella et al., 1994). In addition, range values of factors show that they change between strong and medium dependence.

Table 4. Results of semivariogram analysis related to factors

Factors	Models	Nugget	Sill	Range	RSS	r^2	N/S, %	S.D.C.
Factor 1 Micronutrients	Exponential	0.107	0.789	13980	$7.87x10^{-4}$	0.997	13.56	S
Factor 2 Texture	Spherical	0.362	0.932	25780	$7.81x10^{-4}$	0.998	38.84	M
Factor 3 Organic Matter	Exponential	0.003	0.651	10740	$8.08x10^{-4}$	0.996	0.46	S
Factor 4 Basic Cations	Spherical	0.314	0.700	22860	$7.36x10^{-4}$	0.993	44.86	M
Factor 5 Available Boron	Exponential	0.07	0.572	10050	$1.65x10^{-3}$	0.985	12.24	S

RSS: Sum of Residual Squares; N/S: Nugget/Sill ratio; S:D:C: Spatial Dependence Class; S: Strong; M: Moderate

When investigated the spatial distribution map, factor called micronutrient has got positive values and also this factor has got negative values but still close to zero. It can be seen that low and high values located generally in southeast and norteast part of Giresun province were found for this factor in almost all the study area (Figure 1). In addition, according to distribution map of the factor, there is no problem in terms of insufficient micronutrient elements. Tarakçıoğlu et al. (2003) indicated in their study, that concentration of micronutrient elements such as Fe, Cu and Mn were found as sufficient in hazelnut cultivated area located in Ordu province. On the other hand they also reported Zn as insufficient for hazelnut in these soils.

Texture determined as second factor has the highest values in northwest part of the Ordu province. Horuz (1996) and Tarakçıoğlu et al. (2003) reported in their studies, that they also determined clay and clay loam texture in soils of hazelnut orchards areas located and distributed in the study area. The high clay ratio soils are distributed on west parts of the Ordu province. These areas have high micronutrient values, whereas soils that have high sand content by taking negative values for texture factor have low values in terms of micronutrient factor (Figure 1).

Low values of organic matter factor were determined in east part of Giresun province, whereas distribution of areas with high values for organic matter factor were found in west part of Ordu province, which has also high clay content. On the other hand, as investigating the distribution map in details, it can be seen that there were no big areas that have high positive values. That means, there was not high amount of areas with high organic matter and total nitrogen content in the study area (Figure 2). According to the Horuz's study (1996), 56.9% of soils of Terme and Ünye districts in Ordu province have low organic matter and total nitrogen content.

When investigating the spatial distribution map of the Exchangeable Cations, it can be seen that negative values were determined in soils that are located in Giresun province whereas soils located in Ordu province have positive values. This case can be explained with leaching process and climatic conditions. Because, amount of the precipitation in Giresun is higher than that of Ordu which leads to move the basic cations through the soil profile. Tarakçıoğlu et. al. (2003) indicated in their study that 61.5% and 87.7% of lands cultivated for hazelnut production in Ordu province had sufficient Exc. Ca and Exc. Mg contents, respectively. Moreover, their results also support our obtained results. On the other hand, distribution map of the Available Boron factor generally showed opposite results to Exchangeable Cations factors. Low boron content of soils was determined in west part of the Ordu province, whereas high boron content was found in the east part of Giresun province. Many researchers indicated that boron is very important nutrient element particularly for hazel tree for generating its fruit (Okay et al., 1987; Shrestha et al., 1987; Ferran et al., 1997; Borges et al., 2001; Solar and Stampar, 2001). Therefore, it is necessary to apply boron fertilizer for soils that have insufficient boron concentration. In addition Tarakçıoğlu et al. (2003) announced that 93.8% of hazelnut area' soils located in Ordu province has insufficient boron nutrient element.

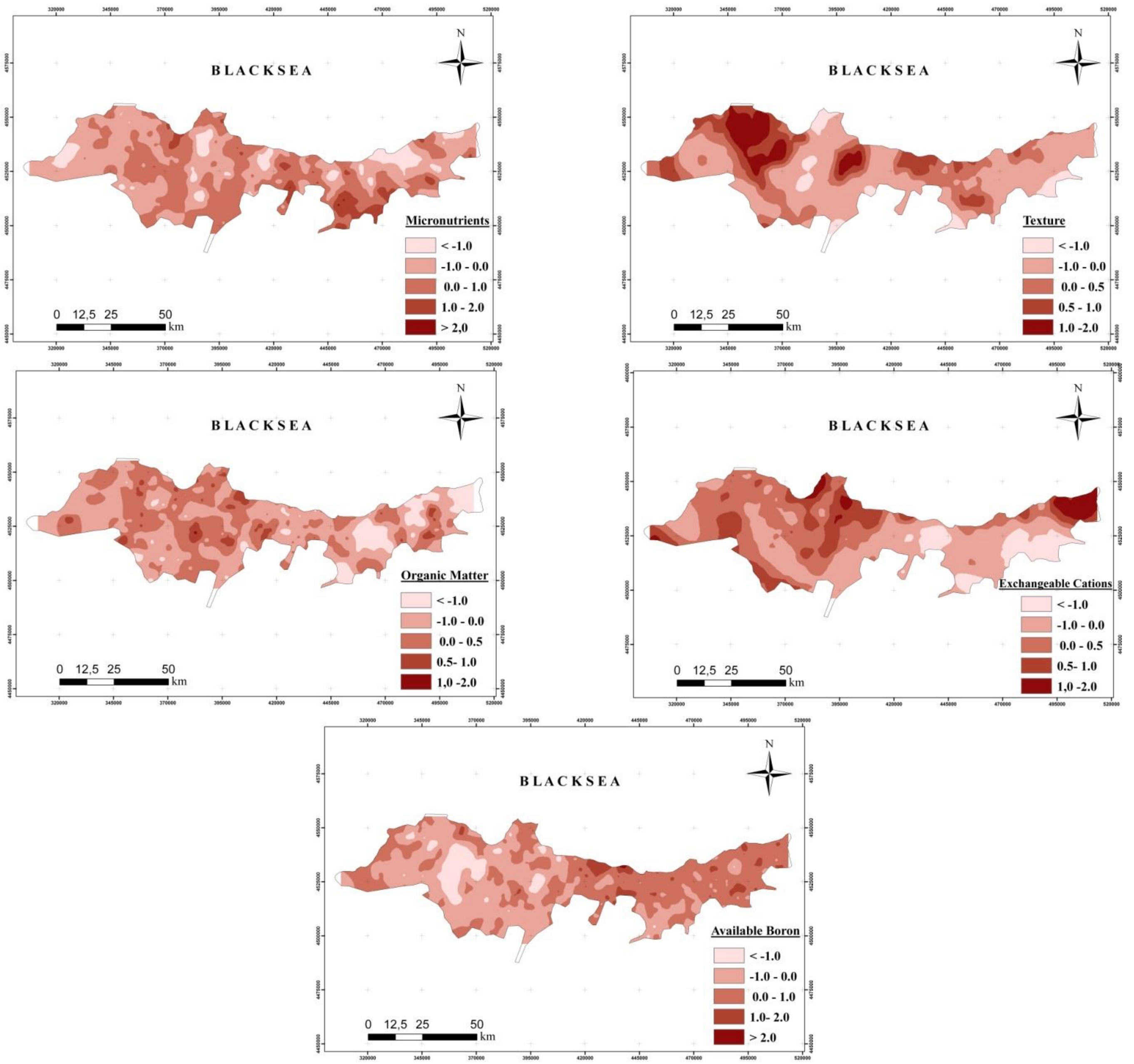

Figure 2. Factor scores maps as calculated by the Kriging method for micronutrients factor, texture factor, organic matter factor, exchangeable cations factor and available boron factor

Conclusion

This study was carried out to generate minimum data set for cultivated hazelnut areas located in Ordu and Giresun provinces using factor analysis. According to evaluation of results for 17 physical and chemical soil properties, 5 new different factors were determined and those factors were called as Micronutrients, Texture, Organic Matter, Exchangeable Cations and Available Boron. According to micronutrient factor map that explains in the highest ration for variability belonging to data set, soils used for hazelnut cultivation have sufficient contents of micronutrient elements, but negative values of this factor showing insufficient content of micronutrient elements can be found in the study area. That is why, particularly for insufficient lands in terms of micronutrients, micronutrient fertilizers should be applied. Hazelnut cultivated areas located in east part of the Giresun province have generally high content of sand and low content of organic matter. This case has negative effect on hazelnut cultivation due to low water retention, unsuitable soil structure and leaching process of the basic cations. Therefore, in order to reduce the effect of these limitation factors on the whole hazelnut production area, organic manure should be added, lime to increase pH value, and also boron fertilizer should be added to the soil in order to increase the avaiable boron concentration in soil.

References

Akova, Y., 2005. Fındık, T.C. Başbakanlık Dış Ticaret Müsteşarlığı İhracatı Geliştirme Etüt Merkezi Yayınları, www.atonet.org.tr/yeni/files/_images/distic/sektorler/findik.pdf, 14.07.2009.

Anonymous, 1990. Analytical for Atomic Absorption Spectro Photometry. Perkin Elmer, Norwalk, Connecticut, USA.

Anonymous, 2008. Ordu Tarım İl Müdürlüğü Kayıtları, Ordu.

Anonymous, 2010. Türkiye İstatistik Kurumu, http://www.tuik.gov.tr

Borges, O.M.P., Carvalho, J.L.R.S., Silva, A.P., Santos, A., 2001. Effects of foliar boron sprays on yield and nut quality of "Segorbe" and "Fertile de Coutard" hazelnuts. Ada Horticulturae, 556, 299-302.

Bray, R.H., Kurtz, L.T., 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci., 59, 39-45.

Bremner, J.M., Mulvaney, C.S., 1982. Nitrogen-Total. Chemical and Microbiological Properties. In: Methods of Soil Analysis, Part II., ASA Agronomy Monograph, no 9 (2nd ed), Madison, pp. 595-625.

Ferran, X., Tous, J., Romero, A., Lloveras, J., Pericon, J.R., 1997. Boron does not increase hazelnut fruit set and production. Hort Science, 32(6), 1053-1055.

Gee, G.W., Bauder, J.W., 1986. Particle-Sieze Analysis, in Klute, A. et. al. (ed.), Methods of Soil Analysis Part I, Agronomy 9, 388-409.

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., 1995. Multivariate Data Analysis With Readings. Fourth Edition, New Jersey, Pentice-Hall International, Inc., USA, 745s.

Hendershot, W.H., Lalande, H., Duquette, M., 1993. Soil reaction and exchangeable acidity. In: Carter MR (ed.), Soil Sampling and Methods of Analysis, Canadian Society of Soil Science.

Horuz, A., 1996. Terme-Ünye fındık bahçesi topraklarının besin element durumu ve bunların toprak özellikleriyle olan ilişkileri. Ondokuz Mayıs Üniversitesi, Fen Bilimleri Enstitüsü, Toprak ABD., Yüksek Lisans Tezi, Samsun.

Isaaks, H.E., Srivastava, R.M., 1989. An introduction to applied geostatistics. Oxford University Press, New York.

Kalaycı, Ş., 2010. Faktör Analizi. SPSS Uygulamalı Çok Değişkenli İstatistik Teknikleri. (Ed. Ş Kalaycı), Asil Yayın Dağıtım Limited Şirketi, Ankara.

Nael, M., Khademi, H., Hajabassi, M.A., 2004. Response of soil quality indicators and their spatial variability to land degradation in Central Iran. Appl. Soil Ecol., 27, 221-232.

Nelson, D.W., Sommers, L.E., 1982. Total Carbon, Organic Carbon, and Organic Matter. Chemical and Microbiological Properties. In: Methods of Soil Analysis, Part II, Agronomy, no 9, (2nd ed.), Madison, pp. 539-579.

Nelson, R.E., 1982. Carbonate and Gypsum. Chemical and Microbiological Properties. In: Methods of Soil Analysis, Part II, Agronomy, no 9, (2nd ed.), Madison, pp. 181-197.

Okay, A.N., Koç, N., Kılavuz, F.H., 1987. Boş fındık oluşum sebepleri ve giderilmesi üzerine araştırmalar. TC. TOKB. Fındık Araş . Enst. Müd. Giresun.

Rhoades, J.D., 1986. Cation Exchange Capacity. Chemical and Microbiological Properties. In: Methods of Soil Analysis, Part II., ASA and SSSA Agronomy Monograph, no 9 (2nd ed), Madison, pp. 149-157.

Shrestha, G.K., Thompson, M.M., Righetti, T.L., 1987. Foliarapplied boron increases fruit set in 'Barcelona' hazelnut. J.Amer.Soc.Hort.Sci., 112(3), 412-416.

Shukla, M.K., Lal, R., Ebinger, M., 2006. Determining soil quality indicators by factor analysis. Soil and Tillage Research, 87, 194-204.

Sillanpaa, M., 1982. Micronutrient and the Nutrient Status of Soils: A Global Study. FAO Soils Bulletin No: 48, Rome, Italy.

Soil Survey Staff, 1992. Procedures for Collecting Soil Samples and Methods of Analysis for Soil Survey. Soil Surv. Invest. Rep. I. U.S. Gov. Print. Office, Washington D.C.

Solar, A., Stampar, F., 2001. Influence of boron and zinc application on flowering and nut set in "Tonda di Giffoni" hazelnut. Acta Horticulturae, 556, 307-312.

Tanrıvermiş, H., Gönenç, S., Terzioğlu, S.B., 2006. Türkiye'de fındık üretiminin sosyo-ekonomik yapısı tamamlayıcı gelir kaynaklarını geliştirilebilme olanakları ve etkilerinin değerlendirilmesi. 3. Milli Fındık Şurası, Giresun, pp. 125-144.

Tarakçıoğlu, C., Yalçın, S.R., Bayrak, A., Küçük, M., Karabacak, H., 2003. Ordu yöresinde yetiştirilen fındık bitkisinin *(Corylus avellana* L.) beslenme durumunun toprak ve yaprak analizleriyle belirlenmesi. Tarım Bilimleri Dergisi, 9(1), 13-22.

Tatlıdil, H., 2002. Uygulamalı Çok Değişkenli İstatistiksel Analiz. Akademi Matbaası, Ankara.

Wang, Z., Chang, A.C., Wu, L., Crowley, D., 2003. Assessing the Soil Quality of Longterm Reclaimed Wastewater-irrigated Cropland. Geoderma, 114, 261-278.

Wilding, L.P., 1985. Spatial Variability: It's Documentation, Accommodation and Implication to Soil Surveys. In: Soil Spatial Variability, Nielsen, D.R. and J. Bouma (Eds.). Pudoc, Wageningen, The Netherlands, pp: 166-194.

Wolf, B., 1971. The Determination of Boron in Soil Extracts, Plant Materials, Composts, Manures, Water and Nutrient Solutions. Soil Science and Plant Analysis, 2, 363-374.

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The effects of pistachio nut hull compost on soil fertility: A comparative study with manure

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Abstract

The usage of agricultural wastes as soil amendments is an economically feasible and environmentally friendly way of improving soil fertility. In this research composted pistachio nut industry waste (mainly pistachio nut hull or mesocarp) (PC) and farmyard manure (FM) were incorporated into two different calcareous soils differing in texture and carbonates content to test effects of these organic materials on soil fertility parameters. An incubation experiment in the laboratory was set up in 2 (soil) x 2 (compost) x 5 (rates) full factorial experimental design in triplicates. Equivalents of 0, 50, 100, 150, and 200 Mg $ha^{-1}$of composts were mixed thoroughly with 2 kg of air – dry soil and incubated at 25±1 °C for one month. After incubation the routine soil fertility parameters were analyzed. PC and FM have differently affected the investigated soil parameters. The incorporation of both PC and AM reduced the pHs of the soils whereas the treatments increased available phosphorus and DTPA extractable Zn concentration in soils. It can be concluded that despite the usefulness of FM, the PC has advantages over FM on not containing any weed seeds and ease of decomposition rate due to lower C:N ratio. Consequently, the result of our study indicated that PC could be an ideal organic fertilizer for enhancing micronutrient availabilities in the region.

Keywords: Pistachio nut hull or mesocarp, organic waste, animal manure, organic amendments, plant nutrients

Introduction

Organic matter depletion induced-decrease in mineral nutrients in conventional farming is one of the most important reason for the land degradation in arid and semi-arid regions. Soil organic matter has long been known to improve physical, chemical and biological fertility of soils by providing some plant nutrients and enhancing the conditions of growth media and environment (Basta, et al., 1998; McCauley, Jones, & Jacobsen, 2009). They are known for improving soil physical functions such as tilth, erodibility, water holding properties, thermal characteristics, porosity etc. to enhance crop yields. Organic wastes such as animal manures, crop residues, and industrial by-products are commonly recycled back to agricultural land as a source of organic matter (OM). This is an efficient and common management practice in agricultural soils of arid regions (Adani et al., 1998; Delgado et al., 2002). Re-using of organic industrial by-products and agricultural wastes is an easy and economically and environmentally friendly way of waste management and improving soil fertility. Food and agricultural industries have a lot of organic wastes or by-products resulting in the processing stages of agricultural yields. Use of these wastes directly or after some decomposition processes is dependent on

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properties of materials such as carbon to nitrogen ratio, soluble salt content etc. According to properties of wastes these materials can be used as soil conditioners or organic plant nutrient sources for soils.

In the arid environment of South East Anatolia pistachio is commonly grown fruit crops. After harvesting pistachio nuts have a series of crop processing that produce a lot of organic wastes (pistachio nut hull). Therefore, the aim of this research was to investigate effects of composted pistachio nut hull on fertility parameters of two calcareous soils differing in carbonate contents and textural class.

Material and Methods

Soils

Two different calcareous soils differing in texture soil samples were air-dried, gently crushed, and passed through a 2 mm sieve. Particle-size distribution was then determined by the hydrometer method (Gee and Bauder, 1986). Soil chemical properties were determined following standard procedures: both pH and electrical conductivity in saturation paste (USDA, 1954; Rhoades, 1996), organic matter by $K_2Cr_2O_7$ oxidation (Nelson & Sommers, 1996), $CaCO_3$ equivalent by a manometric method (Loeppert & Suarez, 1996), available P by extraction with 0.5 M $NaHCO_3$ at pH 8.5 (1 g : 20 mL soil to extractant) (Olsen et al., 1954), cationic micro elements by extraction with DTPA at pH 7.3 (Lindsay & Norvell, 1978), exchangeable cations by extraction 1 M ammonium acetate at pH 7.0 (Helmke & Sparks, 1996). Digestion of soils exposed at $HCl+HNO_3$ (3:1, v/v) with hot plate digestion (Hossner, 1996) and total element content of soils were determined with inductively coupled plasma-optical emission spectroscopy (ICP – OES, PE – Optima 7000 DV). The measured chemical and physical characteristics of the soils are presented in Table 1.

Table 1. Chemical and Physical properties of the experimental soils

Soil tex. class	pH	EC	OM	$CaCO_3$	Clay content	Exchangeable cations				Olsen-	DTPA extractable cationic micronutrients			
						Ca	Mg	Na	K	P	Cu	Fe	Mn	Zn
		µS/cm	--------(g kg^{-1})--------			---------($cmol_c$ kg^{-1})---------				--------------(mg kg^{-1})-------------				
Clay	7.71	714	16.4	321	633	17.03	0.90	2.90	0.18	7.72	0.93	2.49	3.12	0.21
Clay loam	7.76	447	17.7	400	373	11.56	0.30	1.29	0.18	6.70	0.78	3.95	4.06	0.13

OM – Organic matter content; CEC – Cation exchange capacity; EC – Electrical conductivity; Olsen P – Available phosphorus concentration.

Organic Materials

Two organic materials pistachio nut hull waste and farmyard manure were tested in this research as grinded. Pistachios were peeled by standard peeling procedures with 1/1 water mixture (w/v). The pistachio hull may have significant negative implications on environment due to low pH, high salt content and high chemical oxygen demand. Therefore before incorporation the organic material into the soil, pistachio nut hull waste composted. The pH and electrical conductivity were measured in the compost: water mixture (1:2.5, w/v). Total nutrient element concentrations of both organic materials were determined in HNO_3 + $HClO_4$ (3:1 v/v) digest (Miller, 1998) by means of ICP – AES. Carbon content of the materials determined with Elemental Carbon and Sulfur Analyzer (Eltra CS – 580) and nitrogen content of materials determined with Nitrogen Analyzer (Velp – NDA 701). The measured chemical and physical characteristics of the organic materials are given in Table 2.

Incubation Experiment

The composted pistachio nut industry waste (pistachio nut hull or mesocarp) (PC) and farmyard manure (FM) were incorporated into two different soils. The equivalents of 0, 50, 100, 150 and 200 Mg ha^{-1} of composts were mixed thoroughly with 2 kg of air – dry soil and incubated at 25±1°C for one month. After incubation the following parameters analyzed in soils: pH, electrical conductivity, sodium bicarbonate extractable phosphorus and DTPA extractable iron, manganese, copper and zinc.

Table 2. Total elemental analyses, pHs and EC of soils, pistachio nut hull compost and animal manure

Soils and Organic Material	pH	EC mS/cm	N	C/N	Total Element Contents				
					Fe	Mn	Cu	Zn	P
	------(1:2.5)-------		(%)		-----------------------------(mg kg^{-1})-------------------------				
Clay	-	-	0.070	-	32510	707.9	43.83	52.54	621.9
Clay loam	-	-	0.066	-	23690	496.0	31.63	33.73	802.8
PC	8.41	6.60	2.780	7.71	3172	97.55	19.40	32.05	2648.5
FM	7.10	11.63	1.290	12.19	14735	524.5	29.15	71.68	4469.5

PC – Pistachio nut hull compost; FM – Farmyard manure; EC – Electrical conductivity; N – Total nitrogen percent; C/N – Carbon to nitrogen ratio.

The experiment was set up in 2 (soil) x 2 (compost) x 5 (rates) full factorial experimental design in triplicates. The data were subjected to analysis of variance (ANOVA), including between – subjects factors, using SPSS 16 (SPSS, 2001) and pairwise comparison of the treatments averages was performed by Bonferroni test.

Results and Discussion

Soil pHs

Soil chemical properties, i.e., soil pH and nutrient availability, are substantially improved in soils receiving organic amendments. The pH of both soil decreased upon incorporation of different rate of both FM and PC. Soil pHs ranged between 7.65 to 7.34 for clay textured soil and 7.73 to 7.55 for clay loam textured soil for PC and FM treatments, respectively. Pairwise comparison of soils revealed that application of PC and FM significantly affected soils pH at 0.05 significance level (Tab. 3 and 4). Also, application rates have significant effect on soil pH (Tab. 5). Soil pH linearly decreased with application rates. Several studies reported that compost incorporation raised the pH of soil (Leifeld et al., 2002; Lee et al., 2004; Odlare, 2005). On the other hand, some researchers observed no increase in pH after application of compost (Bartl et al., 2002; Hartl et al., 2003). In contrast to previous reports mentioned above we have observed a decrease in soil pHs after application either of PC or FM. Decrease in soil pHs could be indication of decomposition of PC and FM. Despite alkaline pH of both organic materials, the mineralization processes results in the formation of organic and inorganic acids that also provide H^+ to the soil (McCauley et al., 2009).

Available Phosphorus

Available phosphorus (P) content of soils increased with application rates for FM and PC. Available P concentration increased from 7.85 to 42.9 mg P kg^{-1} for clay soil and from 6.65 to 61.8 mg P kg^{-1} for clay loam soil. The increase observed for the coarse textured soil was comparatively higher possibly due to smaller adsorption capacity of coarse soils. Pairwise comparison indicated that incorporation of PC and FM significantly affected soils available phosphorus concentrations ($p<0.05$) depending on the application rates (Tab. 3, 4 and 5). Similarly, there are several researches reporting such increases in available soil P upon organic amendments with differing origin (Basta et al., 1998; Adediran et al., 2003; Uygur & Karabatak, 2009). On the other hand, such increase in the available P may be related to reduced pH inducing solubilization of P in carbonate fractions; competition of decomposition by products or end products, higher or low molecular weight organic anions, with P; and inhibition of precipitation of calcium phosphate minerals (Grossl & Inskeep, 1991; Delgado et al., 2002, Uygur & Karabatak, 2009). Amendment with organic residues may influence P availability and precipitation in soils by means of competition between organic acids and phosphates for sorption sites that usually favors adsorption of organic acids and delays P adsorption (Violante & Gianfreda, 1993; Staunton & Leprince, 1996; Geelhoed et al., 1999). According to previous reports, organic residues are consistent with the increased chemical recovery of phosphates from soils and the increased available P concentration in soils. The effect of PC and FM on phosphorus recovery contributes to explain why organic amendments increase plant available phosphorus (Erich et al., 2002). This is important to increase crop production in soils where the low available P level is a limiting factor (Buerkert et al., 2001).

Table 3. Pair wise comparison of soils for pH, sodium bicarbonate extractable phosphorus and DTPA extractable zinc

Soils	Means	(i)**	(j)	Mean Differences (i-j) pH	P	Zn	Standard Error pH	P	Zn
Clay	pH P Zn	: 7.52 : 25.035 mg kg^{-1} : 0.646 mg kg^{-1}	Clay Loam	-0.05*	-9.675*	0.238*	0.011	0.414	0.007
Clay Loam	pH P Zn	: 7.57 : 34.710 mg kg^{-1} : 0.408 mg kg^{-1}	Clay	0.05*	9.675*	-0.238*	0.011	0.414	0.007

* Significant at the 0.05 level. ** Means for respective *i* soil without considering compost, manure and application rate; P is sodium bicarbonate extractable phosphorus, Zn is DTPA extractable zinc.

Table 4. Pair wise comparison of pistachio nut hull compost and farmyard manure for pH, sodium bicarbonate extractable phosphorus and DTPA extractable zinc

PC and FM	Means	(i)**	(j)	Mean Differences (i-j) pH	P	Zn	Standard Error pH	P	Zn
PC	pH P Zn	: 7.63 : 15.810 mg kg^{-1} : 0.474 mg kg^{-1}	FM	0.164*	-28.125*	-0.099	0.011	0.414	0.007
FM	pH P Zn	: 7.46 : 43.935 mg kg^{-1} : 0.577 mg kg^{-1}	PC	-0.164*	28.125*	0.099	0.011	0.414	0.007

* Significant at the 0.05 level. ** Means for respective *i* soil without considering soil and application rate; P is sodium bicarbonate extractable phosphorus, Zn is DTPA extractable zinc. PC is pistachio nut hull compost, FM is farmyard manure.

Table 5. Pair wise comparison of application rate of pistachio nut hull compost and animal manure for pH, sodium bicarbonate extractable phosphorus and DTPA extractable zinc

Application rates (%)	Means	(i)**	(j)	Mean Differences (i-j) pH	P	Zn	Standard Error pH	P	Zn
0	pH	: 7.695	2	0.046	-11.238*	-0.171*	0.12	0.463	0.008
	P	: 7.25 mg kg^{-1}	4	0.176*	-24.488*	-0.323*	0.12	0.463	0.008
	Zn	: 0.187 mg kg^{-1}	6	0.280*	-32.288*	-0.532*	0.12	0.463	0.008
			8	0.235*	-45.100*	-0.675*	0.12	0.463	0.008
2	pH	: 7.649	0	-0.046	11.238*	0.171*	0.12	0.463	0.008
	P	: 18.48 mg kg^{-1}	4	0.130*	-13.250*	-0.152*	0.12	0.463	0.008
	Zn	: 0.358 mg kg^{-1}	6	0.234*	-21.050*	-0.361*	0.12	0.463	0.008
			8	0.189*	-33.862*	-0.504*	0.12	0.463	0.008
4	pH	: 7.519	0	-0.176*	24.488*	0.323*	0.12	0.463	0.008
	P	: 31.73 mg kg^{-1}	2	-0.130*	13.250*	0.152*	0.12	0.463	0.008
	Zn	: 0.51 mg kg^{-1}	6	0.104*	-7.800*	-0.209*	0.12	0.463	0.008
			8	0.059*	-20.612*	-0.352*	0.12	0.463	0.008
6	pH	: 7.415	0	-0.280*	32.288*	0.532*	0.12	0.463	0.008
	P	: 39.53 mg kg^{-1}	2	-0.234*	21.050*	0.361*	0.12	0.463	0.008
	Zn	: 0.719 mg kg^{-1}	4	-0.104*	7.800*	0.209*	0.12	0.463	0.008
			8	-0.045	-12.812*	-0.143*	0.12	0.463	0.008
8	pH	: 7.46 mg kg^{-1}	0	-0.235*	45.100*	0.675*	0.12	0.463	0.008
	P	: 52.35 mg kg^{-1}	2	-0.189*	33.862*	0.504*	0.12	0.463	0.008
	Zn	: 0.862 mg kg^{-1}	4	-0.059*	20.612*	0.352*	0.12	0.463	0.008
			6	0.045	12.812*	0.143*	0.12	0.463	0.008

* Significant at the 0.05 level. ** Means for respective *i* soil without considering soil, compost and manure type; P is sodium bicarbonate extractable phosphorus, Zn is DTPA extractable zinc.

DTPA Extractable Cationic Micronutrients

Soil pH is the key parameter determining reactions, solubility and availability of plant nutrients in growing media, including soils. The availability of cationic nutrients is often hindered by decreased solubility in highly alkaline soils (McCauley et al., 2009). Pairwise comparison indicated that the application of either PC or FM significantly affected soils the DTPA extractable cationic micronutrients ($p<0.05$) depending on the application rates (Tab. 3, 4 and 5). Depending on the application rates the ranges of Cu, Fe, Mn and Zn concentrations were: 1.62 – 3.96 mg Cu kg^{-1}, 5.37 – 54.72 mg Fe kg^{-1}, 9.89 – 27.45 mg Mn $kg^{-1}$and 0.269 – 1.054 mg Zn kg^{-1} for clay soil and 1.64 – 2.33 mg Cu kg^{-1}, 11.27 – 33.57 mg Fe kg^{-1}, 11.56 – 25.12 mg Mn kg^{-1} and 0.104 – 0.669 mg Zn kg^{-1} for clay loam soil, respectively. Several researchers have also observed similar results for organically amended soils with compost, manures (Maqueda et al., 2001; McCauley et al., 2009) and biosolids (Cogger et al., 2001; Barbarick & Ippolito, 2003). Wei et al. (2006) similarly reported an increase in Zn and Fe availability induced by long –term application of cattle manure. Benke et al., (2008) reported that annual cattle manure application for over 25 years did not increase DTPA extractable B, but increased Cu and Zn concentrations. The availability of a cationic nutrient is affected by several factors. Of those factors, soil organic matter can affect availability by chelating ions, making them more soluble and possibly more available for plant uptake. McCauley et al. (2009) stated that organic matter affect the availability of plant nutrients trough supplying new exchange sites, increasing the chelating agents, and increasing the solubility of certain nutrients. Many organic substances can serve as chelators for cationic micronutrient. Chelates are soluble organic compounds that bind metals such as Cu, Fe, Mn and Zn and increase their solubility and eventually availability to plants (Clemens et al., 1990; Havlin et al. 1999). Chelation may be particularly important for microelement nutrition of plants in calcareous and alkaline soils of arid regions. As previously noted, metal availability is often inhibited under alkaline soil conditions by competition of Ca ions with cationic microelements for chelating sites, in fact it occurs in favor of Ca for many chelators, results in plant micronutrient deficiencies in such soils. Application of organic residues increases availability of these nutrients for sustainable crop production.

Conclusion

Low carbon to nitrogen ratio of PC facilitated the mineralization that eventually released plant nutrients and organic chemicals. This material was decreased soil pH and dissolved to Ca-phosphates and increased available phosphorus concentration in the soils, also increased DTPA extractable cationic micronutrients, especially zinc. It can be concluded that despite the usefulness of FM the PC has advantages over FM on not containing any weed seeds and ease of decomposition rate due to lower C:N ratio. The result of our study indicated PC could be an ideal organic fertilizer source for areas with micronutrient deficiencies due to abundance of this organic matter in the region.

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References

Adani, F., Genevini, P., Zaccheo, P., & Zocchi, G. (1998). The effect of commercial humic acid on tomato plant growth and mineral nutrition. *Journal of Plant Nutrition*, 561-575.

Adediran, J. A., De Baets, N., Mnkeni, P. N., Kikens, L., Muyima, N. Y., & Yhys, A. (2003). Organic waste materials for soil fertility improvement in the border region of the Eastern Cape, South Africa. *Biological Agriculture & Horticulture*, 283-300.

Barbarick, K. A., & Ippolito, J. A. (2003). Termination of sewage biosolids aff ects wheat yield and other agronomic characteristics. *Agronomy Journal*, 1288-1294.

Bartl, B., Hartl, W., & Horak, O. (2002). Long-term application of biowaste compost versus mineral fertilization: Effects on the nutrient and heavy metal contents of soil and plants. *Journal of Plant Nutrition and Soil Science*, 161-165.

Basta, N. T., Hattey, J. A., Stiegler, J. H., Carter, B. J., Johnson, G. V., Westerman, R. L., et al. (1998). *Phosphorus Management for Land Application of Organic Amendments.* Stillwater, OK: Oklahoma State University, Department of Plant and Soil Sciences.

Benke, M., Indraratne, S. P., Hao, X., Chang, C., & Goh, T. B. (2008). Trace element changes in soil aft er long-term cattle manure applications. *Journal of Environmental Quality*, 798-807.

Buerkert, A., Bationo, A., & Piepho, H. P. (2001). Efficient phosphorus application strategies for increased crop productionin sub-Saharan West Africa. *Field Crops Research*, 1-15.

Clemens, D. F., Whitehurst, B. M., & Whitehurst, G. B. (1990). Chelates in Agriculture. *Fertilizer Research*, 127-131.

Cogger, C. G., Bray, A. I., Fransen, S. C., & Sullivan, D. M. (2001). Seven years of biosolids versus inorganic nitrogen applications to tall fescue. *Journal of Environmental Quality*, 2188-2194.

Delgado, A., Madrid, A., Kassem, S., Andreu, L., & Maria, C. C. (2002). Phosphorus fertilizer recovery from calcareous soils amended with humic and fulvic acids. *Plant and Soil*, 277-286.

Erich, M. S., Fitzgerald, C. B., & Porter, G. A. (2002). The effect of organic amendments on phosphorus chemistry in a potato cropping system. *Agriculture, Ecosystems & Environment*, 79-88.

Gee, G., & Bauder, J. (1986). Particle-Size Analysis. In a. Klute, *In Methods of Soil Analysis: Physical and Mineralogical Methods* (pp. 383-409). Madison - WI: Soil Science Society of America.

Geelhoed, J. S., van Riemsdijk, W. H., & Findenegg, G. R. (1999). Simulation of the effect of citrate exudation from roots on the plant availability of phosphate adsorbed on goethite. *Europan Journal of Soil Science*, 379-390.

Grossl, P. R., & Inskeep, W. P. (1991). Precipitation of dicalcium phosphate dihydrate in the presence of organic acids. *Soil Science society of America Journal*, 670-675.

Hartl, W., Putz, B., & Erhart, E. (2003). Influence of rates and timing of biowaste compost application on rye yield and soil nitrate levels. *European Journal of Soil Biology*, 129-139.

Havlin, J. L., Beaton, J. D., Tisdale, S. L., & Nelson, W. L. (1999). *Soil Fertility and Fertilizers.* Upper Saddle River, N.J: Prentice-Hall, Inc. .

Helmke, P. A., & Sparks, D. L. (1996). Lithium, Sodium, Potassium, Rubidium and Cesium. In D. L. Sparks, *Methods of soil Analyses-Part 3* (pp. 551-574). Madison-WI: Soil Science Society of America, American Sociery of Agronomy.

Hossner, L. R. (1996). Dissolution for Total Elemental Analyses. In D. L. Sparks, *Methods of Soil Analyses-Part 3* (pp. 49-64). Madison-WI: Soil Science Society of America, American Society of Agronomy.

Jones, C., & Jacobsen, J. (2009). *Micronutrients: Cycling, Testing and Fertilizer Recommendations.* Bozeman-MT: Monatana State University.

Lee, J. J., Park, R. D., Kim, Y. W., Shim, J. H., Chae, D. H., Rim, Y. S., et al. (2004). Effect of food waste compost on microbial population, soil enzyme activity and lettuce growth. *Bioresource Technology*, 21-28.

Leifeld, J., Siebert, S., & Kögel-Knabner, I. (2002). Biological activity and organic matter mineralization of soils amended with biowaste composts. *Journal of Plant Nutrient and Soil Science*, 151-159.

Lindsay, W. L., & Norvell, W. A. (1978). Development of a DTPA Soil Test for Zinc, Iron, Manganese and Copper. *Soil Science Society of America Journal*, 421-428.

Loeppert, R. H., & Suarez, D. L. (1996). Carbonate and Gypsum. In D. L. Sparks, *Methods of Soil Analyses-Part 3* (pp. 437-474). Madison-WI: Soil Science Society of America, American Society of Agronomy.

Maqueda, C., Ruiz-Porras, J. C., Morillo, E., & Herencia, J. F. (2001). Effect of an Organic Amendment on Nutrient Availability and Plant Content. *11th International Symposium on Environmental Pollution and its Impact on Life in the Mediterranean Region*, (p. C31). Limassol, Cyprus.

McCauley, A., Jones, C., & Jacobsen, J. (2009). *Soil pH and Organic Matter.* Bozeman-MT: Montana State University.

Miller, R. O. (1998). Nitric-Perchloric Acid Wet Digestion in an Open Vessel. In Y. P. Kalra, *Reference Methods for Plant Analyses* (pp. 57-61). Boca Raton-FL: Soil and Plant Analyses Council.

Nelson, D. W., & Sommers, L. E. (1996). Total Carbon, Organic Carbon and Organic Matter. In D. L. Sparks, *Methods of Soil Analysis-Part 3* (pp. 961-1010). Madison-WI: Soil Science Society of America, American Society of Agronomy.

Odlare, M. (2005). *Organic Residues: A Resource for Arable Soils.* Uppsala, Sweeden: Faculty of Natural Resources and Agricultural Sciences, Department of Microbiology .

Olsen, S. R., Cole, C. V., Watanabe, F. S., & Dean, L. A. (1954). *Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate.* Washington: USDA, 939.

Rhoades, J. D. (1996). Salinity: Electrical Conductivity and Total Dissolved Solids. In D. L. Sparks, *Methods of Soil Analysis-Part 3* (pp. 417-436). Madison-WI: Soil Science Society of America, American Society of Agronomy.

Staunton, S., & Leprince, F. (1996). Effect of pH and some organic anions on the solubility of soil phosphate: implications for P bioavailability. *Europan Journal of Soil Science*, 231-239.

Sumner, M. E., & Miller, W. P. (1996). Cation Exchange Capacity and Excahange Cofficients. In D. L. Sparks, *Methods of Soil Anlyses-Part 3* (pp. 1201-1229). Madison-WI: Soil Science Society of America, Amercan Society of Agronomy.

USDA. (1954). *Diagnosis and Improvement of Saline and Alkali Soils.* Riverside, CA: United States Salinity Laboratory.

Uygur, V., & Karabatak, I. (2009). The effect of organic amendments on mineral phosphate fractions in calcareous soils. *Journal of Plant Nutrition and Soil Sciences*, 336-345.

Violante, A., & Gianfreda, L. (1993). Competition in adsorption between phosphate and oxalate on an aluminum hydroxide montmorillonite complex. *Soil Sience Society of America*, 1235-1241.

Wei, X., Hao, M., Shao, M., & Gale, W. J. (2006). Changes in soil properties and the availability of soil micronutrients aft er 18 years of cropping and fertilization. *Soil Tillage Research*, 120-130.

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Implementation of precision agriculture technology at Russian State Agrarian University – Moscow Timiryazev Agricultural Academy

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Abstract

Information on implementation of Precision Agriculture Technology in the Research Centre on Precision Agriculture at Russian State Agrarian University-Moscow Timiryazev Agricultural Academy is presented. The following main elements of Precision Agriculture Technology are implemented in the Research Centre on Precision Agriculture: seeding (planting) the crops with navigation systems, e.g. Autopilot; precise fertilizing and applying the chemical plant protection means (herbicides) with special scanners and sensors in correlation with current stage of crops and weeds presence and dissemination; crop yield assessment in connection with field maps.

Keywords: Precision Agriculture, GPS system, autopilot, difference in soil fertility, differential fertilizing and applying herbicides, yield mapping.

Introduction

In 2007 at Russian State Agrarian University -Moscow Timiryazev Agricultural Academy within the innovation educational project, at first time within the Russian agrarian education, the Scientific Centre on Precision Agriculture was established. The main researches at the Scientific Centre on Precision Agriculture are carried out in the field experiment and focused on the comparative studying analysis of traditional and precision agricultural technologies.

Material and Methods

In the four field cereal and tilling crop rotation: vetch - oat forage mixture - winter wheat for feeding - winter wheat with mustard for green forage - potatoes - barley two factors are studied – technologies of crops cultivation (factor A) and soil treatment (factor B). Traditional technology is based on usage of modern technique with meeting all the recommended parameters and normative characteristics; precision agricultural technology – on implementation of satellite system GPS that corrects all technological operations (1, 2).

The main soil treatment includes ploughing for all the crops by plough Eur Opal at 20…22 cm, minimal operation – by cultivator Pegasus at 12…14 cm for potatoes and barley and "null" operation – for vetch - oat mixture and winter wheat (2).

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Results and Discussion

The main element of precision agricultural technology that defines the efficiency of its implementation is sowing (planting) crops with using navigation equipment, i.e. autopilot (3, 4).

The results of 5-year experiment on trial of different sawing machines that are used in the field experiment and different sawing methods are presented in Table 1.

Table 1. Inter row distance and deviation from standard inter row distance of sawing machines * (2009-2013)

Crop	Sawing machine D-9-30 (ploughing)				DMC (minimum soil treatment)	
	marker		autopilot		autopilot	
	inter row distance, cm	deviation, cm	inter row distance, cm	deviation, cm	inter row distance, cm	deviation, cm
Vetch-oat mixture	-	-	13,3	+1,3	19,1	+0,3
Winter wheat	16,8	+4,8	13,8	+1,8	19,2	+0,4
Barley	15,2	+3,2	13,4	+1,4	18,7	-0,1

* - inter row distance for D-9-30 –12,0 cm, DMS –18,8 cm

The sawing of cereals (winter wheat and barley) was carried out, in one case, by autopilot, in the other – by marker. The sawing of winter wheat in variant with ploughing was done by the sawing machine D-9-30 with implementing both GPS system and marker. In variants of “null” (without any treatment) and minimum soil treatment sawing was carried out by pneumatic sawing machine of straight sawing – DMC with usage autopilot only. Marker was not used due to construction and technical reasons. Vetch-oat mixture was sawed by two sawing machines: D-9-30 – in variant with ploughing and DMC – in “null” variant with usage autopilot only.

In some years and during the whole period of researches the inter row distances between the neighbor passes of sawing machines during the sawing of cereals and vetch-oat mixture by marker and autopilot were different. The distance between the neighbor passes of sawing machine D - 9-30 in variant with ploughing with using marker in the field with winter wheat was 16,8 cm, barley – 15,2 cm, i.e. the deviations were +4,8 and +3,2 cm accordingly. The deviations in straight lines of passes were accumulated gradually and in 100-150 m in variant with ploughing with using marker the quoin of triangle shape appeared with the base of 1…1,5 m that deteriorates the quality of sawing process, increases the number of gaps and consumption of seeds at 10…15%. This tendency is revealed in case of increasing the sawing area – from experimental plots to industrial fields. During sawing cereals and vetch-oat mixture by autopilot with usage navigation satellite system GPS the average inter row distance was 1,3…1,8 cm, that was within the agrotechnical working conditions of this equipment - ± 2,5 cm and the quality of sawing process increased and became more optimized.

Potatoes was planted by machine GL-34T with standard inter row distance 75 cm with using autopilot and marker (Tab. 2).

Table 2. Inter row distance and position o potatoes plants on the ridges in connection with different planting technoogies*

Year	Inter row distance, cm		Position on the ridge, cm	
	marker	autopilot	marker	autopilot
2009	от 65-до 81	75 ± 2,8	from center ± 6-10	from center ± 2,8
2010	от 60-до 80	75 ± 3,3	from center ± 5-15	from center ± 3.3
2011	от 70 до 90	75 ± 2,5	from center ± 5-15	from center ± 1.5
2012	от 73 до 88	75 ± 2,5	from center ± 2-13	from center ± 1,8
2013	от 70 до 85	75 ± 3,1	from center ± 5-10	from center ± 2.3
in average	от 67-до 85	75 ± 2,8	from center ± 5-13	from center ± 2,8

* - inter row distance –75 cm

Fixed trajectory of moving with using GPS system is repeated in variant with implementing precision agriculture technology for operation of ridge forming on potatoes shoots. While traditional technology of potatoes plants treatment this operation is controlled visually, i.e. agricultural machine is run by operator. Inter row distance between the neighbor passes of potatoes planting machine was different relating the years of researches and was in average from 65…70 up to 85…88 cm for variant of traditional technology, i.e.

the deviation from standard parameter (75 cm) was from -10 up to +13 cm. Using autopilot system in variant of precision soil treatment technology showed the deviation from neighbor passes of potatoes plants from 2, 5 up to 3, 3 cm.

The important condition for proper vegetation of potatoes plants is their location about the centre of ridge that is settled while the ridge forming after shoots appearance. Deviation from the centre of ridge by potatoes plants while ridge forming in variant of traditional technology was from 5 up to 15 cm relating the different years. This deviation caused changes in vegetation mass growing to one side, differences in formation and growing of tubers. In variant with precision technology the potatoes plants were located practically in the centre of ridge with admissible deviation of 1,5…3,3 cm.

One of the components of precision agricultural technologies is fertilizing and applying herbicides in relation with conditions of plants, density of weeds dissemination on the different parts of field with using the special scanners and sensors that correct the dozes of fertilizers and chemical means (3…6).

In the Scientific Centre on Precision Agriculture for the scanning of crops the optical sensor RT-200 GreenSeeker ® (the USA) (Fig. 1) и N-Sensor ® ALS (Germany) (Fig. 2) are used.

Figure 1. System RT-200 GreenSeeker ® in action

Figure 2. Scanning system N-Sensor ® ALS on the tractor's cabin

These sensors work on the base of measuring of NDVI (Normalized Difference Vegetation Index) – simple index of photosynthetically active biomass quantity (vegetation index). This index is widely used for quantity assessment of plant covering.

NDVI is artificial unlimited index and used for assessment of ecological and climatic characteristics of plants and correlation with some other parameters as yield, biomass, content of soil organic substance.

In our researches while the preparation of agricultural machines for acting in barley field the preliminary scanning of leaves surface by sensors Green Seeker was done and NDVI was estimated. The parameters of NDVI were stored in board computer and, the same time, their coordinates in field were defined (7).

The density of plant green biomass depends of weeds dissemination. i.e. the more their quantity and mass the more NDVI parameter. NDVI provides with quality assessment of weed composition.

Difference in quantity of weeds after applying herbicides in the variants of traditional and precision technologies is not significant. In both variants – traditional technology with complete consumption of liquid and precision technology with preliminary estimated consumption of liquid, the number of weeds was practically equal. The consumption of liquid was fixed by board computer. Economizing of liquid in variant of precision technology was 94 l^{-ha}.

Calculation of technical efficiency of applying herbicides:

- Total consumption of liquid for whole experimental field – 534 l
- Consumption of liquid for the plot with traditional agricultural technology
  – 500 l^{-ga}*0,95 =295 l
- Consumption of liquid for the plot with precision agricultural technology estimated on NDVI*0,95=239 l
- Economizing – 56 l
- Economizing per one hectare – 94 l

On the basis of NDVI parameters for winter wheat plants total and differential dozes of herbicides were calculated and downloaded into board computer for applying herbicides both on plots with marker and autopilot usage. On the plots with marker usage herbicides applied by total spraying in doze of 190 mg^{-ha}. On the plots with precision technologies herbicides applied in on-line regime in accordance with NDVI parameter for winter wheat plants (Tab. 3).

Number of weeds didn't differ significantly relating the method of applying herbicides.

Table 3. Dozes of herbicides relating NDVI parameters for winter wheat plants

NDVI	Dozes of herbicides, mg^{-ha}	
	Differential	Total
0,25…0,35	190	
0,35…0,45	160	190
0,45…0,55	130	

The last applying herbicides was carried out with using GPS system that allowed to trace the moving of the machine along the field, correct NDVI parameters and consumption of liquid in each spot.

Later on calculating the consumption of liquid on the basis of NDVI parameters varied. In the one case consumption of liquid increased along increasing NDVI parameters, in the other – it decreased along high parameters of NDVI (Tab. 4).

Table 4. Applying dozes of herbocide cowboy relating NDVI parameters

NDVI	Dozes of herbicides, l^{-ha}		
	Increasing	Decreasing	Total consumption
> 0,30	290	410	
0,30…0,35	314	386	
0,35…0,40	338	362	410
0,40…0,45	362	338	
0,45…0,50	386	314	
0,50…0,55	410	290	

On the plot with ploughing with total spraying herbicides the number of weeds decreased in 5 times; while increasing the doze – in 5 times; wile decreasing the doze – in 3 times. Above ground mass of weeds was equal on all the plots. In variant with direct sawing with total spraying herbicides the number of weeds decreased in 2,7 times, their above ground mass – in 2 times; while decreasing the doze – in 2,5 times; while increasing the doze – 4,2 times.

Next element of precision agricultural technology is evaluation of nutrients content in soil of the precise parts of field. One of the methods for such evaluation – taking and analyzing soil samples to define the content of nitrogen, phosphorus, potassium, microelements for soil mapping. This map is downloaded into special software SMS Advanced that creates the tasks for board computer. As the result, for each square meter the proper quantity of fertilizers and microelements are applied [3]. It is possible as well not to evaluate the soil characteristics, but while harvesting to estimate the yield not as average mean, but on precise parts of field. On the basis of these estimations the yield map is created (Fig. 3).

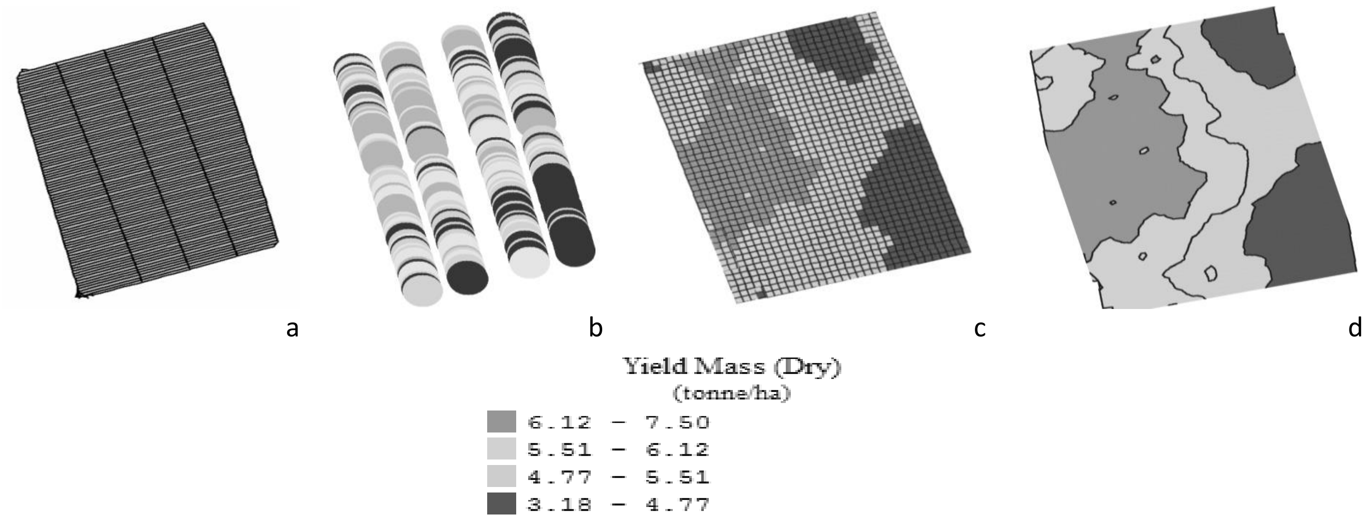

Figure 3. Moels of submitting information about the yield a) network for total yield estimation; b) spots in the centre of each cell of network for total yield estimation, size of spot – 10 m; c) network 3×3 m d) contour

These maps content the information about the level of yield that allows identifying the parts of the field to be fertilized, especially where with the level of yield is low and should be corrected [5]. The summary characteristic is the yield of the crops during the years of researching (Tab. 5).

Table 5. Yield of the crops relating the variants of soil yreatment, (2009-2013), t^{-ha}

Crop	Technology	Soil treatment	Yield, t^{-ha}					
			2009	2010	2011	2012	2013	in average
Vetch -oat mixture	precision	ploughing	21,3	20,5	10,8	20,6	12,1	17,1
		“null”	25,0	19,4	9,4	27.3	14,3	19,1
Winter wheat	precision	ploughing	4,23	4,63	3,70	6,31	6,12	5,00
		“null”	5,09	4,11	3.55	6,15	5.87	4,95
	traditional	ploughing	4,28	4,50	3,65	6,52	5,80	4.95
		“null”	5,18	3,85	3,53	6,35	5.62	4,91
Potatoes	precision	ploughing	41,5	21,7	24,4	19,9	28,6	27,2
		minimal	37,5	20,7	23,2	18,3	25,9	25,1
	traditional	ploughing	38,9	24,2	24,0	19,1	27,6	26,8
		minimal	36,3	19,2	22,9	17,5	26.2	24,4
Barley	precision	ploughing	5,40	3,35	2,64	4,33	5,18	4,18
		minimal	5,78	2,99	2,83	4,20	5,00	4,16
	traditional	ploughing	5,09	3,47	2,76	4.26	5,20	4,16
		minimal	5,39	3,06	3,08	4.18	4,95	4,13

The tendency of increasing yield of vetch-oat mixture for forage in variant of “null” treatment in comparison with ploughing is defined. In the field with winter wheat the significant differences in the yield between technologies and soil treatments are not defined. The level of yield was 0, 05…0, 10 t^{-ha}. In the field with potatoes only soil treatment influenced on the yield – ploughing caused the level of the yield at 2,0…2,5 $^{t-ha}$ higher in comparison with minimal treatment. Barley and winter wheat created the same level of the yield independently on technologies and soil treatments.

Conclusion

On the basis of the 5-year researches it is possible to take the conclusion about the perspectives and topicality of researches on precision agricultural technology with the aim to increasing yield of crops and preservation of sustainable ecological soil conditions.

Acknowledgements

The researches carried out at the Scientific Centre on Precision Agriculture of Russian State Agrarian University - Moscow Timiryazev Agricultural Academy and presented in the above article were done with the support of Grant of the Government of the RF № 11 G. 34.31.0079

References

1. Balabanov, V.I., Zhelezova, S.V., Berezovsky, E.V., Belenkov, A.I. 2013. Navigation technologies in agriculture. Coordinate soil treatment. Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, Moscow.
2. Spaar, D., Zakharenko A.V., Yakushev, V.P. et al. 2009. Precision agriculture. Pushkin, St. -Petersburg.
3. Belenkov, A.I., Zhelezova, S.V., Berezovsky, E.V., Mazirov, M.A. 2011. The elements of precision agricultural technology in field experiment at Russian State Agrarian University - Moscow Timiryazev Agricultural Academy. For Izvestiya TSHA 6, 90 -100.
4. Belenkov, A.I., Zhelezova, S.V., Berezovsky, E.V., Mazirov, M.A. 2012. Methods of precision agriculture technologies in the field experiment at Russian State Agrarian University - Moscow Timiryazev Agricultural Academy. For Izvestiya TSHA Special Issue, 94-101
5. Borovkova, A.S., Zyrulev, A.P. 2012. Differential fertilizing in conditions of forest-steppe zone in Samara region. For Agronomy and Plant protection 3, 11 -15.
6. Mazirov, M.A., Belenkov, A.I., Tyumakov, A.Yu. 2013. Results of the researches in the Scientific Centre on Precision Agriculture at Russian State Agrarian University - Moscow Timiryazev Agricultural Academy during the rotation of cereal and tilling crop rotation. In: Actual tendencies in development of fundamental and applied sciences in XXI century. Russian State University of Land Management, Moscow, p. 74
7. Polin, V.D., Berezovsky, E.V. 2011. Development of weeds protection in the system of precision agriculture in modern ecological conditions. In: Adaptation of agriculture in Russia to the changing climatic conditions (proceeding of International Scientific Conference). Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, Moscow, 131 - 136.

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An investigation of climate trends and Soil fertility at horticultural experience station of Kamalabad of Karaj/Iran after fourteen years

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Abstract

The objective of this study was to describe the climate trends and the variation in physico-chemical properties of four selected soil series (soil series1=Xeric Torriorthents, fine-loamy, mixed (calcareous) thermic; soil series 2=Xeric haplocalcids, fine-loamy, mixed, thermic; soil series 3=Xerifluventic haplocalcids, fine-loamy, mixed, thermic; soil series 4=Xeric haplocampids, fine, mixed, thermic} at different soil depths (0-30, 30-60, 60-90 and 90-120 cm depths) of horticultural experience station of Kamalabad of Karaj/Iran after fourteen years (1998-2012). According to our results, average temperature, total precipitation and total evapotranspiration from1998 (13.91°C) to 2012 (15.33°C) increased. Univariate analysis of variance of soil physico-chemical properties indicated that year had significant effect of all studied soil parameters at the two different sampling times; however, the effect was dependent on the studied soil series and soil depth of horticultural experience station of Kamalabad of Karaj. The results showed that after 14 years, all soil samples were containing higher amount of soil total nitrogen (except of soil series 1 at soil depth of 30-60 and 60-90 cm). Also results showed that the soil series 1 and 4 at all studied soil depths contained higher amount of soil available potassium in 2012 as compared to 1998. The highest value of available phosphor was observed in soil series 2 at soil depth 0-30 cm in 2012. Fourteen years after the first soil sampling, the highest values of soil-pH (in soil series 1 at soil depth 90-120 cm), amount of silt { in soil series 1 at all soil depths (except of soil depth 0-30 cm)} and also amount of clay in soil series 2 at soil depth 60-90 cm were observed in 2012 as compared to 1998. But contrary, the highest values of Ec in soil series 3 at soil depth of 90-120), SP and OC in soil series 4 at soil depth 0-30cm, TNV in soil series 2 at soil depths 60-90 and 90-120cm and amount of sand in soil series 1 at soil depth 90-120 cm in 1998 as compared to 2012. Comparison of plant samples of apricot varieties, which grown at soil series 3 of horticultural experience station of Kamalabad of Karaj in 1998 and 2012 revealed significant changes leaf-K, leaf-B, leaf-Cu, fruit-pH, total soluble solids of fruit, titrable acidity of fruit, fruit-P, fruit-K, fruit-Ca and fruit-Mg during 14-year period. The concentration of leaf-K, leaf-Cu, fruit-P, fruit-k, total soluble solids of fruit and titrable acidity of fruit increased over time.

Keywords: Apricot, climate trends, nutrient, soil fertility

Introduction

Soil fertility is an important factor, which determines the growth of plant. Climate change will have also an impact on the soil, a vital element in agricultural ecosystems. Higher air temperatures will cause higher soil temperatures, which should generally increase solution chemical reaction rates and diffusion-controlled reactions. Solubilities of solid and gaseous components may either increase or decrease, but the consequences of these changes may take many years to become significant (Buol *et al*., 1990). Furthermore,

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higher temperatures will accelerate the decay of soil organic matter, resulting in release of CO_2 to the atmosphere and decrease in carbon/nitrogen ratios, although these two effects should be offset somewhat by the greater root biomass and crop residues resulting from plant responses to higher CO_2. Climate change affected some Southwest Asian countries during the last 15 years. So, many studies have been conducted to assess the regional climate of some Southwest Asian countries such as Iran (Modarres and Sarhadi 2009; Kousari and Asadi Zarch 2010; Kousari *et al*., 2011); Bahrain (Elagib and Abdu 1997); Syria (Evans and Geerken 2004), and the Arab region (Abahussain et al. 2002). The studies of researches showed that fruit trees provide important adaptive values and tend to be more resilient to climate change due to their perennial nature. But they too are affected by climate change in idiosyncratic ways. Climate change especially poses important difficulties for commercial production of fruit trees (Sthapit *et al*., 2012). Dinesh and Reddy (2012) described how fruit yield depends on a narrow range temperature and rainfall in magnitude and timing, even though the plant itself can live through greater extremes. Fruit yield is a function of light interception, variety's photosynthetic efficiency and cost of respiration. Therefore, pruning is commonly used to increase light interception. Temperature determines quantity and quality of fruits produced. Higher temperature at the fruit development stage speeds up maturity, fruit size and quality. Temperature also determines the number and quality of flowers, and thus directly influences the fruiting potential for the season. Rains during fruiting periods may blacken fruits (in mango) or prevent desirable fruit coloration (in guava), making the produce less appealing for the consumers. Increase in humidity can initiate unseasonal flowering. Various quality traits such as fruit coloration, spottiness, fruit texture and taste can be altered by change in temperature, humidity and rainfall. Changes in climate can cause poor harvests or even crop failures. Excess of water and decreased snowfall during winter causes low chilling hours in cropping areas, and this could pose serious threats to apple production worldwide, particularly in India (Singh et al. 2010) The objective of this study was to describe the climate trends, the variation in physico-chemical properties of selected soil locations at different depths and nutrition status of fruit trees at horticultural experience station of Kamalabad of Karaj/Iran after fourteen years (1998-2012).

Material and Methods

The study was conducted at the horticulture experience station of Kamalabad of Karaj in Iran (Fig. 1) where is located in 50.52 longitudes and 35.52 latitudes and has a semi-arid climate. The data for three parameters about average temperature (0$^{\circ}C$), total precipitation (mm) and total evapotranspiration (mm) for two periods 1998 and 2012 were obtained from synoptic meteorological stations of Iran.

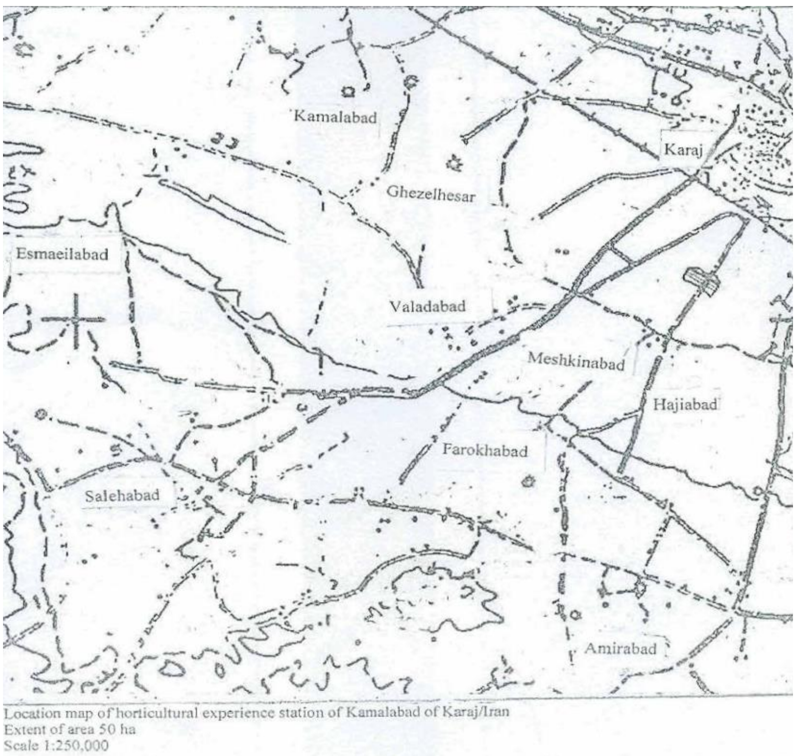

Fig. 1. Location map of horticultural experience station of kamalabad of Karaj/Iran (Source: Fallahi, 1995)

Soil samples of 50 ha horticultural experience station of Kamalabad were collected from four soil series {soil series1=Xeric Torriorthents, fine-loamy, mixed (calcareous) thermic; soil series 2=Xeric haplocalcids, fine-loamy, mixed, thermic; soil series 3=Xerifluventic haplocalcids, fine-loamy, mixed, thermic; soil series 4=Xeric haplocampids, fine, mixed, thermic} at four soil depths (0-30, 30-60, 60-90 and 90-120 cm) in 2012. We used the same soil sampling and analytical methods as those used when the horticultural experience station of Kamalabad was sampled in 1998 (see Fallahi, 1998). Soils were analyzed for physical (electrical conductivity (EC) dsm^{-1}, texture, saturation percentage) and chemical properties included pH, total neutralizing value (TNV) %, organic matter (OC) %, and nutrients (N %, available P ppm, and available K ppm). Of the many fruit trees (stone, pome and nut fruits) grown in the horticultural experience station of Kamalabad, results are given here only for apricot trees (including "Nasiri", "35 shahroodi" and "shahroodi, which grown at soil series 3 (Xerifluventic haplocalcids, fine-loamy, mixed, thermic). Three replicates of plant samples (10-15 young, fully expanded leaves per tree and also 9 fruit per tree) of mature, full bearing apricot trees were collected from the selected sites of apricot location. Leaves were washed with distilled water, oven-dried at 70$^{℃}$ for 48 h, ground in Wiley-Mill and stored for the analysis. The fruit samples were oven dried at 80°C for 100 hrs, frozen at -20°C, and then ground while still frozen. Fruit- samples were wet ashed in a mixture of nitric and perchloric acids (HNO3-HC1O4). Nitrogen was determined by micro-Kjeldahl method (AOAC 1980) and calcium, magnesium and micro elements were determined by atomic absorption spectophotometry (AOAC 1980). P was analyzed by the molibdovanadate method using a Jenway 6305UV–VIS. K was analyzed by flame photometry using a Jenway PFP7 flame photometer (Jenway, Essex, UK).The nutrient values were reported on a dry-weight basis. Chemical attributes of studied apricot variety were determined in individual fruits (three replicates per treatment) and analyzed. The fruit-pH was determined by pH meter (JENWAY – 3505), and titrable acidity (TA) of fruit (as malic acid) was determined by titration of 5 ml filtrated juice by 0.1N NaOH up to pH of 8.3. Total soluble solid of fruit contents were determined by extracting and mixing one drop of juice from each fruit into a refractometer (JENWAY – 6405 UV/V). Soils were analyzed for their physico-chemical properties such as soil texture (Koehler *et al*., 1984), soil pH(1:5) (Mclean, 1982) using 105 Ion Analyzer pH meter, Soil EC(1:5) (Richards, 1954), lime and soil organic matter (Nelson and Sommers, 1982). Total nitrogen in soils were determined using Kjeldahl distillation procedure as described by Bremner and Mulvaney (1982).Water soluble K was detemined in saturation extract by flame photometer and soil P by spectrophotometer. One-way analyses of variance were conducted to determine if significant differences for the plant samples and the data for climate parameters occurred with year sampled (two levels, 1998 and 2012). A comparison of soil physico-chemical properties were evaluated with univariate analysis of variance with year sampled (two levels, 1998 and 2012) and soil series (four levels) and at different soil depths (four levels) and their interaction entered in the statistical model. All statistical analyses were performed on the data using SPSS system. Differences at the $P< 0.05$ level were considered significant.

Results and Discussion

According to figures (Figures 2-4), average temperature, total precipitation and total evapotranspiration from1998 (13.91$^{℃}$) to 2012 (15.33$^{℃}$) increased.

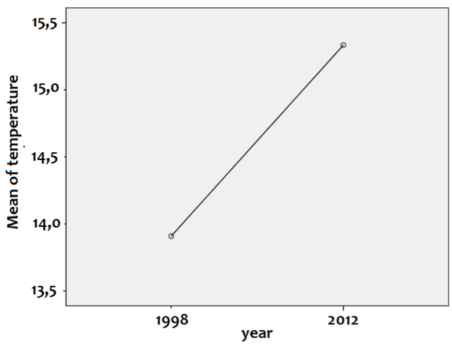

Fig. 2. Mean comparison of average temperature of kamalalabad of Karaj from two sampling times (1998 and 2012)

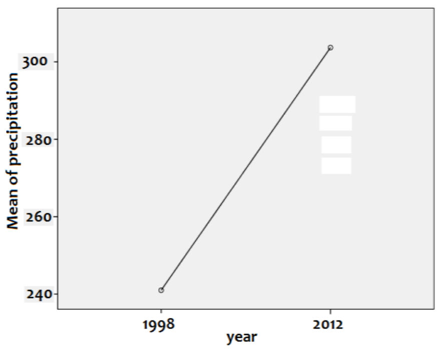

Fig. 3. Mean comparison of total precipitation of kamalalabad of Karaj from two sampling times (1998 and 2012)

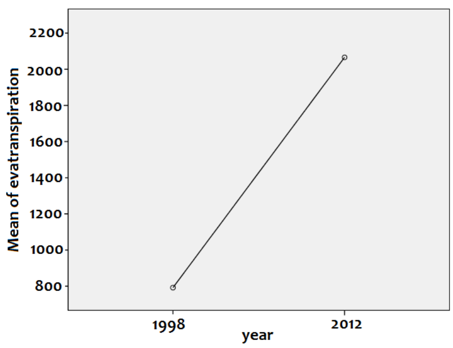

Fig. 4. Mean comparison of total evapotranspiration of kamalalabad of Karaj from two sampling times (1998 and 2012)

Univariate analysis of variance of soil physico-chemical properties indicated that year had significant effect of all studied soil parameters at the two different sampling times (1998 and 2012).; however, the effect was dependent on the studied soil series and soil depth of horticultural experience station of Kamalabad of Karaj. The interaction between sampling times and soil series and soil depths were significant for all studied soil physic-chemical properties (except of soil-pH) (Table 1). The results showed that after 14 years, all soil samples were containing higher amount of soil total nitrogen (except of soil series 1 at soil depth of 30-60 and 60-90 cm); however, the increase in the soil series 1 and 4 (at soil depths 0-30, cm) were much greater (0.11 %) than the other soil samples (Fig 8). Also results showed that the soil series 1 and 4 at all studied soil depths contained higher amount of soil available potassium in 2012 as compared to 1998(Fig 10). The highest value of available phosphor was observed in soil series 2 at soil depth 0-30 cm (10.81 ppm) in 2012 (Fig 9). Fourteen years after the first soil sampling, the highest values of soil-pH (8.3), amount of silt in soil (56%) and also amount of clay in soil (45 %) were observed in soil series 1 at soil depth 90-120 cm for soil pH (Fig 11) and at soil depths 30-60, 60-90 and 90-120 cm for amount of silt (Fig 13) and soil series 4 and 2 at soil depths 30-60 and 60-90 cm for amount of clay, respectively in 2012 as compared to 1998(Fig 15). But contrary, the highest value of Ec (2.83 dsm^{-1}) in soil series 3 at soil depth of 90-120 (Fig 6), SP (58 %) in soil series 4 at soil depth 0-30 (Fig 5), OC (0.98 %) in soil series 4 at soil depth 0-30 (Fig 12), TNV in soil series 2 at soil depths 60-90 and 90-120 cm (16.7 %) (Fig 7) and amount of soil sand (51 %) in soil series 1 at soil depths 90-120 (Fig 14) were found in 1998 as compared to 2012.

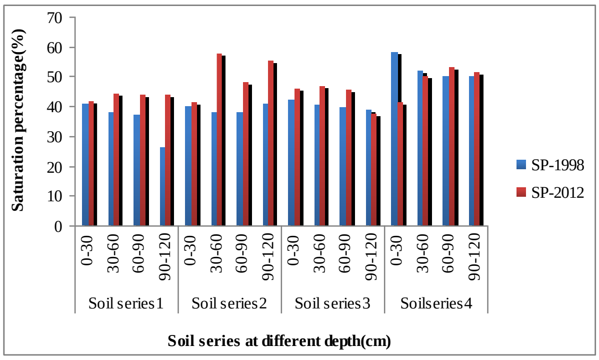

Fig. 5. Comparison of Saturation percentage at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

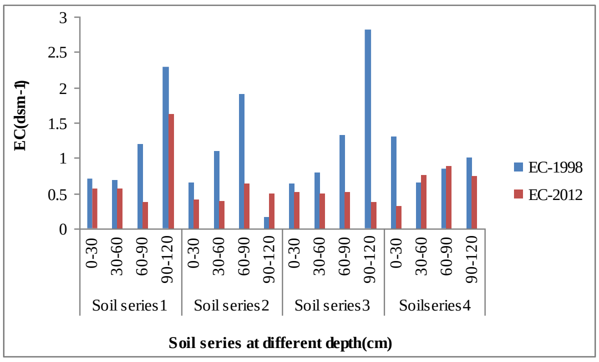

Fig. 6. Comparison of soil EC at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

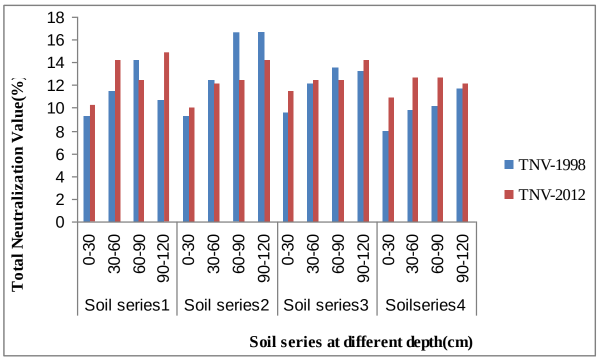

Fig. 7. Comparison of Total unitization Value (TNV) at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

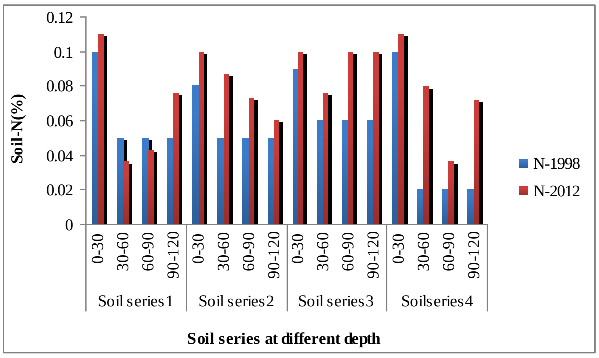

Fig.8. Comparison of soil total N at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

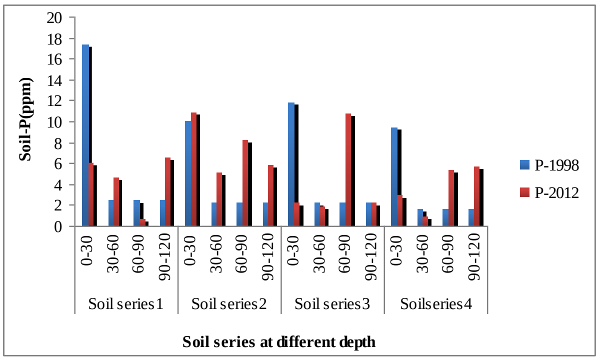

Fig.9 Comparison of soil available P at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

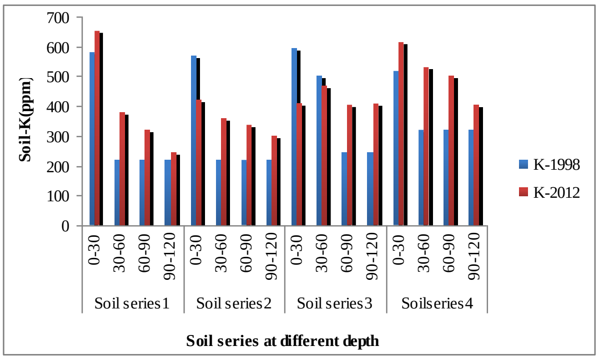

Fig.10 Comparison of soil available K at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

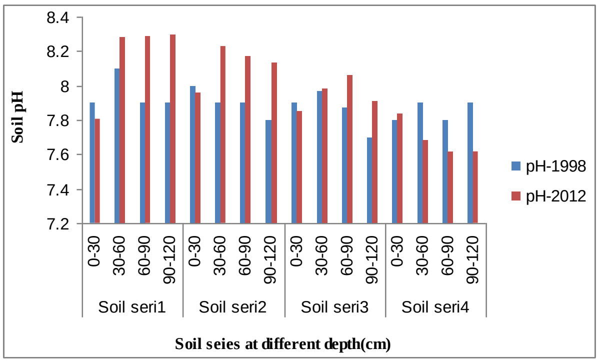

Fig.11 Comparison of soil available pH at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

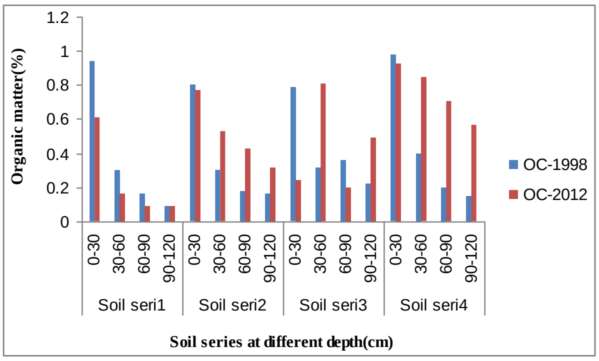

Fig.12 Comparison of soil available organic matter (OC) at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

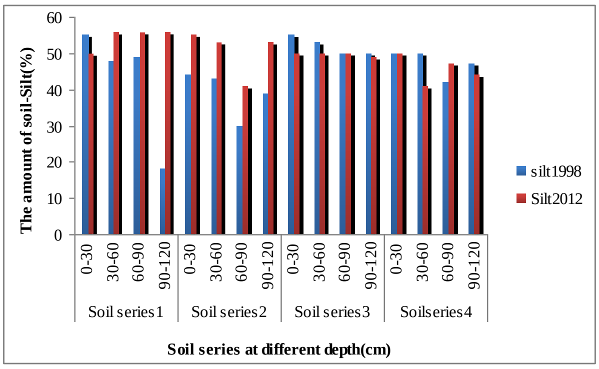

Fig.13 Comparison of silt at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

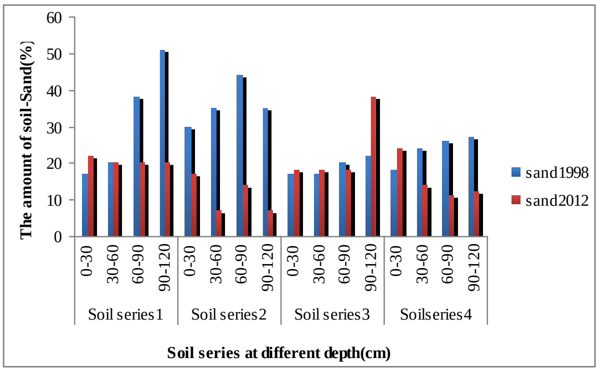

Fig.14 Comparison of sand at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

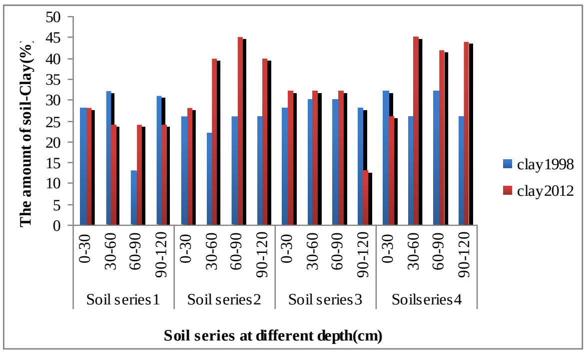

Fig.15 Comparison of clay at different soil series and soil depths (0-30, 30-60,-60-90, and 60-90 cm) of kamalalabad of Karaj from two sampling times (1998 and 2012)

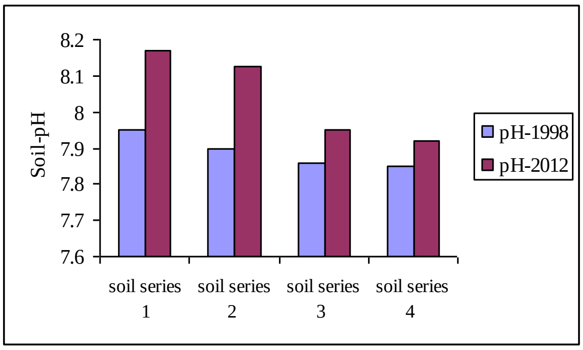

Fig.16 Comparison of soil-pH at different soil series of kamalalabad of Karaj from two sampling times (1998 and 2012)

One–Way analysis of variance was used to detect differences in plant samples ("Nasiri", "No35" and "shahroodi" in 1998 and "Shahroodi", "Gheysi', "Ghorbanmaraghe" and 'Jahangiri" in 2012) of apricot varieties (by year), which grown at soil series 3 (Xerifluventic haplocalcids, fine-loamy, mixed, thermic) of horticultural experience station of Kamalabad of Karaj. Comparison of plant samples in 1998 and 2012 revealed significant changes leaf-K, leaf-B, leaf-Cu, fruit-pH, total soluble solids(TSSA) of fruit, titrable acidity (TA) of fruit, fruit-P, fruit-K, fruit-Ca and fruit-M during 14- year period (table 2). Mean comparison of nutrient status of apricot trees crops in 1998 and 2012 revealed that the concentration of leaf-K (from 2.80 to 3.12%), leaf-Ca(from 1.86 to 1.94%), leaf-Fe(from 344.50 to 597.19 ppm), leaf-Zn (from 41.02 to 42.52 ppm), leaf-Cu(26.94 to32.43 ppm), fruit-N (1.69 to 1.71%), fruit-P (from 0.11 to 0.30%), fruit-k (from 1.18 to 1.91%), total soluble solids of fruit (from 4.85 to 12.36%) and fruit acidity (from 1.46 to 2.39%) increased over time (Table 2 and Figures 20, 21 and 22).

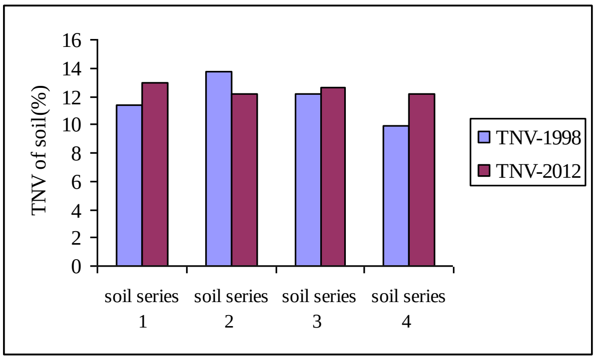

Fig.17 Comparison of soil-TNV at different soil series of kamalalabad of Karaj from two sampling times (1998 and 2012)

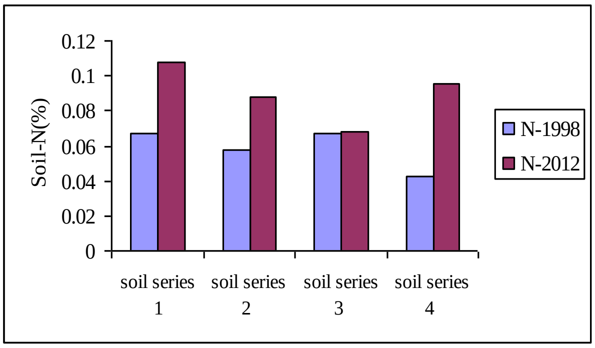

Fig.18 Comparison of soil-N at different soil series of kamalalabad of Karaj from two sampling times (1998 and 2012)

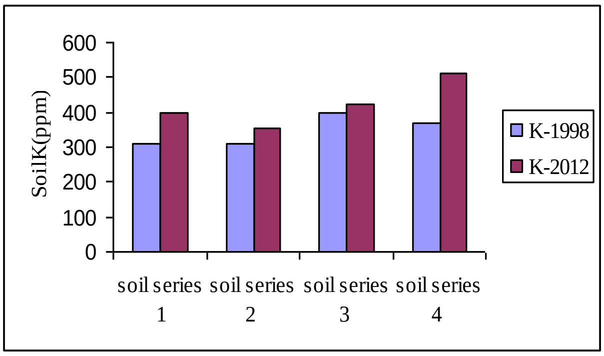

Fig.19 Comparison of soil-K at different soil series of kamalalabad of Karaj from two sampling times (1998 and 2012)

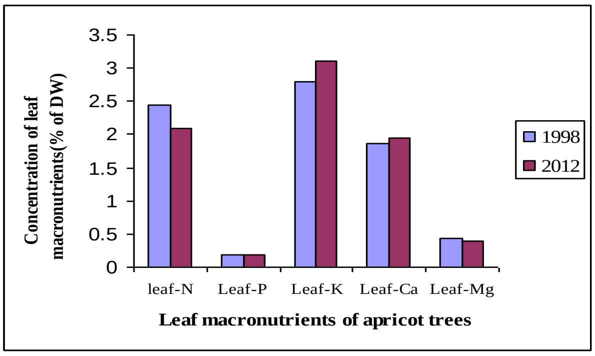

Fig. 20 Comparison of leaf macronutrient of studied apricot varieties, which grown at soil series 3 (Xerifluventic haplocalcids, fine-loamy, mixed, thermic) of horticultural experience station of Kamalabad of Karaj from two sampling times (1998 and 2012)

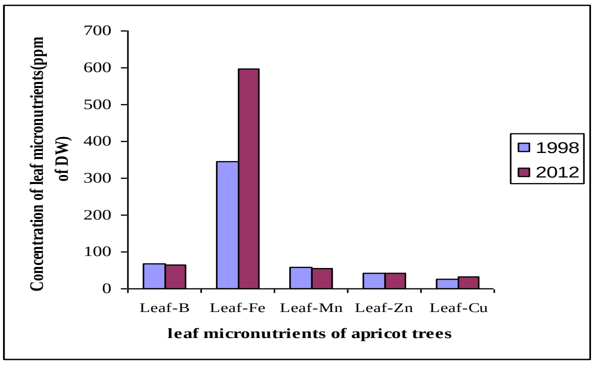

Fig. 21 Comparison of leaf micronutrient of studied apricot varieties, which grown at soil series 3 (Xerifluventic haplocalcids, fine-loamy, mixed, thermic) of horticultural experience station of Kamalabad of Karaj from two sampling times (1998 and 2012)

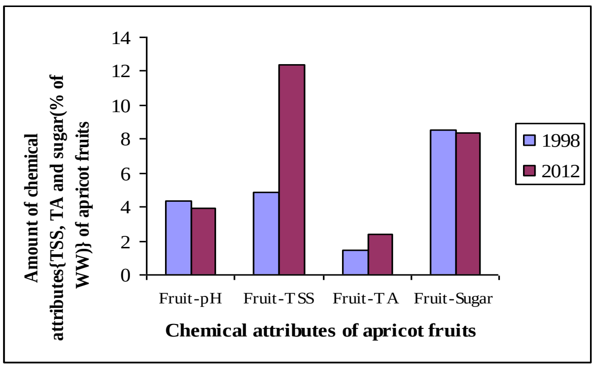

Fig. 22 Comparison of chemical attributes of studied apricot fruits, which grown at soil series 3 (Xerifluventic haplocalcids, fine-loamy, mixed, thermic) of horticultural experience station of Kamalabad of Karaj from two sampling times (1998 and 2012)

Table 1. Tests of Between-Subjects Effects (years, soil locations and soil depths) for physico-chemical properties of horticultural experience station of Kamalabad/ Karaj/ Iran (1998 and 2012)

Dependent Variables		SP (%)		EC dsm^{-1}		pH		OC (%)		N %		Available P(ppm)		Available K (ppm)		Silt %		Clay %		Sand (%)		TNV (%)	
Source of Variation	df	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
year	3	165.474	.000	528.689	.000	2.927	.008	167.001	.000	373.646	.000	18.443	.000	1.195	.000	1.091	.000	2.081	.000	9.268	.000	98.787	.000
Soil-Series	3	164.419	.000	29.350	.000	9.621	.000	246.350	.000	83.626	.000	39.676	.000	3.069	.000	372.954	.000	836.690	.000	755.663	.000	156.833	.000
Soil-Depth	3	11.717	.000	132.846	.000	1.991	.092	704.347	.000	357.584	.000	303.158	.000	2.800	.000	493.105	.000	106.042	.000	986.236	.000	595.409	.000
year * Spil-Series	3	72.723	.000	32.970	.000	2.913	.000	137.094	.000	32.662	.000	39.737	.000	1.191	.000	1.064	.000	1.087	.000	3.176	.000	155.823	.000
Soil-Series * Soil-Dept	9	15.041	.000	92.301	.000	.834	.124	44.023	.000	32.507	.000	31.456	.000	6.8104	.000	344.450	.000	355.196	.000	520.206	.000	36.596	.000
year * Soil-Depthept	9	46.522	.000	30.023	.000	.824	.041	163.597	.000	17.023	.000	228.360	.000	2.756	.000	407.411	.000	485.026	.000	1.190	.000	92.045	.000
year *Soil-Series –Soil-Depth	3	15.345	.000	74.495	.000	.728	.588	43.150	.000	17.619	.000	33.859	.000	4.3793	.000	297.087	.000	340.018	.000	566.066	.000	37.645	.000

Table 2. Tests of ANOVA for apple trees parameters of studied apricot varieties grown (1998 and 2012) at horticultural experience station of Kamalabad/ Karaj/ Iran

Plant parameters	Sum of Squares			df			Mean Square		F	Sig.
	Between Groups	Within Groups	Total	Between Groups	Within Groups	Total	Between Groups	Within Groups	Between Groups	
Leaf N (%DW)	.629	7.781	8.410	1	19	20	.629	.410	1.536	.230
Leaf P (%DW)	.000	.003	.003	1	19	20	.000	.000	.282	.601
Leaf K (%DW)	.527	.986	1.512	1	19	20	.527	.052	10.155	.005
Leaf B (ppmDW)	46.309	138.614	184.922	1	19	20	46.309	7.295	6.348	.021
Leaf Fe (ppmDW)	328392.2	8511660.38	8840052.58	1	19	20	328392.2	447982.13	.733	.403
Leaf Mn (ppmDW)	127.229	1521.017	1648.246	1	19	20	127.229	80.054	1.589	.223
Leaf Zn (ppmDW)	11.439	547.831	559.270	1	19	20	11.439	28.833	.397	.536
Leaf Cu (ppmDW)	154.852	394.951	549.804	1	19	20	154.852	20.787	7.450	.013
Leaf Ca (%DW)	.028	.334	.361	1	19	20	.028	.018	1.586	.223
Leaf Mg (%DW)	.013	.319	.332	1	19	20	.013	.017	.792	.385
Fruit pH	.987	1.210	2.198	1	19	20	.987	.064	15.503	.001
Total soluble solids of fruit (%)	289.592	173.260	462.852	1	19	20	289.592	9.119	31.757	.000
Titrable acidity (TA) of fruit (%)	4.420	4.972	9.392	1	19	20	4.420	.262	16.888	.001
Fruit sugar (%)	.096	73.013	73.109	1	19	20	.096	3.843	.025	.876
Fruit N (%)	.002	1.731	1.732	1	19	20	.002	.091	.019	.893
Fruit P (%)	.183	.034	.217	1	19	20	.183	.002	103.694	.000
Fruit K (%)	2.768	.262	3.029	1	19	20	2.768	.014	200.817	.000
Fruit Ca (%)	.016	.059	.076	1	19	20	.016	.003	5.233	.034
Fruit Mg (%)	.061	.110	.171	1	19	20	.061	.006	10.538	.004

Fourteen years after the first soil and plant sampling of apricot trees at the horticultural experience station of Kamalabad (see Fallahi, 1998 and Mirabdulbaghi, 2005) and also climatic data collecting (from Synoptic Meteorological Stations of Iran), which was sampled in 1998, variation in climatic trends, physico-chemical properties of selected soil locations at different depths and nutrition status of apricot trees at horticultural experience station of Kamalabad of Karaj were found in 2012. The changes in temperature and evapotranspiration at horticultural experience station of Kamalabad of Karaj detected are consistent with observations made at the survey of climatic changes in the case of the eastern and central areas of Iran and, to some extent, the northern parts (Kousari et al, 2011) and that generally also apply to the whole Iran ((Kousari and Asadi Zarch, 2010). We found also that year had significant effect of all studied soil parameters at the two different sampling times (1998 and 2012); however, the effect was dependent on the studied soil series and soil depth of horticultural experience station of Kamalabad of Karaj. The interaction between sampling times and soil series and soil depths were significant (Table 1). This finding agrees with Cambardella and Karlen, 1999 which asserted that soil chemical and physical properties are severely affected by inherent soil factors (pedogenic factors) and external factors (soil management, fertilization and tillage). The most soils of Iran are calcareous in nature. High pH and carbonate levels are common characteristics of these soils (Gharaie, 2009) and also, according to analysis (Fallahi, 1998, Mirabdulbaghi et al 2008) the soil of horticultural experience station of Kamalabad of Karaj was a calcarcous in nature with high pH. Comparison of soil samples in 1998 and 2012 revealed that the soil-pH and TNV of soil of horticultural experience station of Kamalabad of Karaj increased in all soil series(except of soil series 2 for TNV of soil) over time (Figures 16 and 17). We found that after 14 years, all soil series were containing higher amount of soil total nitrogen and available potassium in 2012 as compared to 1998 (Figures 18 and 19). This may be due to the chemical fertilization (Stiles et al, 1997., Cambardella and Karlen, 1999). The optimum range of N, P, K, Ca and Mg in leaves of apricot trees should be 2.00-3.20, 0.18—0.5, 2.00-3.20, 1.20-2.50 and 0.30-0.60 and also the values below 20, 5, 30 and 15 ppm for B, Cu, Mn and Zn in apricot leaves are considered deficient (Bergmann, 2000). According to our results, the concentrations of N, P, K, Ca, Mg, Fe, B, Cu, Mn and Zn in leaves of studied apricot trees were sufficient in both studied years (Figures20 and 21). The process of increasing soil-pH, -TNV,-SP and decreasing soil available potassium and soil available phosphor in soil series 3 at soil depths 0-30 and 30-60 cm in 2012 as compared to 1998(Figures 5, 7, 9, 10 and 11)had not apparently caused significant impact on the decreasing all studied nutrient concentrations in leaves and fruits of studied apricot trees, which grown at soil series 3 (Xerifluventic haplocalcids, fine-loamy, mixed, thermic) of horticultural experience station of Kamalabad of Karaj, in 2012.Data obtained from this study clearly indicated that the concentration of leaf-K, leaf-Ca, leaf-Fe, leaf-Zn, leaf-Cu, fruit-N, fruit-P, fruit-k, total soluble solids of fruit and fruit acidity of studied apricot trees increased over time (Table 2 and Figures 20, 21 and 22).

Conclusion

It was concluded from findings of this study that total precipitation and average temperature at horticultural experience station of Kamalabad of Karaj had upward trend during the 14-year period (1998 and 2012) for these three parameters. The results of soil samples showed that after 14 years, all soil series were containing higher amount of soil studied parameters (except of soil available phosphors in soil series 1 and 3 and soil-TNV in soil series 2) in 2012 as compared to 1998; however, the amount of all physical and chemical properties of soil samples were different in all studied soil depths. Comparison of nutrient status of apricot trees crops, which grown at soil series 3 (Xerifluventic haplocalcids, fine-loamy, mixed, thermic) in 1998 and 2012 revealed that the concentration of leaf-K,-Ca,-Fe,-Zn,-Cu, fruit-N, fruit-P, fruit-k, total soluble solids of fruit and fruit acidity increased over time.

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References

Abahussain, A.A., A.S. Abdu, W.K. Al-Zubari, N.A. El-Deen, M.A. Raheen. (2002). Desertification, in the Arab region: analysis of current status and trends. J Arid Environ 51:521–545.

0AOAC (Official methods of analysis of the association of analytical chemists). (1980) 13th ed. A.O.A.C., Washington, D.C.

Bergmann, W. (2000). Ernahrungs Storung bei Kultur Pflanzen, Gustav Fischer.

Bremner, J.M. and C.S. Mulvaney. (1982). Nitrogen total. p. 595-621. In: Methods of Soil Analysis. Part 2: 2nd edition. A.L. Page, R.H. Miller and D.R. Keeney (eds.) American Society of Agronomy, Madison, WI. USA.

Buol, S.W., P.A. Sanchez, S.B. Weed and J.M. Kimble. (1990). Predicted impact of climatic warming on soil properties and use. In Kimball, B.A., N.J. Rosenberg, and L.H. Allen, Jr. (eds.) Impact of Carbon Dioxide Trace Gases and Climate Change on Global Agriculture. ASA Special Publication Number 53. pp. 71-82.

Cambardella C.A. and D.L. Karlen (1999). Spatial analysis of soil fertility parameters. Precision Agriculture, 1: 5-14.

Dinesh M.R. and B.M.C. Reddy. (2012). Physiological basis of growth and fruit yield characteristics. In: Sthapit BR et al (ed) Handbook of fruit tree species and climate Change, chapter 3. Bioversity International, New Delhi, India.

Drouineou, J. (1942). Dosage rapid, du calcaire actif des sols. Annals Agron., 12: 441–50.

Elagib N.A. and S.A. Abdu. (1997). Climate variability and aridity in Bahrain. J Arid Environ 36:405–419.

Evans, J. and R. Geerken. (2004). Discrimination between climate and human-induced dry land degradation. J Arid Environ 57:535–554.

Fallahi, S. (1998). Detailed studies of soil of horticulture experience station of Kamalabad of Karaj in Iran and Water Research institute, Tehran. Iran. [In Persian].

Fallahi, S. (1995). Detailed studies of soil of horticulture experience station of Meshkinabad of Karaj in Iran and Water Research institute, Tehran. Iran. [In Persian].

Gharaie, H. A. (2009). Lead adsorption characteristics of selected calcareous soils of Iran and their relationship with soil properties. American-Eurasian J. Agric. & Environ. Sci., 6(6):637-642.

Isaac, R.A. and J.D. Kerber. (1971). Atomic absorption and phlame photometry: Techniques and uses in soil plant and water analysis. In: Walsh, L.M. (ed.), Instrumental Method for Analysis and Plant Tissue, pp: 17–37. Soil science society of America.Madison, WI.

Koehler, F.E., C.D. Moudre and B.L. Mcneal. (1984). Laboratory manual for soil fertility. Washington State Univ. Pullman, USA.

Kousari M.R. and M.A. Asadi-Zarch. (2010). Minimum, maximum, and mean annual, relative humidity, and precipitation trends in arid and semi-arid regions of Iran. Arab J Geosci. doi:10.1007/s12517-009-0113-6.

Kousari, M.R., M.R. Ekhtesasi, M. Tazeh., M.A. Saremi-Naeini and M.A. Asadi- Zarch. (2011). An investigation of the Iranian climatic changes by considering the precipitation, temperature, and relative humidity parameters. Theoretical and Applied Climatology103:321-335.

Marinov, P. and M.S. Marinov. (19820. Correlation between level of mineral nutrition, chemical, composition of leaves and fruiting of apricot. Acta Hort. (ISHS) 121:183-194

Mclean, E.O. (1982). Soil pH and lime requirement. p. 199-208. In: Methods of soil analysis. Part 2: 2nd edition. A.L. Page, R.H. Miller and D.R. Keeney (eds.). American Society of Agronomy, Madison, WI. USA.

Mirabdulbaghi, M. (2005). Compatibility of some apricot cultivars grafting on Saint Julian and two apricot seedling rootstocks in soil lime. Proceeding of the international scientific conference<< Modern fruit growing: State and development outlooks>>.vole17, part 2:153-157.

Mirabdulbaghi, M. (2008). Mirabdolbaghi, M. and R. Zarghami, 2008. Prognosis of nutrient status and vegetative vigor in peach trees by floral analysis. Int. J. Agri.Biol., 10: 459–62

Modarres, R, and A. Sarhadi (2009). Rainfall trends analysis of Iran in the last half of the twentieth century. J Geophys Res 114:D03101.

Nelson, D.W. and L.E. Sommers. (1982). Total carbon, organic carbon and organic matter. p. 574-577. In: Methods of soil analysis. Part 2: 2nd edition. A.L. Page, R.H. Miller and D.R. Keeney (eds.). American Society of Agronomy, Madison, WI. USA.

Olsen, R.A. and L.E. Sommers. (1982). In: Page, A.L., R.H. Miller and D.R. Kenney (eds.), Phosphorus in Methods of Soil Analysis, Part 2, pp: 403–30. Soil Science Society of America, Inc. Madison, WI.

Singh, H.P., J.P. Singh, S.S. Lal. (2010). Challenges of Climate Change – Indian Horticulture. Westville Publishing House, New Delhi, India. p. 224. Soltanpur, P.N. and A.P. Schwab. 1977. A new soil test forsimultaneous extraction of macro-micronutrients in soil. Communications in Soil Science and Plant Analysis 8: 195-207.

Sthapit, B.R., V. Ramanatha-Rao and S.R.Sthapit (2012). Tropical Fruit Tree Species and Climate Change. Bioversity International, New Delhi, India.

Stiles, S., C. Warren and W.S. Reid. (1991).Orchard nutrition management. Information Bulletin 219. Cornell Cooperative Extension, Ithaca, New York.

Walkley, A. and J. Black. (1934). An examination of the digital method for determining soil organic matter and proposed modification of the chromic acid titration method. Soil Sci., 37: 29–38.

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Impact of irrigation water quality of shallow groundwater on soils of Guerrara Region, Algeria

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Abstract

The aim of this study is to investigate the impact of irrigation water quality on soils of the oasis. In this context, four sites were selected inside a palm date farm, and in each site a soil profile was excavated for soil classification. In addition, soil samples were taken after each irrigation, to be subsequently analyzed in the laboratory using standard procedure. The morphological and analytical study of the soil shows that the soil is slightly to moderately salty (0.45 – 0.72 dS/m) in non-irrigated soils, and moderately to heavily salted (1.03 – 2.45 dS/m) for irrigated soils. The soil is slightly alkaline with a pH between 7.36 and 7.8, moderately calcareous with a values of $CaCO_3$ about 7.98 – 11.18%, with low to medium levels of organic matter (1.37 – 1.85 %), and with low levels of gypsum(1.85- 11.05). The physical-chemical analysis of water shows that it is generally strongly to excessively salty (2.6 – 6.33 dS/m), neutral pH, with an overall chlorinated facies and calcium sulfate and magnesium. The analytical study of soil and irrigation water and the interactions between them confirm that the irrigation of soil by that water is not a big problem for the soil, provided to have a good irrigation management and leaching with respected of amounts and frequency, allowing the leaching of soluble salts in depth.
Keywords: Oasis agro system, alluvial soil, shallow groundwater, irrigation, Guerrara

Introduction

The palm dates grown in Guerrara Oasis which is dominated by alluvial soils formed of fine aterials carried by floods of Wadi Zegrir. The source of water in the region mainly is shallow groundwater with limited numbers of deep wells. The shallow aquifer is captured by wells with depth ranging from 3-30 meters.These wells are sometimes poorly maintained and neglected, plus the use of other irrigation waters and the passage of the sewage system in the palm, which has influenced the soil and vegetation (KHEMGANI,2010). Indeed, farmers believe that the quality of water has changed and becomes unsuitable for irrigation of several speculations. They confirm that the well water became increasingly salty and they that their pushed to stop the use of it for irrigation in some cases. The salinity of the water wells has evolved from a low to excessively salty.The salinity of the water flood is seen as a problem for the management of soil and irrigation for agriculture. The objective of this study is to investigate the impact of irrigation water quality on soils of the oasis.

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Material and Methods

To achieve the objective of the study a physical-chemical study of soils and water were established. Soil samples were collected after each irrigation and analyzed in laboratory. Water samples are collected at the beginning of the study and analyzed in laboratory. It concerned different parameters of soil such as particle size, total calcium, organic matter, Electrical conductivity, pH, ionic balance and the dry residue. And electrical conductivity and pH of irrigation water.

Location and description of the study erea

For the realization of this study, we opted for the palm grouth of Guerrara which measures 400 ha, with 82,000 date palms. It's located in Guerrara region, located at 110 Km North - East of Ghardaia and at 360 kilometers south of at the South of Algiers and lies between latitudes N 3,629,000 and N 3,627,500 N and longitudes E 639000 and E 641500 East and at an average altitude of 303 m. It covers a total area of 2600 km² (Fig.1). The soils are alluvial and the traditional irrigation system operated the only groundwater (alluvial), using many wells (13000). A system of dikes and dams allowed also to channel floodwaters of the river and towards the study area.

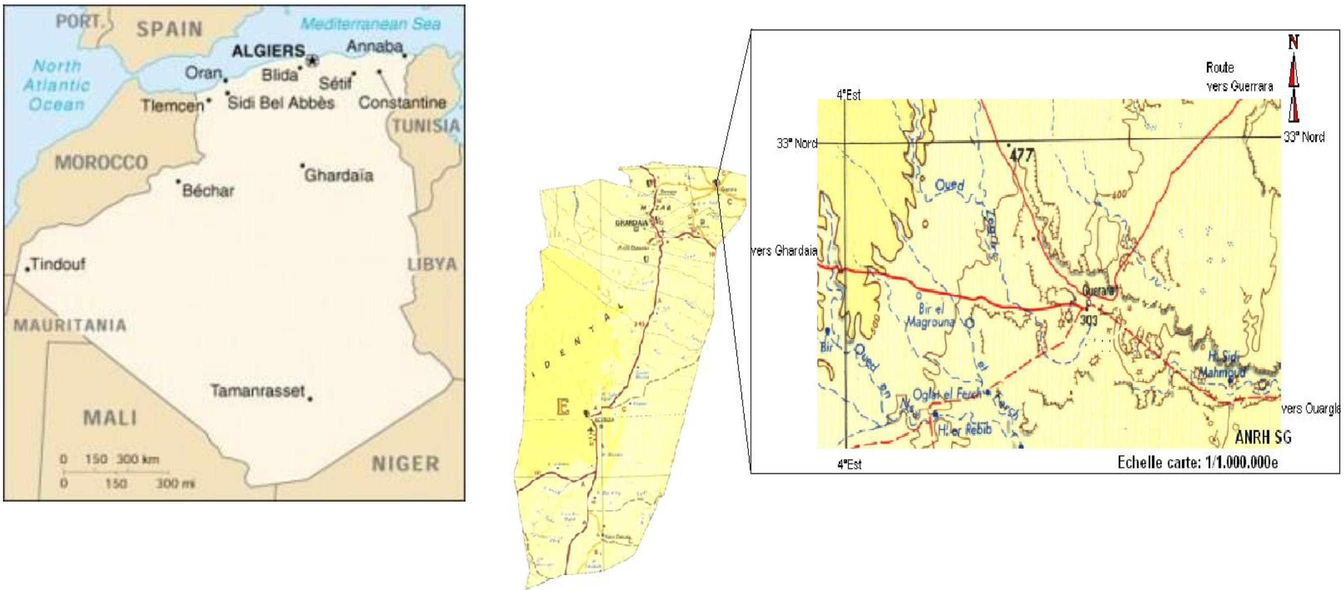

Fig 01: Location of Guerrara region

Geology: The study area has three types of geological formations (Fig 02); the upper cretaceous (CS) from the west to the east and it occupies the Northwestern of Guerrara, the Neogene or Mio-pliocene (mp) and the rest of the field consists of continental Pliocene(pc) as an extended forms of thick and continuous limestone, the continental quaternary (qt) which is presented by the Saharan sedimentary formations as river alluvium (KHEMGANI, 2008).

-**Geomorphology**: The grounds around the study area are highly exposed. They result from a strong fluvial erosion which has cut trays Continental Pliocene and remodeled by the following wind erosion (ASPG, 2008). According to Doufene (2012), the study area has several geomorphological units:

-**Hamada:** which are a plate structural, defined by sandy limestones and sandstones and these tiles are a drop of 75 m over a distance which varies from 2 to 3 Km,

-**Gara:** tabular plates isolated by erosion and crowned by a table of hard rock (Hood-Rey et al, 1969 in (Doufene, 2012).). Plain of Daya El Amied is bounded at the south by a series of Gara. These are shaped by the operation of the water system.

-**Daya:** depressions of small dimensions can vary from one to several tens of hectares, which is found everywhere in arid and Saharan areas (Dutil, 1971, Cooke et al, 1993 in (Doufene, 2012)).

We can also consider the Dayas as lows reserving large amounts of water that seeps quickly enough in the geological formation underlying. These waters contain mineral particles in suspension are a sedimentation end composed mainly of sand and silt.

- **Glacis:** The northern slope of the great depression of Guerrara, and has two floor levels glaze (glaze terrace). It is characterized by the outcrop of sandstone bedrock Mio-Pliocene. The latter is characterized by sand and gravel sandstone. (Djili, 2004).

-Superficial formations: upper Glacis formations are mainly sandy, silty to gravels. They are lined with gravel cover that gives an aspect of their Reg. The thickness is considerable while the color is pale white as it appears on the satellite image, what is due to limestone gravel. Glacis of Amied are formations which exceed 14 m thick with a reddish color. The texture is sandy loam and the surfaces are slightly scattered nodules, apart from the glaze Drain marking training sandy loam mixed with gypsum powder.

Hydrogeology: The local Hydrology is marked by the presence of five exploitable aquifers in Guerrara, including the shallow aquifer: The Mio-Pliocene and Eocene aquifer which locates in the eastern part of Guerrara. It is a sheet of Mio-Pliocene with 125 m thick plus a sheet of Eocene limestone (100 m thick), The Senonian aquifer which is found in the western part of Guerrara and is related to the previous two layers and can be operated at about 430 m of depth, the Turonian carbonate aquifer which has a thickness of 74m, 500 m deep and characterized the western part of Guerrara, the Continental interlayer or Albian aquifer which is about 500 to 900 m depth, The shallow Groundwater which is a superficial or alluvial aquifer which is a river aquifer. It is powered by floods of Zegrir wadi. The depth of this layer varies according to the season; 0.4 to6min times of high water and 10 to35minlow water period. The surface hydrogeology is presented by Zegrir wadi which is one of the major river crossing the region. It's limited to the height of Guerrara to Ben Filah daya(300m), with 270 km of length, and its origin head of Wadi Ajerma(860m)(DUBIEF,1953in DJILI, 2004).

It consists of irregular branched tributaries around a main trunk and connected at angles generally very varied less than 90 °(PEULVAST and VANNEY, 2001 in DJILI, 2004).

To have a good water management, residents of Guerrara have implemented a system that helps guide flood waters inside the palm grouth, and the flood stay weeks to ensure a good supply of alluvial aquifer and subsequently the surplus of water is evacuated (KHEMGANI 2008).

Scal : 1/500000

A	Current alluvium: dayas, chotts sebkhas, silt and Gypso- Salt crusts
D	Recent dunes
Qt	Continental Quaternary: alluvium, regs, terraces
Pc	Continental Pliocene: conglomerates, lacustrine limestones
mp	Pontian (locally equivalent Miocene continental Antepotien (mc)
cs	Upper Cretaceous marine

Fig 02: Geological Map of Guerrara

Methods

The soil survey was conducted by a first step of consultation of basic documents available that could give some information on the study area, we consulted a few theses, journals, maps, aerial photographs, satellite images (topographic and geological maps, and some agro-pedological study of the irrigated palm grouth of Guerrara). The second step is of prospecting-recognition, which consists of a recognition survey of the field, to have a general idea of the study area. At this stage we choose the location of sites of observation, the realization of soil profiles and sampling of water and soil. Water samples were collected at the beginning of the study from 4 shallow wells (one well in each site) and were subjected to chemical analyses in order to have an idea about the water quality. Soil samples were collected for three months (January to April 2013) after each irrigation, by using general soil sampling method of analysis for agronomic interpretation to evaluate some parameters of fertility. We have 4 different sampling areas and in each site we have 3 plots and samples are collected from 0 to 120 cm depth and at list 864 + 24(24 are witness or non-irrigated soils) soil samples were collected and subjected of measure of EC and pH. At the beginning of observation we collected samples from profiles to be subjected to physical and chemical analyses by using conventional methods after a description of soil profiles.

Results and Discussion

The qualitative study of irrigation water indicates that the water is generally not acceptable for irrigation. Water wells A and D are of poor quality and highly mineralized, compared to water from wells B and C. This water is not recommended for irrigation and irrigation may be suitable for some very tolerant species such as date palm. The studied soils are alluvial type, fine texture, usually rich in silt, fine sand and sometimes rich in clay. The particle size analysis shows that soil texture is silty clay loam to sandy. Generally, moderately calcareous soils in most profiles, with grades ranging from1 to 15%. The gypsum content is generally low, with a minimum of1.84%anda maximum of 11% in control soil(bare soil) and 7.36 % for the cultivated soil. This could be explained by leaching depth of gypsum by irrigation. The organic matter content is low to medium and gradually decrease with depth, with slightly higher values in the control profiles relatively to the studied soils. This may be due to the rapid decomposition of organic material and its removal by crops in irrigated soils compared to bare ground. The pH is slightly to slightly alkaline for all soils. The results of physical and chemical analyses of soil (site A) is showed in table 01.

Table 01: Results of physical and chemical analyzes of soil (profile A)

Horizons	Depth(cm)	pH	EC (dS/m)	Anions (meq/l)				Cations (meq/l)			
				Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{-2}	Na^+	K^+	Ca^{+2}	Mg^{+2}
AP	00-44	7,71	0,61	3	51,36	7	0	1,66	0,10	14,60	11,8
C	44-120	7,64	0,72	4	51,34	7	0	2,28	0,11	11,20	9

The evolution of the soil EC in site A is illustrated in table 02 and Fig 03 and Fig 04, it allows to monitor the quantitative changes in the overall salinity after irrigations. EC increased after the first to the third irrigation, then decreased after that at deep depth to reach values less than 2 dS/m. Fr the depth 20 cm, the EC are low and less than 1 dS/m. This shown that there is a large salt leaching by a large supply of irrigation water.

Table 02: The average values of EC (dS/m) in site A

Irrigations	20	40	60	80	100	120	Average
1st	1,922	1,559	1,568	1,573	1,787	1,815	1,704
2nd	1,176	1,580	0,963	1,555	1,094	1,329	1,278
3rd	1,029	0,953	0,990	0,782	0,941	1,091	0,964
4th	1,401	1,274	1,541	1,442	1,513	1,586	1,460
5th	1,420	1,218	1,244	1,264	1,538	1,622	1,384
6th	1,335	0,893	0,792	1,125	1,020	0,884	1,008
7th	0,775	1,019	1,288	1,158	1,046	0,975	1,043
8th	1,132	0,799	0,479	0,672	1,407	0,493	0,830
9th	1,069	0,839	1,019	0,954	0,895	0,674	0,908
10th	1,438	1,033	0,939	0,881	1,094	1,050	1,072
11th	0,775	1,180	1,243	1,158	1,074	0,988	1,070
12th	1,232	1,404	1,566	1,964	1,315	1,090	1,428
Wikness	0,695	0,663	0,803	0,884	1,151	0,857	0,842

The results of salinity changes shows that the all the values of EC are between 0,6 to 1,5 dS / m before irrigations and between 0,4 to 1,9 dS / m at the end of the study. These values reflected that the soil of this land are classified according Servant (1975) as very strongly to excessively salty.

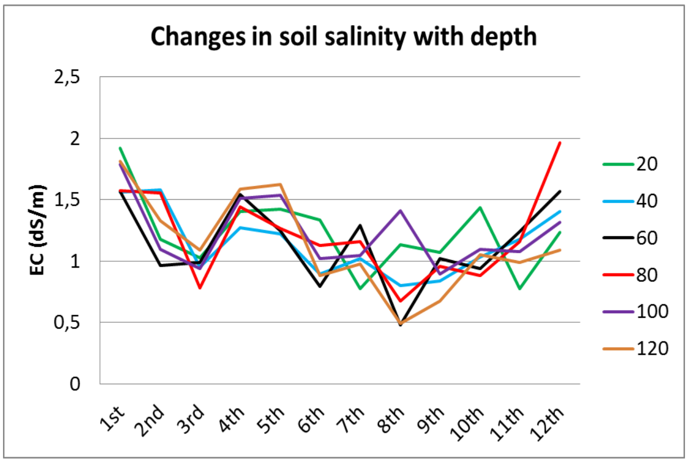

Fig 03: Changes in soil salinity with depth in site A

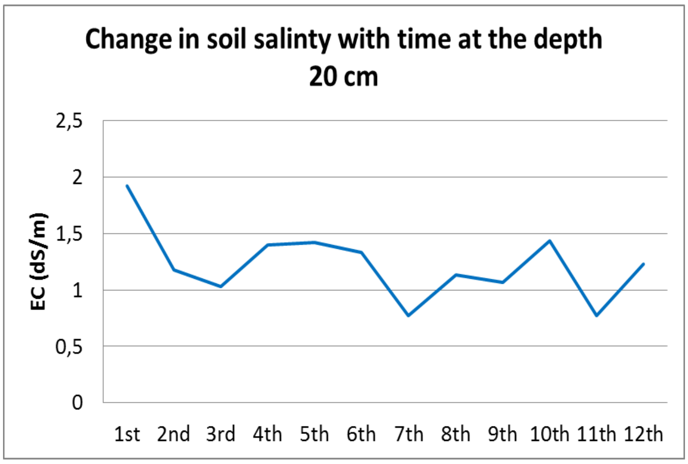

Fig 04: Change in soil salinity with time at the depth 20 cm

For the depth 20 cm, the EC are low and decreased with time from 2 to 0,6 dS/m. shown that there is a large salt leaching by a large supply of irrigation water.

According to the survey, one can say that irrigation water in the palm grouth of Guerrara causes an increase in salinity sol. But this salinity tends to decrease over time, which can be explained by the effect of irrigation on the leaching of soluble salts in the soil. This decrease in soil salinity is acceptable due to irrigation management by doses and frequencies observed. In the (non-irrigated soils), levels of soluble salts are higher in the surface layer and then there's a gradual decrease with depth. For irrigated soils, the levels are low at the surface to increase in depth and decrease again (except in sites A and C), where there's been a slight disruption of irrigations. This shows the very important role of irrigation in the dynamics of soluble salts to depth.

The study of correlations soil - water indicated that the irrigation water of poor quality expresses a general effect on the ground, but more slowly in the presence of doses of leaching. In general, the Cl^{-1}, $SO4^{-2}$, Ca^{+2} and Mg^{+2} promote reduction of EC values (positive correlation to the soil). Finally, it means that the irrigation of soil by that water does not constitute a risk for soil, but provided you have a good irrigation management with acceptable doses and frequency of watering that can decrease the levels of soluble salts in the surface layer or root zone and keep salinity below the threshold, without forgetting the important role of floodwaters of Zegrir wadi in leaching salts.

Conclusion

By the end of this study, which focuses on the survey of the effect of irrigation by the shallow groundwater on the soils the palm grouth of Guerrara, we were able to identify certain morphological characteristics and records of water and soil, by monitoring changes in the salinity of the irrigated soil by these water: The soil is generally moderately calcareous, with low to medium organic matter and gypsum, low to medium salt(witness soils) and moderately to heavily salted for irrigated soils. The results of the physical chemical analysis of irrigation water, in situ and in the laboratory, showed that irrigation water as a whole is excessively strongly salt and the pH is neutral. The concentration of soluble elements of diluted extracts of the soil is low, It generally follows the variation of the electrical conductivity, and gradually decreases with depth for the control soils(non-irrigated) while for the irrigated profiles, contents of soluble salt increases with depth. The results of the study of the change in soil salinity demonstrates that if one provides a good management of irrigation (irrigation doses and frequencies), this poor quality water have little effect on the soil. To highlight the interaction water/bare soil and water/cultivated soil (irrigated), we used some statistical analysis represented by correlation tests, which showed that there's an influence of irrigation water from the aquifer on the soil, but the influence remains weak and slowr especially for heavy soils. Finally, it should be noted that the work on the relationship ground/shallow (or alluvial) aquifer of Guerrara needs to be pursued by other studies on soil functioning compared to the shallow aquifer.

References

AUBERT, J., 1978. Méthodes d'analyses des sols. Centre régionale de documentation pédagogique de Marseille, service d'impression 55, rue Sylvabelle 13006 Marseille, P123.

BANTON, D and BANGOY, L .M., 1999. Hydrogéologie- Multi-sciences environnementale des eaux souterraines. Ed. Presses de l'université de Québec. AUPLEF, 460P.

CHAPMAN, D. and KIMSTACH, V., 1996. Selection of water quality variables. Water quality assessments, Chapman edition, 2nd ed. E & FN Spon, London, p. 59-126.

DJILI, B., 2004. Etude des sols alluviaux en zones arides: cas de la Daya d'El-Amied (région de Guerrara), essai morphologique et analytique. Mémoire Mag. Agronomie . Université de Ouargla, pp 5,8,11,15.

DOUFENE, S., 2012. Caractérisation micromorphologique et minéralogique des matériaux pédo-sédimentaires des systèmes des Dayas : cas de Daya d'El-Amied, Guerrara. Mémoire Mag. Agro. Université de Ouargla, p 4,8.

GUEMARI, F., 2009. Etude des systèmes trditionnels de captage des eaux et d'irrigation dans les oasis de la vallée de M'Zab. Mémoire Mag. Agro. Université de Ouargla. 43p.

HADJ-SAID, S., HAMDI-AISSA, B., TOUIL, Y., 2008. Qualité et resources en eaux souterraines dans un agrosystème oasien au sahara d'Algérie (cas de l'oasis de Guerrara, M'Zab). Bull. du groupe humidimètrie et transferts en milieux poreux, 54, p. 195-198.

KHEMGANI, M., 2008. Caractérisation des sols alluviaux et de la nappe alluviale de l'oasis de Guerrara. Mémoire Mag. Agro. Université de Ouargla. P. 12, 18, 27, 28.

NEZLI, I., 2009. Approche hydrogéochimique à l'étude des aquifères de la basse vallée de l'oued m'ya (Ouargla). Thèse Doctorat hydraulique, université Mohamed Kheider , Biskra.

ZELLA, L., and SMADHI, D., 2006. Gestion de l'eau dans les oasis algériennes. Laboratoire de recherche en hydraulique souterraine et de surface In larhyss journal, 05 juin 2006, pp. 149

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Geochemistry of alluvial and desert aquifers in agricultural soils of South Egypt

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Abstract

Geochemistry study of groundwater at South Egypt where intensive agricultural activity takes place was carried out with the use of GIS to elucidate the factors regulating quality of alluvial and desert aquifers. To achieve the goal of study, 118 groundwater samples were taken from the distributed irrigation wells. The obtained results showed that salinity of the groundwater in the desert fringes of the study area was higher than in alluvium area. None of the studied wells was of first grade quality with respect to salinity. The ECw is low closer to the Nile River, and it increase as one moves into desert. In some reasons the values of ECw in some wells near the Nile are high as a result to decreasing deep of wells and absence of drainage projects in these areas led to the leakage of drainage water to these wells which led to the increasing the salinity of these wells. Water of most wells are moderately alkaline, as p^H values were between 8 – 8.5. More than 50% of the wells can be considered suitable for irrigation according to SARw (less than 10) and RSC (less than 1.25). Concentration of soluble cations and anions in most of the groundwater samples followed the order $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ for cations, and $Cl^- > HCO_3^- > SO_4^{2-}$ for anions. Nitrate (NO_3^-) concentration of the groundwater samples in the study area ranged from 0 to 274.9 mg l^{-1}. In most wells, nitrate concentration was higher than the permissible concentration limits for drinking water and for livestock and poultry. The concentrations of Fe, Zn, Pb, and Cu in all wells were lower than the permissible concentration limits for irrigation water. Only, in about 5% and 22% of wells, Ni and Mn concentrations were higher than the permissible concentration limits for irrigation water, respectively.

Keywords: Geochemistry, groundwater, Qena Governorate, Egypt

Introduction

Egypt is part of arid zone of North Africa where the fresh water resources are limited to the fixed share from the Nile and groundwater systems. Growing population, agricultural expansion, and urbanization has placed a heavy demand on water resources. The governorate of Qena lies within the South Egypt section between Sohag governorate in the north, Aswan governorate in the south, Read sea governorate in the east and New valley governorate in the west. It is located between latitude of 25° 13' to 26° 15' N and longitude of 32°00' to 32° 55' E. The lowest temperature of the year is recorded in January (coldest month) with average value of 23.05 °C and the highest temperature is in June (hottest month) with average value of 41.12 °C. Rains are rare, randomly precipitated and vary in amount in the year months. The mean annual value of rainfall over the area

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is less than 5 mm/year. The annual mean value of wind speed ranges between 8.00 m/sec at Quseir, 4.06 m/sec at Luxor and 1.80 m/sec at Qena. (Mahmoud, 2005).

Geomorphology features

In Qena governorate as a part of South Egypt, the Nile valley broadens and the flat strips of cultivable land, extending between the river and the cliffs that bound its valley on either side, gradually increase in width northward. Near Esna, abut 160 km downstream of Aswan, the sandstone of the bounding cliffs gives place to limestone, and at Qena, about 120 km north of Esna the river makes a great bend bounded by limestone cliffs rising to heights of more than 300m on either side. Past the Qena bend, the Nile swerves in the red sea direction and its valley is much wider, the cliffs of the western side of the valley become much lower than those the on the eastern sides (Fig. 1).

The landforms of Qena governorate are mainly of sedimentary origin and can be summarized as follows. (Said,1981 and 1991; Hamdan, 2005; Mahmoud, 2005).

The young alluvial plains of the Nile: The young alluvial plains form the cultivated lands bordering the stream of river on the east and west. These are dissected by irrigation canals and drainage systems that run generally, parallel to the river itself. The young alluvial plains are almost flat and gently slope from south to north (ground elevation about +90 m at Aswan to about +20 m at Cairo).

The old alluvial plains of the Nile: Such plains are present along both sides of the river stream and exist as terraces found at vary heights above the young alluvial plains. They form a gently undulating dissected pediplains that are surface made of several broad benches like gravelly terraces inter-fingering and occasionally overlaying each other.

The plateau in Qena area is composed of limestone (L. Eocene). The river cuts it own stream through that plateau dividing it into two portions, one to the east of the river and the other on the west, both of them are terminated with cliffs overlooking the flood pain. the eastern plateau has an irregular surface, and rises to more than +450 m at Nag Hammadi.

These plains occupy the southern portion of Qena region, south of the study area, and extend eastward to comprise a portion of the area between the Red Sea and the Nile valley. Nubia Sandstone of different hardness and landforms occupies these plains. Their surfaces are occasionally crossed by shallow wadis, which are almost filled with drifting sand.

The desert hydrographic basins: These are natural drainage lines that may have the shape of elongated deeply incised depressions or gullies opened to the Nile valley. The origin of these wadis is believed to be due to faulting, modified later by erosion and deposition of younger Quaternary sediments.

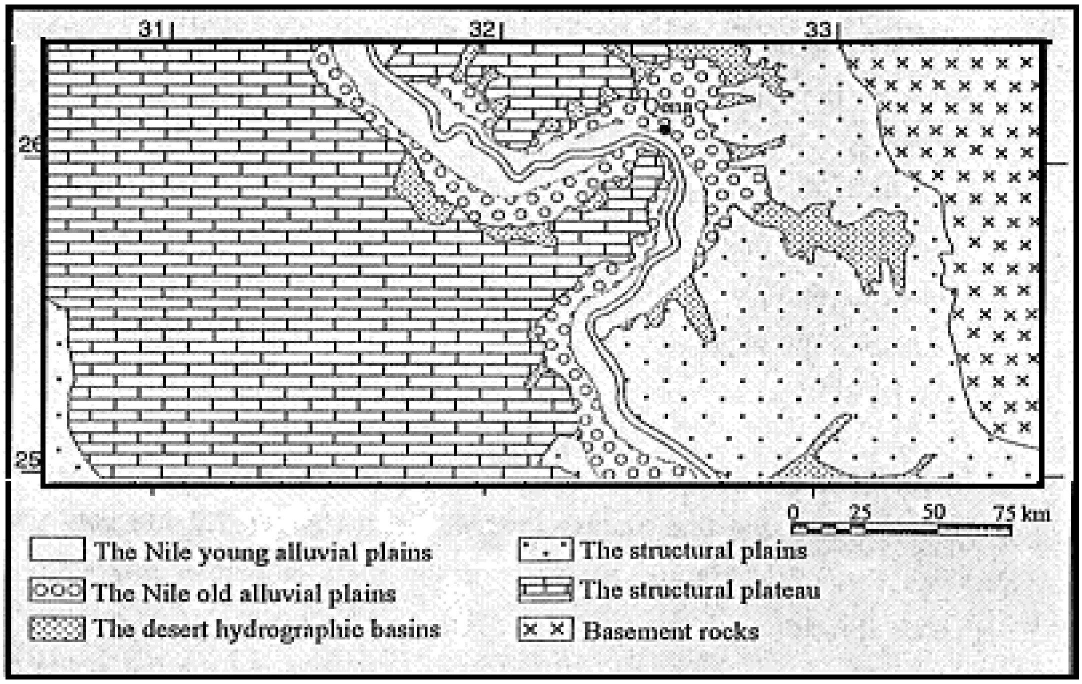

Figure 1. A map of geomorphological features Qena governorate

Ground Water System

Qena region represents an area of most extensive groundwater resources in the upper Egypt, where considerable amounts of groundwater have been exploited and used in the reclamation. Groundwater is very important source for drinking, irrigation and domestic uses in the study area for both rural and urban and it varies from the first to second source of water with the Nile water in the study area based on the agricultural use. There are three main groundwater aquifers in Qena governorate, namely, the upper Cretaceous Nubia sandstone aquifer, Eocene fissured Limestone aquifer and the Quaternary alluvial aquifer (Mahmoud, 2005).

Quaternary Alluvial Aquifer

The Quaternary aquifer represents the most important groundwater aquifer in the area. It is essentially restricted to the Nile valley and also to the bottom of the adjacent Desert wadies. It is mainly consists of graded sands and gravels overlain in the majority of the region, by semi-permeable (semi-confining) silty clay layer (Holocene age), and underlain in some locations by impermeable compact Pliocene plastic clays (very low hydraulic conductivity). Generally, the water in this aquifer is found under semi-confined conditions (under the cultivated area) and unconfined conditions (under the reclaimed area) where the overlay Nile silts layer is absent. The thickness of the groundwater bearing layer (sediments) is different from one location to another within the aquifer. The hydraulic conductivity of the aquifer which is determined from the pumping test ranges from 30 to 100 m/day, with regional average of 50 m/day.

The silty clay layer (upper aquiclude), constitutes the base of the fertile soil being under the extension of the cultivated lands, this layer decreases and finishes in the fringes where the desert sand is prevailed. It has low horizontal and vertical permeability ranges between 0.40 and 1.00 m/day. Values of the regional horizontal and vertical hydraulic conductivity of this layer (clay silt layer) are 0.4 and 0.02 m / day, respectively

The sand gravel layer (aquifer) (the water bearing layer) is mainly composed of graded sand and gravel, It is characterized by thick coarse and well permeable gravely sand deposits that consist mainly of quarts rock fragments of granitic origin and rare carbonate fragments, their thickness ranges from 20 m to 300 m (the maximum thickness is generally near the center of the valley, and reduces towards its edges) (RIGW, 1988).

The thickness of the aquifer increases in the old cultivated land, where it varies between 50 and 70m. The thickness of the aquifer decrease to ward the desert fringes, where it varies between 11 to 20 m at Aswan governorates, generally, the thickness of the Nile valley aquifer increases to ward the course of the Nile valley. Also, it increases from the south to the north parts of the studied area well be outlined (Hamdan, 2005). The depth to ground water generally ranges between 3.0 m and 35 m, the depth to the groundwater at the desert fringes ranges between 7.0 m and 35m while at the flood plane area it ranges between 3.0m and 29 m, the ground water at the desert fringes is deeper than that at the flood plain area. the depth to the ground water is generally increases east ward and west ward of the Nile river "from flood plain area to the desert fringe" which can be related to the high ground surface of the desert fringes relative to the flood plain area. The depth to the groundwater decreases from south to north in the Qena governorate (Hamdan, 2005).

In this study, the groundwater of an alluvium and desert soils where intensive agricultural activities take place were geochemically investigated to evaluate the factors regulating the groundwater quality.

Material and Methods

Qena governorate area represent the South Egypt was divided into 20 sectors that were taken across the Nile valley from the west to the east. A total of 118 sampling sites were collected from the concerned land uses. Regarding the cultivated floodplain and the reclaimed desert lands, a well-constrained Global Positioning System (GPS) was used to navigate and locate the sampling sites accurately. The geographic distribution of the sampling sites is displayed in fig (2).

Water Sampling

Samples were collected from the wells used for irrigation either alluvium and desert reclaimed areas. Two bottles were prepared for each sampling site. One liter and 100 ml bottles were used for collecting water samples for chemical and heavy metal analyses. The bottles were filled during the direct flow of the groundwater of each well using the well pump. For water samples of the deep wells the water was allowed to flow for few minutes and then the sampling were taken. As a general rule the bottles were first rinsed with the water intended for sampling and then filled completely. Water samples of 100 ml were acidified using 1 ml of concentrated analytical nitric acid to be analyzed for the heavy metals. All the collected water samples were placed in an ice box and carried to the laboratory where they were kept in the refrigerator until analysis.

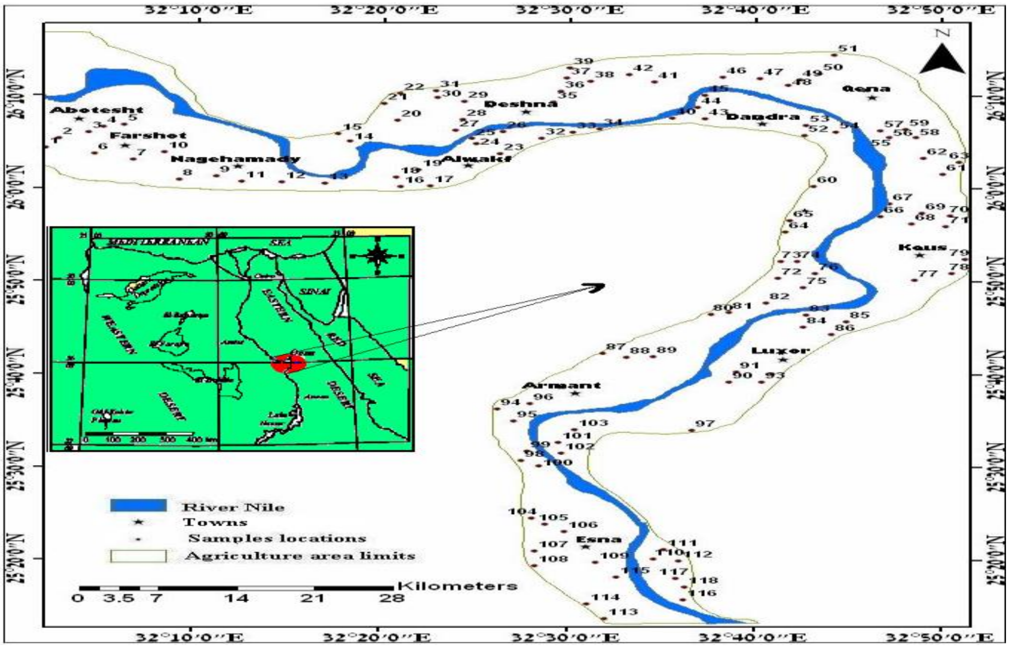

Fig. 2. The map of studied area and the sites of samples

All samples were filtered at 0.45 Am and stored either without additives or acidified to pH 2 with ultrapure HNO_3 for major cations and trace-element determinations. Conductivity and pH, were determined using Mettler instruments Orion pH electrode with automatic temperature compensation. Total alkalinity was also measured by titration with HCl, and the equivalent point determined according to Gran (1952). Major cation (Na and K,) concentrations were determined by flame photometer. Total metal concentrations of Cu, Pb, Zn, Cd and Mn trace elements were also performed with AAS with analytical precision was 5%.

Data preparation and GIS analysis

The data was built using Arc GIS 9.2 (ESRI 2006) The available databases cover the semiconfined zone of the Quaternary aquifer underneath the old agricultural lands and the unconfined zone underneath the valley fringes (the newly reclaimed lands). The collected data are treated using ArcGIS for analysis and visualization (Zhang et al.1999).

Results and Discussion

Water reaction (pH)

The pH values in groundwater samples in study area ranged from 7.4 to 9. The created map of GIS has been classified into four classes, i.e. less than 7.5, 7.5 – 8.0, 8.0 – 8.5, and greater than 8.5 (Fig 3). The map showed that the groundwater, in the most wells (72.9% of wells), were moderate alkaline (pH values between 8 – 8.5).

High pH in groundwater is often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations. In addition, 22.9% of wells are slightly alkaline water and they had pH values range between 7.5– 8. However, little percentage of wells lay in the range of non-alkaline water (less than 1% of wells) and severe alkaline water (3.5% of wells). (Hamdan, 2005 and Mahmoud, 2005).

Results of the water analysis indicate that groundwater in the study area have EC value varied widely from one location to another and ranged from 342 to 11120 uS/m. The created map of GIS (John et al 2003) shows the EC_w is low closer to the Nile River, and it increase as one moves into desert (Fig. 3). The EC_w values ranged between 250 – 750 uS/m were obtained in Nagehamady county which represents about 4% from the study area and the EC_w value ranged between 750 – 2250 uS/m were obtained in the Northern regions of Qena governorate in Farshot and Abu Tesht county as well as in the South region of Qena governorate in Armant and Esna county which represents about 41% from the study area.

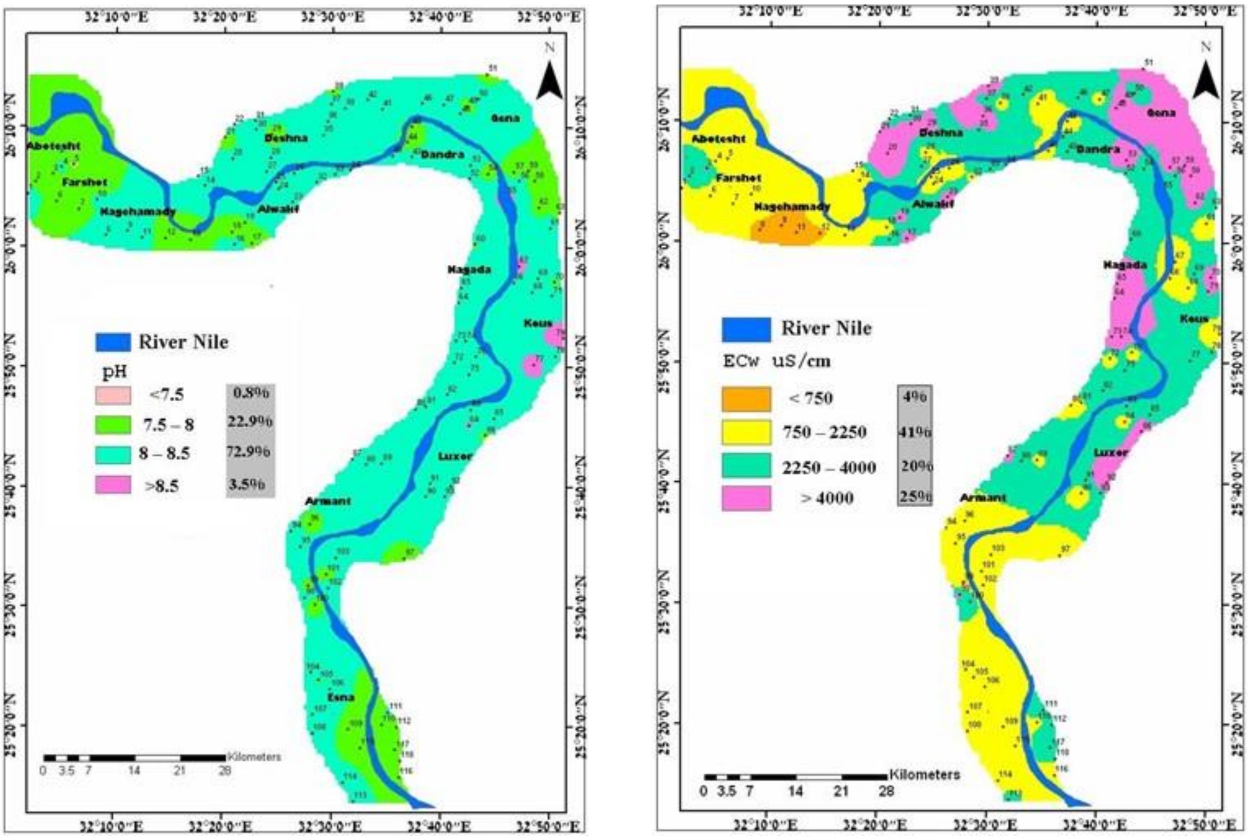

Fig. 3. The created GIS map of pH and ECw of the studied water samples

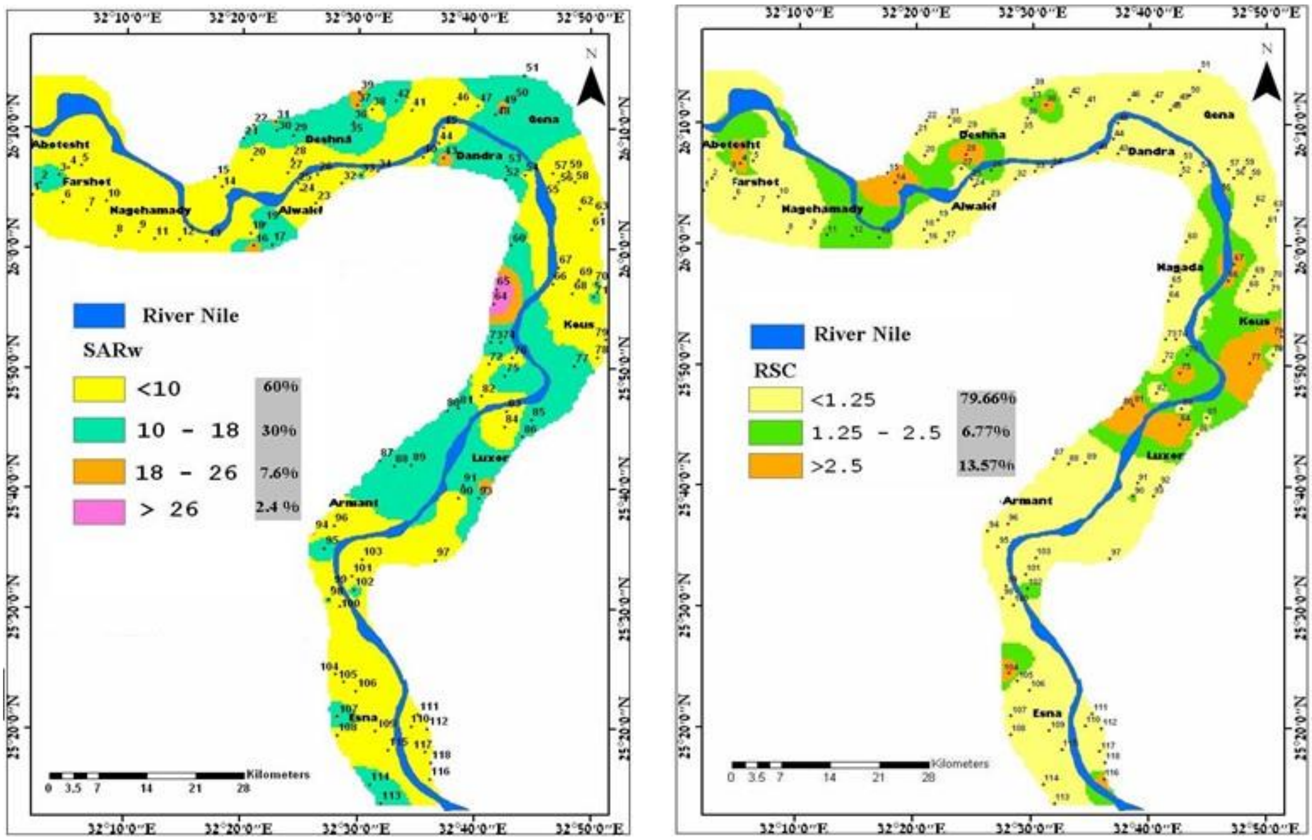

Fig. 4. The created GIS map of SAR and RSC of the studied water samples

The values of EC_w ranged between 2250 – 4000 uS /m and higher than 4000 uS/m were found in the desert areas as well as in some nearby areas from the Nile which represents about 45% from the study area (Clarke, et al., 2004). Values of EC_w decreased in the samples collected from wells of the cultivated lands and in the location near the River Nile, due to the infiltration from the surface water through canals and irrigation water (Farrag, 2000 and 2003). While the EC_w values increase towards the desert and reclaimed lands which can be attribute to the initially groundwater irrigates the reclamation lands is relatively saline, large amounts of the irrigation water is lost by evaporation and avapo-transpiration where the dissolved salts are accumulate in the remaining water that recharge the aquifer again; leaching of fertilizers and natural mineral already present in the desert soil (as gypsum $CaSO_4$ and halite NaCl) caries them into the aquifer; the new reclaimed areas are mainly covered by sands and gravels, therefore the percolation rate of the water is extremely high. Consequently, the leaching process of the surface soil can increase the salt content of the groundwater. Increasing the EC_w values in some wells near the Nile could be explained by the shallow deep of wells and the absence of drainage projects in these areas. This lead to the leakages of drainage water to these wells which lead to the raise the salinity of these wells. Moreover, the maps showed that the EC_w value is higher in the north than in the south of the studied area. This may be due to the flow of groundwater from the south to north carrying the soluble salts with the water. The movement of the groundwater can be attributed to the variation in the topography of the study area. Moreover, the evaporation usually increases from north to south that may be related to large amount of the irrigation water is lost by evaporation and evapotranspiration in the north area where the dissolved salts are concentrated in the remaining water that recharge the aquifer again. In some north areas: Nagehamady, Farshot and Abotesht county, the obtained low EC_w may be due to slow rate of the water flow of the River Nile in these areas which leads to raise the infiltration from the surface water of the River Nile. These results agree with those obtained by (Hamdan, 2005; Mahmoud, 2005: Bauder et al., 2006)

Values of SAR ranged from 0.02 to 38.3. The created map of SAR_w by GIS (Fig 4) shows the distribution of SAR values in groundwater samples. The data showed that SAR less than 10, 10-18, 18-26, and more than 26 were 60%, 30%, 7.6% and 2.4% of the studied wells, respectively .The samples with RSC less than 1.25, 1.25-2.5 and more than 2.5 were 79.7, 6.8 and 13.6% of the studied wells, respectively, (Murtaza, et al. 2005). The negative effects of bicarbonate and carbonate are negated by high levels of Ca^{2+} and Mg^{2+}. To take this into account, the RSC equation is used to indicate the potential for Ca^{2+} and Mg^{2+} precipitation at the soil surface and removal of Ca^{2+} and Mg^{2+} from the soil solution. As RSC increases, much of the calcium and some magnesium is precipitated from the solution when water is applied to soil, increasing the sodium percentages and the rate of sorption of sodium on soil particles which increases the potential for a sodium hazard.

Sodium (Na^+) and potassium (K^+).

Sodium concentration in the groundwater samples in the study area ranged from 0.03 to 102.74 mmol L^{-1}. The created map of Na^+ by GIS (Fig 5) showed that the groundwater samples with Na^+ concentration less than 5, 5 - 10, 10 – 15, 15 – 20 and more than 20 mmol L^{-1} were 13.6, 12.7, 9.3% and 55% of the wells, respectively. However, it appears that Na^+ concentration increase to the east direction of the study area towards the cultivated or desert land. This may be attributed to the presence of halite deposits in the detritus deposits within the Quaternary aquifer as well as to the increase of evaporation from the water table as a reason of highest temperature. In addition, the increase of sodium concentrations in the study area under the urban and suburban sites may be due to the sewage and livestock wastes which reach the groundwater through vertical infiltration, the use of organic fertilizers and the industrial wastes.

The results showed that, K concentration of the groundwater samples in the study area ranged from 0.11 to 1.43 mmol L^{-1}. The created map of K^+ by GIS (Fig.5) shows the high concentration of K was found in cultivated areas and in the areas near the River Nile may be attributed to the presence of clay in the Quaternary aquifer materials as well as to intensive use of fertilizers, especially with the flood system of irrigation and with some crops like sugarcane. Accumulation of fertilizers from year to year it is expected to exhibit a high concentration of K as same as other elements. (Hamdan, 2005; Mahmoud, 2005).

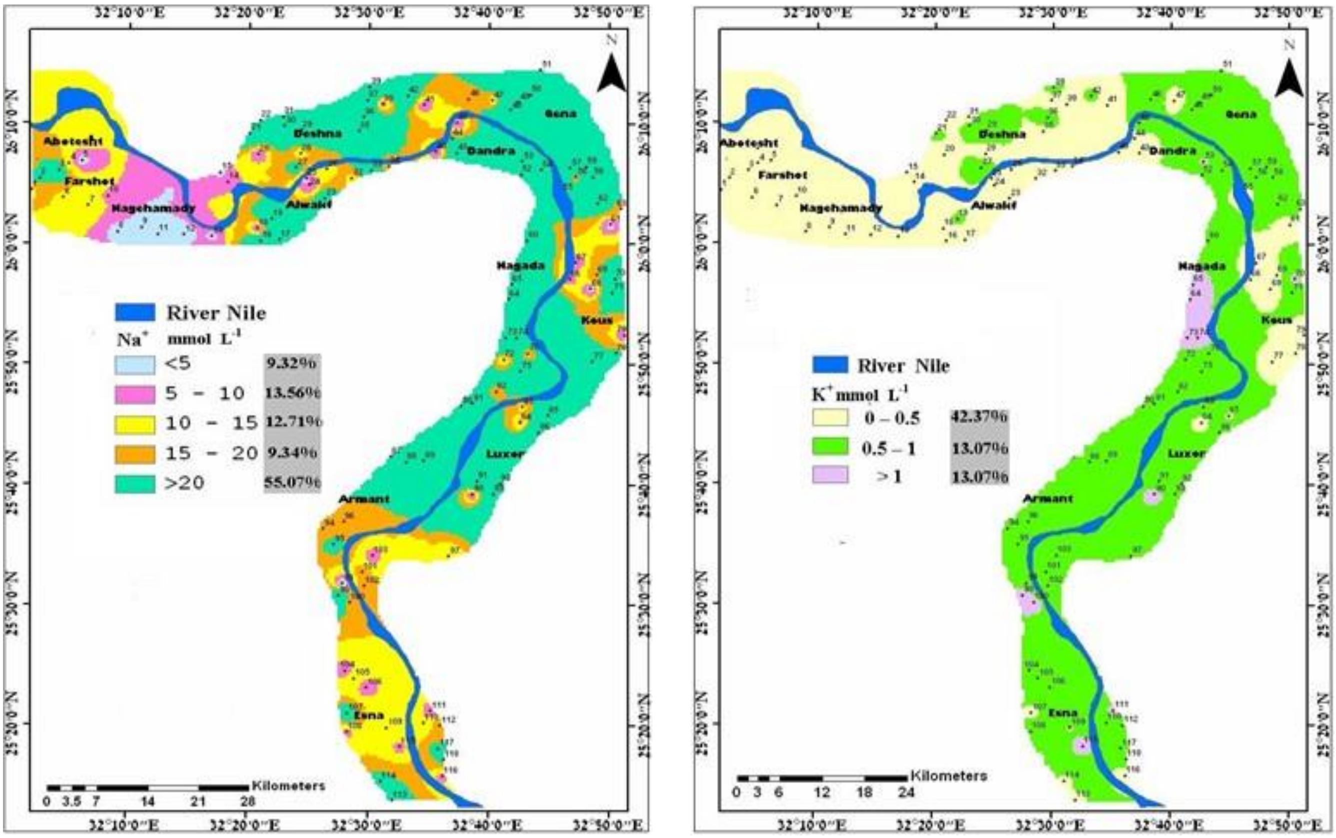

Fig. 5. The created GIS map of Na and K of the studied water samples

Calcium (Ca^{2+}).

Concentration of Ca^{+2} in groundwater samples ranged from 0.35 to 10.75 mmol L^{-1}. The created map of Calcium Ca^{+2} by GIS (Fig. 6) shows the distribution of Ca^{+2} concentration in groundwater samples. The map is classified into five classes (less than 2.5, 2.5 - 5, 5 - 7.5, 7.5–10 and more than 10 mmol L^{-1}). The map showed that calcium concentration increase to the east direction of the study area towards the reclaimed or desert land where the dissolution of the limestone plateau near the areas as well as to the leaching processes of carbonate materials to the aquifer. On other hand, calcium concentration in the cultivated lands showed a low concentration. This may be attributed to the high mixing and recharge from the irrigation canals and the agriculture water.

The created map of Mg^{+2} by GIS (Fig. 6) shows the distribution of Mg^{+2} concentration in groundwater samples. Magnesium concentration of the groundwater samples in the study area ranged from 0.35 to 10.75 mmol L^{-1}. The Mg concentration increase to the east direction of the Qena governorate towards the cultivated or desert land where the limestone plateau and due to the dissolution of carbonate minerals (dolomite). (Hamdan, 2005 and Mahmoud, 2005).

The concentration of bicarbonate in studied groundwater samples ranged from 0.2 to 60.6 mmol L^{-1}.

The created map of bicarbonate by GIS (Fig. 7) contain distribution of the Bicarbonate concentration of the groundwater in Qena governorate has been classified into three classes according to degree of restriction on use (less than 1.5: non, 1.5 – 8.5: slight and more than 8.5 mmol L^{-1}: severe for irrigation) (FAO, 1985).

Moreover, the data showed that the groundwater samples with bicarbonate concentrations less than 1.5, 1.5 – 8.5 and more than 8.5 mmol L^{-1} were 3.38%, 59.32% and 37.3% of the wells, under study respectively. There are two measurements used for assessing the carbonate level of irrigation water, the direct measurement of carbonate and bicarbonate and the residual sodium carbonate (RSC). Carbonate levels alone are sometimes used to assess potential limitations of an irrigation water source. When the sum of carbonate and bicarbonate expressed as mmol L^{-1} exceed 1.5 then problems related to calcium carbonate precipitation may occur (James, 2001). When carbonates exceed 8.5 mmol L^{-1} these problems may be severe. Bicarbonate and carbonate are good indicators of hazard when irrigation water Ca^{2+} and Mg^{2+} concentrations are low, but the RSC equation should be utilized when water Ca^{2+} and Mg^{2+} are high (James, 2001). In addition, bicarbonate concentration increase to the east side from the Nile valley towards the reclaimed or desert land. This may be attributed to solution of carbonate minerals (calcite and dolomite) present in the alluvial deposits. Limestone is common bedrock throughout in the most part from the east side to study area (the limestone plateau). These results agree with those obtained by (Hamdan, 2005 and Mahmoud, 2005).

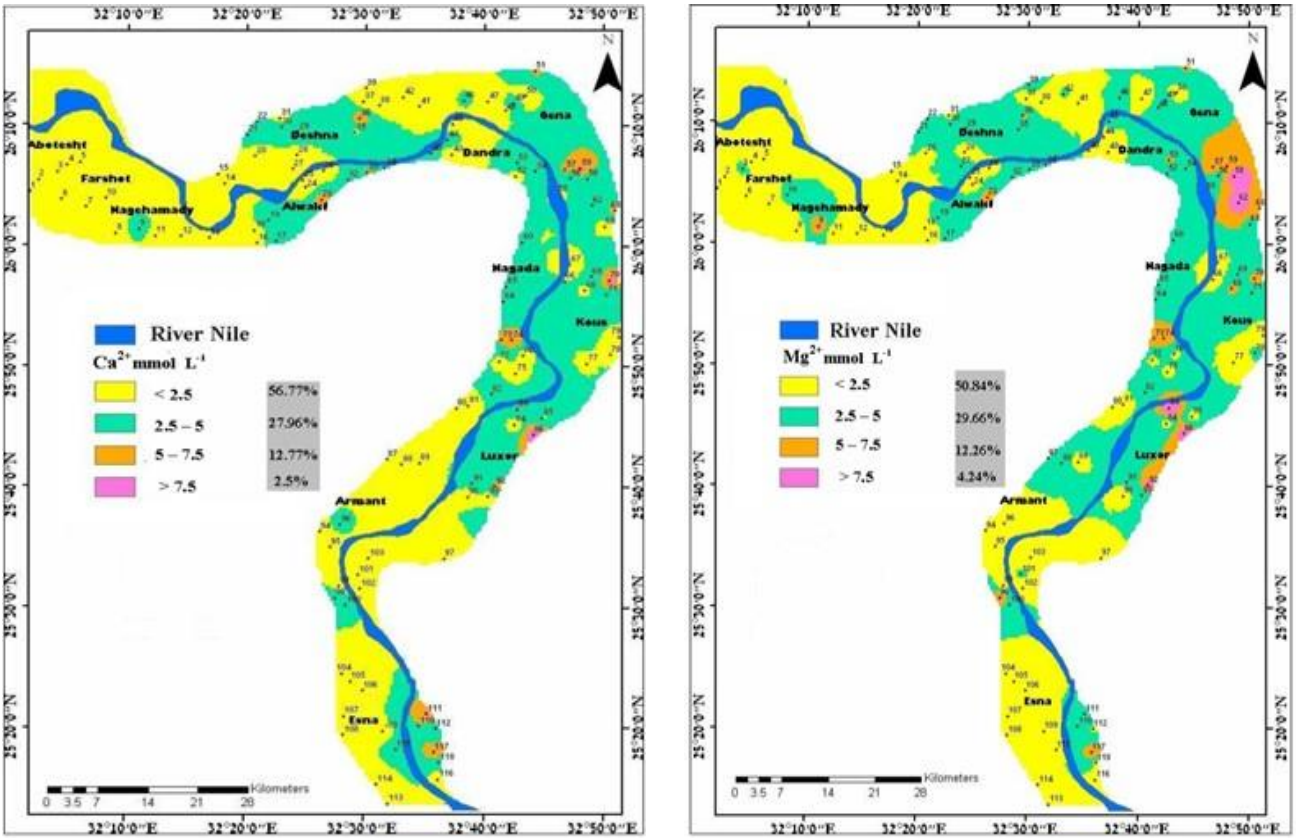

Fig. 6. The created GIS map of Ca and Mg of the studied water samples

Chloride concentration of the groundwater samples in study area ranged between 0.6 to 59.8 mmol L^{-1}. The created map of Chloride by GIS (Fig. 7) shows the chloride concentration in groundwater samples in Qena governorate. Chloride concentration map is classified into three classes according to degree of restriction on use (less than 4: none, 4 – 10: slight to moderate, and more than 10 mmol L^{-1}: severe for irrigation) according to (FAO 1985). Moreover, the data showed that the groundwater samples with chloride concentration less than 4, 4 – 10 and more than 10 mmol L^{-1} were 25.43, 46.61 and 22.96% of the wells, respectively.

It was observed that the concentration of Cl^- increase in most wells in the west and east directions of the study area towards the reclaimed or desert lands. This is due to the presence of halite deposits in the water bearing sediments and the increase of evaporation in the desert land. Moreover, the heaviest application of fertilizer is may account for the higher concentration of chloride in the samples under the agricultural lands.

Natural sources of sulfate in water include the weathering of sulfur bearing minerals, such as pyrite and gypsum. Further additions of sulfate to groundwater arise from the breakdown of organic substances in the soil, from the addition of leachable sulfates in fertilizers, and from other human-related sources include industrial discharges to both streams and the atmosphere, the combustion of fossil fuels, such as coal and gasoline, septic tanks and waste water (Hem, 1992).

The results showed that sulfate concentration in the groundwater samples in the study area ranged from 0.02 to 26.7 mmol L^{-1} . The created map of sulfate by GIS (Fig. 8) contains distribution of the sulfate concentration in groundwater in Qena governorate. Sulfate concentration classified into four classes (less than 1.5, 1.5 – 3, 3 – 4.5 and more than 4.5 mmol L^{-1}). It was observed that the sulfate concentration increase to the east direction of the study area towards the cultivated or desert land. This is due to the presence of gypsum deposits in the deposits within the Quaternary aquifer. Increasing of sulfate concentration in some parts of the study area is a result of the high using of fertilizers and in some municipal wells are domestic wells. This is due to their location under urban areas where the contamination of groundwater with the livestock wastes as well as to a high concentration of sulfate in sewage.

Examination of the data revealed that Na^+ was the most dominant cations followed by Mg^{2+} , then Ca^{2+}, and last K.$^+$ the anionic concentration reflect that Cl^- were the most dominant anions followed by CO_3+HCO_3 and SO_4 it also shows that the ionic composition of all water samples are related to the electrical conductivity values.

Distribution and concentration of Nitrate in the Groundwater

The obtained data showed that the concentrations of nitrate (NO_3^-) in the groundwater samples in the study area ranged from 0 to 274.9 mg L^{-1}. The GIS map (Fig. 8) showed that the groundwater samples with nitrate concentration less than 0, 10 – 45 and more than 45 mg L^{-1} were 17 , 27 and 56% of the wells, respectively.

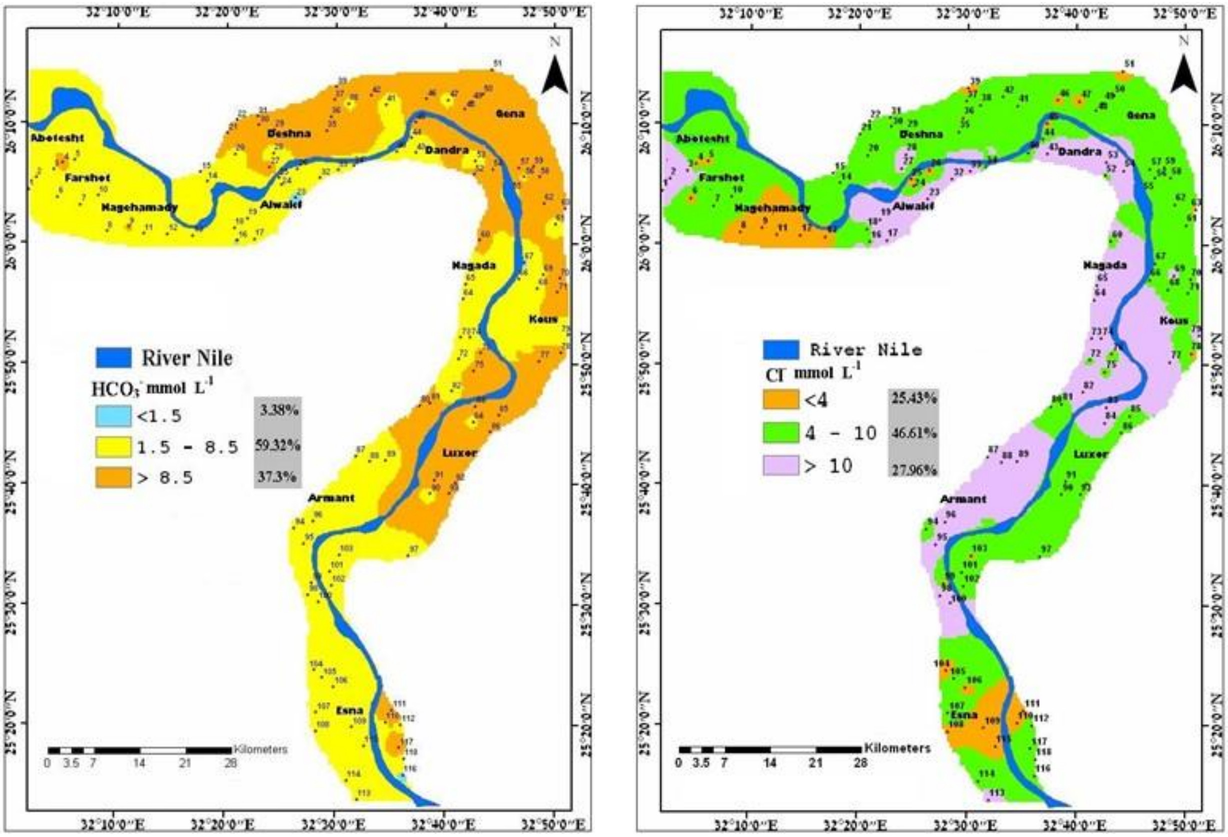

Fig. 7. The created GIS map of HCO_3^- and Cl^- of the studied water samples

It was observed that nitrate concentrations in most wells of study area (about 73% of the wells) were more than 10 mg/L. These concentrations are higher than the permissible concentration limits for recommendations for drinking water according to (WHO, 2004; Jack Arendt, 2002). Moreover, 56% of the wells have nitrate concentrations more than 45 mg/L. These concentrations were higher than the permissible limit of nitrate in drinking water for livestock and poultry, according to United States Public Health Service (USPHS, 1996; Mohamed and Abraham. 2004.).

In addition the data observed that nitrate concentration increase generally in most locations of study area towards the reclaimed land. This can be explained by the intensive agricultural activities, where a large part of the farmlands in the areas and excessive use of nitrogen fertilizers, pesticides and the large quantities of organic fertilizers (manure) application. This lead to a greater concentration of nitrate in groundwater. These results agree with those obtained by (Kelin at al 2005;).

Nitrate can easily infiltrate into the deeper part of the sand aquifer. Under this condition, groundwater generally shows high nitrate levels. Therefore, rapid infiltration of the nitrogen-rich waters into the groundwater system that is under an aerobic condition seems to be the major cause of the high nitrate levels in the reclaimed area, where the sandy aquifer (Gi-Tak, C. K. Kangjoo and Y. Seong-Taek, 2004). In the northern eastern part of the study area (some wells had nitrate contents over the allowable limit) than wells located under the sugarcane and wheat areas in the north of the study area, in those areas where we find that the concentration of nitrate is low this could be due to several reasons, including that most of these areas prime plants wheat and sugarcane those plants have been high consumption of fertilizers, as well as lack of fertilizer rates addition compared with vegetable crops and increase the proportion silt and clay in the texture of these areas all of these factors lead to a lack of quantity of nitrate leaked into groundwater. In some of those areas, the high concentration of nitrate may be due to the lack of a agricultural drainage in those areas and the low depth of the wells that lead to a rise in opportunity of access for agricultural drainage water and wastewater as well as regional sewage in the vicinity of residential areas these water are rich in nitrate. These results agree with those obtained by (College of agricultural sciences. 2002 and Mahmoud, 2005).

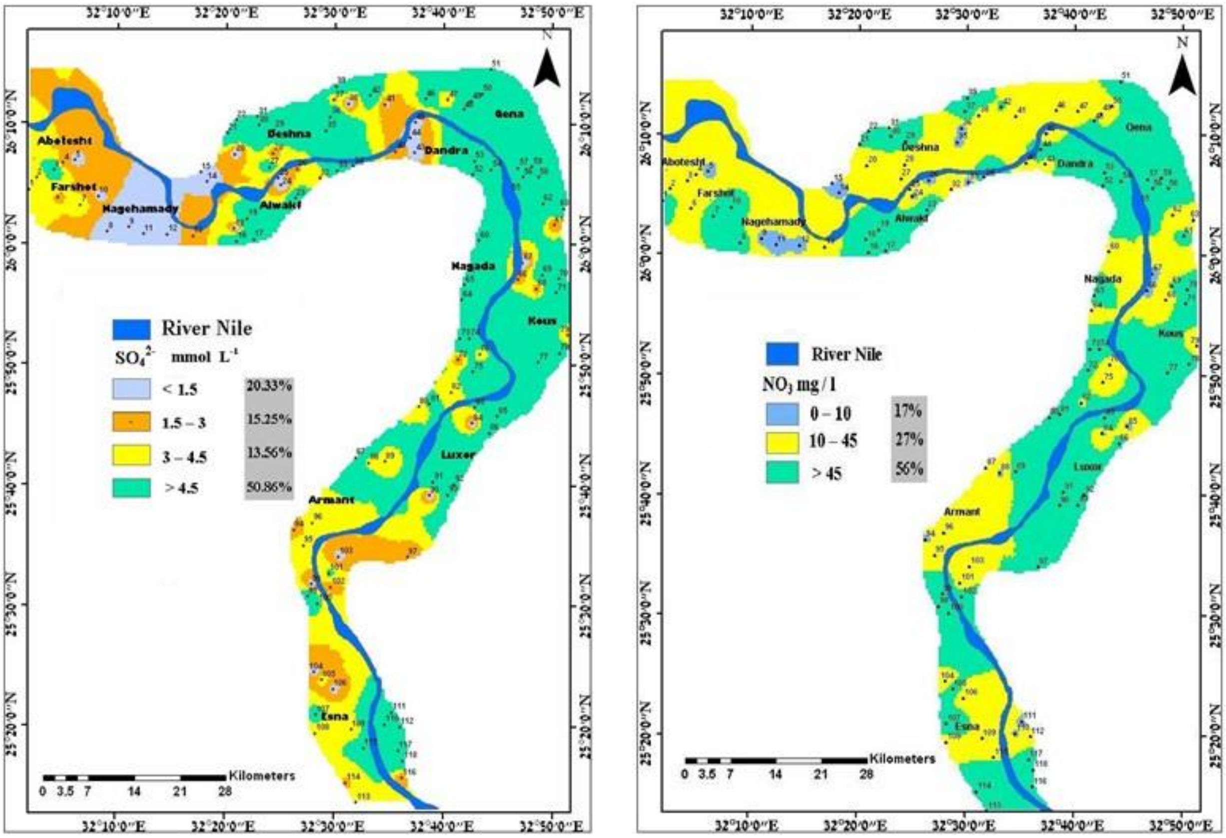

Fig. 8. The created GIS map of SO_4^{+2} and NO_3^- of the studied water samples

Without a reduction in nitrate loading to groundwater, nitrate concentration in the groundwater will likely increase and nitrate pollution will likely affect larger areas and larger volumes of groundwater and surface water. The net effect is that the average nitrate concentration in groundwater of the study area will likely continue to increase. To minimize the nitrate pollution of the groundwater, best management practices for N-fertilizer should be disseminated and applied and excessive fertilizer application prevented. Therefore, increasing the awareness of the negative effects of excessive N-fertilizer on the environment should be taken into account.

Trace and heavy metals in the groundwater:

The concentration of Fe in the groundwater samples in the study area ranged from 0 to 4.35 mg / L. In most wells, the concentration of Fe in the groundwater samples ranged from 0 to 1.8 mg/L with an average of 0.4 mg/L. Although Fe is the second most abundant element in the Earth's outer crust, Fe present in wells water generally are small. The presence of Fe in natural water can be attributed to the dissolution of rocks and minerals (pyrite, magnetite and sidrite), acid mine drainage, landfill leachates, sewage and engineering industries. The data showed that the concentration of Fe in all location did not exceed the permissible concentration limits for irrigation water (5 mg/L). According to (National academy of Sciences1972; Pratt (1972). However, about 44% of the wells had Fe content higher than the permissible limit for drinking water recommendation (more than 0.3 mg/L) according to (WHO, 2004).

Manganese resembles Fe in its chemical behavior and in its occurrence in natural water. Iron and Mn often occur together in groundwater but Mn usually occur in much lower concentration. The results showed that Mn concentration in the groundwater samples in the study area ranged from to 0.98 mg / L (Fig. 9).

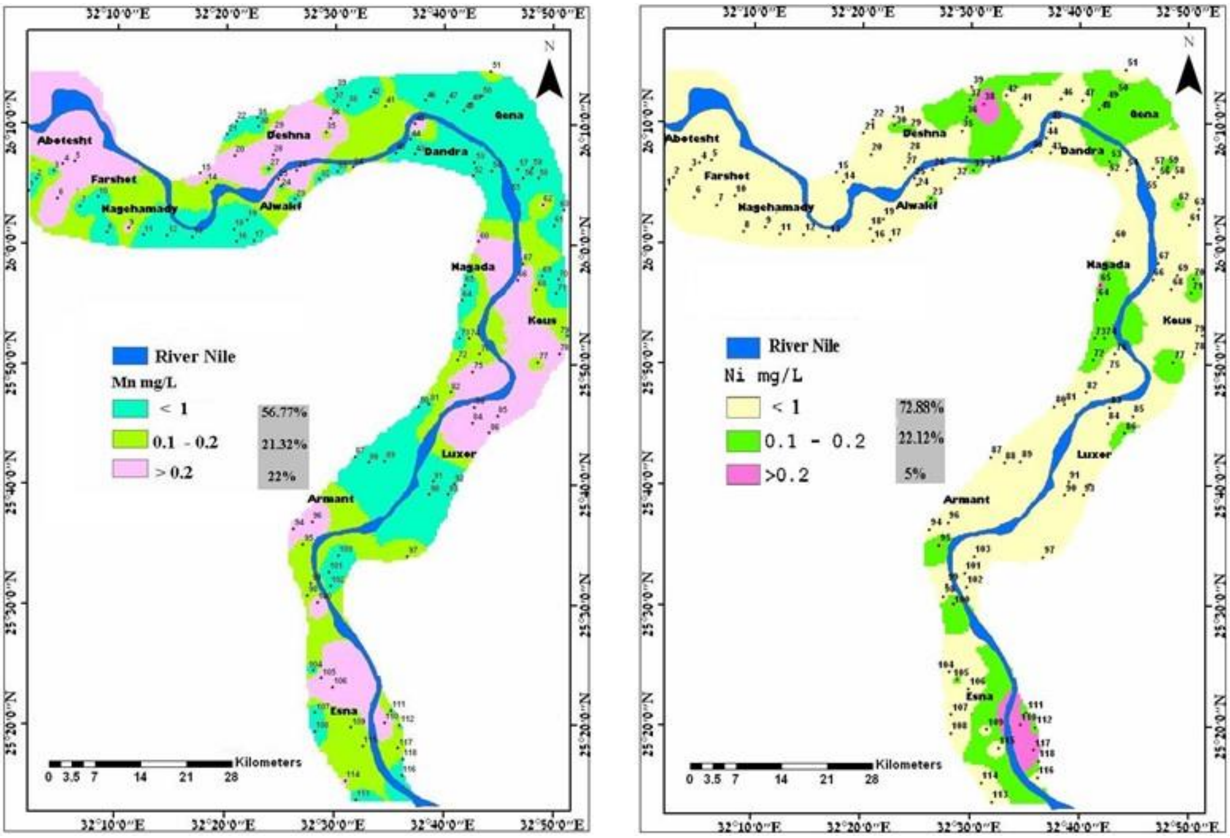

Fig. 9. Created of GIS map of Mn and Ni of the studied water samples

It was observed that, in 22% of wells, the concentration of Mn were higher than the permissible limit of irrigation water (0.2 mg/L). According to (National academy of Sciences 1972; El-Arby and Elbordiny. 2006). In addition, 48% of the wells had Mn content higher than the permissible limit of drinking water recommendations (0.05 mg/L.) according to (WHO, 2004). The GIS map showed that the Mn concentration were higher under the cultivated areas than those under the reclaimed lands. This can be explained by the high content of the silt and clay in the cultivated land. Another effects varying from point sources (the effects of land spreading of sewage and septic system) to non-point sources of groundwater contamination (fertilizers and pesticides), Mahmoud, (2005). Nickel content in the groundwater samples from the study area ranged from below detection limit of AAS. to 0.87 mg / L (Fig. 9). It was found that, Ni concentration is nearly uniformly in the study area and increased near the urban areas where sewage is spreading over the land due to, its content of Ni from the urban places. The concentration of Ni, in about 5% of wells, was higher than the permissible limits of irrigation water (0.2 mg/L). According to (National academy of Sciences,1972; and Pratt ,1972). Zinc concentration of the studied groundwater samples in the study area ranged from below detection limit of AAS. to 0.5 mg / L (max.). It was observed that the concentration of Zinc (Zn) in all groundwater samples was in the permissible concentration limits of irrigation water (2 mg/L). The all wells have Zn concentration less than the permissible limits of drinking water recommendation (3 mg/L) WHO (1996). It was found that the concentration of Zn is increased towards the cultivated land. This may be due to the intensive uses of the organic manure and chemical fertilizers in agriculture. These results agree with those obtained by (EL- Sebaey, 1995; Mahmoud, 2005). Lead (Pb) concentration of the studied of the groundwater samples in the study area ranged from below detection limit of AAS. to 0.55 mg / L. Generally, the concentration of lead (Pb) in all wells were less than the permissible concentration limits for irrigation water

(5 mg/L). According to National academy of Sciences 1972; Pratt 1972). With the exception of two wells (3 and 88), the wells had higher lead (Pb) concentration than the permissible concentration limits of drinking water recommendations (0.015mg/L). According to WHO (2004). Copper are not detected in the groundwater samples in the studied area (below the detection limit of AAS.).

References

Bauder, T.A., R.M. Waskom, and J. G. Davis. 2006. Irrigation water quality criteria. Colorado State University Extension. No. 0.506. vailable at: http://www.ext.colostate.edu/PUBS/crops/00506.html Bolstad, p. 2005. "GIS Fundamentals. A First Text on Geographic Information System "Book masters dist, p 543.

Clarke, K.C., B.O. Parks, and M.P. Crane. 2004."Geographic information systems and environmental modeling", Asoke K. Ghosh. Prentic-Hall of India Private limited, New Dilhi, P. 306.

College of agricultural sciences. 2002. Irrigation water quality. The Pennsylvania State University, USA. (C. F. Mahmoud, 2005)

EL- Sebaey, M.M.M. 1995. Studies on chemical pollution of different water with some heavy metals in Fayoum Governorate. M.Sc. Thesis, Fac. of Agric., Moshtohor, Zagazig Univ., Egypt.

El-Arby, A.M. and M.M. Elbordiny. 2006. Impact of reused wastewater for irrigation on availability of heavy metals in sandy soils and their uptake by plants. J. of Appl. Sci. Res., 2 (2): 106-111

FAO. 1985. Water Quality for Agriculture. FAO irrigation and Drainage Paper No. 29, Rome, Italy.

Farrag, R. M. F. 2000. Potential effects of low quality water for soil irrigation in EL Fayoum Governorate, Egypt. . M. Sc. Thesis, Fac. of Agric. at El Fayoum, Cairo Univ., Egypt.

Farrag, R. M. F. 2003. Land degradation as affected by irrigation water quality in El Fayoum Governorate. Ph.D Thesis, Fac. Of Agric. at El Fayoum, Cairo Univ., Egypt.

Gi-Tak, C. K. Kangjoo and Y. Seong-Taek. 2004. Hydrogeochemistry of alluvial groundwaters in an agricultural area: an implication for groundwater contamination susceptibility. Chemosphere, 55: 369-378.

Hamdan. A.M, 2005. Evaluation of the Nile valley aquifer from Aswan to Assiut using geophysical and hydrological method. Ph.D thesis, Fac. of Sci Geol. Dept., South Valley Univ., Egypt.

Hem, J.D. 1992. Study and interpretation of the chemical characteristics of natural water, (3d ed.): U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Jack Arendt, R.G. 2002. Nitrate in drinking water, DEQ. State of Oregon, department of environmental Quality Western Region groundwater program. http://www.deq.state.or.us/wq/pubs/factsheets/groundwater/nitrated w.pdf)

Jackson, M.L. 1973. Soil chemical analysis. Prentice-Hall, Inc., Englewood Cliffs. NJ, USA.

James, C. 2001. Irrigation water quality. Clemson University, turfgrass program. (C.F. Mahmoud, 2005)

John, P. W., H. Mitasova, and D. Wright. 2003. Water resource applications of GIS. Urisa. Journal [On-line], (Version 1-5-00) Availableat: http://www.ucgis.org/priorities/research/research_white/1999%20Papers/water.html.

Kelin, H., H. yuangfang., L. Hong., L. Baoguo., C. Deli and R.E. White. 2005. Spatial variability of shallow groundwater level, electrical conductivity and nitrate concentration, and risk assessment of nitrate contamination in North China Plain. Environment International .J. 31: 896 – 903.

Mahmoud, A.M. 2005. Hydrogeological and hydrogeochemical evaluation of the area between Qena and qus, eastern desert, Egypt. M.Sc. thesis, Fac. of Sci Geol. Dept., South Valley Univ., Egypt.

Mohamed, A. and J. Abraham. 2004. Vulnerability of groundwater resources from agricultural activities in southern Kuwait. Agric. Water Manage. J., 64 (1):1–15.

Murtaza, G., A. Ghafoor and M. Qadir. 2005. Irrigation and soil management strategies for using saline-sodic water in a cotton-wheat rotation. Agric. Water Manage. 81: 98-114.

National Academy of Sciences and National Academy of Engineering. 1972. Water quality criteria. United States Environmental Protection Agency, Washington DC. Report No. EPA-R373-033. 592 p.

Pratt, P.F. 1972. Quality criteria for trace elements in irrigation waters. California Agricultural Experiment Station. 46 p.

RIGW, 1988. Development of groundwater for irrigation and drainage in the Nile valley and Delta. Technical note, Cairo, Egypt.

Said, R. 1981. The Geological evaluation of the River Nile. Springier-Verlage. Publi., New York. Ink. P. 151.

Said, R. 1991. Quaternary in Said. The Geology of Egypt. A. A. Balkema / Rotterdam / Brookfield, pp. 487-511.

Sharaf, m. a., M. H. Farag and M. Gazzaz. 1988. Groundwater Chemistry of Wadi Uoranah-Al Abdiah Area, Western Province, Saudi Arabia. Earth. Sci .JKAU., 1: 103 – 112.

Tisdale, S.L. and W.L. Nelson. 1975. Soil fertility and fertilizers. 3^{ed} ed. Collier-Macmillan, Canada.

United States Public Health Service (USPHS). 1996. Water quality for livestock and poultry, Drinking Water Standards, Timely, vigortone, Topic. 1010.

Viets, F.G. and W.L. Lindsay. 1973. Testing soils for Zn, Cu, Mn and Fe. P. 153-172. In L.M. Walsh and J.D. Beaton (eds.) Soil Testing and plant analysis. Soil Sci. Soc. Am. Inc., Madison, WI, USA.

WHO - World Health Organization, 1996. Guidelines for drinking Water quality, 2nd Edition. Vol. 2 Health criteria and other supporting information. Geneva: 940-949.

WHO - World Health Organization, 2004. Annual water quality report Municipal Utilities Board of Albertville, 210 west Main street, Albertville, Al 35950, 256-878-3761.

Zhang, N., E. Runquist, M. Schrock, J. Havlin, G. Kluitenburg and C. Redulla. 1999. Making GIS a versatile analytical tool for research in precision farming. Computers and Electronics in Agriculture, 22, 221-231.

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The anthropogenic sodium sulfate minerals as an intensification factor of wind erodibility of the soils in Segzi plain at the east of Esfahan, Iran

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Abstract

The soil control against wind erosion in Segzi is very important because of strategic location of this area that it is nearby some industrial estates. The soils with a soil moisture regime of aridic and a soil temperature regime of thermic, were classified as Gypsic haplosalids subgroups according to Soil Taxonomy. The soil subgroups of the soils have changed to Gypsic Aquisalids after leaching with agriculture surplus water in winter. The natural system of ($NaCl$, $CaSO_4.2H_2O$) in the soils has changed to secondary system of ($Na_2SO_4.10H_2O$, $CaCl_2$) after soil leaching for salt melioration in winter. In this research using chemical and physical analyses, micro morphology and Thermal analyses were resulted that the major factor in wind erosion of the soils is secondary sodium sulfate evaporates as thenardite and so mirabilite in Segzi. And so for control of wind erosion proposed to return to primary salt system adding $CaCl_2$ in soil system as first step of soil salinity melioration.

Keywords: Gypsic Haplosalids, Gypsic Aquisalids, Secondary sodium sulfate, wind erosion

Introduction

Segzi (Sagzi) plain is one of the eastern intensive wind erosion centers of Esfahan city. Therefore, soil stabilization and reinforcement of vegetation to restore the plantation to control wind erosion is a priority for combat desertification center of Esfahan natural recourses department. In this area, irrigation with recycled wastewater and sewage of Esfahan for preserving aquifers underground were done. Although according to Ayers and Westcot (1985) and Boll et al.(1986) using refined wastewater in irrigation, depending on geographical region can be either beneficial or harmful. Abedi-Kupai et al. (2000), in a study of the effects of sprinkler irrigation with treated wastewater on the soil surface were investigated. The results showed that the use of wastewater result in, reducing soil salinity (electrical conductivity of saturated soil paste extract). On the other hand, Hassan-Oghli et al, (2006) examined how changes in the electrical conductivity of the soil saturation as a result of irrigation with domestic wastewater and effluent showed that the use of waste water for irrigation and the cultivation of vegetables for two years, electrical conductivity of saturated soil increase in comparison with control. But Ansarinejad et al. (2010), in his investigation using wastewater found significant effect on increasing the rate of soil permeability in comparison with the use of well water. They showed and reported a positive effect of the wastewater for reclamation of Segzi vegetations and so they expressed that the use of wastewater for irrigation of saline and alkaline soils, has a significant impact on the plant growth. They observed a significant plant cover vitality and plant seedlings on the studied area.

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Movahedian and Afioni (2006), after the research on the effect of industrial wastewater and sewage sludge on soil properties, were observed that in all experimental treatments, the concentrations of heavy metals have been increased in 0 to 20 cm surface depth of the soils. According to Narimanian and Ansarinejad (2012) the segzi area has a mean annual rainfall of 99.6 mm and a potential annual evapotranspiration of 2210 mm. The combat desertification activities were created in the area from 1358 years for the area about 12,000 hectares by dry land forest planting with Haloxylon. Akhavan Ghalibaf(2002) and Akhavan Ghalibaf and Koohsari (2007) showed that shallow ground water containing sulfate ions in the presence of salts of sodium chloride, result in increasing of sodium sulfate concentration in soil surface , which is capable of causing Solonchaks with sulfate type. So it is able to create the kind of bloated salty desert. Because of wind erosion potentials in Segzi plain this research was defined for study of soil chemical variability to control salt systems in the soils for soil stability against wind erosion.

Material and Methods

The studied area located 35km east of Esfahan with a geographical coordinate interval; from 51° 58' E to 52° 3' E and from 32° 42' N to 32° 47' N. The research area pointed by an arrow in a circle in Fig. 1.

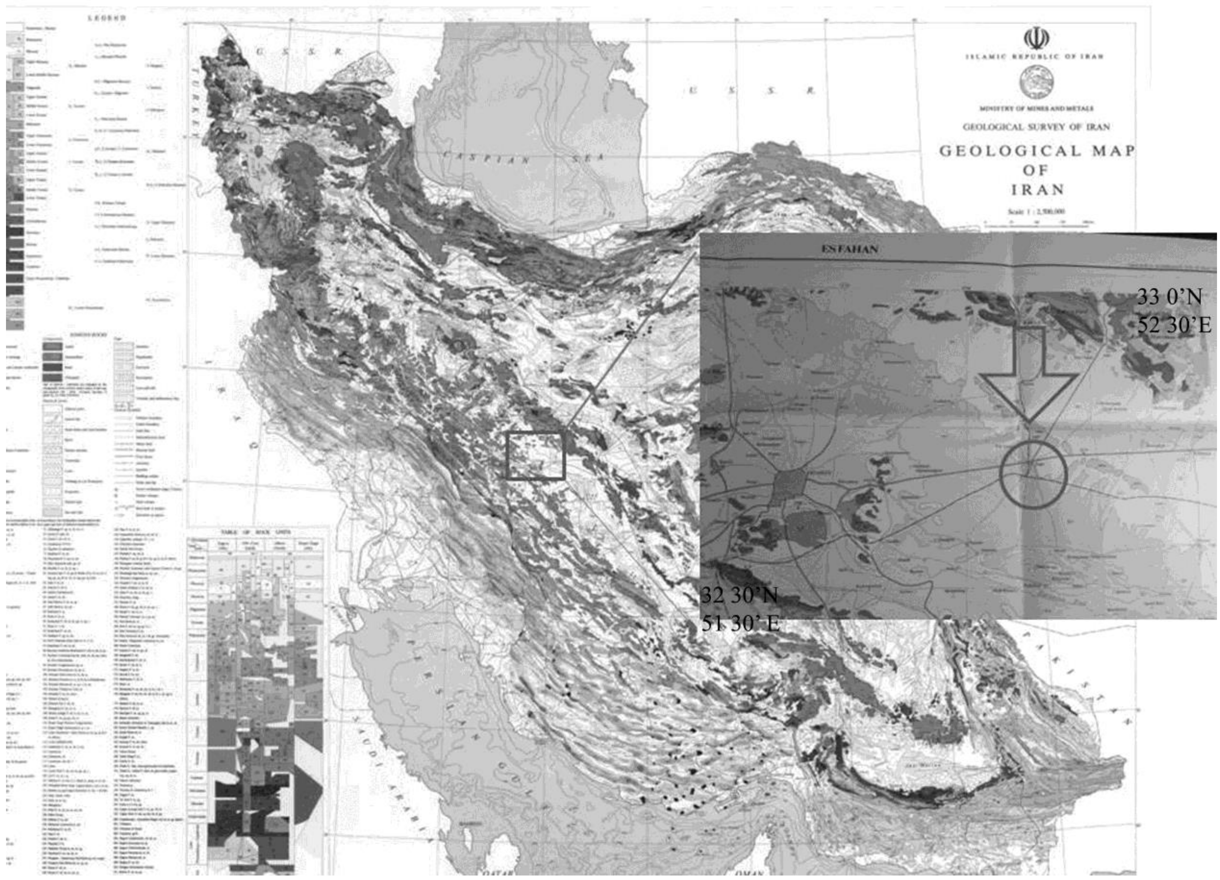

Fig. 1- The research area on the geological map of Iran with scale of 1:2500000 and on the geological map of Esfahan with scale of 1:250000.

The soil sampling with grid method was done in spring and summer of 2013. The routine chemical and physical analyses were done on the soils. Some soil crumbs from surface horizon of sample profiles were prepared for micro morphology study with hardening in resin and taking thin section from them. A surface sample of the soils was prepared for SEM analysis with VEGA 3 TESCAN instrument, from Czech republic. From evaporates on the soils thermo analyses were done with Bahr STA 503 instrument from Germany. Calculation of the salinity parameters were done with Russian method of V.A. Kovda by the its modified method in Pankova et al. (1996) in 1:5 soil and water extracts and so by American soil salinity laboratory,Keys to Soil Taxonomy(2010) in saturated soil paste extracts.

Results and Discussion

From the results of primary usual analyses, selected two sample profile. Profile 1 was a sample one for irrigated area with local ground water and profile 2 was a sample one for irrigated area with refined sewage water in winter. The anion types of the both waters sources are Sulfate-Chloride with a relation of chloride per sulfate equal to 1.5. The ground water has magnesium Cation type and refined waste water has calcium one. The soils have a light texture of sandy loam in surface and a medium to heavy texture of sandy clay loam to silty clay loams in sub surface horizons. From the granulometry analyses from sand fractions of the soil resulted in a low similarity between horizons in a profile there for they showed a litho logic discontinuity in all of profiles. According to geological map of Esfahan(Fig. 1) The soils have formed on the old alluvial and related to the granulometry can be resulted that the soils have the same origin with upper terraces of river alluvials of Zayanderood river where it's valley located 24km south of researched area. From the salinity types analyses in 1:5 soil and water extracts resulted in the soils of the both sample profiles are Solonchaks and because of increasing salinity in the surface horizons, they are Hydromorphic ones with Gypsonous Solonchaks (table 1 and 2). In table 3 has shown some chemical and physical properties from saturated soil paste which are with high SAR and EC. So these soils can be classified in Keys toSoil Taxonomy(2010) as Typic Aquasalids in profile 1 and Gypsic Aquasalids in profile 2. Salinity types in the profiles are sulfate anion type($Cl^-/SO_4^{2-}<0.2$) and Magnesium Sodium Cation type($2>Na^+/(Ca^{2+}+ Mg^{2+} >1$) and $Mg^{2+}>Ca^{2+}$) (Table1, 2 and 3).

Table 1. Ion contents in 1:5 soil and water extracts and some salinity parameters in Russian method.

		(meq/100gr) Anions			(meq/100gr) Cations						
Horizon	Depth (cm)	SO_4^{2-}	Cl^-	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-/ SO_4^{2-}	$Na^+/(Ca^{2+}+ Mg^{2+})$	%Total Soluble Salts
					Profile 1						
A_z	0-30	40.4	5.0	0.4	35.0	0.02	7.0	13.5	0.1	1.7	3.2
IIB	30-80	11.4	3.0	0.6	26.0	0.01	1.5	4.0	0.3	4.7	1.4
IIIC	80-120	28.5	2.0	0.2	19.5	0.01	1.5	15.5	0.1	1.1	2.1
					Profile 2						
A_z	0-40	36.3	4.0	0.4	30.0	0.01	9.0	16.0	0.1	1.2	3.0
IIB	40-55	14.2	3.0	0.4	20.0	0.01	5.0	14.5	0.2	1.0	1.5
IIIC	55-100	19.4	1.0	0.6	50.5	0.01	1.5	16.5	0.1	2.8	2.4

Table 2. Some of the chemical and physicochemical parameters in soil samples.

Horizon	Depth (cm)	pH(1:1)	EC, dS/m (1:5)	$\%CaSO_4.2H_2O$	$\%CaCO_3$	%O.M.
			Profile 1			
A_z	0-30	8.01	10.8	3.01	21.5	0.91
IIB	30-80	8.08	5.89	3.69	38.5	1.21
IIIC	80-120	7.73	5.51	1.28	15.0	0.6
			Profile 2			
A_z	0-40	8.01	9.82	7.2	33.0	1.18
IIB	40-55	7.91	7.19	1.83	42.0	1.23
IIIC	55-100	6.93	3.63	1.6	41.0	1.23

According to Fig. 2 in the thermo gram, endotherms of 100° C and 150° C for Gypsum are absent. But can be seen 118 ° C, 470 ° C and 874 ° C ones. Smykatz-Kloss(1974) , introduced the endotherms of 147 ° C, 215 ° C, 245 ° C and 890° C for Thenardites(Na_2SO_4). Doner and Lynn (1992) reported endotherms of 100 ° C and 548 ° C for Bloedite($Na2MgSO_4.4H2O$). Visible lack of endotherms in the range of 215 ˚ C or less demonstrate endotherms of 147 ° C as 118 in Segzi sample and an more quantity of 470˚ C instead 245˚ C one could be related to the exotherm extensive organic material between 200 and 400 ˚ C. Endotherm of 874 ° C, is more closed to the 890˚ C which provided by Smykatz-Kloss(1974) for Thenardites and it is far more related to endoterm of 548 ° C related to Bloedite.

Table 3. Ion contents in saturated soil paste extracts and some salinity parameters.

			Anions (meq/l)				Cations (meq/l)				
Horizon	Depth (cm)	SO_4^{2-}	Cl^-	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	SAR	*pH*	EC,dS/m
					Profile 1						
A_z	0-30	658.3	332.0	1.6	900.0	4.9	36.0	51.0	136.5	*8.21*	73.7
IIB	30-80	430.2	92.0	1.8	300.0	4.3	9.0	48.0	56.2	*8.27*	25.3
IIIC	80-120	265.6	48.0	1.4	80.0	4.3	15.0	44.0	14.7	*7.80*	19.5
					Profile 2						
A_z	0-40	576.8	274.0	2.2	600.0	3.4	38.0	82.0	77.5	*8.14*	64.5
IIB	40-55	151.9	104.0	1.4	340.0	4.3	18.0	46.5	59.9	*8.26*	29.2
IIIC	55-100	265.1	30.0	1.4	160.0	2.1	16.0	37.5	30.9	*8.02*	9.52

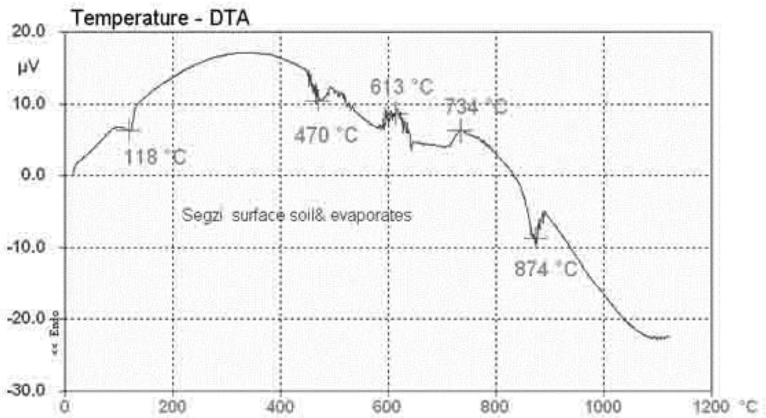

Fig. 2. Thermo gram of surface soil and evaporates in Segzi.

In the thin section from harden crumb (Fig. 3) can be seen filamentous Mirabilite minerals which sampling and preparation was done in cold season(early spring).

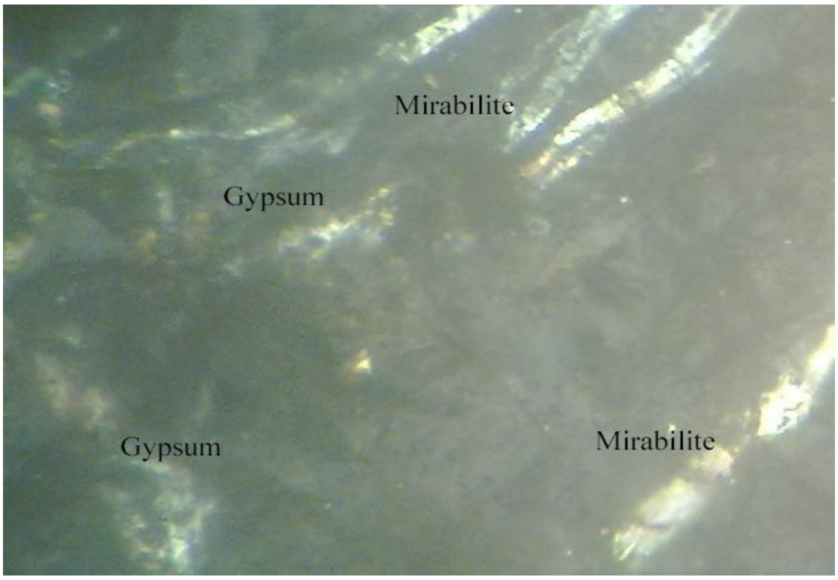

Fig. 3. Thin section under polarized microscope with II Nikol (400×).

The ESM image from Segzi evaporates at summer period of sampling when the soil surface temperature was above 27° C has shown in Fig. 4(left). For compression, this image has a similar shape with Thenardite image from Vidya and Lakshminarasappa(2014)(Fig. 4).

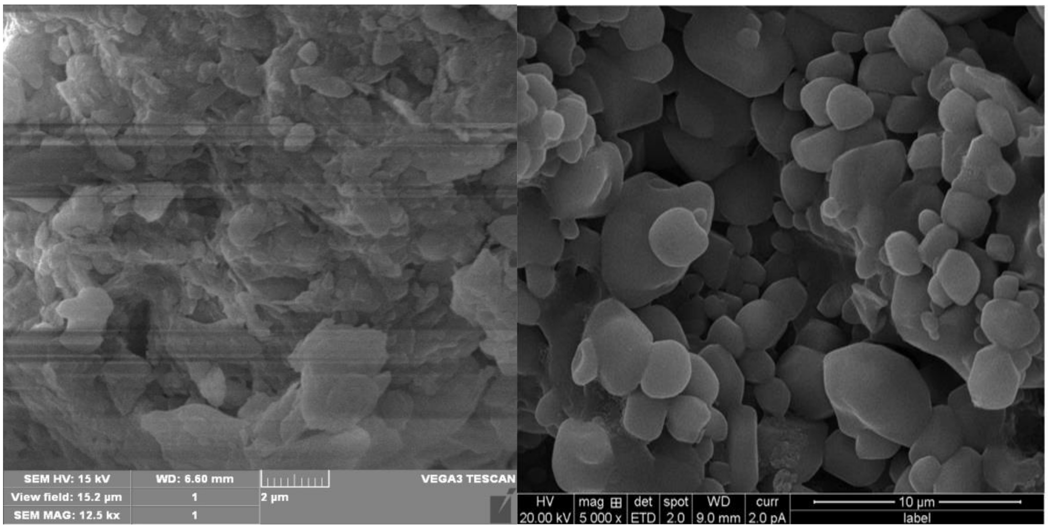

Fig4. ESM image from Segzi evaporates(left) and from Vidya and Lakshminarasappa(2014)

Conclusion

The soils in researched area because of influence with gypsonous wind deposits soil salinity systems in soil have changed in three phases: a)initial system of (NaCl) b) secondary or transition system (NaCl, $CaSO_4.2H_2O$), C1)Third system or anthropogenic system with irrigation in cold season ($Na_2SO_4.10H_2O$, $CaCl_2$). C 2)Third system of salinity in summer change to (Na_2SO_4, $CaCl_2$) and because of no rainfall in warm season it conserved in soil. In winter or rainfall season with cold weather again return to previous system and more stable of ($Na_2SO_4.10H_2O$, $CaCl_2$). These process can be shown in equation 1.

$$CaSO_4 + 2NaCl \rightleftharpoons CaCl_2 + Na_2SO_4 \quad [1]$$

Therefore irrigation with surplus refined sewage water for revival of desert shrubs result in change salinity types from Sodium Chloride to sodium sulfate with extreme wind erodibility in Segzi areas.

References

1.Abedi-Kupai, J., M. Bagheri, M., and B. Mostafazadeh.2000. The study of ground water pollution around of refined sewage center of Shahin_Shahr, Esfahan. Proceeding in third conference of hydraulic. Tehran Technology University, Iran. PP:633-640.(in Persian).

2.Akhavan Ghalibaf M. 2002. Salinity types of the soils related to climatic and lithogenic microzones in Central Iran. 17th World Congress of Soil Science. Bangkok-Thailand.

3.Akhavan Ghalibaf, M. and A.H. Kohsary.2007. A survey of the thermodynamic of evaporate salts in one of the Yazd Playas based on a ground sampling and remote sensing. Iranian Journal of Crystallography and Mineralogy, Iran.19:2. PP:401-413.

4.Ansarinejad, H. Moradi, F. and Narimani J.2010. The project for refined sewage usage for plant cover revival of Segzi plain. Department of Natural recourses of Esfahan City. 54p.(in Persian).

5. Ayers, R. S., and D. W. Westcot. 1985. Water quality for agriculture. Rev. 1, FAO Ro

6- Boll, R., H. Dernbach, an R. Kayser. 1986. Aspects of Land disposal of wastewater as experienced in Germany. Wat. Sci. Tech. 18:383-390.

7.Doner H.E. and Lynn W.C. 1992. Carbonates, Halite, Sulfate and Sulfide Minerals, Chapter 6 in Minerals in soil environments, SSSA Book series: 1. J.B. Dixon and S.B. Weed(Eds). Second Edition. USA. PP: 279-330.

8.Hasan-Oghli A., Liaghat, A. and Mirabzdeh, M.2006. The Affects of irrigation with domestic sewage and Ekbatan industrial city refined sewage in phosphor addition to soils. Agriculture and Natural recourses technology and science Journal. Esfahan Technology University. 10:4, PP:29-44. .(in Persian).

9.Movahedian F. and M. Afioni. 2006. The affect of industrial sewage on some of the chemical properties and heavy metal accumulation in soils, (case study on Segzi plain in Esfahan) First Desert Symposium. International Desert Research. Tehran University. .(in Persian).

10.Narimani, J. and H. Ansarinejad. 2012. The survey on the affect of sewage in revival of plant cover in desert lands(case study on Segzi plain in Esfahan). First Desert Symposium. International Desert Research. Tehran University. .(in Persian).
11.Pankova E.I., I.P.Aidarov, I.A.Yamnova, A.F.Novikova and N.S.Blagobolin. 1996. Natural and Anthropogenic Salinity of the Soils of Aral Sea Basin(Geography, Genesis, Evolution). Russian Academy of Agriculture Science. V.V. Dokuchaev Soil Institute, Moscow State University of Nature Reclamation. Moscow.187p.
12.Smykatz-Kloss, W. 1974. Differential thermal analysis: Applications and results in mineralogy. Springer-Verlag New York, Inc., Secaucus, NJ.
13. Vidya Y S and B N Lakshminarasappa.2014. The effect of isovalent and hypervalent ion doping on the structural and luminescence properties of sodium sulfate. Materials Research press.1015907.1591/1/1/015907.
14. Keys to Soil Taxonomy,2010. Eleventh Edition. USDA, NRCS.337p.

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Neotyphodium-endophytes mediated tolerance to soil abiotic stresses

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Abstract

Soil salinity and soil polluted with heavy metals are important environmental constraints affecting food chain for human and other macro- and micro-organisms. *Neotyphodium*-endophytes are a group of asymptomatic fungi residing within the aerial parts of many cool-season grasses which increase their host tolerance to soil common abiotic stresses. To study endophyte infected (E+) hosts under abiotic stresses compared to endophyte-free (E-) counterparts in the model plant of tall fescue, *Festucaarundinacea*, naturally infected plants were collected from their habitats. The plants were clonally propagated and a part of their tillers were treated with a fungicide mixture containing propiconazole and tebuconazole to prepare endophyte-free plants with the same genotype to the primary source. Infected and non-infected clones were exposed to saline soil or soil contaminated with heavy metals. Under salinity, E+ plants exhibited higher survival rates, increase in root dry matter and a lower shoot-to-root ratio. Endophyte infected plants accumulated more potassium (K+) and had a greater K+:Na+ ratio in their shoots in response to soil salinity. Generally, higher content of Zn and Cd and lower content of Ni were found in E+ plants compared to E- counterparts in soils contaminated with Zn,Cd and Ni high concentrations. In some plant genotypes, fungal endophytemay increase the plant capability to accumulate and tolerate high concentrations of heavy metals, a characteristic useful in polluted soils phytoremediation. Understanding the involved mechanisms of endophyte-mediated plant tolerance to limitations in soil productivity may extend the use of Neotyphodium-grass combinations for forage production, landscape designing and/or phytoremediation in soils affected by abiotic stress conditions.

Keywords: Heavy metal, *Festuca*, *Neotyphodium*, Phytoremediation, Salinity, Toxicity

Introduction

Endophytes are defined as microorganisms that live asymptomatically inside healthy plant tissues for at least part of theirlife [1,2]. Some microorganisms that have been found as endophytes are fungi, bacteria, yeasts and even cyanobacteria [3]. These express several different symbiotic lifestyles defined by their fitness benefits to the host plants [4]. Endophytes receive nutrition and protection from the host plant and improve the plant's ability to withstand environmental stresses and provide increased resistance to herbivores, pathogens and improve plant growth by production of plant hormones [5].

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The genus of *Epichloe*from the fungal family Clavicipitaceae (Ascomycota) which was previouslynamed *Neotyphodium* as asexual forms hs association with cool-seasongrasses in the subfamily Pooideae [6]. Plants usually remain infected throughout their life span and the fungus remains internal throughout the season, including during flowering. Fungal genotypes are transmitted vertically through seeds by hyphal growth into developing ovules, providing opportunities for coevolutionary interactions between host plant and fungus. The rate of vertical transmission can be extremely efficient up to 100%.

The endophytewith the greatest research interest is *Epichloecoenophialum*which is a ubiquitous symbiontof tall fescue (*Festucaarundinacea=Loliumarundinaceum*), and *Epichloelolii* from perennial ryegrass; *Loliumperenne* [7]. They produce alkaloids including saturated aminopyrrolizidine (loline) alkaloids, indolediterpenoid (lolitrem) alkaloids and pyrrolopyrazine (peramine) alkaloids or induce plants to produce phytochemicals that play some role in benefiting the host plant like growth promotion and protection against biotic and abiotic stress factors. Soil nutritional levels and abiotic stresses also may influence alkaloid concentration in the host[8].Protection against invertebrate herbivores and plant pathogens is the most studied benefit of endophyte infection. Enhanced drought tolerance is also a well-known benefit of endophyte infection in tall fescue and perennial ryegrass [9]. Increased tolerance to other environmental stresses like heat, low light and low soil fertility have also been reported [10]. However, there is limited information on the effect of *Epichloe*endophytes on accumulation of heavy metals in aboveground plant parts.

It is believed that the underlying mechanisms for these changes in host plants may include biochemical and hormonal alterations in host plants by endophyte infection. These may enable the grass host plants to have higher potential of residing in non-durable environments when infected than non-infected counterparts. Therefore, further research is warranted to fully understand the role and mode of action of endophyte in each abiotic stress condition and utilizing the enlightened mechanism in an applied manner in agricultural and natural ecosystems. In a series of studies, we evaluated the potential of endophyte infection to create resistance in tall fescue to mineral toxicity.

Material and Methods

Plant materials

Tall fescue genotypes were selected from a germplasm originally collected from natural habitats in Iran. Their infection with *Neotyphodium*-endophyte was confirmed by the direct staining method [11] and specific PCR primers [12]. Seeds from each genotype were sown in plastic pots and grown in a greenhouse. One single plant from each genotype was selected based on the fungus viability and microscopic observation of hyphal density in leaf sheath tissues. Genotypes were then clonally propagated by separation of secondary tillers from the main tillers. Vegetative propagated plants of each genotype were divided into two parts and transferred to adjacent plots in the field and one plot of each genotype was treated foreradication of the endophyte. The treatment was comprised of a fungicide mixture containing propiconazole (1-[{2-(2, 4-dichloro phenyl)-4-propyl-1,3-dioxolan-2yl} methyl]–1H–1, 2, 4-triazole) andtebuconazole((RS)-1-(4-chlorophenyl)-4,4-dimethyl-3-(1,2,4-triazol-1-ylmethyl)pentan-3-ol) at ratios of 2 g of active ingredient and 1mL $L^{-1}$of water, respectively. Plants designed to be E– (non-infected) were sprayed twice at 6 d intervals. Both E+ (infected with endophytic fungi) and E– plants of each genotype were transferred toseveral pots and allowed to grow and produce more tillers in the greenhouse for further studies.

Salinity and Cd contamination

For testing genotypes undersalinity stress, five tiller sections of each endophyte–grass combination (grass genotype combined with endophyte status) were separated, and each section was transferred to 2 Lplastic pots containing half-strength Johnson's nutrient solution [13]. Pots were aerated for 15min h^{-1},and the solution volume in each pot was monitored every dayand adjusted when necessary with distilled water. After3 weeks, NaCl was gradually applied within a 10 d period with10% daily application of the total concentration from stock solutions. Three salinity treatments, 0 mM, 85 mM, and 170 mMNaCl, three endophyte-infected genotypes, and three corresponding endophyte-freegenotypes were replicated three times in a randomized complete block design. Nutrient solutions were renewed on a weekly basis. After 2 months, plants were harvested for analysis. A 0.2 g subsample of each plant was ashed at 550°C for 2 h. The ash was then dissolved in 2M hydrochloric acid (HCl). Aliquots were diluted with distilled water and analyzed for their potassium (K+) and sodium (Na +) contents by flame emission (Flame Photometry 410, Corning).

For Cd contamination test, the nutrient solution was made to contain Cd^{2+}as Cd(NO3)2.4H_2O at different concentrations of 0, 5, 10, and 20 mg L−1(Cd0,Cd5,Cd10, and Cd20). After 6 weeks, plant samples were collected and washed with deionized water before being separated into shoots and roots. Then all samples were ovendried (65 C) for 72 h to reach a constantweight and dry weight of shoots and roots were determined. To determine plant translocation ability (from root to shoot) at different Cd concentrations, the transport index (TI) was calculated as:

$$TI(\%)=\frac{\text{Cd Shoot (mg kg−1)}}{\text{Cd Root (mg kg−1)}}\times 100 \qquad (1)$$

Zn and Ni contamination

The effect of endophyte infection on accumulation of Zn and Ni was assessed in pot experiment. For Zn contamination experiment, endophyte infected (EI) and endophyte free (EF) counterparts of a genotype of *Festucaarundinacea* (75B) naturally infected with *Neotyphodium*endophyteswere cultured in pots containing Zinc pollution supplied as ZnSO4 to soil at concentrations of control (=1.94 mg kg-1 Zn), 200, 400, 800 and 1800 mg kg-1 Zn. Potted clones (3 plants per pot) were transferred into a greenhouse and irrigated daily (without leaching). After 5 months of growth, the number of plant tillers was counted. Shoots and roots were harvested, washed with distilled water and dried at 70 ˚C for 48 h. Zinc content of leaf and root tissues were determined by atomic absorption spectroscopy (Perkin Elmer, Analyst 200) after digestion of the dried material in HNO3 by microwave (Standard NF EN ISO 11885).

For Ni contamination test, two tall fescue genotypes (75B and 75C) infected by their natural fungal endophyte and their non-infected isolines were cultivated in plastic pots (Size: 20*15 cm)filled with soil contaminated with Nickel (as$NiCl_2$) at concentrations of 0, 30, 90, and 180 mg kg-1. After 10 weeks, plants were washed with deionized water. Oven-dried samples were ashed in a furnace at 480 C for 5 h, dissolved in HCl and made up to volume using distilled water. Metal concentration was determined by atomic absorption spectrophotometry (GBC 932 AB PLUS type).

Statistical analysis

The experiments were conducted according to a completely randomized design in a factorial arrangement. Analysis of variance (ANOVA) procedure was performed using SAS statistical program (v. 9.1) and the differences between specific pairs of means were identified using least significant difference (LSD) test ($P<0.05$).

Results and Discussion

Salinity

Endophyte infection significantly influenced root dry matter but not shoot dry matter of genotypes grown in the nutrient solution. Endophyte-harboring plants tended toward a less allometric (shoot-to-root) value when compared to E– plants (1.63vs. 2.40; Tab. 2). This might be an indication of drought and, possibly, salt resistance[14]. Extensive root growth has been suggested as a possible component of resistance to salinity because it may allow for water exploration at soil depths with lower salt contents [15].

Endophyte infection also affected Na and Cl– concentrations in roots to a greater extent than it did in shoots. In contrast, the concentration of K+ in roots was not affected by the endophyte. In shoots, endophytes consistently increased K+ concentrations when compared with E– clones associatedwith a higher K+:Na+ratio in E+ plants. On average, endophyte-infected plants accumulated 16.1% more K+ in shoots and had 35.6% higher shoot K+:Na+ratio than E– plants.Greater K+:Na+ratio in E+ plants, might reduce the disturbance of metabolism in plants exposed to salinity stress [16].

Cd contamination

Plants infected by endophyte showed higher amount (up to 6–16%) of Cd in their roots than in non-infected ones. The positive effect of endophyte infection on Cd accumulation by plant shoots in all treatments was also significant. Endophyte infected plants with highest biomass production and Cd content in root and shoot showed higher removal efficiency. It seems thatthe grass infected by endophytemay have a high potential for removal of Cd from the medium [17].

Zn contamination

On average, the number of tillers was 85% greater in infected *F. Arundinacea* in Zn contaminated soil. Infected plants had higher shoot biomass than endophyte free plants but not significant; however, root dry weight in E+ plants was 87% greater than non-infected counterparts. Shoots of E+ plants had averagely 65.9% greater concentration of Zn than E- plants. Zinc concentration in E+ plants roots was also greater than non-infected plants but the difference was not significant. Endophyte infection also increased Zn transfer to shoots in *Festuca* so that Zn transport index (TI) was 43.4% greater in E+ thanE-, where interaction between Endophyte and Zn concentration was not significant [18].

Ni contamination

Concentration of Ni in shoots of E- plants of genotype 75B was significantly ($p<0.05$) higher than the E+ counterparts. Endophyte infection provided lower levels of Ni uptake and its translocation to shoots under Ni stress. In contrast to genotype 75B, Ni contents of shoot in genotype 75C was higher in E+ plants compared to the E- plants. Therefore, in contrast to the other stresses, response to endophyte infection was dependent to plant genotype (Table 1). Since leaves are the important part of forage plants and are used as a source of livestock feed, reduced Ni accumulation in leaves of E+ tall fescue plants could be considered as an important defensive mechanism induced by endophyte, which prevents leaf toxicity and damage to the leaves when the plant is grown in high Ni contaminated soil [19].

Table 1. Effects of endophyte infection on host plant in response to different mineral stresses in culture medium.

Abiotic stress	Medium	Extreme level	Endophyte effect
Salinity	Hydroponics	170 mMNaCl	Lower Na+ accumulation, higher K+ accumulation
Cd contamination	Hydroponics	20 mg L−1	Higher accumulation of Cd in plant shoots
Zn contamination	Potted Soil	1800 mg per kg^{-1}	Higher Zn accumulation
Ni contamination	Potted Soil	180 mg per kg	Higher or lower accumulation of Ni dependent to plant genotype

Conclusion

Endophyte infection might help the grasses to compensate toxic effects of Na+with higher concentrations of K+ and a higher K+:Na+ratio in shoot tissues. Also, growth of *F. arundinacea* infected with endophyticfungi could enhance the reduction of cadmium and zinc pollution in contaminated soils compared with non-infected ones. However; accumulation of nickel in aboveground parts of plants depended to both endophyte and plant genotype. Within a population of tall fescue, there is tremendous genetic plasticity among endophytes and their host, each interactive with specific environmental factors which serve to ensure the survival of endophytic infectionswithin a location. Therefore, endophyte-infected grasses may thrive better thantheir E– counterparts under abiotic and metal stresses; however, it may be dependent on the plant genotype–endophyte combination.

References

Arnold, A.E., Mejia, L.C., Kyllo, D., Rojas, E.I., Maynard, Z., Robbins, N., Herre, E.A. 2007. Understanding the diversity of foliar endophytic fungi: progress, challenges, and frontiers. Fungal Biol. Rev. 21, 51-66.

Sánchez Márquez, S., Bills, G., DomínguezAcuña, L., Zabalgogeazcoa, I .2010. Endophyticmycobiota of leaves and roots of the grass (*Holcuslanatus*). Fungal Divers. 41,115-123.

Krings, M., Taylor, T.N., Hass, H., Kerp, H., Dotzler, N, Hermsen, E.J. 2007. Fungal endophytes in a 400-million-yr-old land plant: infection pathways, spatial distribution, and host responses. New Phytol. 174, 648–657.

Strobel, G., Daisy, B., Castillo, U., Harper, J. 2004. Natural products from endophyticmicroorganisms. J. Natu. Prod. 67, 257-268.

Rodriguez, R., Redman, R. 2008. More than 400 million years of evolution and some plants still can't make it on their own: plant stress tolerance via fungal symbiosis. J. Exp. Bot. 59,1109-1114.

Schardl, C. L. 1996. *Epichloe* species: fungal symbionts of grasses. Annu. Rev. Phytopathol. 34,109–130.

Schardl, C. L., Leuchtmann, A., Tsai, H.-F., Collet, M. A., Watt, D. M., Scott, D. B. 1994. Origin of a fungal symbiont of perennial ryegrass by interspecific hybridization of a mutualist with the ryegrass choke pathogen *Epichloetyphina*. Genetics 136, 1307–1317.

Malinowski, D. P., Belesky, D. P., Hill, N. S.,Baligar, V. C.,Fedders, J. M. 1998. Influence of phosphorous on the growth and ergot alkaloid content of*Neotyphodiumcoenophialum*-infected tall fescue (*Festucaarundinacea*Schreb.). Plant Soil 198, 53–61.

Lewis, G. C., Ravel, C., Naffaa, W., Astier, C., Charmet, G. 1997. Occurrence of *Acremonium*endophytes in wild populations of *Lolium* spp. in European countries and a relationship between level of infection and climate in France. Ann. Appl. Biol. 130:227–238.

Malinowski, D. P., Belesky, D. P. 2000. Adaptations of endophyte-infected cool-season grasses to environ-mental stresses: mechanisms of drought and mineral stress tolerance. Crop Sci. 40, 923–940.

Saha, D. C., Jackson, M. A., Johnson-Cicalese, J. M. 1988. A rapid staining method for detection of endophytic fungi in turf and forage grasses. Phytopathol. 78, 237–239.

Doss, R. P., Clement, S. L., Welty, R. E. 1998. A PCR-based technique for detection of *Neotyphodium*endophyte in diverse accessions of tall fescue. Plant Dis. 82, 738–740

Johnson, C. M., Stout, P. R., Broyer, T. C., Carlton, A. B. 1957. Comparative chlorine requirements of different plant species. Plant Soil 8, 337–353.

Gardner, F. P., Pierce, R. B., Mitchell, R. L. 1985. Physiology of Crop Plant. 1st edn., Iowa State University Press, Amsterdam.

Maas, E. V., Nieman, R. H. 1978. Physiology of plant tolerance to salinity, in Jung, J. A.: Crop Tolerance to Sub Optimal Land Condi-tions. American Society of Agronomy, Madison, Wis. pp. 277–299.

Sabzalian, M. R., Mirlohi, A. 2010. *Neotyphodium*endophytes trigger salt resistance in tall and meadow fescues. J. Plant Nutr. Soil Sci. 173, 952-957.

Soleimani,M., Hajabbasi,M. A., Afyuni, M., Mirlohi, A., Borggaard, O. K., Holm,P. E. 2010. Effect of endophytic fungi on cadmium tolerance and bioaccumulation by Festucaarundinacea *and* Festucapratensis.*Int. J. Phytorem. 12, 535-549.*

Zamani, N., Sabzalian, M. R., Khoshgoftarmanesh, A., Afyuni, M. 2014. *Neotyphodium*endophyte changes phytoextraction of Zinc in *Festucaarundinacea* and *Loliumperenne*. Int. J. Phytorem. (in press).

Mirzahosseini, Z., Shabani, L., Sabzalian, M. R., Sharifi-Tehrani, M. 2014. *Neotyphodium*endophytes may increase tolerance to Ni in

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Effect of water deficit on grain yield and Fe, Zn, Mn and Cu uptake of wheat cultivars

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Abstract

Water deficit is an environmental factor that may influence grain yield and nutrient uptake of wheat (*Triticum aestivum* L.). The objective of this study was to evaluate the effects of water deficit on grain yield micronutrient uptake of bread wheat cultivars.Two field experiments were conducted at the Agriculture Research Station of Saatlo in West Azarbaijan during 2010-11 and 2011-12 to examine the effects of water supply (normal irrigation and post anthesis drought stress condition) on micronutrients uptakes and grain yield in five winter wheat cultivars (Zarrin, Peshgam, Orum, Zareh and Mihan). Irrigation and cultivars showed significant differences in grain yield, and micronutrients uptakes. Grain yield and grain micronutrients uptakes (Fe, Zn, Mn and Cu) in all cultivars decreased with decreasing water availability. These results suggest that wheat cultivars respond differentially to water deficit and macronutrients. The highest grain yield per unit area was obtained under well-irrigation and water deficit in Zareh and Mihan cultivars, respectively. The highest Zn uptake by grains under well-irrigation was observed in Peshgam cultivar. Zareh cultivar had the most Fe, Mn and Cu uptake under well-irrigation. However under water deficit condition Mihan has the highest Fe, Zn, Mn and Cu uptake by grains.

Keywords: Grain yield, micronutrient, water deficit, wheat cultivars

Introduction

Plants are exposed to a multitude of natural biotic and abiotic stresses. Drought is a major abiotic stress that severely affects food production worldwide. In some locations, naturally available water supplies do not allow the production of maximum yield from irrigable lands. In other regions, water resources are limited, leading to insufficient irrigation. Several studies have been conducted with spring and winter wheat to evaluate the effect of limited irrigations on crop quality and production. Stress was most critical during and after heading. Stress is likely to occur when the plants appear wilted and the leaves curl. Yield is reduced the most when stress starts during soft dough, flowering or heading. Stress during the maturing process results in about a 10% lower yield (Bauder, 2001).

Yield and yield components of wheat are influenced by several factors such as water stress and cultivar (Emam et al, 2007 and Tayyar and Gul, 2008). Drought stress caused the concentration of Fe, Zn, Mn and Cu to decrease in corn flag leaf, but increased in seed, because of decrease in seed yield with increasing drought

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stress. Total absorption of nutrients in seed was decreased (Rafiee et al, 2004). Ortiz–Monasterio and Graham (2000) indicated that Fe and Zn were not significantly affected by the dilution effect. Several studies have related grain mineral composition to grain protein content in wheat, and significant correlations have been found between protein content and the concentrations of Zn, Fe and Cu present in the grain (Lorens and loewe, 1977 and Dikeman et al, 1982). This research was carried out to evaluate micronutrient uptake, grain yield and straw production in ten bread wheat cultivars under different watering conditions. Contents of N, P, K, Ca, Mg, Fe, Mn, Cu and Zn declined in all sugar beet genotypes under water deficiency, but the intensity of reduction varied among the genotypes (Maksimovic *et al.,* 2003).

A positive relation was reported between grain Fe and Zn contents by Graham et al (1999) and Garvin et al (2006). According to Graham et al (1999) phosphorus and Mg in the grains are mainly found in phytate and their consistent correlation with Zn suggests that high grain Zn may be associated with high phytate in wheat. Although plants were marginally deficient or deficient in N, P and Zn under drought stress, but high concentration of boron was found in this condition (Zubaidi et al 1999). Compared with bread wheat, durum wheat had much higher concentration of sodium, higher concentrations of calcium and sulfur, but lower concentrations of potassium, magnesium, manganese and copper. Total amounts of P, Zn and Na in the shoot continued to increase throughout the growing season with significant increases occurring during grain filling, whereas there was little increase in the amount of N, K, B and Mn during grain filling. This research was carried out to evaluate grain yield and Fe, Zn, Mn and Cu uptake of wheat cultivars under different watering conditions.

Material and Methods

Field studies were carried out during 2011-12 and 2010-11 in the Agricultural Research Station of Saatlou, in west Azarbayjan province, Iran (45°01´E, 37°43´N, altitude 1320 m a.s.l). The soil texture was clay with low EC (0.81 dSm^{-1}) and pH of 7.7. The Most important soil characteristics are shown in Table 1.

Table 1. Soil and water characterization of the experimental site

Soil	pH	EC (ds/m)	P	K	Fe (mg kg^{-1})	Mn	Zn	Cu
	7.7	0.81	11.2	270	7.03	6.87	0.66	2.02
Water	pH	EC (ds/m)	CO_3^{-2}	HCO_3^-	Cl (meq L^{-1})	Ca	Mg	Na
	7.4	1.8	0	8.8	11.5	5.1	5.0	11.5

Two field experiments were conducted with RCB design in three replications to examine the effects of water supply (normal irrigation and post anthesis drought stress condition) on micronutrients uptakes and grain yield in five winter wheat cultivars (Zarrin, Peshgam, Orum, Zareh and Mihan).

Each plot consisted of six rows of 5 m long and 20 cm apart. All plots received 30 kg ha^{-1} urea (46%N), 18 kg ha^{-1} $ZnSO_4.7H_2O$, 80 kg ha^{-1} KH_2PO_4, 110 kg ha^{-1} $HPO_4(NH_4)_2$ before planting and 160 kg ha^{-1} urea at tillering and pre-anthesis. Wheat seeds were sown on 10 October 2010 and 2011. All plots were irrigated equally to increase the soil moisture up to the field capacity. Irrigation intervals were regulated according to the irrigation treatments.

At maturity, 20 plants from the four middle rows next to guard rows were harvested and grain and seed micronutrients (Fe, Zn, Mn and Cu) were measured (Gupta, 2000 and Karla and Maynard, 1991). In both years, plots were harvested with a small-plot combine in mid-July. The combined analysis of variance of the data was carried out, using SAS and SPSS soft-wares.

Results and Discussion

Grain yield was significantly affected by drought stress and cultivars ($P \le 0.01$). Grain yield per unit area decreased with decreasing water availability. The values ranged from 7148 kg ha^{-1} in full irrigation to 3954 kg ha^{-1} in post anthesis drought stress condition (Figure 1). These results are in agreement with those reported by Guttieri et al, (2000) and Guttieri et al (2005). In this study, Mihan cultivar with 6000 kg ha^{-1} and Orum cultivar with 4983 kg ha^{-1} had the highest and the lowest grain yield respectively. The interaction of irrigation × cultivars for grain yield was also significant (P≤0.01). The highest grain yield per unit area was obtained for Zareh (7858 kg ha^{-1}) under well-watering and for Mihan (4983 kg ha^{-1}) under post anthesis drought stress condition (Table 2). Water deficit did not affect kernel number in wheat. The rate of dry matter accumulation by kernels was considerably decreased by water deficit in both studied wheat cultivars (Plaut et al., 2004). Abdoli et al (2013) report that Post anthesis water deficiency stress significantly reduced the grain yield (18%), the 1000 grain weight (20%) and significantly increased the number of fertile spikelet per spike (3%) in cultivars.

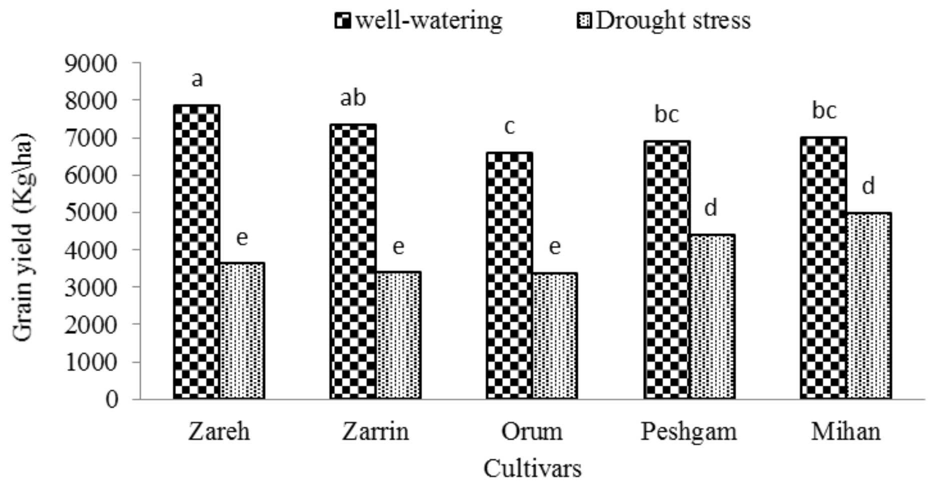

Figure 1. Grain yield of wheat cultivars under different irrigation treatments.

Grain Fe, Zn, Mn and Cu uptake were significantly affected by irrigation treatments (P≤0.01). The interaction of irrigation × cultivars for grain Fe, Zn, Mn and Cu uptake was also significant (P≤0.01). Fe, Zn, Mn and Cu uptake decreased under water deficit condition (Figure 2, 3, 4, 5). Water limitation led to decreased Fe, Zn, Mn and Cu grains with average of 50%, 36%, 43% and 16%, respectively. In this study, the highest Fe, Mn, and Cu grains under well-watering were observed in Zareh with 418 gr ha^{-1} Fe, 612 gr ha^{-1} Mn and 44 gr ha^{-1} Ca while the highest grain Zn uptake under well-watering was observed in Peshgam with 237 gr ha^{-1} Zn. But under post anthesis water stress the highest Fe, Zn, Mn and Cu grains was observed for Mihan cultivar with 264, 188, 362 and 38 gr ha^{-1} respectively (Figure 2,3,4,5).

A positive correlation was observed between grain Fe, Zn, Mn and Cu uptake and grain yield of Mihan and Peshgam under water stress that could be due to increased remobilization of stored pre-anthesis assimilates and macronutrients. There was also a positive relation between grain Fe and Zn contents that may common transport mechanisms to the grain. Similar correlation between grain Fe and Zn contents was also reported by Graham *et al.,* (1999) and Garvin *et al.,* (2006). According to Graham *et al.,* (1999) phosphorus and Mg in the grains are mainly found in phytate and their consistent correlation with Zn suggests that high grain Zn may be associated with high Phytate in wheat.

In this study difference between cultivars in the highest and the lowest Fe, Zn, Mn, and Cu uptake by grains had 39%, 44%, 39% and 45% under well- watering, while this difference between cultivars had by an average of 52%, 47%, 36% and 49% under sever water deficit, respectively. These results indicate that grain Fe, Zn and Cu contents decreased due to water deficit reduction and these micronutrients were more considerable in drought susceptible genotypes (Zarrin and Orum). Feziasl *et al.,* (2009) reported by using linear correlation coefficients between nutrient ratios in plant and grain yield, to make nutrient balance in plant, dry land wheat requires more Mn than other micronutrients (Fe, Zn, Cu and B) and this showed that soil Mn critical level for dry land wheat is high in this area.

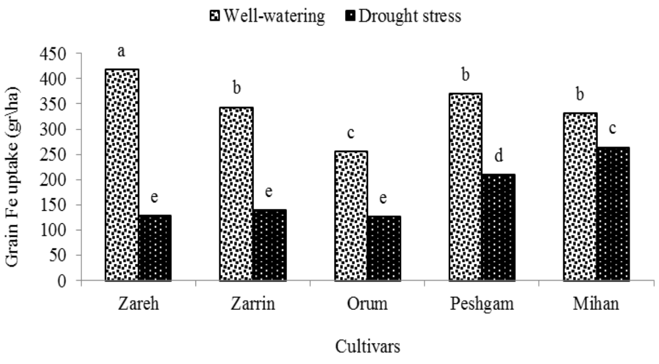

Figure 2. Grain Fe uptake of wheat cultivars under different irrigation treatments

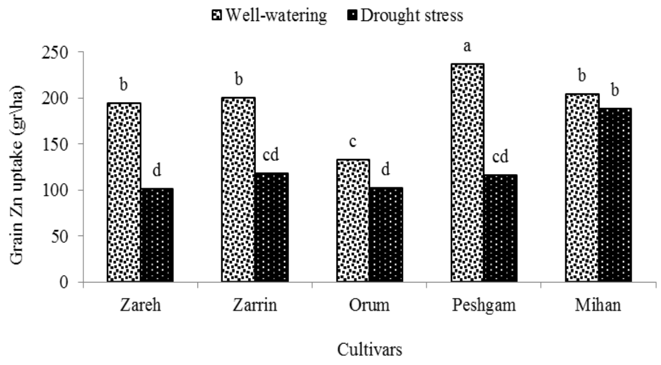

Figure 3. Grain Zn uptake of wheat cultivars under different irrigation treatments.

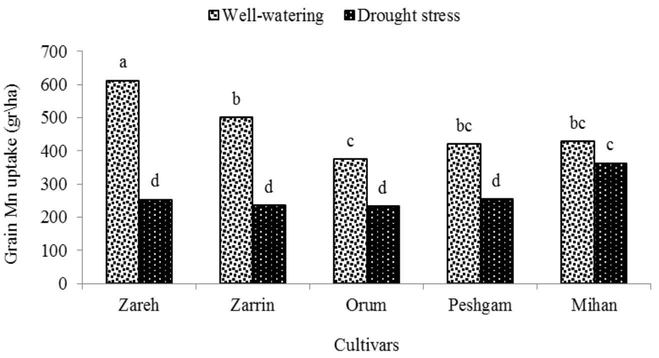

Figure 4. Grain Mn uptake of wheat cultivars under different irrigation treatments.

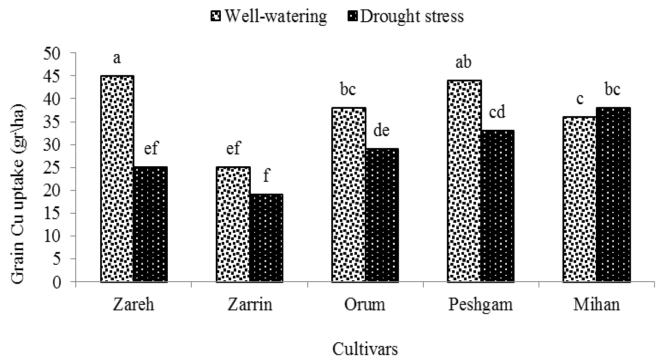

Figure 5. Grain Cu uptake of wheat cultivars under different irrigation treatments.

Conclusion

The results of this experiment showed that the highest grain yield and Fe, Zn, Mn and Cu uptake by grains under water deficit condition from Mihan wheat and this variety can be grown in large areas of the country with a cold climate and water deficit at the end of the growing season and can be used to replace the older cultivars.

References

Abdoli, M., Saeidi, M., Jalali honarmand, S., Mansourifar, S., Ghobadi, ME., Cheghamirza, K., 2013. Effect of source and sink limitation on yield and some agronomic characteristics in modern bread wheat cultivars under post anthesis water deficiency. Acta agriculturae Slovenica, 2: 173 – 182.

Bauder, J., 2001. Irrigating with limited water supplies. Montana State University Communication Services, Bozman, MT 59717.

Dikeman, E., Pomeranz, Y., and Lai, F.S., 1982. Minerals and protein in hard red winter wheat. Cereal Chem. 59: 139-142.

Emam Y, Ranjbar A.M , Bahrani M.J., 2007. Evaluation of yield and yield components in wheat genotypes under post - anthesis drought stress. J. Sci. Technol. Agric. Natur. Resour 11: 328-333.

Feiziasl, V., Jafarzadeh, J., Pala, M. and Mosavi, S.B.,2009. Determination of critical levels of micronutrients by plant response column order procedure for dryland wheat in Northwest of Iran. International. J. Soil Sci., 1: 12-26.

Garvin, D.F., Welch, R.M., and Finlay, J.W., 2006. Historical shifts in the seed mineral micronutrient concentration of US hard red winter wheat germplasm. J. Sci. Food Agric. 86: 2213-2220.

Graham, R.D., Senadhira, D., Beebe, S., Iglesias, C. and., Monasterio, I., 1999. Breeding for micronutrient density in edible potions of staple food crops: conventional approaches. Field Crops Res. 60: 57-80.

Gupta, P.K., 2000. Soil, plant, water, and fertilizer analysis. Agrobios, New Dehli, India.

Guttieri, M.J., Ahmad, R., Stark, J.C., and Souza, E., 2000. End-use quality of six hard red spring wheat cultivars at different irrigation levels. Crop Sci. 40: 631–635.

Guttieri, M.J., McLean, R., Stark, J.C., and Souza, E., 2005. Managing irrigation and nitrogen fertility of hard spring wheats for optimum bread and noodle quality. Crop Sci. 45: 2049-2059.

Kalra, Y.P. and Maynard, D.G., 1991. Methods manual for forest soil and plant analysis. Forestry Canada.

Lorenz, E. and Loewe, R., 1977. Mineral composition of U.S and Canadian wheats and wheat blends. J. Agric. Food Chem. 25: 806-809.

Maksimovic, I.V., Kastori, R.R., Petrovia, N.M., Kovaaev,L.M. and Sklenar,P.S., 2002. The effect of water potential on accumulation of some essential elements in sugar beet leaves (Beta vulgaris ssp. vulgaris). Natu. Sci., 104: 39-50.

Ortiz –Monasterio, J.I. and Graham, R.D., 2000. Breeding for trace minerals in wheat .UNU Food Nutr. Bull. 21: 392-396.

Plaut, Z., Butow, B.J., Blumenthal C.S. and Wrigley, C.W., 2004. Transport of dry matter into developing wheat kernels and its contribution to grain yield under post-anthesis water deficit and evaluated temperature. Field Crops Res., 86: 185-198.

Rafiee,M., Nadian., H.A. nour-mohammadi, G. and Karimi, M., 2004. Effects of drought stress, phosphorous and zinc application on concentration and total nutrient uptake by corn (Zea mays L.). Iranian, J. Agric. Sci., 1: 235-243.

Tayyar S, Gul M.K., 2008. Evaluation of 12 bread wheat varietes for seed yield and som some chemical properties grown in North north western Turkey. Asian J. Chem 20: 3715-3725.

Zubaidi, A., McDonald, G.K. and Hollamby, G.J., 1999. Nutrient uptake and distribution by bread and durum wheat under drought conditions in South Australia. Australian. J. Plant Physiol., 39: 721 – 732

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Effect of drought stress on grain yield and P, K, Ca and Mg uptake of wheat cultivars

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Abstract

Plants are exposed to a multitude of natural biotic and abiotic stresses. Drought is a major abiotic stress that severely affects food production worldwide Plant nutrient uptake from the soil is dependent on soil moisture, fertilizers applied, soil chemicals, and some other environmental factors. The objective of this study was to gain a better understanding of how water deficit affects grain and macronutrients yield of bread wheat cultivars. Two field experiments were conducted at the Agriculture Research Station of Saatlou in West Azarbayjan during 2010-11 and 2011-12 to examine the effects of water supply (normal irrigation and post anthesis drought stress condition) on macronutrients uptakes and grain yield in five winter wheat cultivars (Zarrin, Peshgam, Orum, Zareh and Mihan). Irrigation and cultivars showed significant differences in grain yield, and macronutrients uptakes. Grain yield and grain macronutrients uptakes (P, K, Ca and Mg) in all cultivars decreased with decreasing water availability. These results suggest that wheat cultivars respond differentially to water deficit and macronutrients. The highest grain yield per unit area under well-irrigation and water deficit was obtained for Zareh and Mihan cultivars, respectively. The highest grain P and K uptake under well-irrigation was observed Zarrin and Orum cultivars, respectively. Also in this study Zareh cultivar has the most Ca and Mg uptake under well-irrigation, but under water deficit condition Mihan has the highest grain P, K, and Mg uptake.

Keywords: Grain yield, nutrient uptake, water deficit, wheat cultivars

Introduction

Moisture stress is an environmental factor that may influence end-use quality of wheat (*Triticum aestivum* L.). In most parts of Iran, limited precipitation is mainly occurred in cold and winter seasons and cannot be directly used by plants (Ghamarnia and Gowing, 2005). Therefore, shortage of water resources has become the major limiting factor for wheat production (Nasseri and Fallahi, 2007).

Several studies have been conducted with spring and winter wheat to evaluate the effect of limited irrigations on crop quality and production. Stress was most critical during and after heading. Stress is likely to occur when the plants appear wilted and the leaves curl. Yield is reduced the most when stress starts during soft dough, flowering or heading. Stress during the maturing process results in about a 10% lower yield (Bauder, 2001).

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Yield and yield components of wheat are influenced by several factors such as water stress and cultivar (Emam *et al.,* 2007; Tayyar and Gul, 2008). Translocation of nitrogen (N), phosphorus (P), and potassium (K) also appeared to have been impeded by water deficit. In the case of nutrients uptake, only N uptake in grain was increased (21%) when supplementary irrigation occurred at grain-filling stage. Supplementary irrigation at elongation stage increased biomass and N, P, and K uptake in the whole plant, but it was appeared to decrease translocation of assimilates and nutrients to the heads. So it decreased or had no effect on N, P, and K concentrations in grain (Wang *et al.,* 2005). N, P, K, Ca, Mg, Fe, Mn, Cu and Zn contents declined in all sugar beet genotypes under water deficient, however the intensity of reduction varied among the genotypes (Maksimovic *et al.,* 2003).

Reduction of N content under water deficit was reported for many plant species including maize, bean, citrus and festuca grass (Huang 2001 and Bruce *et al.* 2002). Genotype had a significant effect on grain macronutrients (Ca, Mg, and P) concentrations. This effect was mainly the result of the higher concentrations reached in the synthetic line. Similar results have been reported for micronutrients evaluated in a wide range of synthetic lines (Ortiz-Monasterio and Graham, 2000 and Calderini and Ortiz-Monasterio, 2003). Many studies have assessed interactions of genotype and environment on wheat end-use quality parameters (Peterson et al, 1992; Robert and Denis, 1996; Robert, 1997; Grausgrruber et al, 2000; Mikhaylenko et al, 2000). This research was carried out to evaluate grain yield and P, K, Ca and Mg uptake of wheat cultivars under different watering conditions.

Material and Methods

Field studies were carried out during 2011-12 and 2010-11 in the Agricultural Research Station of Saatlou, in west Azarbayjan province, Iran (45°01´E, 37°43´N, altitude 1320 m a.s.l). The soil texture was clay with low EC (0.81 dSm^{-1}) and pH of 7.7. The Most important soil characteristics are shown in Table 1.

Table 1. Soil and water characterization of the experimental site

Soil	pH	EC (ds/m)	P	K	Fe (mg kg^{-1})	Mn	Zn	Cu
	7.7	0.81	11.2	270	7.03	6.87	0.66	2.02
Water	pH	EC (ds/m)	CO_3^{-2}	HCO_3^-	Cl (meq L^{-1})	Ca	Mg	Na
	7.4	1.8	0	8.8	11.5	5.1	5.0	11.5

Two field experiments were conducted with RCB design in three replications to examine the effects of water supply (normal irrigation and post anthesis drought stress condition) on macronutrients uptakes and grain yield in five winter wheat cultivars (Zarrin, Peshgam, Orum, Zareh and Mihan).

Each plot consisted of six rows of 5 m long and 20 cm apart. All plots received 30 kg ha^{-1} urea (46%N), 18 kg ha^{-1} $ZnSO_4.7H_2O$, 80 kg ha^{-1} KH_2PO_4, 110 kg ha^{-1} $HPO_4(NH_4)_2$ before planting and 160 kg ha^{-1} urea at tillering and pre-anthesis. Wheat seeds were sown on 10 October 2010 and 2011. All plots were irrigated equally to increase the soil moisture up to the field capacity. Irrigation intervals were regulated according to the irrigation treatments.

At maturity, 20 plants from the four middle rows next to guard rows were harvested and grain and seed macronutrients (K, P, Ca and Mg) were measured (Gupta, 2000 and Karla and Maynard, 1991). In both years, plots were harvested with a small-plot combine in mid-July. The combined analysis of variance of the data was carried out, using SAS and SPSS soft-wares.

Results and Discussion

Grain yield was significantly affected by drought stress and cultivars ($P \le 0.01$). Grain yield per unit area decreased with decreasing water availability. The values ranged from 7148 kg ha^{-1} in full irrigation to 3954 kg ha^{-1} in post anthesis drought stress condition (Figure 1). These results are in agreement with those reported by Guttieri et al, (2000) and Guttieri et al (2005). In this study, Mihan cultivar with 6000 kg ha^{-1} and Orum cultivar with 4983 kg ha^{-1} had the highest and the lowest grain yield respectively. The interaction of irrigation × cultivars for grain yield was also significant ($P \le 0.01$). The highest grain yield per unit area was obtained for Zareh (7858 kg ha^{-1}) under well-watering and for Mihan (4983 kg ha^{-1}) under post anthesis drought stress condition (Table 2). Water deficit did not affect kernel number in wheat. The rate of dry matter accumulation by kernels was considerably decreased by water deficit in both studied wheat cultivars (Plaut et al., 2004). Abdoli et al (2013) reported that Post anthesis water deficiency stress significantly reduced the grain yield (18%), the 1000 grain weight (20%) and significantly increased the number of fertile spikelet per spike (3%) in cultivars.

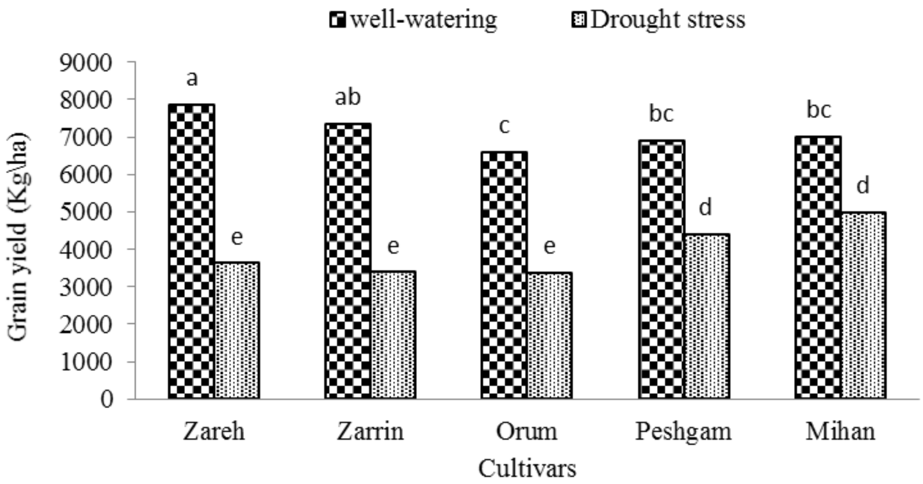

Figure 1. Grain yield of wheat cultivars under different irrigation treatments.

Grain P, K, Ca and Mg macronutrients uptake were significantly affected by irrigation treatments (P≤0.01). The interaction of irrigation × cultivars for grain P, K, Ca and Mg uptake was also significant (P≤0.01). P, K, Ca and Mg uptake decreased under water deficit condition (Figure 2,3,4,5). Water limitation led to decreased grain K, P, Ca and Mg uptake by an average of 51%, 41%, 67% and 60%, respectively. In this study, the highest grain K, P, Ca, and Mg uptake under well-watering were observed in Zarrin46 kg ha^{-1} K, Orum with 18.7 kg ha^{-1} P and Zareh with 8.2 kg ha^{-1} Ca and 16.9 kg ha^{-1} Mg. But under post anthesis water stress, the highest K, P and Mg content that wrer uptake by grain was observed in Mihan cultivar with 27.5, 13.7 and 9.3 kg ha^{-1} respectively (Figure 2,3,4,5).

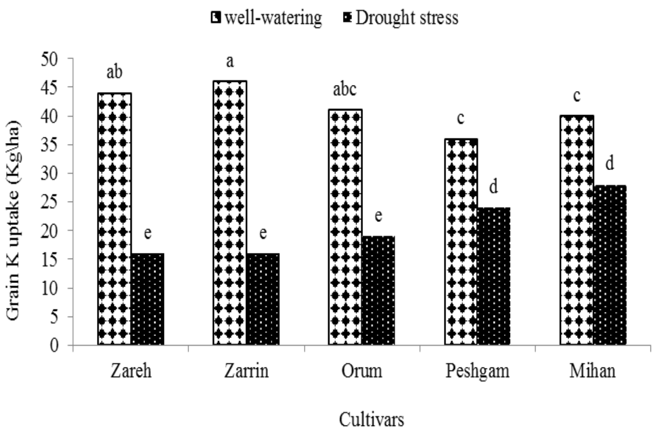

Figure 2. Grain K uptake of wheat cultivars under different irrigation treatments.

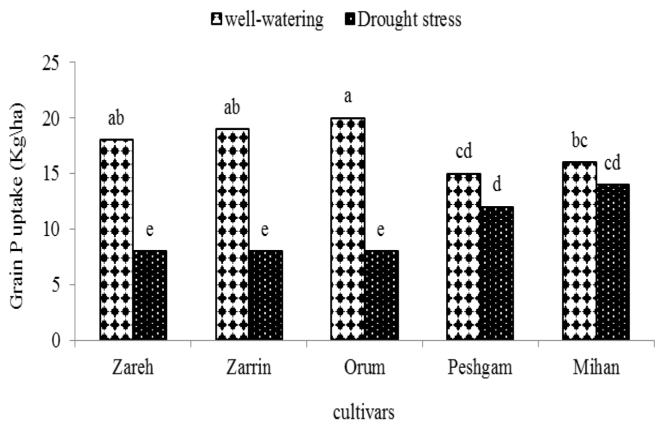

Figure 3. Grain P uptake of wheat cultivars under different irrigation treatments.

K plays essential role in the stomata activity and water relations of plants (Marshner and Chakmak, 1989 and Mngel and Kirkby 2001). Since, Mihan genotype had the highest of grain K and Mg uptake and produced the highest grain yield under drought stress, there might be a positive correlation between K and Mg uptake and drought resistance. The capacity of plants to maintain high concentrations of K in their tissues seems to be a useful ratio to take into account in breeding genotypes for high tolerance to drought stress.

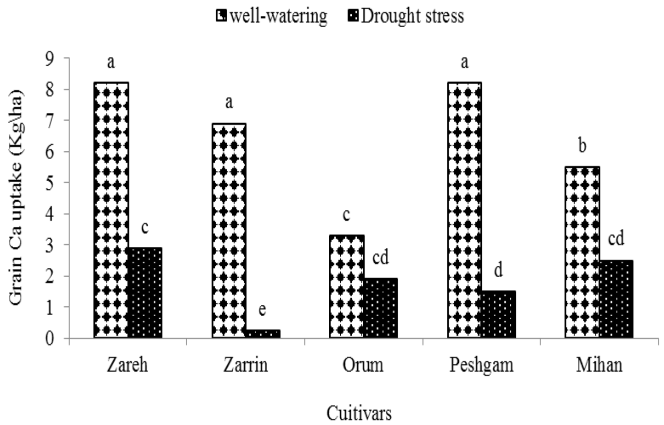

Figure 4. Grain Ca uptake of wheat cultivars under different irrigation treatments.

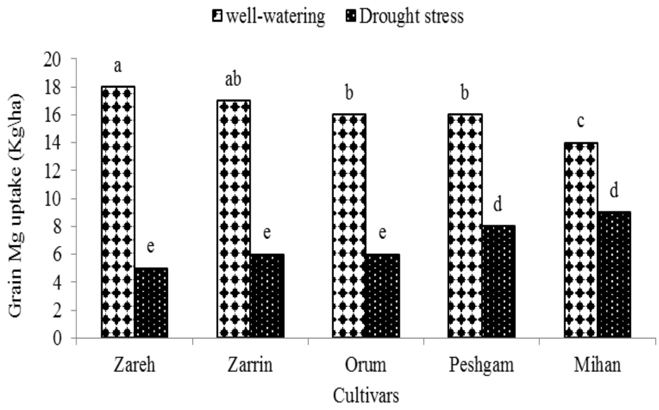

Figure 5. Grain Mg uptake of wheat cultivars under different irrigation treatments

The beneficial effect of an adequate K supply was ascribed to the role of K in retranslocation of photoassimilates in roots which contributed to better root growth under drought stress (Egilla et al 2001). A positive relation was also observed between concentrations of K, P and Mg in grain and grain yield of Mihan cultivar under water stress that could be due to increased remobilization of stored pre-anthesis assimilates and macronutrients. Similar relation between grain Fe and Zn contents was also reported by Graham et al (1999) and Garvin et al (2006).

Conclusion

The results of this experiment showed that the highest grain yield and grain potassium, phosphorus and magnesium uptake under water deficit condition from Mihan wheat. This variety can be grown in large areas of the country with a cold climate and water deficit at the end of the growing season and can be used to replace the older cultivars.

References

Abdoli, M., Saeidi, M., Jalali honarmand, S., Mansourifar, S., Ghobadi, ME., Cheghamirza, K., 2013. Effect of source and sink limitation on yield and some agronomic characteristics in modern bread wheat cultivars under post anthesis water deficiency. Acta agriculturae Slovenica, 2: 173 – 182.

Bruce W.B, Edmeades G.O, Barker T., 2002. Molecular and physiological approaches to maize improvement for drought tolerance. J. Exp. Bot 366: 13-25.

Bauder, J., 2001. Irrigating with limited water supplies. Montana State University Communication Services, Bozman, MT 59717.

Calderini, D.F. and Ortiz-Monasterio, I., 2003. Grain position affects grain macronutrient and micronutrient concentrations in wheat. Crop Sci. 43: 141-151.

Egilla, J.N., Davies, F.T., and Drew, M.C., 2001. Effect of potassium on drought resistance of *Hibicuse rosa – sinensis* cv. Leprechaun: plant growth, leaf macro and micronutrient content and root longevity. Plant and soil. 229: 213-224.

Emam Y, Ranjbar A.M , Bahrani M.J., 2007. Evaluation of yield and yield components in wheat genotypes under post - anthesis drought stress. J. Sci. Technol. Agric. Natur. Resour 11: 328-333.

Ghmarina H, Gowing J.W., 2005. Effect of water stress on three wheat cultivars. Proceeding of the ICID 21th European Regional Conference, May 15-19, Frankfurt (Oder) and Slubic-Germany and Poland pp: 1-4.

Garvin, D.F., Welch, R.M., and Finlay, J.W., 2006. Historical shifts in the seed mineral micronutrient concentration of US hard red winter wheat germplasm. J. Sci. Food Agric. 86: 2213-2220.

Graham, R.D., Senadhira, D., Beebe, S., Iglesias, C. and., Monasterio, I., 1999. Breeding for micronutrient density in edible potions of staple food crops: conventional approaches. Field Crops Res. 60: 57-80.

Grausgruber, H.M., Oberforster, M., Werteker, M., Ruckenbauer, P., and Vollmann, J., 2000. Stability of quality traits in Austrian-grown winter wheats. Field Crops Res. 66: 257–267.

Gupta, P.K. 2000. Soil, plant, water, and fertilizer analysis. Agrobios, New Dehli, India.

Guttieri, M.J., Ahmad, R., Stark, J.C., and Souza, E., 2000. End-use quality of six hard red spring wheat cultivars at different irrigation levels. Crop Sci. 40: 631–635.

Guttieri, M.J., McLean, R., Stark, J.C., and Souza, E., 2005. Managing irrigation and nitrogen fertility of hard spring wheats for optimum bread and noodle quality. Crop Sci. 45: 2049-2059.
Huang B., 2001. Nutrient accumulation and associated root characteristics in response to drought stress in tall fescue cultivars. Hort. Sci 36: 148-152.
Kalra, Y.P. and Maynard, D.G., 1991. Methods manual for forest soil and plant analysis. Forestry Canada.
Maksimovic, I.V., Kastori, R.R., Petrovia, N.M., Kovaaev,L.M. and Sklenar,P.S., 2002. The effect of water potential on accumulation of some essential elements in sugar beet leaves (Beta vulgaris ssp. vulgaris). Natu. Sci., 104: 39-50.
Marshner, H. and Cakmak. I., 1989. High light intensity enhances chlorosis and necrosis in leaves of zinc, potassium and magnesium deficient bean plant. plant physiol. 134: 308-315.
Mengel, K. and Kirkby. E. A., 2001. Principles of plant nutrition. 5th edition. Kluwer Academic Publishers, Dordrecht. 848 p.
Mikhaylenko, G.G., Czuchajowska, Z., Baik, B.K., and Kidwell, K.K., 2000. Environmental influences on flour composition, dough rheology, and baking quality of spring wheat. Cereal Chem. 77: 507–511.
Nasseri A, Fallahi H.A., 2007. Water use efficiency of winter wheat under deficit irrigation. J. Bio. Sci 7: 19-26.
Ortiz –Monasterio, J.I. and Graham, R.D., 2000. Breeding for trace minerals in wheat .UNU Food Nutr. Bull. 21: 392-396.
Peterson, C.J., Graybosch, R.A., Baenziger, P.S., and Grombacher, A.W., 1992. Genotype and environment effects on quality characteristics of hard red winter wheat. Crop Sci. 32: 98–103.
Plaut, Z., Butow, B.J., Blumenthal C.S. and Wrigley, C.W., 2004. Transport of dry matter into developing wheat kernels and its contribution to grain yield under post-anthesis water deficit and evaluated temperature. Field Crops Res., 86: 185-198.
Robert, N., 1997. Structuring genotype x environment interaction for quality traits in bread wheat in two multi-location series of trials. Euphytica., 97: 53–66.
Robert, N. and Denis, J.B., 1996. Stability of baking quality in bread wheat using several statistical parameters. Theor. Appl. Genet. 93: 172–178.
Tayyar S, Gul M.K., 2008. Evaluation of 12 bread wheat varietes for seed yield and som some chemical properties grown in North north western Turkey. Asian J. Chem 20: 3715-3725.
Wang, Z., Li, S., Vera, C.L., and Malhi, S.C., 2005. Effects of Water Deficit and Supplemental Irrigation on Winter Wheat Growth, Grain Yield and Quality, Nutrient Uptake, and Residual Mineral Nitrogen in Soil. Communications in Soil Science and Plant Analysis. 36: 1405 - 1419.

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Effect of foliar spraying with macro elements on qualitative characteristics of saffron stigma

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Abstract

The effect of foliar sprying with macro elements on qualitative characteristics of saffron stigma were studied in a field experiment using a complete randomized block design with three replications. Fertilizers applied were N, P, K, NP, NK, PK, NPK and bulk. The treatments after dissolution in concentration of 5 mg per liter were sprayed at February and March months. After separation stigma of the saffron flower, qualitative characteristics on saffron stigma were measured according to the standard methods of food quality. The rasults showed that there were significant differences between foliar sprying with macro nutrients and qualitative characteristics of saffron stigma.The highest safranal, crocin and picro crocin were observed in k treatments, the lowest safranal and picro crocin in p treatment and the lowest crocin were absorved in NP, N and P treatments.

Keywords: saffron, foliar spraying, macro elements, qualitative characteristics

Introduction

Saffron (*Crocus sativus* L.) is the world's most expensive spice and 95 % of the production is coming from Iran. It has been used as food additive, culinary proposes, medicinal and coloring agents. The novel use of saffron in recent years has been associated in cancer cure. This delicate spice has been utilized for thousands of years for different parts of world particularly Iran, China, Spain, Italy, India, Turkey and Greece.

Traditionally in Iran, the leaves of saffron are used as forage for animal feeding. It was stated that saffron produce about 150 g leaf dry matter per squire meter. Saffron cultivated area in Iran is about 47000 ha. Therefore, annually considerable amount of leaf dry matter can be produced from saffron fields. Information about the feeding value of saffron leaves is scarce. Valizadeh (1989) demonstrated that the nutritive value of saffron leaves was intermediate (3). His result showed that digestibility of saffron forage compared with alfalfa due to high fibrous tissues and low protein and mineral content was fairly low.

Housini (1998) stated that saffron is a low nutrient demands plants and requires a modest amounts of nutrients and high application of fertilizers and in particular nitrogen fertilizer promotes vegetative growth

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and lowers the yield (2). In 2002 the net income from exporting 121 tons of saffron exceeded 51 million US $ (3). The three-branch style of saffron flowers (stigma) is the most important economic part of the plant and known as Saffron. Saffron has a long history of use as a spice and for its wonderful color, odor and taste. In the traditional medications saffron has several properties such as relaxant, expectorant, exhilarating agent, digestion stimulant, spasm calmative, menstruation and fetus abortion.

The purpose of this study is foliar spraying saffron with macro elements and assessment effect of this foliar spraying on qualitative characteristics of saffron stigma.

Material and Methods

The effect of foliar sprying with macro elements on qualitative characteristics of saffron stigma were studied in a field experiment using a complete randomized block design with three replications. Fertilizers applied were N, P, K, NP, NK, PK, NPK and bulk.

The treatments after dissolution in concentration of 5 mg per liter were sprayed at February and March months.

After separation stigma of the saffron flower, qualitative characteristics on saffron stigma were measured according to the standard methods of food quality.

Statistical analysis was made with MSTAT-C and Excel. Means were compared with LSD test at 5 % probability level.

Results and Discussion

The results showed that there were significant differences between foliar sprying with macro nutrients and qualitative characteristics of saffron stigma.The highest safranal was observed in k treatment and the lowest safranal in p treatment was observed.

The highest and the lowest crocin were observed in k and NP, N and P treatment respectively. The highest picro crocin was observed in k treatment and the lowest picro crocin in p treatment was observed

Table1: Effect of foliar spraying with macro elements on qualitative characteristics of saffron stigma

picro crocin	crocin %	safranal	treatment
CD63.70	D145.0	BC36.24	N
D63.33	D145.6	C35.05	P
A59.64	A169.0	A38.60	K
BCD63.86	D143.4	BC36.44	NP
ABC64.35	BC155.1	B36.77	NK
AB64.43	AB161.8	B36.94	PK
BCD63.89	CD149.9	B36.88	NPK
CD63.75	CD148.5	BC35.96	BLANK
0.608%	7.295%	1.377%	LSD

References

1- Amirghasemi, T. 2002. Saffron, Red Gold of Iran. Azadeghan Publishing Company. Pp.3.
2- Housini, M. 1998. Effect of nutrient foliar application on yield of saffron. Iranian Scientific and Industrial Research Organization-Khorasan Center.
3- Valizadeh, R. 1989. Evaluation of saffron leaf as animal feed. Iranian Industrial and Scientific Research Organization-Khorasan center (Technical report)

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Application of Diagnosis and Recommendation Integrated System (DRIS) on growth and yield of lentil by using biochemical fertilizers

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Abstract

Field experiment was conducted at College of Agriculture and Forestry to study the application of bio-chemical fertilizer on growth and yield of lentil using Diagnosis and Recommendation Integrated System (DRIS) regime. The experimen involved three levels of nitrogen fertilizer (0, 40, and 80 kg N/H) added as urea, and five levels of phosphorus [(0, 40, and 8 kg P/H) as super phosphate beside two levels of rock phosphate (40 and 80 kg P/H)]. K was added to all treatments at a rat of 10 kg K/H. A factorial experiment within split plot design was used. All the combinations of fertilizers above was splitte into inoculated by a mixture of the three rhizobial strains *R.leguminosarum* (Le_{719}, Le_{726}, and Le_{735}), and not inoculate Samples of soils and plants were taken at three interval times (75,105, 137 days) after cultivation. The results of this stud can be summarized as follows: 1- Successful and activity of using DRIS regime in determining the diagnosis deficiencies an was noticed sharply. The results also showed that nitrogen was the most limited factor. Moreover, there were n differences in diagnosis and recommendations at all stages of growth of lentil which give us an indication that DRIS regim has the superiority and elasticity in finding the diagnosis and this may give the farmer enough time a head to eliminate th deficiency of the limited factor that affecting the yield. 2- By application of DIRS regime, it was found that the bes treatment was the (inoculated with rhizobia + 80 kg P/H + 80 kg N/H+ 10 kg K/H) .3- locally norms values which obtaine showed the successful application of DRIS regime during all stages of growth.

Keywords: DRIS, bacterial inoculation, chemical fertilizers, lentil.

Introduction

Lentil (lens culinanis) known in Turkey, Syria, and Iraq before 8000 years (Cubero 1981), and considere a famous crop that helps in human nutrition and for animals without any harmful for both soil and environment. However, lentil residue used as store for nitrogen, carbon, and other nutrient. Beside ability of lentil in nitrogen fixation by Riyzobia about 88-104 kg N/H/ly (Singh 1981, Islam and Afandi 1980) declared that lentil contain a high percent of protein 22-26% Meanwhile, Whitchead et al., 1998 considered lentil as a cheap representative source compared to meats in countries have high prices for meats. Increasing of growing lentil area word-wide reached to 3404 million Hectare as FAO reported (FAO 1998) and with a production o 3 million tons with average of 878 kg/H. Canada cultivate lentil since 1970 and now produce 200 000 tons (6.6% of world-production) Anon 1995. However lentil grow in Arab countries such as Morocco, Egypt, Syria, and Iraq. Area of lentil was increased in Iraq lately reached to 22130 hectare in 1996. The importance of lentil beside the soil considered as a complex system and un-homogenous in nutrient elements availability. The physiochemical characters leads to make a useful fertilizer recommendation for lentil crop, but this step is not easy. However, analysis for plant was made to evaluate the ability of supplying nutrient to plant at different growth stages to diagnosis the shortage of such nutrient and the ability of diminishing this shortage quickly at early growth

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stages, without ignoring the bio-chemical analysis of soil. For that Beaufils (1973) modified plant system that diagnosis the factors limits nutrient and productivity which knows as DRIS (Diagnosis recommendation of integrated system) then Sumner 1977 was recommended and reviled that DRIS is a good measure or test for pre-knowing the shortage or/and deviation of nutrient(s) balance to get optimum yield. DRIS was applied to different crops such as tomato and cucumber(Al-Khafaji,1993),corn(Hassan, 2000), potato(Al-Zobaie,2000), and soybean (Dizea, 2001), corn (Al- Falahi, 2005). DRIS declared as a good tool and usable by scientists. Upon that and for getting an optimal fertilizers recommendation in lentil, A DRIS was applied, the aim of this study was to determine and test DRIS application by using a mixture three R. bacteria imported from ICARDA (Aleppo-Syria) and chemical fertilizers to get. 1. possible application of DRIS on lentil. 2. Study the efficiency of bio-chemical fertilizer and its interactions.3. Usable of Rock-phosphate as cheap representative chemical phosphate fertilizer. All the above listed points considered a pioneer study locally and/or world-wide.

Material and Methods

Field experiment was conducted at College of Agriculture and Forestry Calciorthid soil (table 1) to study the application of bio-chemical fertilizers on growth and yield of lentil using Diagnosis and Recommendation Integrated System (DRIS) regime, in Factorial Experimental design within split plots. The experiment involved three levels of nitrogen fertilizer (0, 40, and 80 kg N/H) added as urea, and five levels of phosphorus (0, 40, and 80 kg P/H) as super phosphate beside two levels of rock phosphate (40 and 80 kg P/H)]. K was added to all treatments at a rate of 10 kg K/H. All the combinations of fertilizers above was splitted into inoculated by a mixture of the three rhizobial strains *R.leguminosarum* (Le_{719}, Le_{726}, and Le_{735}), and not inoculated. Sample of plants were taken at three interval times 75,105, 137 days after sowing as representing stage of vegetative growth, flowering, and harvesting stages. Ten plants of each plot were taken randomly. Dry weight was taken for shoots and roots, measurements for N,P, and K was determined (Rayan et al 2001).Duncan Multiple Range Test was used statistical.

Table.1. Some of the chemical and physical

Analysis	Value	Unit	Method	Reference
	Calciorthid			
ECe	**1.03**	$ds.m^{-1}$	EC- meter	Richards (1954)
pH	**7.8**	**-**	pH –meter	Mckeague (1982)
CEC	**25.1**	$C.mole^{-}.kg^{-1}$	Na acetate - NH_4^+ acetate	Richards (1954)
O.M.	**18.2**	$gr.kg^{-1}$ soil	Walkley Black	FAO (1974)
$CaCo_3$	**345**	-	Titration	FAO (1974)
Soluble Ions				
Ca^{+2}	**3.28**	$C.mole^{-}.kg^{-1}$	EDTA titration	Richards (1954)
Mg^{+2}	**0.35**	$C.mole^{-}.kg^{-1}$	EDTA titration	Richards (1954)
K^+	**0.26**	$C.mole^{-}.kg^{-1}$	Flamephotometer Flamephotometer	Richards (1954)
Na^+	**0.21**	$C.mole^{-}.kg^{-1}$		Richards (1954)
N	**13.5**	$mg.kg^{-1}$	Microkjeldahl	Page (1982)
P	**25.5**	$mg.kg^{-1}$	Olsen method by Spectrophotometer	Page (1982)
K	**80**	$mg.kg^{-1}$	NH_4^+ acetate, by Flamephotometer	Black (1965)
Fe	**8.26**	$mg.kg^{-1}$	DTPA extraction	Lindsay (1978)
Clay Loam		texture		
Sand	**399**			
Silt	**304**	$gr.kg^{-1}$ soil	Pipette	Day (1965)
Clay	**296**			
Total bacteria	**1.58×10^8**	$CFU.gr^{-1}$ soil	Standard plate tech.	Black (1965)
Total fungi	**2.15×10^4**			

Results and Discussion

Nutrients balance test at fist growth stage (75 days)

Table 2 showed a shortage in nitrogen element in control treatment and consider a limiting yield factor due to its negative index this quantity of nitrogen usually noticed in Iraqi soils. However, the table showed a good index values for each of P and K. the results were in agreement of Hassan 2000, and Al-Zobaie 2000) .Yield percentage of control treatment reached to 61.3 which mean that the soil contains applicable amounts of nutrients that support lentil plants. Decreasing in nitrogen was found at the first five treatments when P was added at levels (P_0 P_1 P_2, RP_1 and RP_2). N-index was increased when 40 kg N/H was added to a value of +3 for the treatment (6-10) with average increase of 12 units (-9 + (+3) = 12 (ignoring of sign). This was occurred by the increasing of nitrogen concentration in plant, and this caused an increase in yield percentage by 8.77 (Appendix 8). Which gave an increase in yield to 132.93 kg/H. When N was added at 80 kg N/H treatments (11-15), N-index was increased to +6.4 which equal to 3.4 units compared to treatments (6-11), with yield percentage 84.28 which equal to 5.71 units increase compared to 40 kgN/H. However, when 80 kg N/H was added (without P) treatments (1,6, and 9) yield percent was increased by 6.28 compared to 40 kg N/H treatment. Also noticed that addition of N at levels 0, 40, 80 kg N/H (without P) caused to imbalance in nutrition status and a decline in P-index from (+4 to -2 , then to -4) with increasing in N-index from -7 to +5, then to +6) also a decrease in k-index from +3 to -3, then to -2) this was contracted with increasing in yield percentage from 61.36% to 74.16%, then to 82.44%). The cause for this increasing in yield was due to the addition of nitrogen which was a limiting yield factor. However, N concentration was increased in plant to (3.28, 3.70, and 3.82%). When P levels was added (0, 40, 80 kg P/H) in treatments (1,2, and 3), an increase in plant P concentrations was observed (0.422, 0.444, 0.456%) and P index . (+4, +7, +10) with increase in yield percentage (61.36, 71.32, 75.92)Respectively, with a decreases in N-index (-7, -8, -11). Similar trend was found when P was added as rock phosphate . Results revealed that increasing in yield percentage caused by N additions was more tan that occured by P added for the same levels .

Treatment (6-15) showed a kind of positive nutrition's balance between N and P indeces with a decrease in K-index due to the absorption of both N and P in large quantities without K addition to soil which cause to clear negative K-index and the approaching to maximum yield was not attended.

Results also showed that inoculation by bacteria caused an effect in balances between nutrients, absolute total (AT) for control treatment was 14 which is close to nutrient balance and when inoculation by Rhizobia (Treatment 16) the AT = 12. Nitrogen concentrations was increased in treatments 16-30 due to formation of root nodules, it was more clear in treatments (16-20)that inoculation by Rhizobia without N-addition, N-index was decreased compared to treatments 1-5 (not inoculated by Rhizobia).

Addition of 40 kg N/H with inoculation by Rhizobia cause to increase in N conc. by 1.56% (treats. 21-25) compared to un inoculated(treats. 6-10). However, addition of 80 kg N/H (treats 26-30) cause an increase in yield by 88% and reached to optimum balance in nutrients AT = 7 compared to un inoculated (treats. 6-10) where AT = 10. Treatment 21 had 5.37 increasing in yield compared with treatment 6. When 40 kg P/H with inoculation by bacteria treatment 17 yield percentage increased by 2% and N-index from 8 to 6 beside P conc. By 1.8% and P index = + 2 compared to treatment 2. same trend was found with 80 kg P/H (treat 18), yield percentage increased 2.93% and N-index from -11 to -9, P conc. By 2.19% compared to treatment 3 (without inoculation). Inoculation by Rhizobia with N and P interactions proof abetter balances in nutrient elements and higher yield was found compared to control. Treatments 28 gave best balances of indeces NPK (-2, +1, +1) AT = 4 ,with yield of 1514.67 kg/H, and fertilizer efficiency of 38.64% compared to control treatment.

The results showed that addition of aquite small amount of K (10 kg/H) or may be little bit more may reach to amaximum yield and best balances in nutrients elements with AT = O. The results also found in agreement with Al-Kafagi 1993 on Tomato and cucumber, and Hassan 2000 on corn, Al-Zobaie 2000 on potatoes Dizea 2001 on soybean, and Al-Falahi on corn. Again treatment 28 considered the best treatment in yield and balances beside its data was closed to domestic standard norms that was determined from the international yield groups which finally leads the successful of DRIS for this study, The data was in agreement with Halmark et al., 1990, Hassan 2000, and Al-Falahi 2005. the littérateurs cited that domestic standard norms gave a good efficiency in diagnosis.

Table 2. Concentrations, nutrient ratio and DRIS indices of lentil in the first stage (after 75 days of planting)

No	Treat.	Leaf composition (%)			Nutrient Ratio			DRIS indices			A T	Yield kg/ha	R.Y.
		N	P	K	N / P	N / K	K / P	N	P	K			
1	$B_0 N_0 P_0$	3.28	0.422	2.27	7.77	1.44	5.38	-7	4	3	14	929.33	61.36
2	$B_0 N_0 P_1$	3.34	0.444	2.29	7.52	1.46	5.16	-8	7	1	16	1081.00	71.37
3	$B_0 N_0 P_2$	3.36	0.456	2.31	7.37	1.45	5.07	-11	10	1	22	1150.00	75.92
4	$B_0 N_0 Rp_1$	3.32	0.452	2.30	7.35	1.44	5.09	-10	9	1	20	1074.00	70.91
5	$B_0 N_0 Rp_2$	3.33	0.452	2.30	7.37	1.45	5.09	-9	8	1	18	1051.67	69.43
6	$B_0 N_1$ P0	3.70	0.435	2.30	8.51	1.61	5.29	5	-2	-3	10	1123.33	74.16
7	$B_0 N_1 P_1$	3.78	0.448	2.34	8.44	1.62	5.22	5	-1	-5	11	1231.00	81.27
8	$B_0 N_1 P_2$	3.80	0.470	2.31	8.09	1.65	4.91	4	5	-9	18	1248.33	82.42
9	$B_0 N_1 Rp_1$	3.66	0.452	2.29	8.10	1.60	5.07	2	3	-5	10	1196.33	78.98
10	$B_0 N_1 Rp_2$	3.68	0.453	2.31	8.12	1.59	5.10	2	3	-5	10	1151.67	78.03
11	$B_0 N_2 P_0$	3.82	0.410	2.32	9.32	1.65	5.66	6	-4	-2	12	1248.67	82.44
12	$B_0 N_2 P_1$	3.80	0.446	2.32	8.52	1.64	5.20	6	-2	-4	12	1311.33	86.58
13	$B_0 N_2 P_2$	3.92	0.466	2.34	8.41	1.68	5.02	7	2	-9	18	1354.67	89.44
14	$B_0 N_2 Rp_1$	3.88	0.460	2.35	8.43	1.65	5.11	6	1	-7	14	1271.67	83.96
15	$B_0 N_2 Rp_2$	3.90	0.462	2.34	8.44	1.67	5.06	7	1	-8	16	1196.33	78.98
16	$B_1 N_0 P_0$	3.36	0.431	2.37	7.80	1.42	5.50	-5	1	4	10	944.67	62.37
17	$B_1 N_0 P_1$	3.50	0.452	2.39	7.74	1.46	5.29	-6	3	3	12	1114.33	73.57
18	$B_1 N_0 P_2$	3.54	0.466	2.47	7.60	1.43	5.30	-9	4	5	18	1194.33	78.85
19	$B_1 N_0 Rp_1$	3.50	0.458	2.41	7.64	1.45	5.26	-7	4	3	14	1141.67	75.37
20	$B_1 N_0 Rp_2$	3.52	0.460	2.43	7.65	1.45	5.28	-7	4	3	14	1125.33	74.30
21	$B_1 N_1$ P0	3.78	0.430	2.46	8.79	1.54	5.72	4	-8	4	16	1204.67	79.53
22	$B_1 N_1 P_1$	3.78	0.430	2.44	8.79	1.55	5.67	5	-7	2	14	1335.67	88.18
23	$B_1 N_1 P_2$	3.80	0.448	2.46	8.48	1.54	5.49	2	-5	3	10	1365.00	90.12
24	$B_1 N_1 Rp_1$	3.77	0.432	2.46	8.73	1.53	5.69	3	-7	4	14	1234.33	81.49
25	$B_1 N_1 Rp_2$	3.78	0.431	2.45	8.77	1.54	5.68	4	-7	3	14	1153.00	76.12
26	$B_1 N_2 P_0$	3.86	0.436	2.45	8.86	1.58	5.62	6	-6	0	12	1300.33	85.85
27	$B_1 N_2 P_1$	3.85	0.456	2.43	8.44	1.58	5.33	4	-1	-2	7	1381.33	91.20
28	$B_1 N_2 P_2$	3.88	0.468	2.46	8.29	1.58	5.26	1	1	-2	4	1514.67	100.00
29	$B_1 N_2 Rp_1$	3.84	0.456	2.41	8.42	1.59	5.29	4	-1	-3	8	1270.67	83.89
30	$B_1 N_2 Rp_2$	3.86	0.468	2.48	8.43	1.56	5.41	3	-2	-1	6	1208.33	79.78

NORMS			
	n/p	n/k	k/p
norms	8.20	1.53	5.32
c.v	9.28	8.21	9.38

Testing balances in nutrients at second growth stage after (105 days):

Plant samples (leaves and stem) was taken in second growth stage at (flowering stage). Table (3) showed a decrease in all nutrient elements due to the dilution effect. (Abuthahi and Al-Younis 1988). However ratios between nutrients almost still constant and close to the data at first growth stage. This may give rise to clear proof stability to the ratios between nutrients at different plant stages and during plant growth.. Table 3 showed a small decline in N, P, and K indeces, this may due to huge uptake of N and P at the second plant stage and processes of metabolism compared to first stage of growth. Moreover, same trend was found, N was the limiting growth factor until treatment 5, P was found in a good indexes, but negative in K-index because there was no addition of K-fertilizers. Data showed that N-indeces was decreased when 40 kg N/H was added specially in treatments get higher addition of P-fertilizers (treats 3, and 8). But when 80 kg N/H was added there was a kind of balances noticed between indeces except for treatment 13 (may due to addition of high P-fertilizer leads to more uptake of P and other nutrients for metabolism and growth processes). Negative K-index also noticed which give rise to a solid balances in nutrients. However, K considered at this point (treatments) as a limiting growth factor, because no maximum yield was approached.

Addition of bacterial inoculation gave a good nutrients balance due to the increase in N-concentration and fixation by plant through root nodules (treat 16-25). It looks that Rhizobia share in balances between N, and P added (treat. 21, 11, 17, 2, 18, and 3). Moreover treatment 28 considered the best. Now, When maximum yield with least AT value and high indeces of nutrients was approached at second plant growth, this will give an agreement and concolidated successful of DRIS on lentil crop. Tables (2, and 3), and the data was in agreement with Walworth et al., 1986, Walworth and Sumner 1987, Wortmann et al., 1992. Finally, adiagram can be drawn (Tisdale et al., 1993) to explain ratios of nutrient elements n/p, n/k, and k/p, and values, of critical ratios for first stage. Values of ratios at inside the small circle represents demotic standard norms in this study (8.29, 1.58, and 5.26) which is close to N/P ratio that locate between 9.53-7.05 which was equal to ± 15% of n/p norm (8.29). However, rations located between the two circles represents critical boundaries, where values in the large circle represents ± 30% of norm (8.29, 1.58, and 5.26). any ratio beyond this range considered (in large circle) means big index and found in huge quantity otherwise, sharp negative index as arrows pointed. If arrow direction up-word means more quantity index, down -word means deficiency and if to right means enough quantity .

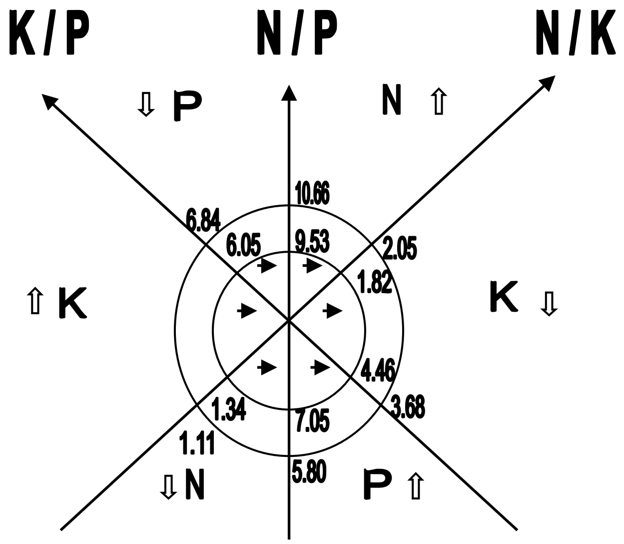
The results gave a high diagnosis and recommendation for this system on lentil crop without effect by plant growth periods or stages, this may considered a great efficiency and strong for DRIS application in field and the farmer will have a plenty of time to re-add any quantity of fertilizers at different plant growth period to avoid deficiency in nutrient elements for plant. But here we have to make attention, that avoiding taking any concentration or ratio alone, it should be taken as a group frame of concentrations for nutrients that shares in balances.

Finally, adiagram can be drawn (Tisdale et al., 1993) to explain ratios of nutrient elements n/p, n/k, and k/p, and values, of critical ratios for first stage. Values of ratios at inside the small circle represents demotic standard norms in this study (8.29, 1.58, and 5.26) which is close to N/P ratio that locate between 9.53-7.05 which was equal to ± 15% of n/p norm (8.29). However, rations located between the two circles represents critical boundaries, where values in the large circle represents ± 30% of norm (8.29, 1.58, and 5.26). any ratio beyond this range considered (in large circle) means big index and found in huge quantity otherwise, sharp negative index as arrows pointed. If arrow direction up-word means more quantity index, down -word means deficiency and if to right means enough quantity.

Table 3. concentrations ,nutrient ratio and DRIS indices of lentil in the first stage (after 105 days of planting)

No	Treat.	Leaf composition (%)			Nutrient Ratio			DRIS indices			A T	Yield kg/ha	R.Y.
		N	P	K	N / P	N / K	K / P	N	P	K			
1	$B_0 N_0 P_0$	2.48	0.32	1.82	7.75	1.36	5.69	-6	1	5	12	929.33	61.36
2	$B_0 N_0 P_1$	2.64	0.36	1.81	7.33	1.46	5.03	-7	9	-2	18	1081.00	71.37
3	$B_0 N_0 P_2$	2.68	0.38	1.80	7.05	1.49	4.74	-8	14	-4	28	1150.00	75.92
4	$B_0 N_0 Rp_1$	2.66	0.36	1.80	7.39	1.48	5.00	-3	7	-4	14	1074.00	70.91
5	$B_0 N_0 Rp_2$	2.68	0.36	1.81	7.44	1.48	5.03	-5	8	-3	16	1051.67	69.43
6	$B_0 N_1$ P0	2.84	0.32	1.82	8.88	1.56	5.69	5	-6	1	12	1123.33	74.16
7	$B_0 N_1 P_1$	2.87	0.37	1.81	7.76	1.59	4.89	-1	7	-6	12	1231.00	81.27
8	$B_0 N_1 P_2$	2.87	0.40	1.82	7.18	1.58	4.55	-7	16	-9	32	1248.33	82.42
9	$B_0 N_1 Rp_1$	2.84	0.36	1.80	7.89	1.58	5.00	0	5	-5	10	1196.33	78.98
10	$B_0 N_1 Rp_2$	2.82	0.38	1.79	7.42	1.58	4.71	-3	11	-8	22	1151.67	78.03
11	$B_0 N_2 P_0$	2.94	0.33	1.82	8.99	1.62	5.57	8	-7	-1	16	1248.67	82.44
12	$B_0 N_2 P_1$	2.94	0.36	1.83	8.17	1.61	5.08	3	2	-5	10	1311.33	86.58
13	$B_0 N_2 P_2$	2.97	0.39	1.84	7.71	1.61	4.78	-1	8	-8	17	1354.67	89.44
14	$B_0 N_2 Rp_1$	2.96	0.38	1.82	7.79	1.63	4.79	1	7	-8	16	1271.67	83.96
15	$B_0 N_2 Rp_2$	2.94	0.37	1.81	7.95	1.62	4.89	2	5	-7	14	1196.33	78.98
16	$B_1 N_0 P_0$	2.56	0.30	1.80	8.53	1.42	6.00	1	-5	4	10	944.67	62.37
17	$B_1 N_0 P_1$	2.71	0.36	1.80	7.53	1.51	5.00	-3	7	-4	14	1114.33	73.57
18	$B_1 N_0 P_2$	2.79	0.37	1.84	7.54	1.52	4.97	-4	8	-4	16	1194.33	78.85
19	$B_1 N_0 Rp_1$	2.78	0.36	1.84	7.72	1.51	5.11	-4	6	-3	13	1141.67	75.37
20	$B_1 N_0 Rp_2$	2.78	0.36	1.82	7.72	1.53	5.06	-2	6	-4	12	1125.33	74.30
21	$B_1 N_1$ P0	2.85	0.33	1.83	8.66	1.56	5.56	5	-4	-1	10	1204.67	79.53
22	$B_1 N_1 P_1$	2.84	0.36	1.85	7.89	1.54	5.14	-1	4	-3	8	1335.67	88.18
23	$B_1 N_1 P_2$	2.85	0.38	1.86	7.50	1.53	4.89	-4	9	-5	18	1365.00	90.12
24	$B_1 N_1 Rp_1$	2.82	0.36	1.84	7.83	1.53	5.11	-2	5	-3	10	1234.33	81.49
25	$B_1 N_1 Rp_2$	2.79	0.36	1.87	7.75	1.49	5.19	-3	5	-2	10	1153.00	76.12
26	$B_1 N_2 P_0$	2.98	0.34	1.91	8.76	1.56	5.62	5	-5	0	10	1300.33	85.85
27	$B_1 N_2 P_1$	2.99	0.36	1.88	8.31	1.59	5.22	3	1	-4	8	1381.33	91.20
28	$B_1 N_2 P_2$	2.98	0.35	1.92	8.51	1.55	5.49	3	-2	-1	6	1514.67	100.00
29	$B_1 N_2 Rp_1$	2.92	0.36	1.86	8.11	1.57	5.17	1	2	-4	8	1270.67	83.89
30	$B_1 N_2 Rp_2$	2.97	0.36	1.85	8.25	1.61	5.14	3	2	-5	10	1208.33	79.78

NORMS			
norms	n/p	n/k	k/p
	8.33	1.45	5.30
c.v	9.2	15	13.1



	K/P	N/K	N/P
+30%	6.84	2.05	10.66
+15%	6.05	1.82	9.53
The optimum values	**5.26**	**1.58**	**8.29**
-15	4.47	1.34	7.056
-30	3.68	1.11	5.80

+Figure 1: shows the optimum values and critical ratios concentrations of nutrients in the plant, which we reached in our study (after 75 days)

References

Alzobaie, Salam Zaki Ali (2000) . Identify food NPK balance for potato production in Abu Ghraib, Ph.D thesis , Department of Soil Science , Faculty of Agriculture , University of Baghdad .

Anonymous (1995). Food Production Yearbook. Food and Agriculture Organization (FAO) .Vol.49, Roma Italy.

Anonymous (1998) . Annual Report of the National Programme for the development of agriculture and grain legumes

Beaufils, E. R. (1973). Diagnosis and Recommendation Integrated System (DRIS) Ageneral scheme for experimentation and calibration based on principles developed from research in plant nutrition. University of Natal soil sci.Bull.1,1-132. (Cited by sumer 1977. Plant and Soil .46:359-369) .

Black, C. A. (1965). Methods of soil analysis. Part 2. Chemical and Microbiological properties. Amer. Soc. of Agron. Inc puplisher, Madison Wisconsin, U.S.A.

Cubero, J. I. (1981). Organ taxonomy and donestication. Pages 15–38 in lentil (C. Webb and G. Hawtin, eds.) Commonwealth Agricultural Bureaux. England.

Day, P. R. (1965). Partical fractionation and partical analysis. pp.: 546-566. In C. A. Black (ed.). *Methods of soil analysis*, Agon. No.9, Part 1: *Physical and mineralogical propertyies.* Am. Soc. Agron., Madison, WI, U. S. A.

Di zea , Aloand Tahir Rashid (2001) . Determine the best balance of NPK for the soybean crop in sedimentary soils using the method of DRIS, Ph.D thesis , Faculty of Agriculture , University of Baghdad .

Al-Falahi , Mohammed Howeidi Mnaged (2005) . Evaluation system (DRIS) and the effect of foliar feeding NPK elements in the growth and holds maize (Zea Mays L.), PhD thesis , Faculty of Agriculture , University of Baghdad .

FAO, (1998). FAO. Production year book 52. Roma. Italy. Summer field, R. J. and E. H. Roberts, 1985. Grain Legum crops. London. Collins.

Hassan Abdul-Karim Hamad (2000) .Testing the Diagnosis and Recommendation Integrated System on the plant and soil in fertilized maize. Ph.D thesis , Department of Soil - Faculty of Agriculture - Abu Ghraib - the University of Baghdad .

Islam, R. and Afandi, F. (1980). Response of lentil *Lens culinaris* cultivars to inoculation and nitrogen fertilization. In: lentil, Webb and G. Hawtin (ICARDA).

Al-Khafaji, H.E., Mohammed A.K. (1993) . Relationship with magnesium, manganese, zinc and its effect on the nutrition of tomato and cucumber plants in greenhouses heated. Ph.D thesis. Department of Soil Science, Faculty of Agriculture, University of Baghdad.

McKeague, J. A. (ed). (1978). Manual on soil sampling and methods of analysis. Canadian Society of Soil Science: 66-68.

Page, A.L.; Miller, M.H., Keeney, D.R. (1982). Methods of soil analysis part 2: Chemical and microbiological properties. Agron. Series No.9 Amer. Soc. Agron. Soil Sci. Soc. Am. Inc. Madison U.S.A.

Richards, L. A. (ed.) (1954). Diagnosis and Improvement of soil and alkali soils. U. S. D. A. Hand book No. 60.

Ryan, J.; Estefan, G., Rashid, A. (2001). Soil and Plant Analysis Laboratory Manual. 2nd Edition. ICARDA. Aleppo, Syria.

Singh, K. B. (1981). Yield Potential of tall Cickpeas at increased plant density. International chickpea Newletter 4: 10-11.

Sumner, M. E. (1977a). Application of Beaufiles diagnostic indice to maize data puplished in the literature irrespective of age and Condition. Plant and Soil 46: 359- 369.

Sumner, M. E. (1981). Diagnosis the suifur requirement of corn and Wheat using foliar analysis. Soi; Sci. Soc. AM. J. 45: 87-90.

Tisdale, S. L.; W. L. Nelson and J. D. Beaton. (1993). Soil fertility and fertilizers. 5th ed. Macmillan publish company. New York.

Walworth, J. L. and summer, M. E. (1987). Diagnosis and Recommendation Integrated System (DRIS). Advance In Soil Sci. 6: 149-189.

Walworth, J. L. Sumner; M. E. Issac, and Plank, C. O. (1986). Preliminary DRIS norms for alfalfa in the southeastern U.S and comparison with Midwestern norms. Agron. J. 78: 1046-1052.

Whitehead, S. J.; Sumner, R. J. Field; Muehlbauer; F. J. Ellis, R. and Wheeler, T. R. (1998). Biomass production, partitioning and structure in lentil. Grain Legumes: 22-4th quarter.

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Monitoring of soil moisture and salinity at wide areas by using wireless sening network

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Abstract

The century in which we live, data collecting and converting to knowledge is transformed like an economical and strategic source. At the present day, data produced or acquired with multilayered and hierarchic logic that are visible and shared, transformable and appraisable for reveal of decision. When the data is noticeable and being shared can provide economical and strategic results. Data share on the paper is difficult and wasting time, high cost and effort needed. At the information age, data existing is not only enough in any places, data gains value during they are fast, attainable, accurate, analysable, problem solving according to decision maker demand. It is believed that yield quality and quantity are related to the proper irrigation methods. Understanding of variable about environment according to time and location make contribution to farmers decision for their cultivation methods. For instance, knowing of soil, climate, soil moisture characteristics helps with using less water and energy during irrigation season and make contribution to yield quality and quantity. After all, water and soil are not limited. At the soil moisture deficiency conditions, irrigation is needed for optimum plant growth and yield. Over irrigation at the arid and semi-arid climate condition caused high water table and salinity increases. Changes of salinity severity during season can damage plant according to plant type and cause yield losses. Wireless sensing network is a current system applied to more fields. By using of Wireless sensing network system data can be derieved from medium and transformed to knowledge for data evaluation and analyse. In the resaerch, soil moisture, salinity and temperature monitored with wireless sensing network system in a yield growing season and data (temperature, salinity , moisture) were compared with clasical methods. According to this result, mechanicism of wireless sensing network observed and monitored.Changes of moisture and salinity with time and learning of water budged is a special point for irrigation otomation by passing from data sent with cable system to mobile phone. This project needs more tests and improvements. At the same time, this system should be compared with current systems and economical analyses should be made.

Keywords: Soil moisture, salinity, wireless sensing network, irrigation systems

Introduction

The optimum productivity can be achieved when absence of sufficient moisture in the soil for ideal plant growth by irrigation. Especially in arid and semi-arid climate conditions in case of using water more than plant needs consequently it will result to groundwater and salinity problems. According to the type of plants, severity and seasonal variations of salinity are damaging in different ways cause to lower yield. Wireless

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Sensing Networks is a new technology, recently being on the agenda and that can be applied in many fields. By using wireless sensing networks data can be collected interactively with media, these data are transformed into information, being evaluated in collectively and as necessary, based on information modifications may be made on the media. Wireless Sensing Networks (K2A), which can communicate wirelessly with each other among themselves, that can contain different types of sensors and specifications, composed of wireless sensing unit structures. In the rapid development of Micro-electromechanical (MEMS) and Radio Frequency Systems (RF); has enabled the development of micro-sensing available on the network which consume less power and inexpensive, too. These sensing nodes provide identification of variety of physical information such as temperature, humidity, salinity, etc. As a result of evaluation of soil moisture and salinity information, this system providing irrigation according to needs of the plant. The project was conducted in GAP Agricultural Research Institute and is still ongoing. The full name of the project (Tagem-bb-090202j03) is "The monitoring of soil moisture and salinity in large areas using by wireless sensing networks".

Material and Methods

Projects mainly measure soil moisture and salinity in the field with sensors by programming with installation of the station. Within the project; soil moisture and, temporal and spatial variation of salt, from 1 minute up to 1440 minutes can be done per day at a desired frequency measurement. And a radio frequency (2.4GHz) signal converter (ZigBee unit) in the station sends that measures as a radio frequency (RFID). This signal comes to the collector. The system is working point to point structure. Collector unit is the same as the signal emitted. When installation the stations to the field, the signal emitted and the collecting unit is defined by programming. This collector (an antenna connected on it which has a high flow rate) is connected to the computer via the USB connection. And also there is a software program which is a part of the project, known as Tarver (the name of the professional field data collection is intended as an abbreviation) installed on the computer. Collector takes measurements of signal values that contain the soil moisture and salinity from stations in the field according to specified time from1 minute to 1440 minutes. This signal in Tarver program is presented to the operator with a significant chart and figures. The operator observes availability of soil moisture and salinity. Critical level indicators can be made for salt, soil moisture, as well as soil temperature values in the Tarver program. If there is an irrigation need based on water consumption of plant species, it gives the command to the program to start irrigation. This time, signal follows reverse way from the collector goes to the station. There are relays at each station which is a sending open and closed command to solenoid valves. According to the coming command station opens the relay and starts irrigation. Meanwhile, sensors in the station are sending moisture and salt values, according to the desired frequency, as a feedback to the collector. Operator in the Tarver program can see the change of moisture and salt. When soil reaches to optimum level of moisture and salt according to the needs of plant species and salt tolerance, then close relay command send to the program. As the signal from the collector to the station, this command closes the solenoid valves. The system is working with mutual communication protocols. Considering the field conditions, electricity need is provided by solar panel which has a size of 20x20cm that charges the tiny battery (4.6 volts) placed to the station. Or station can be operated by 3 AA batteries. And also, the battery or the accumulator support is available in the unit collector. The electronic cards which contain the stations and the relay modules were placed in the appropriate boxes for the external conditions (IP 65 Protocol) because of operating in field conditions. The system is communicating very well within a range of 1-3 km. This range can be increased with higher dB antenna.

Realization Status of Major Activities:

The Station: A station consists of a mainboard which contains connected solar panel, soil moisture and also salt sensor and the RF unit containing the communication module, irrigation relays, accumulator, charging and regulating section comprised of a control unit and soil moisture and salinity measuring sensors. Installation completed station is given below as Figure 1.

These stations have started to be named from GAP001 to GAP050 and the devices as a whole was named as station. Stations sends RF signals to the coordinator. Stations are activated according to the conducted program (from 1 minute to 1440 minutes of the range) by communicating with moisture in the soil (15-45-75cm depth) and salt sensors (if salt is available in 15 cm depth) and receiving datas. These datas are converting to the RF signal and send to the coordinator which has been structured in the system room.The coordinator is the same as communication modules of the stations. Unlike high-dB antenna was added, and the power supply is directly connected to the computer by RS232 port where software is running in order to prevent power cuts of the computer. The system in the form of point to point structure, coordinator is getting each of station informations and transmits to the software in this way. The software named as Tarver pro which has SQL based archive and as SCADA (Supervisory control and data collection system) software allow concurrently to multiple number of users to entry the system. These users authorization levels can be defined in two different statuses.The system is able to do DEBUG with the internal support of control. In this way, the system running process can be monitored.

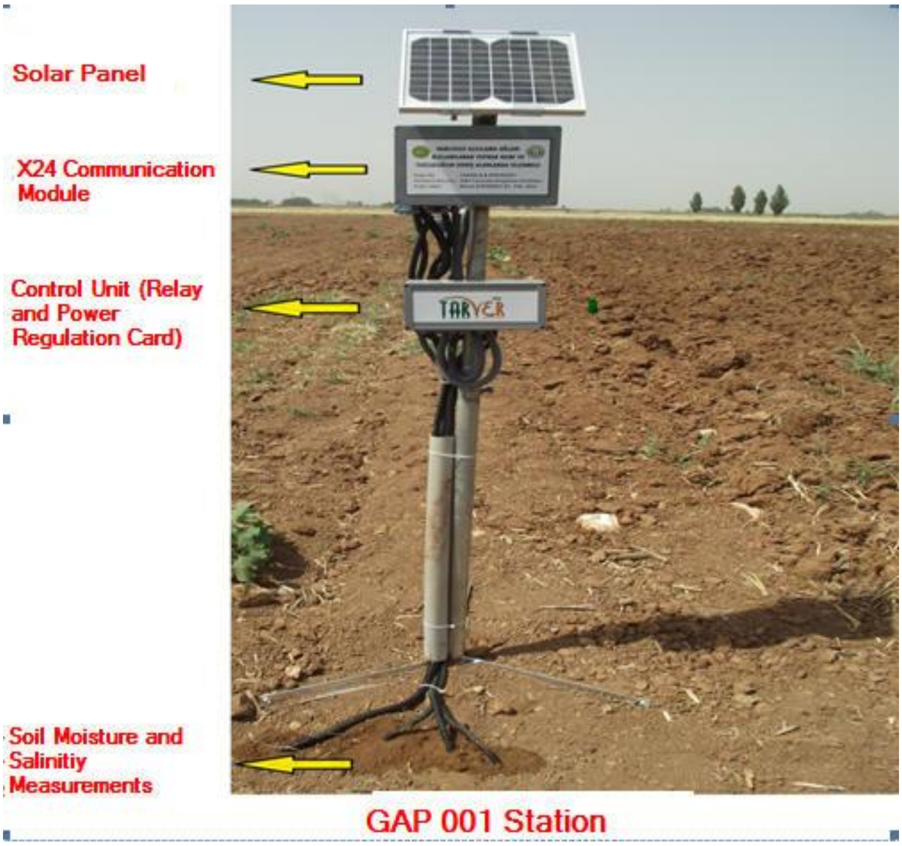

Figure 1. GAP001 Completed Station

These stations have started to be named from GAP001 to GAP050 and the devices as a whole was named as station. Stations sends RF signals to the coordinator. Stations are activated according to the conducted program (from 1 minute to 1440 minutes of the range) by communicating with moisture in the soil (15-45-75cm depth) and salt sensors (if salt is available in 15 cm depth) and receiving datas. These datas are converting to the RF signal and send to the coordinator which has been structured in the system room. The coordinator is the same as communication modules of the stations. Unlike high-dB antenna was added, and the power supply is directly connected to the computer by RS232 port where software is running in order to prevent power cuts of the computer. The system in the form of point to point structure, coordinator is getting each of station informations and transmits to the software in this way. The software named as Tarver pro which has SQL based archive and as SCADA (Supervisory control and data collection system) software allow concurrently to multiple number of users to entry the system. These users authorization levels can be defined in two different statuses. The system is able to do DEBUG with the internal support of control. In this way, the system running process can be monitored.

Project Application Schema: The Project was established in the Talat Demirören research station in the month of May-June. As seen below, Figure 2, the point of application is to create a grid on the basis of the parcel by using of GPS (Global Positioning Device). Also, the control room is hosting the antenna which collects the data of the entire system, the coordinator, computer and uninterruptible power supply. Project-related assembly, measuring, weighing and control units are located here.

Figure 2. Project Application Schema in Talat Demirören Resarch Station

Parcel Identifier And The Status Of The Station: The stations have been established on the basis of the parcel on the field. Each parcel is being tested in different ways in terms of horizontal and vertical distances between stations and grids.

Software: Tarver Pro program has been developed to work with X24 series devices with SQL based archive and SCADA software. The program allows concurrently to 128 users to entry the system. These users authorization levels can be defined in two different statuses. Authorized operations;

1. ADMIN: has the authority to access all the system.

2 USER: has the authority only instant to monitor the situation.

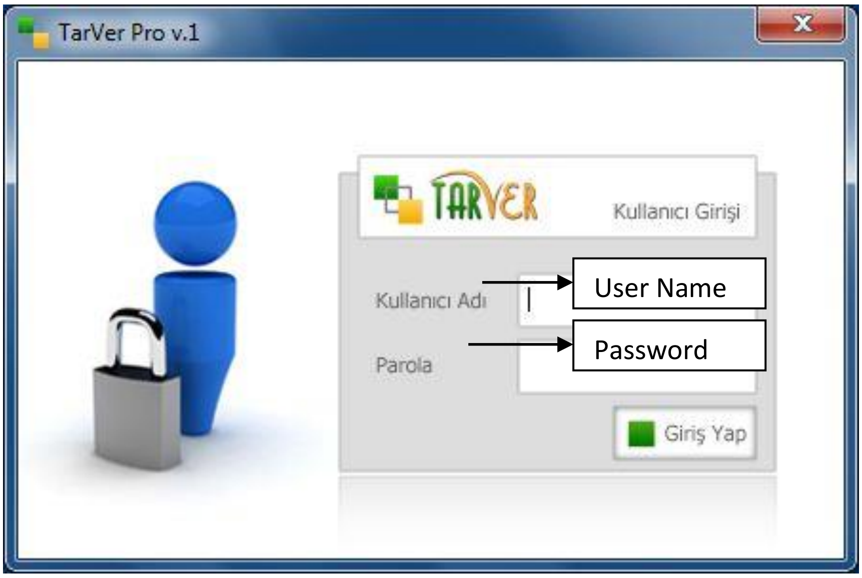

Figure 3. Login Screen of the program

When the program is started, the first screen is the login screen. The entry is done by one of defined user name and password in a controlled manner Figure 3. When Loggeg in, the main menu will come as a first. From this menü it can be accessed to the sub-menu and the desired tracking or adjustments can be made. There are 4 sub-menus which are instant tracking, Reports, Settings and about the Tarver Pro, in Figure 4.

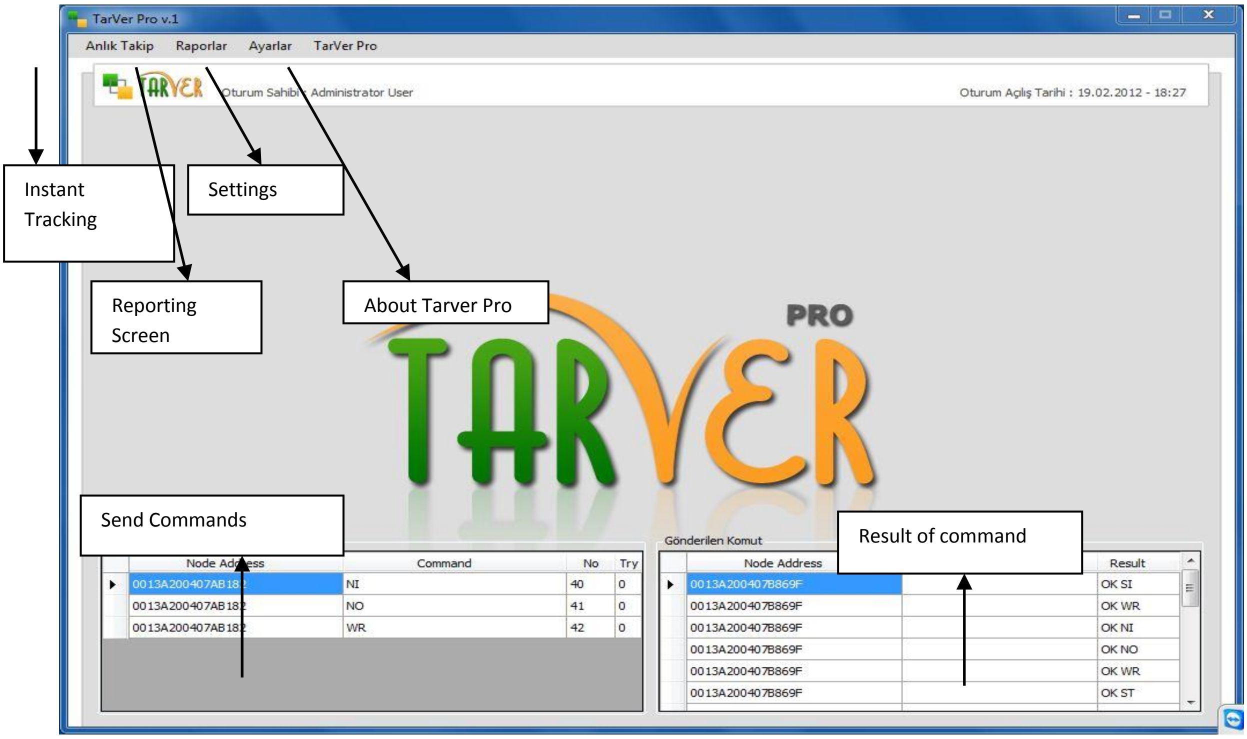

Figure 4. Menus of the program

Results and Discussion

Basic expectation from this project is to develop an irrigation system that will make agriculture providing by sustainable water and energy savings together with salinity control. At the beginning the system was in the form of measuring soil moisture and salinity based on the temporal and spatial variation of salt and the soil moisture. However, the possibility of making irrigation has been asked to investigate in the group meetings. In fact, the biggest handicap was expected to be the communication and software. However, besides these two, it has been detected that several research projects carried out many institutions including the Universities used for soil moisture and salinity sensors were not to be calibrated according to the country lands in the last 6-7 years. Even, how to make the calibration was one of the uncertain topics. This situation resulted to one-year extension to the project for how to improve calibration methods and calibration of the measurement values for the soil (Vertisols type) of the Harran Plain. To be addition of irrigation modules to the system again resulted to one year extension for requesting the budget required based on group meeting. To summarize the current situation, the system is working at 5% level of communication failure. Soil moisture sensor calibration is completed with the accuracy of level of R^2 is 0.82, according to the Harran plain Vertisols type soil structure. Technical analysis and measurements on the system together with salt sensor are still on going.

Conclusion

It is known to correlate in increase in the quantity and quality of product with optimum irrigation. It is known that to know variables based on location and time directly affect farmers planting plans. For example; to know characteristics of the soil, meteorological conditions with known soil moisture will result to increase in products quality and quantity performed in production compared to irrigation scheduling with a less usage of water and energy. It should be remembered that soil and water resources are not unlimited. The innovation of the project is transition from wired phone to mobile phone for water budgeting and irrigation automation at this moment. Likewise the development process is expected to be. There is a need of more testing and continuous development of the project. It has been underlined that this system should be tested by other Research Institute calibration of the sensors in different soils type for extensions. In addition, an economic analysis is also required for comparison with the present system.

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Evaluation of differences in fertilizer consumption of autumn tomato production in greenhouse

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Abstract

In this research; the fertilizing practices, which are done with chemical fertilizers for approximately 5 months by 12 different greenhouses tomato growers from 5 areas around Antalya are recorded according to amounts of chemical fertilizers which are collected from the conversations with the growers. The consumption of fertilizers done by those growers is calculated both on monthly basis and total of 5 months according to active nutrient contents of N, P_2O_5, K_2O, CaO, MgO and SO_3. With this article, fertilizer consumption between growers within the month due to some general trends can be seen, although great differences between the growerss were examined. No grower fertilizing the soil analyzed based on the analysis it was determined that making. Growers production of N + P_2O_5 + K_2O+ CaO + MgO + SO_3 season during the active nutrient contents on the basis of total fertilizer use; for 1. month minimum 9.56 kg.da^{-1} while maximum 36.70 kg.da^{-1}, for 2. month minimum 13.94 kg.da^{-1}while maximum 63.83 kg.da^{-1}, for 3. month minimum 9.03 kg.da^{-1}while maximum 28.06 kg.da^{-1}, for 4. month minimum 4.96 kg.da^{-1} while maximum23.24 kg.da^{-1}, for 5. month minimum 1.41 kg.da^{-1} while maximum 19.98 kg.da^{-1}, for 6. month minimum 0 kg.da^{-1}while maximum 9.77 kg.da^{-1}have applied fertilizer. During the production season of the growers on the basis of active nutrient contents separately N, P_2O_5, K_2O, CaO, MgO, SO_3 examined patterns of use; minimum 17.78 kg N.da^{-1} maximum 31.00 kg N.da^{-1}, minimum 7.10 kg P_2O_5.da^{-1}maximum 34.67 kg P_2O_5.da^{-1}, minimum 22.88 kg K_2O.da^{-1}maximum 44.59 kg K_2O.da^{-1}, minimum 1.52 kg CaO.da^{-1}maximum 9.92 kg CaO.da^{-1}, minimum 0 kg MgO.da^{-1}maximum 6.83 kg MgO.da^{-1}and minimum 0.17 kg SO_3kg.da^{-1}maximum 7.58 kg SO_3.da^{-1}fertilizer were applied. During the production season of the growers on the basis of active nutrient contents separately N/P_2O_5, N/K_2O, N/CaO, K_2O/P_2O_5, K_2O/CaO examined patterns of ratio; minimum 0.89 maximum 2.10 ratio of N/P_2O_5, minimum 0.56 maximum 0.89 ratio of N/K_2O, minimum 2.44 maximum 16.26 ratio of N/CaO, minimum 1.06 maximum 3.22 ratio of K_2O/P_2O_5 and ratio of K_2O/CaO reached up to minimum 2.62 maximum 23.48. In this article, 12 different growers fertilizer application and general trends in the causes of the differences interpreted deficiencies, excesses and imbalances on the evaluation were presented and some recommendations.

Keywords: Greenhouse fertilization, autumn tomatoes, fertilizer consumption, fertilizer

Introduction

Agriculture is defined as "Using the natural resources to the benefit of humans, by the production of plants and animals.". However, while using those natural resources, regardless of how humans consider the conservation of nature, it is not possible to do it without harming the nature. Therefore, agriculture has also an ecological importance as much as it's economical importance (Kansu 2001).

In Turkey, the total area of greenhouse production is 59.961 ha today. 60 % of the total area of greenhouse production in Turkey is in Antalya. 96% of the greenhouses in Turkey are used for the production of

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vegetables. 64 % of the total vegetable production is tomatoes, while the rest is divided as 21% is cucumber, 9% is pepper and 4% is eggplant production. Total fertilizer consumption in Turkey is 5.383.867 tonnes as of year 2012 (Anonymous 2012). This total fertilizer consumption consists 63.70 % of 21 % nitrogen fertilizers, 34,5% of 16-18% phosphorus fertilizers and 1,8 % 48-52% potash fertilizers. On the other hand, despite having 60% of the total greenhouse production in Turkey, the total fertilizer consumption in Antalya is 193.197 tonnes, which is equal to the 1,9% of the total fertilizer consumption in Turkey. As for Antalya, most used fertilizers are 21 % nitrogen fertilizers by the ratio of 63%, which is followed by 16-18% phosphorus fertilizers(29 %) and 48-52% potash fertilizers (8.3%) (Tüik, 2006). In greenhouses, especially in the seasons with intense production, fertilizers are used in high volumes, which pollutes water resources (especially water wells), endangering the quality and quantity of plant production in the area (Kaplan et al 1999). Being one of the most important inputs of agricultural production, fertilizers, by helping achieve high yield and quality, have a significant effect in making agricultural production a profitable economical activity. Fertilizer useage have an effect between 50-75% in terms of increased production (Eyüpoğlu, 2002).

Material and Methods

The main materials of Research are around the Antalya city, at 12 different greenhouses belong to 5 different region where intense tomato production takes place between August 2013 and February 2014.Growers of the greenhouse characteristics, location and area dimensions in table 1 are indicated. Growers have used a fertilizer independently of one another in accordance with their knowledge and experience. Every application have been recorded with meet face to face. As a result of each application to be recorded according to the fertilizer from month to month, and the total amount of active nutrient contents in the amounts used were calculated.

Table 1. General characteristic features of research greenhouse

Growers Greenhouse Number	Growers Name Surname	Greenhouse Covers	Location	Size (m^2)
1	Ali ARSLAN	Plastic	Gaziler	2.400
2	Metin ZOR	Plastic	Gaziler	2.800
3	İsa KANDEMİR	Plastic	Kırcami	2.200
4	Ali KÖSEM	Glass	Varsak	2.250
5	Osman ÇETİN	Plastic	Varsak	2.850
6	Ramazan ÇAKMAK	Plastic	Altınova	7.000
7	Abdurrahman ASLAN	Plastic	Dumanlar	10.000
8	Veysel ÇETİN	Plastic	Altınova	2.700
9	Hüsnü KOLAY	Plastic	Gaziler	7.000
10	Uğur ŞAHİN	Plastic	Varsak	4.000
11	Mehmet ÇETİN	Plastic	Varsak	2.500
12	Yılmaz KURUCAN	Plastic	Gaziler	10.000

Results and Discussion

On active nutrient contentsbasis fertilization during production season

Around the Antalya city, at 12 different greenhouses belong to 5 different region where intense tomato production takes place; it is recorded face to face with required controls that growers fertilization rules with their own habits in 6 months of production season.

Wide differences determined between growers in fertilizer consumption. During the production season, minimum nutrition consumption determined as 47.16 kg.da^{-1} and the maximum value determined as 109.14 kg.da^{-1}. That important difference is not related to soil analysis. For Autumn term tomato cultivation the determined average as 86.06 kg.da^{-1} is lower doze than 161.26 kg.da^{-1} which Engindeniz et al. (2010) determined. The data presents that fertilizer consumption rate in Antalya main district at Autumn term tomato cultivation is lower than other greenhouse areas.

Table 1. Monthly and total fertilizer consumption quantities as active nutrient contents at greenhouse autumn term tomato cultivation

Growers	Fertilizer Consumption ($Kg.da^{-1}$) ($N+P_2O_5+K_2O+MgO+Ca+SO_3$)						Total
	1.Month	2. Month	3. Month	4. Month	5. Month	6. Month	
1	15,05	23,12	23,53	11,40	1,41	0	74,51
2	19,49	63,83	9,03	6,04	10,75	0	109,14
3	26,35	39,86	19,75	11,15	4,87	0	101,98
4	13,28	21,25	28,06	5,92	5,92	0	74,43
5	36,70	27,92	20,46	5,94	9,33	2,60	102,95
6	9,56	15,44	11,30	4,96	5,93	0	47,19
7	18,71	24,07	15,44	6,22	5,10	0	69,54
8	25,61	33,95	17,31	15,84	6,86	0,30	99,87
9	22,43	21,17	14,10	23,24	5,54	9,77	96,25
10	22,90	24,33	25,41	5,89	19,98	2,51	101,02
11	18,39	13,94	17,36	8,21	5,89	1,91	65,07
12	11,64	35,84	16,02	9,70	9,70	7,46	90,36
Maximum	36,70	63,83	28.06	23,24	19,98	9,77	109,14
Minimum	9,56	13,94	9,03	4,96	1,41	0	47,19
Mean	20,01	28,73	18,15	9,54	7,61	2,05	86,08

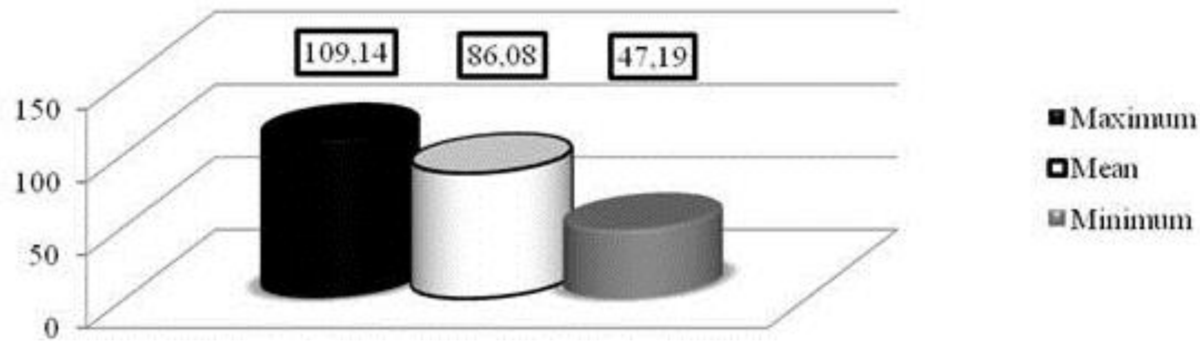

Figure 3.1. Maximum, Minimum and Mean Values of Running Efficient Nutrition Quantities at Greenhouse Autumn Term Tomato Cultivation

On efficient nutrition basis fertilization during production season

Growers efficient nutrition consumptions are indicates important differences when it is analysed from Table 2. While the minimum Nitrogen consumption was 12.78 $kg.da^{-1}$, the most consumption reaches to 31.00 $kg.da^{-1}$. P_2O_5 consumption, that difference shows more variation between 7.10 - 34.67 $kg.da^{-1}$. Variation at K_2O consumption is relatively lower. It is calculated as 22.88 - 44.50 $kg.da^{-1}$. CaO consumption rates are determined between 1.52 - 9.92 $kg.da^{-1}$. There were growers which were not using any Magnesium but there were also growers that use 6.83 $kg.da^{-1}$of Mg. In SO_3 consumption, important variations determined as 3.70 - 7.58 $kg.da^{-1}$.

When it is compared with Engindeniz et al (2010) research results means as N, P_2O_5, K_2O, 62.82$kg.da^{-1}$, 47.43$kg.da^{-1}$, 51.01$kg.da^{-1}$, it has shown lower values like 23.46$kg.da^{-1}$, 17.04$kg.da^{-1}$, 32.04 $kg.da^{-1}$at Antalya main district Autumn term tomato production.

On efficient nutrition basis used fertilizer rates during production season

Although quantities of nutritions that used with fertilizers, rates between those nutritions are important too for plant yield and quality. Thus, active nutrient consumption basis calculated some rates are shown at table 3.3. Important differences determined according to table. The most differences determined between K_2O/CaO and N/CaO rates, at least differences calculated between N/K_2O and N/P_2O_5. It reduces the problems originating from unstable usage of those plant nutritions because the usage doze differences of N/K_2O and N/P_2O_5 are not at higher levels. Minimum N/K_2O rate 0.56, maximum 0.89 and mean as 0.73 should be analysed as acceptable rate. But it may not be a positive evaluation to evaluate those rates monthly. It is remarkable that minimum N/P_2O_5 equilibrium is 0.89.

Table 2. On efficient nutrient basis used N, P_2O_5, K_2O, CaO, MgO and SO_3 quantities ın greenhouse autumn term tomato cultivation (kg.da^{-1})

Growers	Fertilizer Consumption Autumn Term Tomato Cultivation (Kg.da^{-1})						Total
	N	P_2O_5	K_2O	CaO	MgO	SO_3	
1	23,05	12,54	27,52	4,95	3,45	3,00	74,51
2	31,00	34,67	36,61	2,19	3,45	1,58	109,14
3	30,33	24,00	34,17	5,76	4,34	3,38	101,98
4	15,82	15,97	25,55	4,48	5,04	7,58	74,43
5	24,92	19,45	44,59	8,26	3,02	2,71	102,95
6	12,78	7,10	22,88	2,32	1,11	1,00	47,19
7	22,80	13,94	30,13	2,52	0	0,17	69,54
8	27,63	15,77	38,15	7,53	6,02	4,78	99,87
9	27,86	13,25	35,38	6,78	6,83	6,15	96,25
10	24,72	20,38	35,69	1,52	5,18	5,97	101,02
11	16,37	11,73	23,81	9,09	5,18	4,83	65,07
12	24,24	20,00	30,00	9,92	2,93	3,29	90,36
Maximum	31,00	34,67	44,59	9,92	6,83	7,58	109,14
Minimum	12,78	7,10	22,88	1,52	0	0,17	47,19
Mean	23,46	17,04	32,04	5,44	3,88	3,70	86,08

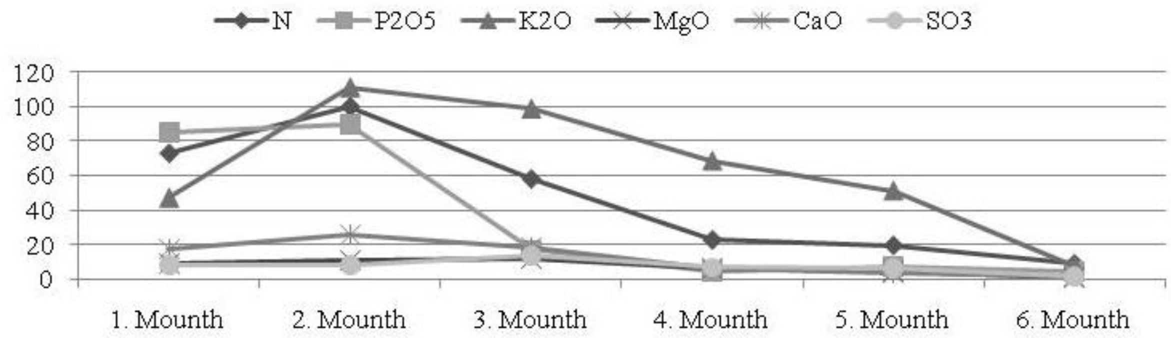

Figure 2. Monthly Variation of Efficient Nutrition Consumption Averages In Greenhouse Autumn Term Tomato Cultivation (kg.da^{-1})

Table 3. On Efficient Nutrition Basis Used N/P_2O_5, N/K_2O, N/CaO, K_2O/P_2O_5, K_2O/CaO Rates During Production Season In Greenhouse Autumn Term Tomato Production

Number of Growers	Rates During Production Season (6 month) In Greenhouse Autumn Term Tomato Production				
	N/P_2O_5	N/K_2O	N/CaO	K_2O/P_2O_5	K_2O/CaO
1	1,84	0,84	4,66	2,19	5,56
2	0,89	0,85	14,16	1,06	16,72
3	1,26	0,89	5,27	1,42	5,93
4	0,99	0,62	3,53	1,60	5,70
5	1,28	0,56	3,02	2,29	5,40
6	1,80	0,56	5,51	3,22	9,86
7	1,64	0,76	9,05	2,16	11,96
8	1,75	0,72	3,67	2,42	5,07
9	2,10	0,79	4,11	2,67	5,22
10	1,21	0,69	16,26	1,75	23,48
11	1,40	0,69	1,80	2,03	2,62
12	1,21	0,81	2,44	1,50	3,02
Maximum	2,10	0,89	16,26	3,22	23,48
Minimum	0,89	0,56	2,44	1,06	2,62
Mean	1,45	0,73	6,12	2,03	8,38

Results of these type greenhouses should be considered together with plant analyses. We accept that 0.89 rate is a low rate for N/P_2O_5. Supreme variation of N/CaO rate calculated the lowest 2.44 and the highest 16.26. That situation indicates to growers different habits of Calcium fertilizations. Another similar variation indicates that minimum 2.62, maximum 23.48 and mean 8.38 of K_2O/CaO rate. That large variation which is not referred to soil and plant analyse, should be examined in detail.

Çıtak et al. (2007) are stated that rates should be arranged well between nutritions to solve problems about physiological failures. Jarvan and Poldma (2004) are indicated that inappropriate nutrition rates prevents absolutely required nutritions intake and in excessive situations it may cause nutrition deficiency linked with disease and reduces the market prices of product. Merhaut (2001) is informed that optimum rates should be like this for K/N rate 1/1, K/Ca rate 4/1, Ca/Mg rate 2/1, K/Mg rate 8/1.

Orman and Kaplan (2004) are stated from their research at Kumluca and Finike to determine tomato plant nutrition requirements in greenhouse conditions that N/K rates are between 0.88-2.95 in Kumluca county, 0.86-2.55 in Finike county and in these places, nitrogen fertilizations should be applied carefully, should be avoided from extreme Nitrogen fertilizations also potassium fertilizations should be arranged well. Aktaş (2004) is indicated at apple production lack of calcium reasoned bitter pit like some other storage diseases and also at tomato, pepper, melon vegetable productions, calcium deficiency reasoned disease named like blossom-end rot is more likely reasoned from raised K/Ca and K+Mg/Ca rates. Campbell (2000) is represented that as such N/K rate is more important than nitrogen concentration and it should be between 1.2-1.8 for tomato.

Conclusion

Fertilization of agricultural practices on the one hand, one of the most important contributions in production, while on the other hand may cause detrimental.The amount and time of the occurrence of this negativity is seen as the most important factor.Along with these studies fertilizing habits from manufacturer to manufacturer with knowledge and experience from area to area growers were found to vary in accordance.In addition to this, refrain from fertilization of agricultu ral soils cannot be said of the fact must be taken into. Fertilizers, soil analysis results in the control of experts prepared with reference to the application with a fertilization program, the decrease of the negative effects on the environment, economic and high yield potential will be achieved. For this purpose, should be considered as key factors in fertilizer application, the mistakes, the elimination of extremism, and in particular cultivated species, cultivar-specific fertilization program should be brought to the forefront the idea of the creation.The resulting data; made based on soil analysis determined that the huge differences in fertilizer consumption, nutrition of plants are on the point of imbalance can be created.Particularly inadequate and overuse are seen as likely to be.

References

Anonymous, 2012. http://www.gubretas.com.tr/FILES/4Q2012TR.pdf

Campbell, C. R. 2000. Reference Sufficiency Ranges Vegetables Crops. Tomato, Greenhouse. (http://www.ncagr.com/agromoni/saaesd/gtom.htm, Update: July.

Çıtak, S., S. Sönmez, M. Kaplan, 2007. Bitki Beslemede Besin Maddesi Oranlarının Önemi ve Etkileri. Hasad Dergisi, Yıl: 22, Sayı: 262, 74-80.

Engindeniz,S., Yılmaz,İ., Durmuşoğu, E., Yağmur, B., Eltez, Z.R., Demirtaş,B., Engindeniz., 2010. Sera Sebzelerinin Karşılaştırmalı Girdi Analizi., Ekoloji,19,74,122-130.

Eyüpoğlu F., 2002. Türkiye gübre gereksinimi tüketimi ve geleceği Tarım ve Köyişleri Bakanlığı KHGM .Toprak ve Araştırma Enstitüsü. Teknik yayın no :T-2. Genel yayın no : 2.

Jarvan,M., Poldma, P.2004.. Content of Plant Nutrients in Vegatables Depending on Various Lime Materials Used for Neutralising Bog Peat. Agronomy Research 2(1), 39-48

Kansu, İ.A. 2001. Tarım ve Doğa. Çukurova Üniversitesi Ziraat Fakültesi Genel Yayın No: 242. Adana

Kaplan, M., S. Sönmez, ve S. Tokmak, 1999. Antalya-Kumluca Yöresi Kuyu Sularının Nitrat İçerikleri. Turkish Journal of Agriculture and Forestry, 24, 1-9.

Merhaut, D.J. 2001. Fertility Management in the Landscape. Proceedings of the UCR Turfgrass and Landscape Management Field Day.

Orman, Ş. ve Kaplan, M. 2004. Kumluca ve Finike Yörelerinde Serada Yetiştirilen Domates Bitkisinin Beslenme Durumunun Belirlenmesi. Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, 17 (1), 19-29.

Tüik, 2006. Türkiye İstatistik Kurumu, Tarımsal Yapı, Üretim, Değer, Ankara.

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Impact of trifluralin herbicide on nitrification and autotrophic nitrifying bacteria

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Abstract

In vitro experiment for 2 month were conducted to know the impacts of Trifluralin herbicide as recommended dose, over dose and low dose on the inhibition of Nitrification in calcareous soils, result shows the hazardous impacts of this herbicide on the production of both NH_4-N and NO_3-N respectively, nitrification totally inhibited during the first week of incubation of herbicide application to be 90%, 80%, 70% for over, recommended and low doses respectively without N source application after 2 month, inhibition of NH_4-N production remain 60% with over dose and 75 ppm N fertilizer at the end of experiment , then decreased to 38% with over dose and 150 ppm N fertilizer, to be enhanced positively with 225 ppm at same period. While the production NO_3-N increased with increasing N application and the incubation duration with all doses of herbicide and inhibited only 9% with over dose and75 ppm N fertilizer to be enhanced with the rest of herbicide doses at the end of experiment. Number of NH_4 oxidizing bacteria *Nitrosomonas* * 10^5 g^{-1} dry soil incubated at 25C° ranged between 0.42 in control to 2.96 with 225 ppm N fertilizer and negligible with all herbicide doses during first week of incubation to 0.67 after 2 month with low herbicide dose and high N fertilizer source. Number of NO_3 oxidizing bacteria *Nitrobacter* * 10^5 g^{-1} dry soil incubated at 25C° ranged between 0.15 in control after week to 3.8 after 2 month with 225 ppm N fertilizer source and negligible values with all herbicide doses after week then increased gradually to be stimulator at the end of experiment to as high as 8.3 with 225 ppm N fertilizer source..

Keywords: Nitrification inhibition, trifluralin herbicide, nitrifying bacteria, ammonia, nitrate

Introduction

Nitrification is an essential process in the global nitrogen cycle in soil, and involves the biological oxidation of ammonia via nitrite to nitrate. Nitrifying bacteria play a. Ammonia-oxidizing bacteria (AOB) play an important role in the nitrogen cycle (Kowalchuk & Stephen, 2001). AOB involved in the aerobic oxidation of ammonia to nitrite are called *Nitrosobacteria* (e.g., the *Nitrosomomas* and *Nitrosospira* genera). The bacteria responsible for the conversion of nitrite to nitrate are called *Nitrobacteria* (e.g., the *Nitrobacter* and *Nitrospira* genera). *Archaea* are also involved in ammonia oxidation (Ko¨nneke et al., 2005; Leininger et al., 2006).

Nitrification is a chemoautotrophic process carried out by two bacterial groups that oxidize ammonium to nitrite and nitrite to nitrate (fenchel et a., 1998). This process is important to the nitrate content in soil, which is the major source of nitrogen assimilated by higher plants and, thus, of considerable ecological and agricultural importance (hansson et al., 1991; tu, 1996). Studies performed on different soils show varied effects of different pesticides on nitrification, negative effects such as nitrification reduction or inhibition (Tu,

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1991; 1994; Vink & Van straalen, 1999). The chemical composition of trifluralin herbicide which named commercially as Triflan is $C_{13}H_{16}F_3N_3O_4$ α,α,α,-trifluro-2,6-dinitro-N,N-dipropyl-P-toluidine is widely used in Iraqi Kurdistan Region for controlling the seasonal weeds in field crops farms. This herbicide can be used as mixture with solid fertilizers as urea before planting in an average rate of 600 ml/d, the soil has ability to absorb this herbicide, so it considered very persistent against infiltration and then a little mobility in the soil. The decomposition of this herbicide start when a reduction of NO_2 group occurred to amino group, then patrial oxidation of trichloromethyle to carboxyl group. The requested time for losing 50% from this herbicide ranged between 57-126 days, the residual effect in soil is 6-8 months; however the decomposition rate is faster in anaerobic conditions. The aim of this article is to show the inhibition rate of trifluralin herbicide application on nitrification and the structure of autotrophic nitrifying bacteria responsible of the availability of nitrogen element for plant growth.

Material and Methods

Bulk soil samples of calcareous soils were collected from the field of Agriculture and forestry faculty in Summail district in Duhok governorate, Iraqi Kurdistan Region, air dried, grinded and sieved at 2mm sieve. 750 g of fine earth put in a plastic plate and reached to the field capacity of moisture content.

Table(1). Some chemical and physical properties of the studied soil.

PSD g/kg			Text.	Total% $CaCO_3$	Active% $CaCO_3$	(A/T)* 100	O.M%	pH
clay	silt	sand						
539.0	433.4	27.50	SiC	24.75	15.50	62.62	1.18	7.90
EC $dS.m^{-1}$	CEC $cmol.kg^{-1}$	SP%	Exchangeable Ca meg/100 g soil			Ava.N $mg.kg^{-1}$	Ava.Pmg.k g^{-1}	Ava.K $mg.kg^{-1}$
0.55	29.12	44.42	22.53			56	3.52	25.3

Nitrogen fertilizer as urea were added to the pots at 75, 150, 225 ppm N fertilizer by three replicates, the doses of Triflurane herbicide were used as recommended doses 0.048%, extensive doses 0.48% and light doses of 0.0048% at a range of 600 ml/d.

Some of trifluralin herbicide properties

Triflan is $C_{13}H_{16}F_3N_3O_4$ α,α,α,-trifluro-2,6-dinitro-N,N-dipropyl-P-toluidine, has many commercial names as Triflumac, trifluyam, triflure, trif, triflan, tefraline, floral, agrotrifluran, herbiflurin, and calliforate. It belong the chemical group 2,6- dinitroaniline, molecular weight 335.3 g/mol. Solubility in water 0.184, 0.221, 0.189 mg/l at pH 5, 7, 9 respectively, in acetone, chloroform, toluene, ethyl acetate more than 1000, in methanol 33-40 g/l at 25 C°, in hexane 50- g/l at 25 C°. The treatments were incubated at the room temperature 20± C°, the available nitrogen NH_4 and NO_3 determined periodically after 7, 20, 30, 40, 60 days by kjeldadahl method and the number of nitrifying bacteria *Nitrosomonas* and *Nitobacter* by standard plate technique.

Results and Discussion

Figure 1and 2 shows amount of NH_4-N ppm produced incubated at 25C° and inhibition% of NH_4-N ppm that the inhibition of NH_4-N is approximately total with the three herbicide treatments only , and have a tremendous effect even when a source of nitrogen fertilizer were added and this due to poisonous effect of this herbicide on *Nitrosomonas* NH_4-N oxidizing bacteria, similar result were obtained by Bollen 1961and Martin 1963 whom declared that the nitrifying bacteria has a sensitivity toward some chemical compounds, and the greatly differ according to the dosage ,soil properties and environmental factors. Also Ogunseitan and Odegemi 1985 in a laboratorial test, they added a chemical compounds as Lindane by 100 mg. Kg^{-1} soil, Captan 100 mg. Kg^{-1} soil, and Malathion 50 mg. Kg^{-1} soil, the result is the nitrification process inhibited for 30 days.

Impact of herbicide on the amount of NO_3-N ppm and inhibition% of NH_4-N ppm produced incubated at 25C° in figure 2 is approximately the same with the inhibition of NH_4-N in the beginning of the experiment while this influences decreased more apparently after one month then stimulates the production of NO_3-N after 45 days to the end of experiment. Same result were obtained with another herbicide by (Marcela Herna´ndez et al, 2011) whom declared that simazine [50 lg g^{-1} dry weight soil (d.w.s)] completely inhibited the nitrification processes in the fertilized agricultural soil. The inhibition by simazine of ammonia oxidation observed was similar to the reduction of ammonia oxidation by the nitrification inhibitor acetylene.

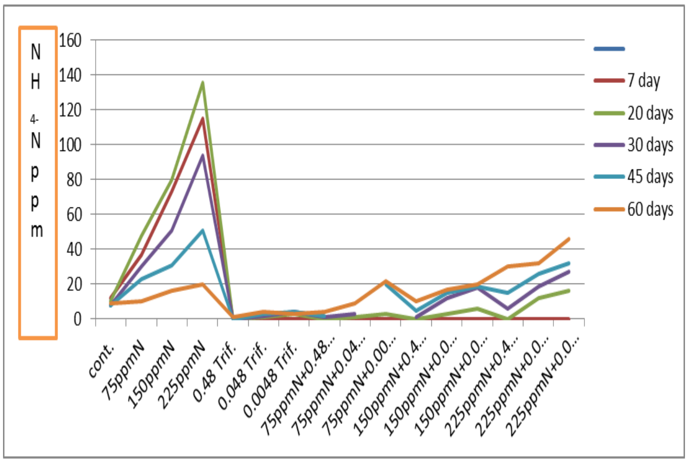

Figure 1-Amount of NH_4-N ppm produced incubated at 25C°.

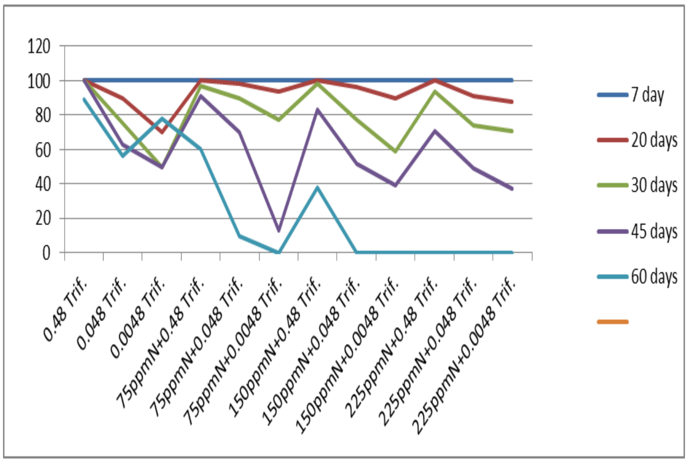

Figure 2-Inhibition% of NH_4-N ppm produced incubated at 25C°.

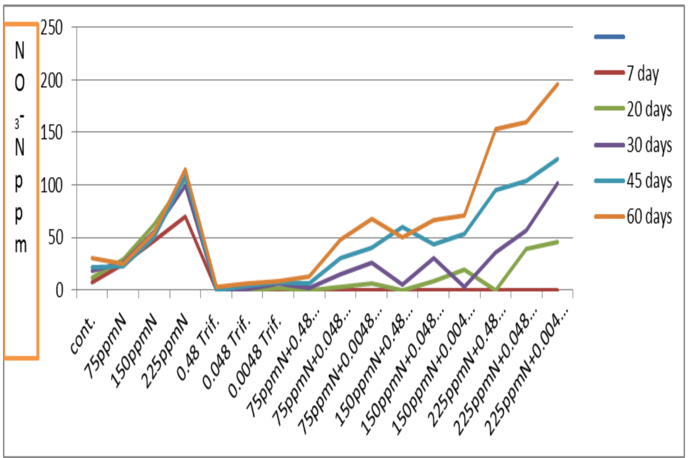

Figure 3. Amount of NO_3-N ppm produced incubated at 25C°.

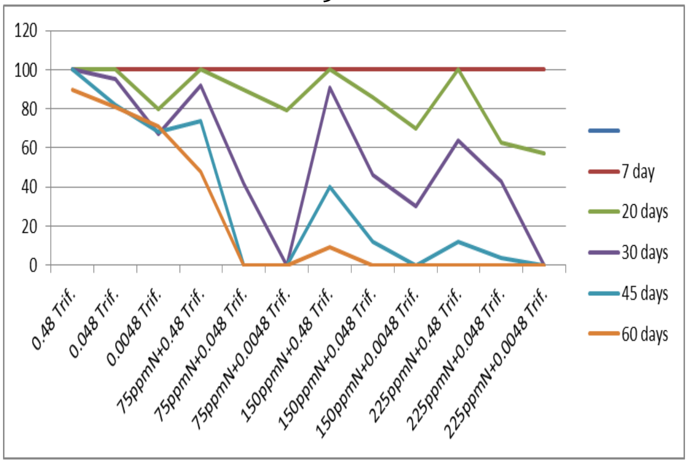

Figure 4. Inhibition% of NO_3-N ppm produced incubated at 25C°.

Herbicide impacts on the number of ammonia-oxidizing bacteria (AOB) *Nitrosomonas* * 10^5 g^{-1} dry soil incubated at 25C° are shown in tab. (1) to be total with all doses even with nitrogen application source in the first week of incubation. The effects lasts to 45 days after incubation, then vanished after 2 month. Somewhat results were obtained by (Marcela Herna´ndez et al, 2011) suggest that the s-triazine herbicide not only inhibits the target susceptible plants but also inhibits the ammonia oxidation and the ammonia oxidizing bacteria in fertilized soils. Nitrification in particular has been shown to be very sensitive to chemicals, and nitrifier activity is, therefore, often used as an indicator of chemical disturbances, such as those produced by pesticides (Pell et al., 1998). Some pesticides have been found to reduce the nitrifying bacterial population. Even if this is only a short-term effect (2 weeks), it can be assumed that some pesticides have an impact on bacterial populations and structures and, thus, on soil micro-biodiversity (Tu, 1991).

Trifluralin impacts on the number of NO_3 oxidizing bacteria *Nitrobacter* * 10^5 g^{-1} dry soil incubated at 25C° are shown in tab. (2) to be total with all doses even with nitrogen application source in the first week of incubation. The effects lasts to 45 days after incubation, then become stimulator after 2 month. The nitrification of soil and nitrifying microorganisms are influenced by soil pH (De Boer & Kowalchuk, 2001; Nicol et al., 2008), temperature (Avrahami et al., 2003; Tourna et al., 2008), availability of CO_2 (Azam et al., 2004), and xenobiotics (Li et al., 2008; Schauss et al., 2009). It was assessed that the impact of clomazone herbicide on microbial activity was variable and depended on the dosage of the chemical. In all soils treated with the lower pesticide doses SIR rates and DHA activity were stimulated. In turn, the higher doses of herbicide significantly decreased both tested parameters. The pesticide also influenced on the rates of ammonification and nitrification processes as indicated changes in concentrations of NH_4^+-N and NO_3^--N during the experiment.

Table 1. Number of NH_4 oxidizing bacteria *Nitrosomonas* * 10^5 g^{-1} dry soil incubated at 25C°.

treat.	7 day	20 days	30 days	45 days	60 days
cont.	0.42	0.48	0.15	0.19	0.16
75ppmN	0.62	0.67	0.23	0.2	0.15
150ppmN	1.27	1.28	0.49	0.48	0.36
225ppmN	2.96	2.83	0.95	0.83	0.62
0.48 Trif.	0	0	0	0	0.12
0.048 Trif.	0	0	0.1	0.2	0.28
0.0048 Trif.	0	0.1	0.12	0.13	0.18
75ppmN+0.48 Trif.	0	0	0.11	0.11	0.13
75ppmN+0.048 Trif.	0	0.1	0.23	0.25	0.27
75ppmN+0.0048 Trif.	0	0.12	0.15	0.28	0.56
150ppmN+0.48 Trif.	0	0	0.1	0.12	0.29
150ppmN+0.048 Trif.	0	0.12	0.34	0.26	0.38
150ppmN+0.0048 Trif.	0	0.2	0.36	0.3	0.47
225ppmN+0.48 Trif.	0	0	0.19	0.27	0.49
225ppmN+0.048 Trif.	0	0.34	0.41	0.47	0.55
225ppmN+0.0048 Trif.	0	0.39	0.59	0.5	0.67

Table 2. Number of NO_3 oxidizing bacteria *Nitrobacter* * 10^5 g^{-1} dry soil incubated at 25C°.

treat.	7 day	20 days	30 days	45 days	60 days
cont.	0.15	0.19	0.23	0.3	0.25
75ppmN	0.25	0.26	0.26	0.24	1.52
150ppmN	0.5	0.69	3.1	3	2.6
225ppmN	0.94	3.3	3.71	3.35	3.8
0.48 Trif.	0	0	0	0	0.1
0.048 Trif.	0	0	0.19	0.26	0.24
0.0048 Trif.	0	0.13	0.25	0.23	0.26
75ppmN+0.48 Trif.	0	0	0.12	0.14	0.31
75ppmN+0.048 Trif.	0	0.12	0.33	0.57	2.71
75ppmN+0.0048 Trif.	0	0.16	0.3	0.56	3.19
150ppmN+0.48 Trif.	0	0	0.14	0.48	2.73
150ppmN+0.048 Trif.	0	0.24	0.48	0.61	3.1
150ppmN+0.0048 Trif.	0	0.4	0.56	0.98	3.25
225ppmN+0.48 Trif.	0	0	0.51	1.8	6.6
225ppmN+0.048 Trif.	0	0.57	1.31	3.1	6.81
225ppmN+0.0048 Trif.	0	0.63	3.3	3.6	8.3

Conclusion

- Trifluralin hazardous impacts is obvious even with low doses in whole nitrification process and autotrophic nitrifying bacteria.
- Nitrification inhibition is approximately total during first week of herbicide application and lasted to 45 days.
- Over dose of Trifluralin herbicide inhibited nitrification overall experiment time.
- Nitrification and nitrifying bacteria are so sensitive toward this herbicide, so recommended to not been used in growing season with commercial crops as wheat because it negatively influenced the nitrogen transformation and availability in the soil at least 45 days.

References

Tu, C. M., 1991, Effects of some technical and formulated insecticides on microbial activities in soil. J. Environ. Sci. Health, B., 26(5-6): 557-573.

Tu, C. M., 1996, Effect of selected herbicides on Activities of microorganisms in soils. J. Environ. Sci. Health, B 31(6): 1201-1214.

Vink, K. & Van Straalen, N. M., 1999, Effects of Benomyl and diazinon on isopod-mediated leaf litter decomposition in microcosms. Pedobiologia,43(4): 345-359.

Kowalchuk GA & Stephen JR (2001) Ammonia-oxidizing bacteria: a model for molecular microbial ecology. Annu Rev Microbiol 55: 485–529.

Pell, M., Stenberg, B. & Torstensson, L., 1998, Potential denitrifacation and nitrification tests for evaluation of pesticide effects in soil. Ambio., 27 (1): 24-28.

Hansson, G. B., Klemedtsson, L., Stenström, J. & Torstensson, L., 1991, testing the influence of chemicals on soil autotrophic ammonium oxidation. Environ. Toxic. Wat. Qual., 6: 351-360.

Fenchel, T., King, G. M. & Blackburn, T. H., 1998, Bacterial biogeochemistry: the ecophysiology of mineral cycling, 2nded. Academic Press.

Marcela Herna´ndez et al.2011,Simazine application inhibits nitrification and changes the ammonia-oxidizing bacterial communities in a fertilized agricultural soil

Ko¨nneke M, Bernhard AE, de la Torre JR, Walker CB, Waterbury JB & Stahl DA (2005) Isolation of an autotrophic ammonia oxidizing marine archaeon. Nature 437: 543–546.

Leininger S, Urich T, Schloter M, Schwark L, Qi J, Nicol GW, Prosser JI, Schuster SC & Schleper C (2006) *Archaea* predominate among ammonia-oxidizing prokaryotes in soils. Nature 442: 806–809.

De Boer W & Kowalchuk GA (2001) Nitrification in acid soils: micro-organisms and mechanisms. Soil Biol Biochem 33: 853–866.

Nicol GW, Leininger S, Schleper C & Prosser JI (2008) The influence of soil pH on the diversity, abundance and transcriptional activity of ammonia oxidizing *Archaea* and Bacteria. Environ Microbiol 10: 2966–2978.

Avrahami S, Liesack W & Conrad R (2003) Effects of temperature and fertilizer on activity and community structure of soil ammonia oxidizers. Environ Microbiol 5: 691–705.

Azam F, Gill S, Farooq S & Lodhi A (2004) Effect of CO_2 on nitrification and immobilization of NH4 +-N. Biol Fertil Soils 40: 427–431.

Li X, Zhang H, Wu M, Su Z & Zhang C (2008) Impact of acetochlor on ammonia-oxidizing bacteria in microcosm soils. J Environ Sci 20: 1126–1131.

Tourna M, Freitag TE, Nicol GW & Prosser JI (2008) Growth, activity and temperature responses of ammonia-oxidizing Archaea and Bacteria in soil microcosms. Environ Microbiol 10: 1357–1364.

Schauss K, Focks A, Leininger S, et al. (2009) Dynamics and functional relevance of ammonia-oxidizing Archaea in two agricultural soils. Environ Microbiol 11: 446–456.

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Improvement of the engineering properties of soils using biological method

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Abstract

Improvement of the engineering properties of soils has always been an issue of interest for civil engineers. One of the newest methods that has been studied for this purpose is biological method. This method that is actually a combination of various sciences such as biology, biochemistry and civil engineering uses biological organisms such as bacteria that are commonly found in soils. The mechanism of this improvement in properties of soil is based on deposits of calcium carbonate made by biological organisms. The purpose of this study is to investigate the feasibility of using this method in order to reduce the permeability of the soil for engineering problems that require low permeability. As a case study, this paper presents the use of this technique for permeability reduction of the soil base of the Shiraz landfill in Fars province, Iran. For this purpose, Bacillus Sphaericus with four different values of optical density (OD) between 1 and 1.8 was used. Soil permeability was measured using the falling head test. Tests showed that the Bacillus Sphaericus with higher OD decreases permeability of soil of Shiraz landfill more efficient. This study showed that the method can introduce a new option for changing the soil properties where low permeability soil layer such as landfill liners is needed.

Keywords: Permeability of soil, Microbial calcite precipitation, Falling head test, Shiraz landfill soil

Introduction

Engineering properties of soil in many parts of the world cannot meet the demands of the engineers. Considering the population growth, one of the most important issue is the need to find ways to improve the soil with a minimum consumption of resources and waste generation [1]. The demand for new sustainable methods to improve soil properties continues to increase, with more than 40,000 soil improvement projects being performed per year at a total cost exceeding US$6 billion/year worldwide [2].The majority of these soil improvement techniques utilize mechanical energy and/or man-made materials, both of which required substantial energy for material production and/or installation [2].

Microbial-induced carbonate precipitation (MICP) has been the subject of research for several industrial applications. Several researchers have shown that MICP can be used to improve the mechanical properties of porous materials [3, 4, 5, 6, 7].This process involves hydrolysis of urea by bacteria containing the enzyme urease in the presence of dissolved calcium ions, resulting in calcium carbonate precipitation [3].

To make landfill floor impermeable, usually a layer of fine grain soil or polymeric coatings is used that imposes considerable costs. In order to reduce costs and take advantage of the existing soil, it is intended to study the

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use of a biological method to reduce permeability of Shiraz landfill soil and efficiency of this method will be investigated.

Material and Methods

The bacteria used for bacterial precipitation of calcium carbonate, due to the high activity in producing the calcium carbonate was B. sphaericus (PTCC 1487, Persian Type Culture Collection). B. sphaericus is unlike to cause human disease. No measurable health effects were seen in laboratory animals that were exposed to large concentrations of B. sphaericus by multiple routes of exposure. Cases involving human health effects following exposure to this organism are extremely rare. Mild eye and skin irritation may occur in humans following contact with B. sphaericus [8, 9].

Liquid culture media consisted of 3 g/L nutrient broth powder, 2.12 g/L $NaHCO_3$, 20 g/L yeast extract and 10 g/L urea. Materials used for the medium is shown in Table 1. The distilled water with the contents of the above (minus urea) was firstly used. Then sterilized by autoclaving for 20 min at 120 °C and finally urea was added by a syringe filter with the pore size of 0.22μm. Liquid media cultures and B. sphaericus were incubated at 28.5 °C on a shaker at 190 rpm for 48 hours.

The pH value of the medium before autoclaving was 7.8 then 7.9 and after adding urea was 8.0. To prevent contamination of the liquid medium, the entire process has been done under the laboratory hood.

Table 1. Liquid Culture Media

Components of liquid culture media	Sodium bicarbonate	Nutrient broth	Ammonium chloride	Urea	Yeast extract
g/L	2.12	3	10	10	20

To measure the concentration of bacteria, the spectrometer was used (Figure 1). The device can determine Optical Density for a solution.

Figure 1. Spectrometer

After bacterial growth reaches the desired optical density, bacterial solution should be transferred to the soil. Bacteria need cementation solution to produce calcite. So as Calcium is needed, calcium chloride solution was selected .Bacterial solution desired OD and calcium chloride of 10g/L and the ratio of 1:1 were combined together and added to the soil. The soil samples were prepared with unit weight of 18 KN /m^3 and water content of 15% which were the natural conditions of soil in the Shiraz landfill site .The soil of Shiraz landfill was classified as SC. Having prepared the soil sample falling head permeability tests were performed on samples.

Results and Discussion

A number of the permeability tests were performed on untreated samples to check the performance of the method in reducing the permeability of the soil. The average permeability of the untreated samples was 5E-5 cm/s.

Some series of tests with different ODs (1, 1.2, 1.5 and 1.8) and different days after treatment (1, 3, 5, and 7) were performed. The obtained hydraulic conductivity is demonstrated in Table 2.

Table 2. Permeability of Treated Samples

Days after treatment	Permeability (cm/s)			
	OD=1	OD=1.2	OD=1.5	OD=1.8
1 day	3.46E-05	2.96E-05	2.35E-05	1.41E-05
3 days	2.24E-05	1.88E-05	1.31E-05	6.20E-06
5 days	1.75E-05	1.31E-05	8.47E-06	2.30E-06
7 days	1.48E-05	1.03E-05	6.04E-06	5.23E-07

Table 3 shows the normalized permeability (normalized by the untreated permeability of soil, 5.5E-5).

Table3. Normalized Permeability of Treated Samples

Days after treatment	Normalized permeability			
	OD=1	OD=1.2	OD=1.5	OD=1.8
1 day	0.63	0.54	0.43	0.26
3 days	0.41	0.34	0.24	0.11
5 days	0.32	0.24	0.15	0.04
7 days	0.27	0.19	0.11	0.01

Table 4 shows percentage of decrease in the permeability of different condition.

Table4. Decrease in Permeability of Treated Samples

Days after treatment	Decrease in permeability			
	OD=1	OD=1.2	OD=1.5	OD=1.8
1 day	37.1	46.1	57.2	74.3
3 days	59.2	65.9	76.2	88.73
5 days	68.2	76.1	84.6	95.82
7 days	73.1	81.2	89.02	99.05

To display the changes in permeability, the graphs of test results are plotted. Figure 2 shows the permeability of treated samples and trends of it with the same time after treatment for different OD. Figure 3 illustrates the effects of days of treatment for the same OD.

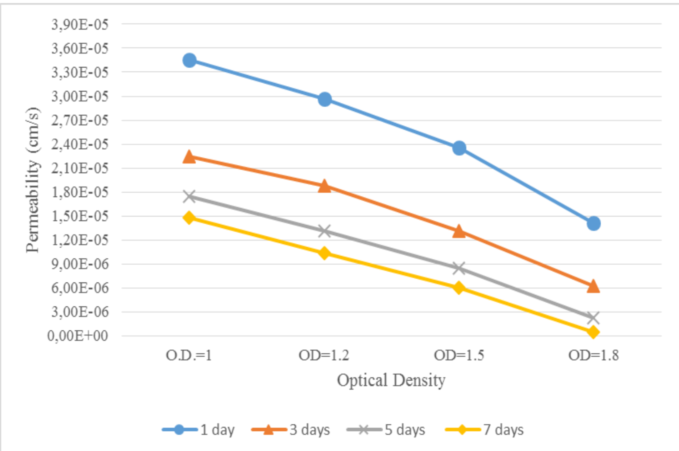


Figure 2. Permeability of Treated Samples with Change of the OD

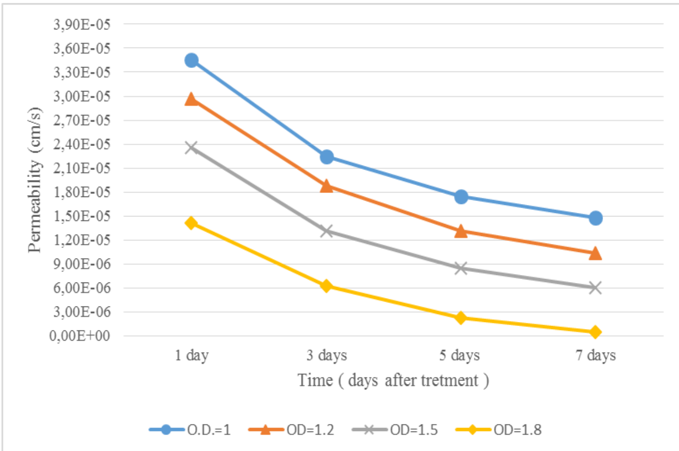


Figure 3. Permeability of Treated Samples with change of Treatment Time

Figure 4 and Figure 5 are normalized permeability of samples which give us a good view about the ratio of permeability of treated soil according to untreated permeability of soil.

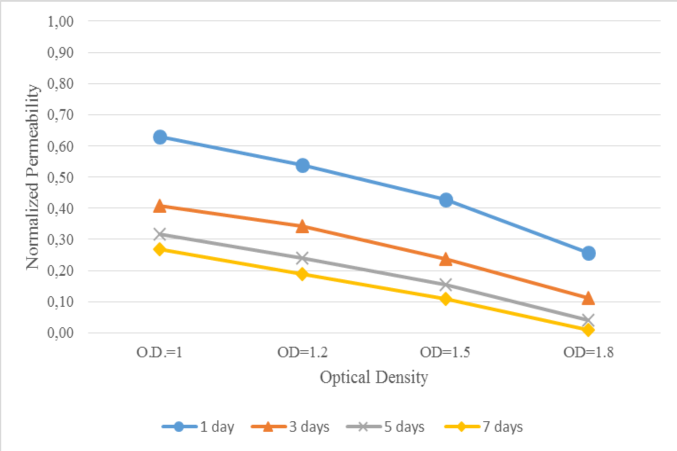


Figure 4. Normalized Permeability of Treated Samples with Change of the OD

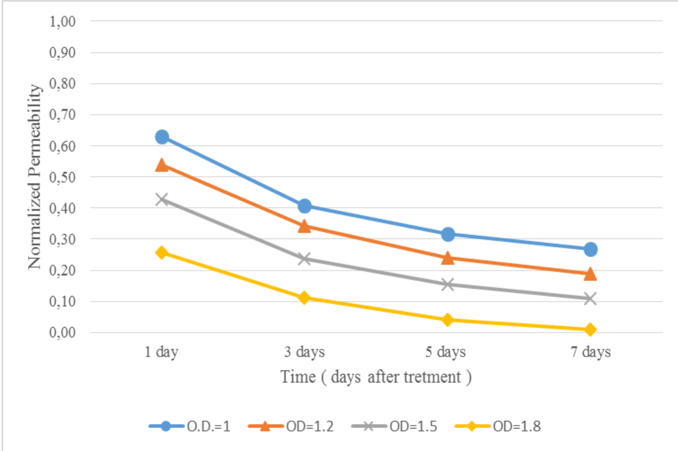


Figure 5. Normalized Permeability of Treated Samples with Change of Treatment Time

Figure 6 and Figure 7 show the percent of permeability reduction with different OD and in different time after treating.

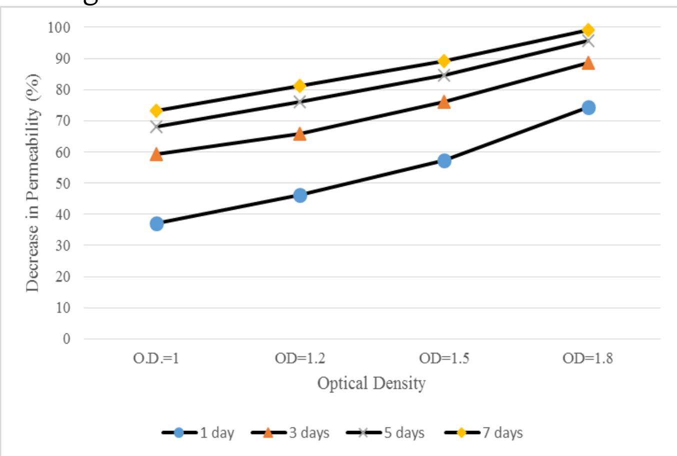


Figure 6. Percent of Decrease in Permeability, Different OD in Same Treatment Time

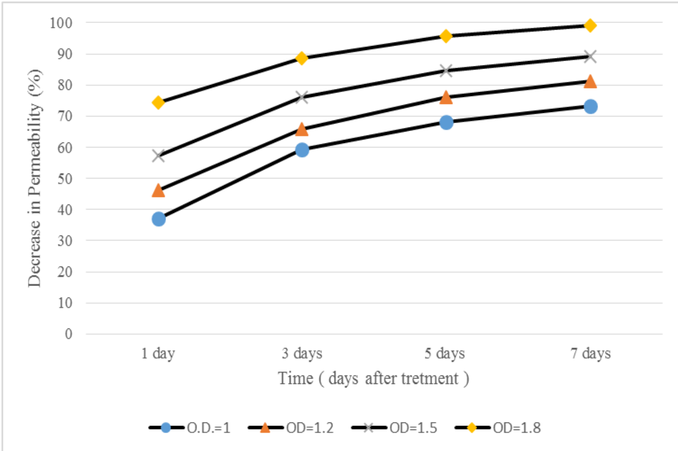
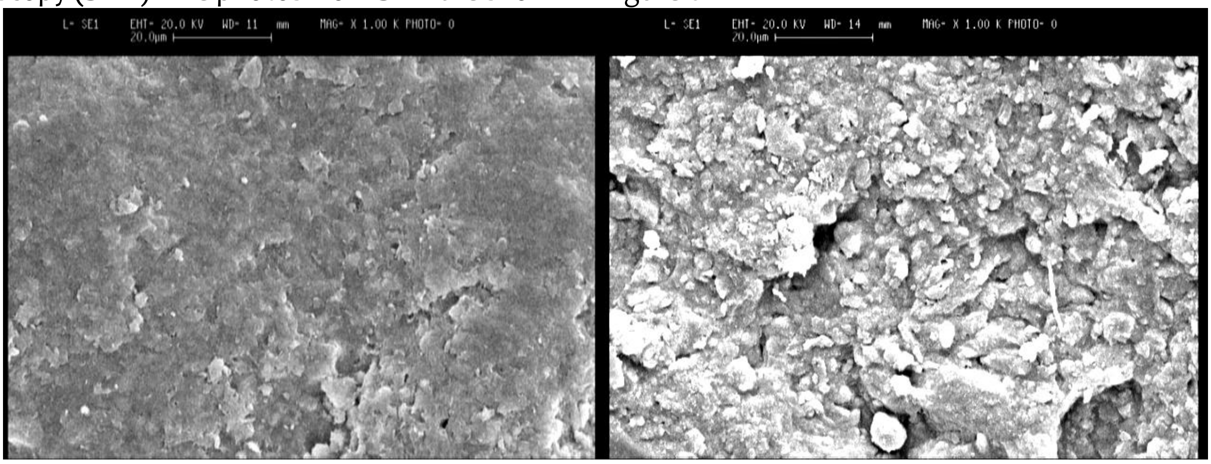


Figure 7. Percent of Decrease in the Permeability, Different Treatment Time for Same OD

All these graphs show that using this method had a good effect on reducing the permeability of the tested soil. Results show that with the increase of OD of bacteria solution and time after treatment of soil, permeability of soils decreases more.The deposited $CaCO_3$ crystals were investigated by scanning electron microscopy (SEM). The photos from SEM are shown in Figure 8.



a. Untreated Soil

b.Treated soil

Figure 8. SEM Photo of Samples a.Untreated soil b.Treated soil, Magnification of 1000 (20μm)

Conclusion

Based on the results cited the following can be concluded.

The results from biological treatment with B. sphaericus indicated significant effects on reducing the permeability of soil of Shiraz landfill.

Tests showed that permeability of treated samples decreased with increasing of optical density.

At the best condition, permeability of treated soil had a reduction of 99% compared to the initial untreated state.

In these series of tests maximum reduction in soil permeability was at maximum OD and maximum of treatment days.

Graphs for the samples treated with the same OD demonstrated that the rate of reduction in permeability decreases as the time of treatment increases.

For the same time of treatment the rate of reduction in permeability increased as OD increased.

References

[1] Van passen, L. A., 2009. Microbes turning sand into sandstone using waste as cement. *4th YGEC*, 135-138.

[2] DeJong, J.T., Mortensen, B.M., Martinez, B.C., Nelson, D.C., 2010. Bio-mediated soil improvement. *Ecological Engineering,vol. 36, no.2,* 197-210.

[3] Harkes, M.P., Van Paassen, L.A., Booster, J.L., Whiffin, V.S., van Loosdrecht, M., 2010. Fixation and distribution of bactrial activity in sand to induce carbonate precipitation for ground improvement. *Ecological Engineering, vol.36, no.2,* 112-117.

[4] Nemati, M., Voordouw, G., 2003. Modification of porous media permeability, using calcium carbonate produced enzymatically in situ. Enzyme and Microbial Tech-nology 33, 635.

[5] DeJong, J.T., Fritzges, M.B., Nusslein, K., 2006. Microbially induced cementation to control sand response to undrained shear. Journal of Geotechnical and Geoen-vironmental Engineering 132 (11), 1381.

[6] Le Metayer-Levrel, G., Castanier, S., Orial, G., Loubiere, J.F., Perthuisot, J.P., 1999. Applications of bacterial carbonatogenesis to the protection and regeneration of limestones in buildings and historic patrimony. Sedimentary Geology 126, 25-34.

[7] Whiffin, V.S., Van Paassen L.A. and Harkes, M.P., 2007. Microbial carbonate precipitation as a soil improvement technique. Geomicrobiology journal, vol. 24, 417-423.

[8] Office of Environmental Health and Safety, 2006. Washington State Department of Health. Larvicide:Bacillus sphaericus. <http://www.doh.wa.gov/ehp/ts/Zoo/WNV/larvicides/Bsphaericus.html >.

[9] Willem, D., Kathelijn, C., Nele, D.B., Willy, V., 2008. Bacterial carbonate recipitation as an alternative surface treatment for concrete.Construction and Building Materials 22, 875–885

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Study on clay core replacement with fiber reinforced concrete (polypropylene) core in the rock-fill dams

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Abstract

This paper is intended to present the results of an experimental investigation upon the possibility of clay core replacement with fiber (polypropylene) reinforced concrete core in rock-fill dams. Within the rock-fill dams, usually clayey soil is used as the main core material of the whole structure. Due to the fact that this kind of soil, being used; would have caused many problems such as; huge amount of clay materials required for the core, more time needed to complete the project, the clay core precise parameters monitoring and control (e.g. humidity), and etc., this paper attempts to present some kind of fiber reinforcement concrete; in order to solve these problems. In order to achieve this; different mix designs are presented; employing the polypropylene fiber; optimized form of mix designs in terms of permeability, flexibility, and concrete strengths criteria is obtained. Afterwards, a comparison between fiber reinforced polypropylene concrete, and the clay core has been made. At the end, the economic issues and environmental outcomes of the proposed concrete has been determined and explained.

Keywords: Fiber Reinforced Concrete (Polypropylene), Rock-Fill Dams.

Introduction

In recent decades, more rock-fill dams have been constructed compared to other types of dams (e.g. concrete dams); especially in developing countries, due to the bed independence, especial shape of valley and simpler construction technology. Rock-fill dams consist of two main parts, core zone and shell zones. The function of main core in rock-fill dams is to caulk and save the water behind the dam. In most cases, the main cores are made of clay. The necessity of studying the use of non-clay cores has recently raised due to some problems involved in core construction such as; the high volume of clay materials needed for core, too much time required for implementation, the clay core needs highly detailed quality control (e.g. moisture and compaction control), extreme sensitivity of the clay materials to climate change and season, grading filters and transition zones sensitivity to prevent leaching, permeability of clay materials, and etc. Concrete as a non-clay material can be used instead of clay, which has its own disadvantages, because of the possibility of cracking in large deformation. To overcome these disadvantages; the addition of other materials to concrete such as fiber, is considered. Fibers can be classified into different types such as steel fiber, polypropylene fiber, polyethylene fiber, etc. Polypropylene fiber forms a linear polymer; prepared by the polymerization of propylene, after finding the catalyst; by which the zyglrnata was produced [3]. Polypropylene fibers have significant properties such as; high melting point, durability, high resistance to crushing and breaking, simple

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production, fire and abrasion resistance and low permeability [1]. This study investigated the influence of adding polypropylene fibers to the concrete. Determination of the changes in permeability, strength and plasticity of concrete due to fiber addition is the main aim of this study. With this regard, several samples with different fiber percentage have been prepared, tested and the test results are reported and discussed.

Material and Methods

Mix Design

In this study, initially the fibrous concrete mix designs are prepared. The concrete mix designs are shown in table 1. In these schemes; the type 2 cement of Firoozabad factory and the polypropylene fiber made in Iran have been used.

Construction and Maintenance of Specimens

To make each material mix; all the elements of the design have been weighed up first. Then, they are poured into the mixer for 5 minutes with the following sequence: 1-Fine aggregate 2-cement 3- coarse aggregate 4-water 5- polypropylene fiber

It should be noted that polypropylene fiber should be added in a gradual manner to be mixed better. ASTM standards were followed in samples preparation and tests [1, 4, and 5]

According to the standards, for each of mix design cited in table 1, 4 samples of 15*15*15 cm (cube) dimensions for the pressure tests, 5 samples of 16*4*4 cm (cube) dimensions for the tensile and bending tests, 1 cylindrical specimen with a diameter of 15 cm and 30 cm in height for the permeability test, 1 cylindrical specimen with a diameter of 8.4 cm and 16.8 cm in height for the Brazilian tensile test, and 1 cylindrical specimen with a diameter of 8.4 cm and a height of 16.8 cm for the deformability test have been made.

After making and forming the samples, they were sunk in a water pool to be fully cured. Age of specimens for compression test, and the tensile test were 7 days and age of plasticity test samples and permeability test samples were 28 days.

Table 1: Concrete mix designs

Specific Weight (Kg/ m^3)	Aggregate/cement Ratio		Fiber/cement Ratio (F/C) (%)	Water/cement Ratio (W/C)	Number of Mix Design
	Fine Aggregate/cement Ratio (S) 0-5 mm	Coarse Aggregate/cement Ratio (G) 5-15 mm			
2426.54	1.69	1.87	0.1	0.4	1
2422.7	1.69	1.87	0.2	0.4	2
2420.72	1.69	1.87	0.3	0.4	3
2420.1	1.69	1.87	0.4	0.4	4
2418.97	1.69	1.87	0.5	0.4	5
2417.83	1.69	1.87	0.6	0.4	6
2417.05	1.69	1.87	0.7	0.4	7
2389.57	1.69	1.87	0.8	0.4	8
2375.14	1.69	1.87	0.9	0.4	9
2372.4	1.69	1.87	1.0	0.4	10
2311.35	1.69	1.87	1.25	0.4	11
2309.78	1.69	1.87	1. 50	0.4	12
2305.9	1.69	1.87	1.75	0.4	13
2301.36	1.69	1.87	2	0.4	14
2428.68	1.69	1.87	0	0.4	15

Equipment and Techniques; Used In the Research

200 Tons Concrete Breaker Jack (Pressure Test)

Concrete Breaker Jack **wa**s used to obtain the compressive strength of the concrete. The speed of load application was 0.6 MPa per second. The starting time for samples under load was 1 minute and 20 seconds in order to show the amount of sample pressure after the first occurrence of cracks.

Image 1: Typical test samples

Tensile Testing Machine Due To the Bending

This device was composed of a piece of cube at the bottom (with 2 fixed fulcrums) and a vertical axis in the top, which moves. The speed of loading was 1mm per min.

After loading the sample, as soon as the first crack in the sample appeared; the device stoped and the amount of the force (load) was shown on the screen. Tensile strength was obtained by the following equation:

$$f(t, max) = \frac{3PL}{2h^2}$$

where

P= the amount of failure load (ultimate load)
f (t, max)=tensile strength of specimen
L= the distance between two anchors
h= sectional area of the specimen

Concrete Plasticity Testing Machine

ASTM C469 standard was used to measure the elastic modulus of concrete, to evaluate the efficacy and concrete deformability [4]. Elastic modulus, Poisson's ratio, horizontal and vertical rate of change of the samples was obtained using the results of such tests.

Brazilian Tensile Testing Machine (20 Tons Concrete Breaker Jack)

In this experiment, samples were placed horizontally under the loading rig. The speed of concrete breaker jack was 0.6 MPa per second. The starting point for this sample; under the load was 40 seconds to show stretch-induced stress tolerance of the sample after the first occurrence of cracks. Tensile strength was obtained by putting the amount of force (load) from the machine in the following equation: (ASTM C496) [5].

$$f(Ct) = \frac{2P}{\pi LD}$$

where

P=the amount of failure load (ultimate load)
f(Ct)= tensile strength of specimen
L=sample height
D=sample diameter

Permeability Testing Machine

This device was designed to measure the permeability of concrete specimen. The concrete specimen to determine the permeability test was provided in the form of a cylinder. Then the sample was located under water pressure by the machine from the upper section and the outflow volume of the water from the bottom section of the sample was measured and the output discharge was calculated. Finally, with respect to the output discharge and pressure, the permeability coefficient of the sample was calculated.

Results and Discussion

Compressive Strength

To compare the compressive strength (CS) of fiber reinforced concrete with that for ordinary concrete, the compressive strength ratio (CSR) is defined as follows:

$$Compressive\ Strenght\ Ratio\ (CSR) = \frac{CS_{Polypropylene\ Fiber\ Reinforced\ Concrete}}{CS_{Unreinforced\ Concrete}} \quad (1)$$

Fig. 1 shows the CSR for samples with various polypropylene percentages after 7 days. It is depicted that in the range 0.2 to 0.45 percent, the greatest changes are obtained in compression strength with the peak for 0.4 percent. It can be seen that the compressive strength of fiber reinforced concrete is about 1.6 times than that of normal concrete. Among the crucial features of polypropylene fiber concrete, is that after breaking and cracking the samples can endure compressive stress 30 seconds longer than normal concrete specimens. This matter is very important to the issues that are related to the earthquake loading.

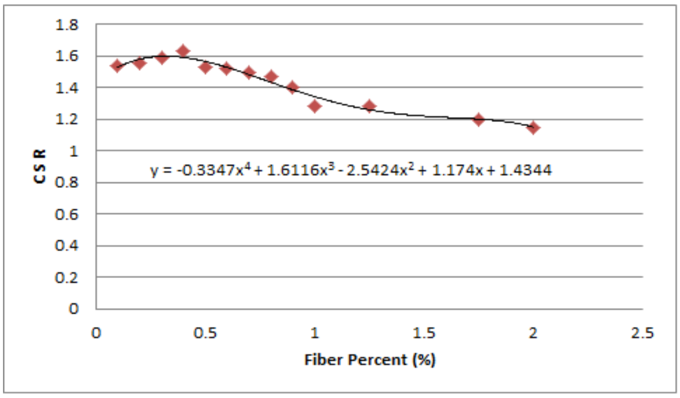

Fig. 1: Compressive Strength Ratio

Tensile Strength Due to Bending

Fig. 2 shows the ratio of tensile strength of fiber reinforced concrete to that for ordinary concrete defined as:

$$Tensile\ Strenght\ Ratio\ (TSR) = \frac{TS_{Polypropylene\ Fiber\ Reinforced\ Concrete}}{TS_{Unreinforced\ Concrete}} \quad (2)$$

due to bending for samples with different polypropylene percent after 7 days. It can be depicted that in the range 0.2 to 0.5 percent fiber, the maximum change in tensile strength due to bending was obtained, with the peak for 0.2 percent. At this point the tensile strength of the fiber reinforced concrete is about 2.67 times than that of normal concrete.

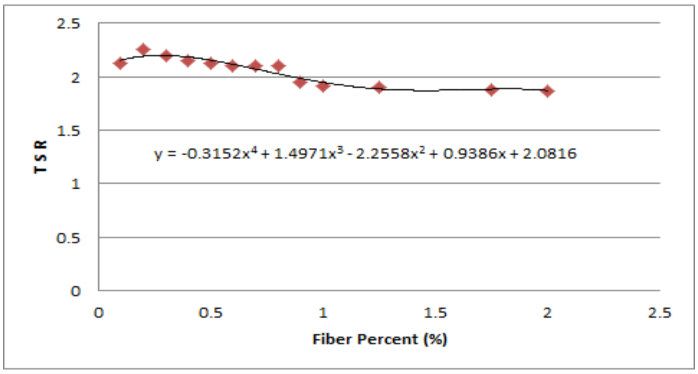

Fig. 2: Tensile Strength Ratio

Brazilian Resistance (Strength)

Fig. 3 shows the ratio of tensile strength due to compression (Brazilian) to that for ordinary concrete defined as:

$$Brazilian\ Strenght\ Ratio\ (BSR) = \frac{BS_{Polypropylene\ Fiber\ Reinforced\ Concrete}}{BS_{Unreinforced\ Concrete}} \tag{3}$$

obtained from laboratory tests on samples with different polypropylene percent after 7 days. It can be depicted that in the range 0.2 to 0.5 percent fiber the maximum change in tensile test was obtained, with the peak for 0.2 percent fiber. The maximum BSR is approximately 3.6.

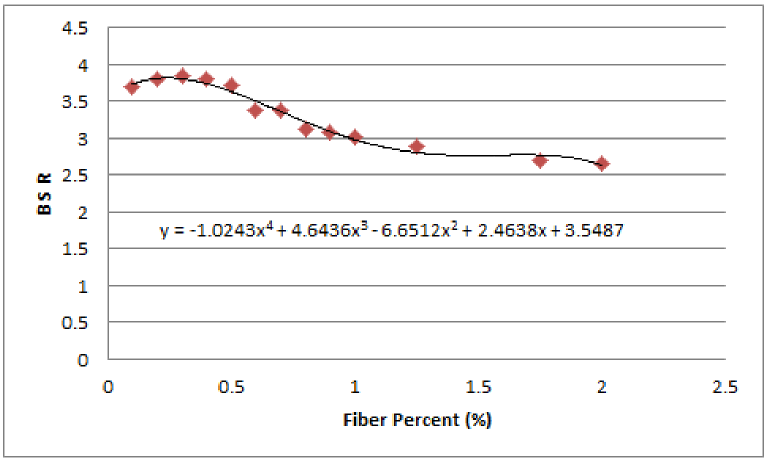

Fig. 3: Brazilian Strength Ratio

Permeability

Permeability ratio (PR) is defined as:

$$Permeability\ Ratio\ (PR) = \frac{P_{Polypropylene\ Fiber\ Reinforced\ Concrete}}{P_{Unreinforced\ Concrete}} \tag{4}$$

The PR for samples with different polypropylene percent after 28 days is shown in Fig. 4. It is seen that in the range 2 to 0.45 percent fiber, the lowest permeability of concrete is observed with the peak for 0.6 percent fiber. Minimum PR is about 0.6. Because of the extent of changes in the permeability of the interval is too small, the optimal range can be declared in the range 0.45 to 0.7.

Degree of permeability of clay is about 10 $^{-6}$ cm /sec. Compared to the amount of polypropylene fiber concrete permeability, one can easily get that these types of concrete is a very good alternative for clay in rock-fill dams. Using fiber concrete in rock-fill dams' core with respect to this property, can see dramatically reduce water leakage at core dam [2].

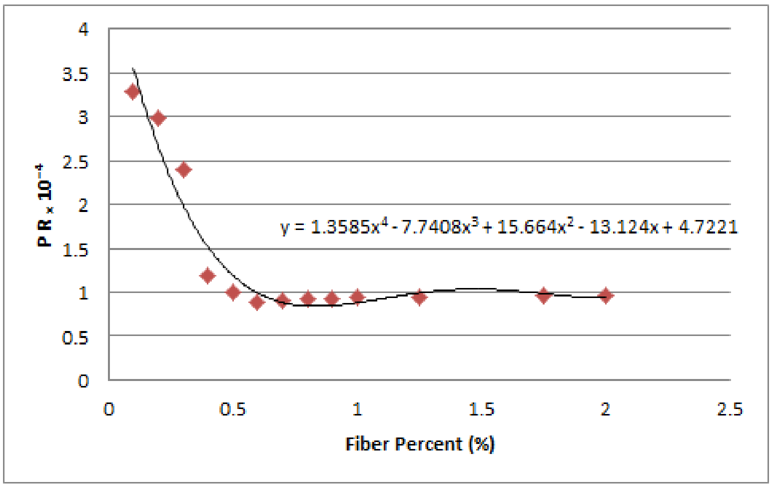

Fig. 4: Permeability Ratio

Deformability

Fig. 5 shows the elasticity ratio (ER) defined as:

$$Elasticity\ Ratio\ (ER) = \frac{E_{Polypropylene\ Fiber\ Reinforced\ Concrete}}{E_{Unreinforced\ Concrete}} \tag{5}$$

for samples with different polypropylene percent after 28 days. It can be derived that the deformability of fiber reinforced concrete increased with increase of fiber percentage. The optimal interval can be declared in the range 0.45 to 0.9 percent. Higher percentages may not be economically efficient. The minimum ER, in optimal rang, is about 0.8. The main reason for using ductile materials in the dam core is preventing cracking of the core against the lateral loads exerted on the dam and the strain caused by it. Beside the characteristic of ductility, it can be noted that damping capacity is also increased, which is important for dam core under dynamic loading.

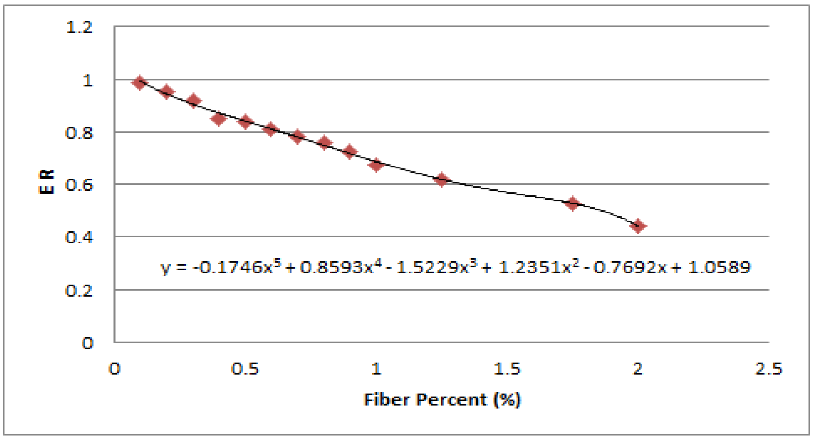

Fig. 5: Elasticity Ratio

Conclusion

This paper explores an appropriate mix design in making polypropylene fiber concrete to reduce permeability, to increase the concrete resistance and to increase degree of deformability of concrete. Resistance (strength) included the tensile strength due to the pressure, the tensile strength due to bending and compressive strength of concrete fiber. The optimal ranges of fiber percent for each of these properties are as follows:

-compressive strength (0.2% to 0.45 %)
-tensile strength due to bending (0.2% to 0.5 %)
-tensile strength due to compression (Brazilian) (0.2% to 0.5%)
-permeability (0.45 to 0.7 %)
-deformability (0.45% to 0.9 %)

In general, the optimal range of fiber is 0.4% to 0.6%; which satisfies all the noted criteria. By replacing clay with polypropylene fibers concrete instead of ordinary concrete, the problem such as; dam core permeability, high volume of clay materials needed for core, too much time for implementation, highly detailed quality control and etc. can be overcome.

References

1- ASTM, "Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals", ASTM C 672, Annual Book of ASTM Standards, Philadelphia, vol. 04-02, 2003.

2- CRD-C 48, US Army "Standard Test Method for Water Permeability of Concrete", 1992.

3- Ahmed, Bukhari, Qureshi, "A study on properties of polypropylene fiber reinforced ", 31st Conference on OUR WORLD IN CONCRETE & STRUCTURES, Singapore, 16 - 17 August 2006.

4- ASTM, "Standard Test Method for Abrasion Resistance of Concrete (Underwater Method)", ASTM C 469, Annual Book of ASTM Standards, Philadelphia, vol. 04-02, 2000.

5- ASTM, "Standard Test Method for Abrasion Resistance of Concrete (Underwater Method)", ASTM C 496, Annual Book of ASTM Standards, Philadelphia, vol. 07-04, 2003.

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An investigation of shaft resistance in pile jacking and pile driving by finite elements method

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Abstract

The piles which are used to transfer structure load to the lower firm layer of soil are classified into two categories: pre-cast piles and bored piles. The pre-cast piles which are mostly steel pipes are used more widely due to their ease of installation especially in granular soils. This kind of piles is usually penetrated into the soil by dynamic hammer. Not only this method produces a lot of noise and vibration, but it also causes decrease in shaft resistance as a result of soil manipulation. Pile jacking technology allows the pile to penetrate into the soil in a static mode without making noise and vibration. In this study, the effect of pile static penetration in granular soil in 3D mode with finite elements method and Eulerian behavior using Abaqus software has been examined. The results are compared with the results of dynamic penetration for exactly the same conditions. The results of the comparison clearly show improvement in shaft resistance of pile penetrated statically due to the omitting vibration in this penetration method.

Keywords: Pile Jacking, Pile Driving, Stress Ratio, Shaft resistance, Finite Elements.

Introduction

The piles are used as a deep foundation to transfer structure load to the lower layer of soil. Based on the method of installation, piles are typically classified into two types including displacement (pre-formed) and non-displacement (bored) piles. Displacement piles such as steel piles are often used in loose and off-shore environments. One issue regarding the installation of pre-formed piles by dynamics methods (pile driving) is that the soil around the piles is pushed away and distorted during the installation. Moreover, pile driving is a technique that is not appropriate for the urban area. The noise and ground vibrations during installation also should be considered because of human disturbance and probable structural damage [1].

In order to address the abovementioned issues, a novel method to install piles without noise and vibration has been proposed. Recently, hydraulic rams are used to produce needed static force to jack pre-formed piles into the ground. This technique of pile installation is known as the pressed-in method [2]. A common pressed-in piling machine is illustrated in Figure 1.

Pile jacking effects on the granular soil during installation is still a top issue for researchers. Some laboratory experiments including demonstrated that the soil around the displacement pile is heavily distorted, [3, 4 and 5]. Their results revealed that soil density changes due to stress in the soil caused by pile installation [6].

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Figure 1. Pile Jacking Machine [2]

Effects of jacked piles on sand compared to other type of installation piles were investigated by [2] on real case of pressed-in pile. They demonstrated that stiffness of pressed-in piles exceeds normal suggested design stiffness for driven and bored piles by factors of 2 and 10 respectively.

Material and Methods

Numerical Method

Finite Elements Method (FEM) is usually used to model pile installation. Researchers prefer to model installation effects often by empirical methods rather explicit method [6]. Installation phase of a pressed-in pile can be simulated by the following numerical frameworks:

Using Small Strain: Some authors including [7], [8], and [9] proposed a numerical frameworks using small strain. In [7], tension piles were calculated by a numerical method by loading the boundary of the mesh and using further traction on the pile shaft. Also, applying soil pre-stress and cavity before the actual pile bearing capacity calculation was proposed by [8]. This also was executed in the general purpose FEM package PLAXIS software [9].

Re-meshing or Updating the Mesh: In an updated Lagrangian scheme for large deformations, the elements Jacobian could become unknown [10]. This issue can be addressed by re-meshing the elements after each step. Moreover, [11] proposed a method by implementing incorporates regular updating of the mesh and interpolation of the stress and material parameters in ABAQUS. Due to the large deformation occurring during pile installation, updated Lagrangian numerical framework is not appropriate to simulate the full installation process. So, other numerical method should be used.

Arbitrary Lagrangian-Eulerian (ALE): This method allows uncoupling of the mesh and material. ALE framework was applied by [12] to develop a constitutive model to simulate the cone penetration test.

According to the reviewed numerical papers in this section, it can be revealed that the most researchers have concentrated on proposing and choosing the best modeling methods of pile jacking. There are a few studies investigated the effects of pile jacking on soil and more specifically there is no researcher focused on comparison of bearing capacity of two kinds of pile installation (pile jacking and pile driving) in granular soils.

Current work

This paper tries to prepare a pile jacking model in ABAQUS 3D software by applying Finite Elements Numerical method and Eulerian behavior for sandy soil with same properties of real pile driving case. This study compares the shaft resistance in both methods of pile jacking and pile driving. The soil model in this method is defined by Eulerian Numerical Framework. In this method, materials can move freely through an Eulerian mesh. The reason for using Eulerian formulation is that no element distortion occurs. Due to the high speed of analysis, the overall behavior of the problem is explicit. In pile installation with static method, it should be assumed that there is no excess pore pressure.

Verification (Mesh Study)

A real case of pile jacking implemented by Dijkstra et al. in [6] is used to verify the proposed model in ABAQUS software. A 0.5 meter diameter circular close ended steel pile is used to jack uninterruptedly into the uniform saturated sand. The pile length and penetration velocity are 5 m and 35 mm/s, respectively. Other soil and pile properties are demonstrated in Tables 1 and 2.

Table 1. Material Parameters for the Soil (Verification Model)

Sat. Vol. Weight	Friction Angle	Cohesion	Dilatancy Angle	Young's Modulus	Poisson Ratio
γ_{sat}	Φ	C	Ψ	E	ν
20	37	0.1	0	10000	0.3
kN/m^3	°	kPa	°	kPa	-

Table 2. Material Parameters for the Pile (Verification Model)

Density	Young's modulus	Poisson ratio
γ	E	ν
kN/m^3	23	0.2
27	GPa	-

In order to provide the conditions for pile penetration in soil, one must define void area about 0.5 m above the ground. Two Geostatic and Jacking steps are defined for the analysis and Simple Mohr-Coulomb model is selected for the soil. The contact between soil and pile is discretized using Abaqus General Contact formulation based on $70\% tan\varphi = 0.527$.

The pile penetrates into the soil by applying 5 m displacement on reference point above the pile. The first step to achieve verification of this problem is choosing the best elements (Mesh study). To this end, many models with different size of elements are analyzed once we reach the optimal model. The type of Eulerian elements is Quadratic and these elements have 8 nodes (EC3D8R). The Advanced elements are selected instead of Medial elements for soil part because of having high speed analysis and ease of access to results. The model prepared in software based on aforementioned information and Tables 1 and 2 illustrated by Figure 2.

A method to calculate the end and shaft bearing capacity is by determining pile reaction force or tension on soil [13]. To this end, in the specified analysis steps, the suitable tension of soil elements contacted with pile is multiplied by their cross section area.

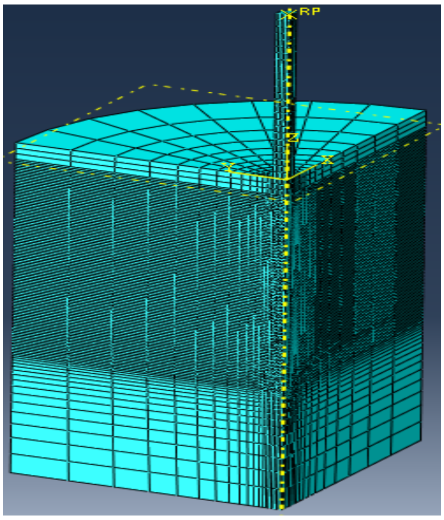

Figure 2. Verification Model in Program

A more accurate method is importing stress of elements nodes to the Civil 3D program and drawing the stress contours (Figure 3). The reaction force of pile can be obtained by multiplying the area between adjacent contours by related tension. For instance, end reaction force can be calculated using contours of vertical stress after full installation.

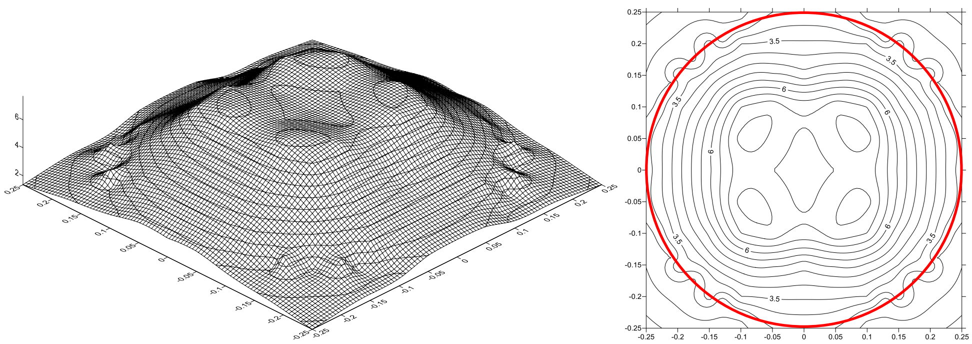

Figure 3. 3D and 2D Contours of Vertical Stress under the Pile in Last Analysis Step

After calculating the end reaction force for each specific step, reaction force-pile displacement curves are drawn (Figure 4). According to curves depicted by Figure 4, the created model by elements with dimension minimum and maximum 6 and 95 cm respectively is similar with the real case results. Therefore, this model is chosen as an optimal model (due to less than 10% error). The accuracy of our model can be proved by comparing the calculated shaft resistance after the full installation (0.94 MN) and shaft resistance in real case (1.1 MN). Therefore features including elements type, dimensions, and void length should be specified in the model.

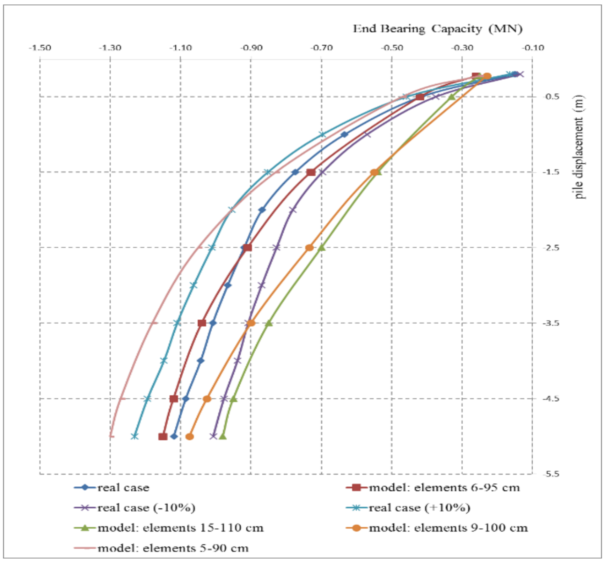

Figure 4. End Load-Displacement Pile During the Installation

Problem Properties

In this section, pile jacking and driving are compared in terms of shaft resistance of open and close ended piles. Lee et al. determined the shaft bearing capacity of open and close ended pile with average diameter 325 mm, length 8.24 m and penetration depth 7.04 for open ended and 6.87 m for close ended piles in Han River sand using Cone Penetration Test. Other parameters of soil and pile are shown by Table 3 and 4. Jacking step for open and close ended pile last 220s and 217s respectively. The optimum velocity of piles installation is 35mm/s which is proved by the previous studies [14].

Table 3. Material Parameters of Soil (Comparison Model)

Sat. Vol. Weight	Friction Angle	Cohesion	Porosity Ratio	Young's Modulus	Poisson Ratio
γ_{sat}	Φ	C	E	E	ν
15.8	33.7	0.1	0.66	10	0.3
kN/m³	°	kPa	-	MPa	-

Table 4. Material Parameters of Pile (Comparison Model)

Density	Young's modulus	Poisson ratio
γ	E	ν
kN/m³	23	0.2
27	GPa	-

Results and Discussion

Radial stress (S11 in cylindrical coordinate) condition of both closed and open ended pile after full installation, are shown by Figure 5. Shaft resistance is derived by shear stress. To this end, radial stress multiplied by Side Coefficient (K) results in shear stress.

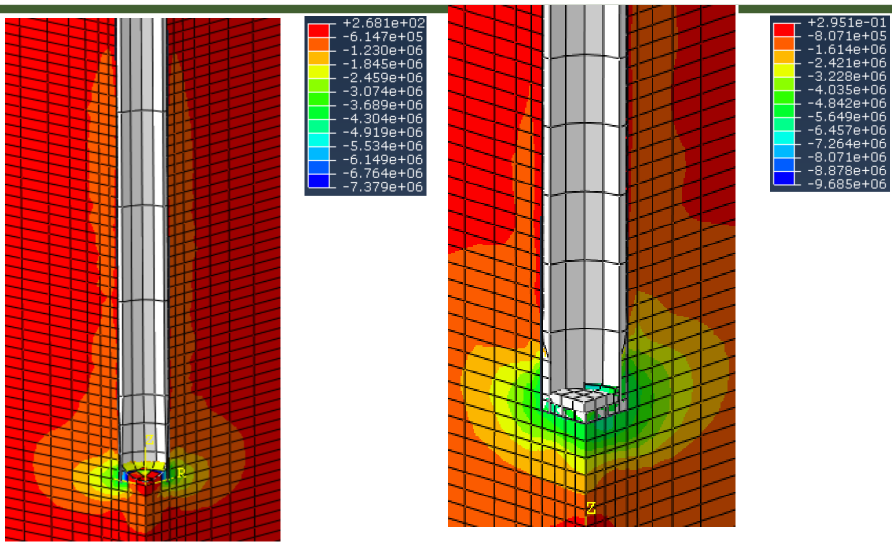

Figure 5. a) Radial Stress for Open Ended Pile, b) Radial Stress for Close Ended Pile

Also Eulerian Void Fraction (EVF) criteria is an appropriate metric for recognizeing the condition of void in the soil. Using EVF one can represent the soil flow in or around the pile. This creteria for open eneded pile is shown by Figure 6.

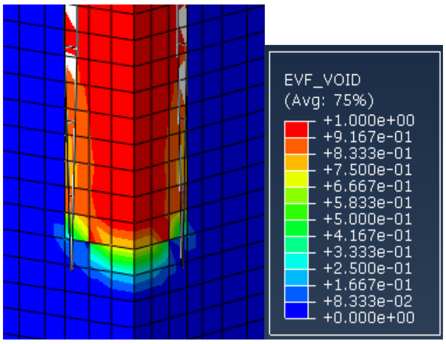

Figure 6. EVF-Void for Open Ended Pile

Shaft Resistance

As shown in Figure 7 and Equation 1, the bearing capacity in open ended pile is calculated by a combination of the internal shear stress within the soil plug τ_i and external shear stress τ_e. In close ended pile the term τ_i is omitted [15], [16].

$$q_s = \tau_e + \tau_i \tag{1}$$

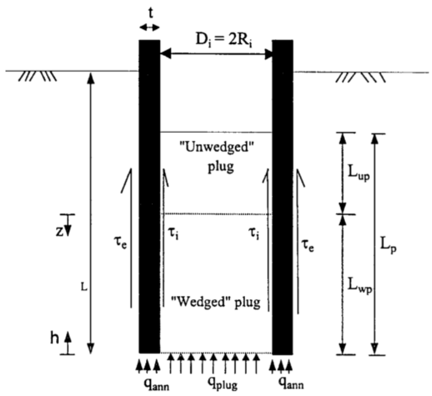

Figure 7. Bearing Capacity of Open Ended Pile [15]

As shown in Figure 5, the soil is not plugged into the pile because of density and mechanical properties of soil and geometric and mechanical properties of pile. This phenomenon is known as full-coring. Therefore, the internal shear resistance of pile (τ_i) reaches to 0. Based on above statement, calculated shaft bearing capacity of both pressed-in and driven piles are shown in Table 5.

Table 5. Shaft Resistance of pressed-in and driven piles (MN)

Open ended pile		Close ended	
Pile jacking	Pile Driving	Pile jacking	Pile Driving
0.84	0.32	1.16	0.62

The effect of pile jacking compared to pile driving on shaft bearing capacity is clearly demonstrated by Table 5. Open ended and close ended piles experienced an increase of %160 and %80, respectively for shaft resistance. The reason for this increase is soil condition improvement after full installation. Using the traditional pile installation method (pile driving) causes considerable amount of soil disturbance around the piles. Therefore, the friction between the soil and pile is decreased significantly and the pile shaft resistance decreases dramatically. However, end bearing capacity in pile is neglected compared to shaft bearing, by comparing two jacked and driven piles, it can be concluded that pile in dynamic method has greater bearing value, relativley. Due to the high friction of preformed piles with soil, these piles are usually applied in granular soil. Therfore, the evaluation metric in this research is shaft bearing capacity. Soil plugged in the pile causes an increase in shaft bearing capacity. But, it did not happen for the open ended pile in our model and a "Full coring" behaviour was observed. According to Table 5, regardless of little difference in dimensions of two open and close ended piles, shaft resistance of close ended pile is greater than shaft resistnace in open ended pile due to more densifiation of soil around the pile.

Conclusion

Below are the overall conclusions of the study:

The selected numerical method; Eulerian method; comparing to the other methods presented in the literature, was very accurate and fast. Therefore, this modeling method can be used for necessary controlling of the pile installation issue that is part of large-deformation problems.

The new technique of static pile installation behaves better in granular soil comparing to the traditional methods (pile driving) which not only created noise and severe vibrations, but also caused the decrease in pile resistance due to the hammer disturbance effect. In granular soil, the shaft resistance of pile increases to three times.

Generally, it can be noted that the close ended piles are more efficient in granular soil compared to open ended due to their better condition in shaft resistance.

References

[1] D. White, T. Finlay, M. Bolton, and G. Bearss, 2002. Press-in piling: Ground vibration and noise during pile installation, *Geotech. Spec. …*, vol. 29, pp. 363–371.

[2] A. Deeks, D. White, and M. Bolton, 2005. A comparison of jacked, driven and bored piles in sand, *Proc. …*,

[3] M. K. Chong, 1988. Density changes of sand on cone penetration resistance, in *Proc. First Intl. Symposium on Penetration testing ISOPT-1*, pp. 707–714.

[4] D. J. White, 2002. An investigation into the behaviour of pressed-in piles, University of Cambridge.

[5] J. Dijkstra, W. Broere, and A. F. Van Tol, 2008. Density changes near an advancing displacement pile in sand, in *Proc. 2nd BGA Intl. Conference on Foundations ICOF*, pp. 545–554.

[6] J. Dijkstra, W. Broere, and A. van Tol, 2009. Eulerian simulation of the installation process of a displacement pile, *Geotech. Spec. Publ.*, pp. 135–142.

[7] S. van Baars and W. van Niekerk, 1999. Numerical modelling of tension piles, in *In International Symposium on Beyond 2000 in Computational Geotechnics* , pp. 237–246.

[8] W. Broere and A. F. Van Tol, 2006. Modelling the bearing capacity of displacement piles in sand, *Proc. Inst. Civ. Eng. Geotech. Eng.*, vol. 159(3), pp. 195–206.

[9] R. Brinkgreve and W. Broere, 2004. Plaxis Manual, *Plaxis BV.*

[10] I. M. Smith, D. V. Griffiths, and L. Margetts, 2013. Programming the finite element method, *John Wiley Sons. Chicago.*

[11] Y. Hu and M. Randolph, 1998. A practical numerical approach for large deformation problems in soil, *Int. J. Numer. Anal. Methods Geomech.*, vol. 22(5), pp. 327–350.

[12] P. Van Den Berg, 1994. Analysis of soil penetration, Delft University of Technology,

[13] J. Dijkstra, W. Broere, and A. Van Tol, 2006. Numerical investigation into stress and strain development around a displacement pile in sand, *… Conf. Numer. …*

[14] J. Lee, R. Salgado, and K. Paik, 2003. Estimation of Load Capacity of Pipe Piles in Sand Based on Cone Penetration Test Results, *J. Geotech. Geoenvironmental Eng.*, vol. 129, no. 5, pp. 391–403.

[15] B. Lehane and K. Gavin, 2001. Base resistance of jacked pipe piles in sand, *J. Geotech. …*, vol. 127, no. 6, pp. 473–480.

[16] S. Henke and J. Grabe, 2008. Numerical investigation of soil plugging inside open-ended piles with respect to the installation method, *Acta Geotech.*, vol. 3, no. 3, pp. 215–223, Aug.

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The role of probiotic microorganisms in the control of health and fertility of soil

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Abstract

The method of microbial diagnostic based on gas chromatography – mass spectrometry of fatty acids, hydroxy acids and fatty aldehydes – was used for the study of the soil microbial community. Mass spectrometry of microbial markers (MSMM) method permits simultaneous determination of more than a hundred microbial fatty acids *in situ* in clinical, biotechnological or environmental samples without precultivation and biochemical test materials and primers. Some beneficial probiotic bacteria in soils microbial community such as *Acetobacter diazotroficus*, *Bacillus* sp., *Bifidobacterium* sp., *Clostridium* spp., *Lactobacillus* sp., *Rhodococcus* sp. and other are discussed in this article. Soil conditions *in situ* as well as physiological features of these microorganisms allows to present the following trophic chain: hydrocarbons (plant's exudates and residues) → products of their oxidation by actinobacteria (nocardia, rhodococci or mycobacteria) → free aminoacids and biomass proteins (metabolism products of nocardia, rhodococci or mycobacteria) → products of their fermentation by clostridia (or propionibacteria)→ volatile fatty acids (acetic, propionic, isobutiric, butyric et all.) and H_2 and CO_2. This syntrophic association may be the basis for agricultural ecosystem and can support the compounds of soil's health and fertility production. Questions concerning the potential effects on soil biofertilization (humus preservation, formation of water-stable aggregates) in agricultural systems are considered.

Keywords: probiotic bacteria, soil, biofertilization, fatty hydroxy acids biomarkers.

Introduction

The soil of agrocenosis is inhabited by a complex community of microorganisms, also referred to as the microbiota, which are believed to have an important role in health and fertility of soils. This concept came to environment researches from medical practice. A probiotic has been defined as "a preparation or a product containing viable, defined microorganisms in sufficient numbers, which alter the microflora in a compartment of the host and by that exert beneficial health effect in this host" (9). A prebiotic has recently been (re)defined as "a selectively fermented ingredient that allows specific changes, both in the composition and/or activity in the gastrointestinal microbiota that confers benefits upon host well-being and health" (7). Finally, a synbiotic is the combination of a probiotic and a prebiotic (4).

Anaerobic bacteria of g.g. *Bifidobacterium* and *Lactobacillus* as the most known genus with pro-biotic properties for the human health (3;9) were the first ones in our consideration of bacterial communities of soils. Carbohydrate degradation has been extensively studied in a variety of different *Bifidobacterium* species (11) and selected

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exopolysaccharide-producing strains of lactic acid bacteria [6] for definition of their role in synthesis of (potential) prebiotics. In environment, including in the soil, a bifidobacteria are more widespread, than lactobacilli since these bacteria prefer neutral pH values for the metabolic activity and as an organic substrate – easily oxidizing carbohydrates. *Bifidobacterium* is a "useful" genus for the soils, thanks to its ability to producing of a number of enzymes, amino acids and regulators of plants' growth [1]. The species of bacteria such as *Bifidobacterium longum* [13], *Lactobacillus rhamnosus* and other lactic acid bacteria [6] are known as bacteria bringing benefit thanks to the metabolites. These anaerobic species of bacteria occur of various habitats including in the soil [12], but their probiotic effects it isn't discussed.

In this context the purpose of this article was consideration of aerobic and anaerobic structures of microbic cenosis of different soils types with allocation of bacteria - probiotics and their contribution in the preservation of soils' Corg in agrocenosis and formation of water-stable soil aggregates.

Material and Methods

Characteristics of 326 soil samples of different types were analyzed. Podzols, soddy podzols and sandy soddy podsols, meadow-gley podsols, meadow-brown, brown forest, gray forest, podzolic, chernozems leached and typical chernozems (middle- and south taiga, forest-steppe, steppe and south steppe zones) and chestnut soils were studied in the territory of the Russian Federation and agricultural alluvial calcareous soils (Calcic Fluvisols Oxyaquic) of Konya province (Çumra area) – in the territory of Turkey.

The samples of soils were selected in different physiographic conditions taking into account their anthropogenous use: virgin and bare fallow, a deposit (are excluded from crop rotations of 5 and more years) and an arable land (the soils which are in intensive agricultural use – grain crop rotations and maize monoculture).

The mixed samples were prepared in field conditions from 5-7 separate samples of a soils layer of 0-10 cm. Selection was made in chessboard order the soil drill by diameter of 25 mm, the volume of 200-250 cm^3 .The mixed sample dried at the room temperature and, having been placed in a plastic bag, were stored to the analysis in a deep freeze. The determination of organic substance content and soil pH were carried out by standard techniques.

The gas chromatography – mass spectrometry (GC-MS) analysis was provided by chromate-mass-spectrometer AT-5973 D (Agillent Technologies, USA) detection with a special program was designed to permit selective accumulation of specific ion signals from microorganism marker compounds. The areas of markers peaks were integrated automatically (mass-phragmentography) and supervised manually under regular programs of the device using internal standard. Then these data were input into account program prepared in electronic EXCEL tables. The method allows defining the bacteria species of number more than 10^3-10^4 cells/g of soil. The methodology of a molecular method of gas chromatography-mass spectrometry (GC-MS) was in detail presented by [5, 8].

Anaerobic components of microbial communities were studied by cultivation on the selective medium BACTEC PLAS in anaerobic bottles (USA) in which the gas phase consisted of carbon dioxide and molecular nitrogen in the ratio 1:1. Further the structure of anaerobic community was studied by the gas chromatography (GC) method, and volatile fatty acids of anaerobic bacteria were studied on the gas chromatograph GC-14 A ("Shimadzu», Japan).

Systematization and generalization of an experimental material was executed by statistical methods in MS Excel.

Results and Discussion

Data about soils of farmland (the arable land, the bare fallow, the deposit and the virgin) for studying of the general tendencies conditionally are divided into two groups: soils with < 6,9 (podzols, soddy podzols and sandy soddy podsols, meadow-gley podsols); II - soils with pH > 7,0 (chernozem leached, the chestnut soil, etc.). The analysis of data showed that bifidobacteria were present at the quantities more 5% in arable land and deposit. Quantities of bacteria of this genus is twice lower in the virgin, and in the bare fallow its presence is noted only in soils with pH< 6,9. In agricultural alluvial calcareous soils (Calcic Fluvisols Oxyaquic) *Bifidobacterium* sp. are defined under *Beta vulgaris saccharifera*, in number from 0,5 to 2,2% at the depth from 10-20 cm up to 50-60 cm, respectively. Bacteria of g. *Lactobacillus* sp. were identified only in the acid soils of an arable land and bare fallow

(Table 1). In separate research of poor sandy soddy podsols (the Humus = 0,8%) lactobacilli dominate (13%) in NPK + lupine, and a bifidobacterium – NPK + straw (17%). *Bifidobacteria* and *Lactobacillus* were not observed in concentration higher than 10^3 after barley cultivation on these soils but bifidobacteria dominated (12%) after the following culture in a crop rotation (*Zea mays* L.). Lactobacilli weren't identified in the rhizosphere soil of the maize. However, in the rhizoplane of the maize which was grown up in a long-term monoculture (65 years) on the chernozem leached, quantity of lactobacilli reached 2,6% whereas bifidobacteria – were ten times less. Thus the quantity of specific bacteria depends on the crop cultivated in the rotation, i.e. from roots' exudates which initiate and modulate dialogue between roots and these soil microbes.

Table 1. Quantity of *Bifidobacterium* sp. and *Lactobacillus* sp. as a part of microorganisms' community* soils of different agricultural uses, %

Bacteria	An arable land		Bare fallow		Deposit		Virgin	
	I	II	I	II	I	II	I	II
Bifidobacterium sp.	5,4	7,3	3,59	---	6,4	5,1	2,6	4,3
Lactobacillus sp	1,4	---	0,1	---	---	---	---	---

* defined bacteria and micromycetes; I – for soils with < 6,9 (are podzols, soddy podzols and sandy soddy podsols, meadow-gley podsols); II - for soils with pH > 7,0 (chernozem leached, the chestnut soil, etc.) --- - the species isn't identified

The quantity of these species of probiotics didn't correlate with the quantity of Corg. in the studied soils. However the content of Corg correlated with the total number of microorganisms in all samples irrespective of type of the soil of r^2=0,8-1,0 (it is noted, direct dependence in soils pH less than 6,9 and inverse relationship at pH more than 7,0). Significant positive correlative dependences were established between number of an anaerobic bacterium *Clostridium* sp. and humus content (r^2 = 0,58), and also of aerobic actinobacteria *Nocardia* sp. (r^2 = 0,59), which capable to decomposition of polymeric carbohydrates in soils. Clostridia dominated in different types of soils, but in a higher quantity in that ones which weren't exposed to intensive agricultural use. *Rhodococcus* dominated in different types of soils, including the arable land. Associative diazotroph *Acetobacter diazotrophicus* dominated in the arable land. The quantity of nocardia reached dominating sizes only in the deposit soils (Table 2). Aerobic bacteria – *Rhodococcus* both *Mycobacteria* and anaerobic – *Propionobacteria* dominated in the community of bacteria in the long-term field experiment (65 years) of maize monoculture. Corg in the soil didn't change for this long-term of cultivation.

Table 2. Quantity of *Clostridium pasteurianum* and *Nocardia* sp. as a part of microorganisms' community soils of different agricultural uses, %

Bacteria	An arable land		Bare fallow		Deposit		Virgin	
	I	II	I	II	I	II	I	II
Clostridium pasteurianum	2	3	9,8	10	13	3,3	7,8	2,6
Nocardia sp.	0,5	0	3,3	---	0,7	13	0,7	0,5
Rhodococcus rhodochrous	18	---	13	20	8	---	32	6,8
Acetobacter diazotrophicus	9,7	9	4,6	4,1	4,1	3	3,5	7,7

Apparently, bacteria are united in aerobic and anaerobic consortium in which are in trophic interrelation in chain: hydrocarbons (plant's exudates and residues) $\rightarrow$ products of their oxidation by actinobacteria (nocardia, rhodococci or mycobacteria) $\rightarrow$ free aminoacids and biomass proteins (metabolism products of nocardia, rhodococci or mycobacteria) $\rightarrow$ products of their fermentation by clostridia (or propionibacteria) such as volatile fatty acids and H_2 and CO_2. It promotes creation of oxidation-reduction conditions for formation of humus substances in different types of soils and to its preservation at the expense of enough of acetic and propionic acid for further assimilation of these acids by other aerobic subdominants acetobacteria in particular. The autochthonic organic substance (humus) thus isn't exposed to degradation. Thus the protective role of soil microbiota is developed by preservation of the major factor of its fertility – quantity of humus.

The quantity of water-stable units is one of the most important characteristics of soils for its fertility quantity differences in taxonomical structure between microbic communities that inhabit aggregates of different size and the difference from the bulk soil were shown. On the total number of microorganisms in community of units of essential distinctions wasn't noted (Table 3).

Table 3. Structure of bacteria community of units with a diameter 0.002 and 1-2 mm from the bulk soil (Kursk' chernozem)

Bacteria, cells/g × 10^6	Nucleus, <0,002	Nucleus, 1-2	Soil
Acetobacter diazotrophicus	9,71	7,54	18,61
Actinomadura roseola	4,21	4,48	3,50
Agrobacterium radiobacter	14,86	17,62	1,77
Bacillus sp.	3,54	6,40	12,63
Bacillus subtilis	1,54	2,54	3,21
Bacteroides hypermegas	0,09	0,00	0,20
Bacteroides ruminicola	0,78	0,84	2,20
B. fragilis	0,00	0,14	0,00
Bifidobacterium sp.	12,27	8,66	2,17
Butyrivibrio 1-4-11	1,18	1,21	1,16
Butyrivibrio 7S-14-3	30,38	27,47	18,26
Clostridium difficile	0,28	0,00	0,00
C. propionicum	7,06	1,52	0,96
C.pasteurianum	10,09	9,45	0,00
C.perfringens	0,06	0,05	0,20
Corynebacterium sp.	1,20	1,65	2,41
Cytophaga sp.	0,74	0,58	3,45
Desulfovibrio sp.	0,96	0,00	0,00
Eubacterium lentum	10,00	5,37	6,83
Eubacterium sp.	0,04	0,05	0,04
FeRed	2,52	0,09	0,00
Methylococcus sp.	0,00	0,99	4,97
Micrococcus sp.	10,83	12,95	12,38
Mycobacterium sp.	2,64	1,89	0,00
Nitrobacter sp.	7,22	6,14	14,76
Nocardia carnea	2,03	3,70	2,24
Nocardia sp.	157,87	8,54	121,17
Pseudomonas fluorescens	2,09	1,13	6,38
P. vesicularis	0,34	0,16	2,27
P.putida	0,71	0,57	6,34
Propionibacterium sp.	8,40	12,91	5,99
Pseudonocardia sp.	3,87	4,22	3,75
Rhodococcus terrae	3,50	10,10	15,84
R.equi	3,65	5,42	3,99
Ruminococcus sp.	101,97	76,80	89,34
Sphingobacterium spiritovorum	1,84	1,05	3,87
Sphingomonas capsulata	0,87	0,55	2,31
Staphylococcus sp.	3,73	3,61	3,00
Streptomyces sp.	18,00	20,34	21,03
Wolinella sp.	0,00	0,00	2,03
Xanthomonas sp.	0,92	0,86	6,17
Total number	442	284	406

The number and the variety of the anaerobic species which concentrate in units were approximately twice more in comparison with the soil. It is more characteristic for units of the soil of diameter < 0,002 mm. Additional four species of anaerobic bacteria were observed in the nucleus of water-stable units of such size which aren't found in a soil sample in concentration higher than 10^3 cells/g of a substratum. These are two species of clostridia – *Clostridium difficile* and *C. pasteurianum,* sulphate- reducing bacterium *Desulfovibrio* sp. and also the anaerobic Gr $^-$ iron reducing bacteria described earlier as a Gr $^-$ species, reducing of Fe (III) in kaolin (5). The maintenance of one more species of clostridia –– is 7 times higher. As a result, concentration of clostridia in water-stable units with a diameter <0,002 mm exceeded that in the soil by 17 times as a whole. Only two additional anaerobic species of bacteria is revealed (there is no sulphate-reducing *Desulfovibrio* sp. and *Clostridium difficile*) for units with a diameter of 1-2 mm. As a result the number of anaerobic clostridia in these units was 6,5 times higher in comparison with their quantity in the soil *Bifidobacterium* sp. is 6 times higher in a nucleus of the unit of smaller diameter, than in the soil, and is 4 times higher in the units of the bigger size. High needs of bifidobacteria in carbohydrates which these bacteria decompose with formation, except milk acid, CO_2, ethanol and/or acetic acid and the high contents (10%) CO_2 demands for growth in the medium are known [(1)]. Thus, considerable concentration of the anaerobic bacteria in nucleus of water-stable units which take part in anoxic stages of carbon, nitrogen, sulfur and the iron cycles providing the trophic and energetic relationship and formation of specific organic substances was shown.

The clostridia, which are producers of various volatile fatty acids (VFA), apparently, have the main role in formation of specific organic substance. The increased concentration of a sulphate-reducing *Desulfovibrio* sp. in the units of <0,002 ($9{,}0 \times 10^5$ cell /g) in comparison with the soil assumes its participation in anaerobic oxidation of metabolites' clostridia. Absence of *Desulfovibrio* in the units of 1-2 mm testifies that there were no thermodynamic conditions for anaerobic process of a sulphate-reduction in this microcosm yet. The quantity of iron reducing bacteria in units of <0,002 mm it was rather great ($25{,}2\times 10^5$ cells/g). The quantity of this species decreases in 25 times with increase of the particles size to 1-2 mm. The iron reducing bacteria participate in the process of anaerobic reduction of Fe (III) and, therefore, in change of Fe (III)/Fe (II) ratio and oxidation-reduction conditions in the aggregates. So reorganization of the metabolic status of microbial community towards domination of anoxic condition became apparent. Besides, iron as the polyvalent cation, can cause a recharge of a dispersed particles' surface, creating special conditions of their coagulation. Therefore, the value of iron reducing bacteria in formation of nucleus of water-stable aggregate can be shown both in the metabolic relation of functioning of a microbiocenosis, and in formation of physical and chemical conditions of aggregate stability.

Mycobacterium sp. from aerobic species was found in number of $3\cdot\times10^6$ cells/g in water-stable aggregate and wasn't identified in the soil. This bacterium can form a pseudo-mycelium with a growth on firm substrate, possesses hydrophobic mycolic acids and by that increases water-stable nucleus of an aggregates and its resistance to processing by ultrasound. Essential excess of number (in 7-8 times) was noted also for an aerobic bacterium *Agrobacterim radiobacter* (14,9 -17,6 $\times10^6$ cells/g) in nucleus aggregates in comparison with 1,8 $\times10^6$ cells/g in soil. It is known that for this culture growth on media with carbohydrates is accompanied by plentiful formation of extra cellular polycarbohydrate slime. Apparently, the biogenesis gel of this culture participates in stabilization process of microbic consortium structure and aggregate fraction. It is possible to say that pro-biotic properties of these anaerobic (*Clostridium difficile*, *C. pasteurianum*, *C. propionicum*. *Desulfovibrio* sp. and iron reducing bacteria) and aerobic (*Mycobacterium* sp., .*Agrobacterim radiobacter*) species consist in increase of aggregate stability of the soil.

Further biochemical opportunities of anaerobic consortium of the unit with the diameter of 1-2 mm were studied. The analysis of the structure of anaerobic community showed significant growth of such species: *Eubacterium nodatum*, *E. moniliforme*, *Clostridium* spp., *Enterobacter aerogenes*(10^9 cells/g) and *Fusobacterium*, *Enterococcus*, *Ruminococcus* (10^8 cells/g).

Metabolites of anaerobic consortium contained 8 types of VFA among which unbranched acids dominate: bytiric (3,8 mM/ml), propionic (1,8 mM/ml) and acetic (2,4 mM/ml) acids – products of carbohydrates fermentation by primary fermentative bacteria. Isovaleric acid also was produced in rather large number (1,0 mM/ml) - product of an anaerobic fermentation of proteins and aminoacids.

Secondary anaerobic bacteria (H_2 utilizers) use metabolites of primary anaerobic as electron donors in an oxidation-reduction chain. That is, it is possible to assume that in the energetic metabolism anaerobic ecosystems of aggregate nucleus are based on hydrogen. A layered microbial architecture as presented in Figure 1 has been proposed when carbohydrates are the primary substrate.

At infringement of soil structures an oriented movement of bacteria in a direction of a gradient pH and also electron donors and acceptors changes take place. Bacteria cells are capable to measurement of these gradients, "remember" what level is ecologically optimum for their ability to live and purposefully aspire to returning in the adapted habitats. Apparently, a substratum - substratum signals of their metabolites also play great value in this process.

Conclusion

Anaerobic bacteria of g.g. *Bifidobacterium* and *Lactobacillus* as the most known genera with pro-biotic properties for the human health didn't correlate with quantity of Corg. in the studied soils. Bacteria of g. *Lactobacillus* sp. were identified only in acid soils of an arable land and bare fallow. In separate research on poor sandy soddy podsols (the humus = 0,8%) lactobacilli dominated (13%) in the variant of NPK + lupine. The bifidobacteria were present at the quantities more 5% in arable land and deposit. Lactobacilli weren't identified in the rhizosphere soil of the maize. However, in the rhizoplane of the maize quantity of lactobacilli reached 2,6% whereas bifidobacteria – were ten times less. Thus the quantity of specific bacteria depended on the crop cultivated in the rotation: from roots' exudates.

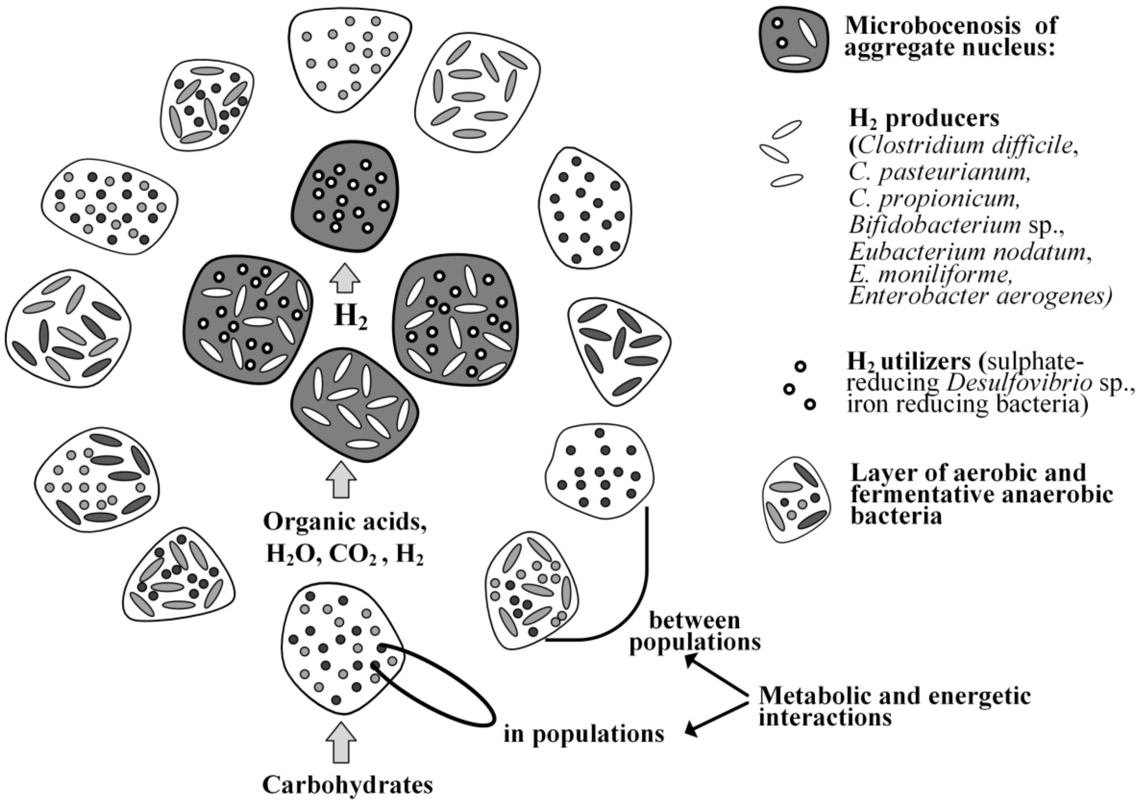

Figure 1. Schematic representation of architecture of water-stable aggregate

Associative diazotroph *Acetobacter diazotrophicus* dominated in the arable land. The quantity of nocardia reached dominating sizes only in the deposit soils. Aerobic bacteria – *Rhodococcus* both *Mycobacteria* and anaerobic – *Propionobacteria* dominated in the community of bacteria in a long-term field experiment (65 years) of maize monoculture. Corg in the soil didn't change for this long-term cultivation. Significant positive correlative dependences were established between number of anaerobic bacteria *Clostridium* sp. and humus content (r^2 = 0,58), and also `of aerobic actinobacteria *Nocardia* sp. (r^2 = 0,59).

Apparently, bacteria are united in aerobic and anaerobic consortium in which the following products are linked by trophic interrelation in the chain: hydrocarbons (plant's exudates and residues) $\rightarrow$ products of their oxidation by actinobacteria (nocardia, rhodococci or mycobacteria) $\rightarrow$ free aminoacids and biomass proteins (metabolism products of nocardia, rhodococci or mycobacteria) $\rightarrow$ products of their fermentation by clostridia (or propionibacteria) of volatile fatty acids and H_2 and CO_2. It promotes creation of oxidation-reduction conditions for formation of humus substances in soils of different types and for humus preservation at the expense of sufficient acetic and propionic acid content for further assimilation of these acids by other aerobic subdominants, by acetobacteria in particular. The autochthonic organic substance (humus) thus isn't exposed to degradation. So the protective role of a microbiota of the soil - the preservation of a major factor of its fertility – high quantities of humus

Considerable concentration of the anaerobic bacteria which take part in anoxic stages of the cycle of carbon, nitrogen, sulfur and iron providing the trophic and energetic relationship and formation of specific organic substance in nucleus of water-stable units was shown. The clostridia, which are producers of various volatile fatty acids (VFA), apparently, have the main role in formation of specific organic substance. Pro-biotic properties of anaerobic (*Clostridium difficile*, *C. pasteurianum*, *C. propionicum*. *Desulfovibrio* sp. and iron reducing) bacteria and aerobic (*Mycobacterium* sp., .*Agrobacterim radiobacter*) species consist in increase of aggregate stability of the soil. *Bifidobacterium* sp. in this anaerobic consortium participates in creation of specific organic substance (milk acid, ethanol and/or acetic acid), and also CO_2. Pro-biotic role of this species in forming of soil nucleus aggregates was revealed.

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References

1. Biology of the prokaryotes.1999.Lengeler. J. W, Drews G., Schlegel H.G. (Eds.) Georg Thieme Verlag .Thieme,Stuttgart, New York, p.p.371-375
2. Canfield, D.E., Rosing, M.T., Bjerrum, C. 2006. Early anaerobic metabolisms. Phil. Trans. R. Soc. B. 361.1819–1836.
3. Gibson G.R, Roberfroid MB. 1995. Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics. J. Nutri. 125.1401–1412.
4. Gibson, G. R., Probert, H. M., Loo J. Van, Rastall R. A., Roberfroid, M. B. 2004. Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. Nutr. Res. Rev.17**.** 259-275.
5. Osipov, G.A., Turova, E.S. 1997. Studying species composition of microbial communities with the use of gas chromatography-mass spectrometry. Microbial community of kaolin. FEMS Microbiol Rev. 20.437-446.
6. Pepe O., Ventorino V., Cavella S., Fagnano M., Brugno R. 2013. Prebiotic Content of Bread Prepared with Flour from Immature Wheat Grain and Selected Dextran-Producing Lactic Acid Bacteria. Appl. Environ. Microbiol. 79. 12. 3779-3785.
7. Roberfroid, M. 2007. Prebiotics: the concept revisited. J. Nutr.137**.** 830-837.
8. Shekhovtsova, N.V., Osipov, G.A., Verkhovtseva, N.V., Pevzner, L.A. 2003. Analysis of lipid biomarkers in rocks of the Archean crystalline basement. In: Proceedings of SPIE. 4939. 160-168.
9. Schley PD, Field CJ. 2002. The immune-enhancing effects of dietary fibres and prebiotics. Br. J. Nutr. 87.221–230.).
10. Schrezenmeir, J., de Vrese, M. 2001. Probiotics, prebiotics, and synbiotics–approaching a definition. Am. J. Clin. Nutr.73**.** 361-364.
11. van den Broek, L. A., Hinz, S. W., Beldman, G., Vincken, J. P., Voragen, A. G. 2008.*Bifidobacterium* carbohydrases—their role in breakdown and synthesis of (potential) prebiotics. Mol. Nutr. Food Res. 52**.**146-163.
12. Veith B, Herzberg C, Steckel S, Feesche J, Maurer KH, Ehrenreich P, Baumer, S, Henne A, Liesegang H, Merkl R. 2004. The complete genome sequence of *Bacillus licheniformis* DSM13, an organism with great industrial potential. J Mol Microbiol Biotechnol. 7. 204–211.
13. Viborg, A.H, Katayama, T., Hachem, M.A., Andersen, M. CF., Nishimoto, M., Clausen, M. H., Urashima, T., Svensson B., Kitaoka, M. 2014. Distinct substrate specificities of three glycoside hydrolase family 42 β-galactosidases from *Bifidobacterium longum* subsp. *infantis* ATCC 15697. Glycobiology.24. 208 - 216.

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Geochemical combination in the structure of soil cover Baraba lowland

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Abstract

Baraba lowlands - a vast low plain drainless - in conditions of semi-arid climate formed as an area of accumulation of soluble salts. However, the spatial distribution of them in Baraba largely depends on the nature of the surface, meso- and microrelief, which varies greatly in different parts of the lowlands. Key areas, selected for study, are confined to the three geomorphological districts: Ob plateau, high and low geomorphological steps Baraba. Each key area is a catena, comprising three main elementary landscape: eluvial, transit and accumulative. Eluvial elementary landscape catena at Ob plateau has a height of 152.5 meters above sea level. Leached chernozems formed here. Balance of substances is mainly determined by the migration of cyclic type, performing the biological cycle of carbon and nitrogen. Transit elementary landscape with altitude of 152.5 – 112.0 m asl has a more pronounced slope to the north-east. This fact intensifies the process of surface leaching. On the other hand, a higher level of groundwater determines the increase manifestation of solodization process. Therefore, the main soil cover of this site constitute complexes hidrometamorphosis chernozem with gray forest solodized and soloth soils. Accumulative elementary landscape is characterized by a predominance of concave surfaces with numerous micro-depressions. The aggregate of processes solodization, alkalinization, peat formation generates extreme complexity of soil cover here. Unlike landscapes Ob plateau the highest position on the high geomorphological steps Baraba can not be attributed to eluvial elementary landscapes. Low altitude gradient in mesorelief and proximity of groundwater to the surface causes semihydromorphic conditions. In low geomorphological steps of Baraba ridges relief predominates. On ridges the eluvial elementary landscapes are formed. Automorphic mode here promotes steppization and the formation of chernozem with signs of alkalinity. Middle position of the catenas occupied soils with a predominance of processes alkalinization of the soil profile - hidrometamorphosis chernozem salty, deep and medium solonetses. At the bottom of the slopes evaporative-percolate mechanism of soil differentiation dominated, which results in the formation of complexes solonchakous meadow and saline soils with soloth soils. Catenas end with extensive undrained blind valley, in which peat bog and fen peat-gley soils, often slightly saline, are formed.

Keywords: relief, catena, elementary landscape, structure of soil cover, salinization-desalinization

Introduction

Intensive use of land in agricultural production in the last 30-35 years has led to a significant deterioration of properties of the soils and other landscape components: vegetation, microclimate and hydrological conditions. Nature-and landprotection direction in land use and ecological adaptation of agriculture become important concept. This circumstance gave new impetus to studies of the structure of the soil cover (SSC). F.I.

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Kozlovsky formulated the basic principle of the development of the concept of SSC: it is integration studies of soil and geosystem containing it. "It contains a "coded" information as about the soil cover, so as about other ingredients and geosystem in general, including its history and modern modes" [Kozlovsky, 2003, p. 296]. The structure of the soil cover SSC is an integral characteristic of the landscape. Component composition of soil cover reflects the spatial differentiation of elementary soil processes, but geometric characteristics (number and area of elementary soil areals (ESA) and the elementary soil structures (ESS)) create the possibility of quantitative assessment the distribution of these processes in space. Development of quantitative methods for studying the structure of the soil cover provides the basis for the introduction in this branch of science of information technology, particularly geographic information systems (GIS).

Material and Methods

Research was applied by comparative-geography method (Fridland, 1972[1]). Baraba lowland is a huge accumulative plain. Its area is 17 million ha, or 170 thous. km^2. In the course of geological development on its territory three geomorphological districts emerged: Ob plateau, high and low geomorphological steps Baraba, which are in geochemical connection and which we view as makrokatena. Key areals, selected for study, characterize the each geomorphological district (Fig.1).

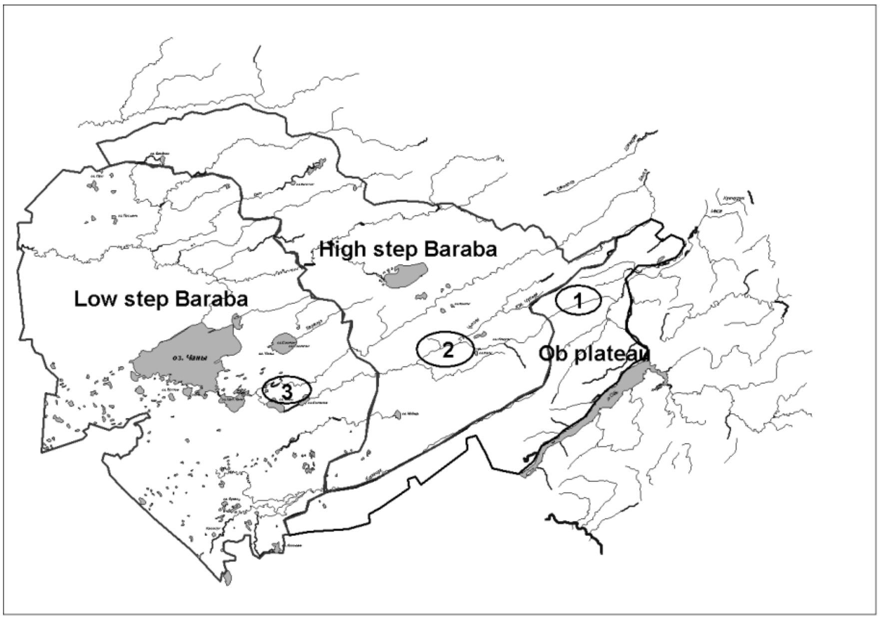

Fig. 1. Location studied key areals on the territory of Baraba lowland

Genetic and geochemical connection between elementary areals inside key ranges have been studied by using Caten approach (Milne, 1935[3]). Gradient character of action of ecological factors, associated with differences in altitude level and inclination of locality, allows for standardization of relief elements by the aggregate of landscape features. Polynov's and Glazovskaya's systematic of elementary landscapes (Polynov, 1956[6]; Glazovskaya, 1964[2]] is the basis of the standardization. It reflects the different migratory conditions of water runoff and substance. There are three main types of elementary landscapes or catena positions: eluvial with the dominance of material removal processes with surface runoff, transit with different ratios of carry-over and afflux of material, and accumulative with a predominance processes of inflow substances. Each key areals, selected for study, is a mesocatena, comprising three main elementary landscape: eluvial, transit and accumulative. Within the transit landscape may be marked out trans-eluvial, trans-eluvial-accumulative and trans-accumulative elementary landscapes according as ratios of carry-over and afflux of material. Characteristic mesorelief of three studied key areals varies considerably (Fig. 2), and causes the differences in the nature of the soil cover.

Accurate affixment of elementary landscapes to certain mesorelief elements as well as their compliance with the term a "location", introduced by L.G. Ramensky (Ramensky, 1938[7]), allows us to use the terms "elementary landscape", "element of relief," "position of catena", "location" as synonyms.

In the key area of the Ob plateau geomorphological profile was laid with length of 16 km from the highest point of 164 m above sea level to the lowest 107 m above sea level. Soil profiles were performed in soil habitats of each type of elementary landscape and soil samples have been selected. The component composition of the soil cover, geometric characteristic of elementary soil areas and soil properties were studied.

In key areas of high and low levels of geomorphological Baraba lowland map used for the study of soil and the materials of topographic survey conducted by the state soil service. Series the geomorphological profiles performed in accordance with the naturally changing geochemical conditions, reveals regularity of genesis and factors of differentiation of the soils at different levels of natural systems. Soil names are given in WRB system, 2006.

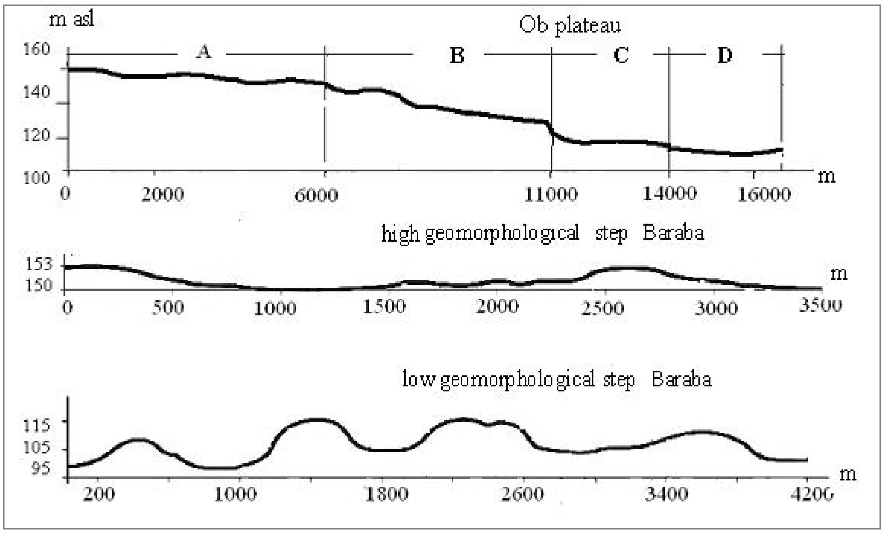

Fig. 2. The relief of studied key areals in Baraba lowland

Results and Discussion

Ob plateau. Overall slope of the locality from the southwest to the northeast is only 0,2 °, but the great length of the catena (16 km) allows us to observe the manifestation of consecutive increase of hydromorphism and salinization. Genesis of soils is due to the previous history of the formation of the Ob plateau. Common traits for the soil cover as a whole are the following factors: relict hydromorphism, loess carbonate sediments, surface uniformity, the relative proximity of groundwater. However, the waviness of relief, albeit insignificant, creates conditions for the spatial differentiation of the water regime and elementary soil processes: leaching, salinization of soil and solonetzic solodization. Their different combination in depending on the location of the range in the relief forms diversity of soils and soil complexes.

Conditionally Caten can be divided into several sections - catenas first order, differing in the dominant type of water regime (look Fig. 2). A plot A with marks above 152.5 m above sea level, has a slope angle of just 0,1 °. On closed round-oval elevations with altitudes 163.72 - 153.75 m asl leached Voronic Chernozems Pachic are formed. It is eluvial position. In transaccumulative weakly expressed flat depressions combinations of Calcic Chernozems Sodic and Solodic Planosols Albic are located. On the periphery of local depressions – Endosalic Gleysols Sodic. Balance substances in biogeocenoses of eluvial position is determined mainly by the migration of cyclic type [Mordkovich et al, 1985[4]], performing biological rotation of carbon and nitrogen, partly vertical - entering substances with precipitation - and planar connecting the biogeocenosis with lower ranges. In transaccumulative position of the plot A the formation of a combinations of Calcic Chernozems Sodic and Solodic Planosols Albic and Endosalic Gleysols Sodic is due to the formation of geochemical solonchak barrier on the border between the areals of the leaching process and accumulation process.

The plot B with an altitude of 152.5 - 118.75 m asl has a more pronounced slope to the north-east (0,3 °) and ends with steep slope (6,6 °) of ancient lakeside swell. This fact increases the process of surface leaching. On the other hand, a higher level of groundwater compared to the level of A determines the increase solodization process. Therefore, the main soil cover of this site is constituted by Voronic Chernozems Pachic (Meadow-chernozemics leached) soils in complex with Greyic Phaeozems Albic.

The segment C of the studied mesocatena (height above sea level 118,75-112,5 m) is characterized by a predominance of eluvial-accumulative environments in which the complexes Calcic Chernozems Sodic with Greyic Phaeozems Albic are formed. However on local elevations automorphic soil didn't form as it was in areas A and B, but semihydromorphic Meadow-chernozemics soils. It is associated with a near to surface standing groundwater. In local depressions - areals of Solodic Planosols Albic and Haplic Gleysols Dystric.

Plot D represents superaqueous position of the described mezokatena and is characterized by a predominance of concave surfaceses with numerous micro-depressions. This fact causes dominance of accumulation processes in soils differing in degree of manifestation in microdepressions and associated microelevations. Additive effect of microprocessors solodization, alkalinization, peat formation generates extreme complexity of soil cover. Flow of matter and energy is due to water migration.

Thus, the main current trends of soil cover on the Ob plateau are leaching processes on local eluvial position and solodization in subordinate that.

High geomorphological step Baraba lowland

Relief Baraba has been formed by processes of water erosion and accumulation on the background of epeirogenic movements. Pokrass E.P. and Bazilevich N.I. (Pokrass et al., 1954[5]) distinguish high geomorphological stage - the north-eastern part of Baraba with altitudes of 115-150 m above sea level, and low - southwest -105-115 m asl. Unlike landscapes of Ob plateau the highest position on the high geomorphological step Baraba can not be attributed to eluvial elementary landscapes. Low altitude gradient in mesorelief and proximity of groundwater to the surface causes semihydromorphic conditions.

Elevated mesorelief elements are mild manes, the exceeding over the basis of erosion is not more than 3 m (look fig. 2). Width of the manes - 0.5 -1.0 km, length -2,5-3 km and more. Geochemical situation here is conditioned by two main processes: firstly, the humus-accumulative, migrate cyclic type (biological cycle of carbon and nitrogen) [Mordkovich et al, 1985[4]], and secondly, eluvial-accumulative - vertical ascending-descending migration of water and mineral substances. Infiltration deep into soil profile in low alkalizing groundwater solodization helps manifestation solodization process - impoverishment of the humus horizon of meadow chernozem soil with sesquioxides and the relative enrichment of silica. So, in eluvial-accumulative positions are formed: 1) elementary areas Luvic Chernozems Sodic (Meadow-chernozemics solodic soils); 2) combinations of Luvic Chernozems Sodic with Solodic Planosols Albic in microdepressions.

The middle of the slopes - a transit position catenas – are occupied by soils with a predominance of processes alkalinization of the soil profile: Luvic Chernozems Sodic (Meadow-chernozems solonetzic and Gleyic Solonetz Albic (Solonetzes meadowish). Natric horizon is found at a depth of 12-18 cm. Here are migrating substances mixed type - vertical and planar.

Lower slopes with a small angle form trans-accumulative catena position. It is characterized by a significant influence of saline groundwater on the whole soil profile. Type of migration predominantly vertical, exudation-flushing water regime in this position results in the formation of complexes Endosalic Gleysols Sodic (Meadows solonetzic and solonchakous) with Solodic Planosols Albic.

Catena ends with extensive undrained depressions in which there is accumulation of organic matter and salts as a consequence of surface runoff from the upper biogeocenosis and salts from the groundwater. On the territory of Haplic Gleysols Dystric (Meadow-boggy humus), Histic Gleysols Dystric (Peaty and peat boggy), often slightly saline in the lower part of the soil profile, seldom solonchakous are formed.

The main trend of modern development of soil cover here is drying of wetlands, reducing their size. On released from water spaces concentration of salts in the upper horizons enhances and Meadows solonchakous soils are formed.

Low geomorphological step Baraba lowland

Alternation of narrow and extensive unidirectional ridges on the background of spacious wetland imparts unique appearance of terrain and creates a special hydrological regime. Slopes of ridges are often terraced that emphasizes water-accumulative and water-erosion origin of ridges. The eluvial landscapes are formed on ridges. On the general background of waterlogged areas the drainage ridges create conditions for development automorphic local processes, which formed chernozem soils as a result. As a rule, soil profile has still the signs of alkalinity in the form of relatively heightened amounts of the sodium in the composition of absorbed cations and water-soluble salts.

There are often microdepressions on the ridges. They are occupied with Endosalic Gleysols Sodic (meadow solonetzic) loamy soils with predominance physical sand or chernozem-meadow loamy. Last are usually occupied by birch and aspen groves.

On the upper slopes Luvic Chernozems Sodic (meadow-chernozemics solonetzic soils) are located in subjection at chernozems solonetsous. They are also formed on the low flat ridges or elevated areas of interfluves, and are periodically influenced by groundwater. The indications of gleying – glaucous and rust stains on the bottom of the profile – show modern processes overwetting. There are processes that are typical for transeluvial-accumulative elementary landscapes.

Increasing intensity of accumulation processes results in the formation chernozem-meadow alkaline soils, passing with decreasing altitudes into meadow solonchakous. Slope ends with salt marshes or meadow-boggy soils of inter-ridges spaces in the central part of which we often can see the water surface of the lake.

On the flat lower ridges Gleyic Solonetz Albic (solonetzes meadowous deep) are formed. Natric horizon is usually located nearer to day surface as they reduce the height of a locality.

As the slopes of the ridges are very short, the change in soil is fast, sharp increase in salinity leads to the formation of contrasting soil cover on the slopes of ridges, especially in the lower position thereof.

In general, the territory is characterized by dominance of accumulative elementary landscapes.

Conclusion

Summing up the analysis of geomorphological profiles, it should be noted the association of soil combinations to relief positions with a certain geochemical conditions, which determines their similarity in genetic traits: a set of soil varieties, types of substances migration, the mechanism of differentiation of soils that in the aggregate creates a certain type of elementary landscape.

As a rule, eluvial, transeluvial, eluvial-accumulative relief position with zonal soils and their complexes, as well as meadow-chernozem soils and their complexes have been plowed.

Often transeluvial-accumulative position with chernozem-meadow complexes is involved in arable land, but their efficiency and technological quality is very low. It requires a deep agroecological analysis to adapt the production to these conditions.

References

1. Friedland V.M. The structure of Soil Cover. - M.: Misl, 1972. – 423 p.
2. Glazovskaya MA Geochemical aspects of typology and technique studies of natural landscapes. - Moscow: MGU, 1964. - 229 p.
3. Milne G. 1935. Composite Units for the Mapping of complex soil association. Trans. of the Third Intern. congress of soil science, Oxford, England, London. - V.1.
4. Mordkovich V.G., Shatokhina N.G., Titlyanova A.A.. Steppe catenas. - Novosibirsk: Nauka, 1985. – 118 p.
5. Pokrass E.P., Bazilevich N.I. The main features of geomorphology and geology elements Baraba Lowland. Proc. Soil Inst. Dokuchaev. - Moscow, 1954.- T.XLII. - P. 5-103.
6. Polynov B.B. Geochemical landscapes. Selected Works. - Moscow: Publishing House of the USSR Academy of Sciences, 1956. - P. 477 - 486.
7. Ramenskii LG Introduction to complex soil-geo-botanical study of land. - M.: Selkhozgiz, 1938. – 620 p.

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Assessment of gasgeochemical state of soils, grounds and surface atmosphere during land use engineering for construction

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Abstract

The intensive urbanization involves reclamation of reserve territories, often adverse environmentally. More often territories with a high level of ground water are used for inhabited construction. The overflow land and river valleys concern to them. The land use engineering is carried on waterlogged overflow land according to Town-Planning Code of the Russian Federation. Territories were being covered with piled-up transportic grounds (Rulebook Urban Development, 2011). Often grounds contain construction waste, presented by mineral and organic components. Transportic technogenic grounds and underlying natural peat-like layers are able to generate biogas, which consists of methane and carbon dioxide. The heightened methane concentration in soils and grounds causes risk of fire and explosion situation. At the same time sanitary-hygienic danger of atmospheric pollution occurs. The high methane and carbon dioxide content in the atmosphere is dangerous for human health. Also these gases' emission causes increase greenhouse gases' content in the atmosphere and influences on the global climate changes. All aforesaid is responsible for the actuality of this research.

Keywords: greenhouse gases, methanogenesis, methane oxidation

Introduction

The intensive urbanization involves reclamation of reserve territories, often adverse environmentally. More often territories with a high level of ground water are used for inhabited construction. The overflow land and river valleys concern to them. The land use engineering is carried on waterlogged overflow land according to Town-Planning Code of the Russian Federation. Territories were being covered with piled-up transportic grounds (Rulebook Urban Development, 2011). Often grounds contain construction waste, presented by mineral and organic components. Transportic technogenic grounds and underlying natural peat-like layers are able to generate biogas, which consists of methane and carbon dioxide. The heightened methane concentration in soils and grounds causes risk of fire and explosion situation. At the same time sanitary-hygienic danger of atmospheric pollution occurs. The high methane and carbon dioxide content in the atmosphere is dangerous for human health. Also these gases' emission causes increase greenhouse gases' content in the atmosphere and influences on the global climate changes. All aforesaid is responsible for the actuality of this research.

Material and Methods

The object of this research is located in Moscow region in the overflow land of Moscow River. The territory was used in agriculture before 2003. Since 2004 the land use engineering has been begun according to the rules of Town-Planning Code. Territory was being covered with piled-up transportic grounds.

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The four key area was put for research. The soil survey and gasgeochemical survey conducted. The morphological descriptions of soil profiles conducted in the field condition. We selected 145 samples of soils and grounds. There were selected 182 air samples for determine concentration of methane and carbon dioxide in soils and grounds. 202 air samples were selected for definition these gases's concentration in surface atmosphere and 2m height.

Blast-hole gasgeochemical survey. The airproof tubes were installed to the 60cm depth into the soil. In an hour the samples of soil's air were selected in the glass flasks with NaCl brine. Then concentration of methane and carbon dioxide was determined by the gas chromatograph.

Research of methane and carbon dioxide emission from soil into the atmosphere was conducted by the static chamber method. The low hollow metal bottomless cylindrical container (volume of 1100 cm3) were used as chambers. They were crashed into the soil's surface to the 5cm depth. The air samples of surface atmosphere were selected immediately and in an hour. The first sample characterized the concentration of gases in the atmospheric air, the second sample indicate processes of the emission or absorption of gases from soils. The emission (absorption) of gases was calculated using the formula:

$$q\ (mg \bullet m^{-2} \bullet h^{-1}) = \Delta Ch / \Delta t,$$

where ΔC - change in concentration of gases in the chamber (mg • m-3) during the exposure time (Δt, 1:00), h - height of the camera (0.1 m).

The research of the potential activity of methane bacterial oxidation was carried out according to the method by Zvyagintsev (Zvyagintsev, 1991). The samples of soil in the flasks were incubated above water of room temperature during 4 days for better moisturization and extraction of microorganisms from latent state. Then the flaks were closed, after which methane approximately 100% concentration was introduced in the amount of 0,2 cm^3. In the 0,5 cm^3 air sample from flask determined initial (C_0) and then every other day – the residual concentration in the gas chromatograph. Simultaneously the abiotic absorption of methane was evaluated. For this the experiment was repeated but before the addition of methane in the gas phase of fask acetylene (3cm^3), as an inhibidor of methane oxidation process, was injected. The measurement of residual methane was also performed for 4 days. The rates of methane oxidation and abiotic absorption were calculated by the formula:

$$V\ (ng / g \text{ per hour}) = (dC \bullet K \bullet Vgf) / (MP \bullet t),$$

where dC - concentration difference in the first and the last measurement, ppm; K-conversion factor mg/m3 (0,657 at 20 ° C); Vgf - volume of gas phase cm^3; MP - soil sample weight, g; t - time hour. The rate of methane oxidation was calculated as dC = dC without acetylene - dC with acetylene.

The research of granulometric texture, the content of organic carbon, pH, the specific surface was carried by the standard methods (Vadyunina, Korchagina, 1986).

Results and Discussion

Assessment of gasgeochemocal state of soils and their ecological functions was conducted on natural Gleysols, Fluvisols and Albeluvisols, either on Technosols Transportic and Regosols, formed corresponding before and after land use engineering. Gleysols and Fluvisols were formed in conditions of the central and lower overflow on alluvial sediments of Moscow River. Albeluvisols were formed on old alluvial sediments. Technosols and Regosols were formed on technogenic grounds. The depth of technogenic grounds varies from 1,0 to 7,3m. In most cases there is a buried clayed layer with inclusion of organic and sometimes interbedded with peat on the territory of low overflow. Groundwater was found at the 2-4m depth. Capillary fringe groundwater tapers from the 1,2m depth. Flooding of the territory is fixed.

As a result of land use engineering there was a change of soil in researched area. Technosols and Regosols with unfavorable physical properties were formed in the thickness of technogenic sediments on buried natural alluvial soils with good morphological and physico-chemical properties. Technosols have loamy, sometimes sandy granulometric texture, contain construction and household garbage (25-30%). Construction waste is represented by rubble, asphalt crumbs, broken brick, concrete rubble, shards of glass, plastic, metal and wood.

Natural soils have a cloddy crumb structure that is favorable for life of soil fauna and microorganisms. Organic carbon content in soil thickness (10-50cm) of automorphic Albelyuvisols and Flyuvisols is 0,7-0,9%. In hydromorphic Gleysols concentration of organic carbon is 1.5%. In the upper horizon and Albelyuvisols (0-10cm) the content of organic carbon is 1,76% (Table 1).

Technosols are generally have blocky structure, predominantly loamy, sometimes sandy granulometric texture. Compared to natural soils increase of physical clay content (from 13,9 to 20,9% in Albelyuvisolys in Technosols), and specific surface area of particles (from 84,7 to 178,4 mg$\bullet$m^{-2} in Flyuvisols in Technosols) is marked. Fragments and thick bands of lowland peat unevenly distributed in the soil profile. The content of organic carbon in the column (10-50cm) is from 0,9 to 1,8%.

Table 1. Chemical and physical properties of natural and undeveloped soils and anthropogenic soils

	Fluvisols	Gleysols	Albeluvisols	Regosols	Tecnosols Spolic	Tecnosols	Tecnosols Humic
Physical clay, %	15,8±1,2	19,5±1,5	13,9±0,0	15,9±0,9	16,9±0,5	15,3±0,0	20,9±0,0
Silt,%	6,6±0,7	7,7±1,3	6,8±0,0	6,2±0,5	6,2±0,5	7,2±0,0	5,5±0,0
Specific surface area,mg $\bullet$ m^{-2}	84,7±8,3	105,1±11,7	92,1±0,0	90,2±10,4	137,8±15,7	178,4±0,0	110,1±0,0
Sorption ng $\bullet$ g^{-1} per hour	19,7±2,4	27,1±3,3	7,8±0,0	18,1±3,3	16,4±2,0	22,0±0,0	18,3±0,0
pH	7,7±0,1	7,6±0,1	6,6±0,0	7,8±0,2	6,8±0,4	7,3±0,0	7,2±0,0
Organic carbon,% (0-10cm)	-	-	1,76±0,0	0,8±0,0	-	-	-
Organic carbon,% (20-50cm)	0,9±0,1	1,5±0,2	0,7±0,0	1,7±0,3	1,8±0,3	0,9±0,0	0,9±0,0

Albelyuvisols and Flyuvisols, formed in automorphic conditions, are characterized by low rates of methanogenesis: 0,02-0,03 ng$\bullet$g^{-1} per hour. Hydromorphic conditions and increased organic matter content in Gleysols cause a high rate of methanogenesis (0,13 ng$\bullet$g^{-1} per hour). In natural soils, high rate of bacterial formation of methane is offset by a corresponding bacterial oxidation (4,6-6, ng$\bullet$g^{-1} per hour, Gleysols 19,7 ng$\bullet$g^{-1} per hour), not allowing a large accumulation of methane in the soil column (Table 2).

Table 2. Rates of methanogenesis, methane oxidation and methane content in the soil and atmosphere and emission rate.

	Methanogenesis, ng $\bullet$ g^{-1} $\bullet$ h^{-1}	Methane oxidation, ng $\bullet$ g^{-1} $\bullet$ h^{-1}	CH_4 in soil, ppm	CH_4 emissions, mg $\bullet$ m^{-2} $\bullet$ h^{-1}	CH_4 in the atmosphere, ppm	CH_4 at the 2m height, ppm
Gleysols	0,13±0,06	19,7±7,3	10,3	0,1	3	2,6
Albeluvisol	0,03±0,01	4,6±1,9	2,6	0,0	2,3	2,5
Fluvisols	0,02±0,00	6,4±4,8	0,3±0,1	0,0	0,4±0,2	-
Tecnosols Spolic	0,07	0,0	2871,5	-2,9	64,9	2,6
Tecnosols Humic Gleyic	0,04	1,8	593,6	0	2,3	2,5
Tecnosols Humin (automorphic)	0,04	0,0	3080,0	0,06	34,5	2,7
Regosols (automorphic)	0,03	66,7	208	-0,01	2,4	2,2
Tecnosols (automorphic)	0,1±0,02	7,3±4,9	297,9±33,1	0,24□0,0	2,7±0,1	2,6±0,04
Regosols (hydromorphic)	0,62	34,7	2,6±0,1	-0,001	2,4±0,1	2,4±0,04
Tecnosols Humic (hydromorphic)	0,01	15,7	9,8	0,0	2,7	3
Tecnosols (hydromorphic)	0,01±0,0	13,3±6,2	3,6±0,6	0,01	3,7±0,6	2,6±0,1

The unfavorable physical and mechanical properties, as well as the availability of natural and anthropogenic organic residues in piled-up grounds and processes of its decomposition led to an increase of the methanogenesis rates up to 0,62 ng$\bullet$g^{-1} per hour (in Regosols). In technogenic grounds high rates of methanogenesis are not compensated by corresponding oxidation (0,0-1,8 ng$\bullet$g^{-1} per hour), that leads to the accumulation of methane in the soil to abnormal or potentially dangerous quantities (and 3080,0 2871,5 ppm). The location in hydromorphic conditions and large amount of organic matter contributes to the creation of anaerobic conditions and increases speed of methanogenesis, but prevents bacterial methane oxidation processes (Table 2).

In the low concentrations of methane in Technosols and Regosols, the methane emission into the atmosphere is small (up to 0,1 mg•m^{-2}•h^{-1}) or completely absent (Table 2). Above the points with anomalously high concentrations of methane in Technosols (3080,0 and 2871,5 ppm) its accumulation in the atmosphere occurs and reaches 34,5 and 64,9 ppm, respectively, which is 0,5-0,9 Tentative Safe Exposure Level (TSEL). The average methane concentration in the surface layer of the atmosphere over this territory is 2,6 ppm (Table 2).

As a result of processes of methane oxidation and decomposition of ground's organic matter the formation of carbon dioxide and its accumulation in the soil and ground occur. In late-autumn period in Fflyuvisols before land use engineering CO_2 content in the soil was low and amounted to 375,0 ppm, emissions into the atmosphere gas was 16,4 mg/m2 per hour, CO_2 content in the surface atmosphere was near 157,3 ppm (Table .3). Carbon dioxide content in the soil air of Albeluvisols and Gleysols during the summer was up to 2547,0 ppm and 2959,0 ppm, respectively). Perhaps this is caused by recreational load in the researched area.

Table 3. Carbon dioxide content in soils, atmosphere and emission rate

	CO_2 in the soil, ppm	CO_2 emissions, mg•m^{-2}•h^{-1}	CO_2 in the atmosphere, ppm	CO_2 at the 2m height, ppm
Fluvisols	375,0±52,4	16,4±10,1	157,3±40,0	-
Gleysols	2959,0±0,0	152,0±0,0	1712,0±0,0	1825,0±0,0
Albeluvisol	2547,0±0,0	265,1±0,0	1632,0±0,0	1476,0±0,0
Urbic Tecnosols Spolic Gleyic	9123,0±0,0	127,7±0,0	1746,0±0,0	1580,0±0,0
Urbic Tecnosols (automorphic)	2503,1±393,4	35,6±18,3	1592,7±56,7	1734,6±155,5
Urbic Tecnosols Humic	2366,9±388,1	104,4±54,2	1654,9±50,1	1846,3±85,3
Regosols	2237,3±140,5	154,2±48,5	1602,6±42,9	1554,7±50,7

After filling the territory with piled-up grounds increased content of carbon dioxide in soil and ground (an average of 2237-9123,0 ppm) is observed. This is due to increased methane oxidation processes and oxidation of organic matter of piled-up grounds for aerobic conditions. Emission of CO2 in the atmosphere increased with its accumulation in soils and grounds. In places with abundant grass and woody vegetation in automorphic Albelyuvisols and hydromorphic Gleysols rate of carbon dioxide emission was respectively 265,1 and 152,0 mg • m^{-2} per hour, Regosols - 154,2 ± 48,5 mg • m^{-2} per hour. This can be explained by processes of respiration of roots and microorganisms. In technogenic grounds without vegetation emission's rate is lower (above 41,6 ± 15,2 and 79,8 ± 39,7 mg • m^{-2} per hour respectively). In the surface layer of atmosphere carbon dioxide content decreased by 1.7 times compared with the thickness of the soil and averaged 1681,4 ppm (Fig. 1).

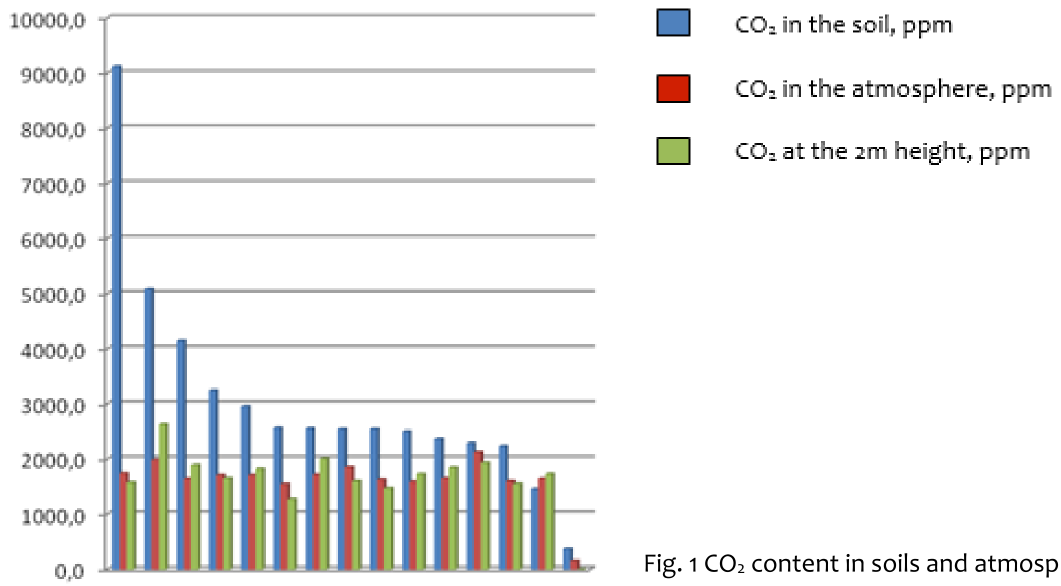

Fig. 1 CO_2 content in soils and atmosphere

Carbon dioxide emissions from soils and grounds make the definite contribution to the total fluid content in the atmosphere But it should be understood that the concentration of carbon dioxide in the atmosphere is integral and characterizes the contributions of other sources with possible large intensity.

By the criteria of risk of fire and explosion situation the methane concentration in natural soils and Regosols was at a normal level. The methane content in the atmospheric surface layer does not reach critical values. However, in the concentrations of methane in the soil near 2872 and 3080 ppm increasing of emissions and gas accumulation in the atmosphere (up to 35 and 65 ppm, respectively) is observed. This content of methane in the air is 0,5-0,9 TSEL (GBV 2.1.6.696-98).

The sanitary-hygienic criteria of CO_2 in the atmospheric surface layer is equal to 1681,4 ppm (this is 0,4 MPC hygienic regulations) (GN 2.2.686-98). Unfavorable for the life of people and animals the carbon dioxide concentration in the surface atmosphere is 800 ppm (0,2 MPC) (Robertson, 2008).

Conclusion

- As a result of land use engineering for construction natural hydromorphic soils were covered with organogenic and mineral grounds, which served as the parent rocks for Technosols and Regosols.
- Availability of peat-humus fragments, organic waste disposal, high density, low specific surface area of piled-up grounds under flooding conditions contribute to the creation of anaerobic conditions, which causes intensive processes of methanogenesis.
- In natural soils high rate of bacterial methane formation is compensated by respective bacterial oxidation, preventing the accumulation of methane in the soil and atmosphere. In technogenic grounds the ecological functions of soil are not realized - high intensity of methanogenesis is not provided by methane oxidation, that leads to the accumulation of methane in the soil, ground and atmosphere.
- According to the criteria of risk of fire and explosion situation methane content in natural soils and Regosols is at a normal level. In Technosols methane concentration reaches potentially dangerous and abnormal values. There is an increasing of methane concentrations in the atmosphere to 0,5-0,9 TEL inder its potential dangerous concentrations in soil.
- The processes of methane oxidation and oxidation of organic substances in piled-up grounds under aerobical conditions result in accumulation of carbon dioxide in the soil in an average of 3000 ppm. Gas emissions from soils and soil make the definite contribution to the total fluid content in the atmosphere

References

Vadyunina AF Korchagina ZA Methods of study of the physical properties of soils. - M. Agropromizdat, 1986. – 146p.

GBV 2.1.6.696-98 Exposure Limits (WEL) of pollutants in the air of residential areas. Hygienic standards

GBV 2.2.5.686-98 Maximum allowable concentration (MAC) of harmful substances in the air of the working area. Hygienic standards

GN 2.2.5.1313-03 State sanitary-epidemiological rules and regulations. Chemical factors of the industrial environment.

GOST 25100-95 Grounds. Classification

Methods of Soil Microbiology and Biochemistry: Textbooks / Ed. DG Zvyagintsev. - Moscow: MGU, 1991. – 304p.

Correlative base World soil resources: a framework for international classification and correlation of soil. Moscow: KMK. 2007. 278p.

Robertson DS Ecological Bulletin Russia: "The negative impact of rising levels of carbon dioxide in the atmosphere on the human body" / / Moscow: Moscow - 9/2008. P.23-25

Rulebook. Urbanism. Planning and construction of urban and rural settlements, 2011

Terpelets VI, VN Slyusarev Teaching manual for the study of agro and agro-chemical methods of soil investigation. - Krasnodar Univ FSEIHPE KubGAU 2010. – 65p.

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Effect of potassium and boron nutrition on fruit yield and quality in greenhouse tomato in hydroponic culture

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Abstract

The effect of different levels of potassium (125, 250 and 375 mg/l) and boron (0.5, 1.0, 1.5 and 2.0) on tomato yield and quality were investigated in perlit culture using a factorial randomized design with three replications. Different potassium levels had no significant effect on tomato yield and yield components. The effects of potassium levels were significant on Brix, Ec and pH value of fruit juice. The effects of boron levels were significant on tomato yield, yield components, Brix, Ec and pH value of fruit juice. The interactive effects of potassium and boron levels were significant on all measured parameters. The greatest and the least tomato yield, fruit size, fruit number and Brix value of fruit juice were obtained from K250B1.0 and K375B2.0 treatments, respectively. The highest and the lowest Ec value of fruit juice were observed in K375B2.0 and K125B0.5 treatments, respectively. The greatest and the least tomato Ec value of fruit juice were observed in K125B0.5 and K375B2.0 treatments, respectively.

Keywords: Hydroponic culture, Boron, Potassium, Tomato

Introduction

Tomato is produced all over the country and cultivated during the cool season. At present, tomatoes rank third, next to potatoes and sweet potatoes, in terms of global vegetable production. It is the most consumable vegetable crop. Since balance of plant nutrients in growth medium is a fundamental factor in crop production, determination of optimum level of each plant nutrient in hydroponic systems in of great importance. Potassium is the most prominent inorganic plant solute and is the only mineral nutrient that is not a constituent of organic structures. Its function is mainly in osmoregulation, the maintenance of electrochemical equilibrium in cells and its compartments and the regulation of enzyme activities. It is necessary for the translocation of sugars and formation of carbohydrates (Imas). Melton and Dufault (1991) found that K did not significantly influence any of the growth variables of tomato plants (fresh shoot weight, stem diameter, leaf area, shoot and root dry weights). Boron is one of the important micronutrient among essential elements for plant growth, and plays a significant role in the physiological and biochemical processes within plants (Tariq and Mott, 2007). The requirements of B in vegetables generally more than other crops. Application of different levels of B influenced the growth and yield in different crops also reported by Quaggio and Ranos (2001) in potato, Efkar et al (1999) in potato and Sohel et al(2005) in broccoli. Therefore, an

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attempt was made to study the effect of potassium and boron nutrition on fruit yield and quality in greenhouse tomato in hydroponic culture.

Material and Methods

To study the simple and interactive effects of three levels of potassium(125, 250 and 375 mg K/ liter) and four levels of boron (0.5, 1.0, 1.5, 2.0 mg B/ liter) on tomato yield, yield components (fruit size, fruit number) and quality a factorial pot experiment with 12 treatments was conducted using a completely randomized design and three replications. The experiment was performed in greenhouse of Zanjan agricultural college in 2008. The treatments were prepared with the addition of K_2SO_4 and H_3BO_3 to the base nutrient solutions. All fruit s were harvested at commercial maturity. Fruit quality was determined by measuring Brix, EC and pH value of fruit juice.

Results and Discussion

Effect of K: The effects of K levels were not significant on tomato yield and yield components. The results agreed partially with the findings of Balliu and Ibro (200). The effects of K levels were significant on Brix, EC and pH value of fruit juice. The highest Brix value of fruit juice was obtained from the application of 250 mg K/liter. Increasing the potassium levels increased the EC value of fruit juice but it decreased the pH value of fruit juice (table 1).

Table 1: Effect of levels K on tomato yield, yield components and Brix, EC and pH value of fruit juice

K levels (mg/liter)	Ec (ds/m)	Brix (%)	pH	Diameter fruit (CM)	Number fruit	yield (gr)
K125	6/544 B	8/694 A	4/292 A	3/566 A	10/92 A	811/3A
K250	6/691 AB	9/05 A	4/209 AB	3/531 A	11/29 A	819/7A
K375	6/939 A	8/152 B	4/151 B	3/513 A	10/79 A	804/8A

Effect of B: The effects of B levels were significant on tomato yield, yield components (fruit size, fruit number) and Brix, EC and pH value of fruit juice. The highest yield, fruit size, fruit number and Brix value of fruit juice were obtained from the application of 1.0 mg B/liter. Increase in the boron levels resulted in a significant increase in the EC value of fruit juice but the pH value of fruit juice decreased as the boron levels increased (table 2). The results are in partial agreement with the findings of Tariq and Mott (2007) and Alam (2007).

Table2: Effect of levels B on tomato yield, yield components and Brix, EC and pH value of fruit juice

B levels (mg/liter)	Ec (ds/m)	Brix) % (	pH	Diameter frui (CM)	Number fruit	yield (gr)
B0.5	6/215 D	8/800 A	4/304 A	3/559 AB	11/11 B	862/5 A
B1.0	6/552 C	8/839 A	4/200 B	3/638 A	12/42 A	886/3A
B1.5	6/894 B	8/494 AB	4/193 B	3/52 AB	10/89 B	760/9B
B2.0	7/238 A	8/394 B	4/172 B	3/428 B	9/58 C	737/9B

Interactive effects of K and B: The Interactive effects of K and B levels were significant on all measured parameters. The greatest and the least tomato yield, fruit size, fruit number and Brix value of fruit juice were obtained from $K_{250}B_{1.0}$ and $K_{375}B_{2.0}$ treatments, respectively. The highest and the lowest the EC value of fruit juice were observed in $K_{375}B_{2.0}$ and $K_{125}B_{0.5}$treatments, respectively. The highest and the lowest the pH value of fruit juice were observed in $K_{125}B_{0.5}$ and $K_{375}B_{2.0}$treatments, respectively.

References

1. Alam, M. N. 2007. Effect of boron levels on Growth and yield of cabbage in calcareous soil of Bangladesh. Journal of Agriculture and Biological Sciences. 3(6): 858-865.
2. Balliu, A. and V. Ibro. 2002. Influence of different levels of potassium fertilizers growth, yield and ascorbic acid content of tomato fruit growth in non-heated greenhouse. ISHS Acta Horticulture 579.
3. Imas, P. 1999. Quality aspect of K nutrition in horticultural crops. Proceeding of the IPI-PRI-KKV workshop on: Recent Trends in Nutrition Management in Horticultural Crops.
4. Melton, R. R. and R. J. Dufault. 1991. Nitrogen, phosphorus, and potassium fertility regimes affect tomato transplant growth. Horticultural Science. 26(2): 141-142.
5. Tariq M., and C. J. B. Mott. 2007. Effect of Boron sopplt on the uptake of micronutrients by radish. J. Agricultrual and Biological science. 1 (2).

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Effect of levels of supplementary nitrogen and potassium in nutrient solution on growth and yield of tomato

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Abstract

A completely randomized factorial experiment was set up with 12 treatments and three replicates to study the effect of nitrogen and potassium on tomato yield and growth parameters of tomato plant (Shoot and root dry weights, plant height and mean area of leaf) in hydroponically grown tomato in greenhouse of agricultural college of Zanjan University in 2008. In this experiment, tomato speed of RioGrand ug was selected and simple and interaction effect of four levels of N (100, 200, 300 and 400 mg/l) and three levels of K (125, 250 and 375 mg/l) on tomato yield, the growth parameters of tomato plant was investigated. The results of this experiment showed that the effects of nitrogen levels were significant on all measured parameters. The effects of potassium levels were not significant on any measured parameters. The interactive effects of nitrogen and potassium levels were significant on all measured parameters. The greatest and the least tomato yield and root dry weights were obtained from N200K250 and N400K375 treatments, respectively. The highest and the lowest shoot dry weight, plant height and mean area of leaf were observed in N200K250 and N400K375 treatments, respectively.

Keywords: Nutrient solution, Yield, Growth, Tomato

Introduction

Tomato is one of the most important and popular vegetables in the world. It can be used as fresh vegetable or processed easily as a paste, sauce, powder, or as whole. Therefore, tomato is a vegetable crop of greatest importance in processing industry (Imas, 1999). The yield of the tomato varieties in the tropics is very low. Among the various factors limiting the yield of tomato, a plant nutrient is the most important one. For higher yield, adequate supply of balanced fertilizers should be needed (Imas, 1999). Fertilizers play a important role in the production of both quality and quantity of tomato. For good production, tomato plants should be provided with balanced fertilizers. Many researchers worked on the nutritional requirement of tomato. But their results were so diversified that it was very difficult to express the adequate requirements of fertilizers in the tropics (Imas, 1999). In the field, better N uptake and utilization with adequate K mean improved N use and higher yields. Crops respond to higher K levels when N is sufficient, and greater yield response to N fertilizer occurs when K is sufficient. Corn studies in Illinois and Ohio provide examples of this economically and environmentally. K plays a key role of crop quality. Potassium has a crucial role in the energy status of the

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plant, translocation and storage of assimilates. Increasing vegetative growth due to increasing potassium fertilizer levels has been reported by Gupta and Sengar (2000); Sun Hong Mei et al (2001).on tomato plant. Since balance of plant nutrients in growth medium is a fundamental factor in crop production, determination of optimum level of each plant nutrient in hydroponic systems in of great importance.

Material and Methods

To study the simple and interactive effects of four levels of nitrogen (100, 200, 300 and 400 mg N/ liter) and three levels of potassium (125, 250 and 375 mg K/ liter) on tomato yield and the growth parameters of tomato plant (shoot and root dry weights, plant height and mean area of leaf) a factorial pot experiment with 12 treatments was conducted using a completely randomized design and three replications. The experiment was performed in greenhouse of zanjan agricultural college in 2008.

Results and Discussion

Effect of N: The results of this experiment showed the effects of N levels were significant on yield and the growth parameters of tomato plant. The highest tomato yield was obtained from the application of 200 mg N/ liter and at higher N concentrations yield decreased significantly (table1). With increasing N concentration in growth medium up to 300 mg N/ liter, the growth parameters of tomato plant increased but root dry weight decreased significantly. Reports on the effect of nitrogen on tomato growth were presented by Erdal et al (2007); Rahman et al (2007); Melton and Dafault (1991).

Table 1: The effect of N levels on yield and the growth parameters of tomato plant

N levels (mg/liter)	mean area of leaf (cm^2)	plant height (cm)	root dry weight,gr	Shoot dry weight , gr	yield (gr)
N100	122/06 C	87/74 D	9/368 A	79/00 D	1106/0 A
N200	137/53 B	99/76 C	9/574 A	87/46 C	1129/0A
N300	165/00 A	120/5 A	9/111 B	104/9 A	607/9 B
N400	162/50 A	109/7 B	8/643 C	94/99 B	405/2 C

Effect of K: The effects of K levels werenot significant on yield and the growth parameters of tomato plant (table 2). Melton and Dafault (1991) found that K did not significantly influence any of the growth variables of tomato plants (plant height, leaf area, shoot and root dry weights).

Table 2: The effect ofK levels on yield and the growth parameters of tomato plant

K levels (mg/liter)	mean area of leaf (cm^2)	plant height (cm)	root dry weight,gr	Shoot dry weight , gr	yield (gr)
K125	146/60 A	104/4 A	9/181 A	91/54A	811/3A
K250	147/90 A	105/2A	9/239 A	92/30A	819/7A
K375	145/81 A	103/6 A	9/101 A	90/94A	804/8A

Interactive effects of N and K: The Interactive effects of N and K levels were significant on all measured parameters. The greatest and the least tomato yield and root dry weights were obtained from N200K250 and N400K375 treatments, respectively. The highest and the lowest shoot dry weight, plant height and mean area of leaf were observed in N200K250 and N400K375 treatments, respectively.

References

1. Erdal, I., A. Ertek, U. Senyigi, and M. A. Koyuncu. 2007. Combned effects of irrigation and nitrogen on some quality parameters of processing tomato. World J. Agri Sci. 3 (1): 57-62.
2. Gupta, C. R. and S. S. Sengar. 2000. Response of tomato (Lycopersicon esculentum Mill.) to nitrogen and potassium fertilization in acidic soil of Buster. Vegetable Sci. 27(1): 94-95.
3. Imas, P. 1999. Quality aspect of K nutrition in horticultural crops. Proceeding of the IPI-PRI-KKV workshop on: Recent Trends in Nutrition Management in Horticultural Crops.
4. Melton, R. R. and R. J. Dufault. 1991. Nitrogen, phosphorus, and potassium fertility regimes affect tomato transplant growth. Horticultural Science. 26(2): 141-142.
5. Rahman , M. J., A. T. Mondol, M. A. I. Rahman, M. N. Bgume, R. A., and Alam, M. K. 2007. Effect of irrigation and nitrogen on tomato yield in the grey terraces soil of Bangladesh. J. soil. Natur. 1(3): 01-04.

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The manifestation of the land degradation in the Irkutsk region at conditions of the anthropogenesis

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Abstract

This paper discusses the problem of the soil degradation in the Irkutsk region. These problems are still unresolved. The analysis of the current ecological status of soils of the area, the literature review and our own material are present. The influence of the regional characteristics of soils on the degree of development of negative processes and their consequences is highlighted. The main factors of the negative human impacts on the soil and agricultural lands are revealed. The soil erosion, soil compaction, the pollution by chemicals and oil products, acidification of the environment, reducing the content of organic matter in soils, which lead to the depletion of soil fertility cause the greatest preoccupation in the Irkutsk region among the processes that cause soil degradation.

Keywords: Soil, factors of soil formation, processes of soil degradation

Introduction

Stability of the Baikal region is defined - and still will be long defined, natural and-resource potential, among which: large stocks of available useful mineral deposits; significant wood, water and biological resources; unique object of a world heritage, an enormous source of fresh water - lake Baikal. One of the unique natural resources which has a lot of specific differences from all other resources is the soil. The major characteristic of the soils, from the point of view of their use in agriculture, is fertility. Owing to fertility soil becomes irreplaceable natural resource. Today capacity of soil to restore and support the development of a life has appeared not boundless. The most significant and unexpected changes for residents of region have occurred and are occurring as a result of degradation of soils. The erosion of soils, sealing of soils, pollution by chemicals and petrochemicals, acidification of environments, decrease in a content of organic substances in soils which lead to a depletion of soil fertility cause the greatest trouble in Irkutsk region among the processes causing degradation of soils.

Goals of the work are focusing of the attention to uniqueness of soil resources, irretrievability of their natural riches providing competitive advantages and stable progress of region; proving an indispensability of protection of soils in modern conditions.

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Material and Methods

The analysis of a soil conditions of Irkutsk region is conducted for inclusion in "National program of actions on struggle against desertification and degradation of soils" developed by the Ministry of nature and ecology of the Russian Federation.

Results and Discussion

The soils of region are characterized with sharply expressed regionality. The actions conducted on the soils of European Russia and other Siberian regions directed on increase of soil fertility can't give a positive effect on soils of Irkutsk region always. It is connected with features of soils of region. Our soils have different history of progress of soils, different combination of modern and ancient factors of soil formation. The consequence of these all is different composition of properties of soil capability (Vorobyova et al, 2010).

The greater length of the region from the south to the north defines significant changes of horizontal zonality. The variations of climatic conditions, influence of an exposition, meridian, arid mountain horizontal zonality are shown in region. The frozen ground, heterogeneity of soil-forming solids, complex evolution, their change as a result of anthropogenous influence of soils play an essential role. The long-term frozen ground in soils, buried humic horizon, second (relict) humic horizon, solothization and salting of soils are appeared. The presence of the buried humic horizon in soils is a consequence of Pleistocene-and-Holocene cryogenesis, the subsequent formation of hummock-and-cathole microrelief, its anthropogenous transformation in spotty detrital-hummock-and-cathole microstructure.

The second humic horizon in wood soils is considered as the result of degradation olden wide humic horizon of meadow-steppe soil at replacement in Holocene steppe vegetation by taiga. The territory is characterized with small polygonal jointing testifying about modern cryogenic processes (Kuzmin et al, 2002).

In Irkutsk region degradation of soils and as consequence their desertification is shown practically everywhere.

The reasons of that are negative for growth of plants agrochemical and physical and chemical properties of soils and lands of agricultural purpose. Degradation appears as a result of change of climatic conditions, unbalanced economic use of lands, activity of the industrial enterprises, as well as due to natural soil-and-lithological factors, including the salting of soils and waters, close stratification of the salted solids, easy granulometric structure of soil and agricultural land uses. The important aspect of activization of negative processes becomes cutting down of woods which leads to increase of albedo, to reduction of leaking a moisture in ground, to strengthening of erosive processes in territory at Angara river. Let's consider principal causes of soil degradation.

Erosion of soils. The first information about washed off and out arable lands and occurrence of deposits in Irkutsk province had appeared in 1888. The part of the fresh arable land which are cleared away from wood on southern slopes, almost entirely was destroyed by downpours and spring streams in northern volosts of Nizhneudinsk and Balagansk districts in 1923. The development of erosive and deflationary processes and Irkutsk agricultural college in 1966, in Irkutsk region was studied by Irkutsk state university in 1978. The inventory of soils broken by erosion-and-deflationary processes was carried out by Irkutsk branch of East Siberian Scientific-Research and Design Institute of Land Management (Parshikov, 1967). Generalization of all scientific and statistical information existing in the region, geographical analysis of prevalence of erosion and a deflation of soils in territory at Angara river have been carried out by Sh.D. Hismatulin (2000).

Researchers from the Institute of Geography of the Russian Academy of Sciences calculated the degree of potential erosion risk in forest area, which can manifest itself in a felling coupe, eradicating and plowed areas (Ishmuratov et al, 2000).

It is possible to judge displays of erosive process in territory of Irkutsk area according to the materials published earlier. Three types of erosion are water, wind (deflation) and joint (water and wind). The share of soils broken by water erosion fall at 33-35 %, share of wind erosion is 52-53 %, share of joint erosion is 13-14 %. These figures vary greatly in several areas.

Deflation processes dominate in Alarsky, Ekhirit-Bulagatsky, Bayandaevsky and Nukutsky districts. So, 53 - 73% of this area falls at eroded land, with the share of lands damaged by water erosion is 23-30%, and joint manifestations of planar washout and deflation are according to 15-18%.

On the contrary processes of water erosion prevail in Bohansky district. It is up to 60 %. The share of deflated land decreases up to 25 %. Joint manifestation of water erosion and a deflation is about 17 %. Processes of water and wind erosion are shown in relatively same identical proportion (40-45 %) in Osinsky district.

Meanwhile, Osinsky district concerns to territory from strong potential danger of water-and-wind erosion according to character of a relief, a bias of a surface, granulometric composition of soils, presence or absence of a long-term frozen ground in lands. All administrative districts of Irkutsk area are subjected with erosion practically. These districts are Presayansky (Tulunsky, Kuitunsky, Ziminsky, Zalarinsky, Cheremkhovsky, Usolye-Siberian, Irkutsk); 2) At lake Baikal (Olkhonsky); 3) at Angara river (Bratsky, Ust-Udinsky). The level of erosional feature of agricultural land uses in Bratsky, Tulunsky, Ust-Ilimsky and Olkhonsky districts makes 47 % from the area of the agricultural grounds (Ishmuratov et al, 2000). The agricultural lands of region are most strongly subjected to negative processes. Regular researches on estimation of erosion and deflation of soil are not realized now. Lands of the northern territories of Irkutsk region are not studied practically.

Saltings of soil. The inventory information says that region had 77 000 ha of salted soils of agricultural land uses in 1980 and 100,2 of ones in 1990. The information about square of the salted lands on districts is not present or significantly differs because of ambiguity of completeness of the accountence. Scientific researches about processes of soil salting at an irrigation as well as the ways of desalination of soils were conducted at Irkutsk state university (Karnaukhov et al, 1974).

It is established, that at an irrigation irkutsk black soils are salted, they lose structure and form subsidences. It is offered to irrigate by method of overhead irrigation in autumn and for warming of soils and accelerations of germination of grasses in the spring for accumulation of a moisture and thermal amelioration. Now amelioration of soils practically is not realized.

Observable processes of aridization of climate in the Baikal region (degradation of a frozen ground, measurement of hydrological and hydro-geological modes, an increase of quantity of dusty storms) tend to increase the areas of salted soils, to occurrence "salty" tornados. The regular researches of salt structure of soils, the control and recultivation of the salted soils are necessary in the region.

Bogging and flooding of soils. We have no yet the information about the sizes of soils flooding in the region. There are data of 1985 and 1990 of a department of land tenure and land management about quantity of boggy and waterlogged soils of agricultural purpose without the instruction of the reasons caused negative effects. The square of waterlogged lands of agricultural areas has made 46.1 ha. Boggy ones has made 54.8 ha. Researches of inundated and marshy soils were conducted by the senior lecture of ISU Ivanjuta L.A. (1981-1999) and now are not conducted.

Strengthening of physical influence on soil is appeared at an increase of mechanization of technological operations in field-husbandry, lea management, and truck farming and with an increase of the sizes of the cultivated land, as well as with increase of capacity and working speeds of agricultural implements.

The negative influence of the mechanized tillage of soils is connected with deterioration of physical properties of soils and as a result is connected with decrease in their fertility. The solidification can reach significant depth of all thickness of soil profile. There are individual researches in the region in which influence of tillage on physical properties of ground was studied. Investigations have appeared episodicly (2-3 years of researches). They have been concerned the soil structure and water mode.

Researches were carried out on faculty of agriculture and faculty of mechanization of Irkutsk agricultural institute in the end 60th and the beginning of 70th. Radical measures of protection of soils at solidification are not exist yet. In the mean time, it is necessary to develop diagnostics of the soil solidification for detailed soil inspections and allocation of contours of solidificated soils, to establish the control over a condition of old-arable soils. Besides at tillage it is necessary to consider characteristic feature of the territory at Baikal a hummock-and-cathole relief which researches were engaged by V.P. Parshikov, 1968 (East Siberian Scientific-Research and Design Institute of Land Management); S.A. Fillipova, 1972 (ISU); V.A. Kuzmin, 1970-2000

(Federal State budgetary Institution of Science the Institute of Geography named after V.B. Sochava of Siberian Branch of the Russian Academy of Sciences).

Pollution of soils. Researches of soils depending on an origin of pollution sources (agricultural, industrial or household) are conducted by academic institutes of the Siberian Branch of the Russian Academy of Science; establishments of the Ministry of Agriculture; High schools of city (Irkutsk state agricultural academy and Irkutsk state university) etc. Data about character of pollution and estimation of a degree of pollution are lot. But they are not systematized and not generalized. Especially sharply there is a question on soil pollution by petrochemicals. Soils in the places of disposal sites of toxic and containing radionuclides, the wastes in seats of air carry of decaying contents of city and industrial dumps, grounds near sediment bowls and industrial drains are not studied. These questions also should be considered in the program of the control and soils protection of soils and the agricultural grounds.

Recreational load. The recreational load is shown most sharply on coastal alluvium of lake Baikal and on island Olkhon. The increase of albedo, aggression of mobile sands, an increase of the square of salted soils (island Olkhon and territories at Olkhon), simplification of granulometric composition, reduction of structural properties of soil aggregates take place in connection with aridization of climate, destruction of woods. That is both consequence and the reason for the further progress of erosion and soil degradation.

Thus, soil degradation in Irkutsk region requires the system approach to studying a process of soil and lands degradation and problem solution of struggle with it. The important link in similar researches is definition of temporary variations of soil cover, estimation of criteria of desertification and establishment of their quantitative characteristics as well as the profound studying of desertification dynamics.

Conclusion

Until now processes of developments of soil degradation in Irkutsk region are poorly studied. Existing information are separated. The separate investigations (monitoring of a qualitative condition of the lands of agricultural purpose (five zones of region are explored only), there are supervision over a coastal zone of the Bratsk water basin) which have been directed on studying of a condition and an estimation of influence of those or other technogenic influences on a qualitative condition of the grounds were spent. Despite of importance of the problem solution of degradation soil for progress of an economic complex of region following questions have not solved and among them are the specific reasons of degradation of the lands are not revealed with sufficient reliability; the forecast of their progress for next decades is not developed; the scientifically-proved measures on prevention of the further progress of negative processes on protection and rational use of natural resources are not defined. Now materials of soil researches have become outdated in connection with the change of soil classification in Russia, application of new standards of the description of soil cuts and introduction of GIS-technology. Existing data on soils of region have prescription more than 30 years. Besides there is no map of modern agricultural state of agrarian resources.

The important deterrent is absent of the federal law about soil protection and special service of the accountance and the control of an ecological condition of soils. There is no regional or federal program on monitoring the grounds.

The professional approach to soil resources is necessary for restoration and increase of soil fertility of Irkutsk region. Professional approach consists of introduction of scientifically-proved systems of agriculture; application new large-scale soil maps; carrying out ecological and agroecological monitoring of the lands, ecological examination in the field of land tenure, an estimation of land-resource potential, a cadastral assessment and inventory of the grounds. In view of a specific character of land tenure of region it is necessary to turn special attention to professional trainings (Granina, 2012).

Today in conditions of an accrueing world economic crisis the ecological situation in regions and in the country as a whole becomes the most meaningful factor of progress of economy and maintenance of stable progress of a society. Capacity of the nature to restore and support progress of a life it has appeared not boundless.

References

Bychkov V.I., 1979. Allocation of erosion-meliorative fund of the Upper Angarski Krai on the basis of typification of the grounds // Ground of Irkutsk area, their use and amelioration.-Irkutsk: Institute of geography of the Siberian Branch of the Russian Academy of Science and the Far East. Pp.70-75 [in Russian].

Vorobiyova G.A., Vashukevich N.V., Kuklina S.L, 2010. Soil resources as an essential component of sustainable development strategy of Irkutsk region. № 4. http: eizvestia.isea.ru [in Russian].

Granina N.I., 2012. Land as a natural resource and object of economic management. The features of personnel training. News of Irkutsk state agricultural academy pp 34-39 [in Russian].

Ishmuratov B.M., Kalep L.L. , Hismatullin S.D., Chudnova V.I., 2000. Natural-and-economic potential of an agriculture of Irkutsk region and the concept of its progress during economic reforms. Novosibirsk: Publishing house of Institute of geography of the Siberian Branch of the Russian Academy of Science. p. 180 [in Russian].

Karnauhov N.I., Morozova K.V., 1979. Agrarian land improvements of Irkutsk region // Ground of Irkutsk region, their use and amelioration. Irkutsk: institute geography of the Siberian Branch of the Russian Academy of Science and the Far East,. pp. 113-125 [in Russian].

Kuzmin V.A., 2002. Soil-and-ekologich dividing into districts in Irkutsk region// Soil science. 12. pp. 1436–1444 [in Russian].

Kuzmin V.A., Kozlova A.A., 2012. Soils and a soil cover of Southern Baikal region in conditions of paleocryogenic microrelief. Petrozavodsk: the Karelian centre of science of the Russian Academy of Science. book. 3. pp. 174–175 [in Russian].

Khismatulin Sh.D. 1979Issues of rational use of salted soils of the Irkutsk region. Soils of Irkutsk region, their use and amelioration.-Irkutsk: Institute of Geography of the Russian Academy of Sciences and the Far East. pp.76-87 [in Russian].

Ivanyuta L.A., Ivanyuta S.I., 1988. Features of the content and distribution of manganese, copper and zinc in the peat soils of the Eastern. Soils south of Middle-Siberia. Irkutsk: Publishing house of ISU. pp. 61-70 [in Russian].

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Impact of the development the animal husbandry on the condition humus in soils of Perm Krai

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Abstract

The adopted a program developing agricultural production (2020) in Russia provides for its the further development with a priority direction animal husbandry. Industrialization of agrocomplexes and farms, wide application of fertilizers and pesticides allowed increase in the productivity agrocenoses, but worsened their ecological and safety of received production. Transition to intensive technologies in agriculture showed their active influence not only on agrocenoses, but also on the equilibrium of the entire system. Regulation of the balance of humus in the soil and extended its reproduction can be done in two ways: a) an increase in revenues in the soil organic matter (organic fertilizers, afterreap and root residues), b) the reduction of organic matter mineralization using agricultural methods. Perm Krai is located in the Western Predural'e and defined by the coordinates 56°06′-61°39′ north latitude and 51°47′-59°03′ east longitude. From the north to south the area krai extends for 600 km, from east to west in the southern part of the region – 200 km, and in the northern – 500 km. On the Krai territory secreted 6 naturally-farming districts. Earlier, the authors have conducted of agroecological assessment on the humus condition in the soils of the Perm Krai in these districts. The purpose of research is to determine the effectiveness of use of wastes animal husbandry to ensure the sufficient balance of the humus in the soil. Degree of development of territory of the region is different, that is expressed in of agricultural area and stooks cattle. Amount of agricultural lands per 1 head of cattle varies from 4.0 to 8.9 ha, at norm 2 ha. With such development of cattle breeding in the Perm Krai and the use of wastes industry has note very low saturation 1 hectares of agricultural land the organic matter (0.65-1.42 t/ha). Thus, it was found that for increasing saturation 1 hectare of plough land and 1 hectares of agricultural land is necessary to increase the number of animal husbandry, a minimum of 2 times, and increase the use of wastes animal husbandry only cattle will enhance the saturation of one hectare of plough land to 3-5 t/ha.
Keywords: humus, organic matter, soil, animal husbandry

Introduction

The adopted program of agricultural production development in Russia (till 2020) presupposes its further development with animal husbandry defined as its prioritizing direction. Meanwhile agricultural complexes and farms industrialization, mineral fertilizers and pesticides broad application allowed to increase agrocoenoses specific productivity but worsened their environmental friendliness and production safety. The transition to intensive technologies in agriculture showed their active influence not only on agrocoenoses, but on the whole system balance.

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There are two ways to regulate humus balance in soil and to produce it extensively: a) to increase organic substance (fertilizers, crop-root remains) flow into soil; b) to decrease organic substance mineralization by agricultural ways (Mydrykh, 2013, pp. 335-338; Buzmakov et al., 2003, p. 208).

For the last 25-30 years sod-podzolic agrogenic soil of Non-Black Earth Belt lost 20-30 % of organic substance. The reasons for this are as follows: fresh organic substance flow into soil decrease; intensification of organic substance mineralization as a result of intense soil treatment; cultivated crop share increase and perennial grass in field crop rotation decrease; a prolonged usage of mineral fertilizers without lime; plough-layer dilution by less humus with considerable increase of plough depth; humus isolation from the field enriched in fine soil in field work; water, wind soil erosion display (Zavyalova, 2006, p. 46-53).

The research is aimed at defining animal husbandry branch wastes usage efficiency to provide non-deficit humus balance in soil.

Material and Methods

Perm Krai is situated in Western Predural'e region and defined by 56°06′-61°39′ of northern latitude and 51°47′-59°03′ eastern longitude. From north to south the territory of the Krai stretches for 600 km, from west to east in the southern part of the Krai – for 200 km, in the northern part – for 500 km. According to natural-agricultural zoning Perm Krai territory is totally situated in boreal belt, here three natural-agricultural zones are outlined: middle taiga, south taiga, forest steppe within which natural-agricultural provinces and districts are pointed out. On the Krai territory 6 natural-agricultural areas are outlined (Table 1). Earlier the authors assessed the humus soil state of Perm Krai in the mentioned above districts (Samofalova et al., 2013, pp. 84-91).

To estimation of influence the livestock industry on the soil humus status of Perm Krai used data from reports Federal State Institution State Agrochemical Service Centre "Perm" and National Atlas of the soils of the Russian Federation (National Atlas…, 2011). Data on average-weighted humus content, land area, cattle stock of administrative districts are calculated by natural-agricultural areas.

Results and Discussion

The extent of Perm Krai territory development varies (Table 1).

Table 1. Agricultural land area in natural-agricultural areas, hectare thousand

Natural-agricultural area	Kind of land area		
	agricultural land area	plough	hayfield, pasture field
1 Northern middle taiga	2,38	2,20	0,18
2 Komi-Perm Northern-Western Southern taiga forest	56,00	48,28	7,72
3 Central-Eastern Southern taiga forest	159,94	138,05	21,89
4 Western-Southern-taiga-forest	330,72	288,41	42,32
5 Southern Southern-forest	44,85	37,06	7,79
6 Southern-Eastern forest steppe	184,08	168,72	15,36

The Western part of the Krai concentrates the most agricultural land area (42.5 % of the Krai agricultural land area), the Northern part concentrates the least agricultural land area (7.5 %). Southern-Eastern forest steppe agricultural land area (91.7 %), Western Southern-taiga-forest agricultural land area (87.2 %), Central-Eastern Southern-taiga-forest and Komi-Perm Northern-Western Southern-taiga-forest agricultural land areas (86.3 %) and Southern Southern-forest agricultural land area (82.6 %) have the most part of plough.

The maximum average-weighted humus soil content is marked in Southern Southern-forest and Southern-Eastern forest-steppe areas amounting to 4.5-4.7 %. In Central-Eastern Southern-taiga-forest area the average-weighted humus content constituted 2.9 %, in Western Southern-taiga-forest area – 2.7 %, in Komi-Perm Northern-Western Southern-taiga-forest area – 2.4 %, in Northern middle taiga area – only 1.9 %.

Analyzing average-weighted humus content we can conclude that more than 50 % of ploughs have a low rate of soil humus, 10.2 % – an average rate and only 1.9 % – a high rate (Figure 1).

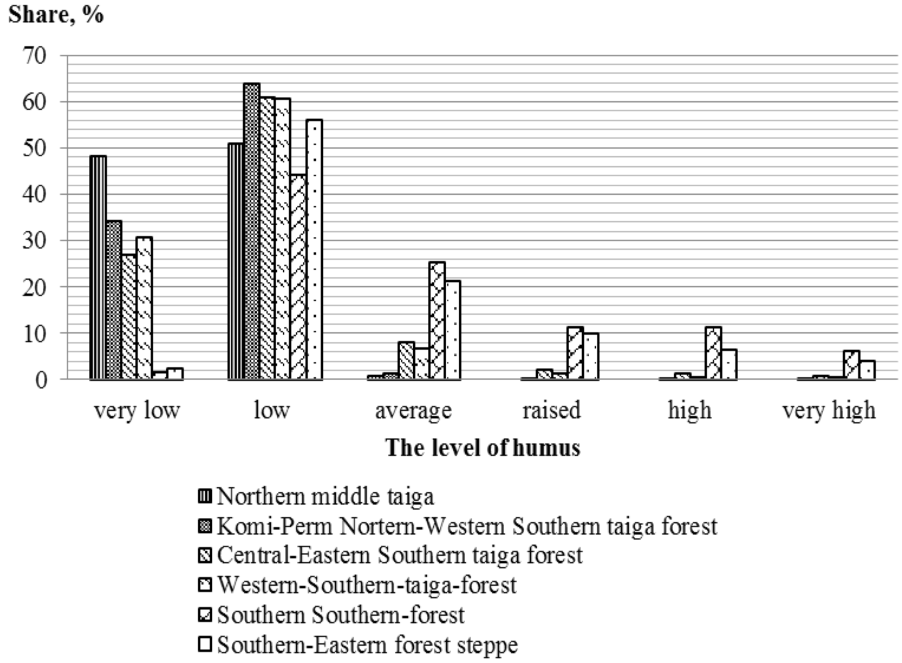

Figure 1. Degree of provision of humus in the soil in the cropland natural-agricultural areas in the Perm Krai, 2011 year

It should be mentioned that out of all considered natural-agricultural areas only Southern Southern-forest area has less than 50 % (44.2 %) soil with a low rate of humus content. This area is also marked for the maximum meaning of high humus rate soil (17.6 %) and the highest humus content of 4.7 %. In Southern-Eastern forest steppe area the considered marks constituted 56.1 %, 10.3 % and 4.5 % correspondingly.

In Northern middle taiga area all types soil are characterized by very low (48.2 %) and low (51.0 %) of humus rate. There are no high humus content types of soil in this area. It can be explained by the fact that initially in this area low-productive podzolic types of soil were formed.

Earlier the authors specified agro-climatic conditions influence on the humus formation process within Perm Krai in natural-agricultural areas and established the equation of humus content dependence on biological production index, moisture index, the number of days with the temperature of 5 °C above zero, the annual fall-out number, mm, and the total of temperatures of 10 °C above zero.

The agro-ecological assessment of Perm Krai soil humus state revealed that humus formation conditions in Perm Krai in middle-and Southern-taiga subzones mostly depends on plant biological productivity and consequently on plant type. In connection with this, we can assume that in agrocenoses perhaps worsening conditions humus formation, due to the change reduction the species diversity, as well as ploughing the soils and soil depletion. All this leads to humus content reduction in soil. To solve this problem to develop and apply effective arable farming systems with optimal usage of agro-chemical substances and biological factors of soil fertility reproduction is necessary. One of the most important ways of keeping soil fertility and raising agricultural crop rotation productivity consists in organic and mineral fertilizers and their combination usage.

To state whether agricultural areas are enriched in organic fertilizers cattle number and organic fertilizers agricultural areas saturation analysis has been conducted. The krai territory exploration rate being different, it is reflected in cattle stock, organic fertilizers stock and agricultural areas saturation (Table 2).

Table 2. Agricultural areas organic fertilizers saturation

Natural-agricultural area	Cattle stock (animals)	Organic fertilizers stock, ton thousand	Organic fertilizers saturation, ton	
			plough	agricultural area (hectare)
1	267	1,53	0,70	0,65
2	13690	78,72	1,17	0,95
3	39371	226,38	1,97	1,74
4	66205	380,68	1,29	1,12
5	8233	47,34	1,29	1,08
6	43924	252,56	1,32	1,20

The number of agricultural areas per one animal cattle has been stated to vary from 4.0 to 8.9 hectare with the norm of 2 hectare. It means that agricultural areas are used only to 37-49 % and in Northern middle taiga area – only to 22 %. Under such a level of animal husbandry development in Perm Krai and the branch wastes quantity a very low rate of one hectare of agricultural areas organic substance saturation (0.65-1.42 hectare thousand) is marked.

Having made some calculations we define the necessary quantity of cattle animals in natural-agricultural areas with 2 hectare per one animal and the possible organic fertilizers saturation rate under such conditions (Table 3).

Table 3. Optimal cattle stock number calculation in natural-agricultural areas

Natural-agricultural area	Cattle stock (animals)	Organic fertilizers stock, ton thousand	Organic fertilizers saturation, ton	
			plough	agricultural area
1	1189	6834	3,11	2,88
2	28002	161009	3,33	2,88
3	79970	459825	3,33	2,88
4	165361	950826	3,30	2,88
5	22426	128947	3,48	2,88
6	92042	529239	3,14	2,88

The calculations have revealed that in Northern middle taiga area animal cattle quantity must be 4.5 times as many than being in stock now. In Komi-Perm Northern-Western Southern-taiga-forest area this index must be increased by 2 times, in Southern-Eastern forest steppe area – by 2.1 times, in Western Southern Southern-forest – by 2.7 times. Under such cattle stock number organic fertilizers plough saturation will constitute 3.11-3.48 hectare thousand, it being 1.9-4.8 times more than under cattle stock in the areas at present.

Scientific establishments have developed the norms of organic fertilizers usage which will provide non-deficit humus balance with obligatory observation of crop rotation, advanced agricultural equipment, zone shares of mineral fertilizers for different areas, types of soil and other factors. For non-fine soil areas the shares of organic fertilizers on clay-loam soil constitute 10 hectare thousand per year, on sabulous soil – 12-15 hectare thousand per year (Zhukov et al., 88, p. 40).

At present organic substance plough saturation in natural-agricultural areas amount only to 0.70-1.97 hectare thousand which indicates a low level of animal husbandry organic wastes application. The calculations made to define the optimal cattle stock number don't provide the minimal level of organic fertilizers saturation either and constitute only 3.11-3.48 with the norm of 10-15 hectare thousand. In this connection additional sources of soil filled in with organic substance must be used. Consequently, the following measures can be proposed:

– the usage of animal husbandry branch wastes from other species of animals and birds;
– filling of blowholes the straw into the soil: in organic substance content and the influence on humus reproduction one ton of straw equals 3-4 tons of dropping mass;
– filling of blowholes the green fertilizer into the soil (legumes – lupin, peas, seradella, heading; nonlegurninous – rape, runch); for example, perennial lupin accumulates up to 20-30 hectare thousand and more of roots out of which up to 2-4 hectare thousands of fresh humus are formed;
– chalking;
– rational (minimal) soil treatment;
– anti-erosion soil protection, etc.

Conclusion

So, on the basis of the researches carried out it is concluded that for the purpose of one plough hectare and one agricultural area hectare saturation increase in Perm Krai the number of cattle stock need be raised by 2-4 times which will contribute to animal husbandry branch wastes usage going up and this in its turn will make for soil humus content improvement. Thus, the cattle stock number increase will allow raising the one plough hectare saturation with organic fertilizers with the latter providing conditions of low-productive podzolic soil humus formation process and structuring process close to optimal in Perm Krai.

References

1. Buzmakov V.V., 2003. Land use and ecology. In: A.V. Medvedev, L.G. Trushnikov. Vyatka, Moscow.
2. Mudrykh, N.M., 2012. Effect of Fertilizers on the Productivity of Crop Rotation and on Organic Matter in the Soil. In: I.A. Samofalova, A.I. Kosolapova, V.R. Yamaltdinova. 8th International Soil Science Congress on «Land Degradation and Challenges in Sustainable Soil Management», Izmir. Volume I. pp. 335-338.
3. National Atlas of the soils of the Russian Federation, 2011. In: S.A. Shoba et al. Astrel: AST, Moscow.
4. Samofalova I.A., 2008. Modern status of land resources in Perm Krai. In: N.Yu. Kamenskih, A.T. Kaigorodov. Perm Agrarian Bulletin, Perm. P.1., pp. 117-122.
5. Samofalova I.A., 2013. Humus Soil State of Perm Krai. In: N.M. Mudrykh. Research Bulletin SWorld. V. 46. № 3. pp. 84-91.
6. The Department of Agriculture and Foodstuffs of Perm Krai. Analytics. Agro-industrial Complex Development Totals of Perm Krai [Electronic Recourse]. – Access Regime: http://agro.permkrai.ru/analitics/.
7. Zavyalova N.E., 2006. Influence of methods of land use on the content of inert and active components in the composition of soil humus of Perm Krai. Perm. pp. 46-53.
8. Zhukov A.I., 1988. Humus balance regulation in soil. In: P.D. Popov. Russian Agricultural Industrial Publishing House, Moscow.

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Biological activity of sod-podzolic soils on different kinds of farmland

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Abstract

In recent decades, Russia has witnessed an annual reduction and throwing of productive lands. Stopping use of soils results in the loss or modification of some properties to their natural condition. Soil quality assessment is necessary to carry out not only by the physical, chemical and physical-chemical parameters, but also the biological activity of the soil is to be taken into account, as it allows to judge the condition of soil fertility. The purpose of research is to determine the influence of type of agricultural land use on the biological activity of sod-podzolic heavy loamy soils. Investigations were carried out on different kinds of land: the ploughland (45 years), fallow land (15 years). Analysis of soil samples showed that the sod-podzolic soil on different kinds of agricultural land had almost identical conditions of the physical-chemical parameters. Cellulolytic activity and nitrification power were defined for soils of different agricultural land use. The intensity of the nitrification process in the investigated soils of the plough land and of the fallow land was low and amounted 0.8-1.4 mg N-NO_3/kg of soil. The lowest nitrification power marked at the fallow land, where the conditions for the activity of nitrifying bacteria are less favorable because of lack of oxygen and very low content of organic matter in the soil. Change of use type of agricultural land led to a decrease process of cellulose decomposition in soils. So, the activity of cellulolytic microorganisms on the plough land and fallow land amounted 29.87 and 18.01%, respectively. Thus, the cellulolytic activity of the soil at the different kinds of land is weak on the intensity scale destruction cellulose proposed by D.S. Zvyagintsev. The lowest activity of cellulolytic microorganisms and power of nitrification was noted also in the soil of fallow land. It was established that removing the agrogenic sod-podzolic soil from active use in post-agrogenic status leads to a reduction of its biological activity. Thus, in sod-podzolic soils with very low humus content (1.4-1.9 %) agrochemical properties too little transformed due to changes of agricultural land use. Indicators of soil microbial activity are more sensitive than agrochemical. Recommendations have been given to improve the conditions of biological activity and actions to restore soil fertility.

Keywords: Plough land, fallow land, soil fertility, cellulolytic activity, nitrification power, sod-podzolic soils.

Introduction

In recent decades, Russia has witnessed an annual reduction and throwing of productive lands (Loiko et al., 2008, pp. 126-139). Perm Krai is no exception. On the territory of Perm Krai there is an annual reduction of the plough land, which is removed out of agricultural use and is gradually becoming a fallow land with different return periods (5, 10, 20 years, etc.). According to the Ministry of Agriculture and Food of Perm Krai, for the period of 2007-2010 the area of agricultural lands has reduced by 147655 ha, and by 133577 ha for the plough land (Ministry…, 2013). The reduction of these areas raises questions about the quality of soils left for plough lands and fallow lands.

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Stopping use of soils results in the loss or modification of some properties to their natural condition. The processes that predominate in virgin soils are restored, sometimes even more intensely, in post-agrogenic soils. After 15 years of self-restoration, the soils on the fallow lands don't meet the soil requirements set for productive agricultural lands (Samofalova, 2010, pp. 65-69).

The scientists of Perm Agricultural Research Institute have found out that degradation processes are taking place all over the territory of Perm Krai and if the current situation is not going to be changed, then the storage of nutrient elements in the soil will be completely depleted within 5-7 years, and that this situation will become irreversible (Samofalova et al., 2008, pp. 117-122; Popova et al., 2009, pp. 52-60).

Soil quality assessment should be carried out not only by the physical, chemical and physical-chemical parameters, but also the biological activity of the soil is to be taken into account, as it allows to judge the orientation of soil formation processes as well as the condition of soil fertility (Valkov et al., 2006, pp. 117-120). The microbiological activity of soils depends on their type, properties and agricultural use of soils. The anthropogenic impact can cause, more or less intensely, the depression of functions, performed by microorganisms, that leads to the disturbance of their activities. The microbiological activity results in the decomposition of dead biomass and the return of accumulated nutrient elements into the biological cycle. The deviation of this process can lead to the accumulation of coarse organic matter, that bonds a considerable amount of biogenic elements into a state that is unavailable to plants (Kuprevich, 1951, pp. 863-866; Samosova et al., 1976, pp. 243-244; Scherbakova, 1986, pp. 12-13 Titova et al., 2005, p. 66).

The peculiarities of sod-podzolic soils are in their acidity, marked differentiation of soil horizons, relative poverty of nutrient elements and organic matter, feebly marked structure and the presence of the inert podzolic horizon as well as in the flushing type of soil water regime that determines the low level of biological activity of this type of soils (Rybalkina, 1957, pp. 5-173; Aristovskaya, 1965; Mishustin et al., 1966; Mishustin, 1972, pp. 54-96).

Taking all of this into account, the purpose of this research is to determine the influence of agricultural land use on the biological activity of sod-podzolic heavy loamy soils.

Material and Methods

The investigations were carried out on the territory of Federal State Unity and Scientific Experimental Enterprise "Lipovaya Gora", Perm District, Perm Krai. Research subject – sod-podzolic heavy loamy soils on different kinds of land: the ploughland (45 years) – land plot 1, fallow land (15 years) – land plot 2. Soil samples were taken from elementary land plots (land plot with the area of 1 ha) to the depth of 0-20 cm. Number of soil samplings: six. The agrochemical properties of each selected sample were determined according to standard methods. The investigations of the biological activity of soils of agro lands included: the activity of cellulolytic microorganisms (placed in the Petri dish after 60 days of composting at temperature and moisture parameters optimal for the development of microorganisms) and the soil nitrification power (as per Kravkov).

The analysis of soil samples showed that the sod-podzolic soil on different kinds of agricultural land had almost identical conditions of the physical-chemical parameters. The investigated soils have very low humus content (1.42-1.90 %) regardless of type of agricultural use. It's important to mention that the humus content in the soils is close to its critical content, and if below, it is necessary to stop active use of these soils for agricultural purposes. The soils are characterized by medium soil acidity (4.9-5.0). The mineral nitrogen content is very low – 29.2-37.1 mg/kg of soil. The labile phosphorus content in the investigated soils is characterized as medium (70 mg/kg of soil) and high (162 mg/kg of soil), the potassium content is characterized as high (177-240 mg/kg of soil). Thus, the agrochemical parameters of soils of the ploughland and of the fallow land show that they are low cultivated.

Results and Discussion

The investigations determined that sod-podzolic soils are characterized by low nitrification power whereas when cultivated the number of nitrifiers, ammonifiers and their activity in such soils increases. With the rise of soil cultivation the total number of microorganisms also increases that leads to further rearrangement of soil composition. The biochemical parameters of soils are changed as well that results in increase in soil fertility

(Mishustin et al., 1966, pp. 54-96; Romeiko et al., 1969, pp. 67-72; Vavulo et al., 1970, pp. 205-212; Mishustin, 1972; Bobrov et al., 1973, pp. 146-150; Aristovskaya, 1975, pp. 3-4; Moiseeva, 1975).

The intensity of the nitrification process in the investigated soils of the ploughland and of the fallow land was low and amounted to 0.8-1.4 mg N-NO_3/kg of soil. The lowest nitrification power was marked at the fallow land, where the conditions for the activity of nitrifying bacteria are less favorable because of lack of oxygen and very low content of organic matter in the soil.

The researchers point out that the soil cultivation results in changes in the species composition of cellulolytic microorganisms. In aerobic conditions microorganisms of different taxonomic groups: bacteria, fungi, actinomycetes take part in cellulose decomposition. This is especially true for bacteria, which create nutrient elements for other microbes as a result of impact on carbohydrates (Rybalkina, 1958, pp. 261-270; Mishustin, 1972).

It is noted that the change of agricultural land use led to a decrease in cellulose decomposition processes in soils. The activity of cellulolytic microorganisms on the plough land and fallow land amounted to 29.87 and 18.01 %, respectively. According to the intensity scale of cellulose destruction, proposed by D.S. Zvyagintsev, the cellulolytic activity of soils on the investigated lands is weak. The lowest activity of cellulolytic microorganisms and the lowest power of nitrification were also noted in the soil of fallow lands.

Taking into account that transfer of the agrogenic sod-podzolic heavy loam soil into the post-agrogenic state led to a reduction of the biological activity of soils, measures should be taken to restore the fertility of the specified soils (Mudrykh et al., 2012, pp. 335-338; Samofalova et al., 2013, pp. 45-50).

To increase the humus content of the soil it is necessary to grow crops, which saturate soils with organic matter (clover, alfalfa, lupine), and apply organic fertilizers in doses recommended for a specific region (30-60 t/ha). The optimal reaction of soil media for growing permanent legume crops and soil microorganisms is neutral, that's why it is necessary to apply soil liming in the investigated areas, $CaCO_3$ for plough lands is amounted to 4.75 t/ha and 5.7 t/ha for fallow lands.

Conclusion

1. The agrochemical properties of sod-podzolic soils with very low humus content are only slightly transformed due to changes in their agricultural use.

2. The parameters of microbiological activity of soils are more sensitive because the removal of the agrogenic sod-podzolic soils from active use and transferring them into the post-agrogenic state led to a reduction of nitrification power and cellulolytic activity of soils.

To increase the fertility of soils on different agricultural lands it is necessary to apply soil liming, use organic fertilizers and grow crops, which saturate soils with organic matter (clover, alfalfa, lupine).

References

1. Aristovskaya T.V., 1965. Microbiology of podzolic soils. Science, Moscow-Leningrad.
2. Aristovskaya T.V., 1975. Modern criteria of quantitative assessment of role of soil microorganisms in functioning of ecosystems. Books of abstracts of the Vth Session of the All-Union Society of Microbiologists, Section: Ecology of microorganisms, 3-4.
3. Bobrov A.A., 1973. The impact of cultivation on the biological activity of sod-podzolic soils. In: Yu.G. Gelzer. The structure and functions of microbial communities in soils with different anthropogenic impacts. Naukova Dumka, Kiev, pp. 146-150.
4. Kuprevich V.F., 1951. Biological activity of the soil and methods of its determination. Report of Academy of Sciences, USSR. V. 79. № 5, pp. 863-866.
5. Loiko P.F., 2008. The improvement of legislative regulation on prevention of withdrawal of commercially valuable lands and institutional and management aspects of modern agricultural land use in Russia In: P.F. Molchanov. Agricultural state and perspectives in use of withdrawn agricultural lands in Russia. Materials of All-Russian Scientific Conference. Moscow, pp. 126-139.
6. Ministry of Agriculture and Food of Perm Krai. Analytics. The results of the development of the agricultural industry of Perm Krai [Electronic resource]. Path name: http://agro.permkrai.ru/analitics/.
7. Mishustin E.N., 1966. Microbial population of podzolic and sod-podzolic soils. In: V.A. Mirzoeva, V.A. Enikeeva.

Microbial population of soils in northern and middle parts of USSR. Sciences, Moscow, pp. 54-96.
8. Mishustin E.N., 1972. Microorganisms and productivity of farming. Sciences, Moscow.
9. Moiseeva V.K., 1975. Microbiological and biochemical processes of nitrogen transformations in sod-podzolic soils. Author's abstract. Candidate of Science in Biology. Academy of Sciences of Estonian Socialistic Republic, Tallin.
19. Mudrykh N.M., 2012. Effect of Fertilizers on the Productivity of Crop Rotation and on Organic Matter in the Soil. In: I.A. Samofalova, A.I. Kosolapova, V.R. Yamaltdinova. 8th International Soil Science Congress on «Land Degradation and Challenges in Sustainable Soil Management», Izmir. V. I., 335-338.
10. Popova S.I., 2009. Optimal land use structure – the basis of modern farming in Perm Krai. In: A.I. Kosolapova, V.A. Voloshin, N.E. Zavyalova. Modern aspects of sustainable agricultural landscape design and resource-saving technologies in agricultural industry of North-Eastern region of European part of Russia. Materials of Scientific and Practical Conference dedicated to the 95th Anniversary of Perm Agricultural Research Institute. Perm, pp. 52-60.
11. Romeiko I.N., 1969. Biological activity of the soil as the ratio of its fertility. In: E.K. Dubovenko. Ways to improve soil fertility. Kiev, pp. 67-72.
12. Rybalkina A.V., 1957. Microbial population of tundra podzolic and chernozem soils. Microbial population of soils in the European part of USSR. Academy of Sciences Press, USSR, Moscow, pp. 5-173.
13. Rybalkina A.V., 1958. Microbiological characteristics of the soil on some crop rotation fields of Dmitrovskiy state variety test plot № 93 In: E.V. Kononenko. Fertility of sod-podzolic soils. Academy of Sciences Press, USSR, Moscow, pp. 261-270.
20. Samofalova I.A., 2008. Modern status of land resources in Perm Krai. In: N.Yu. Kamenskih, A.T. Kaigorodov. Perm Agrarian Bulletin, Perm. P.1., pp. 117-122.
14. Samofalova I.A., 2010. Agricultural assessment of anthropogenic ally changed virgin and sod-podzolic soils. Materials of Scientific and Practical Conference "The innovative development of the agricultural industry – scientific support", dedicated to the 80th Anniversary of Perm State Agricultural Academy. Perm, pp. 65-69.
15. Samofalova I.A., 2013. Agro ecological typification of lands as the basis for improvement of land regulation, crop rotation and fertilizer systems. In: N.M. Mudrykh, N.Yu. Kamenskih, Yu.A. Lobanova. Bulletin of Altai State Agrarian University. 5(103), pp. 45-50.
16. Samosova S.M., 1976.The study of the soil state on the basis of its enzymic activity. In: V.I. Filchenkova, G.Kh. Musikhina and others. Biological diagnostics of soils. Science, Moscow, pp. 243-244.
21. Scherbakova T.A., 1986. Enzymic activity and fertility of the soil. Abstract of the III All-Union Conference "Microorganism in Agriculture". Moscow State University, Moscow, pp. 12-13.
22. Titova V.I., 2005. Workshop on agroecology. In: E.V. Dabakhova, M.V. Dabakhova. Volga-Vyatka Academy of Civil Service Press, Nizhny Novgorod.
17. Valkov V.F., 2006. Soil Sciences. In: K.Sh. Kazeev, S.I. Kolesnikov. Publishing Center Mart, Moscow, pp. 117-120.
18. Vavulo F.P., 1970. The connection between the nitrification and the fertility of sod-podzolic soils. In: L.A. Karyagina. Physiology and Biochemistry of microorganisms. Science and technology, Minsk, pp. 205-212.

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Environmental impact of fluoride around the aluminum factory in Seydişehir-Turkey: An overview

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Abstract

The main objective of this study is to review the studies on fluoride distribution of the soils and the industrial fluorosis due to the atmospheric emissions of Etibank Seydişehir Aluminum Factory and to create environmental awareness on the subject. Aluminum is produced by electrolysis of aluminum oxide in molten cryolite. The cryolite containing about 50% fluoride is added to lower the melting point of alumina. Particulate and gaseous fluorides are emitted from the smelter to the environment. Water and acid soluble fluoride determinations were carried on soil samples collected at depths of 0-5 cm and 5-15 cm, at 30 different direction sites located in a radius of five kilometers around the Al smelter. Water soluble fluorides were lower than acid soluble ones. Water and acid soluble soil fluorides for the both depths decreased with distance from the source. Prevailing wind (NW-SE) was thought to be effective on the distribution of fluoride in the soils. It was concluded that Etibank Seydişehir Aluminum Factory has affected the accumulation and distribution of soil fluorides by increasing the general fluoride content of nearby soils. Researchers from the Veterinary Medicine Faculty of Ankara University indicated industrial fluorosis due to the high levels of F- in sheep urine samples collected around the factory. The factory should employ some pollution alleviating measures such as modernization, renovation and updating some facilities like replacement of Soderberg smelters by brebake smelters immediately. Air, soil and forage fluoride levels should also be monitored regularly around the factory, in agricultural and grazing areas to evaluate any environmental problems.

Keywords: Fluoride, Aluminum Factory, Soil, Plant, Seydişehir, Turkey

Introduction

Public interest in the fluoride content of diverse components of the environment has begun about a century ago. As an abundant component of earth's crust, fluoride is present in most living and nonliving matters. The particular chemical properties of fluoride and its compounds result in its accumulation in certain tissues and organs, such as bones and teeth of humans and animals or the foliage of plants. The major known role of fluoride in health is its beneficial effect on dental care. High levels of fluoride intake of humans and animals, cause fluorosis (bone disease) and mottling of teeth. And the margin between safe and toxic levels particularly in animals is relatively narrow. Consequently, monitoring and public disclosure of fluoride content of the following are needed to evaluate the potential environmental problems and to establish and enforce standards; ambient air, plant and animal tissues, soil, potable and natural waters, food and beverages (WHO,

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1970), (Edmunds and Smedley, 2004). High fluoride water problems and health aspects in Turkey were reviewed in detail by Oruc (2008).

Fluoride in soils: Fluoride is widely distributed in nature and is a common constituent of most soils and rocks. It occurs chiefly as fluorapatite $Ca_{10}(PO_4)_6F_2$, fluorspar (CaF_2), cryolite (Na_3AlF_6) and in combination with silicates as topaz, tourmaline and micas. In soils fluorides is mainly derived from these minerals and usually has a concentration between 20 and 500 ppm (Robinson and Edgington, 1946), (Fleischer et al. 1974). Total F^- contents of the fifteen Turkish surface soil samples ranged between 72 and 707 ppm with median value of 313 ppm (Oruc and Sağlam, 1980).

Oruc (1977) examined the effects of water-borne F^- on the F^- content of soils and plants in Eastern Turkey where endemic fluorosis was observed. It was reported that the water soluble F^- levels of the soil samples collected from contaminated areas and control sites ranged from 1.64 to 13.74 ppm (median=12) and from 0.05 to 0.54 ppm (median=0.15), respectively. A significant positive correlation (r=0.66, p=0.05) was also found between water soluble F^- levels of soil and plant samples.

The natural fluoride concentrations in soils are usually harmless to most plants and animals. However, agricultural soils may become contaminated with excessive fluorides via air and water pollution from the production of aluminum, phosphoric fertilizers, bricks, ceramics and various other industries. Airborne fluorides may affect agriculture in several ways. Plants can cumulate fluoride directly from atmosphere, which may in turn cause visible injury, damage to fruits and yield changes. Excessive dietary fluoride also can have a serious impact on farm animals. Discoloration, weakening and disintegration of the teeth, lameness and swelling and stiffness of the joints are symptoms often ascribed as fluoride toxicities. Normally, cattle receive small amounts of F^- in the total diet, mostly in forage and minerals supplements. However, the presence of an airborne source can increase F^- contents in forage by as much as ten times the normal level and pose a threat to the livestock's health. Vegetation growing in areas free from F^- air pollution generally contains 10 ppm or less F^- in the foliage, indicating that the most plants are poor accumulators of soil fluorides (Suttie, 1969).

Fluoride distrubition around the aluminum factories: Aluminium is produced by electrolysis of alumina in molten cryolite in the factory. The cryolite (Na3AlF6) containing about 50% fluoride is added to lower the melting point of alumina. Particulate and gaseous fluorides are emitted from factory to the environment. The content and distribution of F^- in soils around aluminium plants has been investigated by several researchers in the last decades. Israel (1974) indicated a strong correlation between F^- levels in surface soils and forages near an alumina reduction facility in Maryland. McClenahan (1976) studied the effects of a major source of airborne fluorides on the geographical distribution of total F^- in soils. He indicated that total soil fluoride increased with depth at low F^- impact sites but decreased with depth high impact sites. Total soil fluorides for all depths decreased with distance from the F^- source. The wind effect was also found to be important on the distribution of total soil fluorides. Hocking et al.(1980) indicated that water, dilute acid (0.1M HCl) and total soil fluoride levels of the surface soils were generally higher in close proximity to the aluminum smelter and gradually decreased with increased distance from the source in Canada. Prevailing wind direction and velocities were also found to be effective on the distribution of the fluorides. Fluoride distribution in soils of the vicinity of an alumina production plant in Greece was studied by Haidouti (1991). He reported that total soil fluoride decreased with depth at high impact sites, but increased with depth at low fluoride impact sites. The water-extractable F^- concentration increased systematically and significantly with depth at high impact areas. Total soil F^- for all depths decreased with distance from the emission source and approximated to background levels at about 20 km. Arnesen et al. (1995) investigated the fluorine pollution of soils around the vicinity of aluminum smelters in Norway. They pointed out that F^- pollution of soil and soil solution can be traced for more than 30 km from one of the pollution sources. However, effects of pollution can only be seen 3–5 km from the source surface soil samples. Increased concentrations of F^- in the soil solution could indicate that plants in areas exposed to F^- pollution may take up F^- from the soil. Pradhan et al. (1998) reviewed the studies carried on the effect of aluminum smelters on health and vegetation in detail and reported that decrease of F^- in soil was found as the distance from the plant site increased and the distribution was as follows: 200-600 ppm for ≥50m, 29-66 ppm up to 1000 m, and 5 ppm at 1600 m, and 1 ppm after 1600. It was also indicated that wind direction and its velocity play very important role on the spreading out of fluorides around the aluminum factories. Blagojević et al. (2002) studied the F^- distribution around the aluminum plant in Montenegro. They reported that total fluorine content of almost all soil samples was above 300 mg/kg – maximum permissible value for the content of this element in agricultural soils. However, the content of available F^- (soluble in water) in the soil samples was very low (average value was 0.70 mg/kg) indicating that major part of deposited F^- had transformed itself into insoluble compounds like CaF_2. Mishra et al.(2009) studied fluoride distribution originating from aluminum smelter operating since 1958, in different environmental segments at Hirakud Orissa, India. It was found that the fluoride contents (ppm) varied from a minimum of 0.5 to a maximum of 0.65 (in pond water, 0.4 - 0.60 in ground water, 88.30 - 191.20 in soil, 23.75 - 65.96 in paddy straw, 15.60 - 70.36 in grass and 10.00 - 44.60 in leaf tissue around the study area, indicating elevated levels of fluoride in soils and vegetation. Koblar et al. (2011) studied on the sudden uncontrolled release of airborne fluorides into the environment from aluminum smelter. Nettle (Urtica dioica) has been found to be a promising passive bioindicator for monitoring phytotoxic effects of fluoride in the soil on the vegetation. Good correlation between labile free fluoride in the soil and total fluoride in the nettle has been found, while total fluoride in the soil, soil pH and the dominant wind direction were also proven as important factors influencing the uptake of fluoride by the nettle.

Brougham (2011) indicated that dust deposition corresponded with aluminum production rates at the smelter showing that, despite better available technology at the smelter, modern aluminum production still impacts on the environment, even after Anglesey Aluminium Metals Ltd ended its operations in September 2009 in England.

Seydişehir aluminyum factory: Seydişehir Town is located at the southeast of Konya very near to the Taurus Mountains and the dominant wind direction is NW-SE (Sarı and İnan, 2011). Seydişehir-Konya Aluminum Plant was commissioned in 1973 and launched full capacity production in 1977 to produce 60.000 tons of aluminum per year, according to the agreement between the Etibank General Management of Turkey and former Soviet Union. There are four electrolysis units and 62 cells in each unit, totalling 248 cells. However, due to huge energy shortage, aluminum production in full capacity could not be maintained in last decades). Meeting around 15% of Turkey's aluminum demand, the factory was privatized in 2005, and the modernization processes started (Eti Aluminyum, 2014). On average, around the world it takes some 15.7 kWh of electricity to produce one kilogram of aluminium from alumina, owing to improvements in design and process that have progressively reduced this intake from about 21kWh in the 1950s. Fluoride emissions, in the form of gaseous hydrogen fluoride and sodium and aluminum fluorides and unused cryolite as particulates are the major undesirable fume components produced during the aluminum smelting process. According to the world-aluminum organization, mean F^- emission intensities are given as: Söderberg Technology=4.84kg F/t Al, Prebake+ Söderberg Technology=1.03 F/t Al, and Prebake Technology=0.68 F/t Al. Such emissions can be reduced through the use of fume control systems, operational good practice and improved technology (Source: www.world-aluminium.org.2014).

Distrubiton of soil fluorides around Seydişehir aluminium factory: Oruc and Kırımhan (1984) studied the distribution of soil fluorides due to the airborne fluorides originating from the Etibank Seydişehir Aluminum for the first time in Turkey. Water (1:10 soil: water extracts) and nitric acid soluble soil F^- determinations were made by using the fluoride selective electrode, on soil samples collected at depths of 0-5 cm and 5-15 cm, at 30 sites, within a radius of 5 km approximately around the source. Most of the sampling locations were on agricultural areas between the north and east sections of the factory. The data in Table 1 show the minimum, maximum and median, F^-, pH, and $\%CaCO_3$ values of 60 soil samples analyzed in the study.

Table 1. Minimum, Maximum and Median Water and Acid Soluble Fluoride Levels (ppm), pH and $\%CaCO_3$ (Oruc and Kırımhan,1984).

Soil Depth		Water Soluble F^-	Acid Soluble F^-	pH	$\%CaCO_3$
0-5 cm	Minimum	1.8	13.7	6.8	-
	Maximum	74.0	1250.0	8.7	25.4
	Median	4.6	21.0	8.2	4.8
5-15 cm	Minimum	1.6	12.7	6.6	-
	Maximum	39.0	412.0	8.8	26.7
	Median	3.3	18.7	9.2	3.9

Since, pH values of the soils are above 7.0 and most of the soils contain some amounts of $CaCO_3$, calcium fluoride can be considered as the form to which airborne fluoride pass into after incorporation in soils

(Blagojević et.al. 2002). Although, the formation of relatively insoluble CaF_2 is expected, the results indicated that accumulation of airborne fluoride in the soils increased the water soluble fluorides in the soils over time. Water and acid soluble fluorides for the both depths decreased with distance from the source. This strongly implies airborne source impact on fluoride distribution within soil profiles in areas close to the factory. It was also indicated that the dominant wind direction (NW-SE) and its velocity played very important role on the spreading out of fluorides around Seydişehir aluminum factory. Hence, minimum values of water and acid soluble fluorides were found in areas between south and west sector and about five km away from the source. Similar results were also indicated by several researchers (McClenahan, 1976), (Pradhan et al. 1998), (Koblar et al. 2011). Oruç and Kırımhan (1984) also determined water and acid soluble of the fluoride content of leaf samples of 15 trees (Populus and Salix ssp.) barely growing just inside the factory. The data in Table 2. gives the minimum, maximum and median floride concentrations.

Table 2. Minimum,Maximum and Median Fluoride Concentrations of the Tree Leaves Collected Inside the Factory (Oruç and Kırımhan, 1984)

Fluoride Concentrations (ppm)	
Water Soluble	Acid Soluble
Minimum: 140	Minimum : 147
Maximum: 2900	Maximum: 13500
Median: 900	Median: 7600

At the time of sampling, marginal necrosis and interveinal chlorosis as an indicators of fluoride injury were readily observed on all tree leaf samples. Very high amounts of fluoride accumulated in the leaves were obviously related to high particulate and gaseous fluoride emissions from the source. Similar results were indicated by several researchers on the fluoride pollution of soils and plants around the aluminum factories have been studied in last 50 years (Israel, 1974; Haidouti, 1991; Arnesen et al. 1995; Pradhan et al. 1998; Blagojević et al. 2002; Mishra et al. 2009; Brougham, 2011).

Fidancı et al. (1998) from Ankara University, Faculty of Veterinary Medicine have studied the fluoride contents of urine, water, plant and soil samples collected from the vicinity of Konya-Seydişehir Alumina Factory, almost 20 years after the first study of Oruc and Kırımhan (1984). As indicated in Table 3. fluoride levels (median and std) of the urine, soil and plant of the samples collected around the factory were found to be much higher than the samples taken from the control sites.

Table 3. Fluoride levels (ppm) of sheep urine, water, plant and soil samles collected from control and from Konya-Seydişehir Aluminyum Factory vicinity (Fidancı et al. 1998)

Sites	Urine	Water	Plant	Soil
Control	1.00±0.08	0.31±0.04	13.0±3.1	66.4±13.1
Al Factory	31.14±3.45	0.32±0.11	41.4±8.7	122.5±25.2

Especially, high fluoride levels of sheeps urine samples was attributed to the industrial fluorosis around the factory. It was considered that particulate and gaseous forms of fluorides emitted from the source have polluted the grazing areas around the source, due to the years of operation of the factory, since 1973. Sahoo and Ray (2004) indicated that aluminum smelter factories contribute fluoride to environment as evidenced by higher fluoride level in water, vegetation and prevalence of fluorosis in goats within 10 km radius in Orissa-India.

Conclusion

Aluminium is the second widely used metal today after iron and steel. Aluminum demand is increasing rapidly due to the increased effects of population, urbanization and socio-economic development in the world and in Turkey as well. State owned Seydişehir-Konya Aluminum Plant was commissioned in 1973, launched full capacity production in 1977 to produce 60.000 tons of aluminum per year, meeting around 15% of Turkey's aluminum demand. Etibank Aluminum factory was privatized in 2005, and the modernization processes started to increase raw aluminum production from 60.000 tons to 70.000-95.000 tons (Eti Aluminyum, 2014).

It means that more particulate and gaseous fluorides will be emitted by the factory unless appropriate control and preventive measures are taken.

So far, studies carried in 1984 and in 1998 on the fluoride levels of soil, plant and sheep urine samples collected from the vicinity of the factory found higher fluoride levels than the control sites indicating, industrial fluorosis at the Seydişehir Aluminum Factory.

Suggestions:

- It was suggested that the emission controlling systems of the factory should be effectively operated. Air, soil and forage fluoride levels should also be monitored regularly inside the factory, in agricultural and grazing areas around the factory to evaluate any environmental problems.
- The factory should also employ pollution alleviating measures such as the modernization, renovation and updating some facilities such as the replacement of Soderberg smelters by brebake smelters soon.

References

Arnesen, A.K.M., Abrahamsen,G., Sandvik,T., Krosgstad., 1995. Aluminium-smelters and fluoride pollution of soil and soil solution in Norway. Science of the Total Environment 163, 39–53

Blagojević, S., M. Jakovljević, M, Radulović, M., 2002. Content of fluorine in soils in the vicinity of aluminium plant in Podgorica. Journal of Agricultural Sciences 47, 1-8

Brougham, M., 2011. Aluminium Smelting: The Toxicity, Scale And Longevity Of Fluoride Pollution In The Environment (PhD) Thesis School of Biology, The University of Newcastle upon Tyne.

Eti Aluminyum., 2014. www.etialuminyum.org

World Health Organization, 1970. Fluorides an Human Health 5,

Edmunds, M., Smedley,P., 2004. Fluoride in Natural Waters, in Essentials of Medical Geology, Elsevier Academic Press Chapter:12, 301-330

Fleischer, M., Forbes, R.M., Harris, R.C., Krook, L., Kubota,J., 1974. Fluoride in Geochemistry and the Environment The Relation of Selected Trace Elements to Health and Disease. Part II, vol. l. National Academy of Science Publication, Washington, DC, pp. 22–25.

Haidouti, C., 1991. Fluoride distribution in soils in the vicinity of a point emission source in Greece. Geoderma 1–2, 129–138

Hocking, M.B., Hocking, D., Smith, T.A., 1980. Fluoride distribution and distribution processes about an industrial point source in a forested coastal zone. Water, Air and Soil Pollution 14, 133-157

Koblar, A., Tavcar, G., Ponikvar-Svet, M., 2011. Effects of airborne fluoride on soil and vegetation. Journal of Fluorine Chemistry 132, 755–759

McClenahan, J.R., 1976. Distribution of soil fluorides near an airborne source. Journal of Environmental Quality 5, 472-474

Mishra, P.C., Meher, K., Bhosagar, K.D., Pradhan, K., 2009. Fluoride distribution in different environmental segments at Hirakud Orissa India. African Journal of Environmental Science and Technology 3 (9), 260-264

Oruc, N., 1977. A preliminary study on the effect of water-borne fluoride o the fluoride contents of soils and plants. Seminar on problems of high fluoride waters. Cento.Sci. Prog.No: 28, June, 6-10,1977, Atatürk Üni. Erzurum, Turkey

Oruc, N., Sağlam, T., 1980 Buhar distilasyonu ve potansiyometrik yöntemle topraklarda toplam florür tayini. Tübitak VII. Bilim Kongresi, Tarım ve Ormancılık Araştırma Grubu 6-10 Ekim, Adana

Oruc, N., Kırımhan, S., 1984. A Preliminary study on the distribution of soil fluorides near an airborne fluoride source. Umwelt'84. V. Deutch-Turkishes Symposium for Umweltingenteurwessen. 11-16 June, 1984, İzmir-Turkey

Oruc N., 2008. Occurrence and problems of high fluoride waters in Turkey: an overview. Environmental Geochemistry and Health 30, 315-323.

Robinson, W.O., Edgington, C., 1946. Fluorine in Soils. Soil Science 61, 341-353

Israel, G.W., 1974. A field study of the correlation of static lime paper sampler with forage and cattle urine. Atmospheric Environment 8, 167-181.

Pradhan, J., Thakur, R.S., Das, S.N., Das, J., Rao, S.B., 1998. Effect of aluminium smelters on health and vegetation. Asian Journal of Chemistry 10(1), 1-3.

Sahoo, N., Ray, S.K., 2004. Fluorosis in goats near an aluminum smelter in Orissa. Indian Journal of Animal Science 74, 48-50.

Sarı, S., İnan, N., 2011. Seydişehir ile Beyşehir'in İklimlerinin Karşılaştırılması. Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi. 26 / 2011

Suttie, W.J., 1969. Fluoride content of commercial dairy concentrations and alfalfa forage. Journal of Agricultural and Food Chemistry 17, 1350-1352.

www.world-aluminium.org.2014

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Nitrogen and phosphorus contamination in some groundwater of Amik Plain (Turkey)

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Abstract

The research was aimed to determine nitrate (NO_3^-), ammonium (NH_4^+) and phosphate (PO_4^{3-}) concentration and to evaluate its pollution levels in groundwater of Amik Plain. For this purpose, a total of 42 groundwater samples were collected from drilled well in September 2012. The groundwater samples were analyzed for temperature (T), dissolved oxygen (DO), salt content (SC), nitrate (NO_3^-), ammonium (NH_4^+) and phosphate (PO_4^{3-}). In addition, descriptive statistical analyses such as minimum, maximum, mean, etc., and correlation analyses among the parameters were made. The average T, DO, SC, NO_3^-, NH_4^+ and PO_4^{3-} concentrations were determined as 23.36 °C, 2.92 mg L^{-1}, 1.46 g L^{-1}, 7.03 mg L^{-1}, 1.60 mg L^{-1} and 73.12 µg L^{-1}, respectively. The 13 of 42 groundwater samples exceeded the permissible limit of 25 °C suggesting for very high quality classes. The DO concentration in all samples found lower than the permissible limit of 8 mg L^{-1} for high quality classes. In other words, all monitored groundwater showed dissolved oxygen deficiency. In this research, NO_3^- contents of the all samples are lower than the desirable limit of 50 mg L^{-1}. In only one samples, NH_4^+ contents was higher than the permissible limit of 6.44 mg L^{-1} recommended by FAO. All the groundwater examined samples in this research were lower than $PO_4^{=}$ limits of 6130 µg L^{-1} by FAO. There was a negative correlation between NO_3^- and SC ($p<0.05$). The salt content was positively correlated with NO_3^- and NH_4^+. In addition, a positive correlation was found between NO_3^- and PO_4^{3-}. As a conclusion, there was no NO_3^-, NH_4^+ and PO_4^{3-} pollution in groundwater samples. Although temperature and salt content seemed to be problems in some of the groundwater samples, dissolved oxygen deficiency was the main problem in the all examined groundwater in Amik Plain.

Keywords: Amik plain, nitrate pollution, groundwater, phosphorus in groundwater

Introduction

Groundwater is the major source of fresh water for drinking, irrigation, and industrial uses. For its sustainable use, both the quantity and quality issues have to be addressed together (Kumari et al. 2014 a). Groundwater is the most reliable water resource, especially in arid and semi-arid regions. Groundwater quality can be affected by numerous types of human activity such as agricultural, residential district, industrial, and municipal activities (Nas and Berktay 2010). The variety and extent of groundwater chemical composition could also be influenced by natural processes such as evaporation, cation exchange, dissociation of minerals, mixing of water, rock weathering, and human activities. The geochemistry of soil and the geological history of rocks has a significant impact on the chemical contamination of groundwater. Therefore, any groundwater suitability assessment for agriculture should include their chemical composition (Narany et al. 2014).

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All over the world, wherever nitrogenous fertilizers have been used extensively to increase the agricultural productivity, high nitrate level in groundwater is evident. Often, nitrate contamination of groundwater may be also associated with point sources such as domestic sewage, industrial waste, livestock feeding operations and septic tanks, etc. Various physical, chemical, and biological processes in the soil zone and ground water determine the nitrate level in ground water (Johnsson et al. 2002).

For sustenance of agriculture, nitrogen as an essential nutrient input is commonly provided in the agricultural area by the nitrogen fertilizers such as ammonium chloride, diammonium phosphate, ammonium sulphate, calcium ammonium nitrate and urea. In addition to fertilizers, farmyard manure is also used. Due to regular and high application of nitrogen fertilizers, a blanket (non-point) source of nitrate has been created in the irrigated cropped land. It is well known that urea and ammonium fertilizers, generally used as a source of nitrogen for paddy and other crops during irrigation, is hydrolyzed by the enzyme urease, and increase the ammonium concentration (Widory et al. 2004). Higher concentration of nitrate may produce methanoglobenemia and gastric cancer (Krishnakumar et al. 2014).

Nitrate is leached into the groundwater from the unsaturated zone depending upon soil moisture status, soil texture and fertilizer management practices. Nitrate dynamics is closely related to water dynamics and its complexity in temporal and spatial scale. The processes such as mineralization–immobilization, nitrification, denitrification, and plant uptake (for the different pathways of nitrogen dynamics) are major soil transformation processes that greatly affect nitrate leaching. These reactions depend on pH, temperature, soil water content and soil biological characteristics. Release of N from biomass depends on oxic conditions, which is likely to occur in the unsaturated zone, whereas, in reducing environment, rich in denitrifying bacteria, denitrification takes place (Rao et al. 2013). Agricultural systems also contribute to excessive phosphorus (P) additions that are adversely affecting water sources worldwide (Webb et al. 2004).

In this research, nitrate (NO_3^-), ammonium (NH_4^+) and phosphate (PO_4^{3-}) concentrations of groundwater samples from Amik Plain were determined and their polluting levels were evaluated.

Material and Methods

Study Area

The study area is in the province of Hatay in the southern Turkey (35° 47'-36° 24' E; 35° 48'-36° 37' N), and has an area about 75000 ha. Amik Plain is bounded by the Nur Mountain to the west, the Syria and Reyhanlı town to the east, Antakya city and Altınözü town to the south, and Hassa and Kırıkhan towns to the north (Fig. 1).

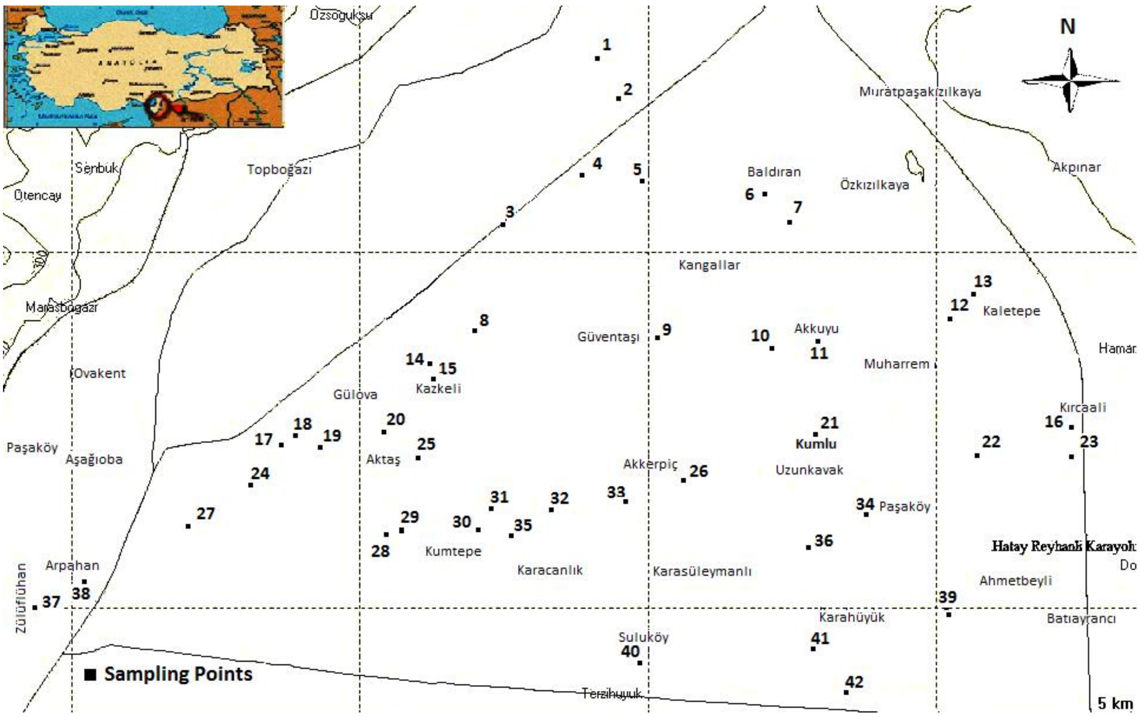

Fig. 1 Geographic location of study area and sampling points

The area has a Mediterranean climate with annual average temperature rainfall and relative humidity 18.8°C 1124 mm and 69% respectively (Gün and Erdem 2003).Parent materials of the study area consist mostly of alluviums and lacustrine. Lacustrine are relatively flat and often have parent materials with uniform properties. The alluvial soils formed by the Orontes, Afrin, and Karasu rivers are the most productive soils. The availability of irrigation water from surface or groundwater sources is a crucial factor for the growth of crops. The dominant crops consist of cotton, wheat and corn (Kılıc et al. 2008).

Water Sampling and Analyses

A total of 42 groundwater samples were collected from different drilled wells in September 2012. Wells were pumped out at least 15 min prior to the sample collection. The groundwater samples were analyzed for the temperature (T), Salt content (SC), dissolved oxygen (DO), ammonium (NH_4^+) and nitrate (NO_3^-), phosphorus (P).

The temperature, SC, DO, NH_4^+ and NO_3^- parameters were measured in situ immediately after collection samples using YSI Professional plus instrument (Pro Plus). Polythene sampling bottles of 500 mL capacity were used as sample container for phosphorus analyses. Bottles were washed with distilled water before using and collected samples acidified with concentrate HNO_3. Collected samples were transported to the laboratory within 24 h. Phosphorus was determined as molybdophosphoric blue color using ascorbic acid method (Murphy and Riley 1962) and its concentration measured using spectrophotometer (Shimadzu UVmini/1240V) at 882 nm wavelength. In addition, NO_3-N, NH_4-N and PO_4^{3-} contents calculated from NO_3^-, NH_4^+ and P values.

Statistical Analysis

Descriptive statistical analysis including mean, standard deviation, minimum and maximum concentration, median, and skewness were calculated to characterize distribution of physicochemical properties of groundwater. Correlation analysis was used to assess the possible relationships among physicochemical properties of the groundwater. The correlation coefficient (r) was used to measure the strength of relationship between two variables. All the statistical analyses were carried out using SPSS software version 17.0.

Results and Discussion

Descriptive statistics for soil characteristics and nitrogen and phosphorus are provided in Tables 1. Result shows that the highest coefficient of variation (138.7%) occurred for P (PO_4^{3-}), while the lowest (12.6%) occurred for T. Low CV values indicate a homogeneous distribution of water variables, while high CV values indicate a non-homogenous distribution of variables in the study area. For example, the mean T value in groundwater was close to that of median values, whereas mean P values were fairly different from that of median values. In other words, the range of T values was fewer variable than the range of P values in the groundwater (Table 1).

In order to assess the contamination of groundwater regarding physicochemical parameters, nitrogen and phosphate, concentrations were compared with the World Health Organization standards (WHO 2004), Classification of Turkish Water Pollution Control Regulation (TWPCR 2008) and FAO standards (Ayers and Wescot, 1994).

The temperature values in the groundwater are ranged between 18.7 (well no. 34) and 29.2 °C (well no. 12). In 31.0% of the samples, T values exceeded the permissible limit of 25 °C suggested for very high quality classes by TWPCR (2008). Dissolved oxygen (DO) is required to convert biodegradable organic matter from one form to another by living organisms mainly bacteria to maintain the metabolic process and produce energy for their growth and reproduction (Alam et al. 2012). In this study, it was found that the DO value of the groundwater samples varied from 1.57 (well no. 6) to 6.96 mg L^{-1} (well no.18). The DO concentrations in all samples were found lower than the permissible limit of 8 mg/L for high quality classes (TWPCR 2008). Kumari et al. (2014 a) found similar results in industrial areas of Ghaziabad (India).

The minimal salt content (SC) value (0.22 g L^{-1}) was determined in well no. 38 while the maximal SC (7.56 g L^{-1}) in well no.35. There was no reference value for SC. But, the groundwater which the salt contents are above 1.5 g L^{-1} may cause salinity problems in soils and may affect plant growth. 8 of 42 samples have salt contents higher than 1.5 g L^{-1}. Isa et al. (2014) found that the salinity and DO of the groundwater in Terengganu (Malaysia) are in the range 0.15 to 0.33 g L^{-1} and 1.23 to 11.08 mg L^{-1}, respectively.

Table 1. Descriptive statistics for physicochemical properties (n =42)

Parameter	Unit	Minimum	Maximum	Mean	Median	SD	*CV (%)	Skewness	Kurtosis
T	°C	18.70	29.20	23.56	22.90	2.96	12.56	0.44	-1.00
DO	mg/L	1.57	6.96	2.92	2.59	1.16	39.72	1.86	3.66
SC	g/L	0.22	7.56	1.46	1.04	1.48	101.37	2.61	7.23
NO_3^-	mg L^{-1}	1.04	42.20	7.03	4.32	8.70	123,75	3.36	11.87
NO_3-N	mg L^{-1}	0.23	9.53	1.59	0.98	1.96	123,27	3.36	11.87
NH_4^+	mg/L	0.18	6.89	1.60	0.94	1.53	95.62	1.68	2.56
NH_4-N	mg/L	0.15	5.67	1.31	0.77	1.26	96.18	1.68	2.55
P	µg/L	0.35	203.50	23.86	17.80	33.09	138.68	4.14	21.58
PO4	µg/L	1.07	623.65	73.12	54.55	101.422	138.67	4.14	21.58

*CV: Coefficient of variation

The lowest NO_3^- concentration (1.04 mg L^{-1}) has been recorded in well no. 38 while the highest NO_3^- concentration (42.20 mg L^{-1}) has been determined in wells no. 16 in the study area. None of the samples from the study area exceeded the desirable limit of 50 mg L^{-1} and 44.5 mg L^{-1} for NO_3^- recommended by WHO and FAO, respectively. Fang and Ding (2010), Alam et al. (2012) and Krishnakumar et al. (2014) found similar results with our findings. On the other hand, in the research by Dar et al. (2010) in Kashmir (India), nitrate concentrations in 85% of wells during summer exceed the permissible limit recommended by WHO. Kumari et al. (2014 b) found that nitrate level was above the permissible limits suggested by WHO at many of the locations in Northern Gujarat (India).

The NO_3-N values in the groundwater are changed between 0.23 mg L^{-1} (in well no. 38) and 9.53 mg L^{-1} (well no. 16). In all water samples, The NO_3-N values are lower than the maximum recommended concentration for irrigation water of 10 mg L^{-1} NO_3-N proposed by Ayers and Westcot (1994).

The NH_4^+ values in groundwater ranged from 0.18 mg L^{-1} (well no. 36) to 6.89 mg L^{-1} (well no. 21). In only one sample, NH_4^+ content was higher than the permissible limit of 6.44 mg L^{-1} recommended by FAO. The NH_4-N in groundwater samples found between 0.15 mg L^{-1} (wells no. 36) and 5.67 mg L^{-1} (well no. 24). Only in one sample, the NH_4-N concentration is higher than

the maximum permissible limit for irrigation water of 5 mg L^{-1} NH4-N recommended by Ayers and Westcot (1994). Our results of NH_4^+ concentrations are dissimilar with results by Champidi et al. (2011) in Erasinos basin (Greece).

The P values in groundwater ranged from 0.35 µg L^{-1} (well no. 31) to 203.5 µg L^{-1} (well no. 21). It has not been established a health-based guideline water value for P in drinking water by WHO. But the Food Standards Agency (2003) determined guideline value for P in drinking water and FAO determined the maximum recommended concentration for P in irrigation water. According to the Food Standards Agency (2003) and FAO (Ayers and Westcot, 1994), PO_4-P limit are 2.2 and 2.0 mg L^{-1}, respectively. None of the groundwater samples in this research exceeded these both P limits. The reason of this situation is to be very low solubility of the phosphorus in the soil (Anonymous 1999). Our findings of phosphorus concentrations are in agreement with results by Mahmud et al. (2007) and Kumari et al. (2014 a) but disagreement with result by Memon et al. (2011) and Krishnakumar et al. (2014).

Correlation Analysis

It was found that there was a negative correlation between NO_3^- and T ($p<0.05$). The salt content was positively correlated with NO_3^- (NO_3-N) and NH_4^+ (NH_4-N). In addition, a positive correlation was found between NO_3^- and P (PO_4^{3-}) (Table 2).

Table 2. Correlation between parameters (n = 42)

	T	DO	SC	NO_3^-	NO_3-N	NH_4^+	NH_4-N	P
DO	-0.050							
SC	-0.279	-0.081						
NO_3^-	-0.354*	0.220	0.345*					
NO_3-N	-0.354*	0.220	0.345*	1.000**				
NH_4^+	-0.081	0-.052	0.355*	-0.058	-0.058			
NH_4-N	-0.081	-0.052	0.355*	-0.058	-0.058	1.000**		
P	-0.251	-0.001	-0.073	0.667**	0.667**	-0.020	-0.020	
PO_4^{3-}	-0.251	-0.001	-0.073	0.667**	0.667**	-0.020	-0.020	1.000**

Conclusion

Groundwater resources are very important in the study area, because rainfall is not sufficient in summer season. Therefore, surface and groundwater are used as the main sources of the irrigation in the research area in the summer season. Sometimes, drainage water is also used for irrigation purpose when the other sources became inadequate. In addition, the peoples who live and work in this area use well water as drinking purpose. Because of these reasons, groundwater quality is very important in Amik plain. The results indicated that there was no NO_3^-, NH_4^+ and PO_4^{3-} pollution in the groundwater of Amik Plain. Despite temperature and salt content seemed to be problems in some of the groundwater and dissolved oxygen deficiency were the main problem in the all examined groundwater in Amik Plain.

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References

Alam, M., Rais, S., Aslam, M., 2012. Hydrochemical investigation and quality assessment of ground water in rural areas of Delhi, India. Environ Earth Sci. 66, 97–110.

Anonymous, 1999. Phosphorus in Minnesota's groundwater. Minnesota pollution control agency. Groundwater monitoring and assessment program.

Ayers, R.S., Westcot, D.W., 1994 Water quality for agriculture. FAO Irrigation and Drainage Paper No. 29, Rev. 1.

Champidi, P., Stamatis, G., Zagana, E., 2011. Groundwater quality assessment and geogenic and anthropogenic effect estimation in Erasinos Basin (E. Attica). European Water, 33, 11-27.

Dar, I.A., Dar, M.A., Sankar, K., 2010. Nitrate contamination in groundwater of Sopore town and its environs, Kasmir, India. Arab J Geosci. 3, 267–272.

Fang, J., Ding, Y.J., 2010. Assessment of groundwater contamination by NO_3^- using geographical information system in the Zhangye Basin, Northwest China. Environ Earth Sci, 60, 809–816.

Food Standards Agency, 2003. Safe upper levels for vitamins and minerals Published by Food Standards Agency p 293-299 (ISBN 1-904026-11-7).

Gün, M. and Erdem, A.M., 2003. Agricultural master plan of Hatay. Ministry of Agriculture and Rural Affairs, Agricultural Directorate of Hatay (in Turkish).

Isa, N.M., Aris, A.Z., Lim, W.Y., Sulaiman, W.N.A.W, Praveena, S.M., 2014 Evaluation of heavy metal contamination in groundwater samples from Kapas Island, Terengganu, Malaysia. Arab J Geosci. 7,1087–1100.

Johnsson, H. , Larsson, M., Mårtensson, K.,Hoffmann M., 2002. SOILNDB: a decision support tool for assessing nitrogen leaching losses from arable land. Environmental Modelling Software Volume 17, Issue 6, Pages 505–517.

Kılıc, Ş., Ağca, N., Karanlık, S., Şenol, S., Aydın, M., Yalcın, M., Celik, I., Evrendilek, F., Uygur, V., Doğan, K., Aslan, S., Cullu, M.A., 2008 Detailed soil surveys, soil productivity and land use planning of Amik plain. Supported by State Planning Organization (DPT-2002K1204802002) (in Turkish).

Krishnakumar, P., Lakshumanan, C., Pradeep Kishore, V., Sundararajan, M., Santhiya, G., Hidambaram, S., 2014. Assessment of groundwater quality in and around Vedaraniyam, South India. Environ Earth Sci. 71, 2211–2225.

Kumari, S., Singh, A.K., Verma, A. K., Yaduvanshi, N.P.S., 2014 a. Assessment and spatial distribution of groundwater quality in industrial areas of Ghaziabad, India. Environ Monit Assess. 186, 501–514.

Kumari, R., Datta, P.S., Singh, C.K., Mukherjee, S., 2014 b. Determining the genetic origin of nitrate contamination in aquifers of Northern Gujarat, India. Environ Earth Sci. 71,1711–1719.

Mahmud, R., Iinoue, N., Sen, R., 2007. Assessment of irrıgatıon water quality by using principal component analysis in arsenic affected area of Bangladesh. J. Soil. Nature. 1 (2), 08-17.

Memon, M., Soomro, M.S, Akhtar, M.S., Memon, K.S., 2011. Drinking water quality assessment in Southern Sindh (Pakistan). Environ Monit Assess. 177, 39-50.

Murphy, J., Riley, J.P., 1962. A modified single solution method for determination of phosphate in natural water. Anal. Chim. Acta. 27, 31-36.

Narany, T. S, Ramli, M.F, A.Z., Sulaiman W.N.A., and Fakharian K., 2014. Groundwater irrigation quality mapping using geostatistical techniques in Amol–Babol Plain, Iran Arab J Geosci doi: 10.1007/s12517-014-1271-8.

Nas, B, Berktay, A., 2010. Groundwater quality mapping in urban groundwater using GIS. Environ Monit Assess 160(1–4), 215–227.

Rao, S.M., Sekhar, M., Rao, P.R., 2013. Impact of pit-toilet leachate on groundwater chemistry and role of vadose zone in removal of nitrate and E. coli pollutants in Kolar District, Karnataka. India. Environ Earth Sci. 68, 927–938.

TWPCR (Turkish Water Pollution Control Regulation), 2008. Regulation modified on Water Pollution Control Regulation, Official gazette No. 26786 (13 February 2008) (In Turkish)

Webb, B., Nash, D., Hannah, M., Adeloju S., Toifl, M., Roddick, F., Nichola Porter, N., 2004. Phosphorus between soil, soil water and overland flow for established and laser graded border-check irrigation systems. SuperSoil 2004: 3rd Australian New Zealand Soils Conference, 5 – 9 December 2004, University of Sydney, Australia. Published on CDROM. Website www.regional.org.au/au/asssi/.

WHO, 2004. Guidelines for Drinking-water Quality, Vol.1. Recommendation. World Health Organization, Geneva, ISBN 92 4 154638 7.

Widory, D., Kloppmann, W., Chery, L., Bonnin, J., Rochdi, H., Guinamant, J.L. 2004. Nitrate in groundwater: an isotopic multi-tracer approach. J Contam Hydrol. 72,165–188.

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Estimation of nutritional status of potato (*SolanumTuberosum L.*) plant by soil and leaf analysis grown in the different regions of Erzurum (Centre, Pasinler and Oltu town) Turkey

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Abstract

This study conducted to determine the fertility potential of potato grown soils in Erzurum region (City center, Pasinler, Oltu). For this purpose total 74 representative soils and leaf were sampled and analyzed. Texture classes of in City center, Pasinler and Oltu soils of Erzurum region agriculture soils, were sandy caly, clay and clay loam respectively. Soil reaction (pH) of Erzurum and Pasinler soil samples were slightly alkaline and neutral pH, Oltu soil samples has a slightly alkaline reaction. Organic matter (OM) content of City center soil samples is usually very low, however lime content of Pasinler and oltu were higher than city centersoilswhich have low content of lime however Oltu soil samples have low OM and Pasinler soil has high OM. Salt content of Oltu Pasinler and City center soil were found have medium, light and average level. Total soil Nitrogen (N) content and plant available nutrient (Phosphorus P, Calcium Ca, Magnesium Mg and Potassium, K) concentrations of soil samples, were in adequate level. Plant available Iron (Fe) and Cupper (Cu) were suffecient level. Lead (Pb) , Nicel (Ni) and Cadmium (Cd) were not toxic level in plant and soil samples. Plant available Manganes (Mn) is low soil samples of Erzurum, plant available Zinc (Zn) and Boron (B) levels were low in soil samples of Pasinler plain. Plant available P content is under sufficient value in plant leaves samples. As a result, Phosphorus (P), boron (B), manganese (Mn) and zinc (Zn) were insufficient level of potato plant leaves which was grown in Erzurum center, Pasinler and Oltu region. The results indicated that growers should be in an attempt of conservation and improvement of current fertility status of the soils.

Keywords: potato, critical nutrient levels, leaf analysis, soil analysis, fertility potential

Introduction

Chemical soil analyses indicates the potential availability of nutrients that roots may take up under conditions favorable for root growth and root activity. Plant analyses in the strict sense reflects only the actual nutritional status of plants. Therefore, in prenciple a combination of both methods provides a beter basis for recommending fertilizer applications than one method alone (Marschner, 1997).

Potato is one of the important products that are cultivated in the world and our country. There have been important developments and variations in the usage of potato in the human nutrition, recently. It is certain that the suitable fertilizer and fertilization will be used to raise the yield of unit of area and reveal the features of required quality (Tugay et al 1999).

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Material and Methods

The samples of the soil from 74 representative soils were sampled (Jackson 1962) in the fields of potato in the early April of 2010 years with the aim of defining the potential of the nutrition in the potato plants that have been cultivated in the region of the center, Pasinler and Oltu in Erzurum. Soil sample was also taken and sieved with 2-mm mesh screen to analyse the different chemical properties and soil nutrient status. Leaf tissue was oven dried at 68 °C for 48hours and ground to pass through a 1-mm mesh screen. The Kjeldahl method and Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigswinter, Germany) were used to determine total N (Bremner, 1982). Macro elements (C,K,Mg, Na and P), micro elements (B, Cu, Fe, Mn and Zn) and some heavy metals (Cd, Ni, Pb) were determined using an inductively coupled plasma spectrophotometer (Optima 2100 DV, ICP/OES; Perkin-Elmer, Shelton, CT) (Mertens, 2005). All data was subjected to analysis of variance using SPSSstatistical program. Means were separated by Duncan's multiple range tests (DM RT) (Düzgüneş et al 1987).

Results and Discussion

Evaluation of the soil analyses results

Texture classes of the soils ranged from 23% of the soils samples are loamy, 1,35% are sandy, 32,4% are sandy and loamy, 41,9% are loamy and 1,35% are loamy. Statistical analysis showed close relation between the plant nutrient availability and the soil texture (Kacar and Katkat 2007).

pH of the soil samples ranged from 6,47-8,50 and averaging 7,60. This finding suggests that 37,84% of the soils are neutral and 62,16% of the soil samples are light alkaline reaction (FAO 1990; tovep 1991; Günes et al. 1998). The pH of the soil is a important factor that affected of the chemical, biological and physical process in soils (Yıldız 2012). The organic matter content of the soil samples ranged from 0,02-4,10% and are averaging 1,61%. This finding suggests that 27,02% of the soil samples are very low, 44,60% of the soil samples are avaraging, 17,57% of the soil samples are sufficient, 9,46% of them are well enough and 1,35% of the soil samples are high. The organic matter of the soil has a negative weight dramatically because of the organic colloids that it contains. The weight that the organic colloids have, are far more than the clay minerals (Bakırcıoğlu 2009). The $CaCO_3$ content of the soil samples ranged from 0-20,99 % and averaging 3,76%. This finding suggests that 51,35% of the soil samples 18,91% of the soil samples are limy, 24,32% of the soil samples are medium limy and 5,41% are very limy. The fact that the lime contents of the soils are made unavailable of micro elements especially phosphorous and zinc (Udo vd 1970; Mengel and Kirkby 1982; Kacar et al. 1998). The EC of the soil samples ranged from 0,23-1,19 dS/cm and averaging 0,45 dS/cm. This finding suggests that 20,27% of the soil samples are light salty, 68,91% of the soil samples are medium salty and 10,82% of the soil samples are excess salty. The saltness stres is an environmental stres factor in terms of the cultivated plants and is the group of the chemical stres. The fact that the growth medium has problem in terms of the salt brings about many negative effects (Yakıt and Tuna 2006). The CEC of the soil samples ranged from 17,07-49,70 cmol kg^{-1} and averaging

22,46 cmol kg^{-1} (FAO 1990; Tovep 1991; Güneş et al. 1998). The total nitrogen amount of the soil samples ranged from 0,06-0,29% and averaging 0,15%. This finding suggests that 4,05% of of the samples are low, 63,51% of the samples are sufficient and whereas 32,43% excess.% of them were rich. NH_4^+-N level of the soil samples ranged from 28-98 mg kg^{-1} and averaging 54,01 mg kg^{-1}. NO_3^- N level of the soil samples ranged from 14-98 mg kg^{-1} and averaging50,89 mg kg^{-1}. Plant available Plevel of the soil samples ranged from 2-76 mg kg^{-1} and avaraging 24,24 mg kg^{-1}. This finding suggests that 1,35%of the samples are so low, 5,40% medium, 54,05%of the samples are sufficient and whereas 39,19% excess. The exchangeable K levelof the soil samples ranged from 1,91-5,67 cmol $kg^{-1}$and averaging cmol $kg^{-1}$and were excess. The exchangeable Ca level of the soil samples ranged from 10,62 to 30,90 cmol kg^{-1}, averaging 14,32 cmol kg^{-1}. This finding suggests that 90,54% of the samples are sufficient, whereas 9,46% of the samples are high. The exchangeable Mg level of the soil samples ranged from 3,07-8,95 cmol kg^{-1}, averaging 4,04 cmol kg^{-1}. This finding suggests that 35,14% of the samples are sufficient, whereas 35,14% of the samples are excess. The exchangeable Na level of the soil samples ranged from 0,39 -1,14 cmol $kg^{-1}$and avaraging 0,53 cmol kg^{-1}.

The concentrations of Fe, Cu, Zn, Pb, Mn, B, Cd and Ni were compared with the critical values (Lindsay and Norwell 1969; FAO 1990; Tovep 1991; Güneş et al. 1998, in Yıldız 2012). Results indicated that the amounts of plant available Fe level of the soil samples ranged from 0,26-8,28 mg kg^{-1} and they are averaging 1,34 mg kg^{-1}. This finding suggests that 55,41% of the samples are sufficient. This finding suggests that 44,60% are excess.

Plant available Cu level of the soil samples ranged from 1,07-4-69 averaging 2,36 mg kg^{-1}.This finding suggests that all of the samples are sufficient. Plant available Zn level of the soil samples ranged from 0,34-7,91, averaging 1,92 mg kg^{-1}. This finding suggests that 14,87% of the samples are so low, 60,82% of the samples are sufficient and 24,32% of the samples were excess. Plant available B level of the soil samples ranged from 0,07-1,06 mg kg^{-1} averaging 0,31 mg kg^{-1}. This finding suggests that 97,3% of the samples are low and 2,7% of the samples are sufficient. The up take of B is limited by pH (<5,5 or <6,8), sandy soil, low organic matter (Yıldız 2012). Plant available Mn level of the soil samples ranged from 1,10-14,87 mg kg^{-1} and averaging 4,97 mg kg^{-1}. This finding suggests that 47,30% of these samples are too low, 51,35% of the samples are low and 1,35% of the samples are sufficient. Taban et al. 1997, Parlak et al. 2008, Turan et al. 2010 have found the same results in the works that they have done with different region soil and plants. Pb concentration of the soil samples ranged from 0,41 mg kg^{-1} and averaging 0,21 mg kg^{-1}. The concentrations of Ni ranged from 0,15-3,99 and averaging 0,84 mg kg^{-1}. Cd concentration of the soil samples ranged from 0,001-0,004 mg kg^{-1} and averaging 0,002 mg kg^{-1}.

Evaluation of leaf mineral content

The content level of macro and micro elements in leaf samples of the potato plant that were compared with the limit values (Yıldız 2012) for potato.

As a result of the evaluation, N content of the leaf samples ranged from 3,21-6,42% and averaging 4,77%. Nitrogen content were high in all leaf samples. P content the leaf samples ranged from 0,10-0,35% and averaging 0,19- 60,81% of the soil samples are low and 38,19% of the leaf samples are sufficient. Available P level were sufficient of the soil samples but, whereas P level of the leaf samples are sufficient. Because; the availability of P are effected by several effects of the internal and external factor in soil. For example; drought, excessive moisture or low temperature, clay type etc. The availability of the plant nutrients from the soil is related to the climate factors. More fertilizer should be used in the places that the temperature is high in the morning. More fertilizer should be used as the intensity of the light increases. Also, the texture class of the soil is very important in irrigation. Although the P level of the soils are low, P content of the leaf samples ranged from 0,02% -0,15%. K content of the leaf samples ranged from 2,40-6,62% and averaging 4,55%. 8,10% of the leaf samples are sufficient and This finding suggests that 91,90% of the leaf samples high level. Ca content of the leaf samples ranged from 0-2,89% and it is averaging 1,24%. 2,7% of the leaf samples are low 82,44% of the leaf samples are sufficient and 14,86% the leaf samples are high. Mg content of the leaf samples ranged from 0,29-1,45% averaging 0,64%. This finding suggests that 31,08% of the leaf samples are sufficient, 68,92% of the leaf samples are high. Na content of the leaf samples ranged from 0,01-0,09% and it is averaging 0,04%. S content of the leaf samples ranged from 0,22-0,80% averaging 0,47%. This finding suggests that 56,75% of the leaf samples are sufficient whereas 43,25% of the leaf samples are high.

Fe content of the leaf samples ranged from 106,50-958,50 averaging 257,15 mg kg^{-1}. This finding suggests that 20,27% of the leaf samples are sufficient 79,73% of the leaf samples are excess. Cu content the leaf samples ranged from 10-27,59 mg kg^{-1} averaging 15,94 mg kg^{-1}. This finding suggests that all of the leaf samples are excess. Zn of the leaf samples ranged from18,82-87,65mg kg^{-1}, averaging 36,96 mg kg^{-1}. This finding suggests that 51,35% of the leaf samples are low, 32,43% of the leaf samples are sufficient and 16,22% of the leaf samples are excess. Mn content of the leaf samples ranged from 22,14-302,32 mg kg^{-1}, averaging 75,00 mg kg^{-1}. This finding suggests that 78,32% of the leaf samples are sufficient and 21,63% of the leaf samples are excess. B content of leaf samples ranged from 0,61-36,16 mg kg^{-1}, averaging 16,14 mg kg^{-1}. This finding suggests that 83,78% of the leaf samples are low, 14,87% of the leaf samples are sufficient and 1,35% of the leaf samples are high. When the temperature decrease, boron availability decrease. The soil humidity also affects the mass flow and availability of the diffusion boron**.** Factors that affected transpiration also, negative affects availability of boron. The tubers are small, deformed and high-coloured when the B is not sufficient in the potato (Mahler 2010). The amount of available boron in the top soils is very changeable and is under the effect of some factors. The amount of available boron changes depending on the texture of the soils, the amount of hydrated iron oxide and aluminium oxide, electrical conductivity, the content of organic substance, the amount and types of changeable cations, the content of lime and the quality of irrigation water (Yıldız 2012). Pb content of leaf samples ranged from 0,01-2,63 averaging 0,74 mg kg^{-1}. Ni content of leaf samples ranged from 0,0-21,95 mg kg^{-1} averaging 3,05 mg kg^{-1}. Cd content of leaf samples ranged from 0,00-1,82 mg kg^{-1} averaging 0,20 mg kg^{-1}. Correlation analyses were applied to the data to determine the reletionships between soil characteristics obtained and leaf mineral content (Table 1).

Table 1.The correlation coefficiencies of soil and leaf properties studied.

Soil / leaf	N	Na	Ca	Mg	NH_4^4	NO_3^-	CEC	pH	O.M	$CaCO_3$	EC	Clay	Silt	Sand	P	B	Cd	Cu	Fe	Mn	Ni	Pb	Zn	K
N	0,287*	0,127	0,140	0,166	-0,098	-0,391**	0,198	-0,413**	-0,288*	-0,349**	-0,333**	-0,108	0,164	0,033	0,049	-0,129	0,113	-0,195	0,034	0,228	0,018	-0,222	0,073	0,191
P	-0,156	0,091	-0,019	-0,030	-0,064	-0,020	-0,036	0,136	-0,082	-0,162	-0,195	0,185	0,108	-0,220	-0,022	-0,215	-0,181	-0,355**	0,018	0,020	0,280*	0,046	-0,120	0,000
Na	0,024	-0,058	-0,151	-0,152	0,000	0,052	-0,141	-0,112	-0,112	-0,256*	-0,227	0,259*	0,136	-0,300**	-0,020	-0,246*	-0,119	-0,315**	-0,032	0,180	0,087	-0,022	-0,136	-0,135
K	0,047	0,179	0,248*	0,192	0,024	0,120	0,211	0,094	0,202	0,007	0,175	-0,094	-0,137	0,144	0,247*	-0,082	0,171	0,148	0,006	-0,147	-0,101	0,006	0,242*	0,172
Ca	-0,198	0,165	0,049	0,007	0,162	0,214	0,026	0,287*	0,100	0,067	-0,024	0,261*	-0,059	-0,222	-0,068	-0,213	-0,032	-0,166	0,115	-0,184	0,130	0,268*	-0,087	0,039
S	-0,260*	-0,034	-0,091	-0,116	0,086	0,292*	-0,147	0,335**	0,114	0,095	0,065	0,426**	0,041	-0,418**	-0,076	-0,075	-0,102	0,066	-0,132	-0,092	0,208	0,279*	-0,209	-0,144
Mg	-0,176	-0,048	-0,112	-0,163	0,136	0,165	-0,127	0,321**	-0,001	0,218	-0,190	0,490**	-0,138	-0,403**	-0,370**	-0,248*	-0,178	-0,146	-0,260*	-0,135	0,058	0,182	-0,339**	-0,132
Pb	-0,223	0,089	-0,019	-0,054	0,034	0,201	-0,054	0,159	0,007	-0,114	-0,073	0,169	0,099	-0,201	-0,038	-0,289*	-0,061	-0,279*	0,053	-0,205	0,203	0,226	-0,080	-0,021
Cd	-0,006	0,129	0,069	0,051	0,009	0,051	0,050	0,054	-0,018	-0,038	-0,062	0,193	-0,052	-0,161	0,037	-0,130	-0,044	-0,154	-0,021	-0,041	0,033	-0,031	-0,136	0,061
B	-0,122	0,099	0,124	0,166	-0,008	0,090	0,105	0,198	-0,045	0,118	0,188	0,083	0,006	-0,079	-0,011	0,000	-0,042	0,302**	-0,023	-0,014	0,172	0,177	-0,037	0,094
Fe	-0,077	0,186	0,154	0,072	0,147	0,420**	0,100	0,140	0,031	-0,007	0,113	0,020	0,060	-0,046	0,019	-0,199	0,240*	-0,191	0,150	-0,169	-0,056	0,393**	0,059	0,113
Cu	0,021	0,110	0,009	0,040	0,030	0,114	0,049	0,334**	0,199	0,177	-0,015	0,138	-0,045	-0,112	0,027	-0,161	-0,111	0,015	-0,136	-0,232*	0,039	0,103	0,037	0,062
Zn	-0,061	0,127	0,028	-0,015	-0,058	0,128	-0,005	0,162	0,079	-0,019	-0,118	0,259*	0,073	-0,275*	0,017	-0,179	-0,088	-0,280*	-0,037	-0,037	0,111	0,167	0,055	0,027
Ni	-0,115	0,079	-0,031	-0,006	0,223	0,132	-0,013	0,053	-0,024	0,000	-0,179	0,509**	-0,101	-0,437**	-0,205	-0,313**	-0,138	-0,234*	-0,110	-0,060	0,068	0,136	-0,277*	-0,007
Mn	-0,090	0,040	-0,059	-0,113	-0,015	0,106	-0,079	0,066	0,010	-0,060	-0,178	0,109	0,073	-0,137	-0,062	-0,209	-0,148	-0,411**	-0,085	-0,028	-0,074	-0,051	-0,136	-0,059

(*: $P < 0.05$, **: $P < 0.01$ level of significance)

Conclusion

Results indicated that the amounts of P, Zn, Mn, and B in the soil and plant samples were deficiency, total soil N content and plant available nutrient concentrations (P, Ca, Mg and K) of soil samples, were in sufficient for potato plant growth. Plant available Fe and Cu were in suffecient level and Pb and Cd were not toxic level in plant and soil samples. Plant available Mn is low soil samples of Erzurum, plant available Zn and B levels were low in soil samples of Pasinler plain. Plant available P content is under sufficient value in plant leaves samples.

As a result, Phosphorus (P), boron (B), manganese (Mn) and zinc (Zn) were insufficient level of potato plant leaves which was grown in Erzurum center, Pasinler and Oltu region. The results indicated that growers should be in an attempt of conservation and improvement of current fertility status of the soils. It was suggested that the P, Zn, Mn, and B sourced soil and foliar fertilizers should be added to increase its productivity by considering with field/greenhouse experiments later on.

References

Bakırcıoğlu, D.,2009.Toprakta Makro ve Mikro Element Tayini. Trakya Üniversitesi Doktora tezi,Fen Bilimleri Enstitüsü, Edirne.

Bremner, J.M. and Mulvaney C.S., 1982. Nitrogen Total. Methods of Soil Analysis Part2. Chemical and Microbiological Properties Second Edition. Agronamy. No: 9 Part 2. Edition P: 597-622.

Düzgüneş, O., Kesici T., Kavuncu O. ve Gürbüz F., 1987. Araştırma ve Deneme Metotları (İstatistik Metotları-II). Ankara Üniversitesi Ziraat Fakültesi Yayınları: 1021, 381 s, Ankara.

FAO, 1990. Micronutrient. Assessment at the Country Leaves an İnternational Study. FAO Soils Bulletion 63. Rome.

Güneş, A., Alparslan M. ve İnal, A., 1998. Critical Nutrient Concentrations and Antagonistic Synergistic Relationships Among the Nutrients of NFT Grown Young Tomato (Lycopersicon esculentum L.) Plants. Journal of Plant Nutrition. 21:2035-2047.

Jackson, M. L., 1962. Soil Chemical Analysis. Prentice-Hall. Inc. Cliffs, USA.

Kacar, B., Taban S., Alpaslan M. ve Fuleky G., 1998. ZinePhosphorus Relationship in the Dry Matter Yield and the Uptake of Zn, P, Fe and Mn of Rice Plants *(Oryza sativa* L.) as Affeeted by the Total Carbonate Content of the Soil. Second International Zinc Symposium. Abstracts, pp, 20. October 2-3, 1998, Ankara-Turkey.

Kacar, B. ve Katkat V. A., 2007. Bitki Besleme. Nobel Yayınları. ISBN:978-975-591-834-1. 559.

Lindsay, W.L. and Norwell W.A., 1969. Development of DTPA Soil Test for Zinc, Iron, Manganese and Copper. Soil Sci. Soc. Amer. Proc. Vol: 33, 49-54.

Mahler, R.L., 2010. Boron in Idaho. In. Essential Nutrients. College of Agriculture, Cooperative Extation Systems, CIS 1085

Marschner, H., 1997. Mineral Nutrition of Higher Plants. 2nd Edition. Academic Press, London 889 p.

McLean, E.O., 1982. Soil pH and Lime Requirement. Methods of Soil Analysis Part2. Chemical and Microbiological Properties Second Edition. Agronamy. No: 9 Part 2. Edition 199-224.

Mengel, K., and Kirkby E.A., 1982. Principles of Plant Nutrition. 3th ed. International Potash Institute. P.O. Box. CH-3048, pp 655, Worblaufen-Bern, Switzerland.

Mertens, D. 2005. AOAC Official Method 975. 03. Metal in Plants and Pet Foods. Official Methods of Analysis, 18th edn. Horwitz, W., and G. W. Latimer, (Eds). Chapter 3,pp 3-4,AOAC-İnternational Suite 500,481. North Frederick Avenue, Gaitherburg, Maryland 20877-2417, USA.

Parlak, M., Fidan, A. Kızılcık İ. ve Koparan H., 2008. Eceabat İlçesi (Çanakkale) TarımTopraklarının Verimlilik Durumlarının Belirlenmesi. Ankara Üniversitesi Ziraat Fakültesi Tarım Bilimleri Dergisi 14 (4) 394-400.

Taban, S., Alpaslan M., Hasemi A.G. ve Eken D. 1997. Orta Anadolu'da Çeltik Tarımı Yapılan Toprakların Bazı Fiziksel ve Kimyasal Özellikleri. Pamukkale Üniversitesi Mühendistik Fakültesi Mühendislik Bilimleri Dergisi. 3(3): 457-466.

Tovep, 1991. Türkiye toprakları Verimlilik Envanteri. T.C Tarım Orman ve Köy İşleri Bakanlığı Köy Hizmetleri Genel Müdürlüğü, Ankara.

Tugay, M. E., Coşkun A.Ş. ve Yılmaz G., 1999. Azotlu Gübre Miktarı ve Verme Zamanlarının Patateste Verim ve Bazı Özellikler Üzerine Etkileri. 2. Ulusal Patates Kongresi28-30 Haziran 1999 G O Ü. Zir Fak., 655-658, Samsun.

Turan, M. A., Katkat A. V., Özsoy G. ve Taban S.,2010. Bursa İli Alüviyal Tarım Topraklarının Verimlilik Durumları ve Potansiyel Beslenme Sorunlarının Belirlenmesi. U. Ü. Ziraat fakültesi dergisi (Journal of Agricultural Faculty of Uludag University) , Cilt 24, Sayı 1, 115-130.

Udo, E.J., Bohn H.L. and Tucker T.C. 1970. Zinc Adsorption by Calcareous Soils. Soil Sci.Soc. Am. J., 34: 405-410.

Yakıt, S. ve Tuna L., 2006. Tuz Stresi Altındaki Mısır Bitkisinde (Zea Mays L.) Stres Parametreleri Üzerine Ca, Mg Ve K'nın Etkileri Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, 2006, 19(1), 59-67.

Yıldız, N., 2012. Bitki Beslemenin Esasları ve Bitkilerde Beslenme Bozukluğu Belirtileri. ISBN 978-605-62759-0-6, 1-477. Erzurum.

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Geological problems in the realization of underground geotechnical structures in urban environment

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Abstract

The construction of shallow tunnels for Sofia Metro is associated with a dynamic variation of geological conditions. This dynamic change is determined by three main factors: /i/ The minimum depth of the tunnels, /ii/ the rapid change of the type and characteristics of the geological layers (Sofia is the bed of a Pliocene lake), and /iii/ flooding in the zone of mineral water springs spills water around the springs, and damaged sewers cause profuse watering of the soil. The combination of these three factors leads to an increased risk in the construction and operation of underground facilities. The risk in the ground is related to a danger of liquefaction during seismic impact , cutting and sinking of pile foundations, deformations under existing facilities and the surface thoroughly watering of trenches accompanied by intensive removal of fine soil particles, changing the terms of interaction between the geological base and the construction of facilities, etc. The report is devoted to the problems posed by the complex geological picture of building underground metro structures . Solutions which theoretically and experimentally verify the basics of earth mechanics have been applied. The results contribute to the risk reduction and financial optimization of underground structures in complicated geological conditions and close to the existing infrastructure. This paper considers appropriate structures that are adequate to the dynamic changes in the geological conditions, as granted or after human intervention. It contains graphics and pictures which reflect all the major problems and their solutions. The idea of the report is: /i/ to answer the question at what phase of the study the geotechnical and hydrogeological conditions in the construction of metro shallow tunnels should be taken into account, and /ii / to emphasize how the good knowledge of the geological conditions helps reduce the risk during building and exploitation of underground structures.

Keywords: Tunnel, geological conditions, Sofia Metro construction

Introduction

The construction of shallow facilities at Sofia Metro (tunnels, stations, shafts) is associated with a dynamic change of the geological conditions. This change is determined by three main factors: /1/ the minimum depth of the facilities, /2/ the quick change of the type and characteristics of the geological strata, and /3/ flooding in the area of the mineral springs.

The combination of these three factors leads to an increased risk during the construction and exploitation of the underground facilities. The realization of the facilities along the metro line with shallow bedding is through underground and open methods. These two methods determine the specificities of the geological problems of the geotechnical structures in urban environment.

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Geological Aspects In Modelling Of Shallow Tunnels Built Through The Underground Method

TBM Tunnels With Back Pressure

A risky case in the construction of Sofia Metro is the boring of TBM tunnels with a small-depth cover under the main water courses in the city.

The pass near the Vladayska River, the tunnel is one-track, 9.39 m in diameter and there are no free options for route selection. Here, the tunnel has to pass along Maria Luiza Blvd. under the foundations of the Lion's Bridge, with the minimum for the first and second metro lines earth cover of 2.5 m. The bridge is founded by help of stripped stone blocks at a depth of 2.80 m under the level of the water course. The wooden piles, 3.5 m long, protect the abutment piers of the bridge from erosion caused by the river. This means that when the TBM machine is passing, it will take away about 0.3 m of the stone foundations and 1 m of the wooden piles in the zone of the metal shoes. Cutting part of the foundation and piles leads to a risky situation during the TBM movement.

The geotechnical conditions along the metro route are changing very dynamically. More often, the small-depth tunnel covers are due to water obstacles abundant in the territory of the city. These obstacles have some specific features.

The first specificity - the soil features in the city near to the crossed rivers are the following (Fig.1):

A contemporary embankment begins from the surface. Often, this embankment consists of rubble with sand filling, silty clays with rubble inclusions and construction debris.

Under the embankment is a layer of Quaternary rubbles – fine to medium rubbles, rock-fill soil and brown to yellow-brown fillings. Sometimes, the filling is of clayey sands. Rubbles continue downward to about 3-4.5 m under the river bed. In the lower part of the layer which joins the rubbles, the filling becomes more clayey.

Under the rubbles are revealed Pliocene depositions with dark-green to oil-green silty clays which have high plasticity and water content indexes.

The second geological feature of the terrains near the river beds is *the existence of fault tectonic areas.* This means that there are faults near the river beds. So far, there are no data for vertical soil displacements due to tectonic forces in the two main layers – rubbles and Pliocene clays.

The third feature is that the *underground water is accumulated mainly in the cohesionless sediments of Quaternary and Pliocene age.* These sediments have alluvial and lacustrine-boggy genesis. The Quaternary rubbles have high permeability (K=8.10x10-5 m/s), while the Pliocene silty clays have low to very low permeability (from K=2.31x10-6 m/s to K=1.16x10-9 m/s).

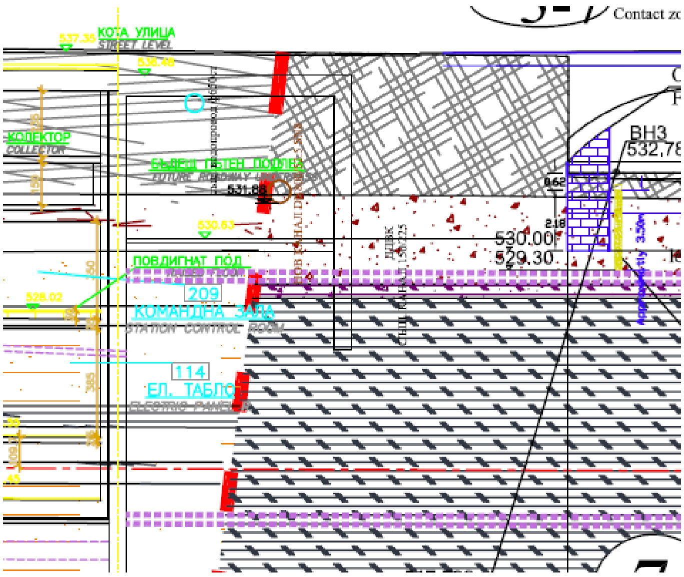

Fig.1: Geological section along the tunnel axis at the Vladayska River in the area of the Lion's Bridge, second metro line

The low permeability of the silty clays is not a sufficient condition for the Pliocene complex to be treated as an impervious bed. This stems from the specificity of the soil structure. The water-logged Pliocene materials are a non-homogenous anisotropic water bearing complex with non-pressurized to pressurized waters. Because of the unsustained aquicludes between the separate water bearing layers, it is assumed that they form a common aquifier. The preliminary criterion for passability of tunnels under small-depth covers under the concrete geotechnical conditions of strongly watered terrains is to calculate the safety coefficient Gs against floating. The sufficient condition for passing through zones with a small-depth tunnel cover requires meeting of three additional criteria. These criteria presume concrete engineering measures to be taken for stabilization of individual sections during tunneling using back pressure.

The first criteria for starting of TBM have two specific prerequisites which guarantee the successful start of the TBM before the tunnel section with a small-depth cover. The first prerequisite presumes construction of entry portals with increased density for TBM at the starting shaft or metro station for passing under shallow sections along the route of the metro tunnel. The second condition presumes creation of variable regime of back pressure in the zone of entering, before and after the area of a reduced tunnel cover.

The second criteria for sufficiency in the settlements analysis for a natural state of the earth massif. In order to assess the effect of TBM passing through the section with a small-depth tunnel cover, a 3D computer-aided model should be developed under the finite elements method.

The third criteria of sufficiency in the analysis of settlements in a reinforced earth massif. The consolidation measures shall affect the Quaternary rubbles with high water permeability. Grouting reaches two goals: /1/ to produce a hardened slab of rubble thereby reducing the settlements of the existing foundations during the TBM passage, and /2/ to create a stable and watertight mass which should prevent the loss of back pressure in the tunnel excavation.

It becomes necessary a new computer-aided model to be used, which should take into account the parameters of the reinforcement works. This model differs from the previous one by the parameters of the consolidated soil layer. In the case of passing under the river, the possible risky situation may be avoided through an execution of injection reinforcement measures in the area of the river bed (Fig.2). After the reinforcement, the upward directed displacements diminish from 2.1 mm to 0.9 mm. This value is safe, which avoids the destruction of the earth bed because of upward displacements and loss of stability in the front area. The maximum settlement under the bridge abutments reduces from 10 mm to 2.5 mm, while the maximum angular deformation diminishes from 1/1000 to 1/3600.

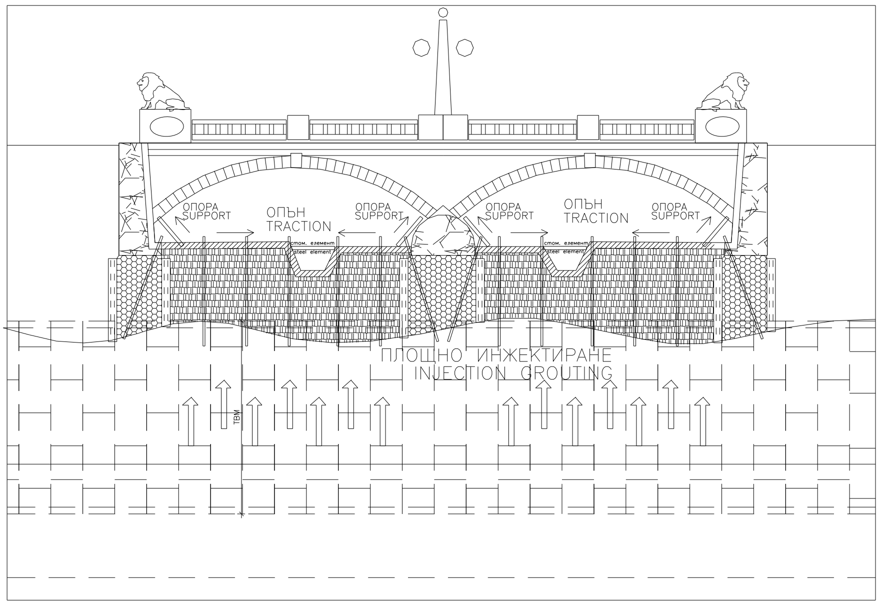

Fig.2: View of the support rings, forces and an option of temporary support and reinforcements of the area under the Lion's Bridge

Shallow Tunnels Under The Mine Method

There are **three aspects** of the geotechnical modelling and the ensuing technological solution from the geological conditions. Tunnels have been built under the mine method using a temporary support of steel frames with the static scheme of a three-hinge arch. After the application of the waterproof coating the constant lining of reinforced concrete is being executed (Fig.3).

The first aspect is related to loads and impacts during the construction and exploitation of the facilities. In case of passing under main transport routes the open method is more costly compared to the mine method. The application of the mine method through partial digging of a heading face allows arch effects to be realised over the upper part of the tunnel, thus avoiding excavations up to the surface and stopping the traffic. The study under a horizontal and vertical earthquake for the dynamic combination of loads in the mine method is recommended to be realised with the highest possible values of the seismic masses to the ground surface.

Fig.3: Temporary support of the reinforced section and concreting of the tunnel lining

The second and the third aspect of the modelling and construction of the tunnels are related to the realization of the nodes of the main component of the temporary support-the three-hinge arch.

The problems are ensuing from the application of solutions for the nodes taken from the routine practice in the mine construction at great depths. The application of this practice for the construction of the toes and connection in the arch leads to enhanced deformability of the supports, which is useful for the deep-mine supports. For constructions in urban environment this deformability may be dangerous and may cause an emergency situation for the transport routes above the tunnel.

The surmounting of such emergency situations requires a number of stabilizing measures which define useful practical recommendations related to: /1/ construction of the arch connection, /2/ skewbacks, /3/ arch effects, and /4/ conditions for combining the internal support with injection reinforcement in the zone of the arch.

Innovative Solutions In Soft Soils Under A Mixed Method Of Connection Between Two Metro-Tunnels

One of the greatest challenges for the designers and contractors is the necessity of building a tunnel connection at the cross-point of he already existing first line and the second one passing at another level and at an angle against the first tube. The stations and the tunnels are existing structures, and the new tunnel connection is being executed after their partial demolition and reconstruction of the connecting areas.

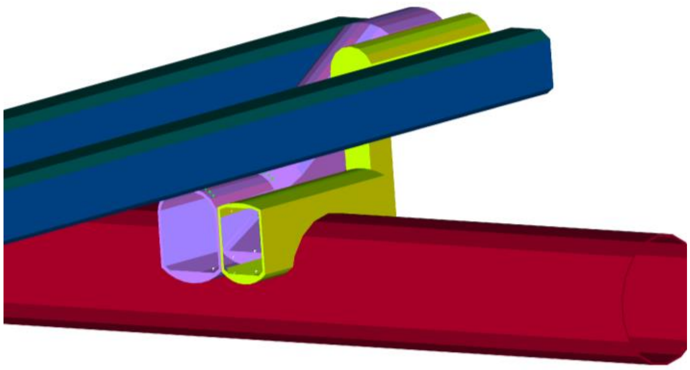

Fig. 4: Model of the tunnel connection between two metro lines

At the existing station of the first metro line there are no available spaces and approaches both for fitting the tunnel dimensions of the new connection and for construction and assembly works (Fig. 5). This imposes the station, at the connecting zone, to be reconstructed and additionally supported without causing further settlement of the earth bed. The problem is even more complex due to the requirement not to stop the use of the station and the traffic on the line.

The new tunnel connection scours the tunnels of the first metro line and enters very loose and watered soil layers due to the nearby mineral water sources.

Fig. 5: The sloping part between the tunnels of the first and the second metro line. The slope is under the tunnels of the first metro line, central boulevard, and the foundations of an existing underpass

Three foundations of the existing underpass (with forces over 440 ton) prop on the structure – circumstances which exclude the application of classical methods in the tunnel construction – water lowering and water abstraction. Water lowering is excluded because it may cause inadmissible settlement in the tunnels of the first metro line founded over the same loose and watered layers where the new connection should pass through. Inadmissible settlements may be expected also under the foundations of the underpass which falls into the zone over the new tunnels.

The limiting geological parameters and the existing structures can be surmounted with the help of the following measures: /1/ big concentrated loads from the underpass foundations are reliably borne, /2/ water retention is realised covering also the neighbouring structures, /3/ no settlements are admitted, /4/ the traffic in the above tunnels is not stopped, /5/ reconstruction of the existing metro station over the full tunnel dimension without stopping the traffic, and /6/ reconstruction and crossing the tunnel of the second metro line driven under the shield method.

All advantages of the mine method’s safety are used during the period of passing through the soft geological strata. This method is united with the technological advantages of the New Austrian Method, the earth massif being compacted by injection.

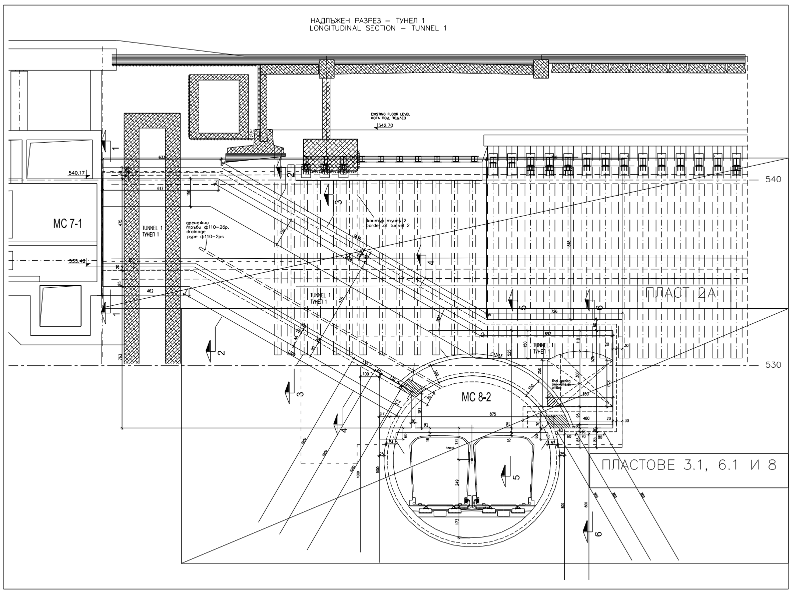

Fig. 6: General view of the tunnel connection and longitudinal section through existing structures and temporary supports in the construction of the first metro line. The two main geological strata where the new construction falls in are marked

The purpose and the result reached by the integration of the various methods is the risk in the construction and operation of the new facilities to be reduced to and even under the safe minimum.

The main risk component is associated with the crossing with partial destruction of the TBM tunnel of the second metro line.

Fig. 7: A new support structure of the existing metro station for entering the new tunnels has been executed. The existing RC walls have been cut

Fig. 8: Steps in crossing the pedestrian connection with the TBM tunnel of the second metro line

The risk of collapse due to the destruction of the existing metro tunnel is reduced through the application of **four preventive measures:** 1/1 strong technological sequence of the execution, /2/ reinforcement of the earth massif, /3/ system of foreset, and /4/ temporary reinforcement of the TBM tunnel.

It is especially important the reinforcement of the earth bed with IBO piles to be in the immediate proximity to the TBM tunnel. There is a danger of liquefaction of the fine sands in this zone, and the water pressure is increased. Therefore, the reinforcement of the earth massif is realised under two basic schemes: /1/ a driven pile structure in case of strong soils in the zone of footing, and /2/ a suspended anchor system in the strong seams when there are floating sands under the bottom of the new tunnel.

The reinforced earth bed secures the most risky moment of the destruction of the TBM tunnel and execution of the bridging slab which closes the contour of the TBM tunnel.

Deep Excavations In The Realisation Of Underground Structures Under The Open Method

Reduced values of the earth pressure similar to the arch effects in tunnels have been found during the monitoring of deep excavations. This control provides data over time for: /1/ tensions in anchors through tensometer, /2/ the deformation line of the wall, and /3/ the limit force in the anchors.

The parameters measured allow the structures to be re-analyzed. The actual values for the earth pressure are determined by the tensions in the anchors and the support deformation. The measured displacement lines are represented by an analytical function. The second derivative of the function defines the bending moments, while the forth one – the earth pressure (Fig. 9).

The summarization of the experience leads to three main conclusions:

The first conclusion is that the measured deformations in the sample sections are smaller than the design ones. The upper limit of the earth pressure is the active pressure. The actual earth pressure is determined by the measured displacements which is the right approach for the solution of the geotechnical problems in deep excavations.

The second conclusion concerns the total length ΣL_i of the anchors – Fig. 9-A. The monitoring revealed that the slipping surfaces in the norms are not realised. In this case, during the execution of the rows of anchors with partial stressing, slipping surfaces emerge gradually with a reduced volume of disturbed geological varieties.

This means that the length of the anchors could be reduced – Fig. 9-B.

The third conclusion is that the length of the anchors could be limited to the zone of activation of the soil massif like a stable earth-RC support wall. In this case, the disposition and the length of the anchors "Lc" is determined by two criteria: /1/ to activate the interaction of the disturbed zone with the construction of the RC wall, and /2/ to secure the general stability to overturning and slipping – Fig. 9-C.

Another indirect fact which is neglected in the geological investigations deserves attention. It is related to the bearing capacity of the earth bed at different depths. The practice is the investigations to indicate equal values of the parameters near to the surface and in depths, as they have been obtained at the laboratory. Exclusions are made for the more deeply embedded Pliocene clays for which the bearing capacity is increased by 5%.

Actually, the soil deformation under a vertical load and in case of impeded side expansion, i.e. under compression, is typical for the deep clay seams. During excavations these conditions will be breached but afterwards, in the execution of impermeable walls and foundation slabs the compression may be restored. This means that there are reserves in the bearing capacity of the deeper clay seams which are recommendable for investigation and use.

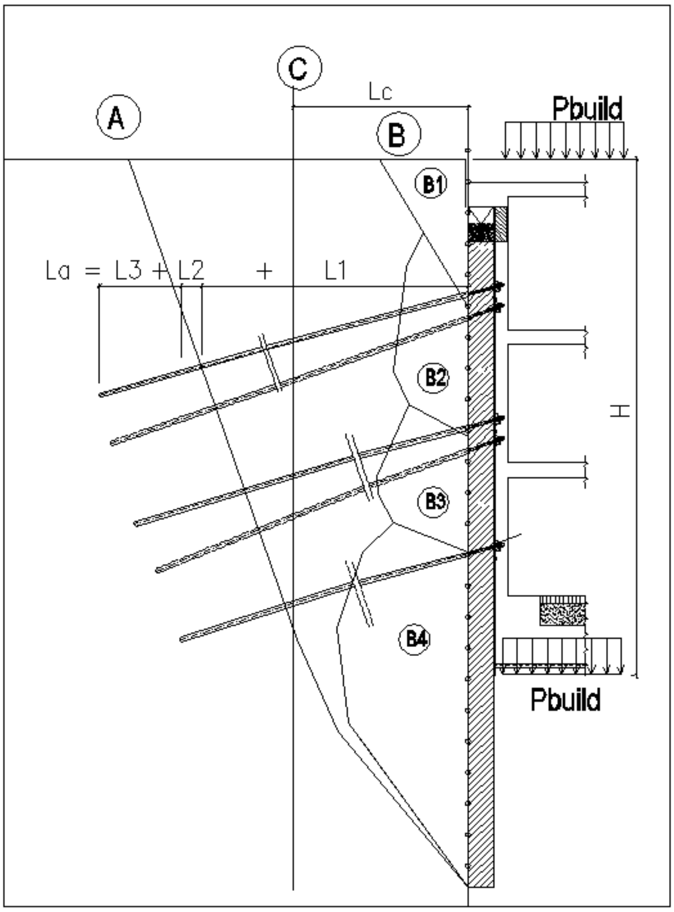

Fig. 9: Cross section through pile and diaphragm walls: A – generally accepted scheme of determination of earth pressure and anchors length; B – experimental scheme of determination of the earth pressure and anchors length, B1-B4 are consecutively emerging slipping surfaces; C – length of anchoring for securing of the general stability of earth–RC retaining wall under the system "soil nailing"

Conclusion

The examples and analyses in the paper aim to answer two main questions: The first question is at what stage of the realization of the shallow facilities built under open and underground method the real engineering-geological and hydrogeological conditions of the construction should be clarified. The answer is that the monitoring and the field methods should not be neglected because they lead to risk reduction and bring an economic effect. The second question is under which circumstances the geological conditions lead to structures with a reduced degree of risk during construction and operation. The answer is reduced to the good and timely clarification of the geology, together with the limiting conditions of the construction and their correct technological binding with the stages of realization and operation of the facilities. The aspects considered are useful for the theory and practice of the geological investigations in the construction of shallow embedded underground structures built under open or underground method. The conclusions and recommendations are of methodological importance. In practice, each case is unique and requires specific investigations for finding the respective conformities in the geological conditions in urban areas.

References

1. Bulichev N.S., Mechanics of Underground Structures, Nedra, 1982.
2/ Ratan Tatiya, 2005. Civil Excavations and Tunneling, Thomas Telford (ed.)
3/ Eurocode 2, 7, 8.
4. Design solutions of the author for structures of Sofia Metro.

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Geological problems in the realization of underground geotechnical structures in natural environment

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Abstract

On one hand, the climate change causes a deterioration of the geological conditions and leads to a destruction of the existing infrastructure. On the other hand, the infrastructural routes pass through sites with a long-term natural balance, and landslide processes may be instigated. The reason is the human intervention. The scale of this intervention is usually sufficient to break the geological balance border between the admissible human intervention and the nature. Crossing this frontier is followed by increased expenditures due to construction and traffic problems. The paper considers the underground stabilization of the slope of a collapsed railroad as well as the measures for restoration of the ecological balance. Attention is paid also to the prevention that can be realized during the construction works and the exploitation of the existing structures. The analysis is illustrated by examples.

Keywords: landslide prevention, slope balance, human intervention, climate change

Introduction

The geological problems causing landslides in the natural environment are in two directions. The first one is in case of infrastructural routes passing through sites of a long-term natural balance. If the scale of the human intervention breaks the equilibrium with the nature, landslide processes may be instigated. The consequences are construction problems and increased costs.

The second direction is ensuing from the lack of prevention in the regulations. The global climate changes impose permanent updating of the current principles and norms for regulating the human intervention in the existing infrastructure subject to a climate change impact. Attention should be paid to the changing geodynamic situation and the corresponding human intervention. Neglecting the natural conditions may put at risk structures and facilities that have consumed huge financial resources with all-ensuing-from-this consequences.

Landslide Processes Caused by Human Intervention

The infrastructural routes pass through potentially hazardous sites, in which no landslide processes have been indicated so far. On one hand, a large part of these sites hasn't slumped due to the ecological balance which is maintained by local forest species (Fig.1). The forest vegetation is grouped around the catchment area of the ground waters; it dries the ground and stabilizes the slope with its root system.

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Fig.1: Trees in the upper part of the slope. Human intervention with an embankment for a new railroad

On the other hand, the lower part of the slope is getting wet and remains wet by the nearby overflowing river and accumulated groundwater leaking through the slope (Fig.2). This part does not slump but it can not play a retaining role in case of a slump activated at the head of the slide.

This issue is considered through a case study from the railway doubling project in Turnak-Asparuhovo section near Varna.

Fig.2: The Luda Camchia River overflows and regularly wets the toe of the slope

The new railroad along the upper part of the slope crosses a geological rocky wedge. This wedge is collecting the major part of the groundwater in the region. The works for the railway embankment cause a considerable increase of the active forces which brings about a landslide process (Fig.3). Due to the influence of the river and the ground water flowing through the slope the landslide comprises the whole slope and causes a considerable displacement of the earth bed.

The slumped earth causes swelling of the wet base of the slope thereby reaching a temporary balance state.

Fig.3: Landslide caused by the embankment of the new railway. Trees slide down to the toe of the slope

Engineering Criteria and Measures for Elimination of Human Intervention Consequences and Permanent Restoration of Slope Balance

The concept for slope stabilization measures is subordinated to two main criteria.

The first criterion is that the fragile slope balance should not be broken during the protective works. Therefore, the main protective structure is Wall No.1 at the base of the slope (Fig.4). This wall has been built in stages and it is envisaged to take up all loads during the construction and operation of the protected slope.

The protective works begin with a technological route along the "tongue" of the landslide under the form of a temporary earthfill approach. Beside the construction of piles this approach serves for stabilization of the slope during the execution of the primary protective structure, under the shelter of which the basic construction works will begin.

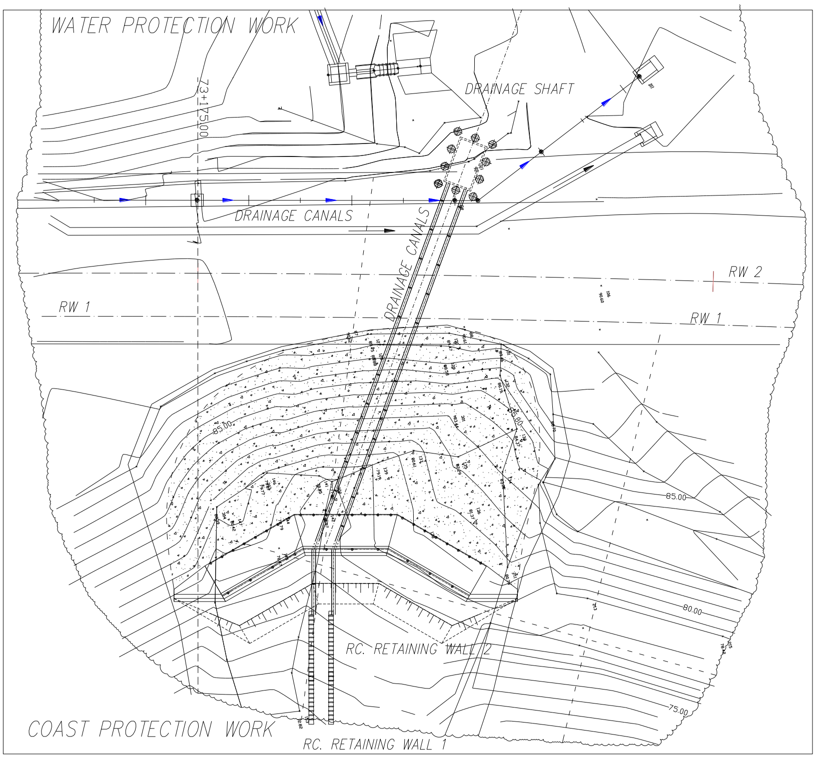

Fig. 4: General layout of the protective works

The earthfill approach is executed with the available slumped material, the prevailing fraction being the rock fraction. The execution of the pile system begins with the primary protective structure, using Ø800 piles at the first row. These piles are longer and have a double function: /1/ temporary support of the landslide body, and /2/ pile foundation of the wall. The second row of piles performs only a foundation function (Fig.5).

The execution of the retaining walls begins with digging down to foundation level under the protection of the longer protective piles.

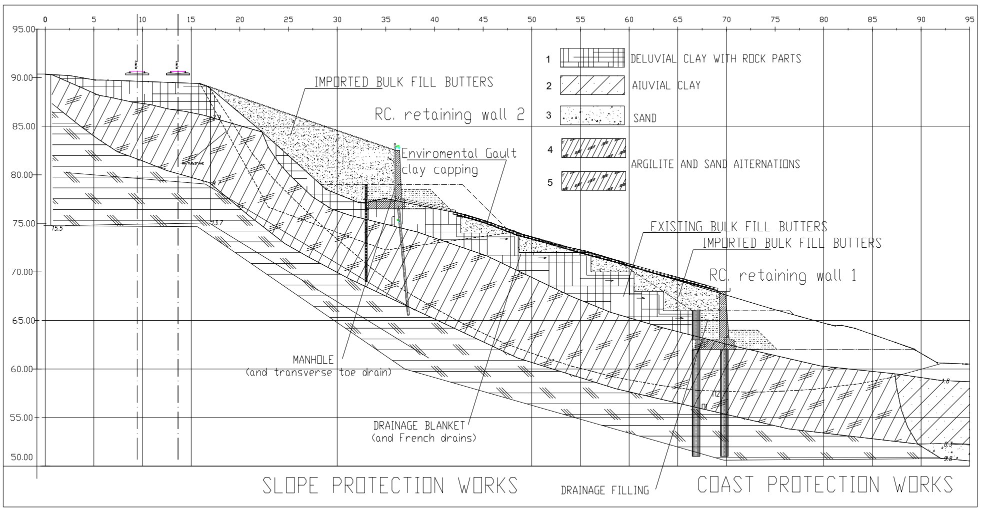

Fig.5: Standard cross sections for slope works – coast protection measures

Before starting the slope change activities, the space between the protective piles and the wall is filled with drain fraction. The slope change is realized through steps made in the slope of the existing earthfill. The steps are 2 m high and have a drain slope of 2%.

After the slope change, the earthfill abutment execution begins. Drainage and water-protective measures are envisaged in the body of the abutment.

The execution of Wall 2 begins after the completion of all kinds of works in relation to Wall 1. Wall 2 is necessary because of three reasons.

The first reason is that its stiffness guarantees the successful operation of the earth bed under route Nr.1 and the width of the necessary bench for disposition of a control post.

The second reason, in comparison to the whole abutment, is that a non-protective digging intervention in the landslide body is avoided, thereby preventing a possible new emergency situation with the slope.

The third reason is that the earthfill works are simplified.

Wall 2 is executed following the same technological sequence like Wall 1. Another temporary road is necessary for the realization of Wall 2.

After the execution of Wall 2 foundation, a working site is formed for the execution of the horizontal drains under the railroad.

The second criterion is the slope to be steadily drained (Fig.6).

For securing the groundwater runoff from the slopes, drainage prisms and perforated PVC pipes have been put within the walls.

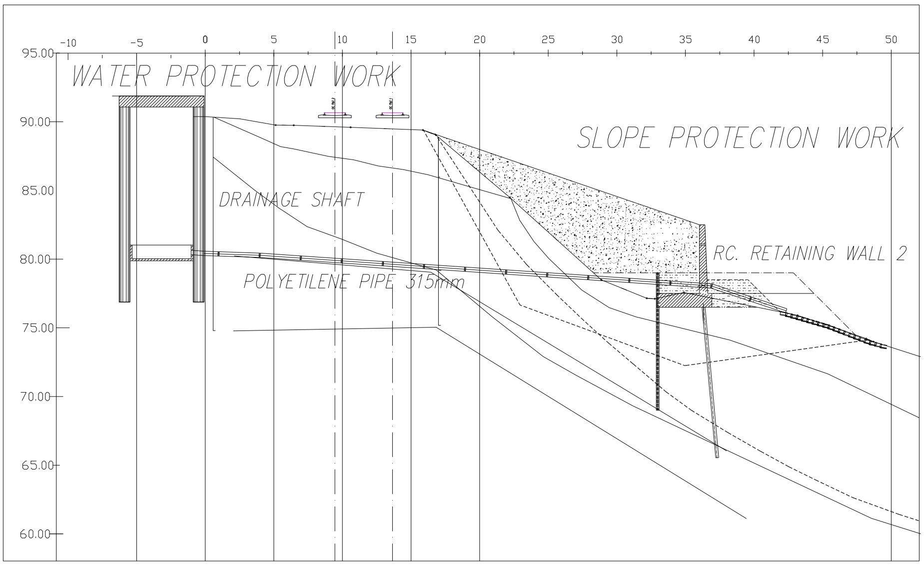

Fig.6: Standard cross sections for slope works – water-protective measures in the upper part of the slope

A drainage system for drying the landslide has been built. The system has three main features.

The first feature is the construction of a preventive linear drainage before water to reach the railway.

Secondly, a linear drainage has been envisaged in the higher located wall.

The third feature is the drainage of deep groundwater through a vertical drain and drain drillings through the embankment body.

The vertical drain is located in the heart of the rocky wedge where an underground catchment area is situated. In this zone, the ground surface is wet, there is water flowing within the landslide even when the adjacent slopes are dry. The vertical drain is necessary because of two reasons: /1/ to provide a water catchment well which will make possible the efficient and long-term functioning of the horizontal drains, and /2/ to create a technologically feasible option for the horizontal drains to be carried out.

Ø315 pipe is necessary for evacuation of water. The second pipe is envisaged as emergency sluice.

When the horizontal drains are ready, the execution of the retaining wall continues. The remaining drain structures are executed before starting the backfill works.

The above measures bring about a restoration of the balance between the increased human intervention and the natural environment.

Global Warming – a Concept for Updating of the Criteria for Preventive Human Intervention in the Design of Geotechnical Structures

The global climate changes are the reason for permanent updating of the current principles and norms for regulation of the human intervention in strengthening the infrastructure subject to the invasion of these climate changes. The rich variety of the natural environment in the country – mountains, plains, rivers – turns to a challenge for us (Fig.7). The climate and the ground conditions demand a new analysis of the situation in order for the forthcoming human intervention to be efficient enough.

The assessment of the situation includes: first, application of scientific approach in the analysis of the new phenomena, and second, it's transposition into design solutions.

Fig.7: Activated landslide along the main railway route Sofia - Plovdiv

The initial moment – making decision for the degree and type of the human intervention should not be based on the information from the mass media. The authorised bodies – investors, geologists and designers – should unite their efforts for elaboration of a policy of prevention, for a specific landslide with specific parameters, geodynamic characteristics and the respective engineering support measures.

There are many cases when the three bodies have carried out successfully their duties. But there are also cases of inadequate from geotechnical point of view solutions which solve the problem for the moment but actually represent a delayed-action bomb, not to mention the capital investments incurred.

The conflict between intentions and realisation derives from the point which should provide safety and perspective for the society – the regulations. They already lag behind from the dynamic of the natural processes thereby working against the timely solution of the problems.

Possibilities for Adequate Response to Disasters

The activated by disasters landslide processes are deepening. The scale of the old landslides is expanding both along the old scarp and at the flanks of the landslide circus. The expanded scale includes new important sites of the infrastructure, water derivations, buildings and structures in the residential areas.

In such unforeseen situation an adequate response is necessary for protecting the affected facilities of strategic importance. There are two main options of response.

The first option is to apply the concept of the total coverage of the landslide. This case comprises the whole landslide circus, including the section of the strategic facility. According to this concept the preparation of a project for strengthening with the necessary degree of safety is possible after studying the whole landslide area. The result of this approach would be a technical concept for strengthening of the growing landslide circus. According to the supporters of this approach the new projects for emergency strengthening should be coordinated with the authors of the studies for the neighbouring regions carried out in the period before the landslide processes expansion. In other words, consultations with a previous contractor for emergency response in the area are advisable.

Such concept although seeming reasonable at first sight, turns to be not viable due to three main reasons.

First of all, this concept is financially unfeasible. For example, in order to save a pipeline for pumping out water from the mine shown on Fig.8 it is necessary to allocate resources for studying the territory of the whole mine and to prepare a general technical concept for strengthening. Most probably, the pipeline will slide down and the operation of the mine will be interrupted. A similar situation is the strengthening of a trunk main (Fig.8). The option for an overall study and support of the slope will endanger the water supply of the city.

Secondly, a shortcoming of the overall study option is the fact that it incorporates terrains with different geological structures. This circumstance would require quite specific engineering solutions.

Thirdly, from managerial point of view, no one has rights on the choice of the team for carrying out emergency measures, which has been set up as a result of a tender procedure.

The continuously expanding landslide zones which cover large mountain areas reduce the efficiency of projects comprising the whole landslide, i.e. the mountain. Obviously, the changing geodynamic situation imposes changes in the concepts and regulations for human intervention. A system of new and adequate assessments for the scale and efficiency of the human intervention should be elaborated.

The new adequate assessment of the efficiency and the degree of the human intervention is supported in the paper by the second option for efficient protection of the strategic-for-the-economy "weak points".

Fig. 8: Landslide caused by water pressure on the slope of an open mine

First of all, the areas of current and possible future landslides which could affect the mine are subject to emergency studies. The mine slope has to be unloaded through **re-sloping**, while the landslide process along the trunk main is terminated through strengthening.

The human intervention in the case of the trunk main can be realised with the help of the measures mentioned below.

In order to find out the reasons for expansion of the geodynamic processes in the facility area, a local geological study is performed and an effective situation of the anti-slide structure is chosen. In this particular case (Fig.9) it is at the base of the earthfill prism where the trunk main has been laid.

The following step is the design of the support structure which should prevent the deformation of the main. The data from the geological report are used as a basis for designing the structure, taking into account the actual degree of additional watering from the slope water and the consequent new landslides.

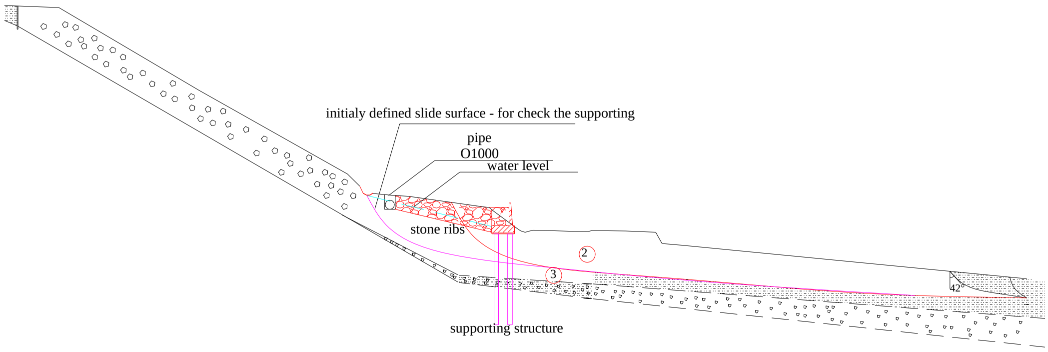

Fig. 9: Design model and detail of trunk main protection in Gabrovo, Bulgaria

The additional watering alters the geological conditions. In order to eliminate the engineering risk a new solution of the stability is imposed taking into account the additional landslides in the watered area. The solution in this radical way makes it possible the sliding force for designing the support to be determined in case the foundation zone of the main is affected by slide phenomena. In this particular case the sliding force is increased 2-3 times compared to the data in the geological report which do not take into account the consequences from the accumulation of watering.

As an inference of all these steps we can be sure that in this boundary case the support structure is reliably designed and anchored, and no new slide processes will be developed in the zone of the main. Besides, the increased earthquake masses which correspond to the mentioned boundary case are a proof for the adaptability of the support to the deepening problems of the global climate, the increased seismic activity being one of them.

Conclusion

The human intervention during the construction of a new railway has disturbed the natural equilibrium and caused a landslide.

The analysis of the measures envisaged for sustainable stabilization of the slope indicates that in case of preventive strengthening the costs can be considerably reduced. These preventive measures represent drainage of ground water from the **stone wedge** and supporting activities in the zone of the road side. This means safe parameters of the human intervention in the construction of the railway and avoiding the disturbance of the balance at the slope.

An alternative has been presented for the facilities to be protected against sliding. During the design it is necessary additional problems with the stability to be considered in relation to the engineering risk and the technology for execution of the support structures.

The delay in amending the regulations and the negligence of the natural conditions will result in large investments without a sustainable effect. This means that the society looses.

References

1. EUROCODE 7, 8.
2. Zhechev N., Optimal Parameters of the Human Intervention in the Landslide-type Natural Processes, National Conference “State and Management of Landslide and Erosion Processes in Bulgaria”, Dec. 2006, Prof. M. Drinov Publishing House, Sofia.
3. The projects in the examples are designed by the author.

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Ecological optimization for complex melioration of heavy clayer alkaline saline

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Abstract

The problems of root melioration of heavy clayey alkaline saline by means of the complex method application influence on the soil foreseeing combination, physical-mechanical, chemical and hydrodynamics methods are examined in the article. The necessity of change calculation occurring on soil environment with the purpose of elucidation conditions of the ameliorative effect, that or other method, for the worst influences on soil-thickness, and also establishment of synergetic effect, when in joint realization of the measures, their effectiveness increased in the most measure, important in melioration of heavy clayey saline. It is investigated physical, chemical and hydrodynamic nature of changes occurring in soil environment with the mixed structure for the complex melioration, mechanism of the swelling and limiting conditions in the process of swelling and limiting conditions in process of swelling formation are revealed. It is confirmed essential theoretical reasons about a differential connection between soil swellings with the absorption of its moisture; it is offered a formula for the calculation of the soil swelling volume. It is offered a theoretical condition for the observation of which washing of heavy clayey swollen saline becomes possible, it is introduced a notion of the soil real porosity for the evaluation of its physical condition after swelling. Three new physical parameters are proposed for the characteristics of the changeability of the physical condition of soil environment with the mixed structure: for the evaluation of the invasion scale in soil environment of the natural addition for the cultivation of soil friability index (K_f), a relative importance of this invasion to the swelling–coefficient of real porosity (K_a), for comparative evaluation of water rate in interaggregate and inside aggregate average coefficient of the relative stability of the velocity (rate) (K_c) and it is proposed a formula of washing norm calculation for the complex melioration with the use of these physical parameters. The necessity of the process of salting out in the period of soil mastering under agriculture achieves the introduction of the notion of the upper limit of economically grounded permissible salt maintenance, defining with the calculation of salt stability of cultures assimilator with the application of zero balance method, worked out on the basis of the principles of the agro ecological optimization of land melioration.

Keywords: Swelling, complex melioration, heavy soils.

Introduction

In the measure system directed to the sanitation of the ecological situations, irrigated territories exposed to the second (irrigation) salting–formation of solonchaks, the central leading place belongs to such from them as soil melioration. In the contemporary stage of the agricultural production on the basis of the private

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sector, its requirements satisfaction and fertility increase are key, decisive. In Azerbaijan conditions, an irrigated territory, where is appreciated intensive technology of the plant growing is Kur-Arazsin lowland. 60 % of the lowland territory belongs to heavy soils with high maintenance of Na in the composition of IEC and with different degree of salting (Abduev, 1968).

The formation of solonchaks of autropogen origin is connected with the construction, water economical structures, in main after the military period. The construction of reservoirs, irrigated channels without revetment, collector-drain system with a great retardation, also an application of the plentiful watering on furrow without proper planning of territory, promoted sharp development of the level of subterranean waters and salting flood–land soils of newly irrigated territories. Salinization gives to these soils quantities which make impossible an application of the extensive methods of melioration, from high swelling. For this reason solonchaks of the natural origin do not introduce an agricultural revolution and on this day, the reason which is their hard meliorating conditioned by low natural permeability. Heavy clayey swollen soils possess special agro physical quantities. In consequence of these specific qualities their introduction an irrigated economy was separated.

Material and Methods

The ground and theoretical basis of the problems

For the assimilation of the heavy clayey swollen saline solonchaks demanded special, differential approach must be observed a principle of the ecological optimization of land melioration, foreseeing the best agreement of the practice of the economical problems solution with the nature law (Volobuyev, 1963; 1981).

The elucidation of the conditions of the most ameliorative effect of one or another method acquires a special importance for relatively the worst influence on soil-subsoil thickness, also synergetic effect establishment, when in computable realization of the measures, their effectiveness rises to the most degree. The last, follows from the essential agromeliorative, chemical and complex methods applicable for washing of heavy clayey salt soils with the purpose of their root melioration. Every ameliorative method in a different degree accelerates process of soil washing. It is discovered a possibility of the further intensification of the salt leaching process, if accounting thinner physical-mechanical, chemical and hydrodynamic changes and reversible processes occurring in soil environment during washing. Soil washing is physical-chemical process, the velocity which is controlled by hydrodynamic effect of water (Rode, 1965; Zlochevckaya, 1969; Voronin, 1986; Suleymanov, 2002). So the receipt of maximum ameliorative methods including agromeliorative, agrochemical and hydrodynamic methods is a complex (Suleymanov, 2002, 2005).

It is possible for the differentiation of the application methods with the specific quantities of heavy clayey solonchaks in application of the approach including the following:

- Physical influence on soil with the purpose of the neutralization of the negative effect of soil swelling for melioration, with the purpose of the preservation of active (upper) layer water permeability till washing end;
- The chemical influence on soil with the purpose of salinity neutralization and structural soil condition preservation, be means of the application of chemical meliorant, after soluble polymer and etc;
- The hydrodynamic influence on soil with the purpose of water velocity optimization giving to washing for the intensification of leached effect of the washing norm.

The main prevention complicating melioration situation is heavy clayey soil swelling for moistening. The natural coefficient of filtration of similar soils $K_f < 0.3$ m day^{-1}. In the condition of Siazan-Sumgait massif this index is close to zero (0.08–0.01 m day^{-1}). For the neutralization of the negative effect of swelling applies a deep friability, physical maintenance of which consists in creation of the additional free spaces, promoting the soil environment with the mixed structure. Namely such structure possesses reserve potential to react to the change of the soil physical condition during swelling and preservation of environment water permeability for washing. The role of porosity for melioration of heavy clayey swelling soils is great because occurring water permeability thanks to porosity is found in direct dependence from its volume and qualitative accessories. The last s conditioned by that, not all soil pores are equally drawn in the process of filtration, the role of free pores is great, strangely changing decrease apart in result of soil swelling. On this reason it was offered to the author to introduce a notion of real porosity, because it gives opportunity to more completed calculation of the changes occurring in pore space of soil layer of mixed structure.

For the evaluation of real porosity it is convenient to use of parameters giving opportunity to fix changes of free pores volumes in the cycle of friability-swelling. By the Knowing volumes of the created additional free pores of the cultivation (V_r) and swelling of soils (V_s) it is possible to calculate volume of real porosity (ΔV) providing water supply.

$$\Delta V = V_r - V_s \quad (1)$$

By limiting condition for which it is preserved water permeability of swelling dispersion environment the mixed structure is where

$$V_r = V_s + \Delta V \quad (2)$$

But for inviolable soil environment real porosity

$$V_r = V_a - V_s \quad (3)$$

Where V_a – active porosity of soil, %

Hence, real porosity – it is residual part of free porosity of soil environment after swelling, equal difference of active porosity and swelling volume.

Hence follows that volumes of additional pores created by mechanical cultivation, must be more volumes of soil swelling:

$$V_r > V_s \quad (4)$$

By the author, the inequality is called theoretical condition of melioration (watching) of heavy clayey solonchaks. And indices for the comparison of different versions it is necessary to introduce coefficient of real porosity (K_r), possessing ratio of summary quantity of free pores (V_a), to soil swelling volume:

$$K_r = V_g V_s^{-1} \quad (5)$$

And indices of soil loosening defining ratio of residual volume of free pores of soil common porosity of the natural addition

$$K_a = \Delta V P_p^{-1} \quad (6)$$

The introduction of these parameters gives opportunity to compare different methods, kinds, schemes of soil cultivation on the quantity of created free pores and promote adoption scientific-grounded, radical ameliorative method of swelling soil washing.

By the limiting condition for the selection of soil cultivation method a determination of the optimum correlation is between volume of swelling and free pores of the created cultivation, so there is a correlation between called parameters must satisfy condition requirement.

$$V_r V_s^{-1} \geq 1 \quad (7)$$

The chemical method of melioration is applied with the purpose of neutralization of free soda and substitution in soil–absorbed a complex of sodium in hydrological salts of iron and aluminum. Long since sour wastes are applied for melioration of saline alkaline soils. Iron as high-valets caution with high electrokinetic's potential and as ion and colloid electrolyte, degidrates hydrophilic soil colloid, thereby improves ameliorative quality of saline alkaline soils.

The combination of deep friability with bringing of chemical ameliorants creates an additional condition for the acceleration of exchange reactions between soil solution and IEC. In result, all 80 cm of soil thickness is found for simultaneous chemical influence of meliorante. This condition promotes increase of leached effect of washing norm in s few orders. The leached effect of water passing over soil layer depends on solution rate in pores. Mechanism of filtration effect is that for salt solution motion under the influence gradient of the pressure in layers convectional stream of ions appears with concentration different from the volume, which provokes a change of ion concentration along stream (mechanic-concentration division of ions, Pakshina, 1980). Diffusiofeoretical stream, appearing under the influence of diffusion potential is directed to meet stream under the influence of hydrostatic pressure gradient (Kemper, 1972), meets with low water permeability and delays washing for heavy soils washing (Pakshina, 1980).

For solution penetrating under the pressure it is occurred carving out of caution surplus from absorption surface soil in the direction of stream (convectional stream of ions), forms difference of potential of diffusion origin. Under the influence of the formed difference of potential (diffusion potential) liquid moves in the opposite direction (osmotic potential), decreasing volumetrically stream rate. The difference of potentials increases, until convectional stream of ions doesn't become equal to osmotic one or till streams of anions and cautions don't become equal (Pakshina, 1980).

The theory of solution filtration over soil and movement of salts for this shows more important, regulation of liquid rate for washing with the purpose of receipt of synergetic effect of complex melioration.

The created mixed structure of soil stipulates difference of the pressure applying structural elements, from their finding depth. So, a process of salt displacement from the sample being on the surface occurs under the pressure of water layer is equal to water thickness in the cheque (0.15-0.2 m), in the depth of 80 cm it occurs under the influence of water layer is equal to 0.95-1.0 m.

It is necessary to introduce parameters giving an opportunity to differ processes occurring in interaggregate and inside aggregate pore space in the profile of soils with the mixed structure. Such is a coefficient of the relative stability of rate–K_{gr} offered by the author for stream rate characteristics is additional free pores, created soil cultivation.

$$K_{sr} = V_{sr} V_a^{-1} \tag{8}$$

Where, V_{gr} – rate of stream in free pores under the pressure of the definite depth of soil cultivation and water thickness in the cheque, m day^{-1}, (is defined in the field conditions); V_a – a rate of stream inside aggregate, m day^{-1}(is equal to K_f soil of natural addition).

Results and Discussion

The complex melioration methods, promoting got of the most melioration effect, are based on the creation and preservation of soil layer with the mixed structure by means of cultivation and bringing of chemical meliorants at the same time. For this a great influence on coil leaching acceleration shows vibroripper. As shown results of the investigations at the expense of additional–interaggre-gate of free pores creating vibroripper, volume of gravitation streams increases till 10-12 %. The creation of the conditions with the help of agromeliorative methods of soil cultivation for the washing of heavy clayey solonchaks is an intensive method. But unstructurally of similar makes impossible to stabilize high rate of soil distilling, observed at the begging of the washing, till completion of meliorative measures the loosened layer of soil settles, but for the feeding of the following portion of the washing out norm. Eroded fraction by water from upper layer of soil is mixed down on the profile stopped up newly created free pores. It is occurred relaxation of soil, water permeability and leaching of salts between tact's of washing is sharply decreased. With the purpose of the preservation of the mixed structural soil condition till washing and soil cultivation method is applied after loosening by weak solution of polymer VO syntesing in Polymer (Baku). The author in the industrial conditions investigates different complex method in the phone of tillage, loosening and Vibroripper. The comparative analysis of the washing results on salt intensify and leaching effect of washing norm is a main problem of soil melioration, especially for melioration of heavy clayey solonchaks. The definition of more effective version of the experiment with the indicatory position shows preference of vibroripper: its combination with bringing of structure-polymer of VO creates a synergetic effect for the further increase of salt leaching. The stabilization of leaching-salt quantity between washing tact's is a condition of getting maximum meliorative effect as compared with rest intensive complex methods of washing. So, if in the control version 1 m^3 the water giving to washing from metric layer leached 7,62 kg salts, so quantity of this index for the version vibroripper + polymer VO forms 30,8 kg, leaching effect of washing water at the expense of intensification of washing, increases more than 4 times. But in the version of washing with bringing OMA salts are removed 3,6 times more than in the control version (Table 1).

Table 1. The indices of effectiveness of washing complex melioration

No. versions	The experiment version: Cultivation kind	The experiment version: Chimeliorant	Washing duration, day	K_f, m day^{-3} x 10^{-3}	Washing effectiveness: Relatively control	Washing effectiveness: On leaching effect water, kg m^{-3}
1	Plowing	Without chimeliorant	186	5.9	1.0	7.62
4	Plowing	OMA	81	13.6	2.30	10.31
5	Ripper	OMA	41	26.8	4.54	27.73
6	Vibroripper	OMA	28	39.3	6.66	23.17
7	Plowing	VO	46	23.9	4.05	18.27
8	Ripper	VO	45	24.4	4.12	20.30
9	Vibroripper	VO	24	45.8	7.76	30.80
13	Plowing	Gaja-manure	76	14.4	2.44	15.23
14	Ripper	Gaja-manure	50	22.0	3.73	15.08
15	Vibroripper	Gaja-manure	48	22.9	3.88	13.20

The calculation of washing norm for soil distilling for melioration is main index. Different formula of calculation existed (Averyanov, 1970; Volobuyev, 1975 and others). For the determination of acceptability formula application for the complex melioration, it is necessary to expose the comparative analysis of physical, chemical conditions of soil environment to the natural and subjected structural change and chemical cultivation. The absence of their application is added from the following theoretical reasons and basis. The existed formulas of washing water calculation are formed for soil environment of natural addition, so its insane is received till washing end then from half-functionality of soil environment it is occurred different physical, physic-chemical processes, among which, and reversible, such as swelling-shrinkage, a changement of saline type for washing, relaxation-condensation, loss of organic part of soil and etc. conditioned soil filtration ability changeability. The complex meliorative method of washing provide combination of chemical meliorants with soil deep cultivation; theoretical essence of which is soil environment creation with the violated capillary connection with additional pore space neutralizing negative effect of soil swelling and salinity by means displacement from IEC of absorbed No. demands formula of the considered dynamical reversible processes occurring in the scale of cultivation-swelling relaxation of soil.

The mathematical model of washing norm calculation for complex melioration of heavy clayey swelling salinity-solonchaks offered by the author, takes into consideration aforesaid changes of soil environment during washing. The calculation of changeability is provided by parameters K_r, K_a .

$$N = \ln\left(S_{ic} S_{op}^{-1}\right) + K_{rp} - \mu gherfc\left(1 - K_r\right) \tag{9}$$

Where, *N*- washing norm, net, m; S_{ic} – initial calculated maintenance of salts in soil with the calculation of bringing chemical meliorant, % ;

$$S_{ic} = S_i + \Delta S_i \tag{10}$$

S_i – initial maintenance of salts in soil; ΔS_i – increase of salt supply in soil at the expense of bringing meliorant; S_{op} – upper limit of permissible salt keeping, %

$$S_{op} = S_o + \Delta S_o \tag{11}$$

S_o – permissible limit of salt keeping, %; ΔS_o – increase of permissible salt keeping at the expense of changes of soil salinity type during washing; K_{rp} – coefficient of real increase; K_r – index of soil friability; *g* – acceleration of free determination 9.8 cm c^{-2}; *h* – soil cultivation depth; μ – coefficient characterizing soil environment with mixed structure is defined in dependence of cultivation changeable techniques.

Parameters including in the formula characterize physical, chemical and hydrodynamic changes occurring in soil environment with changes occurring in soil environment during cultivation and soil swelling, reflecting scales of invasion and quantities mark of porosity get into the first group. Parameters S_{ic}, S_{op}, ΔS_o characterizing quantitative and quantitative changes in salt structure and change of salinity type during washing belong to the 2nd group. Parameters *μ, g, h* which characterize hydrodynamic pressure turning out to be in soil layer with mixed structure, conditioned stream kinetic ness belong to the 3rd group. Approbation of formula is realized in the experiments carried out in the territory of cones of carrying out of Geokchay Shirvan steppe of Kur-Araksin lowland in the industrial conditions in the area of 10 he. Result of the investigations are put in table 2.

Table 2. Calculated and actual norms of washing for complex melioration

No versions	Experiment version		K_a	K_r	Washing norm, $m^3\ he^{-1}$		Relative error %
	Cultivation kind	Chimeliorant			Actual	Calculation	
5	Ripper	OMA	0.10	1.425	20160	18210	9.60
6	Vibroripper	OMA	0.27	2.165	9640	8895	7.70
8	Ripper	VO	0.10	1.425	15440	14970	3.10
9	Vibroripper	VO	0.27	1.165	10470	11209	7.05
14	Ripper	Gaja-manure	0.10	1.425	16640	13420	18.0
15	Vibroripper	Gaja-manure	0.27	2.165	15920	17310	8.30

The relative error between calculated and actual significance of washing norm with the exception of 14th version, forms 3.1-9.6%. It confirms fitness of formula for the calculation of washing norm for complex melioration. But the divergence in 14th version is connected with difficult dissolubility of changeable chemical meliorant. Gaja in combination with manure of doze bringing 40 t he^{-1}, influences on the residual salt maintenance and on investigation results (Gaja on composition maintains 55-60 % of gypsum, but the rest $CaCO_3$). The preference of formula is that parameters entering its structure are determined in the physical areas till melioration. This makes it simpler in the application in practice, but process of washing controlling with setting parameters.

Conclusion

Soil washing is a physical-chemical process, the speed of which is controlled by the hydrodynamic action of water. To obtain maximum synergy must use a method of complex land reclamation by the best combination agromeliorative, agrochemical and hydrodynamic methods, according to the principles of "ecological optimization of land reclamation" provides as follows:

- A physical effect on the soil, creating a horizon in the upper layer of soil with a mixed structure with complementary inter-aggregate pore spaces, quantitatively more swelling volume of soil,
- Chemical effect on the soil, in order to neutralize the alkalinity of the mixed structure, and fastening by the use of chemical and water-soluble polymers meliorate, having aftereffect as fertilizers,
- Hydrodynamic effects on the soil, in order to optimize the rate of filtration of water during washing, to enhance the leaching of the effect of washing the norm.

For a full accounting of variability of the structural state of the soil environment with relaxation and reversibility of chemical processes affecting the filtration properties of the soil, proposed new parameters characterizing the soil environment with a mixed structure: for estimating changes in soil environment with the natural structure of the processing component looseness of the soil – K_r, coefficient real porosity – K_{rp}, to compare the speed of water in the intra- and inter-aggregate ratio of the relative velocity of the medium – K_s. A formula calculation wash standards for integrated irrigation, using these physical parameters.

References

Abduev, M.R., 1968. Diluvial soil salinity forms and questions of their reclamation Baku, "Elm", 275 p.

Averyanov, S.F., 1970. Workshop on agricultural reclamation Moscow, "Kolos", 343 p.

Pakshina, S.M., 1980. Movement of salts in the soil. Moscow, "Nauka", p. 119.

Rode, A.A., 1965. Foundation of Studies about Soil Moisture. Leningrad: Hydrometrologycal publishing house, p. 663.

Suleymanov, N.R., 2002. Evaluation Criteria of physical condition of swelling soils with mixed structure. Thesis of Lectures of All-Russian Conference. “Stability of soils to the natural and man impact”, Moscow: p. 44-45. (in russian)

Suleymanov, N.R., 2002. Conception of True Porosity and its Evaluation in Swelling Soil Sphere with Mixed Structure. Thesis of Lectures of All-Russian Conference. “Stability of soils to the natural and man impact”/ Moscow: p. 115. (in russian)

Suleymanov, N.R., 2005. Explanation of Moisture Movement in Soil from Position of Changeability of Dispersion Medium and Reversibility of Processes / Proceedings of II Conference of Society of Soil Scientists of Azerbaijan, v. XVI, part. II, Baku, p.344-350, (in azeri).

Volobuev, V.R., 1963. Soil Ecology - Baku, Elm, 259 c.

Volobuyev, V.R., 1975. Calculation of flushing saline soils. Moscow, "Kolos", 71 p.

Volobuyev, V.R., 1981. Some philosophical questions of Soil Science. *Pochvovedenie* 2, 5-11.

Zlochevckaya, R.I., 1969. Bound Water in Clay Soil. Moscow: MSU Lomonosov, p. 174.

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Effect of arbuscular mycorrhizal fungi on phosphorus uptake by tall fescue in a cadmium contaminated soil

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Abstract

Arbuscular Mycorrhizal Fungi (AMF) as soil inhabitant microorganisms help plant species uptake water and nutrients and make physiological changes to increase growth and productivity of host plants in stress environments. Heavy metal pollution of soil is a significant environmental problem which inhibits plant nutrients uptake and ceases normal plant growth. In this study, the symbiotic effect of AMF was examined on phosphorus uptake by tall fescue, as an essential nutrient that increases shoot and root biomass, in a soil contaminated with different concentrations of cadmium. A greenhouse pot experiment was conducted in which plants were grown in plastic pots (17×25 cm) containing silty-clay soil contaminated with five ratios of cadmium including 0, 5, 10,15 and 20 mg Cd per kg of dry soil. Potted soil was also inoculated with *Glomusmosseae* mycorrhizal fungus (100 g standard inoculum per pot) in 3 replicates before planting to compare with those remained un-inoculated. Tillers were separated from a tall fescue (*Festucaarundinacea*) genotype collected from a natural rangeland and five tillers with the same size were planted in each pot. Pots were arranged according to a completely randomized design and kept in a normal greenhouse and watered when needed during about three month of experiment. The results showed that cadmium contamination decreased phosphorus uptake in shoots and roots of tall fescue. The highest and lowest concentration of phosphorus was measured in soil containing 0 and 50 $mgkg^{-1}$ of Cadmium, respectively in both shoots and roots of tall fescue. Colonization of roots by *Glomusmosseae* mycorrhizal fungus had also significant and positive effect on increased uptake of phosphorus in roots and shoots of tall fescue compared to un-inoculated treatments. It seems that AFM may mitigate toxic effects of heavy metals on the plants possibly through improving absorption of some nutrient macro elements.

Keywords: Mycorrihzal fungi, *Glomusmosseae*, Phosphorus, Tall fescue, Cadmium.

Introduction

A metal-stressed environment can be defined as heavy metal contamination in soil which is one of the world's major environmental problems, posing significant risks to human health as well as to ecosystems [1]. To encounter with stress environments, there has been considerable interest in the potential use of arbuscular mycorrhiza in agricultural systems. Arbuscular mycorrhizae (AM) represent an almost ubiquitous relationship between soil microflora and plants [2]. The fungal symbiont increases its host's uptake of nutrients and can improve its growth and resistance to environmental stresses [2]. Experiments have shown that the

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mycorrhizal effect can be explained by mechanisms such as enlargement of the absorbing area and volume of accessible soil, decreased soil pH near the fungal hyphae due to exudation of organic acids and absorption of chemical ions [3].

Heavy metals affect plants growth, cause structural damage and disturb nutrients uptake [4]. Heavy metals may also decrease available contents of soils mineral nutrients [5] by inhibiting the mineralize processes and the litter decomposition rate in ecosystems [5, 6]. In contrast, growth stimulation, better mineral nutrition and lower heavy metal uptake are among the benefits of mycorrhizal plants growing in soils with excessive levels of metals [7, 8]. Also, Arbuscular mycorrhizal fungi (AMF) are known to improve plant growth on nutrient-poor soils and enhance their uptake of P, Cu, Ni, Pb, and Zn [9, 10].

The function of all mycorrhizal systems depends on the ability of the fungal symbiont to absorb inorganic and/or organic nutrients available in [11]. In addition, organic carbon derived from photosynthesis is transferred to these symbionts, as biotrophic microorganisms, and this substance maintains the development of spores and fruit bodies in most mycorrhizae types by translocation of the substance to the growing margins of the extraradical mycelium [3]. Therefore, the importance of AM is due to its great capability to increase plant growth and yield under certain conditions. The major reason for this increase is the ability of plants in association with AM to uptake some nutrients such as phosphorus [12]. As a result of this symbiotic association between AM fungi and host plants, increase in P content also has an effect on physiological parameters of plants like the rate of increase in photosynthesis [13]. In fact, phosphorous has an important role as an energy carrier during photosynthesis [14]. The objective of this greenhouse investigation was to evaluate the influence of AM infection on the uptake of P by tall fescue compared to un-inoculated treatments in a contaminated soil.

Material and Methods

Pot Experiment : The soil was collected from the depth of 0-20 cm in Saman located in Shahre-kord, ChaharmahleBakhtiari, (N: 50°49′;E: 32°24). The soil was air dried and passed through a 2-mm sieve and analyzed for the physical and chemical properties [15]. shown in Table 1. Also, air-dry soil was passed through 4 mm sieve and sterilized at 121 °C at 15 psi (lbf/in2) for 20 min using sterilizer to ensure complete removal of naturally occurring AM fungi and its spores [17]. After sterilization, the soil was spiked with three Cd addition levels (Blank, 5, 10, 15 and 20 mg kg–1) applied by an analytical grade cadmium chloride ($CdCl_2.H_2O$) solution mixed thoroughly with 3 kg soil of each pot. The solutions were prepared in deionized water. Treated soil was poured into plastic pots (with a height of 25 cm and diameter of 17 cm).

Table 1. Chemical and physical characteristics of the soil

Texture	pH	EC (ds m^{-1})	OM (%)	P[a]	K[a]	Total Cd (mg kg^{-1})
Siltyclay	8.2	0.9	0.963	15	280	3

[a] The data for Phosphorous and Potassium concentration are given as available content (mg kg^{-1}).

A tall fescue (*Festucaarundinacea*) genotype collected for a natural rangeland of Iran was clonally propagated and used in the present study. Mycorrhizal inoculum was prepared through the trap culture with maize and spores of *G. mosseae*. In mycorrhizal treatments, 100 g of *G. mosseae* inoculum was added to each pot at sowing time in 2 depths just below tall fescue roots and 5 cm below the soil surface.

After a growth period of three months, shoot and root in each pot were harvested separately and measured. Subsamples of fresh roots were taken to assess root colonization rate. Dry weight of roots and shoots was also measured after drying at 65°C for 72 h. The percentages of root fungal colonization was estimated according to the gridline intersect method [17]. The dried tissues were also digested using nitric acid to determine total Cd content according Bremner and Mulvaney [18].

Determination of P content: The P content of root and shoot sample was determined according to Bartels and Bigham [19].

Statistical analyses: All data were subjected to statistical analyses using SAS software package (version 9.0). Means were calculated and compared using least significant difference test (LSD) via SAS software and statisticalsignificance was determined at 5%.

Results and Discussion

The effect of Cd and mycorrhizal treatments on shoot and root P uptakewas significant but their interactions were not significant. P uptake in shoot and root decreased as the levels of soil Cd increased (Fig. 1). The presence of *G. mosseae* significantly increased P uptake in root and shoot of plants compared to those grown without AM fungi (Fig.2). Mycorrhizal plants can absorb more P at lower concentration in the soil solution than non-mycorrhizal plants, as shown by Plenchette and Morel [20] for soybean. One possible explanation is that mycorrhizal hyphae have a higher affinity for P than plant roots [21]. The previous studies have shown that the positive results of Am fungi maybe attributed to the improvement of plant nutrition and water uptake [22].

The plant protection against Cd toxicity in plants inoculated with AMF may also occur indirectly by enhancing plant nutrition and increasing plant growth resulting in a diluting effect of Cd in the plant [23]. This study may show that the roots of plant inoculated with AMF had high ability to take up P and Cd from the soil and transfer to aerial parts of plants. This may help in phytoextraction and decontamination of Cd in contaminated soils.

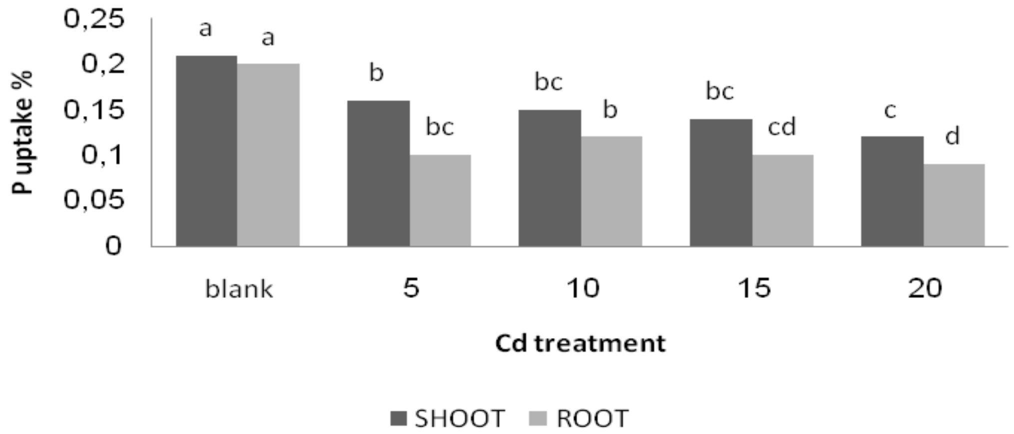

Figure 1. Effects of different levels of Cd on P uptake by Tall fescue.
Different letters above the bars indicate significant difference among means according to LSD at 5% level

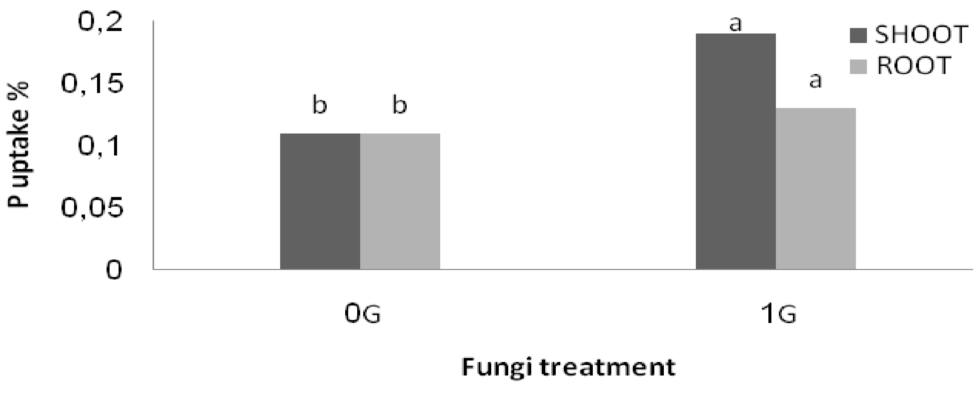

Figure 2.Effects of mycorrhizal inoculation on P uptake by tall fescue. G0=un-inoculated plant G1=inoculated plant with AM fungi, Different letters above the bars indicate significant difference among means according to LSD at 5% level

Conclusion

The present study showed that mycorrhizal inoculation can improve the growth of host plant due to alleviation of metal toxicity in the soil. It seems that AFM may mitigate toxic effects of heavy metals on the plants possibly through improving absorption of some nutrient macro elements like phospurus.

References

1. Miransari, M., 2011. Hyperaccumulators arbuscular mycorrhizal fungi and stress of heavy metals. Biotechnology advances 29(6), 645-653.
2. Smith, S. E., & Read, D. J., 2008. *Mycorrhizal Symbiosis*. Academic Press, London, UK.
3. Smith, SE., Read, DJ., 1997. Vesicular-Arbuscular Mycorrhizas. In: Smith SE, Read DJ, (Eds.) Mycorrhizae pp. 9-61, Academic Press, London.
4. McGrath, S.P., Zhao, F.J., and Lombi, E., 2001.andrhizosphere processes involved in 13 phytoremediation of metal-contaminated soil . 232, 207-214.
5. Derome, J., Lindroos, A.J., 1998. Effects of heavy metal contamination on macronutrient availability and acidification parameters in forest soil in the vicinity of the Harjavalta Cu-Ni smelter, SW Finland. Environ. Pollut .99, 225-232.
6. Ruhling, A., Baath, E., Nordgren, A., Soderstrom, B., 1984. Fungi in metal-contaminated soil near the Gusum Brass Mill, Sweden, Ambio .13: 34-36.
7. Weissenhorn, I., Mench, M., Leyval , C., 1995. Bioavailability of heavy metals and arbuscularmycorrhiza in sewage sludge-amended sandy soil. Soil Biol. and Biochem. 27, 287-296.
8. Loth, F.G., Höfner, W., 1995. Einfluss der VA-mykorrhiza auf die Schwermetallaufnahme von Hafer (*Avena sativa* L.) in Abhängigheitvom Kontaminations grad der Böden, ZP flanzenernaehrBodenk. 158, 339-345.
9. Khan, A. G., Kuek, C., Chaudhry, T. M., Khoo, C. S., Hayes ,W. J.2000. Role of plants, mycorrhizae and phytochelators in heavymetal contaminated land remediation. Chemosphere .41,197–207
10. Zhu, Y. G., Christie, P., Laidlaw ,A. S., 2001. Uptake of Zn by arbuscularmycorrhizal white clover from Zn-contaminated soil. Chemosphere.42,193–199
11. Marschner, H., Dell, B., 1994. Nutrient uptake in mycorrhizal symbiosis.Plant and Soil .159, 89-102.
12. Podila, GK., Douds, DD., 1984. Current Advances in Mycorrhizae Research (Eds).APS Press, St. Paul 2001.Johnson CR. Phosphorus nutrition on mycorrhizal colonizati on photosynthesis, growth and nutrient composition of Citrusaurantium. Plant and Soil 80, 35-42,
13. Paradi, I., Bratek, Z., L.ng, F., 2003. Influence of arbuscularmycorrhiza and phosphorus supply on polymine content, growth and photosynthesis of Plant agolanceolata. Biologia Plantarum 46,563-569.
14. Jacobsen, I., 1991. Carbon metabolism in Mycorrhiza. In: Burrock H, Mosser J, eds. Methods in Microbiology pp. 23, 149-180. Academic Press.
15. Gee, G.W., Bauder, J.W., 1986. Particle saize analysis. Pp, 383-411. In : A. klute(ed) methods of soil analysis . part 1-(2nd – ed) agron. Mongr.9. ASA and SSSA, Madison, WI.
16. Agely,A.A., Sylvia, D.M., Ma,L.Q., 2005. Mycorrhizae increases arsenic uptake by the hyperaccumulator Chinese brake fern (Pterisvittata L.), J. Environ. Qual. 34 2181–2186.
17. Giovannetti, M., Mosse, B., 1980. An evaluation of techniques for measuring vesicular-arbuscularmycorrhizal infection in roots. New Phytol. 84, 227–230.
18. Bremner, J.M., Mulvaney, C.S., 1982. Nitrogen-total. In: A L Page, R H Miller, D R Keeney(Eds). Methods of soil analysis, Part 2-Chemical and microbiological.
19. Bartels, J.M., Bigham, J.M., 1996. Method of soil analysis. Part 3. Chemical methods. SSSA. Medison, WI. USA. Pp, 1-1390.
20. Plenchette, C., Morel, C., 1996. External phosphorus requirement of mycorrhizal and non-mycorrhizal barley and soybean plants. Biology and Fertility of Soils. 21(4), 303-308.
21. Howlever, R., Asher, H C. J., Edwards, D.G., 1981.Establishment of an effective mycorrhizal association on cassavain flowing solution culture and its effects on phosphorus nutrition.New Phytol. 90, 279–283
22. Zhou, X., Zhou,J. Xiang, X., Cébron, A., Béguiristain ,T., Leyval, C., 2013. Impact of four plant species and arbuscular mycorrhizal (AM) fungi on polycyclic aromatic hydrocarbon (PAH) dissipation in spiked soil. Polish Journal of Environmental Studies. 22(4).
23. Chen, B.D, Xiao, X.Y., Zhu, Y.G., Smith, F.A., Xie, Z.M., Smith, S.E., 2007. The arbuscular mycorrhizal fungus *Glomusmosseae* gives contradictory effects on phosphorusand arsenic acquisition by *Medicago sativa* Linn. SciTotal Environ. 379, 226-234.

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Study of the nature and content of water-soluble organic compounds in soils of the North-East of the European part of Russia

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Abstract

Water-soluble low-molecular organic compounds perform essential ecological functions, participating in the global circulation of substances and processes of soil formation. The study of these substances is a complex task due to their small concentrations and chemical lability. Elemental composition of water-soluble organic compounds in soils of the North-East of the European part of Russia is understudied. The use of such physical-chemical methods as gas chromatography and chromato-mass-spectrometry allows to improve the existing information about this group of compounds and to identify patterns of their location in space. Qualitative analysis of particular organic substances was conducted by two methods, identifying compounds without changing their chemical composition and identifying their trimethylsilyl derivatives. Soil sampling for qualitative and quantitative determination of organic compounds was done by the A. Mueller scheme with some changes. Sample preparation included such stages as extraction of acids, sorption concentration, drying at 40 °C, derivatization, then gas chromatography and chromato-mass-spectrometric analyses. This method of sample preparation increases the detection sensitivity of compounds compared with detecting them in the form of ethers (Mueller et al, 2002). All the identified substances belong to the three classes of compounds, alcohols, carbohydrates, and organic acids (aromatic and aliphatic oxyacid). By the gas chromatography method, we made a quantitative analysis of the compounds which were diagnosed as trimethylsilyl derivatives. The weight concentration of carbon in the water-soluble organic compounds is 0.04–0.07 g/dm^3 in the organic horizons and 0.20–0.40 g/dm3 in the undecomposed moss layers. The content of low-molecular-weight organic compounds (alcohols, carbohydrates, and acids) identified by gas chromatography and chromate-mass-spectrometry is 1–30 mg/dm^3 in the organic horizons of the soils and 80–180 mg/dm^3 in the mosses, which does not exceed 26% of the total organic carbon in the extracts.

Keywords: Water-soluble low-molecular-weight organic compounds, soil, gas chromatography, chromato-mass-spectrometry, trimethylsilyl derivatives.

Introduction

The role of organic compounds is so great that the problem of soil organic matter has always occupied a Central place in theoretical and applied soil science. Water-soluble organic compounds (WSOC) of soil include the substance of the chemical composition and structure to the various classes of compounds. As rule researchers have the greatest attention to the study of specific substances in soils of high-molecular composition (fulvic acids). In addition in soils are always present numerous low-molecular-weight organic

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compounds (LMWOC): carbohydrates, alcohols, acids and other study this group of compounds in soils remains quite difficult, due to their low concentration and chemical lability. The peculiarity of virgin biogeocenoses of the European North is the formation of significant quantities of various water-soluble low-molecular-weight organic compounds (LMWOC) that have important ecological functions. These compounds participating in the global circulation of substances characterize the features of modern soil formation. The components and wastes of plants, soil microorganisms, and soil fauna are essential sources of labile organic compounds in soils. These groups closely interact, and their roles are difficult to assess separately [1, 17, 18]. Three habitats are distinguished in the distribution of soil animals: the living plant parts (undecomposed moss), the organic soil horizons (plant waste, litter, peat), and the mineral soil horizons. The tendencies in the dispersal of the organisms among these habitats reflect the adaptation of the communities to the environmental conditions [11, 14, 20]. The formation features of individual LWOCs have been studied under taiga pedogenesis conditions [2, 16, 21-24, 26], but no data are available for soils of tundra landscapes. The main method of determining LWOCs is high-performance liquid chromatography (HPLC), which can identify carbohydrates, alcohols, and aliphatic (usually unsubstituted) acids. As a result, hydroxyl acids—highly reactive compounds widely distributed in nature and stronger than carboxylic acids, whose anions are polydentate ligands capable of forming stable complexes with many metal cations—remain beyond the scope of study. The quantitative analysis of this group of compounds can be performed by gas chromatography and chromate-mass spectrometry.

The aim of this work was to reveal the formation features of LWOCs in living plant parts (undecomposed moss) and the organic horizons (plant material at different stages of decomposition) of virgin and cultivated tundra soils in relation to the composition.

Material and Methods

Studies have been conducted on the Bol'shzemel'naya Tundra of the Vorkuta raion of the Komi Republic. The area is a low-sloping plain under a silty loam cover about 10 m in thickness. The objects of the study include a surface-gleyed tundra soil and a soddy surface-gleyed tundra soil under sown bluegrass–foxtail meadow (Haplic Stagnosols (Gelic)), as well as a peaty tundra gley soil (Histic Cryosol (Reductaquic)) [8].

The virgin surface-gleyed tundra and peaty tundra gley soils significantly differ in their hydrothermal conditions because of the different thicknesses of their organic horizons (Table 1), their different locations (the top and slope of a ridge, respectively), and the presence of a permafrost layer in the soil profile (at depths of 140–150 and 40–60 cm, respectively). Thus, in the second soil, all the factors hamper its warming in the summer and favor its strong cooling in the winter [13, 15]. These conditions determine the distribution features of the biota. A cultivated surface-gleyed tundra soil is developed in the willow–dwarf-birch pit-and-mount tundra. Hypnum mosses with some polytrichum mosses dominate in the ground cover, as well as foxberry (*Vaccinium vitis idaea*); sedges are also found. The O1 subhorizon consists of low- and medium-decomposed litter, wet and loose, with abundant roots of shrubs and subshrubs; the O2 subhorizon is a brown, wet, well decomposed part of the litter with many roots.

The peaty tundra gley soil was developed under dwarf birch lichen-moss tundra; the cover contains green, polytrichum, and sphagnum mosses; lichens; crowberry (*Empetrum nigrum*); and marsh tea (*Ledum palustre*). Cloudberry (*Rubus chamaemorus*) and bog whortleberry (*Vaccinium uliginosum*) are also found on mounts. The qualitative and quantitative compositions of the soil microbiota (bacteria and fungi) and micro- (collembolans, oribatidas) and mesofauna (large invertebrate animals) are also different. Moreover, the difference in the hydrothermal conditions also determines the particular vertical distributions of the soil microorganisms and animals when going from the undecomposed moss to the O1 and O2 subhorizons. The content of different groups of microorganisms and their diversity in the cryomorphic peaty tundra gley soil abruptly decreases between the layer of living organisms and the organic profile; in the automorphic unfrozen surface-gleyed tundra soil, the population density of the organisms decreases gradually [3, 4, 7, 17, 19]. The morphological description of the organic subhorizons: (O1) low-decomposed litter; (O2) dark brown low- and medium-decomposed litter. The entire organic layer is wet and includes many roots of shrubs and subshrubs.

A profile of the soddy surface-gleyed tundra soil was established 50 m from a virgin area on a sown perennial bluegrass–foxtail meadow 53 years old. The composition of the grass stand has been relatively stable during the last 38–40 years; it includes about 40 higher plant species with a predominance of sown bluegrass (*Poa* *pratensis*) and meadow foxtail (*Alopecurus pratensis*) [19]. During the cultivation of the virgin surface-gleyed tundra soils, the soddy process developed, the temperature conditions changed, and the water–air characteristics of the soil improved. The virgin surface-gleyed soils are characterized by almost constant overmoistening, and the cultivated soils of the sown meadow have relatively favorable water and air conditions during the vegetation period [5]. The zonal features of the soil microbiota were largely lost [19]. The organic horizon (At) of this soil consists of poorly decomposed plant material; the turf is brown, compacted, and interlaced by grass roots.

Water suspensions were prepared at a substrate : water weight ratio of 1 : 25, shaken for 15 min on an electromechanical shaker, and filtered through a blue-band filter (with a pore diameter of 2 μm). The total weight concentration of the water-soluble organic carbon $\rho(C_{tot})$ was determined by photometry using the procedure for the dichromate oxidation of water samples with a Fluorat-02 analyzer. The relative error δ of the method is 15% (P = 0.95) [6]. The values of the pH_{water} were measured potentiometrically; the error of the procedure is 0.1 pH units (P = 0.95) [9].

Table 1. Characterization of water extracts from the studied samples

Horizon, cm	$\rho(C_{tot})$, g/dm³	pH_{water}	ρ, mg/dm³			ω(LWOC C), %			
			acids	alco-hols	carbo-hydrates	acids	alco-hols	carbo-hydrates	total
			Surface-gleyed tundra soil						
Moss	0.182	5.6	25.7	16.4	39.3	5.6	3.6	7.5	16.7
O1, 0–6	0.068	5.8	7.7	12.7	11.0	4.7	7.4	5.2	17.3
O2, 6–8	0.063	5.9	1.8	0.6	3.6	1.3	0.4	2.0	3.7
			Surface-gleyed soddy tundra soil						
Moss	0.256	5.9	42.5	33.8	89.7	6.7	5.2	13.9	25.8
At, 0–5	0.061	5.8	2.4	1.6	5.3	1.7	1.0	1.2	3.9
			Peaty tundra gley soil						
Moss	0.397	5.9	39.0	10.3	72.1	3.8	1.0	7.2	12.0
O1, 0–5(7)	0.063	6.6	0.5	0.2	1.2	0.3	0.1	0.8	1.2
O2, 5(7)–10(11)	0.039	6.7	0.2	0.1	0.8	0.2	0.1	0.9	1.2

$\rho(C_{tot})$ is the weight concentration of the total low-molecular-weight water-soluble organic carbon in the objects of the study; ρ is the weight concentration of the extract components; ω(LWOC C) is the weight fraction of the low-molecular-weight water-soluble organic carbon.

The qualitative analysis of the LWOCs was performed by chromate-mass-spectrometry on a Thermo Electron TRACE DSQ spectrometer using two procedures: the LWOCs were determined in their original chemical composition and after transformation into trimethylsilylated derivatives [23]. The samples' preparation was based on the procedure of Muller et al. [25] with some modifications: the acids were silylated rather than methylated to obtain thermostable trimethylsilylated derivatives suitable for gas-chromatographic analysis. The sample preparation procedure increases the sensitivity of determining the compounds by an order of magnitude compared to their detection as esters. The quantitative analysis was performed using a Kristall 2000M chromatograph only for the trimethylsilylated derivatives. The gas-chromatographic analysis was carried out in duplicate. The relative error of measuring the weight concentrations of the LWOCs (ρ) is ±δ ≤ 3% [21, 22, 24]. The chemical analyses were performed in the certified Ekoanalit laboratory of the Department of Soil Science and the Botanical Garden of the Institute of Biology of the Komi Research Center of the Urals Branch of the Russian Academy of Sciences. The analytical data were processed by mathematical statistics methods [10] using Excel 5.0 and Statistica 6.0 software.

Results and Discussion

The two methods for determining the composition of the LWOCs gave complementary results, because the identified organic compounds were almost not doubled (Table 2). An analogous conclusion was drawn earlier from the study of taiga soils [21–24]. This is related to the different dielectric permeabilities of the extractants. The dielectric permeability of butyl acetate, which is used for the direct detection of LWOCs, is $\varepsilon_1 \approx 6$, while that of ethanol, which is used for determining compounds as trimethylsilyl derivatives, is $\varepsilon_2 \approx 25$. The difference between these values determines the list of LWOCs and the degree of their transfer (extraction efficiency) from the water to the organic phase, which is then analyzed by chromate-mass-spectrometry and gas chromatography. The identified compounds belong to three classes: carbohydrates, alcohols, and acids. In the combined set of acids, as for the taiga soils [21–24], two classes were identified: aliphatic and aromatic ones. Each class was subdivided into unsubstituted (mono- and dicarboxylic acids) and substituted, mainly hydroxy (mono, di-, and tricarboxylic acids containing one or several OH groups), acids.

Table 2. Low-molecular-weight water-soluble organic compounds identified by chromate-mass-spectroscopy as derivatives (in italics) and without changing their chemical composition.

<table>
<tr><th colspan="3" rowspan="2">Classes of compounds</th><th>Surface-gleyed tundra soil</th><th>Peaty tundra gley soil</th><th>Surface-gleyed soddy tundra soil</th></tr>
<tr><th colspan="3">Compounds</th></tr>
<tr><td rowspan="8">Carboxyl-c acids</td><td rowspan="6">Aliphatic</td><td rowspan="4">Unsubstituted</td><td rowspan="2">Propanedioic (malonic)</td><td>No</td><td>2-ethylbutanoic (2-ethylbutyric), heptanoic (enanthic), 2-ethylhexanoic, octanoic, nonanoic (pelargonic), 2-nonenoic, decanoic, dodecanoic, octadecanoic, 9-octadecenoic</td></tr>
<tr><td colspan="2">2,4-hexadienoic (sorbic)</td></tr>
<tr><td colspan="2">Hexadecanoic (palmitic), tetradecanoic (myristic)</td><td></td></tr>
<tr><td colspan="3">Pentanoic (valeric), butanedienoic (succinic), gluconic</td></tr>
<tr><td rowspan="2">Substituted</td><td colspan="2">2,3,4,5,6-pentahydroxyhexanoic (galactonic)</td><td>–</td></tr>
<tr><td colspan="3">2-hydroxypropanoic (lactic), 2-hydroxyetanoic (2-hydroxyacetic, glycolic), 2,3-dihydroxypropanoic (glyceric), 1-hydroxypropane-1,2,3_tricarboxylic (isocitric), hydroxybutanedionic (malic), 3-hydroxybutanoic (3-hydroxybutyric)</td></tr>
<tr><td rowspan="2">Aromatic</td><td rowspan="2">Substituted</td><td>No</td><td>2-hydroxy-4-methoxy-6-methylbenzoic (everninic), 2-hydroxyhexanoic (2-hydroxycaproic), 4-hydroxy-3-methoxy-benzoic (vanilic)</td><td>3,5-dimethyl-4-hydroxy-benzenepropanoic</td></tr>
<tr><td colspan="3">3,4-dihydroxybenzoic (protocatechuic)</td></tr>
<tr><td colspan="3" rowspan="2">Alcohols</td><td>–</td><td colspan="2">Ribitol</td></tr>
<tr><td colspan="3">1,2,3-propanetriol (glycerol), pentitol (xylitol), glycitol (sorbitol)</td></tr>
<tr><td colspan="3" rowspan="2">Carbohydrates</td><td colspan="2">No</td><td>D-xylopyranose</td></tr>
<tr><td colspan="3">Galactopyranose, D-fructose, D-glucose, D-turanose, fucose, saccharose, arabinose (D-ribose)</td></tr>
</table>

The weight concentrations of the organic acids were determined only for the acids detected as trimethylsilyl derivatives; therefore, some acids were not taken into account in the quantitative analysis because of the method's limitations. The content of organic compounds without changing the initial composition was not determined. Although the tundra soils contain significantly less organic compounds than the taiga soils [22, 24], it should be taken into consideration that the conclusions drawn from the contents of the acids in the soils significantly depend on the sample preparation procedure, because narrow groups of compounds with specific properties are identified.

The analysis of the results has revealed some general tendencies for the three studied tundra soils. The water extracts from all the organic horizons are characterized as weakly acidic, low-saline, and with a low concentration of LWOC C (Table 1), which agrees with the data on the lysimetric waters from tundra soils [5]. In all the biocenoses, the undecomposed moss layer (which contains living plants and the highest diversity and content of soil organisms [7, 17]) is characterized by the maximum concentrations of total C in the LWOCs; each class of the identified compounds (carbohydrates, acids, and alcohols); and, hence, their sum.

Let us consider the component compositions of the water extracts from different soils.

Surface-gleyed tundra soil. The weight concentration of the total LWOC carbon in the moss is 0.182 g/dm^3, and that of the total carbohydrates, acids, and alcohols is 80 mg/dm^3 (Fig.1), which corresponds to 16.7% of the total LWOC carbon (Table 1). In the O1 subhorizon, the contents of the total carbon and total identified compounds decrease by about 2.5 times compared to the moss layer, which is lower than in the taiga soils of the Komi Republic [6, 21, 22, 24]. When going from the O1 to the O2 horizon, i.e., with the increasing degree of decomposition of the organic substrate, the total content of LWOCs decreases by 5 times because of their decomposition or transformation to specific humic compounds [12]. In the moss layer, carbohydrates make up about half of the total identified organic compounds, which contain significant portions of glucose and saccharose. When going to the O1 and then the O2 horizons, the content of carbohydrates successively decreases by 3 times. Alcohols are found only in the moss layer and the O1 subhorizon: 10% glycerol and 85% glucitol in the former layer and only glucitol in the latter layer. The weight concentration of the total acids in the moss layer is 26 mg/dm3; isocitric acid makes up more than 20%; and lactic, malic, and protocatechuic acids make up 10% each. Isocitric acid is absent in the organic horizons. The content of all the acids in the O1 subhorizon decreases by 3 times; malic, protocatechuic, and lactic acids remain predominant (20–25% for each); and malic acid prevails in the O2 subhorizon (50%).

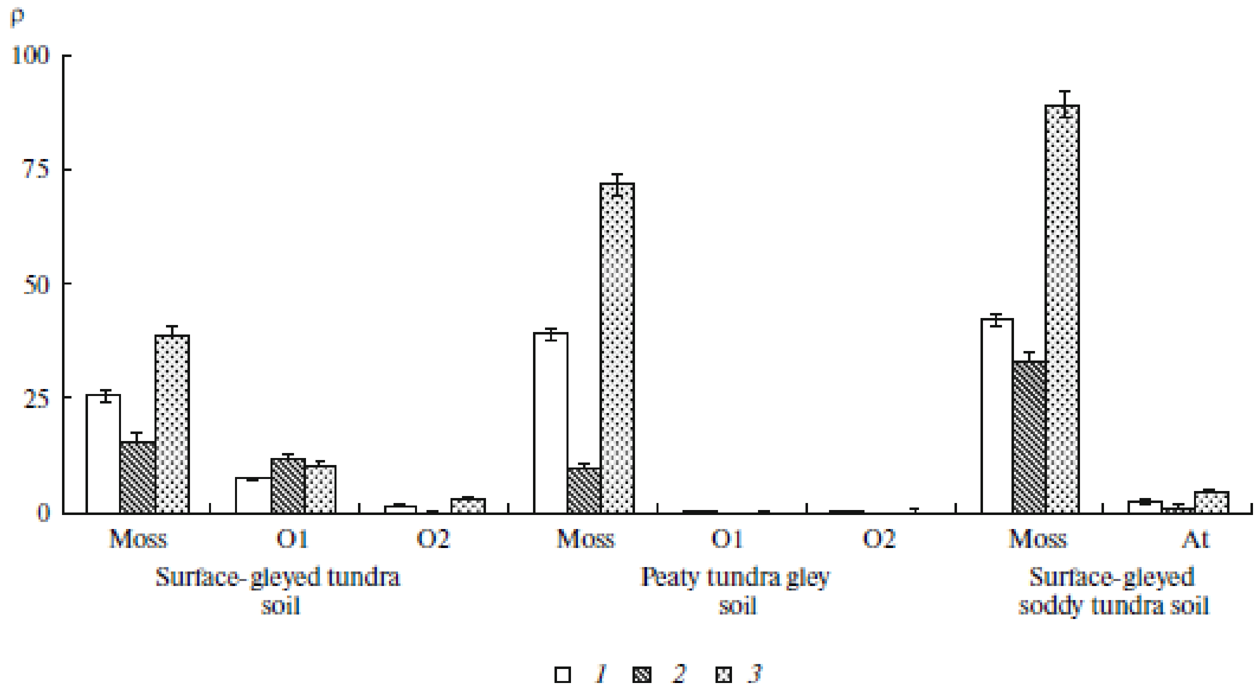

Figure 1. Weight concentrations of low-molecular-weight water-soluble organic compounds in soils: (*1*) acids; (2) alcohols; (3) carbohydrates.

Peaty tundra gley soil. The qualitative composition of the LWOCs in the water extracts from the objects of this biocenosis is similar to that described above. The higher diversity of the aromatic hydroxy acids is observed, which agrees with the data obtained for the hydromorphic series of taiga soils [21, 22]. The moss layer of this soil is also characterized by a higher content of total LWOC carbon (0.397 g/dm^3) compared to the organic horizons; the corresponding value decreases by 6 times in the O1 subhorizon and then by 1.5 times in the O2 subhorizon. The total weight concentration of the individual LWOCs is 121 mg/dm^3 (or 12% of the total LWOC carbon). It decreases to 1–2 mg/dm^3 in the organic profile. When going from the moss to the O1 subhorizon, the contents of carbohydrates, acids, and alcohols decrease by 60, 80, and 50 times, respectively, and the content of alcohols becomes so low that it deserves no special consideration. The content of organic compounds in the O2 subhorizon is even lower than in the O1 subhorizon. In the moss layer, carbohydrates are the predominant identified compounds (72.1 mg/dm^3, or 60% of the total weight) with the predominance of glucose (50%) and xylopyranose (40%). The content of acids is 39 mg/dm^3, including malic (45% of the total weight), isocitric (34%), lactic (<10%), and protocatechuic (<10%) acids. The alcohols (12.7 mg/dm^3) mainly consist of similar amounts of glycerol and glucitol.

Cultivated surface-gleyed soddy tundra soil. The weight concentration of the total LWOC carbon is 0.256 g/dm^3; its value in the organic horizon is lower by 4 times. The total content of water-soluble carbohydrates, acids, and alcohols is 166 mg/dm^3 (or 25.8% of the total LWOC carbon); its value in the organic profile decreases by about 20 times. Carbohydrates make up half of the total found LWOCs (89.7 mg/dm^3) with the predominance of glucose (35%) and xylopyranose (53%). This soil is characterized by its wide diversity of unsubstituted saturated and unsaturated aliphatic acids, which were determined only qualitatively (Table 2). The content of acids is 42.5 mg/dm^3, including 50, 20, and 10% isocitric, malic, and protocatechuic acids, respectively. In the At horizon, the content of acids decreases by 17 times with the predominance of lactic, malic, and protocatechuic acids (30% each). The content of alcohols is 33.8 mg/dm^3, which is mainly due to glucitol (70–80%). The total weight concentration of cations in the water extract from the moss layer is 91.2 mg/dm^3; in the organic horizon, it decreases by 5 times.

The comparison of the accumulation tendencies for the different components of the water extracts from the objects under study revealed the following differences. The unfrozen virgin surface-gleyed tundra soil is characterized by an insignificant (by 1–3 times) decrease in the weight concentrations of the total carbon in the WLOCs, acids, alcohols, and carbohydrates when going from the moss to the O1 subhorizon. In the peaty tundra gley soil, the contents of the individual compounds from all the classes in the living plants are lower than in the upper organic subhorizon by 50–80 times, and the contents of the total organic carbon are lower by 6 times; in the cultivated soil, these parameters decrease by 4 and 20 times, respectively.

We think that all the noted tendencies are due to some factors. The first of them is the difference in the chemical composition of the soil substrates from the typical moss-lichen, shrub, and cultivated tundras. The increased content and the higher diversity of the aromatic hydroxy acids in the peaty tundra gley soil can be related to the presence of lichens and sphagnum mosses in the ground cover, and that of unsaturated aliphatic acids in the cultivated soil can be due to the presence of herbaceous plants. Another reason is related to the vertical distribution features of the soil biota.

Thus, the organic subhorizons of all the soils, which represent plant and animal residues with different degrees of decomposition and humification significantly differing in their chemical composition, are most similar in the content of the individual LWOCs.

The moss layers of the peaty tundra gley soil and the developed surface-gleyed soddy tundra soil are highly similar (60%); they significantly differ from all the other objects of study, including the moss layer of the surface-gleyed tundra soil. Hence, many aliphatic acids in the cultivated soil determined without changing the chemical composition were not taken into consideration. Therefore, the degree of similarity of the moss layers in these soils should be considered as overestimated. However, it should be emphasized that the contents of all the classes of the identified compounds in the moss layers of these two soils are significantly higher than in the organic horizons. Thus, live plants and decaying remains of these soils in relation to formation of water-soluble organic compounds appear like completely different substrates.

Thus, the difference of vegetation, microbiota, representatives of micro- and mesofauna, consequently, the quality and quantity of organic material, which are involved in the processes of salinity and humification in the studied soils determines the difference in the content of water-soluble organic compounds in general and low-molecular in particular.

Conclusion

The concentration of the total LWOC carbon in the organic horizons of the surface-gleyed tundra soil, the peaty tundra gley soil, and the cultivated surface-gleyed soddy tundra soil of the bluegrass–foxtail meadow is 0.04–0.07 g/dm^3; its content in the moss layers of these soils is 0.20–0.40 g/dm^3. The total contents of the identified low-molecular-weight alcohols, carbohydrates, and acids are 1–30 and 80–180 mg/dm^3, respectively, and do not exceed 26% of the total carbon in the extracts. Thus, by the example of the southern tundra soils, it is shown that the formation of water-soluble organic compounds in general and low-molecular-weight organic compounds, in particular, is controlled by the composition of plants, microbial communities, and micro- and mesofauna and depend on the hydrothermic conditions of soil formation.

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References

1. Aristovskaya, T. V., 1965. Microbiology of Podzolic Soils, Nauka, Moscow. [in Russian].
2. Artemkina, N.A. Gorbacheva, T.T., Lukina, N.V., 2011. Low-molecular-weight organic acids in soil water of air-polluted forests in the Kola Peninsula. Lesovedenie 4, 21–29.
3. Soil Atlas of the Komi Republic, 2010. Ed. by G. V. Dobrovol'skii, A. I. Taskaev, and I. V. Zaboeva (Izd. KRT, Syktyvkar) [in Russian].
4. Beznosikov, V.A., Lodygin, E.D., 2012. The fractional–group composition of humus in cryogenic surface-gleyed and hydromorphic soils of the Bol'shezemel'skaya tundra. Vestnik SPbGU, Ser. 3., No. 1, 107–120.
5. Biogeocenotic Studies of Sown Meadows in the East European Tundra, 1979. (Nauka, Leningrad) [in Russian].
6. Vanchikova, V.A., Shamrikova, E.V., Sytar, T.S., Kazakov, V.G. 2006. A new method to determine the carbon content of water-soluble organic compounds in soils. Eurasian Soil Science 39 (10), 1084–1088.
7. Vinogradova, Yu.A., Lapteva, E.M., Khabibullina, F.M. 2012. Structure of soil microbial com- munities in the southern part of the Bol'shezemel'skaya tundra. In Proc. All-Russia C Conf, on Electron Microscopy (Chernogolovka), pp. 397–398 [in Russian].
8. State Soil Map of Russia, 2003. 1 : 1 M Scale. Map Sheet Q-41 (Vorkuta), compiled by I. V. Zaboeva, V. G. Kazakov, M. D. Rubtsov, G. M. Vtyurin, E. N. Rudneva. R. P. Mikhailova, and O. M. Tereshenkov (PKO Kartografiya, Moscow) [in Russian].
9. GOST 26423-85–GOST 26428-85. 1985. Soils. Methods of Determination of the Electric Conductance, pH, and Total Dissolved Solids in the Water Extract (Izd. Standartov, Moscow) [in Russian].
10. Dmitriev, E. A., 1995. Mathematical Statistics in Soil Science (Izd. Mosk. Gos. Univ., Moscow) [in Russian].
11. Zvyagintsev, D.G., Zenova, G.M. 2005. Ecology (Izd. Mosk. Gos. Univ., Moscow) [in Russian].
12. Kaurichev I.S., Nozdrunova, E.M. 1962. On the migration and qualitative composition of water-soluble organic matter in soils of the forest-meadow zone. Izv. Timiryaz. Sel'skokhoz. Akad., Pochvoved. Agrokhim., No. 5, 106–115.
13. Kononenko, A.V., 1986. Hydrothermic Regime of Taiga and Tundra Soils in the European Northeast (Nauka, Leningrad) [in Russian].
14. Kuznetsova, N.A., 2005. Organization of the Communities of Soil Collembolans (Prometei MPGU, Moscow) [in Russian].
15. Mazhitova, G.G. 2008. Soil temperature regimes in the discontinuous permafrost zone in the East European Russian Arctic. Eurasian Soil Science 41 (1), 48–62.
16. Motuzova, G.V., Zorina, A.V., Stepanov, A.A., 2005. Water-soluble organic substances in litters of al–fe-humus podzols of the Kola Peninsula. Eurasian Soil Science 38 (1), 57–64.
17. State of the biotic complex of tundra soils in Vorkuta area, 2011. In Polar Cryosphere and Terrestrial Waters, ed. By V. M. Kotlyakova (Moscow–St. Petersburg), pp. 205–214 [in Russian].
18. Stenina, T. A. 1964. Microbiological characteristics of some soils of the Komi ASSR. Izv. a Komi Fil. Vsesoyuzn. Geogr. O–va (Komi kn. Izd., Syktyvkar, 1964), pp. 38– 48.
19. Khabibullina, F.M., Panyukov, A.N. 2010. Transformation of mycobiota under the impact of agricultural development of soils in the tundra zone. Teoretich. Prikladn. Ekolog., No. 3, 52–58.
20. Chernov, I.Yu., Dobrovol'skaya, T.G., Lysak, L.V., 2001. Soil and microbial diversity. In The Role of Soil in the Formation and Preservation of Biodiversity (Tov. Nauchn. Izd. KMK, Moscow), pp. 22–65 [in Russian].
21. Shamrikova, E.V., Gruzdev, I.V., Punegov, V.V., Aleksandrova, N.B., 2012. Low-molecular-weight organic acids in soils of the northern and extremely northern taiga of the Komi Republic. Voda: Khim. Ekolog., No. 11, 102–107.
22. Shamrikova, E.V., Gruzdev, I.V., Punegov, V.V., Vanchikova, E.V., Vetoshkina, A.A., 2012. Individual organic compounds in water extracts from podzolic soils of the Komi Republic. Eurasian Soil Science 45 (10), 939–946.
23. Shamrikova, E.V., Gruzdev, I.V., Punegov, V.V., Vanchikova, E.V., Vetoshkina, A.A., 2011. Qualitative analysis of water extracts from podzolic soils of the Komi Republic for the contents of organic compounds by the chromate-mass-spectroscopic method. Voda: Khim. Ekolog., No. 11, 58–63.
24. Shamrikova, E.V., Gruzdev, I.V., Punegov, V.V., Khabibullina, F.M., Kubik, O.S., 2013. Water-soluble low-molecular-weight organic acids in automorphic loamy soils of the tundra and taiga zones. Eurasian Soil Science 46 (6), 654–659.
25. Muller, A., Dьchting, P., Weiler, E.W., 2002. A Multiplex GC-MS/MS technique for the sensitive and quantitative single-run analysis of acidic phytohormones and related compounds, and its application to Arabidopsis thaliana. Planta 216, 44–56.
26. Strobel, B.W., 2001. Influence of vegetation on low-molecular-weight carboxylic acids in soil solution—a review. Geoderma 99, 169–198.

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Study of soils formation origin based on mineralogical studies (A case study: Marand region, Iran)

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Abstract

Soil formation and evolution in different parts of the world can be affected by soil forming factors of climate, parent material, relief, organisms and time. In this research the role of parent materials in soil formation and their effect on soil mineralogical and physico – chemical properties were studied. Samples from four selected soil profiles around Abarghan village in the North East of Marand region located between 45° 49' 16" to 45° 57' 12" East longitude and 38° 23' 55" to 38° 28' 59" North lantitude were prepared and phisico- chemical and mineralogical properties analyzied. The area soil moisture and temperature regimes are Xeric and Mesic respectively with 441.7 mm annual rainfall and 10.8 °C mean temperature. Based on mineralogical analysis, soil X – ray diffraction results showed that clay minerals of smectite, illite, chrorite, kaolinite and quartz are dominant in soil samples. Also powder analyzing of parent rock by XRD, refers mainly to the presence of quartz, calcite and feldspar with montmorillonite, illite, chlorite and kaolinite minerals. In profile 1, there is a little calcite in addition to above named minerals while parent rock analysis of profiles 2 , 3 and 4 showed pyroxene and amphibole respectively. Therefore comparison of obtained results from analysis of clay and parent rock in all samples refers to presence of same minerals and autogenic, insitu weathering and formation of soils, except in 2Bk horizon of profile 4 with discontinuity. Also more smictite in profile 1 refers to neoformation of this mineral under weak drainage and moist condition with high amount of base cations.

Keywords: Amphibole, Calcite, Clay minerals, Pyroxene, Qoartz

Introduction

Growing of population in one side and people demanding for better life on the other hand prerequisite attention to nature and in this among soil has specific position. The population of the world in the half of the next century will be double and reach from 5.3 billion in 1990 to more then 10 billion in 2050 (9). Thus, according to the soil importence in relation with food security of growing population in the world, the recognition of physico – chemical and mineralogical properties of soil is important (30). Soil with different properties can be formed by transported and in situ formed parent materials, therefore, clay identification is one of the recognition ways for identifying of soil properties, and some of physico – chemical characteristics such as water holding capacity, permeability, CEC (Cation Exchange Capacity) , soil fertility, etc can be affected by type and amount of minerals especially clay minerals. The perception of clay minerals properties in soil and

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their relation with soil physico – chemical characteristics helps the researches for predicting soil behavior in agricultural fields and environmental activities successfully (27). X-ray diffraction reveals that chlorite present in all bedrock samples and some saprolites, which has weathered completely from bed rockes, and hydrobiotite, vermiculite, kaolinite, gibbsite, and goethite have formed in the soil. Also indicates that bulk mineralogy of bedrock and soil samples is quite similar and that the major differences can be explained by chemical weathering. Chlorite is present in all rock samples and some saprolites (Crt horizons), but is universally absent from the upper soil samples. In contrast, mixed-layer clays (i.e. hydrobiotite), vermiculite, kaolinite, gibbsite, and goethite have all formed in soil samples (24). Alfisols and Mollisols are physically, chemically, and mineralogically different. Alfisols have higher bulk density, pH, and total Fe, Al, Ti, and Mn throughout the soil profile than Mollisols. On the other hand, Mollisols possess higher CEC and exchangeable base cations, and total Ca and Mg than Alfisols. Oxides of Si, K, and P are similar in both soils. Crystalline iron oxides are most prominent in Alfisols, whereas in Mollisols poorly crystalline iron oxides are more abundant. In general, the concentrations of all iron oxides are higher in Alfisols than in Mollisols. More organically bound iron (Fep) occurs in Mollisols than in Alfisols. Since the Alfisols contain vermiculite, kaolinite, and gibbsite, and the Mollisols contain montmorillonite, mica, and kaolinite minerals, we conclude that the Alfisols are at a more developed stage than Mollisols. This is also supported by analysis of metal oxides especially Si, Fe, and Al oxides (23). X-ray diffraction patterns revealed that the soils were similar in clay-mineral compositions, consisting of illite, smectite, chlorite, and kaolinite, for the different physiographic units, but vary in the relative amounts of these minerals. The illite content was highest in piedmont plain (P.P) followed by plateau (Pl), river alluvial plain (R.A.P), colluvial alluvial plain (C.A.P) and lowland (L.L) units. Smectite content was highest in Pl followed by P.P, L.L, R.A.P and C.A.P units. Several processes, such as the diversity of weathering rate, biocycling processes of K accumulation, geomorphologic conditions and soil formation processes, caused significant differences in most K forms in the soils. A wide variation in total K (HF-extractable K) (0.54–1.1%), non-exchangeable K (HF-extractable K) (0.54–1.1%), non-exchangeable K (280–450 mg kg^{-1}) and exchangeable K (217–330 mg kg^{-1}) occurred among the physiographic units, corresponding to variations in their mineralogical compositions, mainly the abundance of illite. Significant differences ($P \leq 0.05$) were found for K, HNO_3- extractable K and non-exchangeable K between the soils with large illite contents (30–50%) and with small illite contents (10–30%). A significant positive relationship existed between mineral K and illite content ($r^2 = 0.85$, $P \leq 0.001$) and non-exchangeable K and illite content ($r^2 = 0.84$, $P \leq 0.001$). The results indicated that these pools of K are mainly released from the frayed edges and wedge zones of illite (28). Results showed that physico-chemical properties, clay mineralogy and soil classification have been considerably affected by parent materials. Clay mineralogy showed that chlorite, kaolinite and Mica (except surface horizon of the soil developed over basalt rock and rock sample of shale) were present in all the soils studied and seem to be inherited only from parent materials. Smectite has pedogenic origin in the basaltic and the granitic soils. These clay minerals show lithologic origin in the soils derived from limestone whereas both lithologic and pedogenic origins seem for the soil derived from gneiss rock. Vermiculite seems to be lithologic in the soil developed over amphibolite and pedogenic in the soil derived from shale and mica-schist rocks. (26). The objective of this work is not only soil clay minerals, but also describe all bed rock minerals and compare these minerals with soil one to indicate soil origin.

Material and Methods

Description Of The Study Area

The study area is semi- mountainous and located in the north east of Marand, between 45° 49' 16" to 45° 57' 12" East longitude and 38° 23' 55" to 38° 28' 59" North lantitude with soil moisture and temperature regimes of Xeric and Mesic and 1000 to 3414 m above sea level (7). Geological formations of Marand is related to second, third and four geological times and its stratigraphy is including Triassic, Jurassic and Cretaceous period. In this area species of sandstones and fossiliferous limestones are created by destruction and dissection of limestone formations (4). Physiographic units in this area are including alluvial deposits of gravelly fan-shaped (fans), alluvial plains and river sediment. Accordingly, 4 profils from pedifement and plain units with different overall slope percentage around Aberghan village in the northeast of Marand were selected. Then after sampling, the soil and bed rock samples from same horizons have transported to the lab and after drying of soil samples and powdering of bed rockes were analyzied. For analysis, soil samples were passed through a 2mm sieve and particle size distribution was determined by hydrometer method. Calcium carbonate equivalent (CCE) was measured by acid neutralization approach. Gypsum ($CaSO_4.2H_2O$) was determined by precipitation with acetone. Organic carbon, pH and EC were measured by dichromate oxidation according to Nelson, in a saturation paste and extract respectively. CEC was determined using sodium acetate (NaOAc) at pH 8.2. (18, 16, 29].).

Mineralogical Analyses

Prior to mineralogical analyses, soil samples were washed to remove gypsum and soluble salts. Carbonates were removed using 1N sodium acetate and continued until no effervescence was observed with 1N HCl. The reaction was performed in a water bath at 80° C. Organic matter was oxidized by treating the carbonate free soils with 30% H_2O_2. Free iron oxides were removed from the samples by citrate dithionate method. Separation of clay fractions were carried out according to Kittrick and Hope (1963). The clay fractions of soil and parent rocks were treated to prepare the following oriented slides: Mg-saturated and glycerol-solvated, K-saturated, K-saturated and heated at 550°C. These slides were scanned using a D8 Advance X-ray diffractometer. Quantification of clay minerals was done (32, 29, 13).

Results and Discussion

All soil pedons were studied and morphological properties reported (Table. 1). Also physical, chemical and mineralogical analysis were carried out and results has reported in Tables 2- 4 and Figure, which comperison of clay percentage and solum depth refers to young soils in alluvial plain. Minralogical examination on soil and parent material samples performed and X-ray diffractometer of clay fraction (< 2mm) of the selected soil and rock samples by various sources were interpreted (29, 13).

Table1. Morphological characteristics and classification of the studied pedons

Horizon	Depth (cm)	Color (moist)	Boundary	Structure	Consistence moist	dry
Fine loamy, Smectitic, Superactive, Mesic, Typic Calcixerept (pedon 1. pediment)						
Ap	0 - 18	10YR 4/2	aw	2fabk	fr	vh
Bw	18 - 64	10YR 4/3	gw	2mabk	vfr	eh
Bk	64 – 112	10YR 4/3	dw	2cabk	vfr	vh
C	> 112	10YR 4/3		m	lo	lo
Coarse loamy, Mixed, Superactive, Mesic, Fluventic Haploxerept (pedon 2. pediment)						
Ap	0 – 18	5YR 3/2	as	2vcgr	vfr	h
Bw_1	18 – 35	10YR 3/4	gw	1mabk	vfr	vh
Bw_2	35 – 72	10YR 3/4	dw	1fabk	vfr	h
C	72 – 115	10YR 3/3	gw	sg	vfr	h
2Bw	> 115	7.5YR 4/4		1mabk	fr	eh
Loamy Skeletal, Mixed, Superactive, Mesic, Typic Calcixerept (pedon 3. pediment)						
A	0 – 18	7.5YR 3/2	gw	1fgr	lo	lo
Bk	18 – 67	10YR 3/2	aw	1vfabk	lo	lo
C	> 67	10YR 3/2		sg	lo	lo
Clay over loamy, Mixed, active, Mesic, Calcic Haploxeralf (pedon 4. plain)						
Ap	0 – 23	10YR 4/3	aw	3mbk	fr	vh
Bt_1	23 – 51	10YR 4/3	gw	2fabk	vfr	sh
Btk_2	51 – 80	10YR 4/3	db	2fabk	fr	h
2Bk	80 – 100	10YR 4/3	aw	1vfabk	efi	eh
3C	> 100	10YR 3/3		gr	lo	lo

In representative soils the peak of smectite with Mg-saturated and glycerol-solvated is 16.8 to 17.3 Å, illite 10 to 10.6 Å, kaolinite 7.1 to 7.2 Å, chlorite 14.2 to 14.8 Å and quartz 4.3 to 4.8 Å (Figure 1). Relative percent of amount of clay minerals in soil and rock samples is shown in Table 4. Resultes of analysis of soil and rock sampels in every pedon shows that there is four main type of clay minerals (chlorite, illite, kaolinite, smectite and quartz) (Table 3, 4) and proceeding of changes in soil and rock sampels is the same. Therefore, we can conclude that the origin of clay minerals in all pedons is related to inheritance of parent material and can be released by insitu weathering. In representative soils chlorite, illite, kaolinite, smectite and quartz minerals have identified. In Iran presence of chlorite, illite, kaolinite, smectite and quartz minerals in different soils by Bahmaniar and Abtahi (2004); Abbaslou and Abtahi (2007); Noruzi Fard et al., (2010); Bayat et al., (2011);

Nadimi and Farpoor (2011) was reported. And also presence of chlorite, illite, kaolinite, smectite and quartz minerals in various soils around the world by Lesovaya et al., (2008); Hur and Jung (2009); Diaz at al., (2010); Mavris at al., (2010); Mella and Mermut (2010) was reported.

Table 2. Physical and chemical properties of in the studied pedons

Horizon	Depth (cm)	Particle size Clay Silt Sand (%)	pH (paste)	OC CCE Gypsum (%)	CEC (cmolckg-1)	EC (dsm-1	Saturation (%)
			pedon 1 (pediment)				
Ap	0 - 18	21 29 50	7.85	0.90 7 0.74	15.8	1.550	31
Bw	18 - 64	25 30 45	7.80	0.63 9 0.037	17	0.602	37
Bk	64 – 112	17 33 50	7.74	0.59 14.3 0.015	18	0.819	33
C	> 112	4 3 93	7.98	0.43 7.6 0.25	6.1	0.604	27
			pedon 2 (pedmient)				
Ap	0 – 18	34 18 48	7.57	0.47 5.7 0.039	15.9	0.448	25
Bw_1	18 – 35	34 18 48	7.48	0.39 4.6 0.033	17.6	0.325	24
Bw_2	35 – 72	9 15 76	7.27	0.20 7.5 0.015	11.6	0.438	33
C	72 – 115	14 8 78	7.76	0.47 13 A little	15.8	0.323	33
2Bw	> 115	37 15 48	7.92	0.39 24 0.096	26.3	0.877	33
			pedon 3 (pedmient)				
A	0 – 18	8 11 81	7.25	1.10 10 A little	15	0.636	28
Bk	18 – 67	21 18 61	7.43	0.63 14.6 0.049	14	0.580	28
C	> 67	14 10 76	7.43	0.55 10.9 A little	13	0.444	32
			pedon 4 (plain)				
Ap	0 – 23	31 18 51	7.49	0.63 3.4 0.021	21.5	0.885	28
Bt_1	23 – 51	59 40 1	7.11	0.55 10.8 0.20	32	1.163	45
Btk_2	51 – 80	63 23 14	6.98	0.52 18 A little	23.8	2.631	54
2Bk	80 – 100	12 20 68	7.21	0.39 10 0.23	16	2.287	32
3C	> 100	2 7 91	7.25	0.39 2.5 A little	17	1.456	27

Table 3. Relative abundance of clay minerals of the studied pedons

Pedon	Horizon	Ch*%	Ill*%	Ka*%	Sm*%
1	B	A little	2.8	4.5	91.3
2	Bw	18.8	12.5	50.0	12.5
3	Bk	26.7	6.7	46.7	13.3
4	Bt	47.8	18.8	24.6	7.2
4	2Bk	55.2	18.4	24.6	0.6

*Ch: Chlorite, Ill: Illite, Ka: Kaolinite, Sm: Smectite

Table 4. Relative minerals abundance of the studied of parent rocks

Paren rockes of pedons	Fe*%	Ca*%	Qu*%	Op*% Cr*%	Py*%	Am*%	Cl. Mi*%
1	61.7	-	-	17.0	16.6	-	5.1
2	45.0	11.2	-	11.0	6.6	-	26.2
3	45.9	15.3	-	17.9	8.2	-	12.7
4	31.0	3.5	60.0	-	-	3.9	2.0
4	88.9	1.6	-	1.8	-	6.3	1.4

*Fe: Feldspar, Ca: Calcite, Qu: Quartz, Op: Opal, Cr: Cristobalite, Py: Pyroxene, Am: Amphibole, Cl. Mi: Clay Minerals

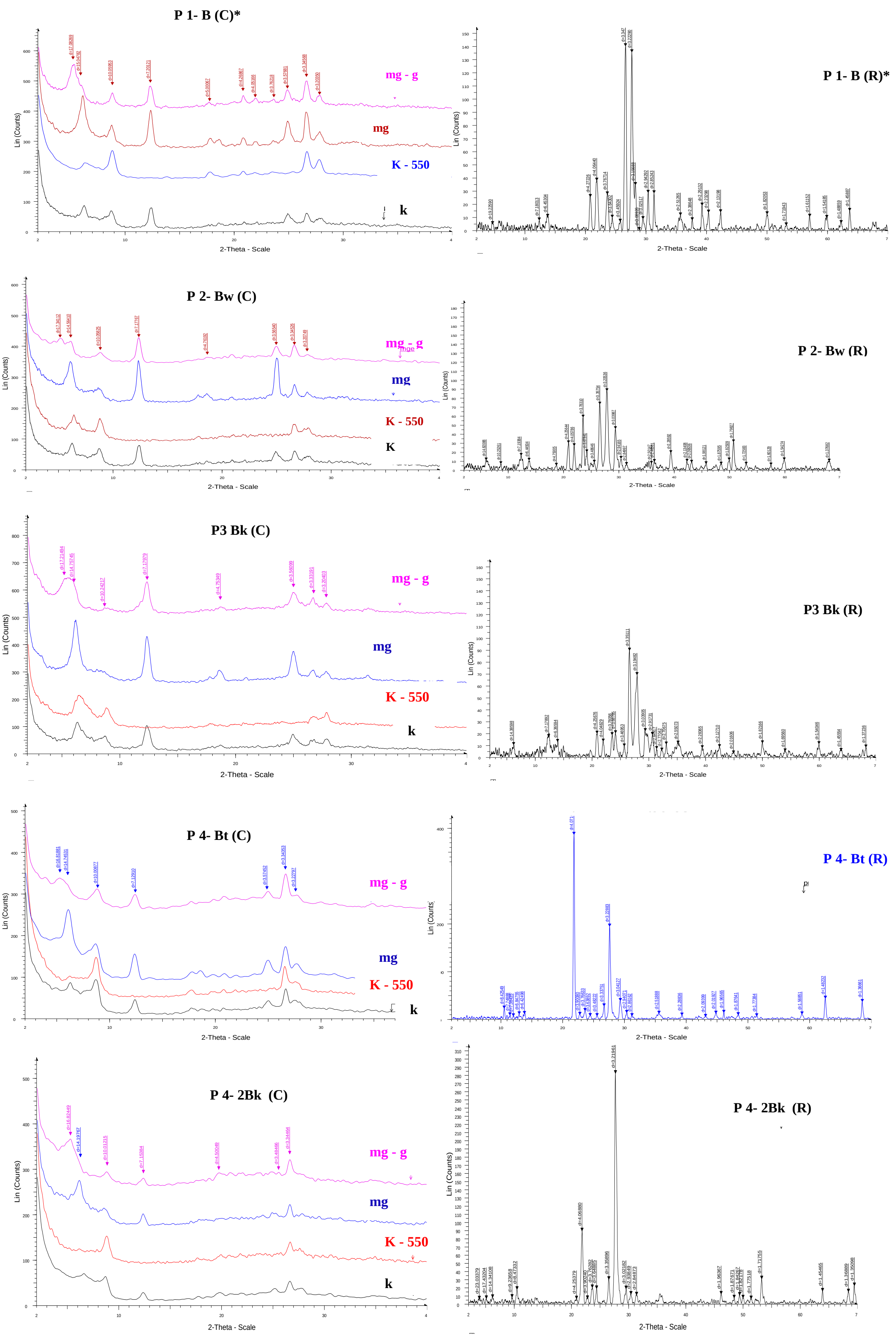

Figure 1. XRD patterns of clay fraction (< 2mm) of the selected studied soil and rock samples
*Cl: Clay; R: Rock

Measuring of vermiculite mineral with laboratory method by Alexiades and Jackson (1964) in representative soils showed that there is no vermiculite in studied samples. But there is a little exception in pedons. 1 and 4 and in pedon 1 smectite can be pedogenesis and created by transformation of chlorite to smectite or neoformation from soil solution under condition of weak drainage, presence of moisture and basic cations in lowlands. For hydroxy interlayer chlorite exiting and conversing to smectite: A – Severe leaching and pH less then 6, B –Soils with this condition that have smectite and chlorite, confirm the prensence of mixed smectite - chlorite mineral and conversing chlorite to smectite (11). With regard to obtained results in studied soils with pH more than 6 , no severe leaching and absence of chlorite – smectite, conversing chlorite to smectite is not possible. Abtahi and Khormali (2001); Ayoubi et al., (2002); Torabi et al., (2005) were indicated that formation of smectite from chlorite in various kind of soils in Iran. Also Egli at al., (2001) stated that the origin of smectite could be traced back to both chlorite and trioctahedral mica which supports the fact that smectite is the end product of chlorite alteration and regularly interstratified mica/smectite (or even smectite). The end product of mica weathering in strongly leached and acidified horizons. Borchardt (1989); De Santiago Buey et al., (1998) refered to potential for smectite that form from mica and chlorite or from illite. Transformation processes could be the origin for the formation of smectite and palygorskite clay minerals in Dashte Palang and Kheir Abad, while in Darab plain due to more favorable drainage conditions, neoformation seems to be dominant (20). In pedon 4 (2Bk horizon) proceeding of changes in soil and rock sampels is not the same and probably it can be releted to presence of lithologic discontinuity in 2Bk horizon.

Conclusion

All in all, in this study the following outcomes can be obtained:

- Deep salum and the relative amounts of Smectite in 1 pedon, can be indicating of development in this pedon than others. Also high percentage of coarse sand particles in pedon 3 indicates little development.
- The kind of identified clay minerals by X – ray diffraction in all pedons are same and including Smectite, Illite, Chlorite, Kaolinite and Quartz based on semiquantitative study major minerals are Smectite, Chlorite and Kaolinite which implies insitu weathering. But in pedon 1 with most Smectite, it can be related to neoformation and conversion from Chlorite
- Identified Calcite in pedons 2 and 3 is highier than other profiles, that is probably due to calcareous parent material which prevents from soil development.
- Compration of clay minerals changing in soil and rock sampling, it seems that clay minerals are created from parent material except clay minerals in 2Bk horizon of pedon 4 that related to lithologic discontinuity.
- In all pedons, Kaolinite has inherited from parent material.
- With regard to weathering of Pyroxene before Amphibole, the prences of Pyroxene in pedons 2 and 3 refers to low weathering and development.
- At all evolution in studied pedons can be described as follows: 1 > 4 > 2 > 3

References

1- Abbaslou, H., Abtahi, A., 2007. Origin and Distribution of Clay Minerals in Calcareous, Gypsiferous, Saline Soils and Sediments of Bakhtegan Lake Bank, Southern Iran. Iran Agricultural Research, Vol. 25, No. 2 and Vol. 26, No. 1-2.

2- Abtahi, A., Khormali, F., 2001. Genesis and morphological characteristics of mollisols formed in a catena under water table influence in Southern Iran. Soil Sci. Plant Analysis, 32(9-10), 1643 – 1658.

3- Alexiades, C. A., Jackson, M.L., 1964. Quantitative determination of vermiculite in soils. Soil Sci. Soc. Am. J, Vol. 29, No. 5, 1964. p. 522 – 527.

4- Anonymus., 1998. Development master Plan of Marand district (existing reports). Aban Consulting Engineers Co, Vol.1.

5- Ayoubi, Sh., Jalalian, A., Eghbal, M.K., Khademi, H., Rouzitalab, M.H., 2002. Identification and genesis of clay minerals in two Paleosols from Sepahanshar (Isfahan) and Emam _ Gheis (Chaharmahal _ Bakhtiari). Irananin Journal of Crystallography and Mineralogy, Vol. 10, No. 2. J, Vol. 29, No. 5, p. 522 – 527.

6- Bahmaniar, M.A., Abtahi, S.A., 2004. Effects of climate on morphological and clay mineralogical characteristics of some soils developed in calcareous parent material in forestry regions of northern Iran. J. Agric. Sci. Natur. Resour., Vol. 11(3), www.magiran.com/jasnr.

7- Banaei, M.H., 1998. Map of moisture and tempreture regimes of Iran soils. Soil and Water Research Institue, Tehran, Iran (in Persian).

8- Bayat, O., Karimzadeh, H.R., Khademi, H., 2011. Clay minerals in two paleosols on geomorphic surfaces in Eastern Isfahan. Irananin Journal of Crystallography and Mineralogy, (Issue 1).

9- Bongaarts, J., 1994. Can the growing human population feed itself. Scientific American Magazine, 36- 42.

10- Borchardt, G., 1989. Smectites, In: Dixon, J.B., Weed, S.B. (Eds.), Minerals in Soil Environments. 2nd ed. SSSAJ Special Publication No. 1, Soil Sci. Soc. Am., Inc.,Madison, Wisconsin, USA, pp. 675–727.

11- Dadgari, F., Abtahi, A., 1985. Genesis, morphology, chemical and mineralogical studies of soil Dasht – Arjan inter mountain basin. Iran agricultural research. 4: 71 – 88.

12- De Santiago Buey, C., Suarez Barrios, M., García Romiero, E., Dominguez Diaz, M.C., Doval Montoya, M., 1998. Electron microscopic study of the illite–smectite transformation in the bentonites from Cerro del Aguila (Toledo, Spain). Clay Miner. 33, 501–510.

13- Deng, Y., White, G.N., Dixon, J.B., 2009. Soil Mineralogy laboratory Manual. 11th edition, Published by the authors, Department of Soil and Crop Sciences, Texas A&M University, College Station, Texas 77843-2474.

14- Diaz, F.J., O'Geen, A.T., Rasmussen, C., Dahlgren, R.A., 2010. Pedogenesis along a thermal gradient in a geothermal region of the southern Cascades, California. www. elsevier. com/locate/geoderma, Geoderma 154 , 495 – 507.

15- Egli, M., Mirabella, A., Fitze, P., 2001. Clay mineral formation in soils of two different chronosequences in the Swiss Alps. www. elsevier. com/ locate/ geoderma, Geoderma,104,145-175.

16- Hesse, P.R., 2002. A textbook of Soil Chemical Analysis. CBS Oublishers and Distributors, 4596/1-A, 11 Darya Ganj, New Delhi- 110 002 (India).

17- Hur, J., Jung, M.C., 2009. The effective of soil properties on the turbidity of catchment soils from the yongdam dam basin in Korea. Environ Geochem Health 31: 365 – 377.

18- Jackson, M.L., 1958. In: Soil Chemical Analysis. An Advanced Course, Univ. Wisconsin,. Madison, USA, p. 498.

19- Kittric, J.A., Hope, E.W., 1963. A procedure for the particle size separation of soil for X-ray diffraction analysis. Soil Sci. Soc. 96: 312-325.

20- Khormali, F., Abtahi, A., 2001. Soil genesis and mineralogy of three selected regions in Fars, Bushehr, and Khozestan provinces of Iran, formed under highly calcareous conditions. Iran Agricultural Research, 20(1):67- 82.

21- Lesovaya, S.N., Lebedeva-Verban, M.P., Chizhikova, P., Romanov, O.V., 2008. Genesis of Soils Developed from Red-Brown Clays and Loesslike Loams in the Southwest of the Central Russian Plain (the Belogor’e Reserve). ISSN 1064-2293, Eurasian Soil Science, Vol. 41, No. 11, pp. 1137–1147.

22- Mavris, C., Egl, M., Plötze, M., Blum, J.D., Mirabella, A., Giaccai, D., Haeberli, W., 2010. Initial stages of weathering and soil formation in the Morteratsch proglacial area (Upper Engadine Switzerland). www. elsevier. com/locate/geoderma, Geoderma 155, 359 – 371.

23- Mella, W., Mermut, A.R., 2010. Genesis and mineralogy of soil formed on uplifted cora reef in West Timor, Indonesia. www. elsevier. com/locate/geoderma, Geoderma 154,544 –553.

24- Munroe, J.S., Farrugia, G., Ryan, P.C., 2007. Parent material and chemical weathering in alpine soils on Mt. Mansfield. Vermont, USA, www. elsevier. com/locate/catena, Catena 70 , 39–48.

25- Nadimi, M., Farpoor, M.H., 2011. Genesis and clay mineralogy of soils on different geomorphic surfaces in Mahan-Joupar area, central Iran. Arab J Geosci, DOI: 10. 1007/S 12517 – 011 – 0350 – 3, pp 1 – 9.

26- Noruzi Fard, F., Salehi, M.H., Khademi, H., Davoudian Dehkordi, A.R., 2010. Genesis, Classification and Mineralogy of Soils Formed on Various Parent Materials in the North of Chaharmahal-Va-Bakhtiari Province. Journal of Water and Soil Vol. 24, No. 4, Sep-Oct2010, p. 647-658.

27- Olyaei, H.R., Abtahi, A., Adhami, A., 2007. Origin and distribution of soil clay minerals in diffrent climate origions of Kohgiluyeh Boyer Ahmad. 10th Soil Sci Congress Iran.

28- Rezapour, S., Jafarzadeh, A.A., Samadi, A., Oustan, Sh., 2009. Impacts of clay mineralogy and physiographic units on the distribution of potassium forms in calcareous soils in Iran. Clay Minerals; v. 44; no. 3; p. 327-337; DOI: 10.1180/claymin.2009.044.3.327.

29- Tan, K.H., 2005. Soil Sampling, Preparing , and Analysis. 2nd ed. S593. T35, 2005, 631.4'1'0278 – dc22.

30- Tavakoli, M., Raiesi, F., Salehi, M.H., 2008. Evaluation of selected soil quality indicators in almond orchard located on north and south-facing slopes in Saman region, Shahrekord. J. Agric. Sci. Natur. Resour., Vol. 15(1), July-Aug 2008 www.jasnr.info, www.sid.ir www.magiran.com/jasnr.

31- Torabi, H., Eghbal, M.K., Jalalian, A., 2005. Mineralogy of soils and differentiation of hydroxy interlayer smectite from vermiculite on Sefidrud river terraces in central Gilan province. Irananin Journal of Crystallography and Mineralogy, (Issue 1).

32- Whitting, L.D., Allardice, W.R., 1986. X – Ray Diffraction Techniques. In: A. klute(ed). Methods of Soil Analysis, Part 1. 2nd 9ed). Agro.

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The effect of fertilizer and gibberellic acid (GA_3) on nutritional level in Sultani Cekirdeksiz grape variety

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Abstract

The aim of this research is the examination of mineral nutrition uptake by foliar analyses in Sultani Çekirdeksiz (Sultana) applied of the different doses of fertilizer and gibberellic acid. This study was conducted own rotted Sultani Çekirdeksiz experiment vineyard at Manisa Research Station in Alaşehir province. Five different GA_3 and four different fertilizer doses including controls were applied on Sultani Çekirdeksiz in the completely randomized block design with split plots as three replications. Each replication had 6 vines. Table grape yield and quality values were obtained from 2010 to 2012. The GA_3 applications were 0, 35, 70, 140, 210 ppm and suggested dose for fertilization was determined by the soil analysis. Four doses were formed by multiplication of suggested dose and 0, 0.5, 1, 1.5 coefficients. Leaf samples were taken at flowering, veraison and harvest times. Total N content was obtained by using Kjeldahl methods. Phosphorus content was determined in spectrophotometer using the phosphor vanado molibdo phosphoric yellow color in the filtrate attained from nitric–perchloric acid mixture and the wet oxidation method. The amounts of K, Ca, Mg, Fe, Zn, Mn and Cu were measured using the atomic absorption spectrophotometer in the filtrate after wet oxidation. The results were presented as percent (%) for macro nutrition elements and as mg kg-1 for micro nutrition elements.

Keywords: Sultani Çekirdeksiz (Sultana), Gibberellic Acid (GA_3), fertilizer, leaf analysis, macro and micro elements.

Introduction

Our country is among important grape growing countries of the world with regard to production and area. According to the data in 2011, a total of 4.296.351 tons fresh grape are produced on a vineyard area of 4.725.454 in our country. Of this production, 2.268.967 tons are considered as table, 1.562.064 tons are considered as dried and 465.320 tons are considered for wining (Anonymous, 2011).

A great deal of table grape production and almost all dried grape production are performed in the Aegean region. The most commonly cultivated grape type in the region is Sultani Çekirdeksiz. Sultani Çekirdeksiz grape cultivation is concentrated in Manisa, Denizli and Izmir. According to latest data, our table fresh grape export reached 240.083 tons in 2011 (Anonymous, 2012).

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One of the most important cultural practices applied in viniculture is fertilization, and it has a distinct significance within cultural practices performed in order to increase productivity and quality. It was determined via studies conducted that consciously performed fertilization practices increase productivity and quality.

Gibberellic Acid (GA3) applications are needed to increase quality of table grapes. However, each type's reaction to GA3 differs. Among them, the type of Sultani Çekirdeksiz in particular gives a positive reaction to GA3 applications. Therefore, GA3 applications are commonly performed by producers to increase quality of table grapes.

Material and Methods

This study was conducted in order to foliar analyses and nutrient values of Gibberellic Acid (GA3) and fertilizer applications in different doses for grape type of Sultani Çekirdeksiz, which is cultivated in Alaşehir Yeşilyurt Enterprise of Manisa Viniculture Research Station Management.

In the study, 4 different fertilizer doses including control and GA3 applications in 5 different doses were set up with 3 repetitions and as 6 vinestocks in each repetition according to randomized blocks test design with split plots. Foliar analyses and nutrient values were detected by performing applications for three years in 2010, 2011 and 2012.

In the test, GA3 applications (Table 1) at 0, 35, 70, 140 and 210 ppm doses in total and zero-dose fertilizer, full-dose fertilizer, half-dose fertilizer and one and a half-dose fertilizer applications (Table 2) according to analysis results were performed in different periods of vegetation.

Table 1. GA_3 Amounts Applied in the Test

Applications	Application Period				
	Length of Sumac 5-10 cm	Length of Sumac 15-20 cm.	Flowering (%50-80)	Grain Size (4-5 mm)	One Week Later
H0 (0 ppm)	-	-	-	-	-
H1 (35 ppm)	-	-	15 ppm	20 ppm	-
H2 (70 ppm)	15 ppm	-	15 ppm	20 ppm	20 ppm
H3 (140 ppm)	20 ppm	20 ppm	20 ppm	40 ppm	40 ppm
H4 (210 ppm)	30 ppm	30 ppm	30 ppm	60 ppm	60 ppm

Table 2. Fertilizer Amounts Applied in the Test

Applications	Name of Fertilizer	Application Period		
		Period of Resting (kg/plot)	April-May (kg/plot)	June-July (kg/plot)
G0 (0 dose)	-	-	-	-
G1 (1 dose)	Ammonium Sulfate (%21 N)	20,0		
	TSP (%46 P2O5)	12,0		
	Ammonium Nitrate (%33 N)	-	13,0	13,0
G2 (0,5 dose)	Ammonium Sulfate (%21 N)	10,0		
	TSP (%46 P2O5)	6,0		
	Ammonium Nitrate (%33 N)	-	6,5	6,5
G3 (1,5 doses)	Ammonium Sulfate (%21 N)	30,0		
	TSP (%46 P2O5)	18,0		
	Ammonium Nitrate (%33 N)	-	19,5	19,5

Foliar samples were extracted in flowering, veraison and harvesting periods; total N % was read via the Kjeldahl method, P amounts in extracts obtained by applying wet oxidation were read in spectrophotometer via vanadomolybdate phosphoric yellow color method; K, Ca, Mg, Fe, Zn, Mn and Cu were read in atomic absorption spectrometer (Kacar and Inal, 2008). Results were determined as % in macro-nutritional elements and as mg kg-1 in micro-nutritional elements.

Results and Discussion

Examining foliar nutrient contents in Table 3, average azote contents for three years in flowering period were determined between 2.25-2.56%; 1.00-1.90% in veraison period and 1.56-1.89% in harvest period; it was detected that all foliar was sufficient with regard to N according to values 1.70-3.00% provided by Jones Jr. et al. (1991) for flowering period and N was lacking according to sufficiency values of 2.00-2.40%provided for veraison period. It was reported in studies performed in terms of N on foliar samples of vineyard areas of the Aegean region that they were 36% insufficient according to Yener et al. (2000), 25% insufficient according to Atalay and Anac (1991), they were generally sufficient according to Irget (1988), Irget and Atalay (1992), they were 57% insufficient according to Kovanci and Atalay (1987), 32% insufficient according to Konuk and Colakoglu (1986) and 58% insufficient according to Kovanci and Atalay (1977).

Examining foliar nutrient contents, average phosphor contents for three years in flowering period were determined between 0.20-0.25%; 0.12-0.25% in veraison period and 0.18-0.28% in harvest period; it was detected that all foliar was sufficient with regard to P according to values 0.15-0.50% provided by Jones Jr. et al. (1991) for flowering period and P was lacking according to sufficiency values of 0.30-0.40% provided for veraison period. It was reported in studies performed in terms of P on foliar samples of vineyard areas of the Aegean region that they were 88% insufficient according to Yener et al. (2000), 55% insufficient according to Atalay and Anac (1991), 80% insufficient according to Irget (1988), Irget and Atalay (1992), 73% insufficient according to Kovanci and Atalay (1977), 52% insufficient according to Konuk and Colakoglu (1986) and they were generally insufficient according to Kovanci and Atalay (1977).

Table 3. N and P Nutrient Values of Foliar Samples for Flowering, Veraison and Harvest Periods for Average of Years

		% N			% P		
Fertilizer	GA3	Flowering	Veraison	Harvest	Flowering	Veraison	Harvest
G0	H0	2,25	1,63	1,56	0,21	0,20	0,26
	H1	2,38	1,62	1,76	0,20	0,17	0,26
	H2	2,47	1,76	1,70	0,20	0,22	0,25
	H3	2,41	1,70	1,76	0,21	0,24	0,28
	H4	2,41	1,72	1,65	0,20	0,17	0,22
G1	H0	2,41	1,77	1,83	0,22	0,14	0,21
	H1	2,40	1,77	1,89	0,20	0,20	0,21
	H2	2,53	1,82	1,76	0,20	0,18	0,20
	H3	2,46	1,84	1,74	0,20	0,16	0,19
	H4	2,47	1,73	1,77	0,20	0,12	0,18
G2	H0	2,44	1,90	1,78	0,21	0,22	0,27
	H1	2,35	1,78	1,70	0,21	0,21	0,22
	H2	2,52	1,00	1,75	0,21	0,18	0,24
	H3	2,36	1,83	1,74	0,21	0,16	0,21
	H4	2,49	1,87	1,79	0,20	0,24	0,24
G3	H0	2,51	1,82	1,78	0,25	0,25	0,25
	H1	2,52	1,87	1,77	0,21	0,20	0,22
	H2	2,45	1,79	1,78	0,21	0,15	0,23
	H3	2,48	1,82	1,84	0,21	0,20	0,22
	H4	2,56	1,82	1,78	0,24	0,20	0,22
	Avg.	2,44	1,74	1,76	0,21	0,19	0,23
	Min	2,25	1,00	1,56	0,20	0,12	0,18
	Max	2,56	1,90	1,89	0,25	0,25	0,28
Threshold Value		1,70-3,00	2,00-2,40	-	0,15-0,50	0,30-0,40	-

Examining foliar nutrient contents in Table 4, average potassium contents for three years in flowering period were determined between 1.75-2.03%; 1.23-1.88% in veraison period and 1.30-1.81% in harvest period; it was detected that all foliar was sufficient with regard to K according to values 1.50-2.00% provided by Jones Jr. et al. (1991) for flowering period and also sufficient with regard to K according to values of 1.30-1.40% provided for veraison period. It was reported in studies performed in terms of K on foliar samples of vineyard areas of the Aegean region that they were 50% insufficient according to Yener et al. (2000), 50% insufficient according to Atalay and Anac (1991), 16% insufficient according to Irget (1988), Irget and Atalay (1992), 55% insufficient according to Kovanci and Atalay (1987), 48% insufficient according to Konuk and Colakoglu (1986) and they were 50% insufficient according to Kovanci and Atalay (1977).

Examining foliar nutrient contents, average calcium contents for three years in flowering period were determined between 2.39-3.28%; 3.69-4.15% in veraison period and 4.20-4.90% in harvest period; it was detected that all foliar was sufficient with regard to Ca according to values 1.00-3.00% provided by Jones Jr. et al. (1991) for flowering period and abundant with regard to Ca according to values 2.00-2.50% provided for veraison period. It was reported in studies performed in terms of Ca on foliar samples of vineyard areas of the Aegean region that they were generally insufficient according to Yener et al. (2000), generally sufficient according to Atalay and Anac (1991), they were generally sufficient according to Irget (1988), Irget and Atalay (1992), they were insufficient and high according to Kovanci and Atalay (1977), 40% insufficient according to Konuk and Colakoglu (1986) and they weresufficient and high according to Kovanci and Atalay (1977).

Table 4. K and Ca Nutrient Values of Foliar Samples for Flowering, Veraison and Harvest Periods for Average of Years

		% K			% Ca		
Fertilizer	GA3	Flowering	Veraison	Harvest	Flowering	Veraison	Harvest
G0	H0	2,00	1,65	1,61	2,79	4,01	4,72
	H1	1,89	1,39	1,54	2,88	4,15	4,44
	H2	1,97	1,67	1,65	3,01	3,97	4,67
	H3	1,96	1,57	1,54	2,81	3,80	4,43
	H4	1,97	1,49	1,58	2,63	3,79	4,45
G1	H0	1,89	1,47	1,33	3,07	3,89	4,50
	H1	1,88	1,37	1,35	2,96	3,82	4,44
	H2	1,86	1,23	1,45	3,28	3,92	4,71
	H3	1,85	1,39	1,47	3,08	4,10	4,73
	H4	1,76	1,39	1,51	3,10	3,76	4,91
G2	H0	1,93	1,58	1,57	2,84	3,98	4,74
	H1	1,99	1,63	1,55	2,80	3,96	4,53
	H2	1,86	1,70	1,47	2,78	3,90	4,41
	H3	1,95	1,69	1,59	2,82	3,91	4,84
	H4	2,03	1,88	1,81	2,73	3,77	4,49
G3	H0	1,87	1,46	1,33	2,96	3,86	4,43
	H1	1,76	1,39	1,30	2,80	3,69	4,20
	H2	1,86	1,50	1,44	2,87	4,01	4,58
	H3	1,81	1,37	1,41	2,88	3,73	4,54
	H4	1,75	1,28	1,34	2,39	3,80	4,25
	Avg.	1,89	1,51	1,49	2,87	3,89	4,55
	Min	1,75	1,23	1,30	2,39	3,69	4,20
	Max	2,03	1,88	1,81	3,28	4,15	4,91
Threshold Value		1,50-2,00	1,30-1,40	-	1,00-3,00	2,00-2,50	-

Examining foliar nutrient contents in Table 5, average magnesium contents for three years in flowering period were determined between 0.56-0.72%; 0.80-0.96% in veraison period and 0.91-1.04% in harvest period; it was detected that all foliar was sufficient with regard to Mg according to values 0.30-1.50% provided by Jones Jr. et al. (1991) for flowering period and abundant with regard to Mg according to values of 0.25-0.50% provided for veraison period. It was reported in studies performed in terms of Mg on foliar samples of vineyard areas of the Aegean region that they were generally insufficient according to Yener et al. (2000), generally sufficient according to Atalay and Anac (1991), they were sufficient in general according to Irget (1988), Irget and Atalay (1992), they were sufficient and high according to Kovanci and Atalay (1987), they were 60% insufficient according to Konuk and Colakoglu (1986) and they were sufficient and high according to Kovanci and Atalay (1977).

Examining foliar nutrient contents, average iron contents for three years in flowering period were determined between 134-323 ppm; 174-260 ppm in veraison period and 209-324 ppm in harvest period; it was detected that all foliar was sufficient with regard to Fe according to values 40-300 ppm provided by Jones Jr. et al. (1991) for flowering period and abundant with regard to Fe according to values 60-175 ppm provided for veraison period. It was reported in studies performed in terms of Ca on foliar samples of vineyard areas of the Aegean region that they were generally sufficient according to Yener et al. (2000), generally sufficient according to Atalay and Anac (1991) and they were generally sufficient according to Irget (1988), Irget and Atalay (1992).

Table 5. Mg and Fe Nutrient Values of Foliar Samples for Flowering, Veraison and Harvest Periods for Average of Years

		% Mg			Fe ppm		
Fertilizer	GA3	Flowering	Veraison	Harvest	Flowering	Veraison	Harvest
G0	H0	0,59	0,81	0,96	183	194	271
	H1	0,65	0,85	0,98	138	194	209
	H2	0,59	0,83	0,96	147	192	266
	H3	0,64	0,81	0,98	163	197	287
	H4	0,61	0,80	0,98	171	183	218
G1	H0	0,68	0,86	1,04	208	241	227
	H1	0,67	0,91	0,97	202	195	262
	H2	0,68	0,82	1,01	181	174	222
	H3	0,69	0,85	0,97	165	255	238
	H4	0,71	0,87	1,01	222	203	282
G2	H0	0,56	0,85	0,94	201	232	229
	H1	0,57	0,85	0,96	147	248	284
	H2	0,60	0,87	0,91	159	208	262
	H3	0,63	0,82	0,95	203	241	285
	H4	0,64	0,83	0,97	134	260	242
G3	H0	0,62	0,88	1,01	180	214	280
	H1	0,66	0,89	0,98	193	192	267
	H2	0,67	0,87	0,96	147	184	324
	H3	0,71	0,91	1,00	323	234	282
	H4	0,72	0,96	1,04	190	214	280
	Avg.	0,64	0,86	0,98	183	213	260
	Min	0,56	0,80	0,91	134	174	209
	Max	0,72	0,96	1,04	323	260	324
Threshold Value		0,30-1,50	0,25-0,50	-	40-300	60-175	-

Examining foliar nutrient contents in Table 6, average zinc contents for three years in flowering period were determined between 23-40 ppm; 34-129 ppm in veraison period and 33-73 ppm in harvest period; it was detected that all foliar was sufficient with regard to Zn according to values 25-100 ppm provided by Jones Jr. et al. (1991) for flowering period and also sufficient with regard to Zn according to values 25-100 ppm provided for veraison period. It was reported in studies performed in terms of Zn on foliar samples of vineyard areas of the Aegean region that they were 4% insufficient according to Yener et al. (2000), 27.5% insufficient according to Atalay and Anac (1991) and they were 48% insufficient according to Irget (1988), Irget and Atalay (1992).

Examining foliar nutrient contents, average manganese contents for three years in flowering period were determined between 53-131 ppm; 91-165 ppm in veraison period and 96-192 ppm in harvest period; it was detected that all foliar was sufficient with regard to Mn according to values 30-150 ppm provided by Jones Jr. et al. (1991) for flowering period and also sufficient with regard to Mn according to values 30-300 ppm provided for veraison period. It was reported in studies performed in terms of Mn on foliar samples of vineyard areas of the Aegean region that they were 32% insufficient according to Yener et al. (2000), 25% insufficient according to Atalay and Anac (1991) and they were 48% insufficient according to Irget (1988), Irget and Atalay (1992).

Table 6. Zn and Mn Nutrient Values of Foliar Samples for Flowering, Veraison and Harvest Periods for Average of Years

		Zn ppm			Mn ppm		
Fertilizer	GA3	Flowering	Veraison	Harvest	Flowering	Veraison	Harvest
G0	H0	28	46	35	53	101	96
	H1	26	42	36	54	111	103
	H2	35	40	36,	71	98	98
	H3	23	43	50	64	91	106
	H4	27	44	36	65	108	106
G1	H0	31	107	46	87	140	156
	H1	37	48	38	96	127	145
	H2	38	36	35	131	138	186
	H3	30	88	48	114	165	171
	H4	32	42	73	130	155	192
G2	H0	32	44	38	84	114	123
	H1	32	44	35	77	127	122
	H2	30	129	33	78	146	137
	H3	40	58	36	81	136	182
	H4	24	43	35	71	118	133
G3	H0	31	36	40	55	99	97
	H1	35	112	37	66	116	118
	H2	32	44	37	75	121	119
	H3	32	34	34	87	131	140
	H4	33	120	37	79	118	128
	Avg.	31	60	40	81	123	133
	Min	23	34	33	53	91	96
	Max	40	129	73	131	165	192
Threshold Value		25-100	25-100	-	30-150	30-300	-

Examining foliar nutrient contents in Table 7, average copper contents for three years in flowering period were determined between 48-94 ppm; 134-181 ppm in veraison period and 129-177 ppm in harvest period; it was detected that all foliar was abundant with regard to Cu according to values 6.0-12.0 ppm provided by Bergman (1993) for flowering period and also abundant with regard to Cu according to values 5-50 ppm provided by Jones Jr. et al. (1991) for veraison period, and it is considered that this might have stemmed from preparations with copper used for agricultural pest control. It was reported in studies performed in terms of Cu on foliar samples of vineyard areas of the Aegean region that they were sufficient and high according to Yener et al. (2000) and also sufficient and high according to Atalay and Anac (1991).

Consequently, it was detected that all foliar was sufficient with regard to N according to values 1.70-3.00%, sufficient with regard to P according to values of 0.15-0.50%, sufficient in terms of K according to values 1.50-2.00%, sufficient with regard to Ca according to values 1.00-3.00%, sufficient in terms of Mg according to values of 0.30-1.50%, sufficient with regard to Fe according to values of 40-300 ppm, generally sufficient with regard to Zn according to values 25-100 ppm and sufficient in terms of Mn according to values 30-150 ppm provided by Jones Jr. et al. (1991) for flowering period, and it was abundant with regard to Cu according to values 6.0-12.0 ppm provided by Bergman (1993).

It was also detected that on the whole foliar, N was lacking according to sufficiency values 2.00-2.40%, P was lacking according to sufficiency values of 0.30-0.40%, it was sufficient in terms of K according to values 1.30-1.40%, abundant with regard to Ca according to values 2.00-2.50%, abundant in terms of Mg according to values of 0.25-0.50%, abundant with regard to Fe according to values of 60-175 ppm, sufficient with regard to Zn according to values 25-100 ppm, sufficient in terms of Mn according to values 30-300 ppm and it was abundant in terms of Cu according to values of 5-50 ppm provided by Jones Jr. et al. (1991) for veraison period.

Table 7. Cu Nutrient Values of Foliar Samples for Flowering, Veraison and Harvest Periods for Average of Years

Fertilizer	GA3	Cu ppm Flowering	Veraison	Harvest
G0	H0	54	164	149
	H1	74	149	129
	H2	68	153	156
	H3	81	171	134
	H4	73	161	145
G1	H0	63	155	138
	H1	62	164	168
	H2	57	152	132
	H3	86	156	177
	H4	65	134	172
G2	H0	68	163	148
	H1	62	147	136
	H2	55	172	158
	H3	79	162	153
	H4	75	170	171
G3	H0	62	157	160
	H1	48	181	168
	H2	68	139	138
	H3	94	164	155
	H4	68	157	141
	Avg.	68	159	151
	Min	48	134	129
	Max	94	181	177
	Threshold Value	6-12	5-50	

References

Anonim, (2012). Akdeniz İhracatçı Birlikleri Ülkeler Ve Yıllar İtibarıyla Türkiye Yaş Meyve Üretim Ve İhracatı [Http://www.Akib.Org.Tr]

Anonim, (2011) Türkiye İstatistik Kurumu, [Www.Tuik.Gov.Tr].

Atalay, İ.Z. 1977, İzmir ve Manisa Bölgesi Çekirdeksiz Üzüm Bağlarında Bitki Besini Olarak N, P, K, CaveMg’un Toprak-Bitki İlişkilerine Dair Bir Araştırma. E. Ü. Ziraat Fakültesi Yayın No:395:159.

Atalay, i Z,, Anaç, D, 1991, Salihli Bağlarının Beslenme Durumunun toprak ve Bitki Analizleri İle İncelenmesi , Tübitak , Proje No:TOAG-659

Bergmann,W. 1993. Ernahrungsstörungenbei Kulturpflanzen. Entstehung, visuelle und anarytische Diagnose. Gustaw Fischer Verlag Jena-Stuttgart.

Çolakoğlu H., 2008, www.toros.com.tr

Jones, Jr. J.B; Wolf, B. andMills, H. A. 1991. Plant Analysis Handbook. Micro-Macro Publishing, Inc. 213, USA

Ilgın, C., Ateş, F., Karabat, S., Yıldız, S., Yağcı, S. 2005. Sultani çekirdeksiz üzüm tiplerinde bazı uygulamaların sofralık üzüm kalitesi üzerine etkileri. VI. Bağcılık Sempozyumu syf 179-185. Tekirdağ.

İrget, M, E, 1988, Menemen Yöresi Bağlarının Beslenme Durumunun Toprak ve Bitki Analizleri İle İncelenmesi, Yüksek Lisans Tezi, İzmir,

İrget, M, E,, Atalay, İ, Z,, 1992, Menemen Bağlarının Demir, Çinko Ve Mangan Durumunun Toprak Ve Bitki Analizleri İle İncelenmesi, Türkiye I, Ulusal Bahçe Bitkileri Kongresi, Cilt: 2, S:487-492, İzmir,

Kacar, B., İnal, A. 2008. Bitki Analizleri, Nobel Kitabevi, Ankara

Konuk, F,, Çolakoğlu, H,, 1986, Gediz Ovası Çekirdeksiz Üzüm Bağlarında Makro Besin Elementleri, Toprak-Bitki İlişkileriVe Bağların Beslenme Durumu, Tariş Araş, Geliştirme Müdür, Proje No: Ar-ge 001, İzmir,

Kovancı, İ,, Atalay, İ, Z, 1977, Çal Bağlarında Makro Besin Elementi Ve Toprak Bitki İlişkileri, Bitki Cilt 4, Sayı:2 192-212,

Uysal, H. 2007. İhracata yönelik sofralık üzüm üretim ve pazarlama olanaklarının geliştirilmesi. Manisa Bağcılık Araştırma Enstitüsü Yayınları yayın no : 60 Manisa.

Yener, H,, Aydın, Ş, Ve Güleç, I, 2000, Alaşehir Yöresi Kavaklıdere Bağlarının Beslenme Durumu, Ege Tarımsal Araş, Ens, Anadolu Dergisi, İzmir.

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Fertilization level and available nutrients content in arable land of the Czech Republic

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Abstract

After 1990 agriculture in the Czech Republic (ca 3.5 mil. ha of agricultural land) underwent a number of radical changes, including some negative accompanying phenomena. Practically all basic inputs (mainly nutrients) were drastically reduced. This included: (1) the input of mineral nutrients in the form of mineral fertilizers (N, P_2O_5, K_2O, MgO) and limy materials; (2) the input of organic matter and nutrients in organic form into the soil. These factors, including unbalanced ratio of used nutrients, have a negative effect on soil fertility. Some of the selected basic parameters of soil fertility are regularly observed in the Czech Republic in long term system of agrochemical soil testing. The results of determination of soil reaction and contents of available essential nutrients (P, K, Mg, Ca) are available for farmers, because primary interest of every farmer must be the care of the soil (its fertility) and determination of application rates of fertilisers. Based on lower consumption of nutrients (in mineral and organic form) year by year, soil fertility (i.e. soil reaction and content of available nutrients) declines – mainly content of available phosphorus and potassium. The content of available phosphorus and potassium in arable land has declined by ca 20%. Simultaneously ca 19% of area of arable land was moved into categories with expressive fertilization of phosphorus fertilizers and ca 15% into categories with expressive fertilization of potassium fertilizers (differences between 1990 – 2010).

Keywords: inputs of nutrients, soil testing, phosphorus, potassium, fertilization

Introduction

The plants need specific conditions of nutrition for their growth and evolution. The crop yield depends, to a high extent, on nutrient supply – mainly from the soil [1].

Since the beginning of 1990s farm animal numbers were substantially reduced (according to the Czech Statistical Office [2] it was 0.81 livestock unit.ha^{-1} (LU.ha^{-1}) in 1989, while in 2011 only 0.46 LU.ha^{-1}). This has resulted in a considerably decreased input of farmyard manure (organic matter) and nutrients in organic form into the soil. Furthermore, there has also been a much reduced return of nutrients to the soil in the form of by-products (straw, tops …).

In 1990, the average consumption of nutrients from mineral fertilizers (N – P_2O_5 – K_2O) by plants was 90 – 57 – 51 kg.ha^{-1} (in total 198 kg of pure nutrients.ha^{-1}), while in 2013 it was reduced to 94 – 12 – 7 kg.ha^{-1} (in total 113 kg of pure nutrients.ha^{-1}) - source of Ministry of Agriculture of the Czech Republic, 2014 [3] (see Figure I). The

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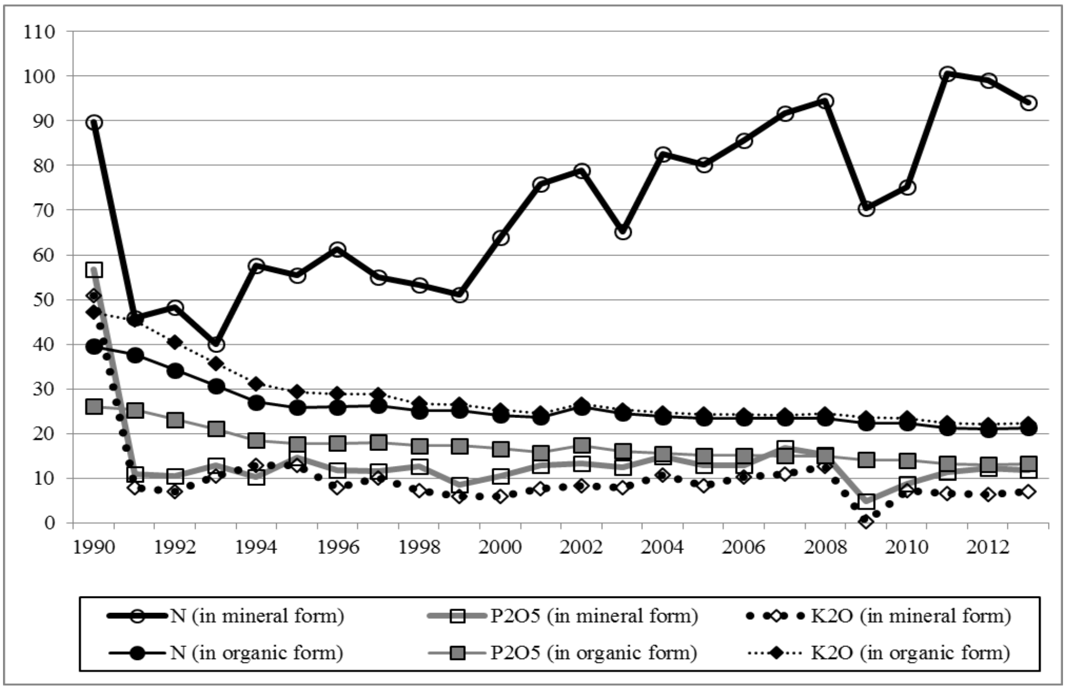
consumption of calcareous fertilizers declined even more and at present it amounts to ca 5 % of the 1990´s consumption.

All these factors, i.e. a substantial reduction in fertilizers application (particularly of P, K, Ca, Mg) and simultaneously limy materials per hectare of agricultural land, a very low return of nutrients into the soil in the form of by-products and an unbalanced ratio of applied nutrients, have caused a substantial degradation of soil fertility in the Czech Republic (mainly decreasing the reserves of available nutrients in the soil).

Soil testing for the content of available nutrients determination is a common base of sustainable fertilizer recommendations. Some of the basic parameters of soil fertility are observed in the Czech Republic since 1961 in regular three- to six-year periods of agrochemical soil testing system. This testing system is provided by the Act No. 156/1998 Coll. about fertilizers in wording of later regulations [4], and covers especially the determination of soil reaction and content of available nutrients - P, K, Mg, Ca. In competent cases (e.g. application of sewage sludge to the soil, soil testing in organic farming, damage of soil by flood, etc.) physical and microbiological parameters are detected [5], [6], [7], [8], [9].



Source: Ministry of agriculture of the Czech Republic, 2014; Czech Statistical Office, 2012; Crop Research Institute, 2014
Figure I: Average nutrients (in mineral and organic form) input into the soil in the Czech Republic
(in kg of pure nutrients.ha^{-1} of agricultural land; relative to 3.5 mil. hectares of farmed agric. land)

Material and Methods

Soil acidity is determined in $CaCl_2$ solution. Mehlich III method is used for the determination of available nutrients in the soil and the contents of soil available nutrients are determined using five categories: *low, suitable, good, high* and *very high* [10].

According to categories of nutrient content in soil and amount of nutrients drawn off from the soil by harvested crops it is possible to determine application rates (fertilizers recommendations) in the Czech Republic.

In the Czech Republic, more than 500 thousands hectares of agricultural land are tested and about 70 – 80 thousands of soil samples analysed for basic soil parameters every year. The average sampling area on arable land and grassland is 7 – 10 ha. One representative soil sample consists of 30 partial small samples.

All sampling areas are fixed by coordinates in the Czech national co-ordinate system S-JTSK and recorded to a special layer of Land Parcel Identification System (LPIS). LPIS is geographic database as part of the Integrated Administrative and Control System (IACS) in the Czech Republic. It can be used for agrochemical soil testing, too. This system makes it possible to provide sampling and mainly results valuation and data comparison from

the same areas during the history of agrochemical soil testing. For the precise localization and better orientation in the terrain GPS equipment is used.
All results of agrochemical soil testing are recorded to LPIS and there are available for government body and – "on line and free of charge" for farmers.

Table I: Fertilizers recommendation according to categories of nutrient content in soil

Category / Content of nutrients	Valuation & Fertilizers recommendation
Low	need of expressive fertilization of relevant nutrient; *coefficient for soil reserve improving 1.5 or 2.0*
Suitable	need of slight fertilization of relevant nutrient; *coefficient for soil reserve improving 1.25*
Good	favourable content – for its maintenance is necessary balance fertilization of relevant nutrient; *coefficient 1.0 – balance fertilization*
High	fertilizing omission of relevant nutrient until achieving of category "good"; *coefficient 0.5*
Very high	fertilizing of relevant nutrient is needless to inadmissible, next raising of relevant nutrient content is unsuitable for environmental protection; without fertilizing

Results and Discussion

Table II: The Czech Republic – soil reaction (arable land & grassland) – changes between testing periods

The Plantation	Testing period	Tested area (ha)	pH value	Ex. Acid	Hard Acid	Acid	Subacid	Neutral	Σ Alkaline
				%	%	%	%	%	%
arable land	A: 1990-1992	2.727.315	6.4	1.22	4.17	9.71	36.44	34.59	13.87
	B: 1993-1998	2.235.838	6.4	1.39	4.74	10.61	40.12	28.47	14.36
	C: 1999-2004	2.535.519	6.3	1.04	5.09	13.53	44.50	21.16	14.05
	D: 2005-2010	2.696.398	6.2	0.65	5.75	17.84	43.99	18.13	13.65
	difference D-A	-30.917	-0.2	-0.57	1.58	8.13	7.55	-16.46	-0.22
grassland	A: 1990-1992	348.529	6.0	6.86	10.80	14.54	37.43	28.30	2.07
	B: 1993-1998	162.435	5.9	6.64	10.96	16.07	42.78	21.72	1.80
	C: 1999-2004	490.808	5.7	4.77	14.24	25.00	45.22	9.51	1.22
	D: 2005-2010	789.440	5.6	3.30	16.55	34.67	38.55	5.94	0.98
	difference D-A	440.911	-0.4	-3.56	5.75	20.13	1.12	-22.36	-1.09

Table III: The Czech Republic – available phosphorus (arable land & grassland) – changes between testing periods

The Plantation	Testing period	Tested area (ha)	available P mg.kg^{-1} of soil	Low	Suitable	Good	High	Very High
				categories in %				
arable land	A: 1990-1992	2.727.315	108	9.11	25.64	29.59	27.31	8.36
	B: 1993-1998	2.235.838	101	11.97	29.75	27.97	23.26	7.04
	C: 1999-2004	2.535.519	95	18.99	29.41	24.84	19.77	7.00
	D: 2005-2010	2.696.398	90	24.94	28.70	22.70	17.42	6.22
	difference D-A	-30.917	-18	15.83	3.06	-6.89	-9.89	-2.14
grassland	A: 1990-1992	348.529	77	12.02	27.91	30.85	19.42	9.80
	B: 1993-1998	162.435	76	12.42	28.97	31.78	17.39	9.44
	C: 1999-2004	490.808	77	17.10	24.24	28.23	19.73	10.70
	D: 2005-2010	789.440	78	17.91	23.50	28.17	19.61	10.77
	difference D-A	440.911	1	5.89	-4.41	-2.68	0.19	0.97

Table III: The Czech Republic – available potassium (arable land & grassland) – changes between testing periods

The Plantation	Testing period	Tested area (ha)	available K mg.kg^{-1} of soil	Low	Suitable	Good	High	Very High
				categories in %				
arable land	A: 1990-1992	2.727.315	279	3.43	17.60	48.75	18.72	11.51
	B: 1993-1998	2.235.838	253	5.73	23.60	48.54	13.83	8.29
	C: 1999-2004	2.535.519	225	8.51	30.97	44.44	10.19	5.88
	D: 2005-2010	2.696.398	239	7.68	28.74	44.24	11.85	7.49
	difference D-A	-30.917	-40	4.25	11.14	-4.51	-6.87	-4.02
grassland	A: 1990-1992	348.529	213	12.47	35.06	25.47	17.34	9.66
	B: 1993-1998	162.435	190	18.27	37.06	22.94	14.12	7.60
	C: 1999-2004	490.808	209	12.44	35.85	26.04	16.97	8.69
	D: 2005-2010	789.440	231	9.49	34.11	26.76	18.11	11.52
	difference D-A	440.911	18	-2.98	-0.95	1.29	-0.77	1.86

Table IV: The Czech Republic – available magnesium (arable land & grassland) – changes between testing periods

The Plantation	Testing period	Tested area (ha)	available Mg mg.kg^{-1} of soil	Low	Suitable	Good	High	Very High
				categories in %				
arable land	A: 1990-1992	2.727.315	178	27.35	31.00	24.80	8.07	8.78
	B: 1993-1998	2.235.838	186	22.38	31.16	28.62	9.26	8.57
	C: 1999-2004	2.535.519	184	20.50	32.37	31.12	8.66	7.35
	D: 2005-2010	2.696.398	185	18.57	34.22	31.21	8.77	7.23
	difference D-A	-30.917	7	-8.78	3.22	6.41	0.70	-1.55
grassland	A: 1990-1992	348.529	213	11.86	17.65	18.75	23.11	28.64
	B: 1993-1998	162.435	223	10.40	17.16	17.44	23.54	31.45
	C: 1999-2004	490.808	212	13.73	21.26	18.76	20.97	25.29
	D: 2005-2010	789.440	198	11.69	21.43	22.62	22.13	22.13
	difference D-A	440.911	-15	-0.17	3.78	3.87	-0.98	-6.51

(Source of table II - IV: Central Institute for Supervising and Testing in Agriculture, 2012)

Conclusion

- The changes of soil reaction are not large, average value of pH of arable land has stopped at the value of 6.2. The soil reaction dos not correspond to such changes, which might be expected considering the drastic decrease of limy materials consumption.
- The content of available phosphorus as well as potassium in the soils fall roughly about 15-20%. On the contrary the content of available magnesium increased by about 5 %.

The outcome of these negative changes is the average increase of soil, decrease in the content of available nutrients (particularly of phosphorus and potassium) [11] in the soils and reduction in the input of primary organic matter into the soil. In many farms these phenomena impaired the soil fertility and ultimately reduced both the yields of crops and their quality.

References

[1] Mengel, K., Kirkby, E. A., 2001. Principles of Plant Nutrition. 5th edition, Kluwer Academic Publishers, Dordrecht / Boston / London.

[2] Czech Statistical Office (2014): http://vdb.czso.cz/vdbvo/en/maklist.jsp?kapitola_id=11

[3] Zpráva o stavu zemědělství ČR za r. 2010: Ministerstvo zemědělství ČR, 210 p., ISBN: 978-80-7434-005-5

[4] Act No. 156/1998 Coll. about fertilizers in wording of later regulations

[5] Čermák, P.: Soil testing in the Czech Republic. Fertilizers and fertilization, Pulawy, 2/2000, p. 6 – 10.

[6] Čermák, P. – Mezuliáník, M.: Soil testing in the Czech Republic. Fertilizers and fertilization, Pulawy, 3b/2000, 14 – 21.

[7] Čermák, P., Klír, J., Budňáková, M.: Potash fertilisation in the Czech Republic, the consumption of potash fertilisers, the content of potassium in the soil, potassium balance, Proceedings „Feed the soil to feed the people – The role of potash in sustainable agriculture“, 2002, p. 50.

[8] Čermák, P., Cigánek, K., Trávník, K., Budňáková, M.: The phosphorus in Czech agriculture, Nawozy i Nawoženie - Fertilizers and Fertilization 4/2002, p. 175-181.
[9] Čermák, P., Budňáková, M.: Nutrient status in the soil, nutrient balance and yields of crops in the Czech Republic, Proceedings from 15. CIEC symposium „Fertilizers and sustainable agriculture“, 2004, p. 44.
[10] Trávník, K., Zbíral, J., Němec, P.: Agrochemické zkoušení zemědělských půd – Mehlich III, 1999, 101 p., ISBN: 80-86051-36-6
[11] Klement, V., Smatanová, M., Trávník, K.: Padesát let agrochemického zkoušení zemědělských půd v České republice (Fifty years of Agrochemical Testing of Agricultural soils in the Czech Republic), Brno, 2012, 96 p., ISBN: 978-80-7401-062-0

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The role of pyrogenic and cryogenic processes in 137Cs migration in frozen soils

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Abstract

This study describes peculiarities of vertical distribution of ^{137}Cs in frozen soils of Central and Southern Yakutia, particularly in the burnt territories of different ages. It also shows the effect of water erosion and cryogenic processes on ^{137}Cs migration in soils during the postfire period. Finally, it presents the data on contribution of wildfires to diffusion of ^{137}Cs in frozen soils of taiga and mountain taiga territories. During last years, the frequency of wildfires in the territory of Yakutia has significantly increased because of thunderstorms and unauthorized controlled fires. Nowadays, many sites of burnt forest, which were formed in different years, are often found near cities and villages. Here we show the results of radio-ecological studies performed on burnt territories of the Central and Southern Yakutia and that differed in forest types and geocryological conditions. The results of this study have shown that the increased concentration of ^{137}Cs was observed in the surface layer (0-4 cm) of the soils. Thus, in all studied soils profile sections the greater amount of ^{137}Cs (80 – 88 % of its total amount in a profile) was concentrated in the upper 4-cm layer of soil. However, it was still detectable until the depth of 8-9 cm. In condition of ubiquitous pollution of the territories with ^{137}Cs, forest fires, in general, reduce its levels in the environment. However, besides fire, permafrost activities (thermokarst, thermal abrasion etc.), which occur after a forest fire on ice-reach frozen soils, also contribute to this process. Thus, forest fires greatly affect redistribution of ^{137}Cs in soils of the Central and Southern Yakutia. Moreover, the influence of cryogenic processes on redistribution of the radionuclide in soil during the post-fire period depends on volume content of ice in frozen soil.

Keywords: frozen soil, pyrogenic and cryogenic processes, ^{137}Cs migration.

Introduction

Today, radioecological studies are performed throughout Russia. These studies are primarily focused on radioactive contaminations caused by nuclear industry, and also on investigations of radiation environment of the territories assigned for construction (roads, bridges and buildings) and mining. Such studies often omit the role of wildfires in radionuclide redistribution in the components of ecosystems. Related studies have been episodically performed in the area near Chernobyl nuclear power plant and also in the territory of Western Siberia (Azarov, 1996; Sherbov et al., 2002).The number of wildfires throughout Russia, including the territory of Yakutia, has significantly increased during the past few years. Thunderstorms and unauthorized controlled fires are the major cause of such increase of wildfires in Yakutia. Only in 2011 265063 hectares of forest have been destroyed by wildfire (Olesova, 2012). Today, one can find many forest sites near villages and cities that have experienced wildfires at different times in the past.

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Radioecological studies have shown that in climatic conditions of Yakutia, products of nuclear tests that fall down from the atmosphere, concentrate in organic part of soil (forest floor and humus horizon), which is the most flammable part of the ecosystem (Sobakin et al., 2009).

We can state that the role of wildfires in diffusion of artificial radionuclides in ecosystems of Yakutia have not been studied. The overall goal of this study is to investigate the role of wildfires in ^{137}Cs diffusion in plain and mountainous taiga areas of Yakutia characterized by different cryogenic conditions.

Material and Methods

During radioecological works in the territory of the Central Yakut Plain two burnt sites have been studied. One of which is located on the elevated, slightly inclined (0-2°) strath terrace of the Lena River, near the city of Yakutsk. This area experienced a severe wildfire 11 years ago, when the piece of pine forest of approximately 300 m in width and 1000 m in length was destroyed by the fire. The fire had completely destroyed the forest floor and the humus horizon of frozen taiga sandy soil. The total volume content of ice in sandy deposits of pine forest was about 30%, therefore the terrain forming cryogenic processes were not apparent there.

The second site of forest destroyed by a wildfire is located in the drainage divide of the Amga River near Myryla village. Here the piece of larch forest of approximately 650 m wide and 1500 m long was burnt out 11 years ago. The site represents the beginning of surface of the drainage divide with the incline of 2-3° towards the river valley. Here in loamy soil deposits the total volume content of ice varied from 40 to 80%. The high ice content in pedogenic rock significantly influences the terrain formation. In this area one may find unique forms of cryolithic micro- and mezorelief, such as baydjarakhs, thermokarst depressions, frost fissures and other formations (Elovskaya and Konorovsky, 1978; Bosikov, 1991).

In the territory of the Aldan Plateau in Southern Yakutia three sites of wildfires, located in the drainage divides of the Kurung and Russkaya rivers, have been studied. This territory is characterized by island distribution of the permafrost (Petrova, 1971; Konorovsky, 1984). Therefore, during the postfire period the effect of cryogenic processes on soil cover was minimal, although wildfires in the studied area occurred at different periods of time (2, 11 and 40 years ago), and in different parts of the drainage divide slopes. In every studied site levels of natural background radiation have been measured prior the selection of the appropriate site for soil sectioning. Soil sampling was carried out by layer-by-layer manner after every 1-5 cm to the depth of 50 cm with the recording of an area. Soil samples were dried to air-dry condition, and then homogenized. The content of ^{137}Cs in soil samples was measured by gamma spectroscopy using Progress-Gamma spectrometer with NaJ(TI) scintillation detector with counting error less than 30%.

Results and Discussion

Radioecological studies, carried out in pine forest, showed that increased concentration of ^{137}Cs in the surface layer of soil (0-4 cm) is common for all sections (Table 1). This data also show that the main portion of total ^{137}Cs in soil profile (79,7-88,5%) is concentrated within the upper 4 cm of soil. Although it is still detectable to the depth of 8-9 cm.

Frozen taiga soils that have not been subjected to a wildfire, showed the maximum concentration of ^{137}Cs just beneath the forest floor layer and the upper part of the humus layer, commonly at the depth of 2-6 cm. Within this part, the highest amount of ^{137}Cs is concentrated (70% and more of its total amount in the soil profile). When examining the vertical distribution of ^{137}Cs within the profiles of soils unaffected by the fire, it can be noticed, that this radionuclide is found in deeper soil layers as compared to its distribution in the burnt areas (Figure 1). Within the studied burnt area the ^{137}Cs contamination density within 9-cm soil layer varied from 620 to 661 Bq/m^2, with average value of 642±16 Bq/m^2. At the same time, from the windward side beyond the range of burnt site at the distance of 6 km its average reserve in soil, measured at five different points was about 667±8 Bq/m^2. The comparison of the average reserve of ^{137}Cs in soils of the burnt area with that of the outside of the burnt area has revealed the average decrease of its content by 3,7%. Apparently, this decrease is caused by the escape of ^{137}Cs with a smoke during the fire. As due to the small inclination of the drainage divide surface, the influence of water erosion processes on lateral migration of ^{137}Cs in taiga soils is minimal during the postfire period in the conditions of cryo-arid climate.

Table 1. Vertical distribution of ^{137}Cs in frozen taiga soil within the burnt area

Horizon	Depth, cm	Bq/kg	Bq/m²	%
		The beginning of the burnt area		
Ao,	0-2	28,3	70	10,6
AoA₁	2-4	29,9	457	69,1
A₁A₂	4-6	2,7	65	9,8
A₁A₂	6-8	2,6	69	10,5
A₁A₂	8-10		∑ 661	∑ 100
		The middle of the burnt area		
Ao	0-2	30,1	75	11,9
AoA₁	2-4	28,4	434	68,9
A₁A₂	4-6	2,8	65	10,3
A₁A₂	6-8	2,2	56	8,9
A₁A₂	8-10		∑ 630	∑ 100
		The end of the burnt area		
Ao	0-2	96,4	260	37,0
AoA₁	2-4	28,3	362	51,5
A₁A₂	4-6	1,6	33	4,7
A₁A₂	6-9	1,2	48	6,8
			∑ 703	∑ 100

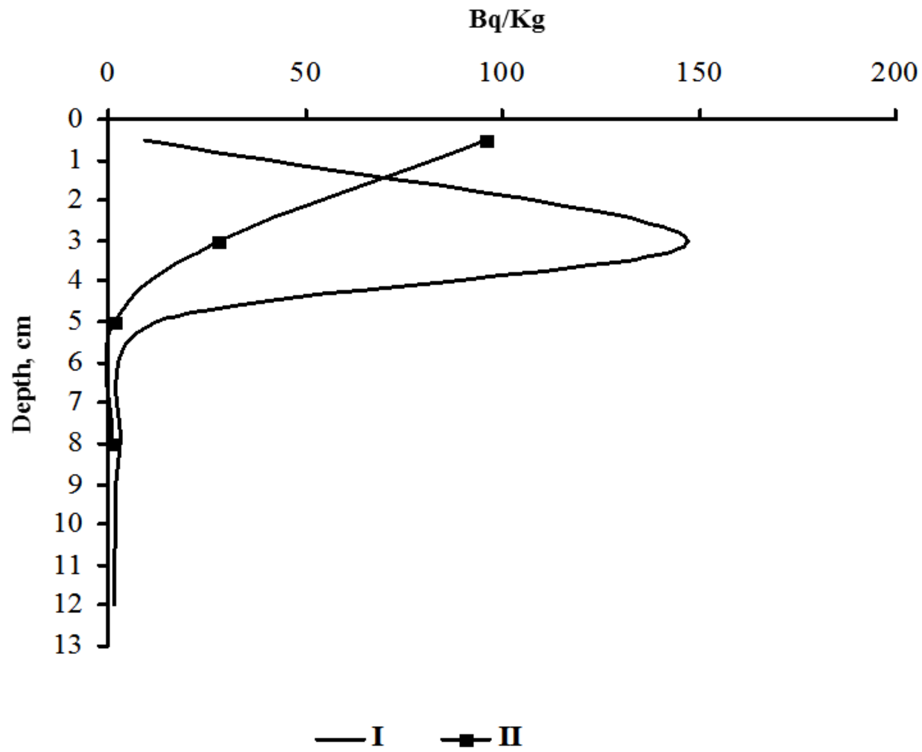

Figure 1. The distribution of ^{137}Cs within the profile of frozen taiga soil:
I – beyond the burnt area, II – within the burnt area.

The second forest site, located in the drainage divide of the Amga River, showed the maximum influence of cryogenic processes on postfire redistribution of ^{137}Cs in pale soils. During the postfire period when the new baidzherakhs were formed thermokarst failures of soil surfaces or extension of hollow area between them led to the partial removal of ^{137}Cs from their surface together with soil. The redistribution of ^{137}Cs in soils of frozen microrelief also increases during the postpyrogenic period. Thus, the soils of cryolithic fissures, where ash accumulated after the fire, showed 1.5 fold increase in ^{137}Cs contamination density as compared to the soils of polygons. The same picture was observed in the soils of mezorelief (baidzherakh-hollow). For the most part, the overall loss of ^{137}Cs in soils after the fire due to its escape with a smoke, influence of cryolithic processes and water erosion, made up 17,8-42,4% and more of its initial amount.

The radioecological works in the territory of Southern Yakutia were conducted in the northern part of the Aldan Plateau. During these works three burnt sites of different ages were studied. The first site covers the upper and the lower part of the right drainage divide of the Kurung River with inclination of approximately 30-40°. The wildfire happened here about 40 years ago. The area of the burnt site is unknown, however, the fire apparently covered drainage divides of the whole river basin. The slope of the drainage divide has southwestern exposition, and its absolute elevation above see-level is about 700-900 m. At this site the drainage divide is mainly composed of metamorphic rocks (gneisses and crystal schists). On the eluvium of these rocks, in the loamy-crashed stone deposits podbur and podzolic soils are formed. The power of a gamma radiation exposure dose at the soil surface varied from 4 to10 μR/hr. The content of ^{137}Cs in soil profiles varied from 2,5 to 314 Bq/kg for the dried mass (Table 2). And its highest concentrations are generally detected in the upper organic layer of soil. After recalculating the amount of ^{137}Cs for square meter of the soil profile, humus-accumulative horizon and forest floor appeared to contain 24-49% and 3-6% of the total amount of radioactive cesium respectively. And the reserve of ^{137}Cs in studied soils of this drainage divide slope varied from 2279 to 2318 Bq/m^2.

Table 2. The vertical distribution of ^{137}Cs in soils of the upper and middle taiga areas that burnt 40 years ago

Sampling site	Soil type	Horizon	Depth, cm	Bq/kg	Bq/m^2	%
The upper part of the drainage divide, the upper taiga zone, the angle of inclination 30-40°	Podzolic	Ao	0-3	91,9	74	3,2
		AoA$_1$	3-4	314,2	345	14,9
		A$_1$	4-5	139,3	794	34,3
		A$_1$A$_2$	5-7	13,2	234	10,1
		B	7-9	8,7	216	9,3
		B	9-12	6,7	217	9,4
		BC	12-17	4,6	249	10,7
		BC	17-25	2,5	189	8,1
					∑ 2318	∑ 100
The lower part of the drainage divide, the middle taiga zone, the angle of inclination 30-40°	Podbur	Ao	0-3	162,1	150	6,6
		AoA$_1$	3-4	243,0	323	14,2
		A$_1$	4-5	183,8	240	10,5
		A$_2$B	5-8	72,0	558	24,5
		B	8-11	15,2	304	13,3
		BC	11-16	7,0	368	16,2
		BC	16-26	4,0	336	14,7
					∑ 2279	∑ 100

The second site is located in the lower part of the left drainage divide of the Kurung River, with elevation of 600-615 m above sea level. The site represents slightly inclined base of the drainage divide adjacent to the flood plain, with southeastern exposure and inclination of 1-7°. Here, the wildfire covered small site of about 150 m wide and 300 m long. In this place on the gneiss eluvium and schists, on the loamy deposits develop podzolic soils.

The power of a gamma radiation exposure dose at the soil surface on the experimental site varied from 8 to 12 μR/hr. The results of studies have shown that during the fire the forest floor had been completely burnt out, and humus horizon partially remained intact (that probably associated with the different humidity of these horizons before the fire) and mineralized. The fire strongly affected the concentration of ^{137}Cs, especially in the upper horizons of soils. Thus, the highest estimated amounts of ^{137}Cs within the upper 4 cm soil layer, were only 86-143 Bk/kg for the dried mass (Table 3).

These numbers are relatively low as compared to soils that have been formed beyond the burnt territory. At the same time, in the soil sections, made in the burnt territories, the ^{137}Cs contamination density remained high, especially on the weakly inclined upper part of the slope. If one considers that in this part of the slope the amount of soil ^{137}Cs decreased only due to the fire, then according to the calculations about 3,2% of its total amount escaped with a smoke. Evidently, in the remaining part of the site the effect of erosion processes during the postfire period was significant. At present, the ^{137}Cs reserve in a soil profile decreased approximately by 40% of its initial amount on the slope, and by 11% at the base.

Table 3. The vertical distribution of ^{137}Cs in podzolic soil of the middle taiga area that burnt 11 years ago

Sampling site	Horizon	Depth, cm	Bq/kg	Bq/m^2	%
The upper part of the slope. Inclination ~1-2°	A_1A	0-3	143,7	1508	72,7
	A_2	3-6	8,3	168	8,1
	A_2	6-9	3,6	109	5,3
	A_2B	9-14	n.d.*	-	-
	B	14-20	2,1	127	6,1
	BC	20-30	1,6	161	7,8
	BC	30-45	n.d.	-	-
				∑ 2073	∑ 100
The middle part of the slope. Inclination ~5-7°	A_1A_2	0-3	86,0	731	57,2
	A_2	3-6	10,1	198	15,5
	B	6-9	8,9	158	12,4
	B	9-15	4,2	191	14,9
	BC	15-21	n.d.	-	-
	C	21-32	n.d.	-	-
	C	32-42	n.d.	-	-
				∑ 1278	∑ 100
The lower part of the slope. Inclination ~1-4°	A_1A_2	0-4	108,5	640	33,8
	A_2	4-8	10,1	277	14,6
	A_2B	8-12	2,8	138	7,3
	BC	12-14	2,6	138	7,3
	BC	16-20	1,4	99	5,2
	BC	20-30	3,4	601	31,8
	C	30-40	n.d.	-	-
				∑ 1893	∑ 100

*n.d. – not detected.

The third site is located on the right drainage divide of the Russkaya River, at the elevation of 700-900 m above sea level. The steepness of this slope is about 30-40°. Two years ago nearly the entire upper part of the drainage divide was destroyed by the fire. Field studies revealed that the slopes had been subjected to a fire of a different strength, depending on their exposition, that may be associated with different moisture of soils during the fire. The southeastern slope had been destroyed by the fire to a greater extent.

Here, small fragments of burnt soil remain trapped between rocks. The entire surface of this site is exposed. On the northern slope the fire burnt mostly the surface part, therefore the soil cover remained unaffected to a greater degree. This slope is primarily composed of gneisses and schists, with the occurrence of individual granite boulders. The power of gamma background radiation on the surface of soils and rocks varied significantly. Occasionally, on the surface of granite boulders, its value exceeded 50 μR/hr. In this case, thorium was the main source of gamma radiation. In boulders its content reached 176 $\times 10^{-4}$%, while the content of potassium and uranium did not exceed their background levels.

In the larger area of the experimental site the gamma background varied from 12 to 20 μR/hr. And the content of natural radionuclides varied within the background values. The density of ^{137}Cs contamination of the examined soil remains was 834-1988 Bq/m^2. And its concentration in the upper part of the soil varied from 62 to 177 Bq/kg of the dried mass. According to our estimates, after the fire the amount of ^{137}Cs at this site in the studied soil profiles, decreased approximately by 14-64% from its initial value (Table 4).

Table 4. The vertical distribution of ^{137}Cs in podzolic soil of the upper taiga area that burnt 2 years ago

Sampling site	Horizon	Depth, cm	Bq/kg	Bq/m^2	%
The upper part of the drainage divide. Northern slope with inclination of ~30-40°	Ao	0-3	177,0	247	24,1
	AoA$_1$	3-5	113,6	316	30,9
	A$_1$A$_2$	5-8	28,3	155	15,1
	A$_2$	8-14	4,0	165	16,1
	BC	14-21	1,2	141	13,8
				∑ 1024	∑ 100
The upper part of the drainage divide. Southeastern slope with inclination of ~30-40°	A$_1$ A$_2$	0-2	74,2	690	34,7
	A$_2$	2-6	1,2	71	3,6
	A$_2$BC	6-20	5,9	1227	61,7
				∑ 1988	∑ 100
The upper part of the drainage divide. Southeastern slope with inclination of ~30-40°	A$_1$	0-10	62,9	327	39,2
	A$_1$A$_2$	10-20	24,2	474	56,8
	A$_2$BC	20-23	5,6	33	4,0
				∑ 834	∑ 100

Here, in the conditions of a steep drainage divide slope the erosion processes play very important roles. Considering that 3% loss of ^{137}Cs in the soil was caused by a fire, the remaining part was simply washed away, and it constitutes 11-61% of its total loss. Such situation is quite possible in the conditions of a steep slope and a humid climate of the studied territory.

Conclusion

Wildfires in plain and mountainous conditions of Yakutia have significant effect on ^{137}Cs redistribution in frozen soils and landscapes in general. In the conditions of cryo-arid climate of the Central Yakut Plain on the flat drainage divide areas the influence of erosion processes on landscape diffusion of ^{137}Cs is minimal during the postfire period. At the same time, in the conditions of mountainous terrain and humid climate of the Aldan Plateau the role of water erosion processes in the landscape diffusion of ^{137}Cs is significant during the postfire period. Besides a fire, slope exposure, its steepness and soil moisture at the time of burning are also key factors in this process. The role of cryogenic processes in radionuclide redistribution in soils during the postfire period is pronounced in landscapes with high volume content of ice in soils.

References

Azarov, S., 1996. Atmosphere contamination with ^{137}Cs during wildfires in the Chernobyl zone. Radiation biology, Radioecology. 4, 506-515.

Bosikov, N., 1991. Evolution of Alases in the Central Yakutia. IP SD AS USSR, Yakutsk.

Elovskaya, L., Konorovsky, A., 1978. Regionalization and land reclamation of frozen soils of Yakutia. Nauka, Novosibirsk.

Konorovsky, A., 1984. Soils of Northern zone of Malyi BAM. Nauka, Novosibirsk.

Olesova, A. 2012. Government report on state and protection of the environment in the Sakha Republic (Yakutia) in 2011. Yakutsk.

Petrova,E., 1971. Soils of Southern Yakutia. Yakutsk Publishing House, Yakutsk.

Sherbov, B., Strahovenko, V., Barashkova, A., 2002. The behavior of ^{137}Cs during wildfires in Altai region. Heavy metals, radionuclides and biophilic elements in the environment. 503-509.

Sobakin, P., Ushnitsky, V., Zakharov, E., 2009. Global contamination with ^{137}Cs in the territory of Yakutia. Radioactivity and radioactive elements in human environment. 539-542.

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Biological soil indicators of natural cenoses of arid ecosystems in Azerbaijan

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Abstract

The biological indicators of gray-brown, gray-meadow and meadow-gray soils of natural ce-noses formed in arid environmental conditions of Azerbaijan were comparatively studied. Gray-brown soils (Siyazan, Sumgayit massive) covered with halophytic vegetation differ with minimal indicators of invertebrates with a total calculation of 11.2 mmol./km^2 biomass and 0.3 g/m^2. Insects are the dominant group - 96.4%, the share of isopods reaches 3.6%. Among insects the species are marked Brackyderma, Bulal, Pacephorus, directly related to the thistles, cruciferous plants characteristic for saline soils. In the soil under the wormwood-ephemeral community significantly increased the abundance and biomass of invertebrates to 16.8 and 1.7 g/m^2. Quantitative indicators of the microbiota are dynamically changed from grass saltwort formation 1490-2260 thousand/g. of soil. Gray-meadow soils (Salyan steppe) under saltwort-grassy phytocenosis differ from the previous few more abundance and biomass mmol/km^2 26.4 2.1 g/m^2 of invertebrates. Besides insects the xerophytic species of Isopodas are marked Armadillidium and Hemilepistus. On sagebrush habitats from wormwood ephemeral vegetation the number (28.0 mmol./km^2) and biomass (2.2 g/m^2) of invertebrates rise. Among the invertebrates, there are also representatives of the gastropods - Mollusca. The total number of microorganisms gradually increases from habitats with halophytic vegetation 761 million /gr. soil to sagebrush habitats with ephemeral vegetation 1,194 million /gr. soil. Meadow-gray soils (Shirvan steppe), formed under the wormwood herbaceus community have an average size of 19.1 mmol/km^2 and biomass of mesofauna 1.3 g/m^2. Among mesofauna dominated lumbricids (Lumbricidae) and isopods (Isopoda) dominate. Microfauna is presented with kollembulas (Collembola) with a population 42.2 million mmol/km^2 and biomass 1.0 g/m^2 and hard ticks Oribatidae with the number of 142 thousand mmol./km^2 biomass and 0.8 g/m^2. The number of microorganisms on cenosis varies between 2500-6930 thousand mmol./km^2. In saline soils microbiota in the group of composition are dominated actinomycetes and spore-forming bacteria of the genus Bacilus. Attenuated oxidative activity (catalase) and suppressed expression of hydrolytic (invertase) enzymes.

Keywords: Invertebrates, microbiota, vegetation.

Introduction

The biological indicators - quantitative (abundance, biomass) and qualitative (group and species composition) data of invertebrates and microorganisms in gray-brown, gray-meadow and meadow-gray soils of arid ecosystems of Azerbaijan are being comparatively studied. The biological factors of soil formation play an important role in the global transformation of chemical elements and transformation of organic residues. Soils formed in arid environmental conditions under natural vegetation are prone to salinity and alkalinity and, therefore, have their own specific biological indicators. Studies have established that a huge mass of salts are

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being involved in biogeochemical cycling through biological processes such as phytogenic, zoogenic and bacterial activity (Volobuyev, 1965). Such is, for example, the role of shellfish in lime salts migration and shrew bringing ground enriched with salts on the soil surface. Significant importance in the biogeochemical saline habitats acquires halophytic vegetation which is able to involve to the construction of its mass and then return to the soil up to 0.5 t / ha of various salts. Speaking of the role of soil biota the vital activity of invertebrates (insects, isopods, microfauna) and micro-organisms should be noted. These invertebrates and macro-organisms are more adapt to the conditions of salinity and used as energetic material residues halophytes (Bababekova, 1988; Samedov, 2003. Samedov et al. 2008, 2011). Therefore, the method of quantitative ecological assessment of animal and microbial population of soils should be widely used in the diagnosis of saline soils. As a result of biodiagnostics it was established that the separate groups and species of invertebrates and microbiota similar to plants can be used as additional edificators saline soils. Thus, soil invertebrates and microorganisms that are actively involved in the migration and concentration of salts in the soil profile as well as in the decomposition and humification of residues halophytic vegetation remnants form characteristic biogeocenoses in saline soils.

In the arid steppes and semideserts of Azerbaijan the average annual temperature varies between 12-13,2 C°, average annual rainfall does not exceed 250-400 mm. Volatilization in arid ecosystems greatly exceeds the amount of precipitation therefore coefficient of moisture is low and equals to $K_n = 0{,}15 - 0{,}30$. The vegetation consists of steppe grasses, sagebrush-ephemeral community, and on saline soils developed halophytic plant combinations. Studies were conducted on the example of gray-brown, meadow-gray, gray-meadow soils which are dominant in arid ecosystems of Azerbaijan. Being the main component of natural biocenosis these soils differ in the nature of soil, semi-desert, transitional meadow-steppe and meadow and also in the processes that affect the biological indicators.

The main purpose of the research was a comparative research of quantitative and qualitative indicators of soil biota (invertebrates, microorganisms) natural habitats investigated soils.

Material and Methods

Definition of group and species composition of invertebrates and microorganisms carried by the standard in soil zoology and microbiology methods (Gilyarov, 1975; Krasilnikov, 1966).

Results and Discussion

Gray-brown soils (Siyezen Sumgait-array) developing under halophytic vegetation differ with minimum number of 11.2 ind/m2 and biomass 0.3 g/m2 of invertebrates. Dominant group of soil invertebrates are insects (Insect) - 96,4%, the share of terrestrial crustaceans (Crustacea) from the group of isopods (Isopod) falls at 3.6%. Among insects have been marked the following types: Brachydema, Bulae, Phacephorus directly associated with halophytic food specialization cruciferous plants, are characteristic of saline soils. In soil under sagebrush ephemeral combination invertebrates significantly increases the quantity (16.8 ind/m^2) and biomass (1.7 g/m2). Of identified invertebrates, insects comprise 88% of the total population 86.9% of the total biomass, which are dominated by species of the genus - Acinopus, Alleculi-dae, a dung as larvae (Scarabaeidae). Other groups include xerophilic wood lice (Isopod) unit of copies lumbricids (Lumbricidae).

Microbiological analysis showed that quantitative microbiota dynamically increase from phytocenosis with grass-formation saltwort 1490 thousand / g soil to saltwort formation with an admixture of salt-tolerant crops - 2260 thousand / g soil and sagebrush grass - 3020 thousand saltwort formation / g soil. The group composition on the number of microorganisms in all the habitats dominated by bacteria 61,7-62.1-64,4% actinomycete population varies 35,5-36,8-37,7% and the number of microscopic fungi is respectively 0.1 - 0.6-1.1%. Gray-meadow soils (Salyan steppe) under saltwort-grassy phytocenosis differ from previous soil with slightly greater quantity of 26.4 ind/m2 and bio-mass of 2.1 g/m2 invertebrates. The main mass of the complex invertebrates are insects - 63.7%. The dominants were Brachydesmus, Bulae, trophic plant-related characteristics of saline soils.

From other groups marked xerophilic woodlice (Isopod) types such as Armadillidium u Hemilepistus populate mostly dense, plastered and saline soils. In respect of trophic groups of identified invertebrates phytophagues-consumers living parts of plants dominates (57.6%), the share saprophages-fed organic residues account for 33.3%, and predators are only 9.1%. Total number of microorganisms is relatively small - 760.8 thous. / G.pochv including actinomycetes as more adapted to salinity up -59.8%, the share accounted 38.0% of bacteria (of which 25% are spore-forming bacteria). Significantly increases the number of microscopic fungi (osmofilov) of the genus As-pergillus u Penicillium, to 2.2%. In the rhizosphere of halophytic vegetation total number of microorganisms increases to 813.2 thousand./g. of soil thanks create favorable symbiotic relationship between halophytic microorganisms and the root system of plants. Meadow gray soils (Shirvan steppe) formed under the sagebrush grasslands have an average size of 19.1 ind/m^2 biomass 1.35 g/m2 Mesofauna. Meadow gray soils (Shirvan steppe) formed under the sagebrush grasslands have an average size of 19.1 ind/m^2 biomass 1.35 g/m^2 of mesofauna. Among Mesofauna dominated lumbricids (Lumbricidae) kind Nicodrilus isopods (Isopoda) genera Armadillidium Protracheoniscus. Microfauna presented springtails (Collembola) hard ticks (Oribatidae), totaling 184.1 thous./m^2 biomass 1.8 g/m^2. Quantitative indicators of microorganisms vary between 2500-2930 thousand. /g. of soil, dominated 74.4% of actinomycetes, bacteria and fungi, are composed by 25.1% and 0.5%.

The results indicate that the studied soils in developing similar to arid environmental conditions still differ in specific, biological indicators that should be used when biodiagnostics soils of arid ecosystems.

- It was established that in the natural cenoses of studied soils under halophytic sagebrush most ephemeral vegetation most adapted to these process conditions were invertebrate groups of insects and isopods.
- Spore-forming bacteria, actinomycetes and microscopic (halophilic) mushrooms were a better adapted group from microorganisms.

Conclusion

The comprehensive studies on the quantitative and qualitative biological characteristics showed that gray-brown, meadow-gray gray-meadow soils developing in dry subtropical climate differ in the group, the species composition of invertebrates and microorganisms. Analysis of complexes of soil animals and microorganisms in saline soils of natural cenoses under various vegetative communities have identified the dominant group of invertebrate animals-insects, isopods, and of microbiota-spore-forming bacteria, actinomycetes and fungi. The findings have important significance in biodiagnostics soils of arid ecosystems.

References

Bababekova, L. A., 1988.Trophic structure of the complexes of Mesofauna in certain types of soils of Azerbaijan. For “Ecology” magazine, №5.

Volobuyev, V. R., 1965. Genetic forms of salinization of the Kura-Araz lowland. Science Academy of AUSSR, Baku, 247 pages.

Gilyarov, M. S., 1975. Accounting for large invertebrates (macrofauna). Methods of soil zoological studies. For magazine «Science», pp. 1-29.

Krasilnikov, N. A., 1966. Methods for studying soil microorganisms and their metabolites. Science Academy of AUSSR, Baku, 147 pages.

Samedov, P. A., 2003. Physical environmental factors and biological activity of soils. В сб. Fundamental physics research in Soil and Land Reclamation. Moscow, Russia, MSU, pp. 194-198.

Samedov, P. A., Bababekova, L. A., Aliyeva, B. B., Mammadzada, V. T., 2008. The comparative characteristics of biological processes gray-brown soils of natural and man-made landscapes of the Apsheron Peninsula. International Conference on Biodiversity, ecological problems of the Altai Mountains and adjacent regions: past, present, future. Russia, Gorno-Altaisk, pp. 116-120.

Samedov, P. A., Bababekova, L. A., Aliyeva, B. B., Mamedzade, V. T., 2011. Biological characteristic of technologically-polluted soils. Azerbaijan, Baku, “Elm”, 104 pages.

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Integrated technologies for the regulation of water, salt and soil conditions supporting agricultural irrigation systems in Kazakhstan

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Abstract

Currently, 2.36 million hectares of existing irrigated land is watered regularly about 1.3 million hectares. Analysis of soil and environmental conditions of irrigated lands in Kazakhstan shows that 40-50% of irrigated land affected by salinization, and 30 % - alkalinization, alkalization, loss of organic reserves and nutrients. This led to a decrease in crop yield by 1.5-2 times.In this regard, the development and adaptation of technologies integrated management of water and land resources, crop irrigation, will improve the efficiency of irrigation systems, water supply and the protection of water and land resources from depletion and pollution.To achieve this goal, were conducted a complex research using the ideas and methods of multivariate experiment. Research results allowed us to develop technologies: increasing the fertility of saline, solonetzous and alkaline soils; irrigation of crops; use of groundwater on sub-irrigation; collector drainage water for irrigation. Established the regions of application of the developed control technology dynamics of water-salt regime of soils and its influence on the ecological condition of irrigated lands.

Keywords: irrigation, degradation, soil, water, desalinization, productivity

Introduction

The experience in operating irrigation systems in Kazakhstan shows that the modern system of water management and protection of water and land resources from depletion and pollution in irrigation systems lead to a breach of natural balance in agroecosystems. This speeds up the pollution of surface and groundwater, increases the level of degradation of irrigated land. Currently, 2.36 million hectares of existing irrigated land is irrigated regularly about 1.3 million hectares. Analysis of soil-ecological conditions of irrigated lands in Kazakhstan shows that 40-50 % of irrigated land affected by salinization, and 30% - alkalinization, alkalization, loss of organic reserves and nutrients. This led to a decrease in crop yield by 1.5-2 times.

Another factor reducing the productivity of irrigated land is the growing water scarcity. For example, in the conditions of southern Kazakhstan, where irrigated land is located in transboundary river basins, water supply existing irrigation systems ranges from 75-95 %, and in dry years, drops to 50-60 %. At the same time, huge amounts of collector-waste and wastewater formed on river basins (up to 30-50 % of the water supply), is reset beyond them, pollute water sources and reduce the environmental impact on the surrounding areas.

Environmental pollution, depletion of its basic resources - land, water, negatively affects the level of productivity and sustainability of irrigated agriculture in the different climatic zones of KazakhstanThis

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adversely affects the outcomes of economic activity, social situation, soil and environmental situation in the natural and economic complexes of transboundary river basins. In such circumstances, the problem of reducing the flow rate of degradation processes and environmental improvement in irrigation systems and river basins in different climatic zones of Kazakhstan has great practical significance. This is achieved through the development of integrated technologies management of water and land resources, irrigation of crops in the irrigation systems of Kazakhstan.

Material and Methods

Development of integrated technology management of water and land resources in irrigated areas was carried out by studying the process of mass transfer and mass exchange at various technologies crop irrigation, flushing of saline soils, chemical reclamation solonetsous and alkaline soils (Aydarov, 1985). Research to establish the parameters of soil processes were conducted on saline and solonetzic chernozems and dark chestnut soils and gray soils of Kazakhstan.

Multiyear complex experiments to establish the parameters of soil processes were conducted by field research and lysimetric. Field studies were conducted on the irrigated lands of the Northern, Central and Southern Kazakhstan. When lysimetric studies, lysimeters were charged with undisturbed soil chernozem, chestnut and sierozem zone of Kazakhstan. Lysimeters area was from 0.03 to 1 m2 and a depth of 1 m to 3 m

In the field and lysimeters, were conducted comprehensive research to establish the dynamics of water-salt regime chernozem and chestnut soils sierozems under irrigation, flushing and chemical reclamation. Investigated the dynamics of hydrochemical regime of irrigating, groundwater and drainage water when changing technical level and drainability of irrigation systems, the level of groundwater occurrence. Multifactor experiment allowed us to establish the field of application the technology of developed integrated management of land and water resources in different soil types in Kazakhstan.

The impact of soil moisturing technology on mass transfer processes in meliorated layer of soil was established by measuring the volume of infiltration water, determination of mineralization when changing flow rate of flushing water at different stages of research. In the filtrate was determined the following group of salts and indicators of soil fertility: CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2+}, Ca^{2+}, Mg^{2+}, Na^+, NO_2, NO_3, P_2O_5, K_2O, humus, pH. The resulting ions are bound to each other on the hypothetical salt following way: HCO_3^- contacted primarily with Ca^{2+}, residue with Na^+ и Mg^{2+}; SO_4^{2-} - first contacted with the residue Ca^{2+}, then – Mg^{2+} и Na^+; Cl^- - first contacted with Na^+, then– Mg^{2+}, only then with Ca^{2+}. This method of connection ion refers to the classical scheme (Aydarov, 1985, Bekbayev, 2002, Vyshpolsky, 2005)

To assess the physico-chemical and nutritional properties of soil were determined: humus, nitrogen, pH; total nitrogen and phosphorus, sodium in the flame, absorption capacity, water extract, gypsum and carbon dioxide, mechanical structure, density. To improve the accuracy of studies listed indicators were determined for each field separately and lysimeter.

Permanent record of filterable water dynamics has revealed infiltration rate when changing the soil moistening. To compare the effectiveness of the flushing regimes were calculated the coefficients that takes into account ability of soil to salt-giving and convective diffusion. When determining the values of the coefficient "α" formula of V.R.Volobueva is used. To determine the coefficient of convective diffusion used the formula S.F. Averianova (Aydarov, 1985). Based on the established coefficient of convective diffusion determined the parameter of Peclet and coefficient of gidro dispersion (Bekbayev, 2002).

To study the migration of organic-mineral compounds at various irrigation technology, flushing and chemical amelioration of soil lysimeters were charged on saline soils chernozem (Kostanay), chestnut (Karaganda region) and sierozem (South-Kazakhstan region) zones of Kazakhstan.

Analysis of the chemical properties of soils shows that lysimeters charged on soils with varying degrees and chemism of salinity. Herewith the character of the distribution of salts in the vertical soil profile corresponds basically superficial and deep epures of salinization (table 1). The deep character of accumulation and distribution of salts on the vertical profile gained the greatest distribution of soil in chernozem and chestnut zones. They have evolved in deep bedding of groundwater level.

In these conditions the character of distribution of salts on the vertical profile depends on the laws of movement of moisture and salts in the root zone of the soil under the influence of precipitation, evaporation and transpiration. In natural conditions and rainfed agriculture the main volume of precipitation is distributed in 1.5 m soil layer and used maximally by plants. During the period of saturation of soils with precipitation occurs takeaway of salts into deep underlying horizons the vadose zone , which returns to its original state regulated by biological barrier, resulting from the selective ability of the root system of plants use mainly fresh water from deep horizons. For this reason, in the root zone is formed descending currents of moisture, which provide a steady migration of salts from the soil surface horizons. Therefore, lysimeters, charged in the chernozem and chestnut areas generally have a deep character of salt accumulation along the vertical profile.

Table 1 - The degree of soil salinity of experimental sites and lysimeters,% from weight of oven-dry soil

Horizons, см	Soil zone								
	Chernozem			Chestnut			Sierozem		
	Ch-1	Ch-22	Ch-3	K-1	K-2	K-3	S-1	S-2	S-3
0…20	1,642	0,441	0,094	0,140	2,514	0,755	2,234	0,873	0,163
20…40	1,561	0,633	0,064	0,660	2,789	0,875	1,610	0,752	0,135
40…60	1,481	0,454	0,086	1,662	2,307	0,957	1,567	0,746	0,123
60…80	1,870	0,265	0,166	1,549	1,942	1,610	1,581	0,864	0,119
80…100	1,577	0,203	0,937	0,584	0,800	1,789	1,568	1,109	0,114
100…125	1,138	0,110	0,784	0,428	0,649	1,319	1,596	1,071	0,115
125…100	0,786	0,110	0,519	0,606	0,756	1,527	1,732	1,018	0,072
0…50	1,577	0,520	0,080	0,400	2,582	0,843	1,820	0,794	0,138
0…100	1,626	0,410	0,269	0,919	2,071	1,197	1,734	0,869	0,123
0…150	1,405	0,304	0,397	0,785	1,613	1,272	1,709	0,926	0,122

The soils with superficial nature of salinity, intense accumulation of salts occurs in the upper soil horizons. In this case, the salt accumulation is developed with the direct participation of groundwater in the soil formation, which enhance the migration of salts from the lower to the upper horizons due to growth of their evaporation. Especially this process is developing intensively in the area sierozem. Therefore lysimeters, charged on saline sierozems basically have superficial salinity.

Results of the study of ion composition of salts show that among the anions dominant is SO_4^{2-} ions and their reserves in meliorated layer of chernozem reach to 63.6 % (Ch-1) the amount of salt. In meliorated layer of saline soils of chestnut and serozemov SO_4^{2-}-ions reserves reached 62.4%, accordingly (K-2) and 67.5 % (S-3) the amount of salt. Cl-ions in meliorated layer of chernozem ranged from 3.3 to 24.6 % of the amount of salts in saline soils of chestnut from 5.7 to 27.3 %. Similar dynamics of chlorine reserves on sites is observed in the root layer of saline sierozems.

To assess the ecologo-reclamation state of irrigated lands and the technical level of irrigation systems, were carried out collecting fund materials in terms of water intake for irrigation and water removal from various irrigation systems. The suitability of irrigating, groundwater and drainage water for irrigation of crops was estimated by danger of soil salinization and solonetsization of soil toxicity of individual ions. For this purpose, used the methods designed by I.N. Antipov-Karataev and G.M. Kader; sodium adsorption ratio (SAR), (SAR *), taking into account the additional effect of the presence of calcium in the soil (USA). Assessing the impact of magnesium is carried out by defining percentage of magnesium from its relationship to the amount of calcium and magnesium cations, which has a detrimental effect on the soil, if its percentage above 50 % (Bekbayev, 2002, Yakubov, 1982)

Results and Discussion

A compilation of submissions of field and lysimetric studies revealed that regardless of soil type, volume and infiltration rate of irrigation water depends on crop irrigation technology, as well as the chemical properties of soils. For example, the cultivation of sorghum, alfalfa and amaranth on flushed chernozem showed that the amount of infiltration losses depending on the mode of irrigation vary widely. (table 2). Growth in the size of irrigation norms and thus decrease the humidity in the root zone of soil increases the size of infiltration losses.

Table 2 - Volumes of infiltration losses during irrigation

Crop	Irrigation rate м^3/ha	Vegetation periods					
		beginning		middle		end	
		м^3/га	% from irrigation rate	м^3/ha	% from irrigation rate	м^3/ha	% from irrigation rate
Sorghum	200	20	10	16	8	14	7
	400	64	16	52	13	40	10
	800	184	23	152	19	104	13
	1200	384	32	324	27	240	20
Alfalfa	200	32	16	26	13	20	10
	400	100	25	80	20	64	16
	800	296	37	372	31	336	28
	1200	612	51	504	42	480	40
Amaranth	200	24	12	20	10	20	10
	400	76	19	60	15	48	12
	800	200	25	152	19	12	15
	1200	480	40	384	32	312	26

Therefore, by optimizing irrigation technology can be provided a high intensity of soil desalinization and surface water by increasing the accumulation of salts in the lower layers of the aquifer and reduce the loss of irrigation water to infiltration (Koybakov, 2000). For example, in the chernozem and chestnut zone, where is salt zone at a depth of 1 m, and in the upper layers of salt are largely absent, the main problem with irrigation is the solonetsization of soils, flushing their nutrients and organic matter. Therefore, during irrigation in this area should be strived to reduce the amount of infiltration losses. Consequently, on the Northern and Central Kazakhstan, where the horizontal drainage works no more than 7 months, and creation of an optimal soil ecological regime of soils via flushing, recharge irrigation strengthens the processes of soil solonetsization and alkalinization must be solved by crop irrigation technology. Therefore in the chernozem and chestnut area in terms of preventing the development of processes of solonetsization and alkalinization regulation limits of soil moisture should not fall below 80-90 % of minimum moisture capacity (MMC). It defines need for application of sprinkler and frequent watering small norms - 200-500 м^3/ha. Irrigating crops with small norms at high values of minimum moisture capacity (85-90 % of MMC) enhances salt-washed from the soil.

In sierozem area where irrigation of crops carried out in a superficial way with large irrigation rate, productivity of irrigated land depends on the technological level of irrigation systems (efficiency irrigation system, irrigation technology), farming systems and the quality of irrigation water. At the same time, cheap and reliable way to reduce the size of irrigation norms is furrow irrigation of crops (figure 1).

Figure 1 – Alternate furrow irrigation of crops in the experimental and production sites of KazSRIWE (basins of the Asa-Talas and area of Aris-Turkestan canal)

Found that when furrow irrigation (control variant), 50-60 % of the supplied water to the field was spent on moisturizing the soil. The rest of the volume of water consumed by the technological losses: 18-20 % by filtering on the temporary irrigation network and irrigation fields, 9-10 % by evaporation from the water surface, 16-19 % of for discharge from irrigated lands (table 3). The share of technological losses was about 46.3 % of the water supply.

Table 3 – The use of irrigation water by furrow irrigation during the growing season (average data)

Option	Gross irrigation rate, м³/ha	Water loss (м³/ha) for				Technological losses,% of irrigation norms		
		Moistening the soil	Filtering	Dropping	Evaporation	Filtering	Dropping	Evaporation
Furrow irrigation (control)	1500	805	285	260	150	19,0	17,3	10
Alternate furrow irrigation	800	496	152	112	40	19	14	5,0

When watering the cotton by alternate furrow has occurred increase in accumulation of moisture (water) in the calculated layer of soil and water losses reduction for filtering on the temporary irrigation network and fields of irrigation, evaporation from the water surface, discharge from irrigated lands. Effectiveness of this technology is confirmed by articles of irrigation water use: 60-70 % spent on moistening the soil, 10-15 % for filtering on the temporary irrigation network and irrigation fields, about 5 % for evaporation, 5-10 % for discharge from irrigated lands.

Production indicators of technological losses typical for many irrigation systems of Kazakhstan, which leads to increase the water scarcity, increase the runoff of drainage waters, which are returned to irrigation sources and polluted. For this reason, river water quality is deteriorating, and the environmental situation in the river basins, especially in the lower reaches becomes threatening to the local population.

Under conditions of constant growth of water scarcity, one of the ways to improve water availability of irrigated land is the use of return water for irrigation of crops and for flushing saline soils. However, a variety of soil zones of Kazakhstan requires the development of technologies for their use based on physico-chemical properties of soils.

Large absorption capacity of chernozems and chestnut soils does not allow widespread use of return water for irrigation of crops and for flushing of saline soils. Application of mineralized water for irrigation of crops on chernozem and chestnut soils enhances the rate of accumulation of salts in the upper horizons of soil root zone. In addition, one of the main reasons limiting the use of return water for irrigation and flushing are the processes of soil solonetsization. Especially this process occurs intensively in the upper horizons of the root zone.

Therefore, in the chernozem and chestnut zone of Kazakhstan, mineralized return water can be used for flushing salt marshes having high reserves of gypsum and carbonates in the soil solid phase. This is due to the fact that the salt marshes with high concentrations of soil solution, provide a washout the salts from the root zone of the soil. The scope and limits the use of return water depends on the degree of soil salinity and mineralization of return water.

In the south, where the soil compared with chernozem and chestnut soils 3-4 times lower than absorption capacity, the volumes and limits of the use of return water are increased. In this zone, in the extremely drought years, the return water is widely used for irrigation of crops and sub-irrigation. Possibility of using groundwater in sub-irrigation indicates growth of irrigated land with shallow ground water. The results of the analysis of materials Zhetysu, South Kazakhstan and Kyzylorda hydrogeological reclamation expedition showed that a total of about half (50.3 %) of irrigated land in Southern Kazakhstan has a depth of groundwater up to 3 m (table 4).

However, for the wider use of groundwater in sub-irrigation, their salinity should not exceed 3 g/l. The results of studying the nature of changing in mineralization of ground water of irrigated land in Southern Kazakhstan show that in the basin of Balkhash-Alakol water complex 86 % of irrigated land has ground water with a salinity of up to 3 g / l (table 5). In Shu-Talas basin water complex, the area of irrigated land with up to 3 g/l is 92.8 %.

Table 4 - Distribution of irrigated lands by the depth of the groundwater

№ пп	Basins	Total of irrigated land	The depth of occurrence, м			
			<1	1,0-3,0	3,0-5,0	>5
1	Balkhash Alakol (Almaty region)	581,6 100	32,9 5,6	240,0 41,3	177,6 30,5	131,1 22,6
2	Shu-Talas (Zhambyl region)	152,8 100	2,30 1,5	44,2 30,0	68,6 44,9	37,7 24,6
3	Syrdarya (South Kazakhstan region)	511,7 100	0,4 0,1	162,0 31,7	175,6 34,3	173,6 33,9
	Kyzylorda region	300,0 100	20,4 6,8	275,0 91,7	4,6 1,5	
	South Kazakhstan	1546,1 100	56,0 3,6	721,2 46,7	426,4 27,6	342,4 22,1

Note: in the numerator: area - thousand hectares; area - as a% of total irrigated land

Table 5 - Distribution of areas with different groundwater mineralization in section of basin

№ пп	Basins	Total of irrigated land	Mineralization, г/л			
			<1	1,0-3,0	3,0-5,0	>5
1	Balkhash Alakol (Almaty region)	581,6 100	283,3 48,4	219,1 37,6	81,2 14,0	
2	Shu-Talas (Zhambyl region)	152,8 100	109,6 71,7	32,2 21,1	7,7 5,0	3,3 2,2
3	Syrdarya (South Kazakhstan region)	511,7 100	156,9 30,7	233,1 45,6	62,9 12,2	58,8 11,5
	Kyzylorda region	300,0 100		153,5 51,2	63,7 21,2	82,8 27,6
	South Kazakhstan	1546,1 100	549,8 35,6	637,9 41,3	215,5 13,8	144,9 9,3

Note: in the numerator: area - thousand hectares; area - as a% of total irrigated land

The study results of changing groundwater depth and mineralization on the areas of irrigation systems indicate that one way to reduce the size of irrigation water is the use of groundwater on sub-irrigation. At the same time one of the negative aspects of sub-irrigation is the accumulation of salts in the root layer of soil. Therefore, in the basin zone of the Balkhash-Alakol about 60 % of irrigated land is saline. The basin of Shu-Talas, compared to other basins the saline land area has a minimum value. In this basin area the saline land is 28.8 %. The remaining land is not saline.

Analysis of the data shows that in the Syr Darya river basin the most saline is the irrigated lands of Kyzylorda region. In this region, the area of non-saline irrigated land does not exceed 1 %, and the remaining 99 % of the area is saline. Collation of data by soil salinity of the southern region of the country shows that, in general non-saline land area is 44.5 %, while the remaining 55.5 % is saline.

In conditions of South Kazakhstan one of the ways to improve the water supply of irrigated land is the use of collector-drainage water for irrigation. Comparative analysis of the volume of collector - waste water discharging outside of irrigation systems show that most of their sizes obtained in irrigation systems of South Kazakhstan region. The total amount of collector waste water in the region 829.4 million $м^3$, which 676.9 million $м^3$ or 81.6 % of the collector-waste waters of Shardara (457.6 million $м^3$) and Mahtaaral (219,300,000 . $м^3$) arrays (table 6).

Table 6 – Collector- waste waters of southern Kazakhstan, million. $м^3$

South Kazakhstan	Kyzylorda region	South Kazakhstan			Zhambyl region		Almaty region
		region	Mahtaaral	Shardara	Asa-Talas	Chu	
1293,76	266,5	829,4	219,3	457,6	-	12,36	185,5

From presented materials follows that the volume of collector- waste water discharging outside the irrigated areas are about 1,294 km3, if use it for irrigation not only increase the water availability of irrigated land, but also reduce the rate of contamination of water and land resources and their degradation.

Increasing the productivity of saline soils is achieved by removing and flushing excess toxic salts from the soil root-zone. The results of field and lysimetric studies have shown that reducing the size of single flushing rates increase the intensity of flushing salts from the root zone of soil, reduce the size of flushing rates (table 7). Therefore, flushing saline soils of Northern and Central Kazakhstan, is recommended to flush with rate of 500 m^3/ha after 2-3 - days. Submission of small norms to the irrigated land carried out by sprinkling machines and aggregates.

Table 7 - Flushing regime and the size of flushing rates

The soil type and number of the site	The sizes of the single flushing rates, м^3/ha	The duration of inter-irrigation periods, day	Salt reserves, т/ha		Flushed salts,t/ha	The flushing rate, м^3/ha	
			Original	Residual		net	gross
Chernozem, Sh – 5	250	1	141,1	69,3	71,8	3600	5000
	500	2	141,8	39,4	72,5	4300	5500
	1000	4	141,9	70,1	71,8	4600	6000
	2000	8	139,5	69,2	70,3	5000	6000
Serozem, S – 1	250	1	450,8	91,4	359,4	11800	14000
	500	2	461,3	92,6	368,7	12800	15000
	1000	4	464,5	91,8	372,7	14000	16000
	2000	8	470,2	92,0	378,2	15800	18000

In sierozem zone (Southern Kazakhstan), climatic conditions allow to flush in the autumn-winter. Herewith irrigation system in southern Kazakhstan are designed mainly for surface irrigation, application small flushing rates (250-500 m^3/ha) is practically impossible. Therefore, flushing saline soils of southern Kazakhstan were proposed flushing by checks with a single flush norm 1000 m3/ha in 4-8 days (figure 2). On light soils, is recommended to carry out a single flushing with norm 2000-2500 m^3/ha in 6-12 days.

Figure 2- Flushing of saline soil by furrows and small checks

The sizes of checks depend on the method of water supply, the slope of land surface , quantities of the single flushing rates. When flushing with single flushing rates within 1000 m^3/ha and slope of the land is less than 0.001, the optimum width of checks (at the higher slope) is 20-30 m, and the length (smallest slope) is 30-40 m. Application of single flushing rates about 2000-2500 m^3/ha allows to increase the width of checks to 30-40 m and a length up to 50-60 m.

Solonetsous soils and solonetses are saline soils, to increase their productivity and improve the ecology of irrigated lands are required chemical reclamation (Vyshpolsky, 2010). For this purpose the commonly used gypsum, phosphogypsum, sulfuric acid, calcium chloride and other chemical meliorants. Each of these chemical ameliorants has chemical activity towards sodium and determines the intensity of desolonetsization and desalination of soils at the same size of flushing rates. Consequently, the development of resource-saving technologies of chemical amelioration of solonetsous soils should be based on the flow of soil-ecological processes in flushed layer for of soils for various natural zones of Kazakhstan.

In conditions of South Kazakhstan, the most effective chemical ameliorants is phosphogypsum is produced as an industrial waste of phosphorus production. Chemical plants of Taraz is accumulated a huge amount of (more than 8 million tons) phosphogypsum, which consists mainly of calcium sulfate (about 80 %). The composition includes phosphates (1,3…2,9 %). For evenness of application should be used spreaders RUM – 5 or 1 – RMG – 4 (figure 3).

Figure 3 - Application of phosphogypsum on reclamation site

Reclamation effect of phosphogypsum should be attributed to acidic meliorant therefore in alkaline medium is more soluble and provides a radical improvement of the physical and chemical properties of solonetsous and alkaline soils (figure 2). Phosphogypsum increases the water absorption speed to 30 ... 35 % and improves water supply of plants. Furthermore, phosphogypsum has fertilizing effect. When introducing of phosphogypsum 4-5 t/ha stocks of phosphor increases by 1.0-1.8 mg per 100 g of soil, which corresponds to the introduction of superphosphate 500-600 kg / ha

Conclusion

Thus, reform of irrigated agriculture has led to a change of ownership forms to the basic means of agricultural production and the creation of small-scale production. The result was a loss of centralized management of water and land resources. This worsened the water supply and the reclamation condition of irrigated lands, reduced their productivity. In the changed economic conditions, growth of degradation processes in the root zone of soil and water shortages during the growing season, the problem of increasing the productivity of irrigated land can be addressed through technical upgrading of irrigation systems, increasing the fertility of degraded (saline, solonetsous and alkaline) soils and implementation of resource saving technologies of irrigation, groundwater use on sub-irrigation and collector- drainage water for irrigation of crops. Therefore, employees of SRIWE, irrigated chernozem soils, chestnut and sierozem zones of Kazakhstan have conducted long-term studies to establish the parameters of integrated water management technologies and land resources. In Kazakhstan, the integrated technology include following saving technologies: desalinization (patent number 17023 Method of flushing saline soils) and desolonetsization of degraded soils (patent number 17024 Method reclamation of alkaline soils, № 20139 Method for determining the dose of the meliorant for reclamation of alkaline soils); irrigation of crops (patent number 20354 Furrow irrigation); the use of groundwater on sub-irrigation (patent number 20448 Method for determining soil moisture); The use of collector-drainage water for irrigation and flushing (patent number 17589 Method flushing saline irrigated lands) by improving their quality

References

Aydarov I.P. 1985. Regulation of water-salt and nutrient regimes of irrigated land. M Agropromizdat,. 304 cp.

Vyshpolsky F.F. 2005. Mukhamedjanov H.V. Technology of water conservation and management of soil-reclamation processes during irrigation. Taraz, 162 p.

Bekbayev R.K. 2002.Modeling reclamation processes on irrigated lands. Taraz: IC "Aqua". 226 p.

Vyshpolsky F.F., Bekbayev R.K., Mukhamedjanov H.V., Bekbayev U.K. 2003. Improvement the method of calculating consumption of groundwater to evapotranspiration // Journal of Agricultural Science of Kazakhstan, № 8. p. 44-47.

A., Vyshpolsky, F.F. Mukhamedjanov, K.V. Bekbayev, U. Ibatullin, S. Yuldashev T., Noble A.D., Mirzabaev Aw-Hassan A., Qadir M.. 2010. Optimizing the rate and timing of phosphogypsum application to magnesium-affected soils for crop yield and water productivity enhancement. Agricultural Water Management 97 1277-1286.

Koybakov B.M. 2000. Irrigation in the Northern and Central Kazakhstan.Almaty, 245 p.

Yakubov H.I., Usmanov A.U., Bronitsky N.I. 1982 Guidance on the use of drainage water for irrigation of crops and washing saline lands. – Tashkent, 77 p.

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Development of plant growth-promoting bacterial based bioformulations using solid and liquid carriers and evaluation of their influence on growth parameters of tea

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Abstract

The potential PGPR isolates are formulated using different organic and inorganic carriers eitherthrough solid or liquid fermentation technologies. Carrier-based preparations of five N_2-fixing and/or P-solubilizing microorganism based bio-fertilizers (F1: *Bacillus subtilis*RC11+ *Bacillus megaterium* RC07+ *Pseudomonas fluorescens* RC77; F2: *Bacillus subtilis* RC63+ *B.megaterium*21/3+ *P.fluorescens*8/4; F3: *B.subtilis*36/10+ *B.megaterium*42/2+ *P.fluorescens*8/6; F4: *B. subtilis,* 39/3+ *B.megaterium*42/4+ *P.fluorescens*9/7; F5: *B.subtilis*RC521 + *B.megaterium*42/4+ *P.fluorescens*9/7), developed in sevenorganic and inorganic solidcarriers (tea waste, peat, perlite, leonardite, zeolite, and vermiculite)and liquid carriers basedformulations were evaluated for their growth promotion and yield of tea.The experiment also included applications of a biological fertilizer, and NPK-fertilizer as well as a control treatment without inoculation and fertilizer application. The experiments were conducted in a completely randomized design with four replicates (each having five rooted cutting sapling) under natural soil conditions. Growth and survival of PGPR formulations in carriers material were evaluated. The efficacy of prepared bioformulations were then evaluated on promoting tea sapling growth characteristics including plant height, trunk diameter, leaf fresh and dry weight, leaf area and chlorophyll concentration in tea. Bio-fertilizers efficiencywas variable and depended on the inoculants strain, carriersand growth parameters evaluated. Of the effective bacterial and carriers formulationstested consistently gave growth and yields of tea equal to or higher than chemical fertilizes applied.The bio-fertilizers used in organic farming, increase plant growth and development of tea was concluded that positive affect.

Keywords: Tea (*Camellia sinensis* L.), solid and liquid carriers, plant growth-promoting bacteria, bio-fertilizers

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Introduction

Tea (*Camellia sinensis*L.) the most important plant of Turkey is used in the traditional preparation of its national food and is planted widely on acidic soils.Currently, Turkey is one of the most important tea producing countries, ranking 5th places in the world after China, India, Kenya and Sri Lanka with annually 200.000 tons of dry tea production. Turkey's tea growing area is only located at the very mountainous eastern end of the Black Sea coast, centered on the town of Rize and Trabzon. In this area, the soils are classified as acid. However, no information is available on the occurrence of PGPR tolerant to soil acidity and its interactions with acid tolerant crops generally grown onacidic soils of the tea gardens of Turkey. The soils of tea land in Turkeyare also generally acidic condition.Tea gardens are usually grown as a monoculture and receive considerable amounts of fertilization, root exudates and leaf litter (Çakmakçı et al., 2010). Tea, one of the widely cultivated crop of on the Eastern Black Sea coast, depends on high agricultural inputs which are not only detrimental to non-targeting organisms but for human health also. The nitrogen, phosphorus and potassium contents of tea plantation were low.Tea is a perennial leaf crop which requires more nitrogen than most other crops and N application significantly increases both the yield and quality of tea (Han et al., 2008).To improve the yield of tea leaves, N fertilizer, especially urea, was applied to tea orchards, and its use has increased year after year. Undoubtedly, excess use of chemical fertilizers has resulted in several problems including persistence of chemicals in plant products and adverse impact on soil environment which in turn leads to loss inproductivity (Chakraborty et al., 2009). Many studies showed that excess amounts of N fertilizer application can cause tea orchard soil acidification (Hanet al., 2008), groundwater and surface water pollution (Liu et al., 2012), affect nitrification rates (Xue et al., 2006), contribute in low N use efficiency and also cause serious environmental pollution (Han et al., 2008). Over application of chemical fertilizers is responsible for altering the soil quality and soil microbial populations (Nath et al., 2013; Bhatt et al. 2012). Relative shortage of soil nutrient content, fertilization extensive management soil acidification problems are more prominent (Liu et al., 2003; Xiao, et al., 2004), which seriously restricted the sustainable development of the tea production and the sustainable utilization of the tea plantation soil, and soil nutrient status is the decisive factor of whether tea grown vigorous and the tea quality (Liang et al., 2003).

In this regardthe use ofPGPRis seenas an important approachin agriculture. The use of beneficial bacteria as agricultural inputs for increasing crop production needs the selection of competent rhizobacteria with plant growth promoting attributes. PGPR are reported to influence the growth, yield, and nutrient uptake by an array of mechanisms. The beneficial rhizobacteria facilitate the plant growth through N_2 fixation, solubilisation of insoluble phosphorus, production of siderophores and phytohormones, lowering of ethylene concentration, production of antibiotics and antifungal metabolites and induced systemic resistance and/or enhance other beneficial bacteria (Saharan and Nehra, 2011; Ahemad and Khan, 2011). The use of PGPR may have more important in plants that their leaves used. As well known only leaves are used in processing in tea and therefore these kinds of bacteria can be more important in sustainable and organic tea production. However, information about the characteristics of composition and diversity of the bacterial community in tea plantations soil ecosystems is scarce.Also, information on use ofbio-fertilizers in tea is very scanty and there is no systematic study to see whether these can be used in tea field with advantage (Saikia et al., 2011). In addition the use of these kinds of bacteria in tea production is also limited because tea is produced in limited countries in the world (Çakmakçı et al., 2011).

In general, shortly after suspensions of bacteria are inoculated into the soil without a proper carrier, thebacteria population declines rapidly for most species of PGPR (Bashan et al., 2014). Biofertilizers must be usually prepared as carrier-based inoculants containing effective microorganisms.The formulation of a bacterial inoculant is defined as a preparation containing one or more beneficial PGPR strains, as well as organic and inorganic carrier materials. Incorporation of microorganisms in carrier material enables easy-handling, long-termstorage and high effectiveness of biofertilizers.Various types of material are used as carrier for seed or soil inoculation. For soil inoculation, carrier material with granular form is generally used. Such carrier materials that offer the available nutrient and/or habitable micro-pore to theinoculant bacteria will be desirable. When PGPR areformulated using inorganic or organic carriers, their stability and durability are increased. The two main aspects dominating the success ofinoculation are the effectiveness of the bacterial isolateand the proper application technology (Bashan et al., 2014). A good formulation promotes survival of bacteria, maintaining a viable population sufficient to expose growth promoting effects on plants.

Thus, the objectives of this study were to develop and prepare some new bioformulations and evaluate their efficacy in possible promotion of tea saplings growth characteristics.The efficacy of prepared bioformulations were then evaluated onpromoting tea saplings growth characteristics including plant height, trunk diameter, leaf fresh and dry weight, leaf area and chlorophyll concentration in teasapling.Solid and liquid carriers and evaluation of their influence on growth parameters of tea evaluation of their influence on growth parameters of tea.

Material and Methods

We selected thirteen different potential PGPR from a pool of 460 rhizobacterial isolates based on their, auxin (IAA)–producing, N_2-fixing, P-solubilizing and/or 1-aminocyclopropane -1-carboxylate (ACC) deaminase-containing strains were tested for their three strains combinations on growth and yield increasing potential under natural soil conditions by conducting pot experiments in two years at the Ataturk Tea and Horticultural Research Institute of Rize (Table 1). Pot experiments were arranged as a completely randomized two-factor design seven carrier materials, eight treatments and four replications (each having five rooted cutting sapling). The treatments included: (1)Control (withoutbacteria inoculation or mineral fertilizers), (2)NPK fertilizer (1400 mg sapling^{-1} year^{-1} incompound NPK 25-5-10 fertilizer), (3) biological fertilizer, (4)F1 (*Bacillus subtilis* RC11+ *Bacillus megaterium* RC07+ *Pseudomonas fluorescens* RC77),(5) F2 (*Bacillus subtilis* RC63+ *Bacillus megaterium*21/3+ *Pseudomonas fluorescens*8/4), (6) F3 (*Bacillus subtilis*36/10+ *Bacillus megaterium*42/2+ *Pseudomonas fluorescens*8/6), (7) F4 (*Bacillus subtilis,* 39/3+ *Bacillus megaterium*42/4+ *Pseudomonas fluorescens*9/7), (8) F5 (*Bacillus subtilis*52/1 + *Bacillus megaterium*42/4+ *Pseudomonas fluorescens*9/7). Saplings were the rooted cuttings,used as planting material. The bacterial strains*Bacillus subtilis* RC11,*Bacillus subtilis*RC63 and *Pseudomonas fluorescens* RC77 were isolated from the rhizosphere of wild red raspberries (Çakmakçı et al., 2007), *Bacillus megaterium* RC07 was isolated from wheat (Çakmakçı et al., 2006), *Bacillus subtilis*RC521 was isolated from the grapevine, and the othereightstrains were isolated from the rhizosphere of tea (Çakmakçı et al., 2010).

For this experiment, pure cultures of 13singlestrains were grown in 50% strength tryptic soy broth (TSB) on a rotary shaker (120 rpm; 25 °C) for 3 days. Bacteria were then harvested by centrifugation (ca. 3000 x g for 10 in), washed and re-suspended in 10 mM sterile phosphate buffer, pH 7 (SPB) to a density of 10^9cfu ml^{-1} for the bacterial strains. For the five microorganisms based bio-fertilizers, frozen bacterial culture seeded in petri dish Nutrient Agar (NA) containing medium, incubated for 24 hours at 27 °C. Pure colonies were taken from fresh culture and transferred to Nutrient Broth (NB) culture media. Horizontal shaker incubator developed a 24-hour culture, inoculated in NB containing the liquid culture media, previously prepared by fermentors and sterilized by autoclaving at 121 °C for 20 min. Bacteria were developed 24 h optimum pH, oxygen, and temperature values. Bacteria inoculated organic liquid carrier, the optimum growth conditions were incubated in the bioreactor. Counts of viable bacteria per millilitre (cfu) made in bacterial concentration was 1x10^8 cells/ml at the end of 48 hours, during which time exceeds, packaging made completely sterile conditions, the product has been kept in a room temperature at 24 °C.

The sixpowdered organic and inorganic solid of tea waste compost (TWC), peat (PET), perlite (PER), leonardite (LEO), zeolite (ZEO), and vermiculite (VER) and one liquid (LIQ)carriers material were chosen as carrier in this study. Sterilization of carrier material is essential to keep high number of inoculant bacteria on carrierfor long storage period. Bacterial isolates was inoculated into NB broth and incubated on a shaker incubator at 150 rpm for48 h. After 48 h of incubation, the broth containing 10^9cfu ml^{-1} was used for the preparation of TWC-based, PET-based, PER-based, LEO-based, ZEO-based, VER-based and LIQ-based formulations. For the preparation of bioformulations, to 400 ml bacterial suspension, a mixture of 1 kg of a purified TWC, PET, PER, LEO, ZEO or VER powder, pH was adjusted to 7 by adding calcium carbonate and 10 g carboxyl methyl cellulose (CMC adhesive) was added under sterile conditions,following the method described byVidhyasekaran and Muthuamilan (1995), Ardakani et al. (2010) and Jorjani et al. (2011).Powdered carriers material and CMC mixed well.The pH of all materials was adjusted to 7.0 by adding calcium carbonate and autoclaved. Then four hundredmiilliters of bacterial suspension containing 1 x 10^8cfu/ml was added to 1 kg of carrier and mixed well under sterile conditions. Carrier material is packed in partially opened, thin-walled polypropylene bags,sealed and incubated at room temperature (24±2). We have developed powdered organic and inorganic carrier based strain mixture formulation of PGPR, in which methyl cellulose and carriers was mixed and blended with equal volume of bacterial suspension at a concentration of 10^9cfu/ml. Formulations were prepared by mixing equal volume of individual strains and blended with carrier.In preparation of teawaste bioformulation, the procedure was similar but tea waste was initially soaked overnight in distilledwater to remove the phenolic components (Chakraborty et al., 2010). Survivability of PGPR was checked at a regular interval of one month for a period of six months using direct plating method in nutrient agar medium. The bio-fertilizer had 10^8 bacterial cells g^{-1}carrier at the time of application to soil. Bacterial survival was tested in seven different carriers; tea waste, peat, perlite, leonardite, zeolite, vermiculite, and one liquid. The initial population of bioformulation in liquid andpowdered organic and inorganic solid-based formulation was10^8cfu/g of the product anddeclined to 1.1-4.4 x 10^7cells/ml after 6 months of storage.

Soil application of solid- based formulation at rate of 2.5 kg formulation mixed with 25 kg of well decomposed farm yard manure (150 mg of the formulated product for one sapling in a pot) per ha on 2 days after planting. Uniform height young rooted cutting were inoculated with liquid liquidcommercial bio-fertilizers and liquid carrier-based bio-fertilizers prior to planting. The liquid formulations and the bio-fertilizers application involved dipping the root system of the saplings into a suspension of each formulations for 60 min, prior to planting. One rooted cutting sapling was planting in each pot and 5 pots were kept as one replication. All pots were placed randomly in an outdoor field and wereallowed to growcontinuouslyin natural conditions. Plant height, trunk diameter, total shoot+leaf weight fresh and dry leaf weight, chlorophyll contents in tea leaveswere determined.

Table 1. Biochemical characteristics of the bacterial strains tested

Bio-formulation	Bacterial strain	Oxidase	Catalase	Sucrose	N_2-fixation	P-solubili-zation	ACC deaminase activity
F1	*Bacillussubtilis* RC11	W+	S+	+	+	+	S+
	*Bacillusmegaterium*RC07	W+	S+	-	+	S+	ND
	Pseudomonasfluorescens RC77	S+	+	-	W+	+	S+
F2	*Bacillussubtilis* RC63	+	S+	-	S+	W+	S+
	*Bacillusmegaterium*21/3	-	+	-	S+	S+	S+
	*Pseudomonasfluorescens*8/4	S+	W+	S+	+	+	S+
F3	*Bacillussubtilis*36/10	-	S+	+	S+	+	+
	*Bacillusmegaterium*42/2	-	+	-	+	+	ND
	*Pseudomonasfluorescens*8/6	S+	S+	W+	+	S+	S+
F4	*Bacillussubtilis*39/3	W+	S+	+	S+	W+	+
	*Bacillusmegaterium*42/4	-	+	-	S+	+	W+
	*Pseudomonasfluorescens*9/7	+	+	S+	S+	+	S+
F5	*Bacillussubtilis*521	-	S+	+	S+	-	S+
	*Bacillusmegaterium*42/4	-	+	-	S+	+	W+
	*Pseudomonasfluorescens*9/7	+	+	S+	S+	+	S+

"S^+": strong *positive reaction,* "+": positive reaction, "W^+": weak positive reaction, ND: not determined.

Results and Discussion

Use of plant growth promoting rhizobacteria (PGPR) can play important roles in developing sustainable systems for crop production. Bacterial formulations were tested with seven carriers as bioinoculant. The impact of storage on viability of inoculum was checked up to six months.All the carriers were near neutral in pH. The pHvalues of seven solid and liquid carriers were in between 6.58 and 7.45(TWC, pH = 7.39; peat, pH = 7.45; perlite, pH=7.10; leonardite, pH=6.58; zeolite, pH=7.26; vermiculite, 7.14;liquid, pH=7.24), which was appropriatefor any type of bacterial species.

On average of carriers materials, inoculation of all bioformulations and mineral fertilizers increased trunk diameter, plant height,total shoot+leaf weight, fresh and dry leaf weight, leaf area, and SPAD chlorophyll content of leavesin tea saplings when compared to the control saplings (Table 2).Of these eight treatments**,** the maximum trunk diameter in tea was found when the NPK application was followed by bio-fertilizer, F2, F3, F1, F5 and F4 mixed bioformulation.Differences in terms of trunk diameter were, however, not significant between triple inoculation with N_2-fixing and P-solubilizing bacteria and NPK application. As an average of seven carriers, mixed inoculations of tea with F1, F2, F3, F4, F5, and bio-fertilizer increased trunk diameter by 14.9, 15.2, 15.2, 14.0, 14,3, and 15.5% as compared to the control and plant heightby 19.3, 20.4, 16.8, 18.8, 20.0, and 20.0%, respectively. NPK applications, however, increased trunk diameterup to 26.0% and plant height by 22.3%.

In addition to the above growth factors, saplings height were also significantly promoted by all treatments with various degree of efficacy (P<0.05). Among them, NPK application was the most effective followed by F2, F5, Bio-fertilizer, F1, F4 and F3 inoculation (Table 2). On an average of carriers, inoculation with F4 mixed bioformulation (*Bacillus subtilis,* 39/3 + *Bacillus megaterium*42/4+ *Pseudomonas fluorescens*9/7) caused maximum increase in the shoot+leaf weight and fresh leaf weight of tea plants that was 46.2 and 39.5% higher than the respective uninoculated control.On average of carrier materials, *application* of tea with F1, F2, F3, F4, F5, and bio-fertilizer gave increases over control respectively of by %20.5, 26.2, 35.3, 46.2, 38.0, and 32.9% inshoot+leaf weight, by 15.0, 26.0, 34.1, 39.5, 35.1, and 36.9% in fresh leaf weight and by 21.3, 26.2, 38.4, 34.8, 36.9 and 32.8% in dry leaf weight.NPK applications, however, increased shoot+leaf weightup to 28.0%, fresh leaf weight by 25.1 and dry leaf weight by 23.9%.The maximum dry leaf weight of Turkish tea clones Pazar was found aftermixed bioformulation F3 (*Bacillus subtilis*36/10+ *Bacillus megaterium*42/2+*Pseudomonas fluorescens*8/6) treatment, followed by F5, F4, MegaFlu, F2, NPK, and F1 treatments.All the treatments enhanced chlorophyll contents and average leaf areaas compared to the control.Among the fertilizer and mixed bioformulationinoculations, the best treatmentwas the third combination, followed by NPK fertilizer, second andfifth triple formulation combination of N_2-fixing and P-solubilizing bacteria in terms of chlorophyll contents. Thus averagely on seven carriers materials, inoculation with F1, F2, F3, F4, F5, and MegaFlu increased chlorophyll contentsover control respectively by 20.4, 23,2, 25.0, 18.2, 22.1, and 21.5% while NPK application increased SPAD value 23.4%. Of the effective bacterial formulations tested consistently gave growth and yields of tea equal to or higher than chemical fertilizes applied. Our previous experiments show that triple inoculation with phosphate-solubilizing bacteria and nitrogen-fixing bacteria resulted in higher plant height, shoot and leaf weight than uninoculated control (Çakmakçı et al., 2013).Our results clearly indicate the beneficial effect of mixed formulations the N_2-fixer and P-solubilizer in inoculants production. Combined inoculations with PGPR have been reported to be more effective than single inoculation on promoting plant growth and providing a more balanced nutrition for various crops (Şahin et al., 2004; Madhaiyan et al., 2010; Yu et al., 2012; Çakmakçı et al., 2013).

Table 2. Effect of bacterial and solid or liquid carriersformulations treatments on the average trunk diameter, plant height, shoot+leaf weight, fresh and dry leaf weight, chlorophyll contents (SPAD) and leaf area of Turkish tea clone Pazar.

Treat-ments*	Carriers **	Trunk diameter (mm)***	Plant height (cm)	Shoot+leaf weight (g sapling^{-1})	Fresh leaf weight (g sapling^{-1})	Dry leaf weight (g sapling^{-1})	SPAD chlorophyll value	Leaf area (cm^2)
Control	TWC	6,91 f-i	47,74 n-o	24,31 l	17,29 lm	9,13 k-m	75,45 a-e	23,3 i-l
	PET	7,08 d-i	48,22 l-o	25,99 l	17,68 kl	9,47 kl	65,54 e-g	23,2 i-l
	PER	5,86 j	45,09 o	24,03 l	15,87 m	8,58 m	56,98 g	20,2 l
	LEO	7,02 e-i	48,80 k-o	25,34 l	15,96 m	8,65 m	59,17 g	20,9 l
	ZEO	6,74 hi	48,21 l-o	25,76 l	15,89 m	8,58 m	56,94 g	19,9 l
	VER	6,61 i	47,93 m-o	25,43 l	16,20 m	9,06 lm	61,96 fg	22,0 kl
	LIQ	7,17 c-i	52,74 i-n	24,43 l	16,20 m	8,55 m	58,92 g	20,9 l
	Average	6,77 b	48,39 c	25,04 f	16,44 d	8,86 f	62,14 c	21,48 c
NPK	TWC	8,07 ab	57,74 a-j	33,35 f-h	21,25 g-i	11,82 e-g	80,76 ab	32,2 a-c
	PET	8,20 ab	58,31 a-j	31,92 g-j	20,47 hi	11,07 g-i	76,24 a-e	27,0 d-j
	PER	7,02 e-i	54,85 d-j	28,80 k	18,38 kl	9,85 j-l	68,13 c-g	24,0 h-l
	LEO	8,13 ab	61,25 a-c	30,12 j-k	19,94 ij	10,42 ij	74,64 a-e	26,2e-j
	ZEO	7,73 a-e	60,28 a-f	30,65 i-k	19,87 ij	10,79 hi	73,65 a-e	26,1 e-j
	VER	7,58 a-g	57,96 a-j	33,88 e-g	21,69 f-h	11,52 f-h	80,40 a-c	28,5 b-g
	LIQ	8,21 ab	63,78 a	35,71 c-e	22,33e-g	11,37 f-h	82,77 a	29,3 b-g
	Average	7,85 a	59,17 a	32,06 c-e	20,56 b	10,98 de	76,65 ab	27,63 ab
F1	TWC	7,97 ab	54,28 e-k	33,70 e-g	21,16 g-i	11,55 f-h	77,37 a-e	26,7 d-j
	PET	7,90 a-c	58,13 a-j	28,56 k	17,94 kl	10,73 hi	76,53 a-e	25,2 g-k
	PER	6,73 hi	53,10 i-n	24,90 l	15,99 m	9,70 j-l	61,82 fg	23,0 j-l
	LEO	8,31 a	58,83 a-i	30,59 i-k	18,75 jk	10,32 ij	79,53 a-d	27,9 c-h
	ZEO	7,75 a-e	62,08 a-c	32,30 g-j	20,40 hi	11,40 f-h	76,80 a-e	33,0 ab
	VER	7,57 a-g	57,23 b-j	28,71 k	17,63 kl	9,87 j-l	72,32 a-f	29,8 b-f
	LIQ	8,24 ab	60,39 a-e	32,53 g-i	20,45 hi	11,71 e-g	79,14 a-d	30,4 b-e
	Average	7,78 a	57,72 ab	30,18 e	18,90 c	10,75 e	74,79 ab	27,99 ab

Table 2. Continiue

Treat-ments*	Carriers **	Trunk diameter (mm)***	Plant height (cm)	Shoot+leaf weight (g sapling-1)	Fresh leaf weight (g sapling-1)	Dry leaf weight (g sapling-1)	SPAD chlorophyll value	Leaf area (cm2)
F2	TWC	8,10 ab	60,91 a-d	28,87 k	18,00 kl	11,44 f-h	76,73 a-e	23,0 j-l
	PET	8,25 ab	58,55 a-i	37,60 bc	24,48 c	12,46 c-e	80,96 a	30,5 a-e
	PER	6,85 g-i	56,00 c-j	29,00 k	18,80 jk	10,72 hi	78,55 a-d	27,5 d-i
	LEO	7,87 a-c	56,58 b-j	36,32 cd	24,66 c	10,37 ij	77,82 a-e	27,0 d-j
	ZEO	7,65 a-f	58,54 a-i	32,20 g-j	21,50 f-h	11,82 e-g	73,95 a-e	25,6 f-k
	VER	7,57 a-g	56,37 c-j	24,31 l	15,94 m	9,72 j-l	68,25 b-g	28,0 c-h
	LIQ	8,31 a	60,83 a-d	32,95 f-h	21,66 f-h	11,70 e-g	79,43 a-d	28,5 b-g
Average		7,80 a	58,26 ab	31,61 cd	20,72 b	11,18 d	76,53 ab	27,16 ab
F3	TWC	7,73 a-e	52,22 j-n	31,83 g-j	22,00 fg	12,80 b-d	77,52 a-e	26,2 e-j
	PET	7,99 ab	59,68 a-h	34,90 d-f	23,70c-e	12,89 b-d	75,85 a-e	26,1 e-j
	PER	7,57 a-g	57,09 b-j	32,00 g-j	21,26 g-i	11,10 g-i	82,02 a	23,0 j-l
	LEO	7,97 ab	56,85 b-j	38,90 b	21,80 f-h	11,80 e-g	75,36 a-e	34,5 a
	ZEO	7,60 a-g	56,48 b-j	30,30 i-k	19,80 ij	11,42 f-h	75,59 a-e	29,3 b-g
	VER	7,45 b-h	54,23 e-k	33,00 f-h	22,09 fg	12,71 b-d	78,70 a-d	26,8 d-j
	LIQ	8,30 a	59,05 a-i	36,24 cd	23,64c-e	13,14 bc	78,70 a-d	29,7 b-f
Average		7,80 a	56,51 b	33,88 bc	22,04 a	12,26 a	77,68 a	27,94 ab
F4	TWC	7,81 a-d	58,73 a-i	46,30 a	29,10 a	15,04 a	75,77 a-e	30,4 b-e
	PET	7,92 a-c	57,36 b-j	35,91 c-e	22,96 d-f	11,13 g-i	58,79 g	30,1 b-e
	PER	6,86 g-i	53,80 g-l	28,97 k	19,97 ij	9,30 k-m	70,73 a-f	24,0 h-l
	LEO	7,80 a-c	56,95 b-j	33,96 e-g	20,41 hi	11,36 f-h	77,51 a-e	25,6 f-k
	ZEO	7,85 a-d	59,98 a-g	37,27 bc	21,80 f-h	12,49 c-e	78,46 a-d	30,7 a-d
	VER	7,60 a-g	55,77 c-j	34,90 d-f	21,65 f-h	11,53 f-h	74,97 a-e	29,4 b-g
	LIQ	8,23 ab	59,86 a-g	39,01 b	24,60 c	12,75 b-d	77,69 a-e	29,3 b-g
Average		7,72 a	57,49 ab	36,62 a	22,93 a	11,94 bc	73,42 b	28,48 a
F5	TWC	7,75 a-e	56,88 b-j	33,42 f-h	24,35 cd	13,36 b	78,85 a-d	25,6 f-k
	PET	7,92 a-c	56,39 c-j	31,34 h-j	19,82 ij	11,28 gh	75,69 a-e	24,0 h-l
	PER	6,86 g-i	54,00 f-k	24,90 l	17,17 lm	9,92 jk	67,54 d-g	23,9 h-l
	LEO	8,13 ab	59,87 a-g	45,20 a	24,50 c	12,85 b-d	77,45 a-e	30,9 a-d
	ZEO	7,81 a-d	60,13 a-g	31,30 h-j	19,83 ij	11,05 g-i	77,69 a-e	30,3 b-e
	VER	7,45 b-h	58,17 a-j	38,80 b	26,08 b	13,48 b	76,69 a-e	27,0 d-j
	LIQ	8,23 ab	60,56 a-e	36,95 b-d	23,75c-e	12,95 b-d	77,33 a-e	27,1 d-j
Average		7,74 a	58,08 ab	34,56 b	22,21 a	12,13 ab	75,89 ab	26,97 b
Bio-Fertilizer (MegaFlu)	TWC	7,90 a-c	58,02 a-j	28,92 k	19,79 ij	10,78 hi	75,41 a-e	26,8 d-j
	PET	8,06 ab	57,39 b-j	30,34 i-k	20,46 hi	11,10 g-i	75,68 a-e	31,1 a-d
	PER	7,17 c-i	53,53 h-m	34,87 d-f	23,65c-e	11,42 f-h	68,30 b-g	27,9 c-h
	LEO	7,97 ab	56,52 b-j	38,90 b	24,60 c	12,50 c-e	74,51 a-e	27,7 d-h
	ZEO	7,86 a-d	62,81 ab	31,32 h-j	22,34e-g	11,86 e-g	80,43 a-c	23,2 i-l
	VER	7,47 b-h	57,10 b-j	33,70 e-g	22,94 d-f	12,52 c-e	75,89 a-e	26,9 d-j
	LIQ	8,29 a	61,21 a-c	34,85 d-f	23,78c-e	12,22 d-f	78,25 a-d	28,8 b-g
Average		7,82 a	58,08 ab	33,27 b-d	22,51 a	11,77 c	75,50 ab	27,48 ab
Average	TWC	7,78 bc	55,82 c	32,59 bc	21,62 ab	11,99 a	77,23 a	26,75 a
	PET	7,91 ab	56,75 bc	32,07 bc	20,94 cd	11,27 b	73,16 b	27,17 a
	PER	6,86 e	53,43 d	28,43 d	18,89 f	10,07 c	69,26 c	24,19 b
	LEO	7,90 ab	56,96 bc	34,92 a	21,33 bc	11,03 b	74,50 ab	27,57 a
	ZEO	7,62 cd	58,56 ab	31,39 c	20,18 e	11,18 b	74,19 ab	27,25 a
	VER	7,41 d	55,59 cd	31,59 c	20,53 de	11,30 b	73,66 ab	27,30 a
	LIQ	8,12 a	59,80 a	34,08 ab	22,05 a	11,80 a	76,53 ab	28,01 a

*Control: without bacteria inoculation or mineral fertilizers; N fertilizer (550 kg ha^{-1} $year^{-1}$ in the form of *ammonium nitrate* 33%); NPK fertilizer (1400 mg $sapling^{-1}$ $year^{-1}$ incompound NPK 25-5-10 fertilizer);F1: *Bacillus atrophaeus* RC11+ *Bacillus megaterium* RC07+ *Pseudomonas fluorescens* RC77; F2: *Bacillus subtilis* RC63+ *Bacillus megaterium*21/3+ *Pseudomonas fluorescens*8/4; F3: *Bacillus subtilis*36/10+ *Bacillus megaterium*42/2+ *Pseudomonas fluorescens*8/6; F4: *Bacillus subtilis,* 39/3+ *Bacillus megaterium*42/4+ *Pseudomonas fluorescens*9/7; F5: *Bacillus subtilis*52/1 + *Bacillus megaterium*42/4+ *Pseudomonas fluorescens*9/7; ** (TWC: tea waste compost, PET: peat, PER: perlite, LEO: leonardite, ZEO: zeolite,VER: vermiculite and LIQ: liquid carriers material; ***Different letters within the same column indicate significant differences according to Duncan's Multiple Range Test ($P \leq 0.05$

As an average of the treatments, among the carrier materials, the best treatment was the liquid carriers, followed by tea waste compost, leonardite, and peat- based formulationsin terms of fresh leaf weight.Under natural soil conditions by conducting pot experiment,liquid carriers and tea waste compostcaused the maximum enhancement in fresh and dry leaf weight and SPAD chlorophyll value in tea, while the liquidleonarditepeatandzeolite was the most effective in terms of trunk diameter and plant height. Among the carriers, liquid, tea waste compost, leonardite and peat performed well and effective in their respective developed bioformulations. Furthermore, formulation of PGPR bacteria may have practical application in promotion of plant growth characteristics which can potentially replace the use of chemical fertilizers. Tea waste, leonardite and peat-based mixedbioformulationwere much better than any other solid carriers-basedinoculant taken in the study.Maximum increase in fresh leaf yield was recorded in the case of tea plants inoculated with tea waste compost- based F4 and F5formulations.Application of the bacterium resulted in significant increase in growth of young tea, measured in terms of growth and yield. As tea plants are cultivated for their leaves, which are harvested, increase in leaf weigh is considered of importance to tea industry. Baby et al. (2002) reported that inoculation of bioformulation or liquid culture into the rhizosphere of tea seedlings significantly increased growth of these seedlings. Application of PGPRs as several kinds of formulations have been reported by several previous workers (Tilak and Reddy 2006; Chakraborty et al., 2009, 2010). Previous studies also demonstrated the application of PGPR in soil have resulted in significant increase in growth of young tea bushes (Sharma et al., 2002; Chakraborty et al., 2006) andhelp in the reduction of the use of chemicals in tea plantations (*Chakraborty* et al., 2009). Similarly, reduction of 25% and 50% N and P fertilizers with addition of bio-fertilizer consortium was found to increase the yield of young tea over control (Saikiaet al., 2011). Results of the above-mentioned studies clearly indicate that development of stable formulations of PGPR is of great importance and is a promising approach to a sustainable agriculture. In our study although all bioformulations performed effectively in promoting tea saplings growth characteristics, but F4 (*B.subtilis,* 39/3 + *B.megaterium*42/4+ *P.fluorescens*9/7) and F3 (*B.subtilis*36/10+ *B.megaterium*42/2+ *P. fluorescens*8/6) mixed bioformulations were relatively more effective. The use and application of such bioformulations in plants can result in the reduction of application of harmful chemicals; protect the environment and biological resources. Due to a great variation in soil ecology of different regions, no single PGPR can be used universally as a bio-inoculant. In this context, the optimization of PGPR inoculums must be rigorously tested in the presence of diverse biotic and/or abiotic factors. In addition, to maintain the maximum viability and activities of PGPR, an appropriate carrier should be developed.

Conclusion

We tested seven organic and inorganic solid and liquid materials with five new bacterial formulations. The study clearly indicates that development of stable formulation of PGPR is of great importance and is a promising approach to a sustainable agriculture. In our study we also showed and proved that development of bioformulations using organic and inorganic carriers including tea waste, peat, leonardite, perlite, zeolite, vermiculite and liquid may be a practical and effective method for biofertilization of tea plant. The results of present study in the development and formulation of PGPR may have practical application in promotion of plant growth which can potentially reduce and avoid the use of chemical fertilizers. The use and application of such bioformulations in the fields can result in the reduction of application of harmful chemicals, protect the environment and biological resources and prevent the accumulation of nitrates and phosphates in agricultural soils.

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References

Ahemad, M., Khan, M.S., 2011. Functional aspects of plant growth promoting rhizobacteria: recent advancements. Insight Microbiol. 3, 39-54.

Ardakani, S.S., Haydari, A., Tayebi, L., Mohammadi, M., 2010.Promotion of cotton seedlings growth characteristics by development and use of new bioformulations. Int. J. Bot. 6, 95-100.

Baby, U. I., Tensıngh, B., Ponmurugan, P., Premkumar, R., 2002.Effect of *Azospirillum*on nursery grown tea plants. In: Sreedharan, K., Vinod Kumar, P. K., Jayarama, Chulaki, B. M. (Eds.), Proceedings of the 15th Plantation Crops Symposium, pp. 369–374.

Bashan, Y., de-Bashan, L.E., Prabhu, S. R., Hernandez, J.-P., 2014. Advances in plant growth-promoting bacterial inoculant technology: formulations and practical perspectives (1998–2013). Plant Soil 378, 1–33.

Bhatt, B., Chandra, R., Ram, S., 2012. Long-term application of fertilizer and manure on rice productivity and soil biological properties.Int. J. Agric. Environ. Biotech.5, 429-433.

Çakmakçı, R., Dönmez, F., Aydın, A., Sahin, F., 2006.Growth promotion of plants by plant growth-promoting rhizobacteria under greenhouse and two different field soil conditions.Soil Biol. Biochem. 38, 1482-1487.

Çakmakçı, R., Erat, M., Erdoğan, Ü.,Dönmez, F., 2007. The influence of plant growth-promoting rhizobacteria on growth and enzyme activities in wheat and spinach plants. J. Plant Nutr. Soil Sci. 170, 288-295.

Çakmakçı, R., Dönmez, M. F., Ertürk, Y., Erat, M., Haznedar, A., Sekban, R., 2010.Diversity and metabolic potential of culturable bacteria from the rhizosphere of Turkish tea grown in acidic soils.Plant Soil 332, 299-318.

Çakmakçı, R., Ertürk, Y., Sekban, R., Haznedar, A., Varmazyari, A., 2013.The effect of single and mixed cultures of plant growth promoting bacteria and mineral fertilizers on tea (*Camellia Sinensis*)growth, yield and nutrient uptake.1st Central Asia Congres on Modern Agricultural Tecniques and Plant Nutrition. 01-03 October, 2013, Soil Water J., Secial Issue for AGRICASIA, 2 (1), 653-662.

Çakmakçı, R., Ertürk, Y., Atasever, A., Ercişli, S., Şentürk, M., Erat, M., Haznedar, A., Sekban, R., 2011.The use of plant growth promoting rhizobacteria for organic teaproduction in Turkey.Proceedings of Tea-Organic-Low Carbon İnternational Symposium.6-9 June, pp. 89-97, Guangyuan, China.

Chakraborty, U., Chakraborty, B., Basnet, M., 2006.Plant growth promotion and induction of resistance in *Camellia sinensis*by *Bacillus megaterium.*J. Basic Microbiol. 46, 186-195.

Chakraborty, U., Chakraborty, B.N., Basnet, M., Chakraborty, A.P., 2009. Evaluation of *Ochrobactrumanthropi* TRS-2 and its talc based formulation for enhancement of growth of tea plants and management of brown root rot disease. J. Appl. Microbiol. 107, 625–634.

Chakraborty, U., Chakraborty, B. N., Chakraborty, A. P., 2010. Influence of *Serratiamarcescens* TRS-1 on growth promotion and induction of resistance in *Camellia sinensis* against *Fomeslamaoensis*. J. Plant Interact. 5, 261-272.

Han, W. Y., Ma, L. F., Shi, Y. Z., Ruan, J. Y., Kemmitt, S. J., 2008. Nitrogen release dynamics and transformation of slow release fertiliser products and their effects on tea yield and quality. J. Sci. Food Agric.88, 839-846.

Jorjani, M., Heydari, A., Zamanizadeh, H.R., Rezaee, S., Naraghi, K., 2011. Development of *Pseudomonas fluorescens* and *Bacillus coagulans* based bioformulations using organic and inorganic carriers and evaluation of their influence on growth parameters of sugar beet. J. Biopest. 4, 180-185.

Liang, Y.F., Tian, Y.H., Wang, G.H., Wang, J.L., Zhou, G.L., 2003. Influence of different land use types on soil erosion and nutrition care effect in loess hilly region. Chinese Agric. Sci. Bullet. 19, 44-46.

Liu, J., Sun, H.W., Liu, J., Qiu, Z.L., Zhao J. H., Yang, D.P., 2003. Analysis of mineral elements in soil of tea plantation and tea in Shandong province. J. plant Resour. Environ. 12, 40-43.

Liu, Z., Yang, J., Yang, Z., Zou, J., 2012. Effects of rainfall and fertilizer types on nitrogen and phosphorus concentrations in surface runoff from subtropical tea fields in Zhejiang, China.Nutr.Cycl.Agroecosyst. 93, 297-307.

Madhaiyan, M., Poonguzhali, S., Kang, B.G., Lee, Y.J., Chung, J.B., Sa, T.M., 2010. Effect of co-inoculation of methylotrophic*Methylobacteriumoryzae* with *Azospirillumbrasilense* and *Burkholderiapyrrocinia* on the growth and nutrient uptake of tomato, red pepper and rice. Plant Soil 328, 71-82

Nath, R., Sharma, G.D., Barooah, M.2013. Screening of endophytic bacterial ısolates of tea (*Camellia sinensis*L.) roots for their multiple plant growth promoting activities. Int. J. Agric. Environ.Biotech. 6, 211-215.

Rivera-Cruz, M.D.C., Narcia, A.T., Ballona, G.C., Kohler, J., Caravaca, F., Roldan, A., 2008.Poultry manure and banana waste are effective biofertilizer carriers for promoting plant growth and soil sustainability in banana crops. Soil Biol. Biochem. 40, 3092-3095.

Saharan, B.S., Nehra, V., 2011. Plant growth promoting rhizobacteria: A critical review. LSMR-21, 1-30.

Sahin, F., Çakmakçı, R., Kantar, F., 2004.Sugar beet and barley yields in relation to inoculation with N_2-fixing and phosphate solubilizing bacteria.Plant Soil 265, 123–129.

Saikia, D. N., Sarma, J., Dutta, P. K., Baruah, D. K., 2011. Sustainable productivity of tea through conservation of bio-mass, addition of bio-fertilizers and reduction of inorganic fertilizer.Two and a Bud 58, 109-117.

Sharma, K. L., Sharma, D. K., Sharma, G., 2002. Long term response of integrated nitrogen nutrition with bioresources on the yield of China hybrid tea (*Camellia sinensis*L.) grown in North West Himalayas. In: Sreedharan, K., Vinod Kumar, P. K., Jayarama, Chulaki, B. M. (Eds.), Proceedings of the 15th Plantation Crops Symposium, 386–391.

Tilak, K.V.B.R., Reddy, B.S., 2006. *Bacillus cereus* and *B. circulans*-novel inoculants for crops.Curr Sci. 90, 642-644.

Vidhyasekaran, P., Muthamilan, M., 1995.Development of formulations of *Pseudomonas fluorescens*for control of chickpea wilt.Plant. Dis. 79, 782–786.

Xiao, R.L., Wang, J.R., Chen, Z.F., Liu, Y.S., Peng, W.X., Peng, P.Q., Tang, Y., 2004.Ecological tea plantations and tea safety hi-efficiency production in the subtropical hill region of China. Res. Agric. Modernization, 25, 360-363.

Xue, D., Yao, H., Huang, C. Y. (2006): Microbial biomass, N mineralization and nitrification, enzyme activities, and microbial community diversity in tea orchard soils. Plant Soil 288, 319-331.

Yu, X., Liu, X., Zhu, T.H., Liu, G.H., Mao, C., 2012.Co-inoculation with phosphate-solubilzing and nitrogen-fixing bacteria on solubilization of rock phosphate and their effect on growth promotion and nutrient uptake by walnut. Eur. J. Soil Biol. 50,112-117.

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The impact of conservation tillage in soil quality and yield in semi-arid conditions

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Abstract

The uncertain rain-fed agriculture in semi-arid and need annual water negatively affects the production and grain yield. These characteristics are an obstacle to rapid changes in varietals' lines or culture systems to cope with climate changes. Soil loss is very advanced by the various phenomena of erosion. These phenomena are exacerbated by production systems (monoculture cereal and fallowing) and the methods and tools used tillage. The wait for the rains to begin the initial tillage of soil is necessary. This situation leads them to significantly reduce the period of crop growth, already reduced in recent years because of climate change, including drought and global warming. The performance impacts of conservation tillage (such as direct seeding) are discussed successively, through the results of tests conducted in the region. A field experiment was conducted during 2007-2012 at farmers' field located in two regions. We proceed to the study of soil parameters such as moisture and organic matter and the parameters of crop yield. The direct drilling studies on cereal crops are beginning to draw tracks and paths for further research and understanding of why not to integrate this system on the farm more respectful towards natural resources and system production sustainability.

Keywords: Conservation tillage, direct drilling, Humidity, Organic matter, Semi-arid, Wheat

Introduction

Cereal production in Algeria remains dependent on soil and climatic factors and techniques and crop rotation factors.

Crop productivity and soil fertility in semi arid area is influenced by tillage and crop rotation management. Rain-fed croplands conditions in the high plains of Setif are highly prone to land degradation due to their extensive agricultural practices.

Technical itinerary flap mainly tillage can lead short or long period the degradation of soil structure, loss of organic matter, erosion and declining of biodiversity. These phenomena are primarily related to the production system, cereal and livestock as well as many other problems related to the land preparation. As well as many other problems related to the land preparation. The soil became more susceptible to wind and water erosion under conventional tillage system. Conventional tillage especially on plowing layer disturb aggregates of soil and increase soil temperature and soil organic decay (Islam, 2011; Benniou, 2012; Aziz et *al.*, 2013).

Many scientific studies drawing attention to the consequences of conservation systems, they emphasize the economic, agronomic interest and respect for the environment that characterizes direct seeding (no till) and

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Simplified cultivation techniques. But very few experiments were conducted on the interest of this agricultural technique practiced on cereal's crops in semi-arid areas (Benniou, 2012).

The greatest portion of the work concerns on the environmental aspects (reduction of soil erosion), crop husbandry (production, control of residues, weed control and crop rotations) and agricultural machines (seeders). But few works has been carried on the impact of this new technology on soil properties and their evolution. Therefore, it is important to study different tillage system in this region. Conservation tillage leaves most of the crop residues on the surface, thus has positive influence to soil chemical, biological and physical quality properties. Tillage practices can modify soil environment, improve porosity, increase disintegration of aggregates and mix plant materials into plow depth which increases crop biomass and soil contact (Aziz et *al.*, 2013).

Conservation tillage such as reduced tillage (or simplified cultivation techniques) that aims at minimum disturbance of soil and maintaining optimal levels of crop residues on soil surface can reduce the adverse effects of convention tillage (Sayre and Hobbs, 2004). Reduced tillage is a suitable alternative to retain crop residues and maintain soil quality on degraded land of arid or semi-arid zone (Wang and al., 2006). The substantial benefits associated with conservation tillage are moisture conservation (Hassan et al., 2005), which saves 25-30% of irrigation water, improved nutrients availability (Govaerts et al., 2005) through proper placement of fertilizer, reduced soil salinity (Bakker et al., 2010), reduced production costs (Gupta et al. 2009), and similar or higher yields compared to convention tillage (Govaerts et al. 2005; Hassan et al. 2005). Crop residue holding capability of conservation tillage practices increase soil organic matter content (Egamberdiev, 2007), decrease soil salinity, reduce soil evaporation losses and thus increase water use efficiency (Deng et *al.* 2003). Tillage effect on weed restriction is also confirmed as part of sub-parts-till were less grass than subparts witnesses and on other hand weeding seem work to have parties was facilitated direct seeding, using a weeding post seedlings (Benniou, 2012).

In this study we assessed the comparable effect of conservation, minimum and convention tillage system based crop rotation system to cereals crop yield and soil fertility in semi arid conditions of Setif High Plain agro-ecosystems.

Material and Methods

Our field experiments were set at farmers' field located Setif district of East Algeria's region. The soil of the selected area has been identified as silty clay. The sol is alkaline whose pH slightly higher than 7 and unsalted (0.31 mmhos / cm).

Soils were cut to the monoculture of cereals for the past 50 years under the rainfed regime.

The climate of the region is typically continental with an average annual rainfall of 320 ± 30 mm and over 90% of the total rainfall is between October to April. The average monthly minimum temperature air is 0°c in January and maximum of 37°c in July. The highest average relative humidity is a little over 80% in January and the minimum is less than 45% in June.

The plots of the preceding cultures were placed in three repetitions in a stript-plot. The trial was planted on land where direct drilling is practiced for the fifth year. The previous crop was durum wheat was planted after the lens, which was planted after durum wheat, which was planted after the lens. So the rotation during the last four years is the following: Wheat- Lens -Wheat-Lens.

The object studied is the technology of tillage at three levels: direct seeding, conventional tillage and minimum tillage:

(a) Direct drilling (DD): total absence of tillage. (b) Tillage treatments comprised of conventional tillage (CT, including disc plow, tiller, rotavator, and leveling operations) and (c) reduced tillage (RT, one tiller followed by harrowing).

The experiment consists of three treatments: direct drilling (zero tillage) conventional tillage and reduced tillage and was replicated thrice in a strip plot design. The size of each experimental plot was 50 m x 20 m. A buffer zone spacing of 1 m and 2.5 m was provided between plots and blocks, respectively. The tools used for preparing the soil are: disc plow, vibrashank cultivator, disc harrow and roto-harrow.

During the season of experience, the culture cultivated followed was conducted in rainfed conditions without irrigation.

Culture Under all cultural methods was planted on 2 of December, but preparing soil tillage, disking and seedbed preparation respectively have over twenty, fifteen, ten and four days before setting up of cultivation . The dose applied seeding is 155 kg / ha to obtain a seeding rate of 270 seeds/ m^2. Seed rate is calculated based on the germination of seed, which was about 95%. Spreading fertilizer background in the form of MAP was performed on 2 of December 2 for the three treatments (DD, CT and RT). The dose application was 90 kg /ha used by Units: 10.80N + 46.80P.

Maintenance fertilizer: at the beginning of April, early-tillering stage, nitrogen fertilization using Uree 46% was applied at 100 kg / ha. Full tillering stage, the second nitrogen fertilization was performed on the three plots (DD, CT, RT), in late April, where it was also used Uree but the applied dose is 130 kg/ ha.

Weeding before sowing on DD plot with Roundup to 2.5 liters/ ha. Early tillering another weeding treatment stage was performed using Granstar fight against broadleaf weeds at a dose of 15 g/ ha. In late April as Topic various products including the applied dose is 180 liters/ ha, with a slurry of 185 liters/ ha.

Soil samples were collected from 0-20 and 20-40 cm layers in the beginning, at the end of experiment and of each replicate during the crop vegetative stages. The soil samples were air-dried, ground to pass through à 2 mm sieve and analysis for chemical and physical contents.

The water profile was measured through the soil samples throughout the physiological cycle.

Results and Discussion

Soil parameters

Evolution of soil moisture

The evolution of soil moisture content by weight in two depths (0-20 cm and 20-40 cm) curves shown in figure 1, show variations from the crop cycle. The average test at the beginning vegetative stage (germination-emergence) amounted to 33.4%, with a standard deviation of 1.79%. Conventional tillage (CT) gave this point a slightly higher moisture (34.76%), followed by the reduce tillage (RT) with 34.03% and lastly direct drilling (31.38%). At this stage, the roughly differences low compared to the average is recorded the test, respectively: 1.36%, 0.63% and 2.02%. These differences clearly demonstrate that the moisture is accumulated in the ground at least further worked, as the TC and RT.

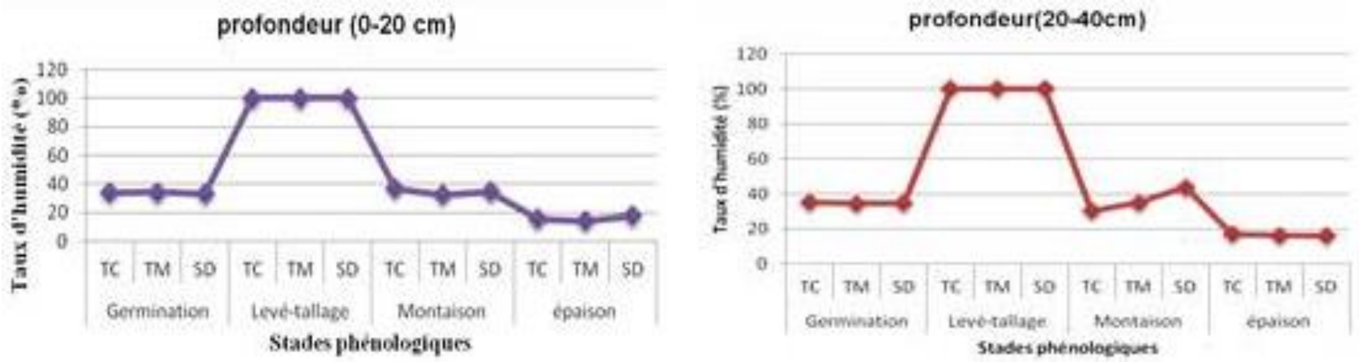

Figure 1: Evolution of soil moisture (Legend: *SD*: DD, *TM*: RT, *TC*: CT.)

In stage from stem elongation, the humidity changes and lowered in the three cultural techniques relative to the beginning of cycle. The average test humidity rises to 34.64% with a standard deviation of 1.79%. Note that humidity is higher in cultural direct drilling (DD) with 36.71% respectively compared to the reduce tillage (RT) (33.65%) and conventional tillage (CT): 33 57%, with differences, calculated relative to the average, at least low: SD (2.07%), RT (-0.99%) and CT (-1.07%). Also, the differences between work cultivation are more or less varied: 3.06% (DD-RT), 3.14% (DD-TC) and 0.08% (RT-CT).

However, heading stage, the humidity changes and also lowers in the three farming techniques. But it was noted that the moisture through cultural techniques is that unlike start of vegetation. The average humidity at heading stage amounted to 16.11%, with a standard deviation of 0.87%. The humidity recorded is higher in direct drilling, which amounts to 16.83% compared with conventional technique (CT) and reduce tillage (RT), respectively 16.33% and 15.16%. Small differences are noted with respect to the test average: 0.72%, 0.22% and -

0.95%. It was explained that variation soil moisture between vegetative cycle beginning (germination-emergence stage) and of the cycle end (heading stage), the profile of direct drilling is due to several effects:

(i) Direct drilling can be considered as a means of managing water resources including water saving at the vegetative end of cycle plant, particularly in rainfed farming conditions in semi-arid (Belgueri et al. 2007).

(ii) In conventional tillage, deep plowing, affects soil structural stability. Of fact, the soil becomes more permeable and allowed accelerating the water evaporation.

As compared to depth, it was noted that soil moisture is higherely in soil depth (20-40 cm) compared to the superficial (0-20 cm) across cropping techniques, except direct drilling and germination stage, soil moisture was higher in surface (0-20 cm). This seems logical because at this stage, the soil is not waterlogged much where tillage is zero. Overall, the underlying soil portion (20-40 cm) holds more water than 0-20 cm depth.

Organic matter

The organic matter content (OM) varies by cultivation technique and depth. The assay MO average is 2.7%, with a standard deviation of 0.15%. It was noted that cultivation technique, namely direct drilling and reduce tillage, occupied the first places in comparison to the conventional technique. Reduced tillage has the highest average with 2.80% a difference compared to the average test of 0.1%.

In technical conservation, the average organic matter content amounts to 2.73%. Finally, there has been the conventional technique (2.56%), a difference of -0.44% from test average. These results seem to us logical because the organic matter accumulation soil direct drilling is done in several years (six years) and no-till farming with diversified cropping (cereals, legumes).

By depth and cultivation techniques, it was noted that in 0-20 cm depth, the rate of the higher organic matter is recorded in direct drilling (2.93%), followed by the 20-40 cm depth (2.54 %). This means that the organic matter is in direct drilling relatively higher surface compared to the soil depth. The difference recorded between depths is 0.39%; this is due to the fact of residues presence permanently in surfaces (effect of previous crops). In reduce tillage, the soil organic matter percentage is also high in the surface portion (0-20 cm): 2.82% compared to the depth (20-40 cm): 2.77%. This is explained by the residues of cereals which are incorporated superficially by the superficial work. However, the opposite is observed in conventional tillage, where the organic matter soil percentage of depth was higher (20-40 cm): 2.77% in comparison to that of the surface portion (0-20 cm) 2.36%. Because tillage facilitates and promotes the organic material burial and accelerates the surface mineralization.

Table 1. Statistical results of the organic matter (U:%).

Technology tillage	Depth 1 (0-20 cm)	Depth 2 (20-40 cm)	Average	Ecart-type
CT	2,36	2,77	2,56	0.15
RT	2.82	2,77	2.80	
DD	2.93	2.54	2,73	
Average	2,70	2,69	2,70	

Parameters linked to weeds

Weeds Infestation

The weeds concurrent cultivated plants in nutrients needed for growth such as water, mineral elements, and more space. A density of 75 plants/ m^2 can reduce 20% of wheat yield (Arnal, 2006).

The variance analysis results showed an insignificant effect of cultivation technique on weed infestation with 37.89% of variation coefficient as shown in Table 2. The essay average of weed infestation totaled 139 feet's/m^2 with 53 feet's/m^2 at standard deviation.

By cultural technique, we recorded the highest weeds number in conservation technique, namely direct drilling (DD) with a count of 172 plants/ m^2. Then, the lowest value is obtained by conventional technique (CT) with enumeration of 85.33 plants/ m^2.

It should be remembered that treatment post planting concerned the three treatments using the Roundup; this is to eliminate weeds, especially in no-till plot that did not receive mechanical control.

It was explained that the high weed infestation registered direct drilling is due to potential stock in weed seeds at the soil surface although the rotation applied alternating crops of grasses and legumes crops (wheat-Lens-wheat-Lens). Direct drilling greatly reduces the labor regulator role on weeds development, but weed control in post planting and crop rotation in rotation can reduce in a significant way the weed infestation. For the reduce tillage one can say that the preparation of seedbed allow to create a favorable environment for germination and weeds growth. However, in conventional tillage, lower weed, that role plowing to bury and distribute weed seeds evenly in soil depth by turning land strips. Therefore tillage helps fight against weeds.

Table 2. Statistical results of weeds infestation (U: Feets/ m^2)

Average technology tillage			Average essay	Standard Deviation	Probability F1	VC%
DD	RT	CT				
171,66	161	85,33	139,33	52,789	0,208 (NS)	37,89

Parameters linked to culture

Stocking densities (Feet's Up/ m^2)

Analysis of variance results showed that the cultivation technique has a significant influence on the seeds lifting with a 14.43% for variance coefficient as shown in the table 2.

The average population density assay/ m^2 rises to 258 feet/m^2 with 37 feet/ m^2 for standard deviation. This density is slightly lower compared to the theoretical density of the area (300 feet/m^2), given the potentialities area.

By cultural technique, it was noted that parcels under direct drilling (DD) have a low density compared to conventional tillage (CT) and reduce tillage (RT), respectively: 172 feet's/m^2, 252 feet's/m^2 and 350 feet's/m^2).

One can interpret these variations by the installation conditions. The average population density is important in conventional techniques (350 feet/m^2). It exceeds the average of the test (258 feet's/m^2) and even the theoretical density (300 plants/ m^2). Probably, the conditions of seed germination seed remained favorable in conventional tillage. This is due to the favorable creation environment for growth and seed germination, ie loosening. Loosening the soil has a positive effect on the flow of water and air and nutrient utilization in depth as highlighted (Soltner, 2005). According to him, soil preparation provides a good structure to the ground while improving.

Then, reduce tillage preparing the seedbed has created a favorable environment for the seed's germination and the recovery rate of land is homogeneous.

So, direct drilling, probably the presence of previous residues crops interfere a little penetration tubes runs the drill into the ground, suddenly, it will not have a good seeds collection. Also, the loss to seeds direct drilling removal is due to unfavorable weather conditions in post exercise, including snow fell during the germination-emergence favored, saturation soil water and is asphyxia plants. This means that direct drilling technique is probably less resistant to weather this stage compared to other cultural techniques that allow good drainage.

However, germination and emergence of crops are based on the structural condition and physical properties of the soil during planting.

Table 3. Statistical results of the stocking (feet/m^2).

Average technology tillage			Average essay	Standard Deviation	Probability F1	VC%
DD	RT	CT				
172	252	350	258,11	37,25	0,012 (S)	14,43
A	B	B				

Grain yield (t/ha)

The calculated averages showed that the average real assay grain yield amounted to 2.26 t/ha, with 0.31 t/ ha for a standard deviation. The variance analysis showed an insignificant effect on the threshold of 5% between the three cultural techniques with 3.30% at variation coefficient.

The conventional technique has captured the first place with 2.5 t/ha grain, followed by the reduce tillage (2.38 t/ha) and finally direct drilling (1.92 t/ha). The recorded between conventional tillage and direct drilling gap stood at 0.58 t/ha. One can say that spite of the yield is lower in direct drilling in comparison to conventional tillage and reduce tillage. But it is interest to the environmental preservation plan, improvement of soil physico-chemical properties, reduction of soil erosion and also economic terms.

Table 4. Results of the real yield (t/ha)

Average technology tillage			Average essay	Standard Deviation	Probability F1	VC %
DD	RT	CT				
1.92	2.38	2.5	2.26	0.31	0,852 (NS)	3.30

Conclusions

The experimentation results obtained show that the soil physical properties, including the water profile and organic matter varies per technology tillage by classifying direct drilling (DD) in the first place with respect to reduce tillage (RT) and conventional tillage (CT). Examination of these soil parameters showed that the no-tillage has changed soil properties (moisture and organic matter).

The soil moisture evolution measures at the vegetative cycle end, shows that DD (no-till) and reduce tillage (RT) have stored more water. What is fundamental in a country where water is the main limiting factor in agricultural production? Also, there has been the organic matter accumulation generally beneficial for soil conservation in favor of direct drilling, especially after a judicious rotation during last five years.

As for the weed infestation, the differences are more or less weak, but the advantage is given to conventional tillage. The simplification tillage (RT) and no-tillage (DD) cause infestation by weeds, which are unfavorable for crop establishment, therefore, we must fight against these weeds per proper rotations and weeding first.

So the crop monitoring showed that the grain yield was best expressed in conventional conduct (CT) in relation respectively to the reduce tillage and direct drilling.

Through our study we noticed the problem of weeds, especially in direct drilling plots, which must be taken into consideration. At the end of the vegetative cycle, increasing the humidity in the soil direct drilling can be beneficial in case of drought.

By way of conclusion, we can say that direct seeding should be considered as a system and not as a simple method of soil preparation.

References

Arnal Atres, P., 2006. Semis direct dans la vallée moyenne de l'Ebre : Résumé des résultats et analyses économique. Troisième rencontres méditerranéennes du semis direct-Zaragoza. Ed ; option méditerranéenne, série A, n°69: 77-80.

Aziz, I., Mahmood, T., Islam, RK., 2013. Effect of long term no-till and conventional tillage practices on soil quality / Soil & Tillage Research 131- 30: 28–35.

Bakker, DM., Hamilton, GJ., Hetherington, R., and Spann, C., 2010. Salinity dynamics and the potential for improvement of water logged and saline land in a Mediterranean climate using permanent raised beds. Soil and Tillage Research 110(1):8–24

Belguerri, H., Bellameche, F., Habitouche, F., 2007. Contribution a l'étude de l'effet de la technique de semis direct sur la production céréalière en milieu semis aride. Cas de la région nord de Sétif. Mémoire d'ingénieur: University of M'sila.47p.

Benniou, R., 2012. Agriculture Conservation Role Of Moisture And Soil Organic Matter Semi-Arid. Journal Of Materials And Environmental Science, 3 (1) (2012): 91-98.

Deng, L., Chen, M., Liu, Z., Shen, Q., Wang, H., Wang, J., 2003. Effects of different ground covers on soil physical properties and crop growth on saline-alkaline soil. Chinese J Soil Sci 34(2): 93–97.

Egamberdiyeva, D., Gafurova, L., Islam, KR., 2007. Salinity effects on irrigated soil chemical and biological properties in the Syr-Darya basin of Uzbekistan. In: Lal R, Sulaimonov M, Stewart BA, Hansen D, Doraiswamy P (eds) Climate change and terrestrial C sequestration in Central Asia. Taylor and Francis, New York, pp 147–162.

Govaerts, B., Sayre, KD., Deckers, J., 2005. Stable high yields with zero tillage and permanent bed planting. Field Crop Res 94: 33–42.

Gupta, R., Kienzler, K., Martius, C., Mirzabaev, A., Oweis, T., De Pauw, E., Qadir, M., Shideed, K., Sommer, R., Thomas, R., Sayre, K., Carli, C., Saparov, A., Bekenov, M., Sanginov, S., Nepesov, M., Ikramov, R., 2009. Research Prospectus: A Vision for Sustainable Land Management Research in Central Asia. ICARDA Central Asia and Caucasus Program. Sustainable Agriculture in Central Asia and the Caucasus Series No.1. CGIAR-PFU, Tashkent, Uzbekistan.

Hassan, I., Hussain, Z., Akbar, G., 2005. Effect of permanent raised beds on water productivity for irrigated maize–wheat cropping system. In: Roth CH, Fischer RA and Meisner CA (eds.) Evaluation and performance of permanent raised bed cropping systems in Asia, Australia and Mexico. ACIAR Proceeding no 121.

Islam, KR., 2011. Continuous No-Till Impacts on Soil Biophysical Carbon Sequestration Soil Science Society of America Journal 09/ 75.

Sayre, K., Hobbs, P., 2004. The raised-bed system of cultivation for irrigated production conditions. In: Lal R, Hobbs P, Uphoff N, Hansen DO (eds) Sustainable agriculture and the Rice-Wheat system. Ohio State University, Columbia, Ohio, USA. pp. 337-355.

Soltner, D., 2005. La base de la production végétale. Science et technique agricoles. Tom I. 20ème Edition, pp : 472.

Wang, XB., Cai, DX., Hoogmoed, WB., Oenema, O., Perdok, UD., 2007. Developments in conservation tillage in rainfed regions of North China. Soil Till Res 93: 239–250.

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Boron adsorption characteristics of selected Benchmark soils of New Zealand

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Abstract

Boron (B) availability in soils depends on the adsorption/desorption process in soils which is controlled by several soil factors. Batch B adsorption studies were conducted by equilibrating 1 g samples ofseven selected surface soils belonging to different Soil Orderswith100 mL solution containing 0-15 mg B/L in the presence of 10^{-2} M $CaCl_2$ as background electrolyte. Boron adsorption in all soils wassatisfactorily described by both the Langmuir and Freundlich isotherms (R^2>0.81-0.98, p<0.01-0.001). The Langmuir adsorption capacities ranged from 1.78 to 6.26 mg B/g, with the Allophanic Soil havingthe highest amorphous Fe oxide content(6.7%) producing the greatest adsorption capacity. Neither the Langmuir nor the Freundlichadsorption capacity parameters had significant relationship with any of the soil properties. However, the Langmuir adsorption capacity had significant positive relationship with amorphous Fe oxidecontent when two of the soils were removed from the analysis.Adjusting the pH of the soils to vary between 2 and 11 resulted in an increase of B adsorption from pH 2 to approximately pH 9, followed by a decrease of adsorption with further increase in pH. The experimental data and model predicationscan be used to manage bioavailability of B in the soils studied.

Keywords: Boron adsorption, New Zealand soils, Soil pH, Langmuir adsorption isotherm, Fraundlich adsorptionisotherm

Introduction

Boron (B) is an essential micronutrient required for optimal plant growth.The B concentration in soil solution, which is the over-riding control for plant uptake of B, depends on B adsorption and desorption processes in soil. Many soil factors such as pH, mineralogy, and organic matter content are responsible for the distribution of B between the soil solid and liquid phases (Keren and Bingham, 1985).

Boron in soil solution is present in the forms of boric acid $B(OH)_3$ and borate ($B(OH)_4^-$ions, the concentration of the latter increases as soil pH increases to 9 (Goldberg and Su, 2007). At pH > 9, the OH^- concentrationincreases causing a decrease in B adsorption due to higher competition of $OH^-$with $B(OH)^-_4$for the adsorption sites in the soil. Maximum B adsorption onsoils depends on the ratio of the affinity coefficient of the $B(OH)_3$, $(B(OH)^-_4$ and OH^-(Stewart, 1988).Boron can specifically adsorb by forming inner-sphere complexation with clay minerals, especially the Fe and Al oxides (Goldberg and Su, 2007) in the soils. Among

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the alumino-silicate minerals in soils, on a weight basis,illite is the most reactive followed by montmorillonite and kaolinite (Keren and Mezuman, 1981).Besides mineralogy,pH doesinfluence B adsorption onto clay minerals.Keren and Mezuman(1981) reported that B adsorption onto illite increased from 4.9 to 7.5 µmol/g as pH increased(7.4 to 8.5), and from 1 to 2.5 µmol/g onto montmorillonite(for the same increaseinpH), and from 1 to 1.49 µmol/g onto kaolinite (pH increase from 7.4 to 10).

The relative distribution of B between solid and solution phases in soil is commonly investigated using Langmuir or Freundlich adsorption isotherm models (Goldberg, 1997; Datta and Bhadoria, 1999). Arora and Chahal (2010) reported that B adsorption in four arid and semi-arid soils of Punjab, India (pH 8.15-8.80) was satisfactorily described by a two-site Langmuir adsorption isotherm. The adsorption at low concentrations (0-5 mg B/L) fitted to the first site with a Langmuir adsorption maxima of 4.5-8.0 mg B/kg and the adsorption maxima was significantly correlated with the clay content in the soils. In comparison to Langmuir adsorption isotherm, the Freundlich adsorption isotherm satisfactorily explained B adsorption at all concentrations. Similarly, Elrashidi et al. (1982) also reported that B adsorption on 7 out of 10 soils from New Mexico, USA (pH 6.0-8.0),conformedto Langmuir adsorption isotherm over a limited concentration range, whereas all 10 soilsweresatisfactorily modelled by Freundlich adsorption isotherm over the entire concentration range (1-10 µg B/ml).The Freundlich adsorption constant was strongly correlated with iron oxide and organic carbon contents and surface area of the soils. A multiple regression model containing these parameters as independent variables explained 98% variability of the adsorption data. Sharma et al. (2006) found that increased levels of farmyard manure application to five soils from India (pH 5.3-9.8) increased B adsorption and the adsorption data was satisfactorily modelled by both the one-surface and two-surface Freundlich adsorption isotherms. However, the model fit to the data was better with the two-surface Freundlich isotherm.

Boron is commonly found to be deficient in New Zealand forest soils and B fertilisers are generally applied to these soils to correct B deficiency (Khan et al., 2012). The rate of B fertiliser application depends on the plant-available B content in the soils (Khan et al., 2012), as well as the B adsorptive capacity of the soils. The current study was setup with the aim to (i) characterise B adsorption in soils from the major Soil Orders in New Zealand forest plantations and correlate the adsorption capacity with selected soil properties and (ii) assess B adsorption on soil under varying soil pH.

Material and Methods

Soil samples

The soils used in the study were collected from forest lands at different locations in the North and South Islands of New Zealand. They belonged to seven of the fifteen Soil Orders in the New Zealand Soil Classification System (Table 1) ((Hewitt 1998). They were collected from the top 10 cm depth, passed through a 2-mm stainless steel sieve while moist and then air-dried, homogenized, labelled, and stored for the analysis of different chemical and physical properties.

Soil analysis

The soils were analysed for pH, cation exchange capacity (CEC), organic carbon, amorphous and crystalline Fe and Al, using the methods described by Blakemore et al. (1987). The pH was determined in a 1:2.5 soil to water (w/v) ratio using a pH meter. CEC was determined by leaching the soils with 1 M NH_4OAc pH 7 solution and determining the concentrations of Na, Ca, Mg, K in the leachate by atomic absorption spectrophotometer. Soil acidity was determined by 1 M KCl extraction of the soils and determining the Al concentration in the extract using atomic absorption spectrophotometer. The sum of the concentrations of Na, Ca, Mg, K, and Al was taken as CEC of the soil. Organic carbon was determined by LECO CR-412 carbon analyser. Amorphous Fe and Al (Fe-Am, Al-Am) were determined by acid ammonium oxalate extraction of the soils and determining the concentrations of Fe and Al in the extract using atomic absorption spectrophotometer. The concentration of Fe and Al in oxalate extract minus the corresponding concentrations in 1 M NH_4OAc pH 7 extract (exchangeable Fe and Al) were taken as amorphous Fe and Al concentrations in soils. Crystalline Fe and Al (Fe-Cr, Al-Cr) were determined by Na citrate extraction of the soils and determining the concentrations of Fe and Al in the extract using atomic absorption spectrophotometer. The concentrations of Fe and Al in Na citrate extract minus the corresponding concentrations in the ammonium oxalate extract were taken as crystalline Fe and Al concentrations in the soils. Particle size analysis was determined using the pipette method of Claydon (1989).

Table1. Physical and Chemical properties of soils

Soil Site	Soil Classification	pH	CEC (meq/100g)	OrganicC (%)	Al-Am (%)	Fe-Am (%)	Al-Cr (%)	Fe-Cr (%)	Particle Size distribution (%)		
									Sand	Silt	Clay
Manawatu silt loam, Palmerston North	Recent Soil	5.9	11.6	1.22	0.15	0.37	0.04	0.15	74.0	15.5	10.5
Tangahoe, Northland	Ultic Red Soil	4.9	15.0	0.92	0.55	1.21	4.17	5.81	3.5	44.0	52.5
Tokomaru silt loam, No. 4 Dairy farm, Massey University, Palmerston North	Pallic Soil	5.9	22.1	3.56	0.20	0.39	0.15	0.22	59.5	28.0	12.5
Carnarvon black sandy loam	Gley Soil	5.6	19.0	4.33	0.20	0.51	0.34	0.32	57.0	31.0	12.0
Tuapaka farm, Palmerston North	Brown Soil	5.3	20.5	4.79	0.43	0.76	1.03	0.40	5.0	72.5	22.5
Egmont silt loam, Taranaki	Alophanic Soil	5.3	21.6	11.20	2.79	3.02	2.38	0.03	12.0	56.5	31.5
Taupo	Pumice Soil	5.7	13.6	2.79	2.13	0.99	0.37	0.25	34.0	45.5	20.5

Boron adsorption at natural soil pH

Samples of 1 g soil were taken in 100-ml polypropylene centrifuge tubes and equilibrated with 20 mL0.01 M $CaCl_2$ solution containing varying concentrations of B (i.e. 0.5, 2, 3, 5, 10 and 15 mg B/L as $B(OH)_3$.The centrifuge tubes were first equilibrated on an end-over-end shaker for 48 h at room temperature (25 ± 2°Ċ) , followed by centrifugation (4000 rpm for 20 min), and filtration through Whatman-42 filter paper. The supernatants were analysed for B using the modified colorimetric Azomethine-H method as described by Gaines and Mitchell (1979). Boron adsorbed to the soil was calculated by the difference between the amount of initially added B and the amount of B left in supernatant solution after subtracting the native B concentration in the soil. All adsorption determinations on soils for the current study were conducted in triplicate. Mean values were used for adsorption analysis. The B adsorption isotherms were described using Langmuir and Freundlich adsorption isotherm models. The linearform of the Langmuir adsorption isotherm is given by equation (1).

$$C/(x/m) = 1/Kb + C/b \quad (1)$$

where C (mg/L) is the equilibrium concentration of B, x/m (mg/kg) is the amount of B adsorbed per unit mass of soil at equilibrium, while b (mg/kg) and K (L/mg) are the Langmuir constants related to the adsorption capacity (maximum B adsorption) and energy of adsorption, respectively. The Langmuir isotherm was constructed by plotting C/(x/m) against C. The adsorption maximum 'b' was calculated as the reciprocal of the slope of the linear plot. The bonding energy coefficient (K) was calculated as the slope divided by the intercept.

The linearized form of the Freundlich isotherm is given by equation (2).

$$\log X = n \log C + \log K \quad (2)$$

where the slope and intercept of the mathematical model, n and K, respectively, areempiricalconstants related to the intensity and capacity of adsorption.

Boron adsorption at varying pH

Soil pH can decrease due to natural processes or by adding acid forming fertilisers. It can increase due to lime application to correct certain nutrient deficiencies or immobilisation of certain toxic metals. In order to understand the mechanism of B adsorption as well as to know how B adsorption may change due to the above natural and management processes, a study was conducted on B adsorption in response to different suspension pHin selected soils (Recent Soil, Gley Soil, Pallic Soil, Allophanic Soil, Pumice and Ultic Red Soil) by varying the pH from 2 to 11. The pH of an extracting solution containing 5 mg B/L was adjusted to the required pH using dilute HCl and NaOH and equilibrated with 1 g of soil on an end-over-end shaker for 48 h at room temperature (25 ± 2 Ċ). Following centrifugation (4000 rpm for 20 min), and filtration of the suspension through Whatman-42, the concentration of B in solution was analysed using the Azomethine-H method. The amount of B adsorbed at the different pHs was determined by the difference between the amount of B added to the soils and the amount left in solution at the end of the adsorption period.

Statistical analysis

Data analysis was carried out using Microsoft Excel 2007. Simple linear correlation and Pearson's correlation matrix were conducted among the soil properties. Statistical analysis of the B adsorption data set was conducted using SAS® (SAS Institute Inc. 2004) to determine the soil properties that influence B adsorption. The pH-B adsorption curves were drawn using SigmaPlot@ (Stat software, Inc. 2008).

Results and Discussion

Soil properties

Organic carbon, pH, CEC, Al-Am, Fe-Am, Al-Cr, Fe-Cr and particle size distribution of the soils are listedinTable 1. The soils were acidic with pH rangingfrom 4.9 to5.9, with the UlticRed Soil having the lowest pH and the Recent Soil having the highest pH.The soils had a wide range of organic carbon content with the Ultic Soil having the lowest value of 0.92% to 11.2% in the Allophanic Soil. The CEC ranged from 11.6 to 22.1meq/100 g soil. Recent, Ultic and Pumice Soils had lower CEC than the others probably due to their lower organic carbon/or clay contents.

Al-Am and Fe-Am ranged from 0.15 to2.79% and 0.37 to 3.02%, respectively, while the range of values for Al-Cr and Fe-Crwere0.04-4.19% and 0.03-5.81%, respectively. The pale colour of thePallicSoil and the red colourofUlticRedSoilareattributed to low and high content of Fe oxide in these soils, respectively, especially the extraordinarily high values of crystalline Fe oxides in the Ultic Red Soil.

Simple Linear Correlations between each pair of the soil properties are presented in Table 2. It is evident that soil pH had a significant correlation with Al-Cr, Fe-Cr, silt and clay content and that the correlation coefficients were negative. Organic C was significant and positively related only with Fe-Am content. Fe-Am was positively related with Al-Am, and Fe-Cr was positively correlated with Al-Cr and clay content. The reason for the significant correlations between the Al forms and Fe forms is that the oxides of these metals increase with soil weathering. This is evident in the Ultic Soil for crystalline form of Fe and Al and in Allophanic Soil for the amorphous form of Fe and Al.

Table 2. Simple linear correlation coefficients between soil properties

	pH	CEC	Org C	Al-Am	Fe-Am	Al-Cr	Fe-Cr	Silt
CEC	-0.06							
Org C	-0.149	0.680*						
ALAm	-0.274	0.56	0.64					
FeAm	-0.544	0.271	0.785*	0.852**				
AlCr	-0.935***	-0.009	0.105	0.286	0.585			
FeCr	-0.744*	-0.287	-0.432	-0.145	0.703	0.837**		
Sand	0.90*	-0.163	-0.294	-0.486	-0.615	-0.768*	-0.487	
Silt	-0.681*	0.322	0.433	0.490	0.530	0.441	0.111	
Clay	-0.936***	-0.099	0.018	0.335	0.545	0.978***	0.848**	0.51

*p<0.05 ** p <0.01 *** p <0.001

Adsorption isotherms

The B adsorption capacity (expressed as x/m) results as a function of equilibrium B concentration (C) for the 7 soils is presented in Figures 1. At low B concentration, B adsorption increased linearly as the B concentration in equilibrium solution increased, demonstrating that all soils tested in this study havestrong affinity for B adsorption. The adsorption isotherms can be divided into a high affinity zone where B adsorption increased at a faster rate with increasing B concentration in solution, and a low affinity zone where there is an apparent low rate of B adsorption with further increase of B concentration in solution. The faster rate of adsorption at low B concentration is due to the availability of a greater number of vacant adsorption sites in the soils relative to those that exist when the B concentration in solution is high. Adsorption isotherms showing such behaviour are classified as L-type.At an equilibrium B concentration of 1 mg/L, which is generally found to occur in soils with sufficient plant-available B (Khan et al. 2012), the B adsorption capacity followed the order Allophanic Soil, Ultic Red Soil > Recent Soil >Gley Soil, Pumice Soil >Pallic Soil, Brown Soil (Figure 1)

Langmuir adsorption model

The Langmuir isotherm gave a good fit to the adsorption data of all 7 soils as shown by the significantly high coefficient of determination (R^2= 0.81-0.98, *p* = 0.05-0.001) (Table 3). The Langmuir maximum adsorption capacity for the soils ranged from 1.78 to 6.26 mg B/kg with the Allophonic Soil having the highest value. The highest maximum adsorption capacity of the Allophanic Soil may be due to the high contents of amorphous Fe oxide and organic carbon in this soil. Amorphous Fe oxides have been shown to have high adsorption capacities for specifically adsorbing anions including borate (Goldberg 1997). Boron can be strongly adsorbed to organic matter by the reaction of borate with polyhydroxy compounds in organic matter to form mono-chelated and bis-chelated B-diol complexes (Goldberg 1997).

The Langmuir maximum adsorption capacities ('b' value) obtained in this study is comparable to the values reported for soils in many other countries for similar solution B equilibrium concentration range.For example, Alleoni and De Camargo (2000) reported that the Langmuir maximum adsorption capacities of five soils belonging to highly acidic (pH 3.2-5.3) Alfisols and Oxisols from the State of Sao Paulo, Brazil ranged from 2.47 to 15.8 mg B/kg for an equilibrium B concentration range of 0-15.56 mg B/L. The Langmuir adsorption capacities of 1.78-6.26 mg B/kg obtained for a similar solution B concentration range (0-12 mg B/L) in the current study is not very different from that of these Brazilean soils. Similarly, Datta and Bhadoria (1999) found that the Langmuir adsorption maxima for 25 surface soils (pH 4.99-6.38) belonging to lateritic and alluvial tracts of the southern part of West Bengal, India ranged from 0.81 to 9.23 mg B/kg. These values were obtained for an equilibrium B concentration range of 0-5 mg B/L which is comparable to the equilibrium concentration range of 0-12 mg B/L in the current study. However, the adsorption capacities of the West Bengal soils were higher (6.56-70.45 mg B/kg) at higher solution B concentrations (5-80 mg B/L). Similarly, Arora and Chahal (2010) found that B adsorption data for four surface soils from arid and semiarid zones of Punjab (pH 8.15-8.80) fitted well to a two-step Langmuir adsorption isotherm, one at low equilibrium B concentrations (0-8 mg B/L) and the other at high B concentrations (8-80 mg B/L). The Langmuir maximum adsorption capacity values at the low B concentrations and high B concentrations were 4.5-8.0 and 36.1-46.3 mg B/kg, respectively. The Langmuir adsorption capacity values obtained in the current study (1.78-6.26 mg B/kg) for solution B concentrations similar to those of ofArora and Chahal (2010) in the 1st step adsorption isotherm were approximately the same as those reported for the low B concentration range values.

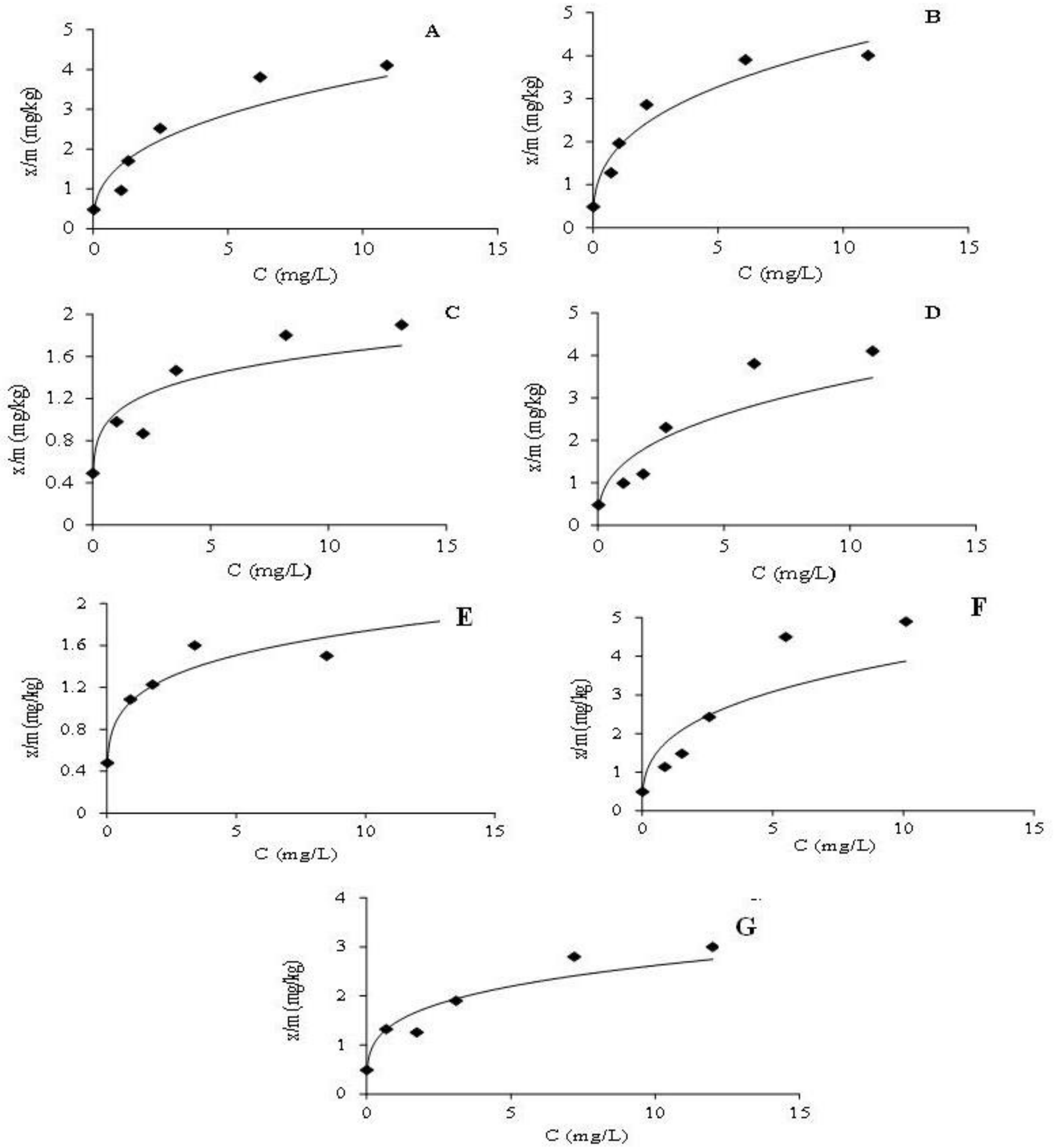

Figure 1. Relationship between B in equilibrium solution and B adsorbed on (A) Recent Soil (B) Ultic Red Soil (C) Pallic Soil and (D) Gley Soil € Brown Soil (F) Allophanic Soil and (G) Pumice Soil

Table 3. Boron adsorption parameters of the fitted Langmuir and Freundlich is other

Soil Orders	Langmuir isotherm parameters			Freundlich isotherm parameters		
	K (L/mg)	b (mg/kg)	R^2	n	K ((mg F/g) (L/mg F)$^{1/n}$)	R^2
Recent Soil	0.44	4.93	0.91**	0.37	0.21	0.89**
Ultic Red Soil	0.94	4.40	0.98***	0.35	0.26	0.96***
Pallic Soil	0.77	2.05	0.96***	0.18	0.02	0.87**
Gley Soil	0.29	5.33	0.81*	0.37	0.15	0.86*
Brown Soil	1.78	1.78	0.98***	0.20	0.03	0.96***
Allophanic Soil	0.33	6.26	0.83*	0.32	0.26	0.86*
Pumice Soil	0.71	3.28	0.96***	0.25	0.16	0.95***

*p<0.05, **p <0.01, *** p <0.001

Freundlich adsorption model

Plots of B adsorption against B concentration in equilibrium solution on a log-log scale showedalinear relationship for all soils with high R^2 values (R^2 = 0.86-0.96, p< 0.01-0.001) indicating that the adsorption isotherm satisfactorilydescribes soil B adsorption onallthe soils (Table 3). The R^2 values for the Langmuir adsorption model and the Freundlich model are not significantly different showing that both the models can be used to describe B adsorption on the studied soils. This is consistent with the significant relationship between the Langmuir maximum adsorption capacity ('b' value) and Freundlich adsorption constant related to the maximum adsorption capacity ('K' value) (R^2 = 0.73, p< 0.05). The Freundlich constant K was the lowest for the Pallic Soil and Brown Soil as found for the Langmuir maximum B adsorption capacity (Table 3). However, the highest K value was obtained for both the Allophanic Soil and Ultic Red Soil, whereas the highest Langmuir adsorption maxima value was found only for Allophanic Soil.

The Freundlich isotherm assumes multilayer adsorption on heterogenic adsorption sites against monolayer adsorption on homogenic sites in the Langmuir isotherm. However, the adsorption data in this study fitted both isotherms equally well as evidenced by similar R^2values (Table 3). This may be due to the low solution B concentrations used in the study where B adsorption was mostly restricted to one type of sites having high energy of adsorption. Adsorption in multilayer/or at sites with different energies of adsorption occurs only after the high energy sites are saturated which happens at high solution B concentrations. This is the likely reason for the better fit of the adsorption data to Freundlich isotherm in the study of Datta and Bhadoria (1999) described previously where the solution B concentration range was 0-100 mg B/L. Similarly, the Freundlich isotherm fitted the data of Arora and Chahal (2010) for the entire solution B concentration range of 0-80 mg B/Lwhereastwo Langmuir adsorption isotherms, one for low B concentrations and the other for high B concentrations,had to be used to satisfactorily model the data.

Relationship between adsorption capacity and soil properties

Pearson's correlation coefficients between the modelled Langmuir maximum adsorption (b), and modelled Freundlich capacityconstantk, and the experimentally determined soil properties showed that none of the soil properties hadsignificant correlation with the adsorption parameters.Polynomial and multivariate regression analysis using combination of soil properties also did not produce any significant relationship. The lack of significant correlation could be associated withthe low number of soils analysed, and the diverse classifications of the soils withwidely different mineral makeup. Highest simple correlation coefficient was obtained for the linear regression withFeAm (0.44 with Langmuir adsorption capacity (b) and 0.47 with Freundlich adsorption parameter (K)). However, when two outlier soils (Recent Soil and Gley Soil) were removed from the linear regression the remaining five soils had a significant correlation between Langmuir adsorption maximum and FeAm (b = 1.673 FeAm + 1.423; R^2 = 0.87, p< 0.01).The reason for the two soils not fitting this relationship is not known. This may be because of the different nature of the amorphous Fe oxides in these soils such as coatings on minerals vs discrete particles or different mineralogy contributing to the adsorption of B. Testing of more samples from each soil group is required to confirm the above relationship.

Influence of pH on B adsorption

Boron adsorption as a function of solution pH showed that for all 6 soils tested, B adsorption increased as solution pH increased up to a pH of around 9 and beyond this pH, adsorption decreased with increasing pH (Figure 2). This is in agreement with the findings of Goldberg et al. (2005)who also reported increased B adsorption with increasing pH, reaching an adsorption maximum around pH 9, with a subsequent decrease of adsorption with any further increase in pH on three soils from California. Similar results were also presented by Keren and Mezuman (1991) for B adsorption on three clay minerals (montmorillonite, kaolinite, and illite).

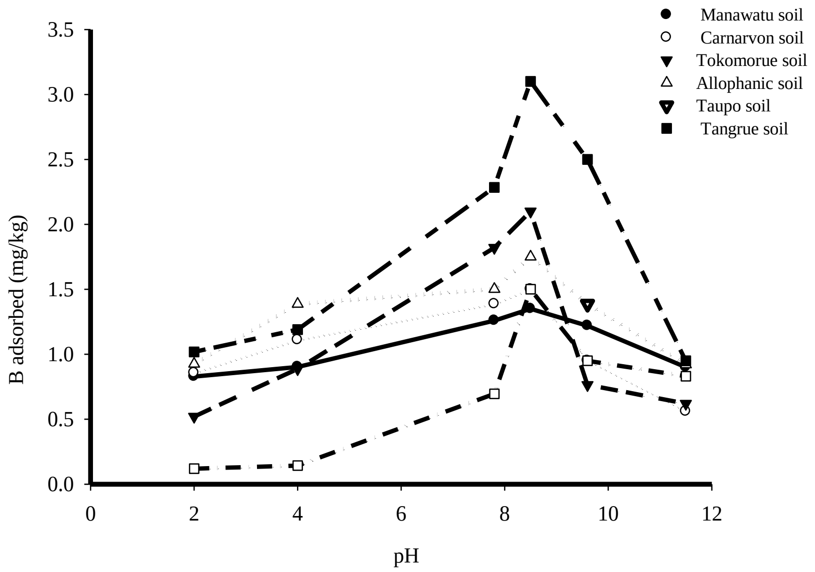

Figure 2. Boron adsorption as a function of solution pH

The sharp increase in adsorption upon raising solution pH from 6.5 to 9 is ascribed to a shift in B speciation from $B(OH)_3$ to the $B(OH)^-_4$ion (Equation 3) which hasthe ability to exchange with the OH^- groups on soil particle surfaces by ligand exchange. As the pH increases the concentration of $B(OH)^-_4$increasesand therefore B adsorption increases. However, any further increase in pH beyond the pH of adsorption maximum decreases B adsorption because of competition with an increasing concentration of OH^- ions in solution. Also the soil particle surface becomes more negatively charged at very high pH (variable charge) and this reduces the potential for adsorption of negatively charged ions like $B(OH)^-_4$.

References

Alleoni L.R.F., De Camargo O.A. (2000) Boron adsorption in soils from the state of São Paulo, Brazil. Pesquisa Agropecuaria Brasileira 35:413-421.

Arora S., Chahal D.S. (2010) Effect of soil properties on boron adsorption and release in arid and semi-arid benchmark soils. Communications in Soil Science and Plant Analysis 41:2532-2544.

Blakemore L.C., Searle P.L., Daly B.K. (1987) New Zealand Bureau Scienctific Report 80. New Zealand.

Claydon J.J. (1989) Determination of particle size distribution of fine grained soils-pipette method: DSIR Divsion of Land & Soil Science technical record LH5. Division of Scienctific and Industrial Research, Wellington, New Zealand.

Datta S.P., Bhadoria P.B.S. (1999) Boron adsorption and desorption in some acid soils of West Bengal, India. Journal of Plant Nutrition and Soil Science 162:183-191.

Elrashidi M.A., O'Connor G.A. (1982) Boron sorption and desorption in soils. Soil Science Society of American Journal 46:27-31.

Gaines T.P., Mitchell G.A. (1979) Boron determination in plant tissue by the Azomethine H method. Communications in Soil Science and Plant Analysis 10:1099 - 1108.

Goldberg, S. (1997) Reactions of boron with soils. Plant and Soil 193: 35-48.

Goldberg S., Corwin D.L., Shouse P.J., Suarez D.L. (2005) Prediction of boron adsorption by field samples of diverse textures. Soil Science Society of America Journal 69:1379-1388.

Goldberg S., Su C. (2007) New advances in boron soil chemistry. In: Advances in Plant and Animal Boron Nutrition (Xu F et al. (ed))pp 313-330. I

Gupta U.C., Jame Y.W., Campbell C.A., Leyshon A.J., Nicholaichuk W. (1985) Boron toxicity and deficiency: a review. Canadian Journal of Soil Science 65:381-409.

Hewitt A.E. (1998) New Zealand Soil Classification. Landcare Research Science Series No. 1. Manaaki Whenua Press, Lincoln.

Keren R., Bingham F.T. (1985) Boron in water, soils, and plants. Advances in Soil Science 1:229-276.

Keren R., Mezuman U. (1981) Boron adsorption by clay minerals using a phenomenological equation. Clays & Clay Minerals 29:198-204.

Khan, R.U., Anderson, C.W.N., Loganathan, P., Xue JianMing, Clinton, P. (2012). Response of *Pinus radiata* (D. Don) to boron fertilisation in a greenhouse study. Communications in soil science and plant analysis 43:1412-1426.

Sharma K.R., Srivastava P.C., Srivastava P., Singh V.P. (2006) Effect of farmyard manure application on boron adsorption-desorption characteristics of some soils. Chemosphere 65:769-777.

Stat software Inc 2008

Stewart B.A. (1988) paper title?Advances in Soil Science 145:257-271.

Yermiyaho U., Keren R., Chen Y. (1988) Boron sorption on composted organic matter. Soil Science Society of America Journal 52:1309-1313.

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The ecological properties of soil in pasture fields of Konya Plain, Turkey

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Abstract

In this study, mycorrhizal fungi potential, total fungus, bacteria and actinomycetes number of (Sarayönü, Çumra, and Karapınar-Konya) pasture soils were determined. As a result of this study, mycorrhizal fungus potential has changed belong to location. Besides, mycorrhizal fungus number has found between 100–160 number 10 g^{-1} soil. The lowest spore number was obtained from in Çumra location. Also, the similar results were obtained from Karapınar and Sarayönü locations. The majority of spore's genus which was obtained from pasture area is *G. mossea*. According to the results the number of other microbial population obtained in this research area. The highest number (1.25×10^5 number g^{-1}) of total fungi obtained from Sarayönü, the lowest number (0.20×10^5 number g^{-1}) of total fungi obtained from Karapınar soils while the highest mycorrhizal infection rate (8.0×10^7 number g^{-1}) was obtained from Karapınar. The lowest mycorrhizal infection rate (3.96×10^7 number g^{-1}) was obtained from Sarayönü. Also both the lowest (2.06×10^7 number g^{-1}) and the highest number (11.5×10^7 number g^{-1}) of actinomycetes were obtained from Karapınar soils.

Keywords: Mycorrhiza, total bacteria, total fungi, total actinomycetes

Introduction

Dry and semi-arid soils generally have a high pH and low precipitation, thus offering mineral element utilization. Vesicular-Arbuscular Mycorrhiza, which is naturally found in such soils, increases the solubility and obtainability of the phosphorus, which has a low solubility, through several ways whose mechanism (of low phosphorus concentration) hasn't been exactly identified yet under the conditions in which plant infection isn't hindered. In addition, it makes it possible to obtain the phosphorus away from the root through its hyphea. (Werner 1987).

In a study, Gök et al. (1997) revealed that the potential for mycorrhizal in the soils is lower in the regions of Middle Anatolia and Çukurova (Low Plain) than the potential in the soils in GAP (Southeastern Anatolian Project) region, but that the potential for mycorrhizal isn't in all cases (soil-plant variation) an exact indicator of the level of mycorrhizal infection, and that mycorrhizal inoculation led to rather higher infection (70-80%) in corn, which was used as test plant, in low-dosage phosphorus applications in all the soils representative of some soils taken from this region in the green house conditions.

More research is needed in different kinds of soil and with different amounts of fertilizer to determine mycorrhizal ecology and its distribution. Mycorrhiza is found widely in nature, but we know little about the effects of the environment, the soil and the plant species on its distribution and effectiveness (Karaarslan et al., 2006).

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Many species and kinds of plants in nature, particularly forest trees, meadow-pasture plants, legumes that form nodules, cultured citrus, some hard-seeded fruit trees and bulbous plants can grow without fertilizer and in areas with little water (Ortaş 1997).

In a study conducted to determine the effectiveness of mycorrhiza spores isolated from vast groups of soil in the Anatolian Plain (V. A. M.), Uyanoz at al. (2006) specified the number of spores in the soils they brought from these vast groups of soil, based on four different sieve sizes (38-50-100-250 μ). According to the results of the study, the highest number of mycorrhizal fungus spores (654 spores/10 gr. soil) was obtained from the soil under the meadow plant sampled from hydromorphic alluvial soils.

The importance of our meadows and pastures not just lies in providing coarse feed for our animals. Besides these economic benefits, they are, along with our forests, rivers, mines and oil, one of our leading natural resources in that they serve another two important functions, that is, they boost the fertility of the soil and also protect our soil by preventing water and wind erosion. The protection, maintenance, rehabilitation of such an important source and an improvement in its feed yield are extremely important for our present and future existence (Bakır 1987).

In our country, studies of the microorganisms in pastures are relatively new, and the number of projects conducted in this issue has increased in recent years and efforts have intensified so as to put into practice the results obtained. Particularly because the fight against soil-based diseases is hard and costly, it is essential to identify the endemic species that could be used in practice and to make them available for cultivation (Yıldız 2009).

With this study, we have determined the potential for natural mycorrhizal spores in pasture-meadows in the Konya Plain, and correlated the figurative findings with each other to give an idea about the biological state in the soil.

Material and Methods

Locations where soil samples were taken: The Konya Plain, which is located in the Central Anatolian Plateau, is situated between the latitude 37° and longitude 33°- 35°. The soil samples used in the study were taken from Konya Plain, and the districts of Sarayönü, Çumra and Karapınar.

Locations where plant samples were taken : In order to determine the effectiveness and numbers of natural mycorrhizal potential in meadows and pastures, plant samples were also taken from locations where soil samples were taken. The common plants in the study were found to be (*Peganum harmala* L./*Zygophyllaceae*, *Cirsium arvense* (L.) Scop./*Compositae*, *Frankania hirsuta* L./*Frankeniaceae*,*Camphorosma monspeliaca* L./*Chenopodiaceae*, *Heliotropium lesiocarpum*/*Boraginaceae*, *Cynodon dactylon* (L.) Pers./*Gramineae*, *Stipa* L.—*Stipa sp.*/*Gramineae*, *Petrosimonia brachiata* (Pallas) Bunge/*Chenopodiaceae*, *Frankania hirsuta* L./*Frankeniaceae*, *Agropyron gaertner* —*Agropyron sp.*/*Gramine*, *Achillea* L.—*Achillea sp.*/*Compositae salvia* L.—*Salvia sp.*/*Labiate*). Moreover, soil samples were taken from the area where these plants were taken (plant rhizosphere zone).

Collection of soil and plant samples : In this study, 45 soil samples whose coordinates were determined using GPS were taken from a depth of 0-20 cm in the districts of Çumra, Karapınar and Sarayönü in the province of Konya in March, 2011 in accordance with the principles reported by Jackson (1962). Moreover, 45 plants were also taken, together with their roots, from locations where soil samples were taken. The soil and plant samples that were taken were kept in conditions suitable for the purpose of the analysis that was going to be made. Spore counts and other routine analyses were made regarding the soil samples that were taken while mycorrhizal infection rates were determined in plant samples.

Soil analyses made on the soil samples : Mycorrhizal spore and fungus-bacteria-actinomycetes counts and other routine analyses were made on the soil samples that were brought while mycorrhizal infection rates were determined on the plant samples. Thus, natural mycorrhizal potentials of the soils and their effectiveness levels were identified.

The counting of mycorrhizal fungus spores : The mycorrhizal spore count in the soil samples was performed using the wet sieving method (Gerdeman and Nicolson, 1963). By the help of sieves with mesh diameters of 50–250 μm, 3 parallel 10 grams of soil samples were weighed from each soil and the spores that were gathered in petri dishes at the end of wet sieving were counted under 40X magnification stereo microscope.

Determination of mycorrhizal spores infection rates in the roots : The plant roots that were taken from field were washed well when they were still fresh, rinsed with pure water, cut in lengths of 1 cm, put in glass tubes and the staining procedure for mycorrhizal infection was conducted according to Koske and Gemma (1989). The spore infection rates of the stained roots were determined under a 40-60 X magnification stereo microscope according to the method specified by Giovanetti and Mosse (1980).

Total bacteria count: This was performed on the soil samples taken in accordance with the purpose of the microbiological analyses using the dilution method in the way Clark (1965) reported.

Total fungus count: The determination of the number of soil microorganisms in 1 g of soil was performed according to their furnace dry weight using the "Koch" method (Kelner, 1948).

Total actinomycete count: This was done in the way Kelner (1948) described.

Results and Discussion

The number of mycorrhizal fungus spores and the results of the rate of plant mycorrhizal root inoculation

The mycorrhiza potential of the soils taken from the Konya Plain varied depending on the area of sampling (Figure 1). That is to say, the highest number of mycorrhizal fungus spores, 320, was found in the soil taken from Beşgöz district with the borders of the town of Sarayönü. However, the lowest number of mycorrhizal fungus spores, 60, was found in the soil taken from Hayıroğlu village of the town of Çumra. Judging from the location means, it is seen that the highest population of mycorrhizal fungus spores was obtained from the soil around Sarayönü and Karapınar. In other words, the population of mycorrhizal fungus spores in the soil around Sarayönü and Karapınar turned out to be more or less the same, whereas the soil around Çumra had a rather lower population of mycorrhizal fungus spores (respectively 146,150 and 89 /10 g soil).

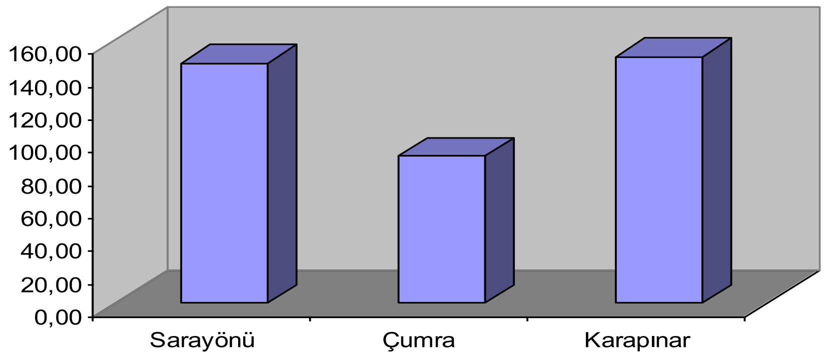

Figure 1. According to the locations of Mycorrhizal fungi spores number (spores number/10 g soil)

On the other hand, the rate of mycorrhizal fungus infection in the samples of meadow-pasture plants taken from different location areas ranged from 20 % to 70 % and infection was detected in all plants. Some pictures are presented in Figure 2. regarding mycorrhizal fungus spores that were infected on the roots of the meadow-pasture plants obtained from the area of the study.

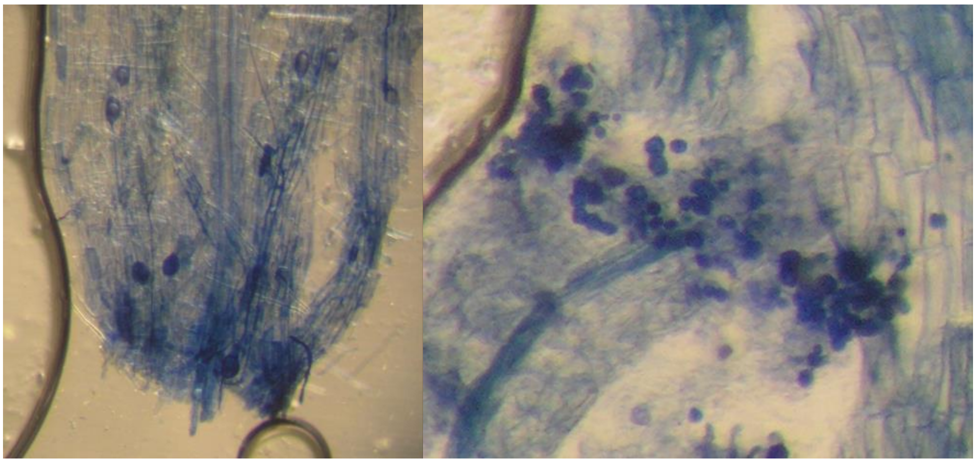

Figure 2. Mycorrhizal fungus spores that are infected on the roots of the meadow-pasture plants

The areas where the study was conducted were those areas of the Middle Anatolia that usually received low precipitation and thus arid. Especially summer months are dry in this region. As was determined in electricity conductivity in summer months, the water potential has a negative effect. This negative effect, in turn, might affect the number and activity of fungus spores and the growth of the plant. A large number of studies have been carried out regarding the distribution of mycorrhizal fungus spores in soils taken from arid and semi-arid regions. It was established that as the salinity of the soil increased in the areas concerned,

The Mycorrhizal fungus colonization decreased (Hildebrandt et al., 2001; Garcia and Mendoza, 2008). In contrast, high fungus colonization was detected in temperate pastures (Garcia and Mendoza, 2008). Also, Asghari et al. (2005) studied mycorrhizal colonization in semi-arid soils in the South-west of Iran. According to the results of the study, the plants involved (Halaxylon aphylium, Kochia stellaris, Halocnemum strobilaceaum, Seidlitzia rosmarinus and Salsola sp.) had differing levels of fungus colonization on the roots. However, it was concluded that certain pasture plants such as Plumbaginaceae, Chenopodiaceae, Juncaceae, Juncaginaceae, Brassicaceae and similar ones are not dependent on mycorrhiza (Hirrel et al., 1978; Brundrett, 1991; Smith and Read, 1997).

It is reported that, in many very arid and semi-arid areas, the most common kind of mycorrhizal fungus spores in the soils with pH over 5.5 was *G. mosseae* (Sieverding, 1991 and Ortaş et al., 1998). As a matter of fact, considering the fact that pH values in all the soils within the research field were over 5.5, it could be guessed that the common kind of spores was *G.mosseae.*

Based on the result of the biological analysis of soil samples taken from the pasture fields that make up the research material, certain biological traits vary with the location. Among the contents of microbial living beings in research soils, the highest value in the amount of total fungus, 1.25x10^5 pcs./g, was found in the soils around Sarayönü, while the lowest value, 0,20x10^5 pcs./g, was found in the soils around Karapınar that were used as pasture. Judging from the pasture mean, the highest fungus population was identified in the soils around Sarayönü, the lowest fungus population in the soils around Karapınar (Figure 3.). When we look at the total number of bacteria, the lowest value was found in the soils around Sarayönü that were used as pasture, which was 3,96x10^7 pcs./g, whereas the lowest value was found in the soils around Karapınar that were used as pasture, which was 8,0x10^7 pcs./g. Considering the mean values, the pasture averages of the bacteria were found to be 5,8x10^7 pcs./g, and the total number of bacteria in the soils around Çumra and Karapınar was found to be higher than the mean of the bacteria in the soils around Sarayönü (Figure 4). Whereas the highest value in the amount of the total actinomycete, which was 11,5x0^7pcs./g, was found in the soils used as pastures around Karapınar, the lowest value, which was 2,06x10^7pcs./g, was found again in the soils around Karapınar. When pasture areas are compared in terms of mean values, the highest actinomycete was identified in the sample taken from Karapınar (Figure 5.).

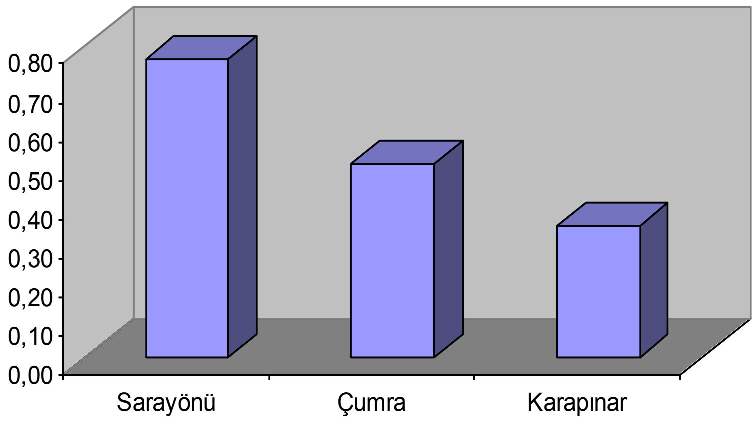

Figure 3. According to the locations of average number of the fungus (x10^5)

In this study, the mycorrhizal fungus potential, the number actinomycete, the total number of bacteria and the total number of fungus were determined in the soils taken from Sarayönü, Çumra and Karapınar in the Konya Plain. The results showed that, although the amounts of organic substances in these soils differed, they were at a low level, and the extent of organic substances in pastures were found to be high when the means were considered ($P<0.01$, $P<0.05$) (Çelik, 2011).

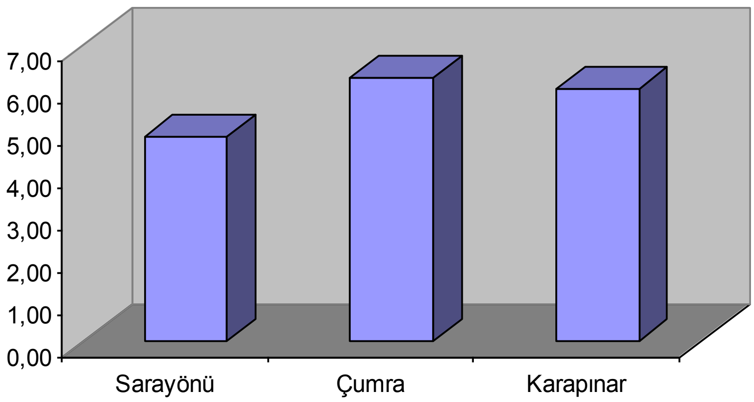

Figure 4. According to the locations of average number of the bacteria (x10^5)

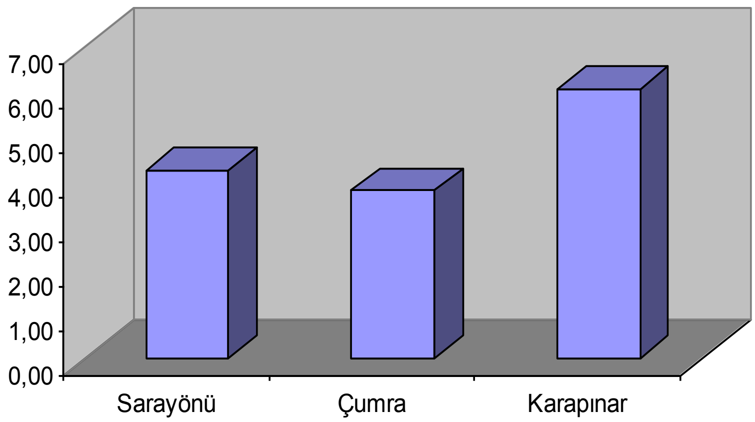

Figure 5. According to the locations of average number of the actinomycete (x10^5)

The vegetation potential on the pasture doesn't affect the level of organic substances in the soil. The levels of organic substances and the level of biological activities in areas of pasture are of importance to productivity capacity of the soil. In other words, they are accepted as a criterion for the productivity of the soil. On the other hand, soil microorganisms (fungi, bacteria, actinomycete, etc.) and macroscopic living beings (earthworms, insects, etc.) mineralize the plant and animal waste in the soil and lead to the emergence of food elements for plants. Moreover, soil aggression increases with the increasing biological activity of the soil. Consequently, many soil characteristics, such as the ability of the soil to hold water, aeration and infiltration, are favorably affected and they also contribute to the capacity of productivity in the soil. Based on these general results, it becomes obvious that chemical traits of pastures (pH, available phosphorus, organic substance), physico-chemical traits of the soils, the slope of the pasture land, the amount of precipitation, how densely the pasture is grazed and whether the pasture is covered with vegetation, the variety of guest plants as well as other ecological conditions in the rhizosphere area have an effect on the microbiological result that were obtained. In view of these findings, we can conclude that microbial population of pasture areas will improve with the elimination of such negative factors in pastures as those resulting from overgrazing, erosion and their abuse. In conclusion, every species of plants or animals plays a vital part in maintaining the balance of nature intact across the Earth, and this balance can only be sustained by healthy and resistant species. With this point in mind, with "Mycorrhiza" in the forefront, other biological and organic-based fertilizers should be employed more widely and in bigger amounts.

Conclusion

Microbiological studies are studies that require precision and patience, and molecular analysis is needed to attain conclusive results. It is noted that the species of the mycorrhizal fungus spore frequently mentioned in our project is *G. mosse*, and the identification made is just a morphological one. For an exact identification, DNA analyses should be carried out. Nevertheless, the study conducted by us lays the basis for the studies to be subsequently conducted.

Acknowledgement

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References

Asghari, H.A., Marschner, P., Smith, S.E., Smith, F.A., 2005. Growth response of *Atriplex nummularia* to mycorrhizal inoculation at different salinity levels. Plant Soil, 273: 245-256.

Bakır, Ö., 1987. Çayır- Mera Amenajmanı. A.Ü. Ziraat Fak. Yayın No.992, Ankara.

Brundrett, M.C., 1991. Mycorrhizas in natural ecosystems Advances in Ecological research. 21, 171-313

Clark, F.E., 1965. Agar plate method for total microbial count (in).Black. C.A. Methods of Soil Analysis. Part 2. American Soc. Of Agron. Pp. 1460–1466. USA.

Çelik, Ö., 2011. Arazi Kullanımının Toprakların Bazı Biyolojik Özellikleri Üzerine Etkisi. Selcuk Üniversitesi Fen Bilimleri Enstitüsü Toprak Bilimi ve Bitki Besleme Anabilim Dalı. Yüksek Lisans Tezi (Basılmamış) Konya.

Garcia, I., Mendoza, R., 2008. Arbuscular mycorrhizal fungi and plant symbiosis in a saline sodic soil. Mycorrhiza, 17, 167-174.

Gerdeman, J.W., Nicolson, T.H., 1963. Spores of Mychorriza Endogene Species. Extracted from Soil by Weh Sieving and Decanting. *Trans. Brit. Mycol. Soc*. 46:235-244.

Giovanneti, M., Mosse, B., 1980. An Evaluation of Techniques for Measuring Vesicular Arbuscular Mycorrhizal Infection in Roots. *New Phytol*., 84: 489-500.

Gök, M., Ortaş, İ., Çakmak, İ., İbrikçi, H., Gür, K., Torun, B., Onaç, I., Coşkan, A., 1997. GAP, Çukurova ve Orta Anadolu Topraklarında Mikorizal Potansiyel, Etkinlik Dereceleri ve Bazı Mikoriza İzolatlarının Bitki Gelişimi ve Besin Elementleri Alımına Etkisi Konulu TÜBİTAK-TOGTAG projesi kesin Raporu. Proje No: TÜBİTAK-TOGTAG / 1277.Adana, (Kasım 1997).

Hildebrandt, U., Janetta, K., Ouziad, F., Renne, B., Nawrath, K., Bothe, H., 2001. Arbuscular mycorrhizal colonization of halophytes in Central European salt marshes. Mycorrhiza, 10: 175–183.

Hirrel, M.C., Mehravasan, H., Gerdemann, J.W., 1978. Vesicular-Arbuscular Mycorrhizae on the chenopodiaceae and cruciferae: do they occur?. Canadian J. Bot., 56: 2868-2817.

Jackson, M.C., 1962. Soil Chemical Analysis. Prentice Hall. Ine. Eng. Cliff. USA.

Karaarslan, E., Uyanöz, R., Çetin, Ü., Gür, K., 2006. The Common Vesicular Arbuscular Mycorrhizal (VAM) Spores Isolated from Major Soil Groups in Konya Plain.18th International Soil Meeting (ISM) on "Soil Sustaining Life on Earth, Managing Soil and Technology" May 22-26, Şanlıurfa-Turkey, p: 152-155, ISBN 975-96629-3-0.

Kelner, A., 1948. Method for investigating large microbial population for antibiotic activity. J. Bacteriol, 56, 157–162.

Koske, R.E., Gemma, J.N., 1989. A Modified Prodecure for Staing Roots to Detect VAM-Mycological Research 92: 486-505.

Ortaş, İ., 1997. Mikoriza nedir?. TÜBİTAK dergisi. Ankara, Şubat 1997 sayı: 351.

Ortaş, İ., Ergün, B., Ortakçı, D., Ercan, Köse, Ö., 1998. Mikoriza Sporlarının Üretim Tekniği ve Tarımda Kullanım Olanakları. Tr. J. of Agriculture and Forestry. 23 (1999) Ek Sayı 4: 959–968.

Sieverding, E., 1991. Vesicular-arbuscular mycorrhiza management in tropical agrosystems. Technical Cooperation (GTZ), TZ-Verlagsgellschaft Rossdorf, Germany.

Smith, S.E. and Read, D.J, ed., 1997. Mycorrhizal symbiosis. Academic Press, London, etc.

Uyanöz, R., Karaarslan, E., Çetin, Ü., Gür, K., 2006. "Determination of Activities of Vesicular Arbuscular Mycorrhizal (VAM) Spores Isolated from Major Soil Groups Konya Plain", 18th International Soil Meeting (ISM) on "Soil Sustaining Life on Earth, Managing Soil and Technology", 381-388, Şanlıurfa, 2006.

Werner, D., 1987. Pflanzliche und mikrobielle Symbiose. G. Time Verlag Stuttgart, New York.

Yıldız, A., 2009. Mikoriza ve Arbüsküler mikoriza bitki sağlığı ilişkileri, ADÜ Ziraat Fakültesi Dergisi; 6(1):91 – 101, 2009.

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Value of the Red Book in protection of soils of Azerbaijan

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Abstract

Unlike many regions of the world Azerbaijan has a unique gene pool of soils which develop in absolutely contradictory ecological conditions. Studying of character of these soils' distribution is necessary for considering geographical, geomorphologic, climatic, historical features of their individual evolution. At various stages of development of a soil science of Azerbaijan such soils have been included in the general classification of soils types, as garden, rice, relic, etc. In due course they lost their nomenclature importance, but kept their historical mission. Unlike the names used earlier, in systematizations of soils, such nomenclature definitions, as technogenic - polluted, cultivated, degraded, salted which are used in modern classification of soils are included. Similarly to the Red book providing protection of a world gene pool of flora and fauna, in the Red book those soils will be placed which have the limited area the distributions which are on the verge of disappearance, and as what have reference values for world classification of soils. Protection of these soils provides, not only their preservation in the form of the reserved earths, but also their further studying from the point of view of global soil formation process. Creation of the Red book of soils of Azerbaijan has expedient necessity which will help to establish natural - evolutionary interrelation of formation of soils in time and space. As modern soils are already strongly changed by population and will change further, it is necessary to keep carefully virgin soils in reserves and old collections soil monoliths and samples in soil museums. Such collections of soils will always be necessary as standards for an estimation of degree of change of modern soils in the central and regional museums.

Keywords: Genofond, resource, relic, evolution

Introduction

NASA, the Institute of Soil Science and Agro Chemistry is a research establishment studying separate types of soils extended in various ecological conditions of Azerbaijan. Employees of institute study a soil gene pool of Azerbaijan develop recommendations about their estimation, rational and effective utilizations ground resources for protection of unique types of soils of Azerbaijan.

Complex representation about a gene pool of soils is represented in demonstration materials and expositions about various sections of a soil science collected in "the Soil museum" of the Institute.

The annals of history of development are connected with names of great soil scientists and agro chemists such as V.P.Smirnov - Loginov, S.A.Zaharov, Hasan bey Zardabi, V.R.Volobuyev, G.A.Aliev, M.E.Salaev, K.A.Alekperov, M.R.Abduev, A.N.Gulahmedov, C. A.Aliev, Z.R.Movsumov, P.B.Zamanov, S.G.Hasanov, I.S.Iskenderov, H.N.Hasanov, G.S.Mamedov, M.P.Babayev and other scientists. Large proceedings,

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monographs, brochures, cards, booklets are collected and presented at stands of the museum. This is a big heritage for young scientists' generation of the country.

At all-round studying of soil formation process as a result of interaction of all components of environment, and also with rules of spatial distribution of various types of soils formed in characteristic ecological conditions we receive representations about difficult dialectic communications in the nature. Such approach to an estimation of natural factors of specific territories allows receiving large information on distribution of various soils' types, their structure, genesis, but also representation all general questions of soil science. Knowledge of laws of placing of different soils' types for their rational and effective use is got especially practical value. On the other hand abiotic and biotic factors in soil formation the nature - security actions which can have both global (within the limits of the State), and regional (within one area, region) character allows to plan role studying. Considering that a soil gene pool of Azerbaijan on presence of various types working out and introduction in practice of security actions has the nation-wide importance gets vital importance for preservation to their subsequent generations.

Material and Methods

Working out of forms of protection of soils are spent on the basis of the deep theoretical analysis of references on the given problematic taking into account ecological conditions in which soils of the Azerbaijan Republic are formed.

Results and Discussion

Soils at rational use in agriculture also get new lines not inherent in them earlier. They respond on such actions, as regulation or a basic change of physical, chemical, water and biological modes with the help agricultural technicians, chemicalixation (application of fertilizers, pesticides, and herbicides), land improvement and irrigation.

However, influences of the human on soils no means always harmonize with the rules of the nature, soil are gradually exhausted, degraded, qualitatively change getting negative properties, collapse or disappear completely under influence also natural processes - of erosion of dusty storms, etc.

Soil resources of the Earth are not boundless - they are limited by land space. Therefore, one of the major problems of mankind is effective utilization of soil fund and, its preservation as biosphere component. The soils covering the Earth are extremely various. In the countries such as the USA, Russia, there are about 10-15 thousand various local types and kinds of soils (N.N.Rozov, M.N.Strogonov, 1978). According to the United Nations, in the different countries it is lost to 5-7 million in hectares of the various earths during the last years have made 300-400 thousand in hectare (V.A.Kovda, 1983). All-round preservation and improvement of soils is necessary for considering as an obligatory part of zone, regional, local systems of agriculture and plans of use of natural resources.

Therefore protection of soils, their improvement and increase of their fertility are major state problems. For Azerbaijan protection of the soil gene pool has priority value. It is necessary to note that by classical works of V.R.Volobuyev, G.A.Alieva, M.E.Salayev there have been begun researches of various types of soils extended in characteristic climatic regions of the country. Morphological signs of these soils were described; specific conditions of soil formation were studied.

Last years the special attention is given to anthropogenic changed, tehnogenic-polluted and degraded soils (M.P.Babayev, G.S.Mamedov).

For Azerbaijan it is characteristic a variety biogenesis and soils. Here contrast ecological conditions in which soils are formed by elements of semidesertic (steppe) and meadow soil formation are found out.

The special importance gets routing field researches of separate regions in which course will probably reveal and describe valuable soil objects, to allocate their contours, and further using these given to make soil cards and their ecology-morphological passports (M.P.Babayev, etc. 2010; 2011).

Drawing up of ecological passports is the first stage for creation of a cadaster of rare and disappearing soils. In this direction in the republic the big researches G.S.Mamedov, etc. 2004) are conducted.

For protection of soils of the republic preservation of the greatest variety of natural soil differences, structures of a soil cover and biogenesis for which there is a threat of essential change, degradation or disappearance under influence of anthropogenesis factors should be considered as the main task.

However except rare and disappearing virgin soils the protection mode should be imposed and on the most typical - reference soils for the purpose of elimination of danger of their uncontrolled development and the organization of timely all-round studying.

The first attempts in this direction are already made by creation a soil museum under the Institute of Soil Science and Agro Chemistry. The huge material - the theoretical data on separate types of soils, exhibits and soil materials are collected, demonstration stands (M.P.Babayev, R. I.Mirza-zade 2006; R. I.Mirza-zade 2011).

All these works on the being are directed on protection of unique types of soils of the republic. In our opinion the problem of protection of soils is necessary for developing systematically and first of all to preparation for creation of "the Red book» where valuable types of soils will be included.

The problem of protection of soils is actual and for soil scientists of Azerbaijan. Scientists of republic do huge research work on studying of soils of separate regions. These researches were based on main principles of classical soil science. Thanks to the system approach, and also the theoretical analysis of the received results it was possible to classify republic soils, and to make their systematization according to the international requirements (M.P.Babayev, etc., M.E.Salaev).

Studying of geographical distribution of soils (G.A.Aliev, V.R.Volobuyev, M.E.Salaev, M.P.Babayev, G.S.Mamedov) were spent in complex research with climatic and bio ecological features of territories. It has been established close confined separate soils and to concrete geographical territories and are revealed distinctive morphogenetic and diagnostic signs which were used further at systematizations of soils.

Regarding soil museum created at NASA, the Institute of Soil Science and Agro Chemistry special mission after protection of soil and other biological resources, and also carrying out among the population general educational and scientifically – informative lectures, seminars is taken away. Demonstrations of the collected material (M.P.Babayev, R. İ.Mirza-zade).

The red book of soils is a document of special importance which merges the objects which are subject to special protection in connection with real-life threat of their disappearance or strong degradation. The number especially protected should include and certain soil differences that naturally offers working out special “the Red book of soils” of Azerbaijan.

Azerbaijan on the climatic parameters and to ecological conditions essentially differs from many regions of the world. Here there are almost many natural complexes with characteristic soils, a biodiversity and economic activities of the person. Protection of these unique natural riches is a nation-wide problem.

Thus, all complex of scientific researches spent in republic, and also presence of legal base is the basic for creation of "the Red book of soils” of Azerbaijan. Following the results of the done scientific analysis of references and the collected demonstration fund and a bench material of a soil museum they can be formulated some conclusions.

Conclusion

1. In separate regions of the country to major factors of degradation of a soil cover use of soils in agriculture and building of the industrial enterprises is anthropogenesis, i.e.

2. For the purpose of protection of a unique soil gene pool of the republic it is offered the regional (territorial) form, i.e. inclusions of soils in structure of flora and fauna of reserves and national parks.

References

1. G.V.Dobrovolsky, E.D.Nikitin - Preservation of soils as irreplaceable component of biosphere, M, the Science, 2000, 154 p.
2. N.N.Rozov, M.N.Strogonov- the Soil cover of the world, M, Izd. The Moscow State University, 1979, 50p.
3. G.Mamedov, M.Halilov- Ecology and world around, Baku, 2004, 504 p.
4. M.Babayev, E.Gurbanov, V.Hasanov – Soil degradation and its protection in Azerbaijan, Baku, 2010, 216 p.
5. M.Babayev, V.Hasanov, C.Jafarova, S.Huseynova – Morphogenetic diagnostics, the nomenclature and systematization of soils of Azerbaijan, Baku, 2011, 452 p.
6. M.P.Babayev, R.I.Mirza-zade- the Soil museum, as the metallurgic centre on studying and protection of the soil gene pool of Azerbaijan, materials of the international conference, Rostov-on-Don, 2006, p. 32-34
7. R.I.Mirza-zade- the Problem of protection of soils of Azerbaijan both its ecology- geographical and general educational value, materials of the international conference, St.-Petersburg, 2011, p.247-250

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The effect of long term NPK fertilization and liming on the soluble zinc content of soil and the zinc content of maize

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Abstract

The effect of NPK fertilization and liming on the soluble zinc content of soil and the zinc content of maize was studied in a long-term experiment of Karcag Research Institute. The soluble zinc content of the soil was characterized with two extractants that are the worldwide applied $CaCl_2$-DTPA-TEA solution and the officially used Hungarian KCl-EDTA extractant. Moderate positive correlation was found between KCl-EDTA-Zn and $CaCl_2$-DTPA-TEA –Zn. The KCl-EDTA extractant dissolved more zinc than DTPA solution. Liming decreased the $CaCl_2$-DTPA-TEA soluble zinc content significantly as well as KCl-EDTA soluble zinc content. The $CaCl_2$-DTPA-TEA extractant indicated the effect of liming more sensitively which can be attributed to the different pH of the extractants. The effect of NPK fertilizers can not be proved on soluble Zn content of soil. but the influence of P fertilization reflected in the Zn content of maize. Leaf samples of maize were collected twice: the first sampling was at the 6^{th} leaf stage of maturity. The second sampling was at early silk. The greater the P doses. The smaller was the plant Zn content. This tendency could be observed especially by the first sampling. The decreasing effect of liming for plant zinc content was proved statistically at the 2nd sampling.

Keywords: zinc, phosphorus, fertilization, Liming, long-term experiment

Introduction

Zinc deficiencies is one of the commonest micronutrient deficiencies and it is becoming increasingly significant in crop production. It can occur due to the low total Zn content of soil. but usually the limited Zn availability causes deficiency (Mengel, 1987).

A major cause of restricted Zn availability is the high phosphate content of soil. Generally proved (Stuckenholz.1965; Ragab,1980, Marschner and Cakmak, 1986). that Zn deficiency is not primarily due to zinc phosphate precipitates, it has plant physiological explanation. Zn transportation from root toward shoots is inhibited by excess phosphate. A further important soil factor is pH. because increasing soil pH reduce Zn availability markedly. Above pH 7 zinc presents in insoluble forms. Especially on soils rich in carbonates the zinc availability is severely reduced (Martens et. al. 1990).

The effect of the different doses of phosphorus fertilizers on zinc availability can be studied in long term experiments most thoroughly. In long term experiments not only the direct effects. that related to the certain

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year but the residual effects. that describes the aftereffect of earlier years can be examined also.

In Hungary several researchers have studied P-Zn antagonism in field experiments (Kádár and Turán, 2002; Csathó et al., 1989. Izsáki , 2011; Zsigrai, 2009). As the effect of P fertilization on the Zn content of plants varies with the different habitats, it is necessary to examine the topic on many kinds of soil types. Hungarian researchers determined the soil zinc status using the dissolved Zn content by KCl-EDTA extractant. Unfortunately this extractant is not known worldwide. and in Hungary there are only few data that compare this extractant with the nationally accepted extractants.

In this paper we study how the different doses of NPK fertilizers and liming affect Zn availability in a long term experiment of Karcag experimental site.

The aims of the presented research were the following:

- to evaluate the effect of long term NPK fertilization and liming on the soluble zinc content of the soil and the zinc content of maize
- To compare the KCl-EDTA extractant that is applied by the Hungarian Fertilization Advisory System with the internationally used $CaCl_2$-DTPA-TEA extractant.

Material and Methods

The effect of NPK fertilization and liming on zinc content of soil and plant was studied at the B17 variant of the National Long-Term Fertilization Experiments of Karcag Research Institute in Hungary (geographical coordinates: 47°18′18.81″N; 20°54′18.67″E). The small plot field experiment was established in the autumn of 1967 with spilt plot arrangement in four replications. The sequence in the crop rotation is: winter wheat–maize–maize–winter wheat. The fertilization treatments are summarized in Table 1.

Table1. Fertilizer doses applied in the experiment of Karcag (kg substance ha^{-1}) (1971-2007)

Treatments	1971-1987			1987-2007		
	N	P	K	N	P	K*
$N_0P_0K_0$	-	–	–	-	–	–
$N_1P_0K_0$	50	–	–	100	–	–
$N_1P_1K_0$	50	22	–	100	26	–
$N_1P_2K_0$	50	44	–	100	52	–
$N_2P_0K_0$	100	–	–	150	–	–
$N_2P_1K_0$	100	22	–	150	26	–
$N_2P_2K_0$	100	44	–	150	52	–
$N_3P_0K_0$	150	–	–	200	–	–
$N_3P_1K_0$	150	22	–	200	26	–
$N_3P_2K_0$	150	44	–	200	52	–
$N_1P_0K_1$	50	–	83	100	–	83/166
$N_1P_1K_1$	50	22	83	100	26	83/166
$N_1P_2K_1$	50	44	83	100	52	83/166
$N_2P_0K_1$	100	–	83	150	–	83/166
$N_2P_1K_1$	100	22	83	150	26	83/166
$N_2P_2K_1$	100	44	83	150	52	83/166
$N_3P_0K_1$	150	–	83	200	–	83/166
$N_3P_1K_1$	150	22	83	200	26	83/166
$N_3P_2K_1$	150	44	83	200	52	83/166
$N_4P_3K_2$	200	65	83	250	79	83/207

* Remark: 83 kg K/ha for winter wheat 166 and 207 kg K/ha for maize

After the harvest of the winter wheat grown in the 20th and 32nd years of the experiment 14.5 and 11.05 t ha^{-1} of lime was used on the plots of replications I. and III.. respectively. The soil of the experimental site is a Luvic Phaeosem with loamy clay texture. solonetzic in the deeper layers. The clay content of soil is 37 %. and the texture is loamy clay. The $CaCl_2$-pH of the non fertilized experimental soil is 5.5-6 without liming. and nearly 7 with liming. The parent material is infusion loess. Soil samples were taken in autumn 2009 from 20 points of each plot from the 0–20 cm soil layer. after the harvest of winter wheat. Leaf samples of maize were collected twice: the first sampling was at the 6th leaf stage of maturity. the second sampling was at early silk. the leaves under the ears were collected.

Analyses

The soluble Zn content of soil samples were measured from $CaCl_2$-DTPA-TEA extractant (Lindsay 1978) and KCl-EDTA (MSZ 20135 1999) extractant by AAS technique (Varian Spectr. AA-20). Later we refer to the extractants as DTPA and EDTA. Table 2. summarises the main characteristics of the applied extractants.

The P content of soil was measured from ammonium-lactate –acetic acid extractant (AL) according to the Hungarian standard (MSZ 20135 1999). The plant samples were digested with cc. HNO_3-cc. H_2O_2 and measured by AAS technique.

Table 2. Main characteristics of the extractants

Extractant	Extractant composition	Soil extractant ratio	Shaking time (min)	pH	Reference
KCl-EDTA	0.05M EDTA (as Komplexon III) 0.1 M KCl	1:2	120	4.36	Official method MSZ20135
DTPA-$CaCl_2$	0.005M DTPA 0.01M CaCl2 0.1M TEA	1:2	120	7.2	Lindsay et al. 1978

All statistical analyses were performed with SPSS (version 13). Significant differences were examined by One Way Anova and Tukey post hoc test.

Results and Discussion

Correlations between the two soil extractants

The relationship between DTPA-Zn and EDTA-Zn content is represented by Figure 1.

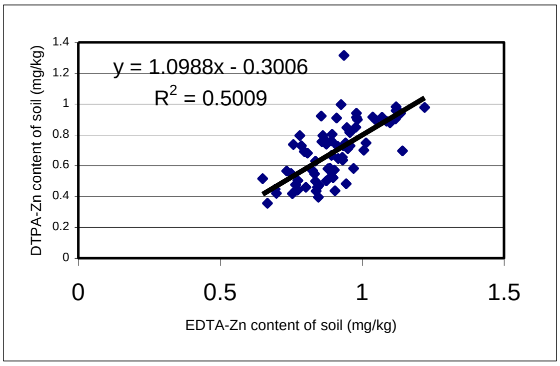

Figure 1. Relationship between EDTA and DTPA extractants, N=80

Moderate positive correlation was found between EDTA-Zn and DTPA-Zn. The EDTA extractant dissolved more zinc than DTPA solution. This can be attributed to the fact that the officially used Hungarian extarctant (KCl-EDTA) is ten times more concentrated both for salt and complexing agent. Therefore it exchanges and binds in metal–chelate-complex more zinc. Moreover the EDTA extractant is acidic (pH=4.36), thus it can dissolve zinc carbonates. that are unavailable for plants. The pH of DTPA extractant is 7.2, therefore it dissolves less zinc from the soil.

Comparisons of the soil extractants based on the Zn content of plants

To evaluate how the applied extractants characterize the plant available Zn forms. we determined the correlations between the dissolved Zn content of soil and the Zn content of leaves at the time of the two samplings for both extractants (Table 3). At the first and second sampling there were not significant correlations nor in case of EDTA neither in case of DTPA extractants. The correlation coefficients were negative in case of EDTA, so the EDTA-Zn content of soil can not be applied for the evaluation of this experiment.

However, the Zn content of plants by the first sampling showed a negative significant correlation with AL-P content of soil. These data confirm the fact also, that beyond the extracted Zn values the P status of the soil is of great importance if we want to characterize the Zn availability of soil. As P-Zn antagonism occurs in plant, non of the Zn extractants can characterize the zinc availability of soil by itself in case of P induced Zn deficiency.

Table 3. Correlations between the plant Zn content and the dissolved Zn and P content (N=80)

	DTPA-Zn	EDTA-Zn	AL-P
Zn content of maize (1st sampling)	0.079	-0.169	-0.251(*)
Zn content of maize (2nd sampling)	0.193	-0.079	-0.151

* Correlation is significant at the 0.05 level (2-tailed).

The effect of liming and long term NPK fertilization on the soluble Zn content of soil

A one-way analysis of variance was conducted to explore the impact of liming on the soluble Zn content of soil. The results are presented in Table 4. Liming decreased the DTPA soluble zinc content significantly at $p<0.5$ level as well as EDTA zinc content (for EDTA: $F(1,78) = 32.98$. $P=0.0001$. for DTPA: $F(1,78) = 131.64$. $P=0.0001$.). For both extractants the differences in Zn content between the groups are large. The DTPA extractant characterizes the differences more sensitively than the EDTA solution. It can be explained by the different pH of the applied soil extractants. As EDTA solution is acidic it may dissolve zinc carbonates that DTPA does not dissolve. Blaskó (2009) examined the KCl-EDTA soluble zinc content of soils for all the experiments in Karcag Research Site. but he did not find significant differences in soluble Zn content between plots treated with and without lime after 12 years of liming.

Table 4. The effect of liming on the DTPA and EDTA soluble zinc content

Treatment	DTPA-Zn		EDTA-Zn	
	Mean (mg/kg)	SD	Mean (mg/kg)	SD
NPK with liming	0.545	a	0.841	a
NPK without liming	0.853	b	0.978	b
Total	0.699		0.910	

*Means with the same letter differ not significantly at P = 5% level

The effect of nitrogen. phosphorus and potassium fertilization on the DTPA and EDTA soluble zinc content of soil can not be detected.

The effect of liming and long term NPK fertilization on the plant Zn content.

The mean value of leaves Zn content was 17.58 mg/kg for 1st sampling. and 13.22 mg/kg for the 2nd sampling. The decreasing effect of liming for plant zinc content is statistically proved at the 2nd sampling (Table 5.) ($F(1.78) = 10.2$, $P=0.002$). This is consistent with the results of several researchers (Kádár et. al., 2007; Hooda et al., 1996) The Zn content of maize harmonizes with the measured soluble Zn contents in soil. With liming the soil pH increases. which reduces the solubility of Zn, therefore the Zn uptake decreases also.

Table 5. The effect of liming on the plant zinc content

Treatment	Zn content of maize (1st sampling)		Zn content of maize (2nd sampling)	
	Mean (mg/kg)	SD	Mean (mg/kg)	SD
NPK with liming	16.89	a	11.98	a
NPK without liming	18.87	a	14.46	b
Total	17.58		13.22	

*Means with the same letter differ not significantly at P = 5% level

Comparing the means of Zn content to the sufficient range in Table 6. it seems as it was under the sufficient range in the plant. Although our experiences are in contradiction with the data of literature. Usually deficiency symptoms were not observed. It occurred only in case of high phosphorus doses at the 1st sampling. We concluded that the species of maize is very important also. when the Zn status is evaluated.

Table 6. Maize leaf analysis for Zn after Bergmann and Neubert. 1976

Stage of maturity	Species	Critical level	Low range	Sufficient range
6^{th} leaves stage	New Jersey	-	<23	23-50
Ear leaf at early silk	MV5	<15	16-20	21-70

The effect of P fertilization reflected in the Zn content of maize at the 1^{st} sampling (Table 7.) ($F(3.76)=11.93$. $p=0.0001$. The greater the P doses . the smaller is the leaves' Zn content. The differences in Zn content between the control and the other groups are significant. Thus P treatment influenced the Zn content of maize to a greater extent than liming. This result harmonizes with the observation of other researchers (Robson ,1993; Kádár , 2002; Kádár and Turán, 2002.; Csathó et al. 1989; Izsáki, 2011). This effect can be only slightly seen at the 2^{nd} sampling, and can not be proved statistically. Blaskó and Zsigrai (1998) experienced the same phenomena. As P is one of the most immobile element. the P fertilization have an effect in the upper soil layers. During the growth of maize its roots reached the deeper soil layers. in which P excess did not occur. therefore the Zn availability was restricted much smaller extent by phosphorus at the time of 2^{nd} sampling.

Table 7. The effect of phosphorus treatment on the plant zinc content

P_2O_5 Treatment	Zn content of maize (1^{st} sampling)		Zn content of maize (2nd sampling)	
(kg/ha)	Mean (mg/kg)	SD	Mean (mg/kg)	SD
0	21.00	a	14.29	a
60	16.98	b	13.18	a
120	14.91	b	12.28	a
180	13.29	b	11.61	a

The N and K fertilization had not significant effect on the Zn and Cu element content of plant.

Conclusions

On the basis of our-examinations we came to the following conclusions:

- Comparing EDTA and DTPA extractants. we suggest the application of DPTA solution, however the soluble P content of soil is to take into consideration also.
- Liming decreased the soil DTPA soluble zinc content significantly as well as EDTA soluble zinc content. The DTPA extractant indicated the effect of liming more sensitively.
- The applied NPK fertilization had no significant effect on soluble Zn content of soil.
- Liming reduced the Zn content of the maize leaves at the 2^{nd} sampling significantly.
- The decreasing effect of P fertilization on the Zn content of plant was proved at the 1^{st} sampling.

References

Bergmann W. and Neubert P.: 1976 Pflanzendiagnose und Pflanzenanalyse Veb Gustav Fischer Verlag Jena

Blaskó L. - Zsigrai Gy.: 1998. A műtrágyázás és a mészállapot összefüggései réti csernozjom talajon. (In: szerk. BLASKÓ L. – ZSIGRAI GY.: Műtrágyázás, talajsavanyodás és meszezés összefüggései az OMTK kísérlethálózat talajain. Kompolt-Karcag. 107-135.)

Blaskó Lajos 2009A KCl kivonatban mérhető cinktartalom. a KCl-EDTA kivonatban mérhető réztartalom in Az országos műtrágyázási tartamkísérletek (OMTK) kutatási eredményei (1967-2001) Debreczeni Béláné- Németh Tamás(Ed.) 2009 p 255-264.

Cakmak. I. & Marschner. H.. 1986. Mechanism of phoshorus-induced zinc deficiency in cotton. I. Zinc deficiency enhanced uptake rate of phosphorus. Physiol. Plantan. **68.** 483–490.

Cohen. J. (1988). Statistical power analysis for the behavioral sciences. Hillsdale. NJ:Erlbaum. In Juiet Pallant: SPSS Survival manual 2005 Published by Allen and Unwin

Csathó P.. Kádár I. & Sarkadi J.. 1989. A kukorica mutrágyázása meszes csernozjom talajon. Növénytermelés. **38.** 69–75.

Hooda P. S. and Alloway B. J. (1996). The effect of liming on heavy metal concentrations in wheat. carrots and spinach grown on previously sludge-applied soils. The Journal of Agricultural Science. 127. pp 289-294 doi:10.1017/S0021859600078448

Izsáki Z. . 2011 A kukorica P-tápláltsága és a foszfor-cink kölcsönhatása műtrágyázási tartamkísérletekben csernozjom réti talajon . Agrokémia és Talajtan. **60.** 147–146

Kádár I. & Turán T.. 2002. P–Zn kölcsönhatás mészlepedékes csernozjom talajon kukorica monokulturában. Agrokémia és Talajtan. **51.** 381–394

Kádár I 2002 Effect of P.Zn and Cu Fertilization on Crops on a Calcareous Chernozem Soil Agrokémia és Talajtan 51 (2001)1-2 185-192

Kádár I.-Marton L.-Németh T.- Szenes I. 2007 Meszezés és műtrágyázás hatása a talajra és növényre a 44 éves nyírlugosi tartamkísérletben Agrokémia és Talajtan 56 (2007)2

Lidsay. W.L - Norvell W.AQ.: 1978. Development of DTPA soil test for zinc. iron. manganese and copper. Soil Sci. Soc. Am. J.42:421-428.

Magyar Szabványványügyi Testület: A talaj oldható tápelemtartalmának meghatározása MSZ 20135 1999.

Martens. D.C. - Lindsay. W. L.: 1990. Testing soils for copper. iron. manganese and zinc in Soil testing and plant analysis . 3rd ed. SSSA Book Series. no.3 edited by Westerman. R.

Mengel K.- Kirkby E.A.: 1987 Principles of plant nutrition Publisher: International Potash Institute ISBN: Nr. 3906535037

Ragab. S. M.. 1980. Phosphorus effects on zinc translocation in maize. Commun. Soil Sci. Plant Analysis. 11**.** 1105–1127.

Robson A.D. 1993 Zinc in soils and plants. Development in plant and soil sciences Ed. in Kluver Academic Publisher ISBN-07923-2631-8 pp. 119-122

Stukenholz. D.D. 1965. Zinc–phosphorus relationships in corn: The influence of temperatureincubation and applied nitrogen. phosphorus and zinc. Diss. Abstr. 25.

Zsigrai Gy.: 2009. Kísérleti eredmények a műtrágyázás. évjáratok. elővetemények hatására eltérő agroökológiai körzetek sajátos körülményeinél. Karcag. (In. szerk. DEBRECZENI B-né – NÉMETH T.: Az Országos Műtrágyázási Tartamkísérletek (OMTK) kutatási eredményei (1967-2001). Akadémiai Kiadó. Budapest. 143-154.) ISBN 978 963 05 8680 1

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Effect of no-tillage on the biodiversity of soil phytopathogenic fungi in the semi arid area (case of Setif area)

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Abstract

The fungi from different soil samples conducted in direct seeding (no tillage) for four consecutive years were investigated in terms of quality and quantity, using the soil dilution plate. A total of nine opportunistic and fungal pathogens were identified. The most common genera are *Fusarium*, *Penicellium* and *Aspergillus*. We found that direct seeding promotes the growth of fung particulary *Fusarium*. Furthermore, the choice of culture and its location in the rotation plays an important role in the distribution of the fungal. The plot conducted in monoculture for four years is the most infected compared to the other plots.

Keywords: Phytopathogenic fungi, Soil, Direct seeding, Rotation, Algeria

Introduction

Soils are excellent cultural media for the growth of many types of organisms. This includes bacteria, fungi, algae, protozoa and viruses. A spoonful of soil contains billions of general the majority of microbial population is found in the upper six to twelve inches of soil and the number decreases with depth. The number and kinds of organisms found in soil depend upon the nature of soil, depth, season of the year, state of the cultivation, reaction, organic matter, temperature, moisture and aeration (Mamatha et al., 2006). A change of the abundance and diversity of fungal communities in soils may therefore have huge impact on terrestrial ecosystems (Walker, 2008). One of the pest affecting the cultivate plants in Algeria is represented by the phytopathogenic fungi. Direct seeding requires the presence of the continuous covered plant residues (Bessam, and Mrabet, 2001) and provides an environment favorable to the growth of many types of organisms like the pathogenic fungi. Through the analysis of the samples of soil from the plots conducted in direct seeding in Setif.

Material and Methods

Sampling : The samples were collected from seven plots conducted under direct seeding for fourth consecutive years and cultivated with Chickpea, Durum wheat, Peas, Lens plant, Chemical fallow and Grazed

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fallow) (Table 1) to identify soil microfungal flora. The plots are located in the Experimental Station of the Technical Institute of Field Crops (ITGC) belonging to Setif area (36 ° N and 5° 22 E). In each plot, we take six soil samples at two layers (Horizon). The first is at a depth and the second is at a depth of 7-15 cm. The sampling is made at 02/04/2011; it represents the stage of plant emergence. Sowing is carried out on 24/11/2010. The samples are collected in sterile polythene bags.

Table 1. Type of the rotation plants during the fourth years by plots

	First year	Second year	Third year	Fourth year
Plot 1	Wheat durum	Wheat durum	Wheat durum	Wheat durum
Plot 2	Wheat durum	chemical fallow	Wheat durum	Wheat durum
Plot 3	Wheat durum	grazed fallow	Wheat durum	Chickpea
Plot 4	Lens plant	Wheat durum	Chemical fallow	Wheat durum
Plot 5	Lens plant	Wheat durum	Chemical fallow	Lens plant
Plot 6	Wheat durum	Peas	Wheat durum	Lens plant
Plot 7	Lens plant	Wheat durum	Lens plant	Wheat durum

Methodology : Isolation of bacteria was performed by making serial dilution of the taken samples and the dilution used for studies were 10^{-2} and 10^{-4} (Rapilly, 1968). Isolation of Fungi was performed by making plate method using Dextrose Potato Agar medium (PDA) (Davet and Rouxel, 1997). Plates and media was weighed out and prepared according to the manufacture's specification, with respect to the given instructions and directions. The plates were incubated at 27°C for 72 hrs to 144 hrs. Pure cultures were obtained and fungi are identified by morphological structures observed by lactophenol staining under 100X lens. The identification of fungal genera was performed according to the identification keys of Subramanian (1983), Lepoivre (2003) and Nasraoui (2006) based on the characteristics of the colonies, mycelium and the conidia.

Results and Discussion

Identification soil fungi

The soil samples were analyzed with respect to different types of fungi. We identified 9 genera of fungi. So, we have not able to determine the species belonging for each genus (Table 2).

Table 2. List of genera of f List of Fungi identified by horizon and plot

Plots	Horizon	Genera
Plot 1	H 1	*Fusarium, Penicillium, Alternaria, Aspergillus, Cladosporium, Erysiphe*
	H 2	*Fusarium, Penicillium,Alternaria ,Aspergillus, Bulmeria*
Plot 2	H 1	*Fusarium,Penicillium, Alternaria, Aspergillus, Cladosporium, Rhizopus*
	H 2	*Fusarium, Penicillium, Alternaria, Aspergillus, Cladosporium, Erysiphe, Rhizopus, Helminthosporium*
Plot 3	H 1	*Fusarium, Penicillium, Alternaria, Rhizopus, Aspergillus, Cladosporium, Helminthosporium*
	H 2	*Fusarium, Penicillium, Alternaria, Aspergillus, Helminthosporium*
Plot 4	H 1	*Fusarium, Penicillium, Alternaria, Rhizopus,Aspergillus, Helminthosporium*
	H 2	*Fusarium, Penicillium, Aspergillus, Helminthosporium*
Plot 5	H 1	*Fusarium, Penicillium*
	H 2	*Fusarium, Penicillium, Aspergillus*
Plot 6	H 1	*Fusarium, Penicillium, Alternaria, Aspergillus, Cladosporium, Rhizopus, Helminthosporium*
	H 2	*Fusarium, Alternaria, Aspergillus, Rhizopus, Helminthosporium*
Plot 7	H 1	*Fusarium, Aspergillus, Penicillium, Helminthosporium*
	H 2	*Fusarium, Aspergillus, Penicillium, Helminthosporium*

Abundance and diversity of soil fungi

The relative diversity and the abundance of the phytopathogenic fungi collected from the soil of different plots are given in the figure 1. The diversity relative and the abundance of phytopathogenic fungi at the two soil horizons (layers) from the 7 plots are reported in the figure 2. We noted that the type and the crop rotation have effect on the diversity and the abundance of phytopathogenic fungi. The genus *Fusarium* is the most present in almost plots. The abundance of *Fusarium* varies with the rotation and the type of crop. In the plot where wheat is grown for four consecutive years, *Fusarium* is the most abundant. We noted that *Fusarium* is more abundant in the superficial layer if the crop is the wheat and in the depth layer if the crop is wheat. The similar results were obtained by Colbach et al. (1996). We found that in the plot 7 grown with the lens plant and wheat alternately, *Fusarium* rate is very low and in the plot 5 where the crop wheat is introduced only once in the rotation, there is no *Fusarium*, which led us to conclude that the better rotation is also an important factor in the abundance of phytopathogenic and opportunistic fungi particularly *Fusarium* in the soil.

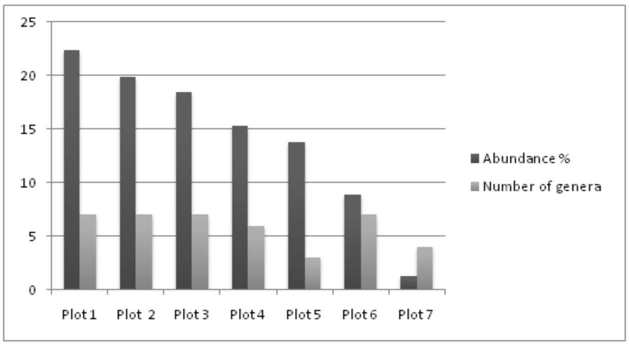

Figure 1. Relative abundance and diversity of phytopathogenic and opportunistic fungi from the soil of the 7 plots

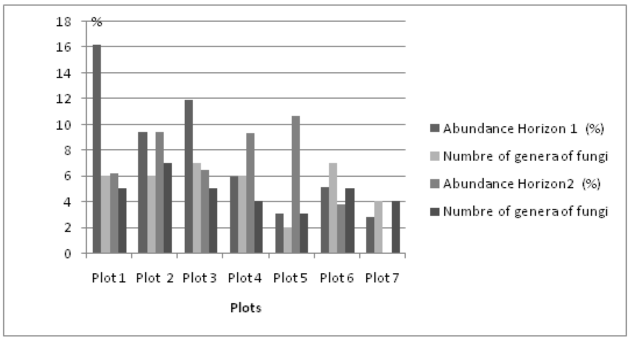

Figure 2. Relative abundance and the diversity of phytopathogenic and opportunist fungi from the soil by horizon in the 7 plots.

Pathogenicity of fungal inventoried in soil

Pathogenicity of fungi varies from one species to another (Table 3). The results showed that *Fusarium* is the most present in all plots. According Segey et al., (2009), that the only disadvantage of this technique (no-tillage) is on increased of this type of fungus in the soil which harms the crops. The rotations of the crops in the same station (plot) affect the diversity, distribution and the abundance of the phytopathogenic fungi soil. However, the incidence of fungal diseases is greatly reduced in soils with the organic amendments.

Table 3. Pathonenicity Scale of the identified fungi

Genera		Scale
Penicellium, Aspergillus	Opportunistic	0
Alternaria, Rhizopus and Erysiphe	Weakly pathogenic	1
Fusarium and *Blumeria*	Moderately pathogenic	2
Helminthosporium and *Cladosporium*	Highly pathogenetic	3

Conclusion

In these work 9 genera of phytopathogenic and opportunistic fungi were identified. *Fusarium* is the most present in all plots. The plot conducted with the monoculture is the most infected. The crop type, crop rotation and the horizon of soil, have an important role in the biodiversity and the abundance of phytopathogenic fungi. The choice of the better crop rotation associated with a fungal treatment can resolved this problem. The no tillage is a technique that it can be applied in many countries with arid or semi-arid climate. Direct seeding can reduce erosion, improve and protect the water quality, enhance the biodiversity, biological activity, reducing the greenhouse effect, enrich the soil with organic matter and improving the soil structure. However, the downside of this technique is the proliferation of phytopathogenic fungi in the soil, especially when the crop rotation is not better and the no using the chemical control. All these drawbacks limit the use of this technique in many countries.

References

Bessam F and Mrabet R. 2001. Time influence of no tillage on organic matter and its quality of a vertic Calcixeroll in a semiarid area of Morocco. Garcia-Torres et al. (eds). In: proceedings of International Congress on Conservation Agriculture. Madrid, Spain. October 1-5, 2001. Vol. 2. pp 281-286.

Colbach N., Maurin N. and Huet P.1996. Influence of cropping system on foot rot of winter wheat in France. Crop Protection 16, 415-422. [Eg.French]

Davet P. and Rouxel F. 1997. Detection and isolation of soil fungi. Eds INRA, Paris, France, 184 p. [Eg.French]

Lepoivre Ph. 2003. Phytopathology: molecular and biological basis pathosysthèmes and control strategies. Presses agronomiques de Gembloux, Ed. De Boeck Universit., 427p.111-140 [Eg.French]

Mamatha K., Grace Nalini Smt. and Sirisha D. 2006. Isolation and Identification of Bacteria and Fungi from different Soil samples. 5 p. *www.stannscollegehyd.com/download/Soil.pdf*

Nasraoui B. 2006. Fungal parasites of cultivated plants: Biology, systematic and pathology. With CD-English version. Centre de Publication Universitaire, Tuinisie, 456 pp. [Eg.French]

Rapilly F. 1968. Les techniques de mycologie en pathologie végétale. Annales des Sci. Nat. Vol. 6 N°1 : 71 – 82. [Eg.French]

Subramanian C.V. 1983. Hyphomycetes Taxonomy and Biology. London: Academic Press. 502 p.

Seguy L., Bouzinac S. and Maronezzi A. C. 2009. Tillage and crop resistance to diseases. Projet ESA2 et SODECOTON, Cirad. [Eg.French]

Varma A. and Oelmüller R. 2007. Advanced Techniques in Soil Microbiology, volume 11. Springer Verlag, 1 Edition.

Walker P. 2008. Impact of Zinc and Cadmium on the Microbial Community in Soils. Term Paper in Biogeochemistry and Pollutant Dynamics.ETH Zürich, 21p.

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Influence on ecological salinization of irrigated soils at the delta rivers Zeravshan and Kashkadarya in Uzbekistan

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Abstract

In article researches directed on improvement of an ecological state the highly saltiness of soils in arid zones are considered. Researches show that the carried-out washings, plannings and introduction the organical fertilizers, also observance of agrotechnical rules of irrigation, promote transformation motley on structure of salted ESA and SSC in the uniform well expressed fertile fields of 20-50 hectares and more. It allows to create models of a sustainable development of agriculture in the territory of farms by melioration and integration of small ESA(3-5 hectares) to large uniform and fertile squares of soils.

Keywords: Elementary soil areas, structure of a soil cover, desert sandy soils, gray-brown soils, meadow alluvial soils, spotty salinization, irrigative condition of lands, ecological condition of lands, agrotechnical and agromeliorative actions, water-salt mode, agromeliorative processing of the soil, technology of furrowing, extent of salinization.

Introduction

In Uzbekistan, in particular and on deltas Zeravshan and Kashkadarya relating to Bukhara and Kashkadarinskii areas, land users become the farms, testifying that regions of our country really pass to the market derivative relations. Such social and economic transformations and development of productive forces is objective regularity. Nevertheless, scales and rates of development of irrigated agriculture here demand search of the most expedient forms of interaction of farmers in various elementary soil areas (ESA) and the structure of a soil cover (SSC). Because, development and distribution of secondary salinization in the form of ESA and SSC on irrigated fields characterizes various degrees and characters of a salinization. Desert sandy, gray-brown and alluvial meadow soils are widespread on irrigated lands of characterized territories. Ground waters in the territory of these soils lie at a depth of 1-3 m, the mineralization of ground waters fluctuates within 3-10 g/l and more, and on a chemical composition they treat chloride-sulfate and sulfate-chloride types of salinization. Evaporation of these mineralized ground waters in summer hot days promotes accumulation on a surface and in a root layer of irrigated soils of toxic salts $NaCl$, Na_2SO_4, $MgCl_2$, Na_2SO_4 and partly $NaHCO_3$. The increase in these processes of accumulation of salts in the top horizons of soils, gradually leads to expansion of their areas in space. This process causes to emergence on the district of various ESA salted seasonal, seasonal and spotty, constant and spotty, etc. soils among cultivated fields [1,2,3].

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The researches executed by us directed on improvement of an ecological state the highly saltiness of soils of the above oases show that the carried-out washings, plans and introduction the organic minerals of fertilizers, also observance of agrotechnical rules of an irrigation, promote transformation motley on structure of salted ESA and SSC in the uniform well expressed fertile fields of 20-50 hectares and more. It allows to create models of a sustainable development of agriculture in the territory of farms by melioration and integration of small ESA (3-5 hectares) to large uniform and fertile squares of soils. For example, in the territory of desert sandy soils new irrigated the saltiness with characteristic for them motley spotty (3-5 hectares) saltiness, after planning and their washing, organized cotton crops on the area of 48 hectares. Watering of a cotton was made according to the scheme of 70-70-65% of limit and field humidity, and was brought nitrogen of 250 kg/hectare, phosphorus and potassium respectively on 200 and 100 kg/hectare and manure of 25 t/hectare. Thus productivity of a cotton I raised from 5-11 to 28,4 c/hectare[4,5,].

Now defining major factors of irrigated soils of the Bukhara oasis are depth soil waters, degree of their mineralization, outflow of waters of drainages and collectors. If at ground waters a superficial bedding (1-2 m) and their degree of a mineralization high (5-10ú/l), besides their outflow needy, processes of salinization develop strongly. Besides, existence of an arid climate and evaporation through capillaries of soils of the mineralized ground waters, causes to accumulation of harmful salts from 1-3% to 3-5%. As a result, on irrigated fields spotty forms of salinization of different size are formed. Now, in farms with a problem of salinization the card on the scale of 1:10 000 where recommend a number of agromeliorative and agrotechnical actions is made[6,7].

According to existing cards in farms these recommendations effectively aren't used since increase of fertility of soils, cultivation of plants, productivity doesn't conform to requirements, also in farms of our country improvement of a meliorative and ecological condition of irrigated lands is directly connected with crop rotation introduction. This question is especially important for Bukhara area where 65% of lands are occupied with cotton, 31% of the territory occupy cereals, and other 4,2% are grown up other cultures.

Material and Methods

Studied lands are located on the average a current of the delta of the river Zarafshan which on administrative division belongs to the farm "Pakhtakor", Vabkent area.

According to Bukhara branch of Uzgiprozem institute, in the territory of economy old irrigated meadow and alluvial soils which their total area makes 2104 hectares are located. From them 120 hectares not salted, 712 hectares the low-salted, 495 hectares middle salted , and 106,1 hectares highly salted soils. Despite outstanding in recent years works on improvement of a meliorative condition of soils of the Vabkent area, including a farm "Pakhtakor", the salted areas weren't washed out. Besides repair work on collectors didn't conform to requirements, as a result on the above lands development of processes of salinization is expected, and this process, in turn, negatively influences fertility of the soil or site class. To increase productivity of cotton, cereals and other agricultural plants in economy, it is necessary to increase estimation point.

Therefore, main objective of this work development number of agrotechnical and agromeliorative actions for improvement water-salt and nutritious modes of the soil. That will carry out a certain task, in sites Sorin and Huzhaporso, Kuchka Osiyo of the farm "Pakhtakor" it is necessary to improve a meliorative condition of 274,0 hectares the highly salted lands. Also, we studied handy methods of cultivation of cotton, cereals and corn.

In the high salted meadow and alluvial old irrigated soils in a layer of 0-100 cm, the quantity of the dense rest makes 0,302-0,98%, a chlorine ion – 0,018-0,035% and a sulfur ion – 0,120-0,182%, in the high salted soils washing works were carried out in months – December and January. (2012-2013). Before washing of the earth were processed. After were leveled by means of a harrow and ridges 50-60 cm high were formed, the top part the 20-30 cm wide was leveled. During a season were twice washed out in norm of 6500 - 8000 m3 on hectare, it is carried also out plowing and soil loosening. After furrowing by means of a cultivator 60 cm wide crops of seeds of a cotton are carried out.

The norm of an irrigation made 1500-2000 m on hectare. I made time of an irrigation 40-50 hours. For improvement of nutritious modes of grades of a cotton of Bukhoro-6, Omad, S-4727 was taken in attention of feature of the soil and the terms accepted in production of introduction of fertilizer. Fertilizers were introduced in the following order: N-300 of kg/hectare, P_2O_5-175 of kg/hectare, K_2O-125 of kg/hectare and 30 tons of manure on hectare. During vegetation observation works of phenology of plants, irrigation terms, time of processing of a cotton and other agrotechnical events were held by means of the standard methods (the NIHI union, 1977).

For washing of the salted lands of a field were plowed under a plough land and were leveled. In experiences sowing works were carried out 15.04.2012.

Results and Discussion

In the made experiments the following research works were analyzed. Therefore, in a farm studied by us, the point of site class of the soil makes 55 points.

- Processing of a cotton between the rows
- Technology of furrowing and fertilizer's introduction.
- To define extent of salinization of soils.
- To study growth and cotton development in the conditions of do not salted soils.

We will pass to the analysis of results of the researches repeated and directly connected among themselves.

Processing of a cotton between the rows. After crops of seeds of a cotton the soil is almost condensed, especially at an irrigation after crops. Therefore, very important, processing of a cotton among the rows, fight against weeds and to keep friability in the top layers of earth. Besides, in our field after cultivation reduction of evaporation of moisture, a field three times was observed were cultivated, in a grasp zone weeds were completely destroyed by working bodies of a cultivator. Grasp of working bodies of a cultivator wide and between beds it was provided the necessary depth of cultivation. At cultivation tried not to do harm to cotton roots, besides, loosening of the soil ended well. Soil particles with a size of 0,10-10 mm there were not less than 40%, and a particle wasn't larger than 50 mm. Cultivation was carried out effectively.

Essence of rows processing in that, it prevents from making broken soil layers. As a result of late preprocessing food of plants therefore development decreased by 5-10% (4-8 days) was broken. Because, at this time weeds managed to grow and well to develop in relation to a cotton. To resist to evaporation of excess moisture from the examinee of a field were carried out, not only cultivation, but

Loosening the rows of the soil is carried out on depth of 10-12 and 15-18 cm, during a season three times was processed. In places where weeds are strongly developed, deep processings between beds were carried out. Some weeds with pedicellate roots (гумай, ажрик) deeply cleared away without leaving in the field. In experience, working bodies of the first cultivation established on depth of 6-8 cm (knifes). And arrow fingers established on the center of 10-12 cm in depth. On this zone of protection width of a grasp didn't exceed 10-12 centimeters.

At cultivation in the second and for the third time to a zone of protection added width on 15-16 cm. When loosening soil from six workers of bodies of a cultivator to steam of bodies established on two extreme rows of plants in an interval 10-12 cm. And other 2 couples on depth of 6-7 cm. If on a cultivator two workers of body, one of them are established on depth of 8-10 cm, and the second on 14-16 cm, in the presence of one worker of body depth establish on the 14-16th.

Furrowing and fertilizer introduction.

Furrowing and fertilizer introduction during a season is closely connected with soil loosening between beds. Therefore when furrowing, it is necessary to consider that the raw passed, in the middle of a furrow and I reached the necessary depth, it is one of major factors in the examinee a field. When furrowing between beds tried not to dig in cotton sprouts the soil because, the cotton was, it is still poorly developed and the first furrowing was carried out superficially, at a depth of 10-12 cm.

At a blossoming that is when the seedling grew by 30-40 cm, depth of a furrow has to reach 14-15 cm and during blossoming of 16-18 cm. During growth of a cotton of food were carried out by a fertilizer instillation on 2-4 cm. For the first two single power supply depth introduction of fertilizer made 15-16 cm. The distance between beds made 15-18 cm. And for the second time fertilizers were introduced at the edges of a furrow in distance of 20-22 cm, other fertilizers on the furrow middle.

During vegetation at first furrowing was carried out through ridges (in certain cases together with food). We were convinced of that that, furrowing on a trace of wheels of a tractor has positive influence on the soil. As a result of cultivation were carried out qualitatively, the soil after washing of salt found agronomical structure.

It is known that after washing the cotton is even more exacting to nutrients and during growth at different times demands in different amounts of nutrients.

On it, in the washed-out soils, respectively, to apply the following norms of application of fertilizers: 250 kg of nitrogen, 175th phosphorus, 125 kg of potassium and 30 tons of organic fertilizer. In the made experiments appointed the following terms of use of fertilizers

The first period - from shoots of seeds before emergence of the first real leaves requirement of a cotton to organic substances and to phosphorus were satisfied.

The second period – in an interval of emergence of the first real leaves and the first buds, a cotton was provided with nitrogen, phosphorus and manure.

The third period – increases in this period requirement of a cotton to nitrogen and to potassium. Therefore, plants were provided with nitrogen, potassium and manure.

The fourth period – time of blossoming and emergence of boxes of a cotton, at this time plants quickly develop their requirement to nitrogen and to phosphorus strongly increase. In the made experiment part of fertilizers, that is, their 55-65% it is applied no later than emergence of 10-12 flowers. Respectively, for good development of a cotton, for early disclosure of boxes, also for a good harvest need of a cotton for nutrients it is provided in time.

Definition of extent of salinization of soils.

It is known that in arid zones, including in soil climatic conditions of the Bukhara oasis during vegetation of plants in a soil profile are observed evaporation of ground waters, salinization processes as a result develop. To prevent these processes on washing fields established norm of an irrigation 500-600M3 on hectare. Owing to what, in the soil salinization processes weren't observed. Because well soluble salts of chlorides from the top and average horizons are washed out in deeper layers of earth and create optimum conditions for cotton development. In the made experiments, on the washed-out old irrigated meadow and alluvial soils, in the horizons of 0-10, 10-20, 30-50 and 50-100 cm the quantity chlorine of an ion made 0,0091-0,0140%, during vegetation in tests the amount of soluble salts didn't exceed 0,005-0,0071%. Means it is possible to come to a conclusion that during growth and cotton development we managed to create optimum conditions.

And so, as a result of works in conditions the high salted old irrigated meadow and alluvial soils of the Bukhara oasis it is possible to draw some conclusions.

In the high salted meadow and alluvial soils of the Bukhara oasis old irrigated if the norm washing will make 6500-8000 m3/hectare, and vegetative irrigation norms of 500-600 m3/hectare, for cultivation of a cotton the optimum water mode is created.

At such norm of washing and a water mode in soils decreases, processes of accumulation of salt. According to the taken data, in studied soils the quantity of the dense rest decreases in the following order: The dense rest – 0,0062%, Chloride ion – 0,017% and SO_4^{-2} ion – 0,092%. That will grow up a cotton according to all requirements, in an interval of crops of seeds and before cleaning (a butonization, blossoming, disclosure of boxes and B'day) application, modern agricultural technologies (an irrigation, processing and application of fertilizers) increases productivity.

Processing of a cotton between the rows, furrowing, timely introduction of mineral and organic fertilizers belong to this agricultural technology. To prevent from salinization processes between the rows loosening of the soil are carried out at a depth of 10-12 and 15-18 cm. Also depending on growth of plants cultivate at distance of 4-5, 6-7, 10-12 and 15-16 cm.

When furrowing that not to dig in a cotton at a depth of 10-12 cm. During a butonization of 15-17 cm and during blossoming of 20-22 cm.

For top dressing salted meadow and alluvial the highly saltedness of soils expediently introduction of 250 kg of nitrogen, the 175th phosphorus, 125 kg of potassium and 30 tons of manure on hectare. This very significant practical action that generations of a cotton would correspond according to all requirements.

As a result of improvement of a meliorative and ecological condition of strongly salted soils from each hectare received 22-23 c of a crop of a cotton. It is 20-25% more than in not washed out soils. Above the provided data belong to too salted meadow and alluvial soils of the Bukhara oasis for which application of scientifically reasonable agricultural technologies, give the chance of them to development. Besides it is required to accelerate and deepen scientifically – experimental works on this occasion.

Conclusion

Thus, the above-stated data relating to influence of processes of salinization on an ecological condition of irrigated soils of the delta of the rivers Zeravshan and Kashkadarya show that development and distribution not ESA and SSC uniform in form and content is caused by distribution of processes of secondary salinization which worsen water and physical and chemical properties of the cultivated lands that influences cotton development, etc. crops.

References

1. Abdullaev A.KH. Ecological aspects of optimization of a mode of an irrigation of crops. Theses of reports of the II congress of soil scientists and agrochemists of Uzbekistan. Tashkent, IPA, AN RUZ, 1995
2. Abdullaev of S. Agrofizicheskiye properties and a salt mode of irrigated soils of oases of Bukhara area. Tashkent, 1975.
3. Bespalov N.F, Sunnatov N. S. Water consumption and productivity of a cotton on the takyrnykh soils of new development of the Karshi . "Irrigated soils and methods of their studying". Publishing house MCX UZSSR, Tashkent, 1976.
4. B.A.Metodik's armor of a field experiment. M, "Ear", 1968
5. Redzhepbayev K. Change of natural and meliorative conditions in a zone of the Karakulsky channel at an irrigation of a way of rational use and an safety of lands. Ashkhabad, 1991
6. A.N. rose trees of a phase, stage and types of secondary salinization of soils at an irrigation. In book. "Problems of the Soviet soil science", сб.14. M.-L. Publishing house of Academy of Sciences of the USSR, 1946.
7. Colibas M, Maianu A.N, Colibas I.The effect of irrigation waters with low salinity and high sodium adsorption ratio on soil salinization and alkalization. Transactions of the 10 th in inernational congress of soil science V.X, Moscow, 1974.

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Assessment of earthworm production in two different periods during the vermicomposting organic materials

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Abstract

In this pepper in order to study the Assessment of earthworm production in two different periods during the vermicomposting organic materials, experiment with eight treatments was conducted using a complete block design with three replications. Eight different organic wastes including, rice hull cow manure, cotton wastes, cow manure and rice hull were used. Each organic waste was transferred to box and converted to vermicompost by the action of worms. Variance analysis results showed that increasing the period of vermicomposting cotton wastes, rice hull, and rice hull cow manure, in 2 months, the weight of earthworms and their average weight will increase and decrease, respectively. In case of cow manure vermicompost, in 3 months after vermicomposting the total weight of earthworm in each treatment increased, will the average weight of earthworms increased in 2 months and then decreased after 3 months. In between of different vermicomposts, cow manure and rice hull cow manure vermicomposts have highest total weight. The lowest total weight of earthworm production was observed in rice hull vermicompost. The highest and lowest content average weight of earthworm in cotton waste and rice hull were observed, respectively. The highest total weight of earthworm production in 3 months period cow manure vermicompost and the lowest one in 2 and 3 months periods rice hull vermicompost were observed. The highest and the lowest average weight of earthworm in treatment 3 months period cotton waste vermicompost and, 2 and 3 months period rice hull vermicompost was observed, respectively.

Keywords: Earthworm, Vermicompost, Organic materials

Introduction

Organic material can be decomposed by earthworms and are converted into valuable products like vermicompost (5). Earthworms are part of the cycle decomposition that consume large amounts of organic residues, therefore affect the structure and dynamics of soil (5). The propose of this study is assessment of earthworm production in two different periods during the vermicomposting organic materials.

Material and Methods

To study the assessment of earthworm production in two different periods during the vermicomposting organic materials, experiment with eight treatments was conducted using a complete block design with three replications. Eight different organic wastes including, rice hull cow manure, cotton wastes, cow manure and rice hull were used. 2 kilogram each of organic waste was transferred to box and the amount of five grams of earthworms were added to each box. That in two time periods (two and three months) after starting of vermicomposting weight of earthworms was measured. After during of vermicomposting, the weight and average weight of earthworms were recorded for each treatment. Statistical analysis was made with MSTAT-C.

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Results and Discussion

Variance analysis results showed that increasing the period of vermicomposting cotton wastes, rice hull, and rice hull cow manure, in 2 months, the weight of earthworms and their average weight will increase and decrease, respectively. In case of cow manure vermicompost, in 3 months after vermicomposting the total weight of earthworm in each treatment increased, will the average weight of earthworms increased in 2 months and then decreased after 3 months. Weights of earthworms produced between treatments were significant at 1% probability level. Cow manure and rice hull cow manure vermicomposts have highest total weight. Appears to food in the context of better conditions for growth of earthworms has provided (4). The lowest total weight of earthworm production was observed in rice hull vermicompost. Fosgate and Babb (1972) also found similar results (4). Average weight of earthworms produced between treatmants was significant at 1% probability level. The highest and lowest content average weight of earthworm in cotton waste and rice hull were observed, respectively. The effect of different types of organic matter in different time periods showed that earthworms produce was significant at 1% probability level. The highest total weight of earthworm production in 3 months period cow manure vermicompost and the lowest one in 2 and 3 months periods rice hull vermicompost were observed. Gang and etal (2005) also found similar results (5). Also the average weight of earthworms in each treatmant was significant at 5% probability level. The highest and the lowest average weight of earthworm in treatment 3 months period cotton waste vermicompost and, 2 and 3 months period rice hull vermicompost was observed, respectively. The average earthworm weight per day, depending on population density type of nutrient. The high density of earthworms my be a problem even when physical condition of the substrate is suitable for producing compost (2). Based on the results, with the prolongation of time of vermicomposting prioed, the worm production declined and worms size were increased. Decomposition of organic wastes due to reduces the weight of earthworms (5).

Table 1. Effect of diffrent organic waste on pobulation of earthworm during of during vermicomposting process

Average weight of earthworm (g)	Total weight of earthworm (g)	Organic waste
0.577a	54.67b	Cotton
0.472b	94.33a	Cow manure
0.378c	87.28a	Cow manure+rice hull
0.392c	16.63c	Rice hull
0.076%	16.20%	LSD

Table 2. Effect of different organic waste and different periods on earthworm populations during vermicomposting process

Average weight of earthworm (g)	Total weight of earthworm (g)	Average weight of earthworm (g)	Total weight of earthworm (g)	Organic waste
3-month period		2-month period		
0.605a	35d	0.55ab	74.33c	Cotton
0.495bc	103a	0.45cd	85.67bc	Cow manure
0.396de	73.44c	0.36e	101.1ab	Cow manure+rice hull
0.344e	14.25e	0.313e	19e	Rice hull
0.078%	22.92%	0.078%	22.92%	LSD

References

Atiyeh, R. M., N. Q. Arancon, C. A. Edwards and J. D.Metzger, 2000. Influence of earthworm-processed pig manure on the growth and yield of greenhouse tomatoes. Bioresource Technology. 75:175-180.

Dominguez, J., C. A. Edwards and M. Webster, 2000. Vermicomposting of sewage sludge: Effect of bulking materials on the growth and reproduction of the earthworm *Eisenia andrei*. Pedobiologia. 44:24-32.

Edwards, C. A., J. Dominguez and E. F. Neuhauser, 1998. Growth and reproduction of the *Perionyx excavatus* (Perr.) (Megascolecidae) as factors in organic waste management. Biol. Fertil. Soils. 27:155-161.

Fosgate, O. T. and M. R. Babb, 1972. Biodegradation of animal waste by *lumbricus terrestris*. J. of dairy science. 6:870-872.

Garg, V. K., S. Chand, A. Chhillar and A.Yadav, 2005. Growth and reproduction of *Eisenia Foetida* in various animal wastes during vermicomposting. Applied Ecology and Environmental Research. 2:51-59.

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The effects of grafted seedling on nutritional status of plants in greenhouse

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Abstract

In recent years, the plant production using grafted seedlings has become more important due to the awareness of producers and consumers, the limiting the use of pesticides and fertilizers with the increasing need for environmentally-friendly farming practices. Grafting is a form of reproduction two plant piece which having a similar organic structure providing continuing to grow as a single plant. The purpose of the vegetable grafting may be listed; fight against soil-borne diseases, low temperature resistance, tolerance to adverse soil conditions such as salinity and extreme humidity, stronger development of the plants, environmental protection, as earliness and yield increase. This form of reproduction is another one of the reasons for preference is grafted seedlings compared to seedlings grown on their own roots, better uptake of water and nutrients and to provide more effective use. The studies to seedlings of the grafting process, show that the flow matter and interfere with the absorption of the macro-nutrient phosphorus, nitrogen, calcium and magnesium ions and from micro-nutrients, iron and boron ions. Also preferably one of the most important effects of rootstocks; even at very low temperatures can provide the absorption of ions. Although grafted seedlings have been used in the world since at the beginning of 20th century they have been produced by the private seedling firms in our country for the last 20 years. Grafted seedlings are widespread in tomato, eggplant and watermelon plants. Nowadays possibilities to use commercially grafted seedlings of pepper and cucumber are also investigated. In this review, production quantities of grafted seedlings in our country and around the world made using the grafted seedlings in vegetable cultivation will be referred to the study of nutritional status.

Keywords: Grafting, grafted seedling, vegetable, plant nutrition.

Introduction

Turkey is situated as the producer and the mainland of lots of fruit and vegetables as a result of her both geological location and ecological advantages (Agaoglu et al., 1997). According to 2013 data, overall 5,94 million tone vegetables were cultivated in undercover in Turkey. The area where greenhouse cultivation is practiced in Turkey has reached to 61,512 ha. In 96 % of our greenhouse property, vegetable cultivation is practiced; the total greenhouse cultivation is composed of tomato in 64 %; 21% in cucumber; 9 % in pepper and 4% in eggplants (Tüik, 2014).

The nutrition needs of the vegetables are very high because of cultivation season being long and products taken much in the greenhouse vegetable cultivation. Depending on that fertilization processes, fertilizers are applied at high levels in greenhouse. There are a lot of factors that affect uptake of the applied fertilizers by

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the vegetables. Beside of the physical, chemical and biological characteristics of the soil, genotypic characteristics of the vegetable are placed among these factors .

It is known that the grafted plants are more effective at the uptake of water and plant nutrition elements compared to the non-grafted plants owing to the strong root systems of their stocks (Cook and Baker, 1983; Lee, 1994), also t they can reduce fertilizer consumption 30 % owing to their strong root systems. Considering the fact that the greenhouse cultivation areas where high fertilizer consumption takes place, usage of grafted plant is seen important for the areas because of both preventing the damages on the environment and decreasing the production cost with low fertilizer consumption.

The history of grafting

Grafting is a way of multiplication that helps two plants having similar organic forms continues to grow as one plant by combining them. While "Scion" forms the ground surface of the plant on the grafted plants, "rootstock" forms the root part. (Yetisir, 2001) Yetisir et al. (2004), lined the purposes of grafting as;

- Easy struggle with soilborne diseases such as *Fusarium*,
- Tolerance for both low soil and air temperature and high soil salinity,
- Better uptake and usage of water and nutrition elements,
- Increase in the yield as a result of the prolonged economical harvest period in consequence of plant strength increased,
- Providing increase in the standard marketable product amount,
- Deduction of such qualities as the resistance against the diseases made by stock, tolerance against low temperature and negative soil conditions, from the various breeding programmes and shortening the time necessary for the breeding,
- Preventing the damage that can be given on the environment as a result of the reduction of the chemicals which will be used in soil disinfection and plant protection, and the uptake of plant nutrition elements in the soil better.

Grafting is an old method in the fruit production. In vegetable and fruit growing , origin of the grafting techniquecoincides with the first quarter of 20th century. The first grafting process was applied with the grafting of the watermelon (citrulluslanatis) on the calabash stock against Fusarium disease , and prosperous results were taken (Ashita, 1927; Yamakawa, 1983).

It was mentioned that the first grafting in vegetable varieties was made in China in the 5th century (Janick, 2002). Grafting in vegetable started in countries as Japan and Korea which had no plant rotation possibility and had to make continuous production as a result of limited agricultural fields, and later it improved in some European and Asian countries as well. Grafting was introduced as commercially applied on cucumber in 1960s and tomato in 1970s in Japan and Korea, and the percentage of the grafted plants for the production of the vegetables (eggplant, cucumber, tomato and various melons) reached to 59 % of the areas in Japan and 81% in Korea until 1990 (Yetisir et al., 2004).

Effects of grafted seedling on nutritional status of vegetables

The grafted plants usually take more water and mineral elements compared to the plants grown on their own roots, so this affects especially ion transport and absorption of phosphorus and magnesium ions. Besides it is known that the ion transport and absorption of some microelements as iron and boron are affected by the stocks (Ertok and Padem, 2007).

In the same way, when the plant nutrition element levels of the commercial varieties grafted on the stocks growing strongly were analyzed, it was confirmed that plant nutrition element accumulation in the graft was more and shoot growth was more powerful differing dependent on the plant variety and rootstock (Ruiz et al., 1996; Ruiz et al., 1997; Kurata, 1994).

In a study, Yuma and Gallicum melon varieties were grafted on 3 different rootstocks [Shintoza, RS- 841 ve Kamel (*C. maxima* x *C. moschata*)]. N, P, S, K, Na, Ca and Mg analysis were made on the leaf samples taken. It was stated that RS-841 stock had higher Na concentration than the control, other stocks had lower values that the control; the concentrations of Ca and K was found more in the grafted plants in proportion to the grafted; however the concentrations of Mg, P and S was found more in the grafted plants. It was stated that the control had less yield than the grafted plants, but the yields of the stocks were close to each other in both varieties , the highest yield was taken from Komel Stock in both varieties , P concentration wasn't affected by the stock and stock x graft interaction (Ruiz et al., 1997).

Den Njis (1985) used cucumber C. ficifolia and S. cyosangulatos as stock in the study which carried out on cucumber growing in low soil temperature in winter period, the researcher emphasized that the stocks increased the vegetative growth and earlier yield in the plants. The researcher stated that the concentrations of Mg, Mn and Cu in the xylem of the grafted plants grown in rock wool is higher in proportion to the ungrafted plants, however statistically there was no such a difference in the plants grown in the soil.

In a study done with two varieties s of melon grafted on three varieties of C. maxima, it was observed that different rootstock genotypes did not affect the macro nutrient content (especially N and Na) in the leaf so much, but there was a strong relation between yield and N, and Na concentration changes in the leaf (Oda, 2002).

In a study done with the grafted plants providing tolerance to the high soil salinity , they grafted the "Durinta" variety of tomato to "Herman" and "Beufort" tomato rootstocks and itself (control), and researched the effects of grafting on the nutrition of tomato under saline irrigation water circumstances (2.8 and 8.8 dS/m). As a result, they stated that grafting factor was only effective on N uptake, not on the uptake of other elements (Oztekin et al., 2009).

Usage of grafted seedlings in Turkey and in the world

Usage of grafted seedlings in vegetable production in the world showed increase year by year . According to 2007 data, usage of grafted watermelon seedlings reached to 100 % in Greece. This rate reached relatively high levels as 98 % in Spain and Korea, 93 % in Japan and 70 % in Israel (Anonymous, 2007).

In our country, commercially production of grafted seedlings was started in Antalya in 1998 (70.000 production) (Ozturk et al., 2002). Ozgur (2002) stated that only 3 commercial firms (Antalya Fide, Grow Fide and Histhil Fide) did grafted seedling production during 1998-2003 in our country and 1,500,000 grafted seedlings were produced during 2001-2002. In our country, the marked amount of increase especially in the production of grafted watermelon seedlings and usage has taken place lately. According to 2007 data, the amount of the grafted seedlings produced in our country reached to 51,700,000. 53 % of this is watermelon plants, 32.9 % of it is tomato plants (17,000,000) and 13.5 % of it is eggplant plants (7,000,000).

Apart from this, the grafted melon and cucumber seedling production is made at low rate (0,6 %) (Yılmaz et al., 2007). Pepper grafted seedling is on trial in the grafted seedling plant technology because of high costs.

In seedling production facilities, seedling costs show difference depending on variety and whether the seedling is grafted or non-grafted. For example, non-grafted watermelon seedlings was sold between 0.20-0.30 Turkish liras in 2008, the grafted one was sold between 0.90-0.95 Turkish liras. Dagıstan (2005) made economical analysis of the grafted watermelon production in our country. In economy analysis, it was confirmed that average 42 % more net profit was provided in the grafted plants in proportion to the non-grafted ones. Considering the marketability rates of the products, this value got high to 62 %. These results showed that the grafted plant provided more profit. Late progresses and present data show that grafted seedling production will increase more and more in our country in future t years.

Conclusion

Production with grafting technique in vegetables is a rather new subject in Turkey although it has been used in developed countries for years in spite of such disadvantages as grafted seedlings 3 times more expensive in proportion to non-grafted ones, necessity of experience in grafting and after grafting care process, high cost of establishment setup producing grafted seedlings , incompatibility problems between stock and graft , however it is seen as alternative solution struggle with soil-borne diseases , increasing yield and fruit quality, decreasing seedling plant number, gaining the soil having salinity problem to agriculture, less fertilizer consumption and decreasing production cost and maybe most importantly in eliminating the problems that will appear as a result of prohibition of methyl bromide in the world and our country (Yetisir et al., 2004; Atasayar et al., 2005). Late progresses and present data show that grafted seedlings production will increase more and more in the world and in our country in future years.

In conclusion of literature surveys, it has been seen that there is a lack of substructure and technical information about cultivation made by using grafted seedling in our country. Especially it is necessary to focus on studies about nutrition conditions of the grafted plants in different varieties , optimum fertilizer doses to be applied on these plants and comparison of stock-graft combinations in terms of nutrition. It is foreseen that these studies will contribute to both farmers and country economy by transmitting these studies to farmers and grafted seedlings producer firms.

References

Ağaoğlu, Y.S., Çelik, H., Çelik, M., Fidan, Y., Gülşen, Y., Günay, A., Halloran, N., Köksal, A.İ., ve Yanmaz, R., 1997. Genel Bahçe Bitkileri. T.C. A.Ü.Z.F. Eğitim, Araştırma ve Geliştirme Vakfı Yayınları No: 4, Ankara.

Anonymous, 2007. Grafted Vegetable Seedlings. www.iasa.co.za/downloads/symposium/2007/Grafted%20Vegetable%20.Seedlings%20Zuker.pdf

Ashita, E., 1927. Grafting of Watermelons (in Japanese). Korea (Chosun) Agr. Uwsl., 1, 9.

Atasayar, A., Polat, E., Onus, E., 2005. Türkiye'de aşılıkarpuz fidesi kullanımı üzerine genel değerlendirme. Türkiye II. Tohumculuk Kongresi, 9-11 Kasım 2005, Adana, 51-58.

Cook, R. J., Baker, K.F., 1983. The Nature and Practice of Biological Control of Plant Pathogens. The American Phytopat hological Society, St. Paul, MN.

Dağıstan, E., Yetişir, H., Sarı, N., Parlakay, O., 2005. Aşılı fide ile karpuz üretiminin ekonomik analizi. GAP IV. Tarım Kongresi, 21–23 Eylül 2005, Cilt I, 375–380.

Den Nijs, A.P.M., 1985. Rootstock-Scion interactions in the cucumber: Implications for cultivation and breeding. Acta Hort.(ISHS) 156:53-60.

Ertok, R., Padem, H., 2007. Sebzelerde aşılama fizyolojisi. Batı Akdeniz Tarımsal Araştırma Enstitüsü, *Derim Dergisi*, 24(2):20-26.

Janick, J., 2002. History of horticulture: History of agriculture and horticultural technology in Asia. Lectures 12-13. Purdue University, USA.

Kurata, K., 1994. Cultivation of grafted vegetables ii. Development of grafting robots in Japan. Hort Scienee, 29 (4), 235-239.

Lee, J.M, 1994. Cultivation of grafted vegetables i. current status, grafting methods and benefits. Hortscience, 29 (4), 235-239.

Oda, M. 2002. Grafting of vegetable crops. *Sci.Rep. Agric.& Biol.Sci.,*Osaka Pref. Univ. 54:49-72 Review.

Ozgür, M., 2002. Türkiye'de sebze fidesi yetiştiriciliğindeki gelişmeler. VI. Sebze Tarımı Sempozyumu, 17-20 Eylül 2002, Uludağ Üni. Bahçe Bitkileri Bölümü, Bursa.

Oztekın, G. B., Leonardi, C., Caturano, E. and Tuzel, Y., 2009. Role of rootstocks on ion uptake of tomato plants grown under saline conditions. Proc. IS on Prot. Cult. Mild Winter Climate Eds.: Y. Tüzel vd Acta Hort. 807, ISHS.

Ozturk, A., Yılmaz, S., Kececı, M., Unlu, A., Devıren, A., Ozçelik, A., Cetinkaya, S., Cevri, H., Akkaya, F. and Ozkan, C.F., 2002. Alternatives to methyl bromide for tomato and cucumber production in Turkey. Proceeding of Alternatives to Methyl Bromide. Sevilla, Spain. pp. 194-199.

Ruiz, J. M., Belakbir, A., Romero, L., 1996. Foliar level of phosphorus as its bioindicators in cucumis melon grafted plants. A Pssible Effec of Rootstock. J. Plant Physiol.

Ruiz, J. M., Belakbir, A., Cantarero, L.I., Romero, L., 1997. Leaf-Macronutrient content and yield in grafted melon plants. A model of evaluate the influence of rootstock genotype. Scientia Horticulturae. 71:227-234.

Tuik, 2014. Tarım Alanları. http://www.tuik.gov.tr/UstMenu.do?metod=temelist

Yamakawa, B., 1983. Grafting. In: Nishi (ed) Vegetable Handbook (in Japanese) Yokende Book Co, Tokyo, 141-153.

Yetişir, H., 2001. Karpuzda aşılı fide kullanımının bitki büyümesi, verim ve meyve kalitesi üzerine etkileri ile aşı yerinin histolojik açıdan incelenmesi. Ç.Ü. Fen Bilimleri Enstitüsü, Doktora Tezi, Adana, 168 s.

Yetişir, H., Yarşi, G., Sarı, N. 2004. Sebzelerde aşılama. Bahçe 33(1-2): 27-37.

Yılmaz, S., Göçmen, M., Ünlü, A., Fırat, A., Aydınsakir, K., Çetinkaya, S., Kuzgun, M., Çelikyurt, M.A., Sayın, B. and Çelik, I., 2007. Grafting as an alternative to MB in vegetable production in Turkey. Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. October 29-November 1, 2007, San Diego, California. pp, 60:1–3.

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Effective methods of improving soil fertility and productivity of cotton in Southern Kazakhstan

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Abstract

Long-term use of irrigated gray soils in production resulted in reduction of total humus concentration by 40-50 %, and these soils have lost plant nutrition elements. Irrigated gray soils due to highly salinized groundwater are susceptible to secondary salinization, which significantly affects the growth and development of cotton. In this regard, development of scientific principles and practical measures to optimize soil fertility and increase the productivity of irrigated gray soils acquire special importance and priority. The purpose of the study is to examine the effectiveness of different types of fertilizers and growth stimulator on cotton. During field studies the following methods such as stationary, laboratory analysis and other methods have been used. Field researches on secondary saline irrigated light gray soils have been conducted in Maktaral district of South Kazakhstan region. Upland cotton variety "Maktaaral 4007" was grown. The study was conducted on efficacy of using various types of nitrogenous fertilizers on the background of phosphate and potash fertilizers and humic liquid fertilizer "Edagum CM" as a bio-stimulator of growth and development. Phosphate and potash fertilizers were applied into the soil prior to planting cotton, and nitrogen fertilizers - in fertilizer during budding. Liquid fertilizer "Edagum CM" was used for seed treatment and spraying of cotton plants during germination and budding. Studied fertilizers influenced on the growth and development of cotton plants, as well as on the yield of raw cotton. On control variant without fertilizers application, yield of raw cotton was 1.66 t/ha. Application of recommended dose of phosphorus-potassium fertilizers and ammonium nitrate provided increase of cotton to 430 kg/ha. Application of calcium nitrate and urea - ammonia mix as fertilizer on the background of phosphorus-potassium fertilizer provides the same increase as in the use of ammonium nitrate in the range of 440-450 kg/ha. The highest yield of raw cotton was at variant with liquid fertilizer humic "Edagum CM" based on peat – 2.28 t/ha, the increase was 620 kg/ha. Analysis of the experimental data showed that secondary saline light gray soils showed the effectiveness of nitrogen fertilizer and humic preparation "Edagum CM" that enhance the improvement of nutrient status of soil and provide a reliable yield increase of raw cotton.

Keywords: irrigated light gray soil, soil fertility, cotton, salinization, fertilizers.

Introduction

Kazakhstan, the third country in Asia on territory, occupies an area of 272.5 million hectares, consisting of ten natural areas. The share of the four zones: steppe, dry steppe, semi-desert and desert is 87.4% of the total area and 88.3% of agricultural land. According to the Ministry of Agriculture, the total sown area of crops in the country in 2012 was 21.5 million hectares, that is 0.3 million hectares, or 1.4% more than in 2011. High crop

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yield in the south provides cotton in artificial irrigation of the area, in 2012 area under cotton was 147.8 thous. ha, which in comparison with 2011 is less to 12.8 ha (http:mgov.kz).

Cotton production in Kazakhstan is characterized by a low degree of integration, cooperation of farms, low use of agricultural technology in production of raw cotton. Basic areas of cotton are located in Makhtaaral district 65-75%. The main reasons of reduction of the areas of agricultural land is soil surface degradation, soil salinization in the areas of irrigated agriculture. Along with the positive there are also negative processes that reduce the efficiency of the use of land resources, especially irrigated soils.

The main reasons of deterioration of irrigated lands are the following factors: in the last 20 years, the areas of saline lands expanded and are more than 2 mln. ha. Therefore it is needed to improve melioration condition of about half of the area of irrigated land. Consequently, to preserve soil fertility, it is necessary, undertake appropriate reclamation and agritechnical activities taking into account the processes occurring in soil salinity.

Recent studies have revealed a significant decrease in the amount of organic matter in soils. According to research data of 1970-1980, in the arable layer of irrigated typical light gray humus contained about 1.1-1.7 % and 0.9-1.3 %, respectively (Kuziev R and Tashkuziev M., 2008). Currently in the topsoil of irrigated gray soil, humus concentration was 0.60-0.90 %, that is less than 0.35 % compared to 1980.

Decrease of humus concentration in soil is accompanied by deterioration of agronomic, agro-physical properties and soil nutrient status. Insignificant application of organic fertilizers, imbalance in the use of fertilizers for agricultural crops has resulted in significant reduction of nitrogen, phosphorus, potassium and some micronutrients in soil. The reason of nutrient deficiency in soils is insufficient return of nutrients removed by crops.

In these conditions it is necessary to make changes to the existing system of land use and crop growing agrotechnology. Such agro-technology in regular crop production with gaining high-quality yield should be aimed at improving humus status, as well as all major chemical, physico-chemical and physical properties of soils and, ultimately, increase their fertility.

Solution of these relevant issues is possible and it is needed to set the task of improving the interaction of natural and economic systems that will allow to effectively use soil potential for sustainable land resource management in terms of the increased anthropogenic impact on the environment. According to the research data, extensive agricultural production resulted in specific irrigation areas in deterioration of soil-reclamation conditions, secondary soil salinization, breakage of previously existing vertical drainage wells, deterioration of hydraulic structures, inter-farm and on-farm irrigation and drainage networks. Many farms do not comply with technological requirements for crop cultivation. Scientifically justified crop rotations are violated, reclamation and construction works are not conducted, work on creation of forest belts, improvement of land cultivation activities are not practically conducted, which led to soil degradation, depletion of land, increased pest infection, diseases and weeds (Otarov A, et al. 2008). Therefore solution of the issues of conservation and reproduction of soil fertility and rational land resource management are relevant issues of soil science, which have national importance.

Material and Methods

This paper summarizes the results of two years research (2012-2013) on different types of mineral fertilizers on cotton, conducted on experimental fields of the Kazakh Scientific Research Institute of Cotton (Atakent settlement, Maktaaral district, South-Kazakhstan region). The station is located in the northwestern part of the Hungry Steppe. Soil type is irrigated light gray soil, cotton crop, variety Maktaaral - 4007.

Field experiment was conducted on the following scheme:

1) Control, 2) $N_{150}P_{80}K_{60}$, 3) $P_{80}K_{60} + N_{KC}$, 4) $P_{80}K_{60} + N_{KAC}$, 5) Edagum.

Area of the plot was 50 m^2 (7.2 m x 7.2 m). Experiment was conducted 3-times. Used fertilizers: ammonium phosphate (P_2O_5 – 46 %, N-11 %), potassium chloride (K_2O – 60 %), ammonium nitrate (N-34 %), (N_{cn}) calcium nitrate (N-17, 5 %), urea ammonium (UAN) and Edagum (humic liquid formulation).

Before sowing cotton seeds were treated with a solution of urea ammonia mixture (option 4) and humic Edagum liquid preparation (option 5). In phase of full shoots and budding, was done a spraying of cotton plants with a solution of urea ammonia mixture (option 4) and humic Edagum liquid preparation (option 5).

Investigated area is in the area of dry steppes with sharply continental climate, which is characterized by large fluctuations in temperature in winter and summer, day and night, small amount of precipitation – according to average long-term data - 261 mm per year. Distribution of precipitation is as follows: in winter precipitation 37 %, in spring – 41 %, in summer – 4 %, in fall 18 %, ie 78 % of precipitation is in winter and spring before planting of cotton. The frost-free period lasts from 143 to 230 days. On geomorphological conditions, the experimental site is located below the ordinary southern gray soils within altitudes from 200 to 350-400 m. The terrain of this band (50-60 km) is sloping slight wavy plain.

Cotton is cultivated on technology developed by scientists of the Kazakh Research Institute of cotton. During growing season of cotton, were conducted phenological observations over the growth and development of cotton and accounting of raw cotton yield. Sowing of cotton was done on April 27-29. Cotton seeds rate was 22-25 kg per 1 ha.

Analysis of soil samples was carried out by conventional methods (Arinushkina, 1977), determination of the aqueous extract on STATE 26433-85-26428-85, potentiometric pH, humus by Tyurin, hydrolyzable nitrogen according to Tyurin-Kononova, mobile phosphorus and potassium on the exchange Machigin (Machigin: 1992), grain size by Kaczynski (Kaczynski, 1965), statistical processing of data Dospehovu (Dospehov, 1985).

Results and Discussion

Available data in the literature on the importance of nitrogen forms in the nutrition of cotton (Jarovenko, 1969) were mostly obtained without account of dependence on the level of phosphorus nutrition or not fully reveal a number of issues related to biochemistry of cotton and soil, as well as interaction between phosphorus and various forms of nitrogen nutrition of cotton (Jarovenko G. and Yusupov, 1975). Many questions remain unresolved, and the available studies do not reveal those regulations of metabolism that occur in application in cotton of oxidized and restored forms of nitrogen depending on the level of phosphorus nutrition. This fact served as a basis for studying of the nutrition regulations of different forms of nitrogen on the background of phosphorus and potassium nutrition.

Gray soils in South Kazakhstan region are most favorable for cultivation of cotton. Systematic application of high doses of mineral fertilizers, tillage and irrigation change all properties of gray soils. There is a necessity to differentiate agrotechnique of cotton growing in accordance with the soil fertility, in creating a new diagnostic system of cultivated soils. Significant impact on the effectiveness of fertilizers and cotton yield have a degree of land cultivation, dose and timing of fertilizer application, soil salinity, moisture content, degree of availability of plant nutrition elements. All these factors must be considered in developing a new system of zonal technology in cotton growing. According to our researches, light gray soil is characterized by the following agrochemical parameters of the plow layer (0-40 cm): very low humus concentration - 0.64-0.70 %, hydrolyzable nitrogen is also very low -28.6-30.1 mg / kg, mobile phosphorus - 29.4-30.8 mg/kg , exchangeable potassium -288-310 mg/kg soil, pH 8.18-8.34, alkaline reaction of medium. The soils are calcareous, CO_2 carbonates is 6.82-6.58 %. These data show that on the content of available phosphorus and exchangeable potassium, light gray soils refer to medium. Granulometric composition influences on a number of important soil properties: porosity, permeability, height of capillary rise, value of absorbency ability, water, air, soil and thermal regime. On granulometric composition the investigated soils are average loamy according to Kaczynski classification (Table 1).

Table 1. Granulometric composition of light gray soil

Number of section	Depth of taking samples, cm	Composition of fraction in % per absolutely dry soil						
		Fraction sizes in mm						
		sand		dust			silt	<0.01
		1.0-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	
P-9	0-14	0.202	41.569	21.836	10.109	11.322	14.962	36.393
	14-45	0.161	46.931	15.752	18.578	4.846	13.732	37.156
	45-90	0.020	27.483	35.265	8.047	13.782	15.403	37.232

Reclamation and environmental condition of irrigated lands have significant role. In spring before sowing cotton, in salt composition predominate sulfate salts, but chlorides as most mobile are washed out, in the summer-autumn period, sulfate concentration also prevail, but proportion of chlorides increases significantly due to the rise from lower soil layers. Chlorides are most harmful for cotton plants (Suleimenov, et al., 2013).

Secondary alkaline soils usually formed as a result of secondary salinization in conditions of shallow location of heavily saline groundwater (less than 1 m) in irrigation. The composition of salts of alkaline soils and marsh soils mainly consists of cations Na^+, Mg^{2+}, Ca^{2+}, and anions Cl^-, SO_4^{2-}, CO_3^{2-}. On the character of salinization and salt composition, alkaline soils are divided into carbonate, soda, chloride, chloride-sulfate and sulfate.

Degree of soil salinity before sowing of cotton is average, in total amount salt concentration is 0.568 % (Table 2). Sulphate concentration from 0.252 to 0.362 % in the root zone, did not affect cotton germination. In the soil lower layers the amount of salt decreases. The studied irrigated gray soils refer to sulphate type of salinity, in total amount of salts the share of sulfate ions is 62-64 %, and the rest part is ions of calcium, sodium, magnesium, chlorine and potassium.

Table 2. Aqueous extract in % for absolutely dry soil of studied sites

Number Section	Depth of taking samples, cm	Amount of salts,%	Alkalinity		Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
			HCO_3^-	CO_3^{--}						
P-9	0-14	0.568	0.017	no	0.025	0.362	0.078	0.030	0.041	0.015
	14-45	0.406	0.020	no	0.012	0.252	0.049	0.015	0.043	0.015
	45-90	0.364	0.020	no	0.006	0.234	0.054	0.018	0.021	0.011

Negative properties of rocks are high water-lifting capacity (2.5-3.5 m), low water output (2-4 % in humidity 40-50 %), relatively low filtration coefficient (average 0.003 mm /s), which explains the rapid rise of groundwater in irrigation and their slow decline in termination of irrigation.

In cotton growing particular significance has effective system of fertilizer application including determining the optimal ways of their application. In the last decade in the CIS much attention is paid to identification of the effectiveness of local-band fertilizer application. Research results indicate that local application of nutrients are used fully and intensely, because of their placement at a specific depth, closer to the roots, thus accelerating the growth of plants and the yield is increased (Khasimov, 1990).

We studied the effectiveness of different types of nitrogen fertilizers on the background of phosphorus-potassium fertilizers in comparison with the recommended dose of mineral fertilizers ($N_{150}P_{80}K_{60}$).

According to conducted phenological observations on all variants of the experiment, compared to the control was observed a slight increase of seed germination, main stem height, number of fruit branches and fruit bolls (Table 3). Number of boxes in control was 3.04 pc. / Plant, 2-4 variants 3.96 and 4.07, the average weight of the bolls on the control of 3.3 g, in 2-4 versions 3.4 and 3.5. Simultaneously Edagum liquid humic preparation has been tested. Before sowing the seeds of cotton were treated with this drug; moreover, was done sprayings of plants in germination phase 5-7 shoots and budding phase. Plant height in variant 5, exceeded plant height for 14cm, the number of bolls to 0.9 pieces, the average weight of one boll increased by 0.2 g, compared to the control.

Table 3. Impact of mineral fertilizers and stimulator on growth of cotton (2012-2013)

Options	Quantity of plants per 1 м^2		Height, cm	Fruit branches	Bolls	Average weight of boll, g
	Pieces	%		piece/plant		
Control	16	68.0	48	3	3.0	3.3
$N_{150}P_{80}K_{60}$	19	80.8	52	4	3.9	3.4
$P_{80}K_{60}$ + N_{cn}	18	76.6	55	5	4.0	3.5
$P_{80}K_{60}$ + N_{uan}	19	80.8	60	5	3.8	3.5
Edagum	20	85.1	62	5	3.9	3.5

Account of raw cotton yield in the studied variants showed that the use of mineral fertilizers provides increase in yield compared to control variant without fertilizer. Thus, the yield of raw cotton in control variant was 1.66 t/ha (Figure 1), the recommended dose of mineral fertilizers (option 2) provided extra (increment) yield 520 kg/ha (0.52 t/ha).

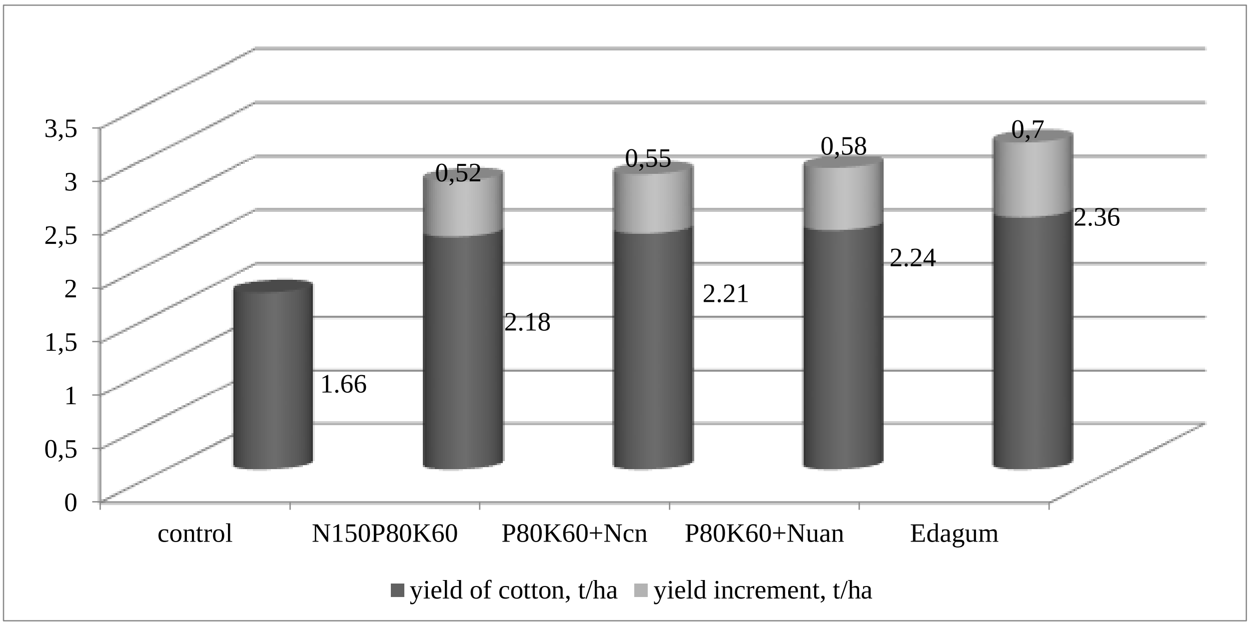

Figure 1. Raw cotton yield, t/ha (average for 2012-2013)

Application of calcium nitrate and urea ammonium mixture on a background of phosphorus-potassium fertilizer increases yield capacity by 550-580 kg/ha. The highest gain of yield is noted on the option with the use of liquid gumi-drug Edagum and is 700 kg/ha.

Conclusion

Irrigated light gray soils in Maktaaral district of South Kazakhstan region are secondary saline soils. The soil has low concentration of humus and hydrolyzable nitrogen, average concentration of available phosphorus and exchangeable potassium. Application of mineral fertilizers and stimulator increases the concentration of soil nutrient, improves plant growth and development, increases the yield of raw cotton.

References

Arinushkina E.P. 1977. Guidance on soil chemical analysis. Moscow, Moscow State University Press.

Dospehov B.A., 1985. Technique field experiment (the basics of statistical processing of research results). M. Agropromizdat.

http:mgov.kz/napravleniya-razvitiya/apk-kazahstana. The official online resource of the Ministry of Agriculture.

Jarovenko G.I., 1969. Physiological and agrochemical bases of increasing the efficiency of nitrogen fertilizer in cotton production. Tashkent.

Jarovenko G.I., Yusupov A., 1975. Effect of source of nitrogen nutrition and phosphorus level on metabolism and productivity of cotton. Agrochemistry. № 2. 12-18.

Kaczynsky N.A., 1965. Soil physics. W 1. - Moscow: Higher School.

Khisamov T.Z., 1990. Formation of cotton yield capacity in conditions of ridge culture on old irrigated soils in Hungry Steppe. Seed production Thesis: p. 158.

Kuziev R.K,. Tashkuziev M.M. 2008. Issues of rational use of land resources, preservation and improvement of fertility of irrigated soils in Uzbekistan. Soil Science and Agrochemistry. Number 1. 63-68.

Machigin: 1992.Soils. Determination of mobile compounds of phosphorus and potassium by Machigin method modified by CINAO. Moscow.

Otarov A., Ibraeva M., Wilkomirski B., Suska-Malawska, Short M., 2008. Characteristics of soil cover and analysis of soil fertility modern condition in South-Kazakhstan oblast. Soil Science and Agrochemistry. №1. 70-78.

Sulejmenov B.U., Saparov A.S., Tanirbergenov S.I., 2013. Condition and prospects of irrigated gray soils in South Kazakhstan. Soil Science and Agrochemistry. № 1. 19-27.

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Bio-ecological characteristics of the soil in Baku

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Abstract

Studies to identify the level of soils biological activity under highways of Baku were comprehensively on the following parameters: enzyme activity, the number of microorganisms and phytotoxicity. A level of the change of biological activity and summary phytotoxicity of soil under highways influence has established. In comparison with the soils of the Central Botanical Garden of soil cover along highways is characterized by the high phytotoxicity that can be connected with the presence of these soils under constant technogen pressure - pollution by the vehicles emission. It is revealed that an activity of urease, invertase, dehydrogenase was lower in the soils near highways which are subjected to intensive technogen load in comparison with the soil of the botanic garden, for which a degree of the technogen effect is essentially less. An availability of the reverse correlation dependence between microbiological and fermentative indices is characteristic for the soils along highways: the low activity of soil ferments corresponds the high number of bacterial microflora. Humus content vibrates from 0.9% till 1.2%, under humus content in the soil of the control zone is 1.6%. Such low humus content is conditioned by nutrient lack in the urban soils that leads to activation of humus mineralization process. An importance of humus for urban soils along the highways is not only in formation of soil fertility, it serves as an important indicator of the ecological potential, determining a degree of the soil resistance to the effect of the technogen factors. Thus, the investigated indices allow to judge changes of the biological activity of soils under an influence of anthropogenic pressing and can serve as a theoretic basis for the development of the condition monitoring methods of the soils along the city highways.

Keywords: The biological activity of soils, enzymes of soil, microorganisms, phytotoxicity, urban soils under highways

Introduction

At present, large cities became focus of the economic, social and especially ecological problem. The powerful anthropogenic loads have focused in them. Forming of urban waste stream and pollutants present a serious threat for the environment of the whole planet. Especially important is the role of the land to the cities, where it is extremely necessary to the conduct of a land policy, which will ensure rational land use, protection of lands and the urban environment, which is impossible without a detailed description of the quality of the land (Sizov, 2000).

Baku is a great megapolis (large cities), industrial center of Azerbaijan, on the territory in which the enterprises of the machine-building, oil-extracting, petrochemical, chemical, food industry, highways, and other sources of environment pollution by heavy metals, as well as oil and oil products are situated.

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Material and Methods

A purpose of the investigation is in the limit of soil ecological monitoring approbation of the most perspective methods of the soil biological value for the study of the soil ecological condition along main transport routes in Baku. The urban soils selected in different functional zones of Baku along main large highways from depth of 0-10 cm at a distance of 3-5 meters from the highways were an object of the given investigation. The soil samples were chosen during a period of 2010 - 2011 years. Collection and analyses of the soil samples have been fulfilled on standard methods (Kazeev et al, 2003; GOST 28168-89, 2008). An isolation of microorganisms from soil samples and a calculation of the total number are carried out by a method of limiting cultivation of the soil sowing on agar sterile nourishing environment (Soil methods.., 1991; Fedorets, 2009). The soil parameters of the fermentative activity are defined by standard methods (Khaziev, 1990; Bulatov, 1999; Practice on Agrochemistry, 2001). A value of the soil phytotoxicity degree is conducted by Grodzinsky (Grodzinsky, 1991).

Results and Discussion

A level of the change of biological activity and summary phytotoxicity of soil under highways influence has established. In comparison with the soils of the Central Botanical Garden of soil cover along highways is characterized by the high phytotoxicity that can be connected with the presence of these soils under constant technogen pressure - pollution by the vehicles emission. It is revealed that an activity of urease, invertase, dehydrogenase was lower in the soils near highways which are subjected to intensive technogen load in comparison with the soil of the botanic garden, for which a degree of the technogen effect is essentially less. An availability of the reverse correlation dependence between microbiological and fermentative indices is characteristic for the soils along highways: the low activity of soil ferments corresponds the high number of bacterial microflora. Humus content vibrates from 0.9% till 1.2%, under humus content in the soil of the control zone is 1.6%. Such low humus content is conditioned by nutrient lack in the urban soils that leads to activation of humus mineralization process. An importance of humus for urban soils along the highways is not only in formation of soil fertility, it serves as an important indicator of the ecological potential, determining a degree of the soil resistance to the effect of the technogen factors. The soils along highways of Baku according to the gradations (Snakin et al, 1995) can be attributed to weakly degraded ones, the productivity reduction corresponds them 20-25% in comparison with the soils of the control zone. Thus, the investigated indices allow to judge changes of the biological activity of soils under an influence of anthropogenic pressing and can serve as a theoretic basis for the development of the condition monitoring methods of the soils along the city highways.

Conclusion

Revealed that the soils of the highways are characterized by enough low fermentative activity and comparatively high number of microorganisms (Table 1). An increase of microbialogical activity on the phone of fermentative activity reduction is characteristic for the soils along highways. Therefore, we can say that a reduction of fermentative activity of microorganisms that leads to a compensatory increase in their numbers occurs in the urban conditions. This leads to the lack of microbiological and biochemical activity conjugation. In the soil cover along the city highways with the intensive heavy traffic subjected to strong anthropogenic and technogenic influence there is a place of microorganisms metabolic roads reorganization and reduction of their fermentative activity. Accounting the aggressive conditions of the environment on the roadside territory of highways in Baku, it is necessary to decrease intensity of pollutant migration in the ecosystem, localizing them in the soil environment. It is possible to be achieved the increase of the soil buffering capacity. It is also necessary to improve soil fertility as a whole for preservation of the ecosystem viability. We can achieve these aims by application of organic and mineral fertilizers, regulation of the water and air regime of soils.

Table 1. Microbiological and biochemical features of soils along the main highway Baku

Name of highway	General number of bacterial microflora (KFU / g)	Phytotoxicity (% germination)	Urease activity, mg NH3 100 g^{-1}	Invertase activity, glucose mg g^{-1}	Dehydrogenase activity, TPF mg g^{-1} 24 h^{-1}	Presence of conjugation microbiology and biochemical activities
G. Zardabi Metbuat av.	$5,7.10^6 \pm 0,20$	81	4,85	70	0,50	Are not conjugate
Tbilisi av.- Bakihanov str.	$6,7.10^6 \pm 0,08$	82	4,5	71	0,44	Are not conjugate
R.Beybutov str.	$6,0.10^6 \pm 0,21$	85	4,7	73	0,51	Are not conjugate
Azadlig av.- 28-May str.	$5,7.10^6 \pm 0,20$	83	4,3	70	0,51	Are not conjugate
Neftchilar av.	$6,1.10^6 \pm 0,14$	79	3,8	69	0,41	Are not conjugate
Nobel av.	$6,0.10^6 \pm 0,10$	80	3,9	70	0,43	Are not conjugate
Khojaly av.	$5,6.10^6 \pm 0,15$	78	4,0	68	0,46	Are not conjugate
Babak av.	$5,9.10^6 \pm 0,21$	79	3,9	59	0,48	Are not conjugate
Heydar Aliyev avenue	$6,3.10^6 \pm 0,20$	81	4,1	61	0,47	Are not conjugate
Control - Botanical Garden	$5,2.10^6 \pm 0,12$	98	3,9	65	0,39	Are conjugate

References

Bulatov A., Makarenko P.P., Shemetov V.Y. 1999. Directory environmental-engineer oil industry on the methods of analysis of environmental pollutants.Part 2: Soil. p. 581-585.

Fedorets N.G., Medvedev M.V. 2009. Methods of soil investigations in urban areas. Petrozavodsk: Karelian Research Centre, 84p.

GOST 28168-89. 2008. Soil. Tackling samples.- Moscow "Standarts'. -7p.

Grodzinsky D.M. 1991. Allelopathy in plant life and tiredness. – Kiev, 400 p.

Kazeev K.S., Kolesnikov S.I., Valkov V.F. 2003. Biological diagnosis and indication of soil: methodology and research methods. Rostov-na-Donu. 204p.

Khaziev F.H. 1990.Methods of soil enzymology. Nauka, 189p.

Methods of Soil Microbiology and Biochemistry. 1991. Ed. D.G.Zvyagintseva. Moscow: MGU. 304p.

Sizov A.P. 2000. Monitoring of urban land with elements of protection. Study guide for students. Moscow. 156 p.

Snakin V.V., Malyarova M.A., Gurova T.F. 1995. Environmental monitoring. Methodic allowance. - M., 86p.

Workshop on Agricultural Chemistry. 2001. Ed. VG Mineeva-Moscow: MGU, 689 p.

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Soil micromorphology from Masudpur I: Snap-shots of Bronze-Age Life in NW India

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Abstract

As a part of the *Land, Water and Settlement* project, geoarchaeological investigations carried out in and around Indus sites of Masudpur I (Sampolia Khera) near the village of Masudpur in Haryana, India have revealed interesting information about the activities and behaviour of the inhabitants of these settlements. In particular, within the sampled sequences from the trenches, several activity areas have been identified, such as open spaces used for crop-processing or general floor build-ups interrupted by occasional disturbed layers, all filled with settlement-derived debris and with evident periods of abandonments. Soil micromorphology has revealed bedded sand deposits beneath Masudpur I indicating a symbiotic relationship with the prevalent environmental system. This paper will highlight the nature of human activities, prevalent environmental conditions and site-formation processes of these sites as depicted through the techniques of thin-section analysis and geochemical studies.

Keywords: Soil micromorphology, symbiotic relationship, thin-section analysis.

Introduction

The mound site of Masudpur I (Sampolia Khera) (Figure 1) is located in the village of Masudpur, in the Hisar district of Haryana in the plains of northwestern India. At present, the site is a part of the Ghaggar river system. Keeping in mind the proximity of the site to the very important urban Harappan site of Rakhigarhi, the *Land, Water and Settlement* Project team conducted sample excavations in the summer of 2009 [58, 66, 67, 68]. Excavation from three trenches, namely the XA1, XM2 and YA3, has revealed Early Harappan/Early Mature Harappan, Mature Harappan and Late Harappan period occupation. On-site soil micromorphological samplings were also carried on to understand the nature of human occupation and their interaction with the surrounding landscapes and environment during these phases of Harappan occupation.

Today, the area has a sub-tropical monsoon climate. This is characterised by scanty and irregular rainfall, hot summers with bright sunshine, a dry cold winter with prevalent aridity and desert and saline soils. Average rainfall is about 350mm. The area consists of a flat to undulating plain partly covered with sand dunes. Sediments are mainly fine alluvium derived from the Himalayas with an admixture of wind-blown sand from the desert of Rajasthan (the Thar) further to the southwest [6, 30]. Soils were classified according to geomorphological units as Torripsamments [21] on dune areas and as Camborthids and Calciorthids on the plain [5, 24]. The alluvium was deposited during the Quaternary by large rivers that have dried up [4].

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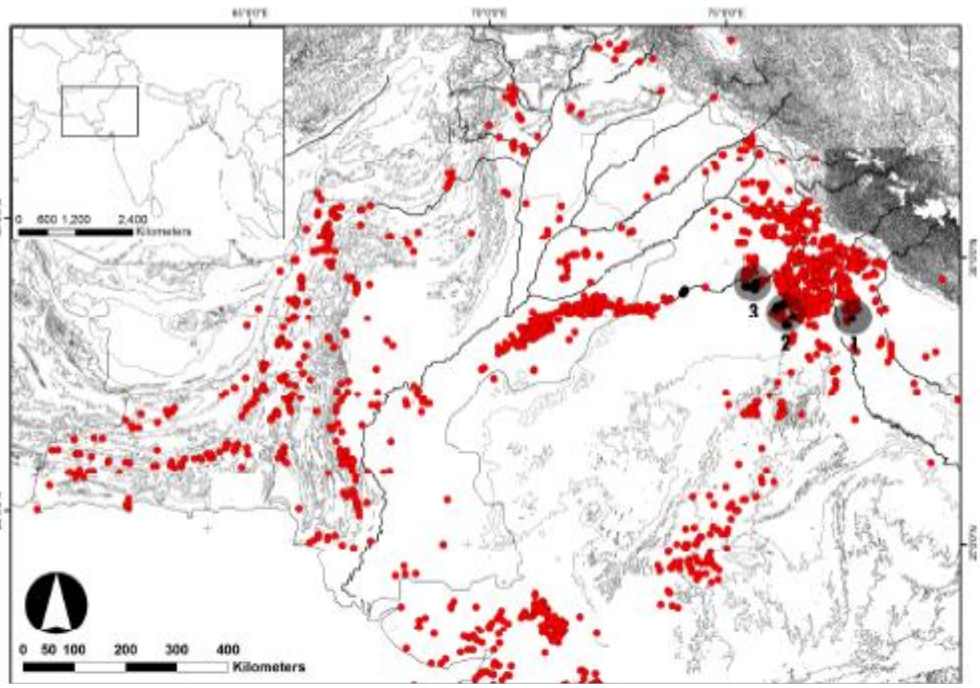

Fig 1: A map of NW India with the studied area (Masudpur 1) shown in circles 2

Material and Methods

Research aims and hypotheses

Soil micromorphological analysis from this site has been conducted with the primary aim of understanding on-site human behaviour throughout the duration of Harappan occupation. This has been addressed through the analysis of site formation processes, influenced by environmental conditions [8, 63, 64, 75]. The resulting insights into human behaviour could provide indications for the Indus `culture' as a whole. This could be crucial to reconstructing ancient circulation, landscape, vegetation, and hydrographic systems on a local scale—all important aspects for understanding the complex human-environmental interaction issues in Indus societies in the 3rd millennium BC in the plains of NW India [65].

Methods

The research has involved field work and laboratory work. Field work involved careful collection of soil block and bulk samples from the archaeological sites. Within the trial trenches, the Harappan contexts were identified on the basis of characteristic material culture attributes and thereafter, the transitional zones were targeted for on-site analysis. After their transportation to the University of Cambridge, laboratory work commenced. These included the manufacturing of the thin sections following the method described by Murphy [54, 33] and further modified and improved by Prof Charles French at the McBurney Laboratory for Geoarchaeology at the University of Cambridge. The manufactured `micromorphological thin sections' were analysed using a polarising microscope which is the best suited for this purpose [22, 71].

The thin sections taken during the course of this research were analysed under a Leica Wild M40 wide-view microscope at objective lense magnifications of _4 to x35 and a Nikon 6613 petrological microscope using a range of different magnifications (5.8-35X, 25X, 40X, 100X, 250X) and three main light conditions: plane polarised (PPL), cross polarised (XPL), oblique incident (OIL) and sometimes fluorescent light. The internationally accepted terminologies of Bullock et al. (1985) and Stoops (2003) and further works of scholars such as Adams et al. (1984), Adams and MacKenzie (2001), Canti (2003), Canti (1998), Courty et al. (1989) and Fitzpatrick (1993) have been followed for descriptions. The thin section reference collections of the McBurney Laboratory, University of Cambridge, have been used extensively.

The thin sections were analysed paying particular attention to the microstructures, coarse and fine fractions of groundmass, inclusions (for e.g. anthropogenic, organic, inorganic residues of biologic origin) and pedo-features. While the coarse/fine fraction ratio (c/f*ratio*) is a crucial reflection of the size distribution of the various components of the fabrics, inorganic residues of biological origin (phytoliths, faecal spherulites, shell and bones), organic components (plant remains and fungal sclerotia) together with the other anthropogenic inclusions (pottery, mudbricks) have been significant in detecting and interpreting the intensity and presence of human influence within the mound sites. It can be mentioned here that the Lumenera Infinity Analyze software (version 6.1) has been used not only to capture the microphotographs but also to record the measurements of the microfeatures with great accuracy.

Results and Discussion

After an initial observation of all the thin sections under the microscope, a conscious selection of the most representative slides was made to avoid repetitious descriptions. Since the samples collected from the XA1 trench revealed the potential Early-Mature and Mature Harappan phases of occupation, all the thin sections from this trench have been considered for detailed description (Figures 2, 3). This would allow gaining a picture of the foundation of the site and the mode of subsequent continuous occupation that followed. Micromorphological analysis, however, has allowed put forward the following interpretation from the XA1 trench of Masudpur I (Sampolia Khera).

The foundation

Collected from the lower part of the west-facing profile, SPK/XA1 Sample 2 represents an interface between the natural soil and human occupation. With a total absence of the characteristic features of an `A' horizon towards the lower part of this sample, such as the richness of organic matter, intense bioturbation with channels, crumb microstructure or earthworm granules, it becomes apparent that the site was not developed on a buried `A' horizon [7, 9, 16, 31, 38, 62, 77]. This is indicative of the truncation of the `A' horizon due to ground re-modelling or surface preparation before long-term settlement took place [10, 42]. However, though this interface between the natural soil and human occupation is not very distinctive, it shows the incorporation of the allochthonous papules of microlaminated clay [11] and coatings of limpid clay. The lower half of this sample also includes the evidence of disruption and further incorporation of material from a well-developed stable land surface or a `B' horizon, due to human induced activities, which might include practices of agriculture/ploughing [3, 17, 27, 35].

The occupational floors/layers and the building up of sediments

All the associated horizons are representative of different occupational floors as determined by the presence of unoriented organo-cultural refuse such as pottery, bones or mudbricks in these thin sections [42, 72]. However, no dump horizons, streets or specific areas of activity can be attributed from such negligible quantities of refuse [46]. There is not only a total absence of compactness and platy structures within these sediments that would indicate trampled roads or beaten floors, but also of features resulting from brushing or floor polishing techniques and vegetal tempering to suggest any plaster flooring [42, 43, 46].

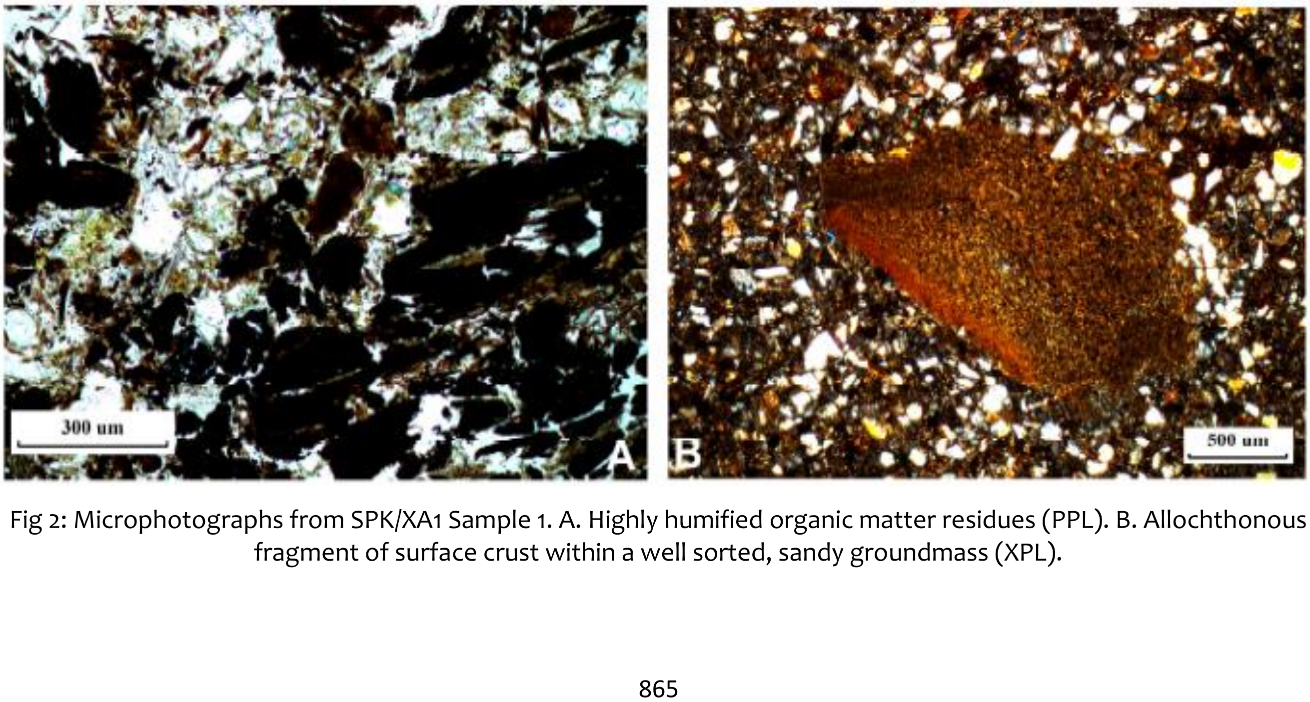

Fig 2: Microphotographs from SPK/XA1 Sample 1. A. Highly humified organic matter residues (PPL). B. Allochthonous fragment of surface crust within a well sorted, sandy groundmass (XPL).

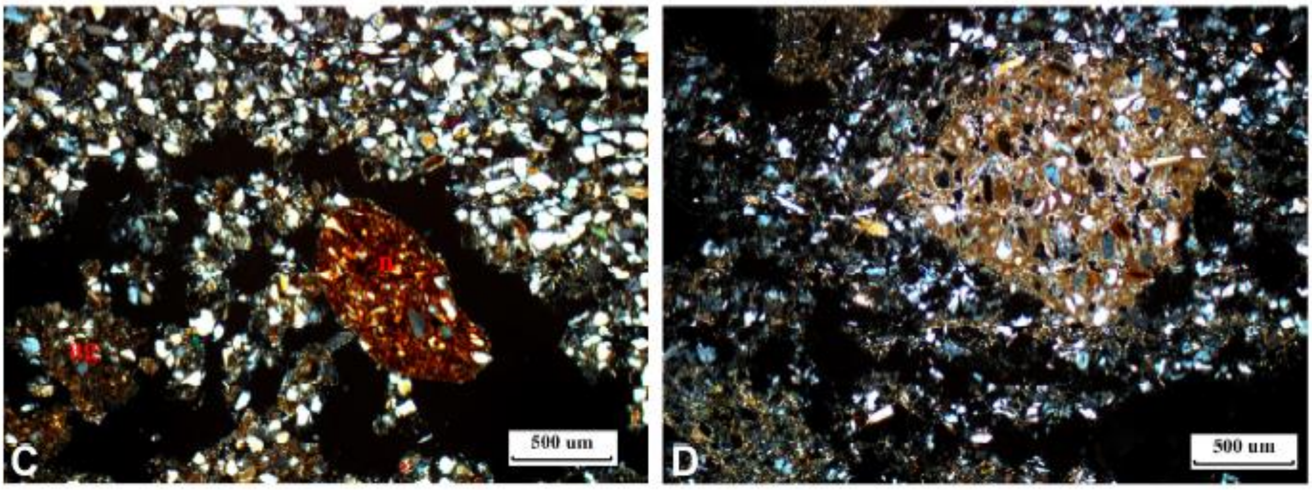

Fig 3: Microphotographs from SPK/XA1 Sample 1. C. Infilled channel with aggregates of groundmass material (ag). Note the anorthic subrounded iron oxide nodule (XPL). D. Recrystallised $CaCO_3$ nodule impregnated with humic substances and oxides (XPL).

Most of these thin sections, on the other hand, have distinctive sedimentary water crusts and water-laid aggregates, which can be indicative of unroofed surfaces like courtyards subjected to the action of water and wind [46, 76]. There is also an overall homogeneity within all these fabrics, the finer fabrics being mostly composed of sandy silt loam and sandy loam, very much like in an alluvial environment. Thus, in comparison with the off-site samples, it can be put forward that all these floors and other structures within the mound are composed of material which is alluvial in origin. This is very similar to what has been observed the Near Eastern *tell* sites. This again suggests that the mound had resulted from the collapse and degradation of walls or other structures which had been built of sundried mudbricks made from local alluvium [23, 29, 32, 37, 41, 55, 60]. Subjected to weathering and bioturbation in humid environmental conditions, degraded rounded to sub-rounded fragments of such mudbricks have been a common observation in the thin sections [20, 34, 48, 73]. Particularly observed in SPK/XA1 Sample 5, this stratigraphic context may indicate the remains from mudbrick collapse. Because of the rounded and subrounded nature of the mudbrick fragments, these are more likely to have been rolled and deposited by the action of water and wind from somewhere closeby, rather than an *in situ* collapse.

In addition to these, there is an ample presence of humified organic matter, especially in sample 1 where a distinctive layer of compressed decomposed humified organic matter has been identified. Combined with the presence of frequent rectangular and elongated phytoliths as observed in SPK/XA1 Sample 1 and SPK/XA1 Sample 2, which are residues from leaves and stems of grass family [61], it can be suggested that these organic materials have been added into the soil due to the usage of plant matter by the dwellers who had brought these onto the site for daily activities.

Cleanliness within the dwelling surfaces

It is apparent from the thin section observations from Masudpur I (Sampolia Khera) that there is a paucity of anthropogenic components. This suggests that these are mostly from accidental discards and not from intentional disposal. This is further indicative of the clean and organized nature of the occupants of the mound during their range of daily activities, sequences of cleaning operations and specific dumping of wastes during the whole length of occupation [42, 44, 45, 46, 47]. Thus, this is reflective of the prevalence of `clean' living surfaces connected with a specifically high standard of living, and/or the ordered management and disposal of their rubbish.

The depositional and post-depositional processes affecting the site

The action of pedogenic processes and the related depositional and post-depositional features working within the site can be discernible through the presence of different types of pedofeatures. Therefore, all these together can contribute towards understanding the broader environment prevalent in and around the site area [12, 13, 26, 36, 51, 53].

To start with, there is major homogeneity in the texture of the finer material, which ranges between sandy loam to sandy silt loam. Such textural homogeneity is further attested when compared to the off-site samples from the village of Masudpur and also from the nearby site of Bhimwada Jodha. This emphasises the local origin of these sediments due to the erosion and deposition actions of water and wind. Sedimentary aggradation also becomes clear either through the banded distribution patterns of fabric, particularly observed in SPK/XA1 Sample 3 and SPK/XA1 Sample 4, or as repetitive sedimentary water crusts, observed in sample 3, 4 and 5 [39, 56, 57]. These again suggest the continuous exposure of the site area to ephemeral rainfall conditions or flushing of water and low energy deposition during the entire period of occupation [52, 56, 57]. The observed surface crustal fragments are generally the result of an alternate dry and disturbed surface, very commonly encountered in the river floodplain environments [14, 49, 50, 57, 74]. Thus, the small *in situ* water crusts are probably formed from dried out water puddles, their subsequent erosion/dispersal either because of trampling action or rolling and transportation resulting in the occurrence of anorthic sedimentary water crusts [52]. All these together suggest the location of the site in an alluvial environment. But there is also an abundant presence of angular and subangular minerals such as fine quartz, mica, feldspar and some tourmaline, which suggest that these had been reworked by the action of water and wind [69]. However, the sedimentation regime remains dominated by the same alluvial processes in all these samples, characterised by a predominance of coarse sand sized particles, further supported through the presence of pellicular grain, single grain, bridged grain and intergrain microaggregate microstructures. Such a coarse fraction of the groundmass suggests the incorporation of locally sourced materials and the influx of channel bed derived sands in the process of the transport of alluvium. Sometimes, their strong orientation pattern (as observed in SPK/XA1 Sample 3) is a probable evidence of the changes in water regimes in the alluvial environment.

From time to time these gradually aggrading sediments were also affected by the action of vegetational growth and the soil fauna as evidenced by superimposed vughy and channel microstructures [3, 28]. Thus, though bioturbation is evident, none of these thin sections are very heavily bioturbated and exhibit rather constant soil faunal activities in all the thin sections. These are suggestive of consistent humid environmental conditions and vegetational growth often disrupting the structural features after deposition throughout the length of occupation [38, 59, 70]. Apart from this, little variation in the presence of textural, crystalline and amorphous pedofeatures has been observed in all these thin sections. Amongst these, the textural pedofeatures are the most dominant which further indicate illuvial processes at work [39]. Observed impure clay coatings and infillings suggest alluvial aggradation, while microlaminated clay coatings, present in the lower part of SPK/XA1 Sample 2, indicate the prevalence of a well-developed `B' horizon before the beginning of occupation at the site [26, 39].

Sporadic wetting and drying conditions due to the fluctuations of the groundwater table from seasonal monsoonal rainfall are indicated by the omnipresence of iron oxide pedofeatures [40]. Crystalline pedofeatures have been very few in comparison to the other pedofeatures and probably a major part of their occurrence can be accredited to anthropogenic activities within the mound such as combustion. The resultant calcium carbonate must have dissolved subsequently in water and had percolated down the profile with further recrystallisation [25]. All these pedofeatures are more or less similar in their types and frequencies and occur in the Early-Mature and Mature phases of Harappan occupation in the site. These suggest the presence of similar types of environmental factors such as rainfall and humidity, during all these time.

Conclusion

Considering all these depositional, post-depositional and anthropogenic features, it can therefore be put forward that the higher ground of Sampolia Khera which was occasionally affected by the influx of channel bed derived sands in an extensive alluviated floodplain system, was first targeted for settlement in the Early-Mature Harappan period. This must have encouraged agricultural exploitation during and after the establishment of the settlement by providing a naturally and seasonally replenishing soil and groundwater system with both nutrient and fine soil additions and a seasonally high groundwater table. With continuous anthropogenic modifications, daily cleaning versus cycles of discard, shifting use of space and abandonment of a particular structure through time, this site stand as a mosaic of Indus occupation for a long span of time.

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References

[1] Adams, A., MacKenzie, W., and Guilford, C. (1984). Atlas of Sedimentary Rocks Under the Microscope. Longman, Harlow.

[2] Adams, A. and MacKenzie, W. (2001). A Colour Atlas of Carbonate Sediments and Rocks Under the Microscope. Manson Publishing Ltd, London.

[3] Adderley, W., Wilson, C., Simpson, I., and Davidson, D. (2010). Anthropogenic Features. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, chapter 25, pages 569-622. Elsevier, Amsterdam.

[4] Ahuja, R., Garlapuri, V., Manchanda, M., and Khanna, S. (1987). Physiography and Soil Associations of Haryana. Journal of Indian Society of Soil Science, 26:261-267.

[5] Ahuja, R. and Khanna, S. (1982). Soilscapes, Geomorphic Processes and Soil Taxonomic New Subgroups Identified in the Ghaggar River Rasin of Haryana and Punjab. Photonirvachak. Journal of Indian Society of Photo-Int. and Remote Sensing, 10(1):7-14.

[6] Ahuja, R., Khanna, S., and Garalapuri, V. (1980). Evolution and Distribution of Aeolian Cover in Haryana. Annals of Arid Zone, 19(3):175-182.

[7] Bal, L. (1973). Micromorphological Analysis of Soils: lower Levels in the Organization of Organic Soil Materials. PhD thesis, Soil Survey InstituteWageningen, The Netherlands.

[8] Binford, L. (1979). Organization and Formation Processes: Looking at Curated Technologies. Journal of Anthropological Research, 35(3):255-273.

[9] Blanchart, E. (1992). Restoration by Earthworms (Megascolecidae) of the Macroaggregate Structure of a Destructured Savanna Soil Under Field Conditions. Soil Biology and Biochemistry, 24(12):1587-1594.

[10] Blume, H. (1989). Classification of Soils in Urban Agglomerations. Catena, 16:269-275.

[11] Brewer, R. (1964). Fabric and Mineral Analysis of Soils. John Wiley and Sons, New York.

[12] Brewer, R. and Sleeman, J. (1969). The Arrangement of Constituents in Quaternary Soils. Soil Science, 107(6):435-441.

[13] Bronger, A., Bruhn-Lobin, N., and Heinkele, T. (1993). Micromorphology of Paleosols-Genetic and Paleoenvironmental Deductions: Case Studies from Central China, South India, NW Morocco and the Great Plains of the USA. Developments in Soil Science, 22:187-206.

[14] Brown, A. (1992). Slope Erosion and Colluviation at the Floodplain Edge. In Bell, M. and Boardman, J., editors, Past and Present Soil Erosion, volume 22, pages 77-87. Oxbow, Oxford.

[15] Bullock, P., Fedoroff, N., Jongerius, A., Stoops, G., and Tursina, T. (1985). Handbook of Soil Thin Section Description. Waine Research Publications, Alkerighton.

[16] Buntley, G. and Papendick, R. (1960). Worm-Worked Soils of Eastern South Dakota, Their Morphology and Classi_cation. Soil Science Society of America Journal, 24(2):128-132.

[17] Cady, J., Wilding, L., and Drees, L. (1986). Petrographic Microscope Techniques. In Klute, A. and Lee, A., editors, Methods of Soil Analysis, Part I. Physical and Mineralogical Methods, 9, pages 185-218. Soil Science Society of America, USA.

[18] Canti, M. (2003). Aspects of the Chemical and Microscopic Characteristics of Plant Ashes Found in Archaeological Soils. Catena, 54(3):339-361.

[19] Canti, M. (1998). The Micromorphological Identification of Faecal Spherulites from Archaeological and Modern Materials. Journal of Archaeological Science, 25(5):435-444.

[20] Carter, T. and Pagliero, R. (1966). Notes on Mud-brick Preservation. Sumer, 1966(22):65-76.

[21] Chaudhary, B. and Aggarwal, S. (2009). Demarcation of Palaeochannels and Integrated Ground Water Resources Mapping in Parts of Hisar District, Haryana. Journal of the Indian Society of Remote Sensing, 37(2):251-260.

[22] Courty, M., Goldberg, P., and Macphail, R. (1989). Soils and Micromorphology in Archaeology. Cambridge University Press, Cambridge.

[23] Davidson, D. (1973). Particle Size and Phosphate Analysis-Evidence for the Evolution of Tell. Archaeometry, 15(1):143-152.

[24] Dhir, R. and Jain, S. (1982). Morphology, Genesis and Classi_cation of Desert Soils. In Randhawa, N., editor, Review of Soil Research in India, volume II, pages 474-483, New Delhi. 12th International Congress of Soil Science.

[25] Durand, N., Monger, H., and Canti, M. (2010). Calcium Carbonate Features. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 149-194. Elsevier, Amsterdam.
[26] Federoff, N., Courty, M., and Thompson, M. (1990). Micromorphological Evidence of Paleoenvironmental Change in Pleistocene and Holocene Palaeosols. In Douglas, L., editor, Soil Micromorphology: a Basic and Applied Science, pages 653-665. Elsevier Science, New York.
[27] Fedoroff, N., Courty, M., and Guo, Z. (2010). Palaeosoils and Relict Soils. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 623-662. Elsevier, Amsterdam, Amsterdam.
[28] Fitzpatrick, E. (1993). Soil Microscopy and Micromorphology. John Wiley & Sons, New York.
[29] Friesem, D., Boaretto, E., Eliyahu-Behar, A., and Shahack-Gross, R. (2011). Degradation of Mud-brick Houses in an Arid Environment: a Geoarchaeological Model. Journal of Archaeological Science, 38(5):1135-1147.
[30] Garalapuri, V. and Goyal, V. (1974). Mineralogical Study of the Fine Sands from the Fringe of Haryana. Indian Journal of Agricultural Research, 8(4):227-232.
[31] Gerasimova, M. and Lebedeva-Verba, M. (2010). Topsoils-Mollic, Takyric and Yermic Horizons. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 351-368. Elsevier, Amsterdam.
[32] Goldberg, P. (1979). Geology of Late Bronze Age Mudbrickfrom Tel Lachish. Tel Aviv. Journal of the Tel Aviv Institute of Archaeology, 6:60-71.
[33] Goldberg, P. and Macphail, R. (2006). Practical and Theoretical Geoarchaeology. Blackwell Science Ltd, Oxford.
[34] Goodman-Elgar, M. (2008). The Devolution of Mudbrick: Ethnoarchaeology of Abandoned Earthen Dwellings in the Bolivian Andes. Journal of Archaeological Science, 35(12):3057-3071.
[35] Jongerius, A. (1983). The Role of Micromorphology in Agricultural Research. In Bullock, P. and Murphy, C., editors, Soil Micromorphology, pages 111-138. AB Academic Publishers, Berkhamsted.
[36] Kemp, R. and Derbyshire, E. (1998). The Loess Soils in China as the Record of Climatic Change. European Journal of Soil Science, 49:525-539.
[37] Kenoyer, J. and Meadow, R. (2000). The Ravi Phase: a New Cultural Manifestation at Harappa. In Taddei, M. and Marco, G., editors, South Asian Archaeology 1997, pages 55-76. Instituto Italiano per l'Africa e l'Oriente/ Instituto Universatario Orientale, Rome and Naples.
[38] Kooistra, M. and Pulleman, M. (2010). Features Related to Faunal Activity. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 397-418. Elsevier, Amsterdam.
[39] Kühn, P., Aguilar, J., and Miedema, R. (2010). Textural Pedofeatures and Related Horizons. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 217-250. Elsevier, Amsterdam.
[40] Lindbo, D., Stolt, M., and Vepraskas, M. (2010). Redoximorphic Features. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 129-147. Elsevier, Amsterdam.
[41] Love, S. (2012). The Geoarchaeology of Mudbricks in Architecture: a Methodological Study from Çatalhöyük, Turkey. Geoarchaeology, 27(2):140-156.
[42] Macphail, R. and Goldberg, P. (2010). Archaeological Materials. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, chapter 26, pages 589-622. Elsevier, Amsterdam.
[43] Matthews, W. (1992). The Micromorphology of Occupational Sequences and the Use of Space in a Sumerian City. PhD thesis, University of Cambridge, Cambridge.
[44] Matthews, W. (1995). Micromorphological Characterisation and Interpretation of Occupation Deposits and Microstratigraphic Sequences at Abu Salabikh, Iraq. In Barham, A. and Macphail, R., editors, Archaeological Sediments and Soils: Analysis, Interpretation and Management, pages 41-76. Archetype Books, London.
[45] Matthews, W. (2005). Micromorphological and Microstratigraphic Traces of Uses and Concepts of Space. In Hodder, I., editor, Inhabiting Çatalhöyük: Reports from the 1995-1999 Seasons (Çatalhöyük vol.4), pages 355-398. McDonald Institute for Archaeological Research, Cambridge.
[46] Matthews, W., French, C., Lawrence, T., Cutler, D., and Jones, M. (1997). Microstratigraphic Traces of Site Formation Processes and Human Activities. World Archaeology, 29(2):281-308.
[47] Matthews, W., French, C., Lawrence, T., Cutler, D., and Jones, M. (1998). Microstratigraphy and Micromorphology of Depositional Sequences. In Oates, D., Oates, J., and McDonald, H., editors, Exacavations at Tell Brak, Volume I, The Mitani and Old Babylonian Periods, volume I of McDonald Institute Monograph, pages 135-140. McDonald Institute for Archaeological Research, Cambridge.
[48] McIntosh, R. (1974). Archaeology and Mud Wall Decay in a West African Village. World Archaeology, 6(2):154-171.
[49] Mücher, H. (1974). Micromorphology of Slope Deposits: the Necessity of a Classification. In Rutherford, G., editor, Soil Microscopy, pages 553-566. The Limestone Press, Ontario.
[50] Mücher, H. and De Ploey, J. (1977). Experimental and Micromorphological Investigation of Erosion and Redeposition of Loess by Water. Earth Surface Process, 2:117-124.

[51] Mücher, H. and Morozova, T. (1983). The Application of Soil Micromorphology in Quaternary Geology and Geomorphology. In Soil Micromorphology. International Working Meeting on Soil Micromorphology, 6, pages 151-194.
[52] Mücher, H., Steijn, H., and Kwaad, F. (2010). Colluvial and Mass Wasting Deposits. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 37-48. Elsevier, Amsterdam.
[53] Muggler, C. and Buurman, P. (1997). Micromorphological Aspects of Polygenetic Soils Developed on Phyllitic Rocks in Minas Gerais, Brazil. In Shoba, S., Gerasimova, M.,and Miedema, R., editors, Soil Micromorphology: Studies on Soil Diversity, Diagnostics and Dynamics, pages 129-138. Wageningen, Moscow.
[54] Murphy, C. (1986). Thin Section Preparation of Soils and Sediments. AB Academic Publishers, Berhamsted.
[55] Nodarou, E., Frederick, C., and Hein, A. (2008). Another (Mud) brick in the Wall: Scientific Analysis of Bronze Age Earthen Construction Materials from East Crete. Journal of Archaeological Science, 35(11):2997-3015.
[56] Pagliai, M. and La Marca, M. (1979). Micromorphological Study of Soil Crusts. Agrochimica, 23:16-25.
[57] Pagliai, M. and Stoops, G. (2010). Physical and Biological Surface Crusts and Seals. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 419-440. Elsevier, Amsterdam.
[58] Petrie, C., Singh, R., and Singh, A. (2009). Investigating the Changing Settlement Dynamics in the Plains: the 2009 Survey and Excavations at Masudpur (Hissar District,Haryana). Puratattva, 39:38-49.
[59] Pulleman, M. (2002). Interactions Between Soil Organic Matter Dynamics and Soil Structure as Affected by Farm Management. PhD thesis, Wageningen University, Wageningen.
[60] Rosen, A. (1986). Cities of clay: the Geoarcheology of Tells. University of Chicago Press, Chicago.
[61] Rosen, A. (1992). Preliminary Identification of Silica Skeletons from Near Eastern Archaeological Sites: an Anatomical Approach. In George, R. and Mulholland, S., editors, Phytolith Systematics: Emerging Issues, pages 129-147. Springer, New York.
[62] Schaetzl, R. and Anderson, S. (2005). Soils: Genesis and Geomorphology. Cambridge University Press, Cambridge.
[63] Schiffer, M. (1983). Towards the Identification of Formation Processes. American Antiquity, 48:675-706.
[64] Schiffer, M. (1987). Formation Processes of the Archaeological Record. University of New Mexico Press, Albuquerque.
[65] Schuldenrein, J. (2002). Geoarchaeological Perspectives on the Harappan Sites of South Asia. Indian Archaeology in Retrospect: Protohistory: Archaeology of the Harappan Civilization, 2:47-80.
[66] Singh, R. and Petrie, C. (2009). Land, Water and Settlement: Environmental Constraints and Human Responses in Northwest India Between 2000 and 300 BC Environment in Ancient India. In Singh, H., Naseem, M., Singh, R., and Singh, A., editors, Monograph of the Department of Ancient Indian History, Culture and Archaeology, volume 21, pages 105-108. Banaras Hindu University, Varanasi.
[67] Singh, R., Petrie, C., French, C., Goudie, A., Gupta, S., Tewari, R., Singh, A., Sinha, R., Srivastava, R., and Yadav, S. (2009). Settlements in Context: Reconnaissance in Western Uttar Pradesh and Haryana, April and May 2008. Man and Environment, 33(2):71-87.
[68] Singh, R., Petrie, C., Joglekar, P., Neogi, S., Lancelotti, C., Pandey, A., and Pathak, A. (2013). Recent Excavations at Alamgirpur, Meerut District: a Preliminary Report. Man and Environment, XXXVIII(1):32-54.
[69] Srivastava, P. and Parkash, B. (2002). Polygenetic Soils of the North-central Part of the Gangetic Plains: a Micromorphological Approach. Catena, 46(4):243-259.
[70] Stolt, M. and Lindbo, D. (2010). Soil Organic Matter. In Stoops, G., Marcelino, V., and Mees, F., editors, Interpretation of Micromorphological Features of Soils and Regoliths, pages 369-390. Elsevier, Amsterdam.
[71] Stoops, G. (2003). Guidelines for Analysis and Description of Soil and Regolith Thin Sections. Soil Science Society of America, Madison, Wisconsin.
[72] Stoops, G. and Nijs, R. (1986). Micromorphological Characteristics of Some Tell Materials from Mesopotamia. Pedologie, 36(3):329-335.
[73] Torraca, G., Chiari, G., and Gullini, G. (1972). Report on Mudbrick Preservation. Mesopotamia, 1972(7):259-286.
[74] Valentin, C. and Bresson, L. (1992). Morphology, Genesis and Classification of Surface Crusts in Loamy and Sandy Soils. Geoderma, 55(3):225-245.
[75] Villa, P. (1982). Conjoinable Pieces and Site Formation Processes. American Antiquity, 47(2):276-290.
[76] Weiss, H., Courty, M., Wellerstrom, W., Guichard, F., Senior, L., Meadow, R., and Currow, A. (1993). The Genesis and Collapse of Third Millennium North Mesopotamian Civilization. Science, 291:995-1088.
[77] Zhang, H. and Schrader, S. (1993). Earthworm E_ects on Selected Physical and Chemical Properties of Soil Aggregates. Biology and fertility of soils, 15(3):229-234.

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Selenium in soils of Moldova

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Abstract

Selenium (Se) is an essential trace element for both animals and human beings, although it is considered to be conditionally required for plants. As compared with other biogenic trace elements Se occurrence in the environment of Moldova is poorly understood. The objective of this study was to establish Se content and distribution in soils of this country. To solve this problem soil and plant samples were gathered in 139 large soil areas from different regions of Moldova. Se content in samples was detected using fluorometric method. It was established that Se concentration in soils ranged from 100 to 668 $\mu g\ kg^{-1}$ dry weight with the mean value 246±73 $\mu g\ kg^{-1}$. Determined local maximum of Se (1933 $\mu g\ kg^{-1}$) was due to anthropogenic impact and wasn't used in statistical analysis. Se concentrations in different soil types were at the mean ($\mu g\ kg^{-1}$) 232±56 in Cambisols (3 areas), 241±85 in Humic Luvisols (18 areas), 245±63 in Luvic Chernozems (15 areas), 277±97 in Haplic Chernozems (14 areas), 236±60 in Xeric Chernozems (70 areas), and 262±109 in Humic Gleysols (19 areas). Mainly, Se content in soils was optimal (more than 175 $\mu g\ kg^{-1}$), however there were soil areas with Se deficiency (lower than 125 $\mu g\ kg^{-1}$). Maximum of Se in soils was observed at the depth of 0.4–0.7 meters and then it decreased on going to parent rock. Se content typically increased with increasing of soil clay particles. The average Se content was 200 $\mu g\ kg^{-1}$ in sandy, 240–242 $\mu g\ kg^{-1}$ in loamy, and 261 $\mu g\ kg^{-1}$ in argillaceous soils. Se washout from terraces and watershed slopes as well as Se accumulation in relief depressions was shown. It caused an increased Se content in Humic Gleysols (up to 668 $\mu g\ kg^{-1}$). As compared to other trace element content in soils Se position was presented according to the following relationship (mg kg^{-1}): $n{\cdot}10^4$ Fe > $n{\cdot}10^2$ Mn > $n{\cdot}10^1$ Zn > $n{\cdot}10^1$ Cu > $n{\cdot}10^{-1}$ Cd > $n{\cdot}10^{-1}$ Se. These elements are able to cause antagonism for Se uptake by plants. High Se concentrations in local water reservors (0.2–6.1 $\mu g\ L^{-1}$, mean 1.8 $\mu g\ L^{-1}$) indicated the substantial presence of soluble Se forms, which were available to plant assimilation. Actually, agricultural crops grown on Xeric Chernozems accumulated the following Se levels ($\mu g\ kg^{-1}$): sorghum – 147, sunflower – 125, maize – 117, clover – 111, alfalfa – 110, oat – 107, barley – 106, wheat – 106. Thus, geochemical conditions of Moldova are favorable for Se bioaccumulation by plants.

Keywords: selenium, soil, plant, bioaccumulation

Introduction

The Republic of Moldova is a small country, which occupies an area of 3,376,000 sq. km. It is located in the south-west of the East European Plain between the Carpathian Mountains and the Black Sea in the basin of the Dniester and Prut. Extent of the country from the north to the south is only 350 km. However, its natural landscapes and associated soils differ widely. The northern part of Moldova belongs to the forest-steppe zone with predominant Luvic Chernozems and Humic Luvisols. Steppe landscapes occupy the southern part with

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Xeric Chernozems. The leading factor of soil-forming differentiating in Moldova is the geological and geomorphological framework of its territory (Kapitalchuk, 2009). Relief breaks latitudinal continual change of soil types and soil cover structure becomes discrete. Thus, there is the Beltskaya steppe area with predominant Haplic Chernozems among the forest-steppe zone in the northern part of Moldova. Forest area with Cambisols и Humic Luvisols occupies the Central Moldavian Elevation (Kodry). There is the Tigechskaya Forest-steppe Elevation with Luvic Chernozems and Humic Luvisols in the south. Besides, soils differentiate depending on relief height and slope exposure.

Soil cover of Moldova was studied actively including agrochemical aspect because of intensive agricultural development in 1970–1980s (Bumbu, 1981; Toma, 1973; Toma et al., 1980). V. Kiriliuk (2006) has summarized data on trace element contents in the environment of Moldova. Scientific publications review indicates that many biogenic elements (especially those with plant physiology importance) have been studied systematically. However, there has been only some contradictory information about ultramicroelement selenium (Se).

On the one hand, Se concentrations in groundwater as well as in wheat flour and dried milk of Moldova have been shown to be heightened (Zelenin, 1972; Svezhentsov et al., 1976; Krainov et al., 1983; Golubkina, 1998). These data suggest a high Se status in the environment of Moldova. On the other hand, C. Moraru (2002) has noticed wide range of Se concentrations in rocks (from 10 to 3300 μg kg^{-1}) and soils (from 10 to 860 μg kg^{-1}) of Moldova. Bogdevich et al. (2002) have shown lower mean Se concentrations in soil-forming loessial deposits (56 μg kg^{-1}) and soils (125–175 μg kg^{-1}). These facts have indicated Se deficiency in the parent rocks and soils of Moldova rather than Se optimum.

Because of uncertain Se status in the environment of Moldova, we have been studying systematically Se biogeochemistry in this territory since 2004. Se is considered to be conditionally required for plants. At the same time, entering into active sites of numerous antioxidant proteins Se is one of the antioxidant protection components in human and animal beings (Golubkina, Papazyan, 2006). We have given priority to Se studying in soils at the initial stage of our research as soil is the primary echelon of Se cycling in ecosystems

Material and Methods

Taking into account local micro- and mesorelief (watersheds, slopes, terraces and floodplains) soil samples were collected in 139 large areas of various soil types throughout Moldova (figure 1) from 2004 to 2010.

Figure 1. Map showing the sampling locations on the territory of Moldova (● – soil sampling sites)

Soil samples were collected using a soil auger. Depending on the soil contour size 5–10 samples were picked, and then the mixed soil sample was compiled. In some cases soil bore pits covering all soil layers from the day surface to the parent rock were made. In this article results on Se concentration in the upper soil layer (0–20 cm) was mainly presented.

Soil samples were dried at room temperature to constant weight (dry weight – dw), powdered in a porcelain pestle and mortar and kept in closed polyethylene containers till the beginning of the analysis.

Se content in samples was detected using fluorometric method (Alfthan, 1984). Concentrations of Mn, Fe, Zn, Cu, Cd in soil samples were analyzed with atomic absorption spectrophotometer Aanalyst800 (Perkin Elmer, USA). The software package used to analyze the data was STATISTICA 10 (StatSoft Inc., 2011).

Results and Discussion

Geochemical conditions of Se cycling and accumulation in soils varied in different types of ecosystems. Therefore, we correlated each soil type with the appropriate native ecosystem, where this type was formed (table 1).

Table 1. Total Se concentrations in soils of different ecosystems in Moldova

Ecosystem	Soils	Number of areas	Range, μg kg^{-1} dw	Soil Se concentration M±SD, μg kg^{-1} dw
Forest	Cambisols	3	190–295	232±56
	Humic Luvisols	18	118–423	241±85
Forest-steppe	Luvic Chernozems	15	185–410	245±63
Rich forb steppe	Haplic Chernozems	14	165–554	277±97
Meager forb steppe	Xeric Chernozems	70	100–370	236±60
Floodplain meadows and forests	Humic Gleysols	19	153–668	262±109
	All soils	139	100–668	246±73

Se concentrations in soils of Moldova ranged from 100 to 668 μg kg^{-1} dw. In one soil sample of Xeric Chernozems collected on terrace above the floodplain of the Dniester Se concentration reached 1933 μg kg^{-1} dw. We excluded this sample from statistical calculations as this hearth of high Se content had anthropogenic reasons.

Based on proposed limits of areas with different provision of soils with Se (Tan et al., 2002), we stated that soils of Moldova contain the optimal amount of Se (more than 175 μg kg^{-1} dw). However, there were soil areas of Humic Luvisols and Xeric Chernozems with Se deficiency (less than 125 μg kg^{-1} dw), and marginal provision with Se (125–175 μg kg^{-1} dw) were observed in Haplic Chernozems and Humic Gleysols. At the same time, we did not find any soil areas with Se concentration above the optimum limit (3000 μg kg^{-1} dw).

Maximum mean Se concentration was observed in Haplic Chernozems (277 μg kg^{-1} dw). This soil type formed under conditions of rich forb fescue-feather steppe on relief elements with altitudes of 160–220 m asl (Atlas, 1988). The relative humidification factor K_w, which is the ratio of annual precipitation to evaporability, for this heights range is 0.65–0.72 (Kapitalchuk, 2010). Humidification conditions are the determinant environmental factor of phytocenosis differentiation in Moldova.

With decreasing relief height humidification conditions are reduced. At the altitude of 40 m asl K_w is reduced to 0.42. Correspondingly biomass and its annual growth are reduced in ecosystems. At low relief elements formed meager forb fescue-feather steppe ecosystems on Xeric Chernozems, where mean Se concentration was reduced to 236 μg kg^{-1} dw. Most probably, it was connected with reduction of Se entrance in the topsoil due to smaller amount of destructed organic matter.

Forest ecosystems are located at altitudes over 200 m asl. Different subtypes of Humic Luvisols were formed under the forests of common oak (*Quercus robur*) and durmast oak (*Quercus petraea*) with mixture of other species. They occupy relief elements with heights of 200–370 m asl (Atlas, 1988). K_w reaches values of 0.69–0.93 (Kapitalchuk, 2010). Beech and beech-oak forests growing on Cambisols occupy the highest watersheds at altitudes of 370–430 m asl. These ecosystems have steady water balance (K_w≈1). Mean Se concentrations in soils of forest ecosystems were lower than those in Haplic Chernozems. Apparently, it was primarily connected to Se leaching or washing-out from the upper soil horizon due to increased precipitation and partly fewer Se amount, coming into the soil by the annual destruction of organic matter. Annual growth of biomass in oak-forests is slightly less than this in rich forb steppe.

Mean Se concentration in Luvic Chernozems (245 μg kg^{-1} dw) occupied an intermediate position between forest and rich forb steppe ecosystems. This subtype of chernozem formed at altitudes of 180–260 m asl under the oak-forests with forb cover and meadow-steppe vegetation (Atlas, 1988), where the relative humidification factor is 0.66–0.78 (Kapitalchuk, 2010).

Relatively high Se content in Humic Gleysols (262 μg kg^{-1} dw) was connected to washing-out of soil rich trace element from the river terraces and watershed slopes and its accumulation in the relief depressions. Se concentrations in soils increased from watersheds to floodplains (figure 2) in parts of the Dniester River Valley with narrow terraces and steep slopes (Kapitalchuk et al., 2011).

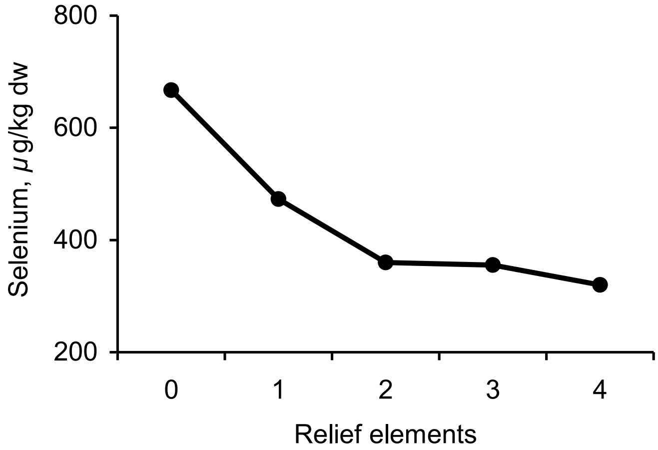

Figure 2. Se concentrations in soils of different relief elements in the Dniester River Valley: 0 – floodplain, 1–4 – terraces above the flood plain.

We have considered the differences between Se content in the upper layer (0–20 cm) of different soil types. However, it should be noted that Se is unevenly distributed along the vertical soil profile. Figure 3 shows maximum Se concentration in the soil was commonly occurred at a depth of 40 to 80 cm. Furthermore, Se content decreased in the upper soil layers and on going to parent rock.

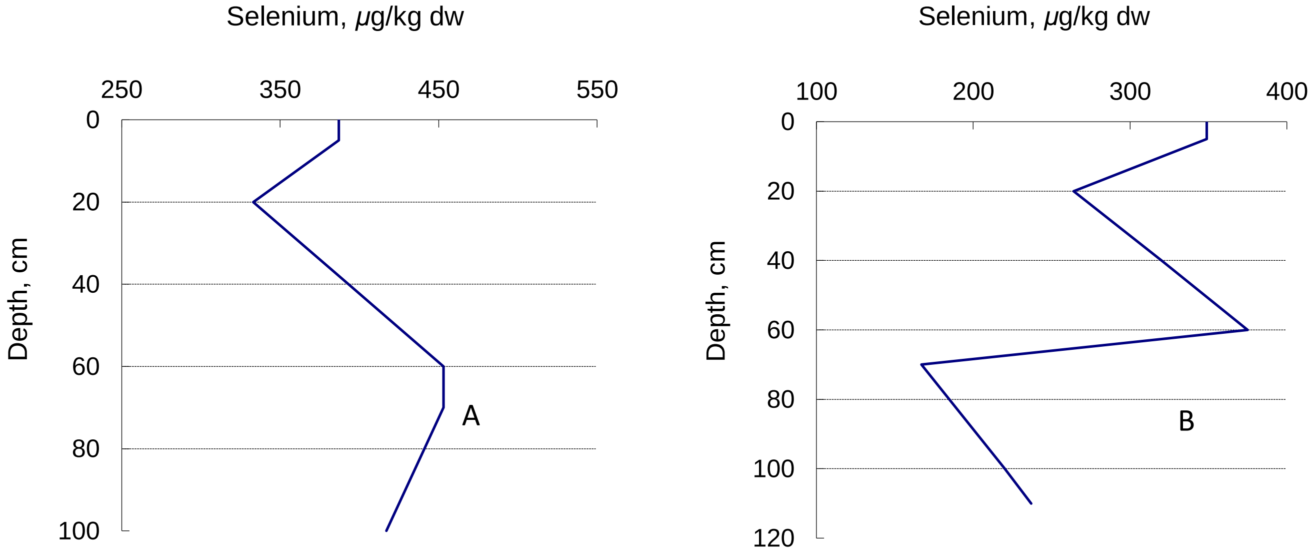

Figure 3. Se distribution along the vertical soil profile: A – Xeric Chernozem, B – Humic Gleysol

Vertical Se distribution in Humic Gleysol was more complicated (figure 3, B). Evidently, Se concentration in different soil horizons depended on trace element content in soil particles incoming both from the adjacent slopes or terraces and from river deposits after floods.

Se content in the parent rocks first and foremost determines its concentration in soils (Kiriliuk, 2006). Among the most common groups parent rocks are eluvial and eluvial-diluvial light clays and heavy loams in the northern part and loess-like medium and heavy loams in the southern part of Moldova. Formed on sands, sandy loams and limestone soils are less common. Recent diluvial and alluvial deposits are found everywhere on the floodplains and at the beam bottoms.

Se amount in the parent rocks varies widely: tertiary sands eluvium – 50–80 μg/kg; limestones – 30–100 μg/kg; clays – 400–600 μg/kg (Kabata-Pendias, 1989). Quaternary loess-like deposits of Dniester-Prut interfluve contains on average 56 μg Se/kg (Bogdevich et al., 2002), and Se concentration in parent loess-like medium and heavy loams of the Dniester Valley at the depth of 140–150 cm is 140–180 μg/kg (Kapitalchuk, Kapitalchuk, 2009).

Se concentrations in soils were usually higher than those in parent rocks. However, the dependence of Se amount from soil texture was preserved. Se content typically increased with increasing of soil clay particles (table 2). Se accumulation in the humus horizon soils occurred mainly through its biogenic concentration. Relatively high Se content in diluvial-alluvial soils was mainly connected with trace element washout from elevated relief elements and its accumulation in the floodplains and at the beam bottoms.

Table 2. Se concentrations in soils formed on different parent rocks

Parent rocks	Number of samples	Range, μg kg^{-1} dw	Soil Se concentration M±SD, μg kg^{-1} dw
Sandy loams and light loams	12	100–338	200±53
Loess-like medium and heavy loams	75	149–398	241±58
Light clays and heavy loams	33	118–554	261±90
Diluvial and alluvial deposits	19	153–668	252±72

Se ratio with metals-antagonists is of certain interest. We found that for Moldova soils this ratio was as follows (mg/kg): $n{\cdot}10^4$ Fe > $n{\cdot}10^2$ Mn > $n{\cdot}10^1$ Zn > $n{\cdot}10^1$ Cu > $n{\cdot}10^{-1}$ Cd > $n{\cdot}10^{-1}$ Se. Being a true ultramicroelement, Se took the last position in this series. In most cases relationship among total soil contents of considered here elements was found to be quite weak. There were statistically significant positive correlations (p<0.05) between the following pairs of elements: Zn–Se (r=0.57), Fe–Zn (r=0.59), Fe–Mn (r=0.79) (Kapitalchuk et al., 2011). In other cases, there was a weak positive correlation among the elements in the soil, which reflected a general tendency to increase the trace elements amounts with a weighting of granulometric composition of soils within a subtype as well as in a genetic series of chernozems from Xeric Chernozem to Haplic Chernozems.

It should be noticed that we have discussed above total Se content in soils. However, mobile forms of trace element are of particular importance in the environmental aspect due to their availability for uptake by plants. Natural waters are known to be a reliable indicator of water-soluble forms of elements in soils and rocks.

According to hydrochemical water monitoring Se concentration in local waters and groundwaters ranged from 0.2–6.1 μg L^{-1} (mean concentration was 1.8 μg L^{-1}). In the Dniester River Se content ranged from 0.2 to 3.7 μg L^{-1} with a mean of 1.5 μg L^{-1}. Se position changed significantly in local waters with respect to other elements (Kapitalchuk et al., 2012): $n{\cdot}10^{-2}$ Mn > $n{\cdot}10^{-2}$ Fe > $n{\cdot}10^{-2}$ Zn > $n{\cdot}10^{-3}$ Se > $n{\cdot}10^{-3}$ Cu > $n{\cdot}10^{-5}$ Cd (mg L^{-1}).

In contrast to soil Se, its concentrations in natural waters were comparable with Cu concentration. This fact indicated the presence of substantial amount water-soluble bioavailable Se forms in rocks and soils. Actually, agricultural crops grown on Xeric Chernozems accumulated the following Se levels (μg kg^{-1}): sorghum – 147, sunflower – 125, maize – 117, clover – 111, alfalfa – 110, oat – 107, barley – 106, wheat – 106 (Kapitalchuk et al., 2011).

Conclusion

In this study we have shown that Se concentrations ranged widely from optimum to deficiency, however, mean Se concentrations were optimal in soils of Moldova. At the same time we have demonstrated that soil Se content was closely connected with both granulometric composition of soil and type of ecosystem. Moreover, Se was unevenly distributed along the vertical soil profile. Significant Se concentrations in natural waters indirectly indicated the presence in soils enough water-soluble and bioavailable Se forms.

References

Kapitalchuk, I.P., 2009. Assessing the impact of geomorphological framework on soil differentiation in Moldova. Bulletin of the Institute of geology and seismology MAS. 1, 41–51. (in Russian)

Bumbu, Y.V., 1981. Biogeochemistry of Trace Elements in Plants, Soils and Natural Waters of Moldavia. Kishiniov, Shtiintsa. (in Russian)

Toma, S.I., 1973. Trace Elements in Field Crop Cultivation in Moldavia. Kishiniov, Shtiintsa. (in Russian)

Toma, S.I., Rabinovich, I.Z., Veliksar, S.G., 1980. Trace Elements and Harvest. Kishiniov, Shtiintsa. (in Russian)

Kiriluk, V.P., 2006. Trace Elements in Biosphere Components of Moldova. Chişinău, Pontos. (in Russian)

Zelenin, I.V., 1972. Natural Groundwater Resources of Moldavia. Kishiniov, Shtiintsa. (in Russian). (in Russian)

Svezhentsov, A.I., Toma, S.I., Peetrakov, E.V. et al., 1976. Trace Element Content in Forages and Water Sources of the MSSR. Kishiniov, Kartya Moldovenyaska. (in Russian)

Karinov, S.R., Gudz, Z.G., Zakutin, V.P. et al., 1983. Selenium geochemistry in underground. Geochemistry. 3, 359–374. (in Russian)

Golubkina, N.A., 1998. Influence of geochemical factors on selenium accumulation by crops and farm animals in conditions of Russia, CIS and Baltic countries. Regional Environmental Issues. 4, 94–101. (in Russian)

Moraru, C., 2002. Selenium in groundwater and surrounding media of the Republic of Moldova: country overview. Abstract Book of the Second Inter. Conf. on Ecological Chemistry. Chisinau. P. 54.

Bogdevich, O., Hannigan, R.E, Moraru, C. et al., 2002. The investigation of selenium in the environment. Abstract Book of the Second Inter. Conf. on Ecological Chemistry. Chisinau. P. 168.

Golubkina, N., Papazyan, T., 2006. Selenium in Nutrition. Plants, Animals, Human Beings. Moscow, Pechatny Gorod. (in Russian)

Alfthan, G., 1984. A micromethod for the determination of selenium in tissues and biological fluids by single-test-tube fluorimetry. Anal. Chim. Acta. 65, 187–194.

Tan, J., Zhu, W., Wang, W., Li, R., Hou, S., Wang, D., Yang, L., 2002. Selenium in soil and endemic diseases in China. Sci. Tot. Environ. 284, 227–235.

Atlas of Soil of Moldavia. The sci. ed. I.A. Krupenikov. Kishinev, Shtiintsa, 1988. 176 p.

Kapitalchuk, I.P., 2010. Typology of Forest Environmental Systems of Moldavia. Bendery, Poligrafist. (in Russian)

Kapitalchuk, M.V., Kapitalchuk, I.P., Golubkina, N.A., 2011. Selenium accumulation and migration in components of the biogeochemical soil – plant – man food chain in Moldova. Povolzhskiy Journal of Ecology. 3, 323–335. (in Russian)

Kabata-Pendias, A., Pendias, H., 1989. Trace Elements in Soils and Plants. Moscow, Mir. (in Russian)

Kapitalchuk, I.P., Kapitalchuk, M.V., 2009. Features of selenium distribution along the vertical profile of different soil types in Pridnestrovie. Vestnik Pridnestrovskogo Universiteta. 2(34), 234– 237. (in Russian)

Kapitalchuk, I.P., Kapitalchuk, M.V., Izmailova, D.N., Bogdevich, O.P., 2011. Biogenic trace elements in soils and plants from the Dniester Valley. Bulletin of the Institute of Geology and Seismology MAS. 2, 122–132. (in Russian)

Kapitalchuk, I.P., Kapitalchuk, M.V., Izmailova, D.N., Bogdevich, O.P., 2012. About the ratio of some trace elements in the environmental components of the Dniester Valley. Geoecological and Bioecological Issues of the Northern Black Sea Region, Proceedings of the Int. Conference, Tiraspol. 129–131. (in Russian)

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Usability of different bacteria applications in alkali soil reclamation

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Abstract

The present study was conducted to determine the usability and efficiency of different plant growth promoting bacteria applications in alkali soils reclamation. The experiment was conducted with three sulfur application doses (100, 200, 300 kg da^{-1}), three different bacteria applications (E1, E17, and A1) and three salicylic acid application doses (0.1%, 0.2% and 0.3%) in a randomized plot design with 3 replications. The control pots without any applications were also used and the experiment was terminated at the end of 3-month incubation period. Soil pH, electrical conductivity (EC) and exchangeable Na and total amount of amino acids were measured on samples taken a month intervals. The results indicated that bacteria, sulfur and salicylic acid treatments may help for reclamation of alkali soils.

Keywords: Alkali soil, bacteria, sulfur, salicylic acid

Introduction

Salinity is one of the most significant stresses among the unfavorable environmental factors in agricultural lands (Yadav et al. 2011). Soil salinity restricts plant growth due to high osmotic potential of the solution that inhibits plant water and the other plant nutrition elements uptake (Nishma et al., 2014). In order to minimize the effects of soil salinity, many researchers have been put into finding effective and economic methods to restore plant vegetation in salinity soils. Many advanced facilities such as electromagnetic induction (Herrero and Hudnall 2013), soil reflectance spectra (Goldshleger et al. 2013) and soil mapping techniques to identify soil salinity management fields (Guo et al. 2013) are being distributed in agriculture area to manage salinity stress (Nishma et al., 2014). Some methods that have been used for removal of salt in soil include remove of soil surface layers, soil washing with clean water, use of electro-kinetic extraction, and soil mixing with organic materials to rehabilitate soil structure and soil properties (AE 2001; USEPA 2000). But, these techniques are often unpractical and very costly as well as having other environmental disadvantages (Shan, 2009). On the other hand, soil alkalinity has also negative effect on plant growth. In order to reduce the amount of exchangeable sodium to the critical level in soil different methods are used.

The objective of this study was to determine effectiveness of salicylic acid, elemental sulphur and plant growth promoting bacteria (PGPR) applications on remediation of salt and sodium affected soils.

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Material and Methods

Soil samples were taken from a salt-sodium affected area and put into pots. In the experiment, three sulfur application doses (100, 200, 300 kg da^{-1}), three different bacteria applications (E1, E17, and A1) and three salicylic acid application doses (0.1%, 0.2% and 0.3%) were used and experiments were conducted in a randomized plot design with 3 replications. A group of control plots without any treatment applications also used and the experiments were terminated at the end of 4-month incubation period. Soil pH, electrical conductivity (EC) and Na amount of amino acids were measured on samples taken a month intervals.

Amino acid analysis; 0.1N HCl was added in one gram soil sample, homogenized with ultraturraks and incubated at 40°C for 12 hours. Samples were then vortexed, centrifuged at 1200rpm for 50 minutes and the supernatants were filtered through 0.22µm filters (Millex Millipore). Then supernatants were transferred to glass vials and sent for HPLC analysis. Amino acids were extracted from the samples and analyzed as described by Aristoy and Toldra (1991), Antoine et al. (1999) and Henderson et al. (1999). The amino acid derivatives were analyzed with HPLC on a Zorbax Eclipse-AAA 4.6 x150mm, 3.5µm columns (Agilent 1200 HPLC). The samples were analyzed by measuring the absorbance at 254 nm and the amino acids were identified by comparison with standards. O-phthaldialdehyde (OPA), fluorenylmethyl-chloroformate (FMOC) and 0.4N Borate were used for the derivation processes in an auto sampler. The following were used as the mobile phase in the chromatography system: mobile phase A: 40mM NaH2PO4 (pH 7.8) and mobile phase B: Acetonitrile/Methanol/Water (45/45/10. v/v/v) solutions. The flow rate of the mobile phase was 2mL/minute and the column temperature was 40°C. Aspartate, glutamate, asparagine, serine, glutamine, histidine, glycine, threonine, arginine, alanine, tyrocine, cystine, valin, methio-nine, tryptophan, phenylalanine, isoleucine, leucine, lysine, hydroxyproline, sarcosine, proline quantities from soil samples were determined as pmol/µl.

Soil analysis; some physical and chemical properties of soil were determined after the soil samples were air-dried, crushed, and passed through a 2-mm sieve. Particle size distribution was determined by the methods described by Page et al. (1982). Cation exchange capacity (CEC) was determined using sodium acetate (buffered at pH 8.2) and ammonium acetate (buffered at pH 7.0) according to Sumner and Miller (1996). Electrical conductivity (EC) was measured in saturation extracts according to Rhoades (1996). Soil pH was determined in 1:2 extracts, and calcium carbonate concentrations were determined according to McLean (1982). Soil organic matter was determined using the Smith-Weldon method according to Nelson and Sommers (1982). Ammonium acetate buffered at pH 7 (Thomas 1982) was used to determine exchangeable cations.

Results and Discussion

Some physical and chemical properties of the experimental soil were given Table 1. The soil has loam-textured with saline-alkaline characteristics, and containing middle amount of lime and very less organic matter.

Table 1. Some chemical and physical properties of the experimental soil

pH	EC	(%)			(cmol$_c$ kg^{-1})					(%)		
(1:2.5 s/w)	(mS cm^{-1})	ESP	OM	$CaCO_3$,	CEC	Ca^{++}	Mg^{++}	K^+	Na^+	Clay	Silt	Sand
10.1	16.03	47.8	0.3	9.3	34.3	26.2	0.3	1.9	5.5	22.2	46.7	31.1

Salicylic acid, sulphur and PGPR applications caused significant changes in exchangeable Na content of soil samples depending on incubation period (Table 2). Exchangeable Na decreased with sulfur application at the end of the first month of incubation, slightly increased at the end of the third incubation period as compared with the second incubation period, but it was still lower than the first month incubation value. On the other hand, exchangeable Na linearly decreased with PGPR and salicylic acid treatments depending on the length of incubation period. The lowest sodium content was obtained from A1 PGPR bacteria (Table 2).

Table 2. Amounts of exchangeable Na in soil samples at the ends of the incubation periods

Exchangeable Na $cmol_c\ kg^{-1}$		1st Incubation period (1 month after the trial)	2nd Incubation period (2 month after the trial)	3rd Incubation period (3 month after the trial)
Control		45,7	44,5	45,0
Sulphur**	100 kg da^{-1}	52,0a	42,7b	50,0a
	200 kg da^{-1}	49,2b	43,2b	44,5c
	300 kg da^{-1}	53,0a	46,0a	47,2b
	Ort	51,4 b A	44,0 c C	47,2 a B
PGPR**	E1	56,5c	51,0b	41,0a
	E17	65,2b	50,0b	39,2b
	A1	67,2a	53,2a	39,0b
	Ort	63,0 a A	51,4 a B	39,7 c C
Salicylic acid**	%0.1	52,7a	45,7b	42,0a
	%0.2	50,2b	48,5a	44,2b
	%0.3	49,5b	45,0b	43,0b
	Ort	50,8 b A	46,4 b B	43,1 b C

**$p<0.01$

Soil reaction did not show significant changes with salicylic acid, sulphur and PGPR applications depending doses and the length of incubation periods (Table 3). On the average, soil pH was almost constant with sulfur and salicylic acid applications during the 3-month incubation period. However, soil pH slightly increased with PGPR application at the end of incubation period. Increase in pH with PGPR application may be explained by not production of organic acids as reported by a number of researchers in the previous studies (Gaind and Gaur, 1989; Turan et al., 2006) in saline soils.

Table 3. pH of the experimental soils after incubation periods

pH (1:2.5 s/w)		1st Incubation period (1 month after the trial)	2nd Incubation period (2 month after the trial)	3rd Incubation period (3 month after the trial)
Control		10,07	10,07	9,90
Sulphur	100 kg da^{-1}	9,91	9,91	9,67
	200 kg da^{-1}	9,73	9,73	9,86
	300 kg da^{-1}	9,74	9,74	9,78
	Ort	9,79	9,79	9,77
PGPR	E1	9,24	9,24	9,69
	E17	9,27	9,27	9,63
	A1	9,24	9,24	9,60
	Ort	9,25	9,25	9,64
Salicylic acid	%0.1	9,90	9,90	9,78
	%0.2	9,72	9,72	9,72
	%0.3	9,76	9,76	9,64
	Ort	9,80	9,80	9,72

Electrical conductivity (EC) of soil samples significantly affected by salicylic acid, sulphur, and PGPR applications (Table 4). On the average, soil EC slightly increased at the end of the second incubation period as compared with the first incubation period, but significantly decreased at the end on the third incubation period for both of sulfur and salicylic acid applications. However, PGPR application decreased soil EC regularly depending on the length of the incubation period. The lowest EC value was obtained from salicylic acid application.

Table 4. EC of the experimental soils after incubation periods

EC, mS cm^{-1}		1st Incubation period (1 month after the trial)	2nd Incubation period (2 month after the trial)	3rd Incubation period (3 month after the trial)
Control		9,5	7,8	9,7
Sulphur**	100 kg da^{-1}	10,1ab	10,4a	6,0c
	200 kg da^{-1}	9,0b	9,4b	10,6a
	300 kg da^{-1}	10,7a	10,7a	8,2b
	Ort	9,9 b A	10,2 b A	8,2 b B
PGPR**	E1	17,1b	15,6a	14,5a
	E17	18,1a	13,4b	12,4c
	A1	18,2a	13,8b	13,1b
	Ort	17,8 a A	14,3 a B	13,3 a B
Salicylic acid**	%0.1	10,2a	10,5a	7,5a
	%0.2	8,4b	9,4b	7,9a
	%0.3	8,8b	7,9c	6,7b
	Ort	9,1 b A	9,3 c A	7,4 c B

**p<0.01

Salicylic acid, sulphur and PGPR applications in saline-alkali soil caused significant changes in total amino acid contents (Table 5). As compared to the control, all treatments reduced total amino acid contents of soil. On the average, total amino acid content systematically decreased with the length of incubation period, except slightly increase in sulphur application. The lowest soil amino acid content was obtained from A1 PGPR bacteria application.

Table 5. Total Amino Acids of the experimental soils after incubation periods

Total Amino Acids pmol µl^{-1}		1st Incubation period (1 month after the trial)	2nd Incubation period (2 month after the trial)	3rd Incubation period (3 month after the trial)
Control		43355	40931	42296
Sulphur	100 kg da^{-1}	36670b	34789b	35856c
	200 kg da^{-1}	37958a	35986a	37160a
	300 kg da^{-1}	36815b	35061ab	36370b
	Ort**	37147 a A	35279 a C	36462 a B
PGPR	E1	30937b	29600b	27212a
	E17	32026a	30118a	27683a
	A1	32574a	30578a	26860b
	Ort**	31846 c A	30099 c B	27252 c C
Salicylic acid	%0.1	36426a	34267a	32459a
	%0.2	36354a	34433a	32610a
	%0.3	35258b	33324b	31802b
	Ort**	36013 b A	34008 b B	32290 b C

**p<0.01

When plants experience environmental stress, such as soil salinity they activate various metabolic and defense system to survive. A number of genes corresponding to these stresses and their products were analyzed in some plants (Ono et al., 2003; Marayama et al., 2004). So some amino acid, such as proline, glycine betaine, manitol confer stress tolerance. (Yamada et al., 2005). The physiological significance of amino acid accumulation is controversial, while some researchers have reported that it is a sign of stress (Rai et al., 2003 and Hernandez et al., 2000 and Yamad et al., 2005). Other suggests that at a high concentration it acts as solute intercellular osmotic adjustment (Silveria et al., 2002). Accordingly our results, PGPR application decreased amino acid contents of soil and so effects of salinity stress on soil properties decreased.

Correlation matrix given in Table 6 indicates the overall effects of salicylic acid, sulfur and PGPR applications on exchangeable Na, soil pH, EC and total amino acid contents. Significant negative correlations were obtained between the length of incubation period and exchangeable Na, soil pH and exchangeable Na, EC and soil pH, and EC and total amino acids. However, positive significant correlations were found between EC and exchangeable Na, and soil pH and total amino acids.

Table 6. Correlations of application, doses and properties of the experimental soils

	Incubation	Doses	Na	pH	EC
Doses	0,000				
Na	-0,700**	0,088			
pH	0,116	-0,288	-0,543**		
EC	-0,297	0,022	0,599**	-0,741**	
Amino acids	-0,287	-0,235	0,048	0,673**	-0,513**

** Correlation is significant at the 0.01 level (2-tailed).

In conclusion, the results of this study indicated that bacteria, sulfur and salicylic acid treatments may help for reclamation of alkali soils.

References

AE., 2001. Government report: Salt contamination assessment and remediation guidelines. In: Division ES, editor. Edmonton: Alberta Environment.

Antoine, F.R., Wei, C.I., Littell, R.C., Marshall, M.R., 1999. HPLC method for analysis of free amino acids in fish using o-phthaldialdehyde precolumn derivatization. J Agric Food Chem. 47, 5100-5107.

Aristoy, M.C. and Toldra, O.F. 1991. Deproteinization techniques for HPLC amino acid analysis in fresh pork muscle and dry- cured ham. J Agric Food Chem 39:1792–1795.

Gaind, S. and Gaur, A.C., 1989. Effects of pH on phosphate solubilization by microbes. Curr. Sci. 58:1208–1211.

Goldshleger, N., Chudnovsky, A. and Ben-Binyamin, A. 2013. Predicting salinity in tomato using soil reflectance spectra. International Journal of Remote Sensing, 34(17),pp. 6079-6093.

Guo, Y., Shi, Z., Li, H. Y. and Triantafilis, J. 2013. Application of digital soil mapp.ing methods for identifying salinity management classes based on a study on coastal central China. DOI: 10.1111/sum.12059.

Hernandez, S., Deleu, C. and Larrher, F. 2000. Proline accumulation by tomato tissue in response to sailinty. 6: 551-557.

Herrero, J. and Hudnall, W.H. 2013. Measurement of soil salinity using electromagnetic induction in a paddy with a densic pan and shallow water table. Paddy and Environment, 10.1007/s10333-013-0371-5.

Maruyama, K., Sakama, Y., Kasuga, M., Ito, Y., Seiko, M., Goda, H., Shimada, Y., Yoshida, S. and Shinozaki, K. 2004. Identification of cold inducible downstream genes of the Arabidopsis, DREB1A/CBF3 transcriptional factor using two microarry systems. The Plant Journal. 38: 982-993.

Mclean, E.O. 1982. Soil pH and Lime Requirement. Methods of Soil Analysis Part2. Chemical and Microbiological Properties Second Edition. Agronamy. No: 9 Part 2 . Edition, pp. 199-224.

Nelson, D.W. and Sommers, L.E. 1982. Organic Matter. Methods of Soil Analysis Part2. Chemical and Microbiological Properties Second Edition. Agronamy. No: 9 Part 2 . Edition, pp. 574-579.

Nishma, K.S., Adrisyanti, B., Anusha, S.H., Rupali, P., Sneha, K., Jayamohan, N.S. and Kumudini, B.S. 2014. Induced growth promotion under in vitro salt stress tolerance on solanum lycopersicum by fluorescent pseudomonads associated with rhizosphere. Int. Journal of Applied Sciences and Engineering Research, 3(2): 422-430.

Ono, Y., Seki, M., Nanjo, T., Narusaka, M., Fujita, M., Satou, M., Sakurai, T. and Ishida, J. 2003. Monitoring expression profiles of Arabidopsis gene expression during rehydration process after dehydration using ca 7000 full-length cDNA microrray. The Plant Journal. 34: 868-887.

Rai, S.P.. Luthra,R. and Kumar, S. 2003. Salt- tolerant mutants in glycophytic salinity response (GRS) genes in Catharanthus roseus. Theor. Appl. Genet. 106: 221-230.

Rhoades, J.D. 1996. Salinity: Electrical Conductivity and Total Dissolved Solids. In: Methods of Soil Analysis, Part 3. Chemical Methods, Sparks, D.L. (Ed.). Soil Science Society of America, Madison, WI., USA., ISBN-13: 9780891188254, pp. 417-435.

Shan, W.X. and Guo, H.J. 2009. Changes of proline content, activity and active isoforms of antioxidant enzymes in two Alfalfa cultivars under salt stress. Agricultural Science in China. 8(4); 431 - 440.

Silveira, J.A., Viegas Rde, A., da Rocha, I.M., Moreira, A.C., Moreira Rde, A. and Oliveira, J.T. 2003. Proline accumulation and glutamine synthetase activity and increased by salt- induced proeolysis in cashew leaves. J. Plant Physiol. 160: 115-123.

Sumner, M.E. and Miller, W.P. 1996. Cation exchange capacity , and exchange coefficients. In: D. L. Sparks (ed.) Methods of soil analysis. Part 2: Chemical. properties, (3rd ed.) ASA, SSSA, CSSA, Madison, WI..

Thomas, G.W. 1982. Exchangeable cations. In: A.L. Page (ed.) Methods of soil analysis, Part 2 Chemical and microbiological properties, 2nd edition. Agronomy. 9: 159-165.

Turan, M., Ataoglu, N. and Sahin, F. 2006. Evaluation of the capacity of phosphate solubilizing bacteria and fungi on different forms of phosphorus in liquid culture. J. Sust. Agric. 28:99–108.

USEPA. 2000. Government report: Introduction to phytoremediation. The U.S.Environmental Protection Agency.

Yadav, D.R., Alok, S., Jain, S.K., Verma, A., Mahor, A., Bharti, J.P. and Jaiswal, M. 2011. Herbal Plants Used in The Treatment of Urolithiasis: A Review. International Journal of Pharmaceutical Sciences and Research. 2(6):1412-1420.

Yamada, M., Morishita, H. and Urano, K. 2005. Effects of free proline accumulation in petunias under drought stress. Journal of Experimental Botany. 417: 1975-1981.

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Evaluation of suitable methods for stabilization of coastal dunes in Samsun-Bafra

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Abstract

This study was aimed to prevent harmful sandy movements which occur by the effect of wind, for arable land in sandy land of 20 km coastal zone of Alacam-Bafra District of Samsun. Main titles of study are living and lifeless fences and subtitles are hydroseeding, traditional planting and afforestration. Mat; made by reed plantwas used as lifeless fence which exist in natural vegetation and wild oleaster used as living fence. At the end of the study; development and living rates of trees, wind properties as climatic parameters and soil losses were determined. As a result; comparing living fence with lifeless fence, lifeless fence application was more effective to inhibit the new material movement to the new plots. Removal and depositions were decreased for the subtitles by lifeless fence. Depositions to the plots are in the following order; 1 kg/da/5year for control, 0 kg/da/5year for hydroseeding, 0 kg/da/5year for traditional planting, 5 kg/da/5year for afforestration, 2 kg/da/5year for afforestration+ hydroseeding, 10 kg/da/5year for afforestration+ traditional planting. Removal and depositions of new material to the plots continued for living fence. Long-term average wind directions are in the following order; %54 south-southwest, %31 north-northeast and %15 north-northwest. As a result; lifeless fence is the most suitable application for the temporary stabilization in Bafra district. Also we recommended that afforestration+hydroseeding application as the minimum values for both losses and depositions by durable stabilization in subtitles.

Keywords: Sand dune stabilization, wind fence, afforestration, SPVAACE, hydroseeding

Introduction

The length of the coastal regions worldwide is approximately 600000 kilometers. Coastal regions have a coastline ranging between 100 meters and 1000 meters wide and cover approximately 18% of the earth (Burns, 1997). Coastal areas are very sensitive to population growth. Turkey has Europe's largest sand dune system. 845 km (10.1% of the banks) are the coastal dunes in 8333 km of coastline.

Wind erosion is one of the main factors in soil and environment degradations, air pollution, suspended particles transports, etc. So there must be many studies to get a better understanding of the process of this phenomenon (Refahi, 2004). Wind erosivity and soil srodibility are two suitable indexes that can describe the potential of soils against wind erosion (Chepil and Woodruff, 1963).

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There are a few different techniques that can be used in the restoration and stabilization of damaged or incomplete dunes. One technique is to mechanically move sand into place and then grade it into suitable form (Wilcock, 1977). Another technique is to trap the blowing sand with the use of sand fences. Sand fences are very effective in trapping windblown sand, once they are filled they have little or no further effect on sand movement. However, theadvantage of sand fences is that they can be installed during any season and they are fully effective as sand traps as soon as they are installed (Woodhouse, 1978).

The most effective method of stabilizing coastal dunes is through the use of vegetation. In many cases, vegetation is the least expensive, most durable, most aesthetically pleasing and only self-repairing technique available. Dune plants are especially effective at stopping and holding wind-borne sand. Their Growth produces surface roughness which decreases the wind velocity near the ground, reducing wind erosion at the sand surface. Also the Plant stems and leaves above the sand surface greatly interfere with sand movement by saltation and surface creep (Woodhouse,1978).

The main techniques used in dune stabilization are fencing, thatching, mulching and planting. They can be implemented separately, although planting is usually used in combination with fencing. Other Methods include the placement of gravel and spraying with mud, bitumen or artificial chemical mix. These Methods have been more widely used in arid regions than on humid temperature coasts and their long-term effectiveness is variable under wet and windy conditions (Watson, 1985). Sand fences are used primarily to build frontal dunes. Use of sand fences is more effective than using vegetation alone to build the dune in width and/or height. Although sand fences are more expensive than using vegetation alone, they are much less expensive than using dozers and/or dredges (Miller et al, 2002).

Coastal sand dunes are complex systems, integrating a harsh environment that requires specialized plant communities. The fragile nature and erodibility of dunes makes their stabilization very difficult, thus management and monitoring programs are an essential part of success in reestablishing sand dune vegetation. Stabilization solutions must be compatible with these fragile ecosystems and efforts must be made to minimize any possible human or natural impacts that could cause the project to fail (Olafson, A., 1997). Sand dune areas which cover limited spread endemic and rare species and rich vegetation, are extremely valuable and unique habitat parts.

Chemicals sprayed onto dune surfaces to stabilize them are easier to apply than mulches or the placement of thatching. The function of a chemical spray is to initially stabilize the sand and prevent wind erosion for a sufficient period of time to allow plants to establish that can more permanently stabilize the dune surface. It is clearly important that the chemicals used do not inhibit seed germination, seedling establishment or plant growth (Barr and McKenzie, 1976). Therefore, application of polymers for increasing of soil particles diameter and aggregates is one of the control methods to prevent surface layer erosion. But in polymers applications in wind erosion control some factors must be considered. In fact the mechanisms of erosion control by polymer are increasing dry aggregates stability and their connections and creating a surface layer which is resistant to erosion.

Material and Methods

There is no vegetation in sand dunes. Research area has the characteristics of the sandy soils. Soils have high permeability, low water holding capacity and negligibly low organic matter content. The topography is slightly undulated and slightly hilly. Area is constantly windy in all year. Research area has the typically Blacksea climate. Summers are cool and winters are warm and rainy.

Experiment was conducted fixed and recurrence. In this study, weeds and planting has been applied. In the project lifeless fence has been used for temporary stabilization. Reed plants are used as a lifeless fence. Wild oleasters were used as live fences. Lifeless and live fences were conducted perpendicular to the wind direction with double row. Plot sizes were 5 x10 meter. 10 coastal pines were planted for each plot. Main titles were; lifeless fences (reed plants with double row) and live fences (wild oleaster with double row). Subtitles were; control, traditional planting (*agropyron cristatum, dactylis glomerata L., agropyron intermedium, agroyron elongatum*), hydroseeding (miz of mulch, seeds, water, fertilizer and SPVAACE), afforestration, afforestration + hydroseeding, afforestration + traditional planting.

At the end of the study; development and living rates of trees, wind properties (temperature, precipitation and wind) as climatic parameters and soil losses (determined with total station tool) were determined.

Research area is located in the beach dunes ofleft coastal in Bafra plain. Research area is 60 km far to Samsun and 15 km far to Bafra. Geographical position of research areais given in Figure 1.

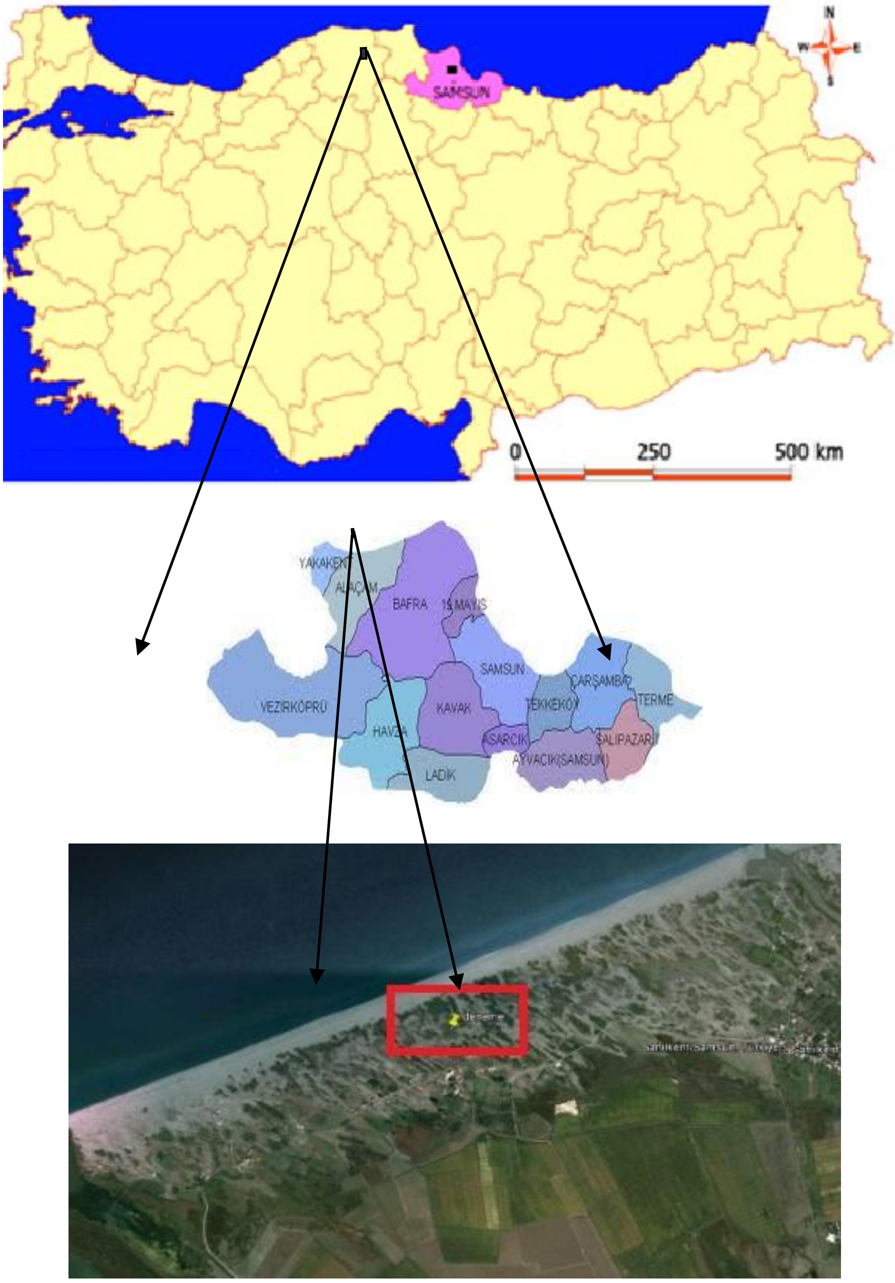

Figure 1. Geographical position of research area (367369° E, 4619621° N).

Results and Discussion

The project was begun with field mapping in October 2008. Field mapping was repeated in October 2012. Values have been evaluated in Netcad data mapping program. 5 year changes were evaluated. Transporting sand dunes is a dynamic process. Dune movement has continued during the test period. Transport and accumulation of sand dunes for 5 year is given in Figure 2.

When compared lifeless and live fences, lifeless fence were more effective to prevent the new material coming to the plots. There was no accumulation in lifeless fence with "traditional planting" and "hydroseeding" application. It has not been observed accumulation in the other plots. Accumulations were generally lower in lifeless fence than live fence. Accumulations were low in all treatments according to the control in lifeless fence. Percentage decreases in accumulation according to the control are in the following order; 9,7% for traditional planting, 25% for hydroseeding, 63% for afforestration, 53% for afforestration + hydroseeding and 63% for afforestration + traditional planting. Depositions to the plots in lifeless fence are in the following order; 1 kg/da/5year for control, 0 kg/da/5year for hydroseeding, 0 kg/da/5year for traditional planting, 5 kg/da/5year for afforestration, 2 kg/da/5year for afforestration+ hydroseeding, 10 kg/da/5year for afforestration+ traditional planting (Figure 2).

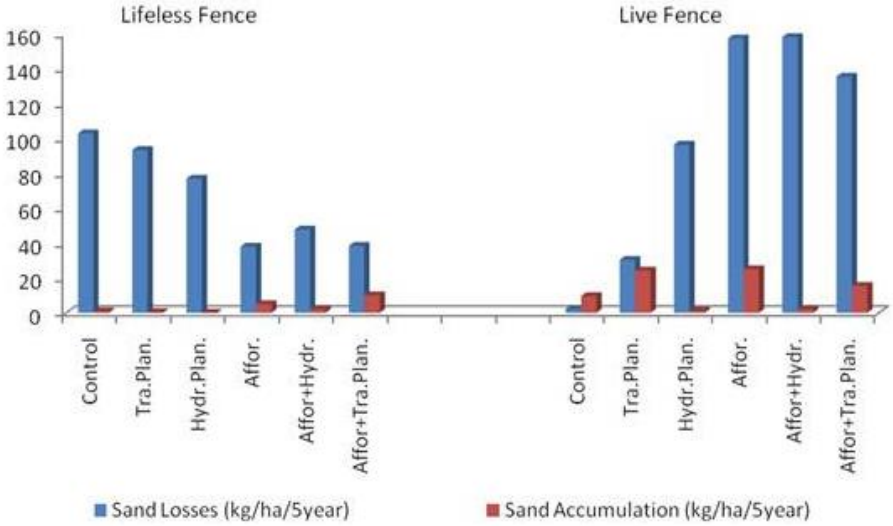

Figure 2. Sand losses and accumulations (kg/ha/5year)

Material transport and accumulation to the plots has continued in live fence. Development of wild oleaster is not equal in the plots. There has been no development on some plots. The wind erosion mostly occurs in areas open to wind activity but causes less damage than water erosion (Ratas, 1978). The wind carries away soil particles when there is no vegetation ground cover, the soil is dry and tillage is recent. Wind erosion has not been recorded as occurred in soil covered by vegetation (Kask, 1996). Heterogeneity of live fence is the most important reason of sand accumulation. Accumulations in "hydroseeding" and "afforestration + hydroseeding" plots are lower than the other plots. Values are higher and closer in other plots. Depositions to the plots in live fence are in the following order; 10 kg/da/5year for control, 1 kg/da/5year for hydroseeding, 24 kg/da/5year for traditional planting, 25 kg/da/5year for afforestration, 2 kg/da/5year for afforestration+ hydroseeding, 15 kg/da/5year for afforestration+ traditional planting (Figure2). The reason of lower sand losses in "traditional planting" and "control" plots is wild oleasters undevelopment. Live fence didn't prevent the incoming materials to the plots but prevent their transportation.

The most important reason to sand movement is effective wind. Wind erosion damages depend on wind characteristics such as; velocity and duration of the wind as well as the amounts and types of transported particles and also surface layer properties. Long-term average wind directions are in the following order; 54% south-southwest, 31% north-northeast and 15% north-northwest (Figure 3).

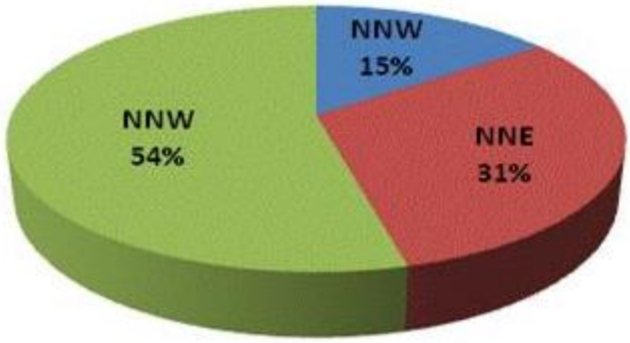

Figure 3. Long-term average wind directions.

The average wind direction is west direction. Winds are usually harder in winter and autumn season. In these seasons rainfall values are high and temperatures are low. Transporting sand dunes are generally less in these seasons. Land surface is constantly wet due to the lower temperature. For this reason, dune movement has slowed during this period. The majority of annual wind erosion damage (80%) occurs on April and May (Ratas, 1978).

Conclusion

Knowledge about impacts on coastal dune vegetation and soil properties of afforestation will enable more appropriate decision about necessity of dune afforestation (Atmaca et al,2006). Although there are several techniques used to stabilize coastal sand dunes, revegetating the sites is probably the best alternative. There are several species of plants to choose from for planting a coastal dune but the objective of the planting should be considered before deciding which species is the best for purpose. It is important to remember that dunes are unique and sensitive ecosystmes. While stabilizing a dune, every effort should be made to protect the integrity of the natural dune ecology.

Using ready fences is more effective to prevent erosion and to provide temporary stabilization. Because the heights and ranges are adjustable, more homogeneous and easy applicable. It does not require too much maintenance. Live fences are effective in long-term stabilization. The most important problem is the initial retention difficulties. If you want to quick results, it should be preferred as lifeless fences. For better results soil surface stabilization should be done. End of the research, according to the minimum values for both losses and depositions by durable stabilization in subtitles "afforestration+hydroseeding planting" application can be recommended.

References

Atmaca, F. and Yılmaz, K., 2006. Effect of Turam Emeksiz Coastal Dune Afforestration to Its Some Soil Properties. Journal of DOA. Vol.12, 2006.

Barr, D.A. and McKenzie, J.B., 1976. Dune Stabilization in Queensland, Australia, Using Vegetation and Mulches. International Journal of Biometeorology 20, p:1-8.

Burns, R.F., 1997. Global Coastal zone. Sea Technology, 1:27-29.

Chepil, W.S., and Woodruff, N.P., 1963. The physics of wind erosion and its control. *Adv. Agron.,* 15:211-302.

Kask, R., 1996. Estonian Soils. Valgus, Tallinn (in Estonian).

Miller, D.L., M. Thetford, and L. Yager. 2002. Evaluation of sand fence and vegetation for dune building following overwash by Hurricane Opal on Santa Rosa Island, Florida. J. Coastal Res. 17: 936-948.

Olafson, A., 1997. Stabilization of Coastal Dunes with Vegetation. Restoration and Reclamation Review. Student On-Line Journal Vol.2, No.5, 1997. Department of Horticultural Science University of Minesota, St.Paul, MN.

Ratas, R., 1978. Soil, weather and wind erosion. Estonian Nature 4, 330-342.

Refahi, H., 2004. Wind erosion and its control. Tehran University, Iran, 320p.

Watson, A., 1985. The control of wind blown sand and moving dunes: a review of the methods of sand control in deserts with observations from Saudi Arabia. *Quarterly Journal of Engineering Geology* 18, 237-252.

Wilcock, F.A. and Carter. R.W.G., 1977. An Environmental Approach to the Restoration of Badly Eroded Sand Dunes. Biological Conservation. Vol.77: 279-291.

Woodhouse, W.W. Jr. 1978. Dune Building and Stabilization With Vegetation. U.S. Army Corp of Engineers. Vol.3: 9-104.

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Solute dispersion in sand columns as affected by effluent surface tension

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Abstract

Transport of a nonreactive solute in soils is principally controlled by soil properties such as particle-size distribution and pore geometry. Surface tension of soil water yields capillary forces that bind the water in the soil pores. Changes in soil water surface tension by contaminants may affect flow of soil water due to decreased capillary forces, caused by lowered soil water surface tension. This study aimed at assessing solute dispersion in sand columns as affected by effluent surface tension. Miscible displacement (MD) tests were conducted on sand columns repacked with sands sieved from 2.0-1.0- 0.5- and 0.25-mm screens. The MD tests were conducted with 0.05 M bromide solutions prepared using water with surface tension adjusted to 72.8, 64, 53.5 and 42 dyne/cm^2. Obtained breakthrough curves were modeled with an Equilibrum Convection Dispersion Equation (CDE) model. Coefficient of hydrodynamic dispersion (*D*) and pore-water velocity increased consistently with decreased particle

Keywords: Breakthrough curve, hydrodynamic dispersion, equilibrium convection dispersion equation, pore-water velocity.

Introduction

Solute flow in a porous medium is controlled by properties of the porous medium and solutes. The pore geometry is the primary soil characteristic that control solute transport (Klute and Dirksen, 1986). Interaction between transported solute and particle surfaces is another factor, which controls transport of the solutes in the vadoze zone.

Many models have been developed to describe transport of water and solutes through porous media. Convection-dispersion equation (CDE) model is among the most commonly used models (Nielsen et al. 1986; Sun 1996). The CDE model is widely used in describing symmetric BTCs, while it is not adequate to analyze asymmetric BTCs, resulted from either physical or chemical nonequilibrium transport or both. Two-region physical nonequilibrium model and two-site nonequilibrium model are widely used to analyze physical and chemical nonequilibrium solute transport, respectively. Two-site/two-region chemical/physical nonequilibrium solute transport model is derived from CDE model (van Genuchten, 1981; Parker and van Genuchten, 1984).

Miscible displacement (MD) tests have long been used to evaluate the solute transport characteristics of porous media (Nielsen and Biggar, 1961; Biggar and Nielsen, 1962; Nielsen and Biggar, 1962, 1963; van Genuchten and Wierenga, 1977; Ersahin et al., 2002; Kamra and Lennartz, 2005; and many others). The MD tests can lead to an understanding of the physical, chemical, and microbiological processes that control solute dispersion in soils (Misra et al., 1974; Nielsen et al., 1974; Starr and Parlange, 1975). Miscible displacement tests are used for assessment of the qualitative and quantitative aspects of chemical transport in disturbed and

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undisturbed soil columns (Nielsen and Biggar 1961, 1962; van Genuchten 1977; Erşahin et al., 2002). These tests give information on response of *D* to soil physical characteristics, diffusion, and ion changes and sorption in soils. For example; asymmetric breakthrough curves (BTCs) obtained from miscible displacement of a nonreactive solute (i.e. chloride) indicates effect of physical nonequilibrium on solute transport. Physical nonequilibrium arises when soil water content, properties of soil texture, structure, and pore-size distribution exhibit a nonuniformity in transport paths (van Genuchten 1981; Brusseau and Rao, 1990). Due to the weak interaction between soil and nonreactive chemicals such as Cl, Br, and NO_3, physical nonequilibrium is generally the principal source of nonuniformity in the transport of nonreactive chemicals (Nikedi-Kizza et al., 1983; Brusseau and Rao).

Interactions between adhesive forces, (forces arising from affinity of water molecules to particle surfaces) and cohesive forces (forces arising from affinity between water molecules) results in capillary forces that bind water in pores. Pore size and water surface tension are two principal factors determining the strength of capillary binding of water in these pores. Changes in surface tension of water may result in altered capillary forces. Therefore, decreased surface tension due to contamination of soil water by surfactants may cause decreased capillary forces in pores. The decreased capillary forces may induce changes in solute transport characteristics. To our knowledge, this notion has not been tested to date. Therefore, this study aimed to evaluate the effect of soil water surface tension and pore-size distribution on bromide transport in sand columns repacked with different particle sizes.

Material and Methods

Miscible Displacement Tests

Miscible displacement (MD) tests were conducted using disturbed sand columns. Plastic columns (30-cm long and 8.5-cm wide (id)) were packed with sands screened from 2-, 1-, 0.5- and 0.25-mm screens. To avoid preferential flow between column walls and sand material, the column walls were sealed with a silicon insulator. Lower end of the sand columns were supported with a fabric. The MD tests were conducted on four different particle sized sand and four different surface tension adjusted (72.8, 64, 53.5 and 42 dyn/cm^2) effluents. Each test was replicated four times (total 64 MD tests).

A column was gradually saturated with a 0.01 M $CaCl_2$ solution from the bottom (van Genuchten and Wierenga, 1977). After saturation, the column was connected to a Mariotte system and the outlet at the bottom was connected to an automatic fraction collector. Steady state water flow was established with tracer solution of 0.01 N $CaCl_2$ under zero column water potential. After steady state flow was established, approximately three pore volumes of surface tension adjusted tracer solution of 0.05 M KBr was applied to displace $CaCl_2$ and then three pore volumes of 0.01 N $CaCl_2$ was applied to displace the KBr solution from the column (Nielsen and Biggar, 1962, 1962). The effluent was collected with the fraction collector and analyzed for bromide with a bromide specific electrode. Following the miscible displacement tests, the sand column was removed and placed in oven with a constant temperature of 105 °C. Relative concentrations (C/C_0) of Br were calculated by dividing the concentration of Br in collected effluent by the concentration of the Br in stock solution. Dimensionless pore volumes were plotted against dimensionless concentrations of Br measured in the collected effluent to obtain a BTC for the corresponding MD test.

The surface tension of effluent used in the MD tests were decreased with TIMSEN™. First we conducted four replicated MD tests with original solution of 0.05 M KBr (surface tension unchanged solution) on each of columns repacked with 2-,1,-0.5, and -0.25-mm sand sizes (16 MD tests). This was our control test. Then we lowered surface tension of KBr solution to 64 dyn cm^{-2} and conducted four replicated MD with this solution on columns repacked with the same sand sizes (16 MD tests). We repeated the test with 53.3 (16 MD tests) and 42 dyne cm^{-2} (16 MD tests). All 64 MD tests were conducted under zero soil water potential. The breakthrough curves (BTCs) were evaluated by a CDE model. The computer model STANMOD (Toride et al., 1999) was used to model BTCs. Pore-water velocity *v* was measured on the columns. Dispersivity was calculated by $\lambda = v/D$.

Results and Discussion

The characteristics of the sand columns and effluents used in the MD of bromide and obtained results are given in Table 1. In general, decreased particle-size and surface tension resulted in a decreased, pore-water velocity (*v*) and coefficient of hydrodynamic dispersion (*D*). However, the response of *v* and *D* to decreased particle-size and effluent surface tension were not entirely consistent across particle-sizes and surface tensions. For example, except at 64 dyn/cm² surface tension (σ_{64}), greatest values occurred for *v* and *D* at 0.5-1.0 mm particle size rather than at 1-2 mm. The response of λ to particle-sizes across surface tensions was highly inconsistent (Table 1).

The variable *D* is resulted from diffusion of solute from greater concentration region to lower concentration region and nonuniform flow of water and solute in the flow paths (van Genuchten and Wierenga, 1977; Nikedi-Kizza et al., 1983; Seyfried and Rao, 1987; Anamosa et al., 1989; Brusseau et al., 1989). The combined effect of dispersion and diffusion is represented by *D* in equilibrium CDE model. In our study, *D* generally decreased with decreased particle-size across all the studied effluent surface tensions, 42 dyn cm^{-2} effluent surface tension (σ_{42}). At σ_{64}; *v*, *D*, and λ behaved highly inconsistently across studied particle sizes (Table 1).

Table 1. Column properties and measured and estimated solute transport variables

Surface Tension (dyn/cm²)	Sand Size (mm)	D (cm²/d⁻¹)	v (cm/d⁻¹)	λ (-)
72,8	2-1	461,4	606,3	0,76
	1-0,5	203,52	683,1	0,29
	0,5-0,25	131,2	422	0,31
	<0,025	172,1	174,8	0,98
64	2-1	131,14	303,1	0,43
	1-0,5	283,6	162	1,75
	0,5-0,25	149,84	220,05	0,68
	<0,025	128,9	150,8	0,85
53,5	2-1	151,6	188,9	0,80
	1-0,5	246,26	257,31	0,95
	0,5-0,25	73,81	71,5	1,03
	<0,025	56,43	11,74	4,8
42	2-1	57,96	229,7	0,25
	1-0,5	133,65	284,23	0,47
	0,5-0,25	29,5	152,2	0,19
	<0,025	165,8	363,1	0,45

The pore-size distribution influences λ, which is expected to be greater for a broader pore-size distribution. A λ greater than 1.0 indicates that the transport is more dispersion dominated, while reverse indicates that the transport is more convection dominated. Our results exhibited that the bromide transport was convective dominated in majority of cases (Table 1) and that the effect of particle-size on dispesivity was highly inconsistent across studied effluent surface tensions.

Conclusion

Pore-size is an important mediator of solute transport in a porous medium. Surfactants can affect the physics of water retention and flow in soil systems, altering contact angle and surface tension. We studied response of solute dispersivity (λ) to effluent surface tension (σ) across different sand particle-sizes on repacked sand columns. Response of λ to decreased σ was highly inconsistent across 1-2, 0.5-1, 0,25-0.5 and <0.25-mm sand sizes, while *v* and *D* responded more consistently. The values of λ were mainly negatively correlated with particle-size across the studied σ. Unexpectedly, decreased σ resulted in a reduced water flow and dispersion in majority of cases in all studied sand sizes. The results indicated that surfactant contaminated effluents may behave differently from uncontaminated effluents in identical soils and vadoze zones.

References

Biggar, J.W., and Nielsen, D.R 1962. Miscible Displacement: II. Behavior of Tracers. Soil Sci. Am. Proc. 25: 1-25.

Brusseau M.L., and Rao, P.S.C., 1989. Sorption nonideality during organic contaminant transport in porous media, Crit. Rev. Environ. Control 19, 33-99.

Erşahin S., F Er., 1999. Topraklarda tercihi akı ile kimyasal taşınması. S. Ü. Ziraat Fak. Derg. 13(19):25-33

Erşahin, S., A.R. Papendick, J.L. Smith, C.K. Keller, and V.S Manoranjan. 2002. Macropore transport of bromide as influenced by soil structure differences. Geoderma. 108/3-4, 207-233.

Karma, S.K. and Lennartz, B., 2005. Quantitative indices to characterize the extent of preferential flow in soil. Environ. Modelling&software, 20:903-915.

Klute, A. and Dirksen, C., 1986. Hydraulic conductivity and diffusivity: laboratory methods.ın A.

Misra, C., D. R. Nielsen and J.W.Biggar, 1974. Nitrogen transformations in soil during leaching. II Steady state nitrification and nitrate reduction. Soil Sci. Soc. Am. Proc. 38:294-299

Nielsen, D. R. C. Misra, J. L. Starr and C.Kirda 1974. Movement and fate of nitrogen fertilizers and other agrochemicals applied to soils. IAEA-PL-539/2:7-18.

Nielsen, D., R., J. W. Biggar, 1961. Miscible displacement in sol I: Experimental information. Soil. Sci. Soc. Am. J. Proc. 25: 1-5.

Nielsen, D.R., Van Genuchten, M.Th., Biggar, J.W. 1986. Water Flow and Solute Transport Processes in the Unsaturated Zone. Water Resources Research, 22(9): 89S-108S.

Nielsen. D. R., and J. W. Biggar., 1963. Miscible displacement in soil: IV. Mixing in glass beads. Soil. Sci. Soc. Am. J. Proc. 27: 10-13.

Nikedi Kizza, P., Biggar., J. W., van. Genuchten, M. Th., Wierenga., P. J., Selim,H. M.,Davidson. J. M., and Nielsen, D. R. 1983. Modeling Tritium and Chloride 36 Transport Through an Aggregated Oxisol. Water Resour. Res. 19: 691 -700.

Parker. J. C., and van Genuchten, 1984. Determining transport parameters from laboratory and field tracer experiments. Bull. 84-3. Va. Agric. Exp. St., Blacksburg.

Seyfried, M. S., and Rao, P. S. C., 1987. Solute transport in undisturbed columns of an aggregated tropical soil: Preferential flow effects. Soil Sci. Soc. Am. J. 51: 1434- 1444.,

Van Genuchten, M, Th., and Wierenga., P. J. 1977. Mass Transfer in Sorbing Porous Media. II. Experimental Evaluation with Tritium ($3H_20$) . Soil. Sci. Soc. Am. J. 41: 272 -278.

Van Genuchten, M, Th., and Wierenga., P. J. 1977. Mass Transfer in Sorbing Porous Media. II. Experimental Evaluation with Tritium ($3H_20$) . Soil. Sci. Soc. Am. J. 41: 272 -278.

Van Genuchten, M. Th. 1981. Non-equilibrium Transport Parameters from Miscible Displacement Experiments. Res. Rep. No. 119, U. S. Salinity Lab., USDA, ARS, Riverside, CA.

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Depleting soils

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Abstract

The 2004 Nobel Peace Prize Laureate WangariMaathai addressed the Kenyan soldiers on one occasion and said: "[You] are trained to protect the borders of the country. [You] hold your gun, what are you protecting? The whole country [soil] is disappearing with the wind and the water. When you look at the rivers and they are brown, that is your country disappearing." Soil does far more than providing food, fiber and fuel. It filters water; sustains ecosystems; and, stores carbon – a vital phenomenon in slowing global climate change. Soils are under threat around the world. Erosion is a major concern. In some countries, soil is lost almost 100 times faster than the rate of its formation. Soils are also being degraded irreversibly because of building activities, pollution and acidification. Incessant construction activities along with unsustainable mining operations and energy-related undertakings in recent years accelerated the degradation of soil in Turkey. Highway travellers can witness the mindless plunder all over the land. One travels smoothly on newly constructed highways while observing piles of leftover destruction everywhere: heaps of broken asphalt from previous roads; newly excavated topsoil dumped into adjacent streams; eroded hillsides; quarries on the horizon. In the age of global climate change, these so-called development efforts sound incomprehensible since such anthropogenic activities are responsible for the change. It has long been proven scientifically that climate change increases the potential erosion rates and reduces soil quality. This fact alone requires each country to adopt and implement sound conservation practices to protect their soils and hence social stability and security.

Keywords: Soil, degradation, erosion, global climate change

Introduction

One can see the traces of future catastrophic events in anthropogenic soil degradation. Erosion is a major concern. Although geologic erosion is a relatively slow process, human activities such as farming, mining, logging and construction speed up this process. Soils are also being degraded as a result of salinization, acidification, and pollution. About 3.5 billion hectares of land area has been affected by soil degradation – by erosion, acidification, pollution, and salinization (Bai et al. 2008, 223–234). Compaction of the soil by heavy machinery and soil sealing by human made structures present further threats to world soils (Banwart, 2011, 151-152). This paper elaborates mainly on soil erosion. Soil sealing will also be mentioned briefly.

Turkey is among those countries the soils of which are very degraded (Banwart, 2011, 151-152). Despite this fact, soil degradation takes place incessantly in every corner of the country. Construction activities along with unsustainable mining operations and energy-related undertakings in recent years accelerated the degradation of soil. Once-bountiful countrysidehas been ravaged by a colony of quarries and mines, highway

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constructions extended toward unspoiled rural land, ever increasing numbers of summer houses on coastal areas, golf courses, and hydroelectric power plant constructions wherever there is a running surface water. Highway travellers can witness the mindless plunder all over the land. One travels smoothly on newly constructed highways while observing piles of leftover destruction everywhere: heaps of broken asphalt from previous roads; newly excavated topsoil dumped into adjacent streams; eroded hillsides; quarries on the horizon. The topography of Turkish countryside is irreversibly changing. In cities, public housing (TOKI) and shopping center (AVM) constructions prevail. All that is done yields a great wealth to a few at an immense cost to the environment and people who have lived on those landsfor ages. Besides, trash is mounting everywhere in countryside. Plastic water bottles, aluminum cans, plastic shopping bags, concrete debris from demolished buildings, asphalt blocks from road constructions, glass, and on and on.In the age of global climate change, these so-called development efforts sound incomprehensible since such anthropogenic activities are responsible for the change, in the first place. It has long been proven scientifically that climate change increases the potential erosion rates and reduces soil quality. This fact alone requires each country to adopt and implement sound conservation practices to protect their natural environment and hence social stability and security.

Soil

Soil is a product of both geologic and biologic processes, which take place slowly over geological time periods. Soil formation starts with weathering of rocks through physical and chemical processes. Rocks are broken down by sunlight, air and water, producing soil precursors. Algae, fungi, lichens, mosses and herbaceous and woody plants affect these soil materials and leave organic waste and nutrients behind. Soil formation is a slow process. Two and a half centimeter of topsoil may form in 1,000 years. Nonetheless the rate of soil formation varies across geographic regions according to the composition of parent rock, the annual amount of precipitation, annual average temperature, the kind and amount of vegetation, and topography. These factors also affect the kind of soil that is formed.

Soil supports life on earth. It is a living ecosystem that contains billions of bacteria, fungi and other microbes and that sustains plants, animals and humans. Soil is an ecological and hydrologic resource. It stores carbon, filters water, sustains ecosystems and provides food, fiber and fuel (Knox et al., 2000; Stocking, 2006; Banwart, 2011). Yet this most fundamental resource is under serious threat around the world."Sadly, soil formed on a geological time scale is being removed on a human time scale (Brown, 2011, p.36). For this reason, soil needs to be considered a nonrenewable resource (Evans et al., 2000, p. 33).

Soil Degradation

Erosion is a significant threat to soil health. Plants protect the soil from wind and water erosion, supporting biological diversity. As long as the rate of erosion does not exceed the rate of soil formation, topsoil continues to accumulate, supporting even more vegetation(Brown, 2011, pp. 34-44). But if it does, soil quality starts to decline. Erosion removes mineral- and nutrient-rich topsoil and leads to a decline in biological productivity (Wackernagel and Rees, 1996). As organic matter and nutrients go away, water-holding capacity of the soil also declines.Land degradation starts when fine soil particles are carried away by water and wind since these particles contain more nutrients than coarse particles (Wang et al., 2006). In some countries, soil is lost almost 100 times faster than the rate of its formation (Banwart, 2011, 151-152). Wind and water erosion remove 75 billion metric tons of soil from the land every year (Pimentel et al., 1995).

Soil erosion is a major threat to ecological and societal wellbeing. Erosion (1) destroys ecosystems; (2) decreases agricultural productivity; (3) reduces the water quality because of sediments and pollutants transportation; (4) diminishes the amount of water that infiltrates in the soil; (5)causes sedimentation in river channels and sewage systems; and, (6)leads to muddy flooding, which damages infrastructure and private property.

Agriculture, deforestation, mining, haphazard construction activities and overgrazing are the main drivers of soil degradation. Excessive tillage in agriculture leads to wind and water erosion. Large-scale erosion, decreased rainfall retention and increased runoff may eventually lead to desertification in semi-arid and arid lands.The United Nations announced in 2010 that desertification affects 25 percent of the earth's land area (Brown, 2011, pp.34-44). According to UNCCD (United Nations Convention to Combat Desertification), desertification threatens the livelihoods of 1,5 billion people globally.

Dust storms are visible indicators of soil erosion. Once vegetation is removed from the soil, small soil particles are blown away by the wind. These particles can remain airborne over great distances. Once fine soil particles are gone, larger particles remain behind. Then sand storms begin. Sand storms are the final phase in the desertification process (Brown, 2011, pp.34-44). Giant dust bowls are historically new, which result mostly from a combination of human activities, such as overgrazing of grasslands, over-plowing of agricultural lands and overcutting of forested areas (Brown, 2011, pp.34-44). John Steinbeck chronicled in the *Grapes of Wrath* the 1930s Dust Bowl of the United States, which resulted from over-plowing of vast areas of grassland. Kazakhstan experienced the same predicament in the late 1960s (Larsen, 2012). The reason was also over-plowing of grassland: 40 million hectares of grassland were over-plowed to grow grain in 1950s and 1960s. Nearly half of the land was degraded by wind erosion once the area was hit by a drought in 1965. In China, 90 percent of grassland was degraded because of overgrazing(Larsen, 2012). Today one fourth of China's land area is covered by desert thatharbors dust storms each spring, the effects of which can extend as far as North America. And, there are the deserts of Africa, which were formed by combined effects of overgrazing and drought. These deserts are the largest source of dust in the atmosphere.

Global climate change exacerbates the extant soil degradation and desertification. Heavy downpours, increased precipitation, and higher temperatures are expected in the future because of global climate change. Droughts are forecasted to become more pronounced as the Earth warms. As the ground warms up, organic matter decomposes more readily, reducing soil fertility and increasing erosion. At the same time, decomposition releases carbon dioxide and other greenhouse gases into the atmosphere, fueling global warming. To mitigate the adverse effects of global climate change requires sound practices for conserving natural resources.

The 2004 Nobel Peace Prize Laureate WangariMaathai addressed the Kenyan soldiers on one occasion and said: "[You] are trained to protect the borders of the country. [You] hold your gun, what are you protecting? The whole country [soil] is disappearing with the wind and the water. When you look at the rivers and they are brown, that is your country disappearing."To protect Kenyan soil from further degradation, WangariMaathai mobilized women around The Green Belt Movement in 1977 to plant trees around the country (Curwood, 2012). What Maathai pointed to in Kenya was materialized in Bodrum in March, 2014: The color of the sea turned to brown when two days of rainfall caused large quantities of soil to be carried by streams from the barren mountains. In April, 2014, the Asian side of the Dardanelles Strait also turned brown because of soil carried by Sarıçay after a heavy downpour.

Large tracts of land in Turkey are confronted with intense soil erosion.Because of its topographical attribute that is characterized by steep slopes, about 77 percent of the country's soils are naturally prone to erosion (Kapur et al., 2008). Steep slopes, especially if they are barren, create runoff conditions with heavy rains and cause soil erosion problems. Leaving steep slopes mostly untouched and keeping a cover of vegetation on them would control soil erosion to a large extent. Yet, ongoing construction of inter-city highways (so called *double roads*) leaves steep slopes barren in many parts of the country. Add to these, quarries and hydroelectric power plant constructions. Leaving soil exposed creates not only erosion but also various pollution problems. Construction projects may unearth natural deposits of acid-forming minerals if proper precautions are not taken.

An example of what exposed mineral deposits might cause in the environment occurred in State College, Pennsylvania in the United States. A highway construction project unearthed a natural deposit of acid-forming pyritic rock, which went unnoticed for a long time (ITRC, 2010). Excavated rock was crushed and used as a road base and fill before its nature was discovered. Within months, metal-laden water infiltration and surface runoff from the exposed pyrite vein and crushed rock piles created serious acidification and contamination problems in nearby high-quality streams and groundwater. Residential water supply wells were also impacted. Highway construction was suspended for many months to find a proper way to neutralize the extensive acidification and heavy metal contamination in the surrounding area. During this time mountains were sealed with heavy plastic covers to minimize water infiltration in the soil and surface runoff.

Soil erosion intensifies on sloping lands where each degree of slope causes more surface soil to be eroded (Pimentel and Burgess, 2013). Land disturbing activities on steep-slope mountains have the potential to induce landslides that pose serious threat to public safety. Such activities also increase stream sedimentation and reduce groundwater replenishment. In March 2014, a deadly mudslide happened in Oso, Washington in the

United States. Forty-two people died. Before the landslide, the area received twice the average rainfall. Also, a small earthquake occurred. But a major reason for the mudslide was the excessive logging of the ancient Douglas fir trees for many years (Baker et al., 2014). There was nothing to hold the land in place during heavy rainfall. Jackson, Wyoming, a resort town in the United States, also faces a massive landslide. Geologists indicated that a combination of land development, historic excavation and moisture from snowmelt and rainfall weakened the rock formations, setting the stage for their collapse. Shortly before the landslide became observable, the area was graded for roads and buildings that could have weakened the hillside (Brown, 2014).

Such events should not be taken solely as natural disasters. Senseless development efforts either leavethe soilbarren or seal it. Both are problematic. Hillsides along hundreds of kilometers of highways in Turkey are disturbed. Some hillsides were covered with steel cages; some were sealed with sprayed concrete; and, some were supported with stonewalls, most of which gave way in heavy rains. All are pitiful attempts. *Man-made structures often fail to hold the soil in place against the workings of wind, water and gravity. The most effective way to protect barren hillsides is to plant on them.*A dense, robust cover of vegetation is the best protection against soil erosion on the hillsides.

Soil sealing is quite common in cities. Sealing of the soil with asphalt and concrete materials creates impervious surfaces, which prevent rainfall from percolating into the ground. Lack of permeable surface also makes cities vulnerable to flood events. Of course, building on floodplains should not be overlooked; it is a major cause of floods.As buildings rise up on floodplains, cities struggle with "[…] floods that bring no richness to the land and steal what little richness is there" - as John Steinbeck (1939, p. 118) indicated in the *Grapes of Wrath.*

Indeed, floods have become a common event in Turkish cities. Just recently, on June 4, 2014, the sea merged with the land in İstanbul when the city was flooded after rainfall. On June 6, 2014, inter-city highway was shutdown in Düzcebecause of mud flood caused by heavy rainfall. At the same time, inner city was flooded as a result of the overflow of the nearby creeks. On the same day, residents of Zonguldak and Bartın were also struggling against muddy floodwater.

It is common to call such events natural disasters. Perhaps to some extent, considering that global warming has changed the amount and intensity of rainfall in many parts of the world. Yet global warming is a human induced phenomenon itself. Societies create their own vulnerabilities. Disasters are joint products of natural events and human activities. Natural events cannot be prevented but disasters can. Both flood events and landslides are predictable, foreseeable.

Resource use has been intensified because of population growth and new needs; but how we use resources is very important. Felling of trees, building on floodplains, sealing or exposing of the soil are all likely causes of soil degradation. Soil degradation and desertification threaten global public health and jeopardize biodiversity. Degraded soil means soil that is no longer available for food production (Wackernagel and Rees, 1996). Countries lose the capacity to feed themselves as they lose their topsoil (Brown, 2011, pp.34-44).

Protecting the Soil

Soil needs to be protected as a non-renewable resource because the rate of soil degradation greatly exceeds the rate of its formation. Soil degradation reduces agricultural productivity; threatens crop yield, hence food security. Soil management needs to be an intrinsic part of development issues such as food security and biodiversity protection. It provides the best tool to handle the challenges of climate change (Lal et al. 2011).

Land areas covered with vegetation are more resistant to water and wind erosion (Pimentel and Burgess, 2013). Plant biomass provides a protective layer for soil. Soil sustains vegetative cover, which, in turn, protects the soil from erosion. Vegetative cover also (1) permits the accumulation of topsoil; (2) prevents soil particles from creating an impermeable layer by binding together (surface capping); (3) facilitates the aeration of soil; (4) makesthe soil more resistant to rainfall runoff; and, (5) allowsmore rainfall to infiltrate the ground, replenishing groundwater. Trees are especially important as vegetative covers since their root systems have the highest potential to hold soil in place.

Government initiative plays an important role in soil protection. Georgia has been experiencing a serious soil erosion problem because of the combined effects of strong mountain winds and lack of rainfall. Over-forestation and over-grazing in the past created this problem. Even though Georgia's soil is rich in minerals, erosion reduced harvests up to 40 percent. Currently, with government support, Georgian farmers try to combat erosion with the help of German farmers (Deutsche Welle, 2012). In Algeria, the government supports planting of perennials such as fruit orchards, olive orchards, and vineyards – crops that can help keep the soil in place (Brown, 2011, p.40). Incontrast, the government of Turkey is in the process to lift a law that protects olive groves for the benefit of energy-related investments.

Protecting agricultural land is essential. Unfortunately, Turkey lost 10% of its farmland between 2002 and 2012 according to TÜİK data. In 2002, the country had 26.5 million hectares of farmland; in 2012, 23.7 million hectares. Even though agriculture is considered to be the primary cause of soil degradation (erosion, pollution and compaction), it does not necessarily have to be practiced as such. Sustainable agriculture protects and replenishes the soil; preserves biological diversity and provides habitat for wildlife. Such farming practices as no-till/low-till, cover crops, diversified crop rotations, livestock-integrated farming, and growing trees for a riparian buffer along streams proved to be beneficial soil protection practices. Such practices also improve ecological biodiversity.

In cities, soil sealing needs to be minimized. Soil management should be directed toward the preservation of existing green spaces and establishment of new ones (Knox et al., 2000). Vacant lands can be secured as green spaces, either as community gardens or public parks. As Alexander and his colleagues recommended (1977:39), decision makers could "define all farms as parks, where the public has a right to be; and make all regional parks into working farms."

Conclusion

Concluding Remarks

Soil is the basis of existence on earth. Soil formation from hard rock takes about 1,000 years. Yet human activities degrade this most fundamental resource faster than its formation. Soil degradation is a global problem. Human induced global climate change accelerates the degradation of world soils. The main threats to soils are erosion, pollution, salinization, acidification, sealing and compaction.

In Turkey, large tracts of land are being severely disturbed either by exposing the soil or sealing it. Extensive highway constructions and quarries often leave denuded landscapes behind, which cannot support any vegetation. Agriculture, which is considered the primary cause of erosion and non-point pollution, seems to be agreeable in Turkey, compared to hundreds of quarries cutting through mountain forests. At least, agriculture can be improved by employing sustainable farming practices. Quarries and large-scale construction activities deforest lands and acceleratenatural erosion, clogging streams with sediments and acid. It should be noted here that quarries in Turkey were excluded from environmental impact assessment in 2004 with a change made in Mining Law.

The importance of vegetation has long been recognized in soil conservation. The most effective way to conserve soil is to establish and maintain ground cover vegetation. Avoidance of unnecessary soil sealing has also been proven to be conducive toboth soil and water conservation.

References

Alexander, C., Ishikawa, S. and Silverstein, M., 1977.A Pattern Language. Oxford University Press, New York.

Bai, Z. G., Dent, D. L., Olsson, L. and Schaepman, M. E., 2008. Proxy global assessment of land degradation. Soil Use and Management. 24, 223–234.

Baker, M., Armstrong, K. and Bernton, H., March 25, 2014. State allowed logging on plateau above slope. The Seattle Times. http://seattletimes.com/html/localnews/2023225363_mudslideloggingxml.html. Accessed on June 26, 2014.

Banwart, S., 2011. Save Our Soils. Nature.474, 151-152.

Batey, T. and McKenzie, D. C., 2006. Soil compaction: identification directly in the field. Soil Use and Management. 22, 123–131.

Brown, L.R., 2011. World on the Edge: How to Prevent Environmental and Economic Collapse. W.W. Norton & Company, New York.

Brown, M., April 20, 2014. Slow-moving landslide devouring part of Wyoming town. http://www.huffingtonpost.com/2014/04/20/hungry-wyoming-landslide-eating-town_n_5182520.html. Accessed on June 26, 2014.

Curwood, S., 2012. Nobel Prize Winner WangariMaathai Remembered. Living onEarth. http://www.loe.org/blog/blogs.html/?seriesID=1&blogID=20. Accessed on March12, 2014.

Deutsche Welle, 2012. United against soil erosion: German farmers in Georgia. http://georgien.blogspot.com.tr/2014/06/global-3000-united-against-soil-erosion.html. Accessed on March 14, 2014.

Evans, C. V., Fanning, D. S. and Short, J. R., 2000.Human Influenced Soils. In:Brown, R.B. (Editor), Managing Soils in an Urban Environment. American Society of Agronomy, Inc., Madison, WI,pp. 33-67.

ITRC (Interstate Technology & Regulatory Council), 2010.Remediation Site, Centre County, Pennsylvania. Mining Waste Treatment Technology Selection Web. Interstate Technology & Regulatory Council, Mining Waste Team, Washington, D.C.www.itrcweb.org. Accessed on April 24, 2014.

Kapur, S., Akça, E., Özden, D.M., Sakarya, N., Çimrin, K.M., Alagöz, U., Ulusoy, R.,Darıcı, C., Kaya, Z., Düzenli, S., Gülcan, H., 2008. Land degradation in Turkey. http://www.scribd.com/doc/2553149/Land-Degradation-in-Turkey. Accessed on May14, 2014.

Knox, E.G., Bouchard, C.E. and Barrett, J.G., 2000. Erosion and sedimentation in urban areas. In: Brown, R.B. (Editor), Managing Soils in an Urban Environment. American Society of Agronomy, Inc., Madison, WI, pp. 179-197.

Lal, R., Delgado, J. A., Groffman, P. M., Millar, N., Dell, C. and Rotz, A., 2011. Management to mitigate and adapt to climate change.Journal of Soil and Water Conservation.66, 276-285.

Larsen,J., 2012. Modern-day dust bowls devastate regions throughout the world. Earth Policy Institute. http://ecowatch.com/2012/12/21/dust-bowls-devastate/. Accessed on June 21, 2014.

Pimentel, D. and Burgess, M., 2013. Soil erosion threatens food production. Agriculture, 3, 443-463. http://www.mdpi.com/2077-0472/3/3/443/htm. Accessed on June 23, 2014.

Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Shpritz, L., Fitton, L., Saffouri, R., and Blair, R., 1995.Environmental and economic costs of soil erosion and conservation benefits.Science, New Series, 267, 1117-1123.

Stocking, M. A., 2006. Tropical Soils and Food Security: The Next 50 Years. In: Kennedy, D. and the Editors of Science (Eds.), State of the Planet 2006-2007. Island Press, Washington, D.C., pp. 49-58.

Wackernagel, M. and Rees, W., 1996. Our ecological footprint: Reducing human impact on the Earth. New Society Publishers, Gabriola Island, B.C., Canada.

Wang, X., Chen, F., and Dong, Z., 2006.The relative role of climatic and human factors in desertification in semiarid China.Global Environmental Change, 16, 48-57.

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Effects of water stress and different levels of nitrogen on yield, yield components and WUE of sunflower hybrid iroflor

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Abstract

Productivity of sunflower (*Helianthus annuus* L.) is strongly regulated by the availability of water and nitrogen, greatest yield losses occur when water shortage occurs at flowering. In order to study the effects of water stress, different levels of nitrogen on yield, yield component and water use efficiency of sunflower hybrid Iroflor an experiment was conducted as a split plot Randomize Complete Blok Design. The treatments were composed of three irrigation treatment (I) including I_1 (optimum irrigation), I_2 (moderate stress) and I_3 (severe drought stress) was done after depletion of 30, 40 and 50 percent of the field capacity, respectively as the main plot and three nitrogen levels N_1, N_2 and N_3 consisting of 80, 140 and 200 Kg N.ha^{-1} respectively were placed as sub plots. Results showed that grain and biological yield, economical and biological water use efficiency, were reduced significantly in response to increasing to drought severity. The effect of nitrogen on grain and biological yield, yield components, economical and biological water use efficiency was significant. The highest water use efficiency was obtained from 200 Kg N.ha^{-1} under optimum irrigation condition. When available water decreased, positive effect of nitrogen application on these traits decreased significantly.

Keywords: Sunflower, Drought stress, Nitrogen, Yield components.

Introduction

Sunflower is one of the major and most important non-conventional oilseed crops in the world due to its excellent oil quality [1]. Sunflower is categorized as a low to medium drought sensitive crop [2]. Data on the effect of the agronomic techniques and irrigation on sunflower oil quality and seed yield are scarce and controversial. Both quantity and distribution of water has a significant impact on yield and oil yield in sunflower [3, 4, 5]. Previous investigations have shown that water stress at various growth stages affect seed yield of sunflower [2,6]. Ahmad *et al* [7] reported that plant height and plant dry matter decreased with increasing water stress under controlled conditions. Chimenti *et al* [8] and Erdem *et al* [9] indicated that grain yield and weight of 1000 grains decreased with increasing drought stress. Karam *et al* [10] showed that with increasing drought stress leaf area index, grain yield and its component decreased. Water stress during the yield formation period reduced yields when compared to full irrigation, but the reduction was much less than when stress occurred during flowering period Tolga and Lokman [6]. The optimization of irrigation water, particularly in Seasons where there is insufficient water for crop demand is essential for water resource

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management. Optimum use implies not only an efficient irrigation system capable of providing good uniformity, but also a proper timing of irrigation so as to conform to the critical stages of growth of the crop concerned. With good planning, design and operation of irrigation schemes, it is possible to analyze the effect of water supply on crop yields [6]. Nitrogen is essential elemental for growth and change its values accessible to the plant performance can affect the intensity. Scientists believe poor management of irrigation and nitrogen; the main factors decreasing the performance of corn are considered [11]. Abbadi and Gerendas [12] showed that optimal and high supply nitrogen in sunflower produced grain yield more efficient than low supply of nitrogen. Palmer et al [13] found that availability of nitrate has a strong effect on leaf expansion in sunflower. Norwood [11] reported in general, increase in moisture enhances corn yield response to N fertilization especially when high N rates are applied. In addition, N uptake was strongly influenced by water supply [14].

The primary objective of this study was to evaluate the impacts of N fertility rates and irrigation rates on sunflower yield, yield components and water use efficiency to develop a best management system for high sunflower yield and WUE simultaneously.

Material and Methods

This study was conducted in a clay loam soil in agronomic year 2010 at the farm of the Hamydiea city located at 13m above the sea level with longitude of 48° 10' and latitude 31° 4'. The experimental design was split plot with three replications in form complete randomized block. The treatments were composed of three irrigation treatment (I) including I_1 (optimum irrigation), I_2 (moderate stress) and I_3 (severe drought stress) was done after depletion of 30, 40 and 50 percent of the field capacity, respectively as main plot and three nitrogen levels N_1, N_2 and N_3 consisting of 80, 140 and 200 $Kg.ha^{-1}$ N respectively were considered as sub plots. For determining soil moisture samples were taken from 2 depths of soil 0-30 and 30-60 cm). Then weight moisture percentage was determined by pressure plate (arm field CAT.REF: FEL13B-1 Serial Number: 6353 A 24S98). In this experiment field capacity of soil was determined to be 24 with permanent wilting point of 12.1. To implement the irrigation operation the water usage volume was calculated by the following equation:

Equation 1. $$V = \frac{(F_C - \theta_m) \times pb \times D_{root} \times A}{E_i}$$

Whereas:

Equation **2.** V =***Volume of irrigation water per cubic meter***

Equation **3.** $=F_C$ ***Percent moisture content at field capacity***

Equation **4.** $=\theta_m$ ***Percent moisture content before irrigation***

Equation **5.** pb ***= Soil bulk density grams per cubic centimeter***

Equation **6.** $=\mathrm{A}$ ***Irrigated area per square meter***

Equation **7.** D_{root} =***Depth of root development according to meters***

Equation **8.** E_i ***= Irrigation efficiency***

Therefore the required water volume in each stage of irrigation in each treatment was calculated and was distributed equally based on the water distribution efficiency of 90 percent by flume and chronometer. The final harvesting area was equal to 4.8 m-2 that was done from two middle lines of planting. Final measurements were conducted from these samples. For moisture measurement grains were located in the oven in the temperature of 72 degrees centigrade for 48 hours. Leaf area index was determined by leaf area meter (LP-80 Accupar PAR/LAI Ceptometer). The yield components including the number of grains head-1 and weight of 1000 grains were calculated. Harvest index was calculated by equation:

HI= Harvest index

Y_e= Economical yield   Equation **9.** HI= Ye/Yb

Y_b= Biological yield

Yield components including grain number per head and seed weight (based on two samples of 500 seeds in each plot) were measured separately from the final harvest plants per plot. Biological and economic water use efficiency was calculated by equations:

WUE=Water Use Efficiency
EWUE= Economic Water Use Efficiency
BWUE= Biological Water Use Efficiency

Equation **10.** $EWUE = \frac{\text{Grain yield (kg)}}{\text{Volume of water consumption (m}^3\text{)}}$

Equation **11.** $BWUE = \frac{\text{Biological yield (kg)}}{\text{Volume of water consumption (m}^3\text{)}}$

Statistical analysis of data was performed using computer software MINITAB and MSTATC and the comparison of the means was done by Duncan's test at a probability level of 5 percent.

Results and Discussion

Seed yield

Effects of irrigation and nitrogen levels on the seed yield were significant (Table1) .Increasing in water deficit levels was associated with decreasing in seed yield (Table 3). The main reason of decreasing of seed yield in treatment under drought stress (moderate and intense) in comparison with optimum irrigation was a significant decrease in seed number in head and seed weight in these treatments (Table 3). It seems to balance water consumption during the different stages of development, including flowering leading to improved performance is sunflower seeds. Roshdi *et al* [15] showed that with increasing irrigation intervals diameter, seed yield and oil yield decreased. The interaction between deficit irrigation levels and nitrogen significantly affected seed yield (Table 1). Grain yield response to N rate was affected by irrigation (Table 4). Grain yield significant response to increase in N rate when the I_1 (optimum irrigation) and I_2 (moderate stress) treatments were applied (Table 4). The consumption of more quantities of fertilizer at optimum irrigation condition caused considerable increase in grain yield whereas at severe drought stress condition using more quantities of nitrogen did not increased grain yield. It seems that this situation results from absorption reduction and increasing nitrogen waste due to water deficit in soil. The results of Martin *et al* [14] confirm obtained results in this survey on nitrogen use efficiency at drought stress condition. Morsi and saleh [16] declared that a simultaneously increase in soil water and N, will result in an increase of seed yield at the time of water stress.

Biological yield

Negative correlation between of drought stress intensity and biological yield indicated that biological yield significantly decreased as the dryness tension intensity increased (Table 2 and 3). Optimum irrigation with 1032 $g.m^{-2}$ dry matter accumulation, and intense dryness tension with 576 $g.m^{-2}$ featured the highest and lowest biological yields (Table 3). These results confirmed Kalamian *et al* [17] and Jasso *et al* [18] who also showed decreasing biological yield because of drought stress. The reason for increase in TDM (Total dry matter) production in plants under optimum irrigation was the extension of leaf area and its higher durability that provided enough physiological resource to take advantage of received light and therefore produce more dry matter [18]. The reduction of nitrogen consumption level from 200 to 80 kg nitrogen ha^{-1} reduced biological yield by the average of 274 $g.m^{-2}$ (Table 3). The reduction of biological yield at little quantities of nitrogen consumption was reported by other researchers [19]. In this study, at greater quantities of nitrogen, accumulation of photosynthetic increased at stem and leaf parts which resulted in increased gathering of nutrients in grain. The nitrogen deficit causes leaf size reduction which in turn is the cause of reduction in the amount of light absorption and light usage for plant photosynthesis which finally leads to reduced biological yield (Table. 3). The interaction between irrigation levels and nitrogen application rates significantly affected on biological yield, (Table 1), Biological yield significantly was enhanced with increasing nitrogen usage in optimum irrigation and moderate drought stress cases. However, in intense dryness tension conditions, this positive impact of nitrogen was very intangible (Table 3).

In other words, lack of positive influence of nitrogen on production of suitable aerial organs, resulting from limited nitrogen absorption and failure in transferring it to the photosynthetic organs in intense dryness tension conditions, led to biomass reduction. The results of Martin *et al* [14] confirm obtained results in this survey on nitrogen use efficiency at drought stress condition.

Seed number per head

In this study deficit irrigation level applied significantly decreased the seed per plant (Table3). During the vegetative and reproductive growth of plants with water stress, especially in the flowering stage and thus increasing floret abortion of one of the reasons for the decrease in seed number. Khalilvand and yanai [20] reported the occurrence of stress at different growth stages, especially during reproductive stages reduces the number of seeds per head. Nitrogen had significant effects on seed number per head (Table 1). Increasing nitrogen applications increased the seed number per head. Seed number per head in the treatments of 200 kg N.ha^{-1} with the highest number of 623 and 80 kg N ha^{-1} treated with the 593 numbers were the lowest seed number (Table 3). Hasanzade [19] reported that the number of grains head-1increased with nitrogen consumption due to the improvement of crop growth rate and stated that increasing nitrogen consumption caused increasing in light use efficiency at flowering stage and increasing in crop growth rate. Since there is a close relationship between crop growth rate and providing elaborate sap during flowering and nitrogen application has a positive effect on these processes, increasing the number of grains head-1due to increasing nitrogen consumption was expected. Mishra *et al* [21] stated that with increasing nitrogen consumption the number of grains head^{-1} increased. The interaction effect of irrigation and N was significant in α=0.05 for seed yield (Table 1).Seeds per head with the application of 140 and 200 kg N ha^{-1} in optimum irrigation and moderate drought stress showed a significant increase than 80 kg N ha^{-1} and severe drought stress, increases in nitrogen did not show significant effect on seed number per head (Table 1 and 4). In other word, in condition of intense water deficit of soil, N absorption will be disrupted by plant and required N for the crucial stage of growth won't be provided even with the increase of nitrate of soil. Sakynzhad [22] declared in his research that irrigation could increase N absorption and the increase of water stress decreases a limitation for plant for utilizing of soil nitrate. Morsi and saleh [16] declared that a synchronized increase in soil water and N, will result in an increase of seed yield and at the time of water stress, N increase will increase seed yield a little.

1000 seed weight

The effects of different amounts of nitrogen and drought stress on 1000-grain weight were significant (Table 1). Results showed that drought stress caused significant decrease in grain weight so that the maximum and minimum 1000-grain weight was obtained in optimum irrigation and severe drought stress, respectively (Table 3). Average value of Grain weight is firstly determined by the quantity of elaborated matter available to be transported to head from flowering stages to grain maturity stage. This is, in turn, a function of the durability of leaf area after flowering stage as well as the sink-source relationship [23]. Decreasing 1000-grain weight at severe drought stress can be related to the lack of stored carbohydrates before pollination stage at productive parts and to decreasing durability of leaf area at plants of under treatment that resulted in a short period of grain filling. Positive correlation of nitrogen with the 1000-grain weight (Table 4) indicate that increasing the use of nitrogen increased 1000-grain weight (Table 3). This is because of ability of the plant to access to more nitrogen and increasing reproductive and productive parts. Fathi *et al* [24] reported that with increasing nitrogen consumption head diameter and 1000-grain weight increased due to more access to absorbing nutrients.

Harvest index

Impact of water deficiency tension was significant on harvest index (Table 1). The table containing comparison of averages of irrigation treatment effect on harvest index showed there was no significant difference statistically between ideal irrigation and moderate dryness tension; however, harvest index significantly declined by applying intense drought stress treatment (Table 2). Considering insignificance harvest index in optimum irrigation and moderate stress treatments in this research, it can be inferred that in temporary dryness tension condition, not only less matters were produced in the whole plant organs but also photosynthetic material allocation decreased proportionally. Grain weight variations in tension and non-tension circumstances confirmed this finding. But, considerable decline of grain yield in intense dryness tension condition was followed by significantly diminishing harvest index. In an experiment conducted by Chimenti *et al* [8] occurrence of moisture tension in pollination and physiological maturity conditions significantly affected sunflower's harvest index. Harvest index reduction was reported owing to water deficiency tension in studies of Soriano *et al* [25]. Richards *et al* [26] believe harvest index in dryness conditions depends on the amount of water consumed after pollination; the more water consumption, the higher harvest index. Effect of different nitrogen amounts was not significant (Tables 1). Insignificant impact of nitrogen is indicative of relatively uniform variation trend of grain yield and total biomass. In other words, nitrogen application seems to be ineffective on changing assimilate distribution. Hay and Walker [27] stated that in modern agricultural crops management, harvest index of a genotype is a typical quality, which varies subtly even in tension conditions.

Water use efficiency

Effects of irrigation treatments and amount of nitrogen consumption were significant on economic and biological water use efficiency (Table 1). Negative correlation of drought stress intensity with economic and biological water use efficiency (Table 2) confirmed this fact by increasing drought stress intensity, the economic and biological water use efficiency diminished significantly. The best water use efficiency was observed in optimum irrigation treatment with economic efficiency of 0.69 and biological efficiency of 2.06 $kg.m^{-3}$ (Table 3). The significant increase in water use efficiency in optimum irrigation condition compared to other irrigation states can be justified due to following reasons: approximately constant volume of consumed water in three treatments of this research, significant enhancement of grain yield and biological yield due to providing the required water for crop during growth period, and positive correlation between grain and biological yields and biological and economic water use efficiency (Table 2). Karam *et al* [10] reported that by increasing water deficiency stress intensity, water use efficiency significantly decreased because of significant decrease in sunflower's grain yield. Lyle and Bordovosky [28] reported when irrigation water volume was constant during corn growth period, and irrigation interval increased from 6 days to 9-12 days, the yield decreased as much as 30%, which consequently reduced economic efficiency. In an investigation on corn crop, Al-kaisi and Xinhua [29] reported a reduction in water use efficiency of corn as the drought stress intensity increased. Positive correlation of consumed nitrogen with economical and biological efficiencies of water consumption (Table 2 and 4) was suggestive of the fact that the respective efficiencies increased significantly as the amount of nitrogen consumption went up. Simultaneous crop maturity in different nitrogen amounts and constant consumed water volume for all nitrogen levels from one side, and significant enhancement of biological and grain yields from other side, were the main factors for promotion of water consumption efficiency in high levels of nitrogen consumption in this research (Table 4).

Mustafa and Abdolmagid [30] reported that increase in nitrogen usage improves evaporation and perspiration levels just up to 2.5 and 5 centimeters, but grain and biological yields increased more remarkably. As more nitrogen was used, water consumption efficiency in moderate moisture tension conditions also significantly increased- the same as ideal irrigation. However, this increase was not significant in intense moisture tension condition (Table 3).

Insignificance biological and economical efficiencies of water consumption in dryness tension conditions can be attributed to inefficient usage of nitrogen element for suitable production from one side and constant water consumption volume during growth period for all nitrogen levels on the other hand.

Conclusion

According to the results of this research, ideal irrigation, besides enjoying more confidence and larger yield level, enables ideal nitrogen usage for production and enhancement of water consumption efficiency. Sufficient nitrogen fertilizer significantly increased corn's grain yield under moderate dryness tension condition. Also, suitable conditions of nitrogen had positive effect on water use efficiency. Thus, if enough water is not available and the crop encounters moderate dryness tension during growth period, by applying more nitrogen, the reductions in grain yield and water consumption efficiency can be compensated to some extent. Prasertsak and Fukai [31] showed that as soil nitrogen increases in moderate stress conditions more nitrogen is absorbed and accordingly, the yield improves. However, this improvement is less than the situation when sufficient amount of water is used. In this research, grain yield and water consumption efficiency were not significant among different nitrogen levels in drought stress conditions. Consequently, when the crop encounters intense dryness tension during growth period, there would be no good reason to increase nitrogen fertilizer in order to alleviate the effects of dryness tension.

Table 1. Analysis of variance for experimental traits

S.O.V	d.f	LAI	Seed number per head	1000 seed weight	Seed yield	Biological yield	HI (%)	Economical water use efficiency	Biological water use efficiency
R	2	0.18 ns	906ns	150.58*	8857*	79917*	6.02 ns	0.039*	0.307*
Irrigation (I)	2	6.4**	65713**	1519.85**	79641**	495495**	85.3**5	0.318**	1.981**
E_a	4	0.112	1396	15.12	1257	12047	1.83	0.005	0.0482
Nitrogen levels (N)	2	0.9**	12535**	133.7**	6287*	69515**	2.71 ns	0.025*	0.278 ns
I * N	4	0.499*	14874**	12.27 ns	5962*	39808*	1.48 ns	0.023*	0.143*
E_b	12	0.060	1238	14.7	1179	10833.18	1.77	0.0047	12.2
CV	-	7.7	5.7	7.3	12.5	13.2	4.8	13.8	12.2

ns*and, **: Not significant, significant at probability levels 5% and 1% respectively

Table 2. Correlation coefficients between some traits related to redistribution and current photosynthesis

Treatment	Drought stress	Nitrogen	Seed yield	Biological yield	Economical water use efficiency
Seed yield	-0.77**	0.75**			
Biological yield	-0.79**	0.85**	0.69**		
Economical water use efficiency	-0.69**	0.91**	0.84**	0.73**	
Biological water use efficiency	-0.81**	0.74**	0.78**	0.86**	0.94**

ns, *and, **: Not significant, significant at probability levels 5% and 1% respectively

Table 3. Mean comparison for experimental traits

Treatment	LAI	Seed number per head	1000 seed weight (g)	Seed yield ($g.m^{-2}$)	Biological yield ($g.m^{-2}$)	HI (%)	Economical water use efficiency ($kg.m^{-3}$)	Biological water use efficiency ($kg.m^{-3}$)
Irrigation								
optimum irrigation	3.98^{a}	690^{a}	66.04^{a}	344.1^{a}	1032.7^{a}	33.39^{a}	0.69^{a}	2.06^{a}
Moderate drought stress	3.25^{b}	626.4^{b}	51.47^{b}	242.3^{b}	748.6^{b}	32.52^{a}	0.48^{b}	1.49^{b}
intense drought stress	2.3^{c}	530.8^{c}	40.11^{c}	156.2^{c}	567.2^{c}	27.68^{b}	0.31^{c}	1.13^{c}
Nitrogen(kg N ha^{-1})								
80	2.81^{b}	593^{b}	48.45^{b}	219^{b}	693.1^{b}	31.46^{a}	0.44^{b}	1.34^{b}
140	3.29^{a}	621^{a}	53.07^{a}	252.5^{a}	786.9^{ab}	31.56^{a}	0.50^{a}	1.57^{a}
200	3.41^{a}	623.1^{a}	56.1^{a}	271.1^{a}	868.6^{a}	30.56^{a}	0.54^{a}	1.74^{a}

Means with same letter in each column are not significantly different at the 5% probability level- using Duncan Multiple Range Test (DMAT)

Table 4. Mean Comparison of average interaction N×I for experimental traits

Treatment (N×I)		LAI	Seed number per head	Seed yield ($g.m^{-2}$)	Biological yield ($g.m^{-2}$)	Economical water use efficiency ($kg.m^{-3}$)	Biological water use efficiency ($kg.m^{-3}$)
Irrigation (I)	**Nitrogen(** N $kg.ha^{-1}$)						
Optimum irrigation	**80**	3.56^{b}	291.3^{b}	1181^{b}	809.6^{c}	0.582^{b}	1.781^{b}
	140	4.04^{a}	346.4^{a}	1332^{a}	1019.1^{b}	0.692^{ab}	2.038^{a}
	200	4.32^{a}	394.7^{a}	1355^{a}	1188.4^{a}	0.789^{a}	2.376^{a}
Moderate drought stress	**80**	2.81^{c}	214.9^{c}	1019^{c}	660.2^{e}	0.429^{d}	1.32^{c}
	140	3.46^{b}	253.1^{b}	1116^{b}	760.7^{d}	0.506^{c}	1.52^{b}
	200	3.48^{b}	258.8^{b}	1135^{b}	824.9^{c}	0.517^{c}	1.649^{b}
Intense drought stress	**80**	2.07^{d}	150.7^{d}	820^{d}	528.1^{f}	0.301^{e}	1.056^{d}
	140	2.39^{d}	158.1^{d}	827^{d}	580.8^{f}	0.316^{e}	1.161^{d}
	200	2.42^{d}	159.8^{d}	842^{d}	592.5^{f}	0.319^{e}	1.185^{d}

Means with same letter in each column are not significantly different at the 5% probability level- using Duncan Multiple Range Test (DMAT)

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References

1. Baydar H., and S. Erbas. 2005. Influence of seed development and seed position on oil, fatty acids and total tocopherol contents in sunflower (*Helianthus annus* L.). Turk. J. Agric. 29: 179-186.
2. Turhan H, Baser I .2004. In vitro and In vivo water stress in sunflower (*Helianthus annuus* L.). Helia 27(40): 227-236.
3. Krizmanic M, I. Liovic, A. Mijic, M. Bilandzic, and G. Krizmanic.2003. Genetic potential of OS sunflower hybrids in different agroecol conditions. Sjemenarstvo. 20(5/6): 237–245.
4. Reddy G.K.M, K. S. Dangi, S. S.Kumar, and A. V.Reddy .2003. Effect of moisture stress on seed yield and quality in sunflower, *Helianthus annuus* L. J. Oilseeds Res. 20(2): 282–283.
5. Iqbal N, M. Ashraf, M.Y. Ashraf, and F. Azam .2005. Effect of exogenous application of glycinebetaine on capitulum size and achene number of sunflower under water stress. Int. J. Biol. Biotechnol. 2(3): 765–77
6. Tolga E, and D. Lokman .2003. Yield response of sunflower to water stress under Tekirdag conditions. Helia. 26(38): 149–158.
7. Ahmad, S. H., R. Ahmad, M. Y. Ashraf, M. Ashraf and E. A. Waraich .2009. Sunflower (*Helianthus annuus* L.) response to drought stress at germination and seedling growth stages. Pak. J. Bot. 41(2): 647-654.
8. Chimenti, C. A., J. Pearson, and A. J. Hall .2002. Osmotic adjustment and yield maintenance under drought in sunflower. Field Crop Res. 75: 235-246.
9. Erdem, T., Y. Erdem, A. H. Orta and H. Okursoy .2006. Use of a crop water stress index for scheduling the irrigation of sunflower (*Helianthus annuus* L.). Turk. J. Agric. For. 30: 11-20.
10. Karam, F., R. Masaad, T. Sfeir, O. Mounzer and Y. Rouphael .2007. Evaptranspiration and seed yield of field grown soybean under deficit irrigation conditions. Agr. Water Manag. 75: 226-244.
11. Norwood, C. A. 2000. Water use and yield of limited irrigated and dry land corn. Soil Sci. Soc. Amer. J. 64: 365 – 370
12. Abbadi, J. and J. Gerendas .2009. Nitrogen use efficiency of Safflower as compared to sunflower. J. Pant Nutrition. Vol. 32(6): 929-945.
13. Palmer, S. J., D. M. Berridge, A. J. S. McDonald, and W. J. Devies. 1996. Control of leaf expansion of sunflower (*Helianthus annuus* L.) by nitrogen nutrition. J. Exper. Bot. 47: 359-368.
14. Martin, D. L D. G. Watts, L. N. Mielke, K. D. Frank, and D. E. Eisen-Hauer. 1992. Evolution of nitrogen and irrigation management for corn production using water high in nitrate. Soil Sci. Soc. Amer. J., 49: 1056 - 1062.
15. -Roshdi, M., H. Heidari Sharifabad, and M. Karimi, GH. Nourmohammadi and F. Darvish .2006. Syrvey on the impact of water deficiency over the yield of sunflower seed cultivar and its components. J. Agri .Sci .12(1): 109- 121.
16. -Moursi, M. A., and S. A. Saleh. 1984. Effect of rate and methods of area application Chemical Composition of maize. Field Crop Abs. 37. 419.
17. Kalamian, S., S. A. M. Modares sanavi and A. Sepehri .2006. Affect on of water deficit at vegetative and reproductive growth stages in leafy and commercial hybrids of maize. Agri. Res. Winter. 5(3): 38-53.
18. Jasso de Rodriguez. D., B. S. Phillips, R. Rodrigues-Garcia and J. L. Angulo Sanchez .2002. Grain Yield and fatty acid composition of sunflower seed for cultivars developed under dry land conditions. Agron, 25: 132-142.
19. Hasanzade, A. 2002. The effect of different amounts of Nitrogen fertilizer on yield and yield component and grain oil of sunflower. Uremia. Agri .SCI. Research 2:1:25-33.
20. -Khalilvand, B. and M. Yarnia. 2007. The effects of water deficit stress on some of the physiological characters of sunflower in the different density of planting [P]. Journal of Agricultural Sciences. Islamic Azad University. Tabriz Branch 1(2):37-52
21. Mishra, A., P., Dash, and R. K. Paikaray. 1995. Yield and nutrient uptake by winter sunflower (*Helianthus annuus*) as influenced by nitrogen and phosphorus. Indian Journal of Agronomy, 40: 137-138.
22. Sakynzhad, I. 2002. Water stress effect on the uptake process of nitrogen, phosphorus, potassium and sodium in different periods of growth, according to morphological and physiological characteristics of corn in Ahvaz climate. Doctoral thesis crop physiology. Islamic Azad University branch Ahvaz. 288pp
23. -Daneshian. J. M. R. Ardakani and D. Habibi .2005. Drought stress effects on yield, quantitative characteristics of new sunflower hybrids. The2, international conference on integrated approaches to sustain and improve plant production under drought stress. Roma. Italy. P: 406.
24. Fathi, G., G. K. Mc. Donald, and R. C. M. Lance .1997. Effects of post – anthesis water stress on the yield and grain protein concentration of barley grown at two levels of nitrogen Australian journal of Agricultural Research., 48:67-80.
25. Soriano, M. A., F. Orgaz, F. J. Villalobos and E. Fereres. 2004. Efficiency of water use of early plantings of sunflower. Eur. J. Agron. 21: 465–476.

26. Richards, R. A., G. J. Rebetzke, A. G. Condon and A. F. van Herwaarden. 2002. Breeding opportunities for increasing the efficiency of water use and crop yield in temperate cereals. Crop Sci. 42: 111–121.
27. Hay, R. K. M, and A. J Walker. 1989. An introduction to the physiology of crop yield. Publrshed in the united states with john willey and sons. Inc. New York. 292p.
28. Lyle, W. M., and J. P. Bordvosky. 1995. Leap corn irrigation with limited water supplies. Transaction of the Asae. 38: 455-462. In field crop Abst. 1996 (49)8: 715.
29. Al-Kaisi, M. M., and Y, Xinhua .2003. Effects of nitrogen rate, irrigation rate and Plant Population on corn yield and water use efficiency. Agron. J. 95: 1475-1482.
30. Mustafa, M. A., and E. Abdolmajid. 1982. Interrelationships of irrigation frequency. Urea nitrogen and gypsum on forage Sorghum growth on a salin sodic Caly soil. Agron. J. 74: 447 - 450.
31. Prasertask, A., and S. Fukai. 1997. Nitrogen availability and water stress interaction on rice growth and yield. Field crops Res. 52: 249-260

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Soil quality index for assessing alpine grassland soils on the Qinghai-Tibetan Plateau of China

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Abstract

The soil quality assessment can provide a tool to quantify the combined physical, chemical and biological response of soil to different disturbances and land use changes. Our objective was to employ a modified soil quality index (SQI) to assess soil quality. Four experimental sites with different degradation levels (i.e., severely degraded grassland (SDG), heavily degraded grassland (HDG), moderately degraded grassland (MDG) and non-degraded grassland (NDG)) were selected as a case study conducted in alpine meadow of Qinghai-Tibetan Plateau (QTP). Fifteen physical, chemical and biological soil indicators were chosen in each type of grassland. In order to select the appropriate indicators, PCA and correlation analyses were also employed. Therefore, the ratio of microbial biomass nitrogen to total nitrogen (MBN/TN), urease, proteinase and soil organic carbon (SOC) were found to be most important indicators for assessing soil quality. We concluded that there were significant differences of SQI in different types of grasslands under the severity of disturbance. NDG had a higher SQI than the other three types of grasslands, and SDG had the lowest SQI among the four experimental sites. It was concluded that SQI is effective for assessing the soil quality of alpine grasslands in the QTP. The intensity of disturbance had a negative effect on soil quality in the QTP.

Keywords: soil quality index, Qinghai-Tibetan Plateau, alpine grasslands

Introduction

Soil degradation can affect the soil systems functions including (1) buffering the formation, attenuation, and degradation of natural and other compounds; (3) supporting a medium for plant growth and (4) serving as a reservoir of water and essential nutrients; and (4) regulation of the water flow in the environment (Franzluebbers, 2002; Masto et al., 2008). Therefore, it is quite important to assess soil quality and health in various ecosystems. Consistent and accurate assessment of soil quality requires a systematic method for interpreting and measuring soil properties (Granatstein &Bezdicek, 1992). To our knowledge, individual soil properties may not be adequate indicators of soil quality (Masto et al., 2008). Assessing soil quality relies on a combination of physical, biological, chemical, biochemical and microbiological properties of the soil, and the selected properties should be those most sensitive to changes in the ecosystem (Jimenez et al., 2002). In general, there are many different ways to select soil indicators to assess soil quality, for example, according to previous researchers, they should be selected according to soil functions and management goals, which are often primarily focused on the effects on the ecosystem; these include the general environmental effects of ecosystem management strategies, including land use change and soil erosion (Rapport et al., 1997; Andrews et al., 2002). Overall, soil quality indictors should be: (1) sensitive to changes in soil management strategies; (2) well correlated with soil

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functions; (3) useful in revealing ecosystem processes and (4) cheaply and easily measured (Parisi et al., 2005). To identify the smallest number of measurable and appropriate soil properties that determines the major processes that are occurring in soil, the widely accepted concept of a minimum data set (MDS) was used (Masto et al., 2008). Previous studies about soil quality assessment were mainly in forest, agriculture or temperate ecosystems, few studies were documented in Qinghai-Tibetan Plateau.

The Qinghai-Tibetan Plateau (QTP), which is the largest geomorphological unit on the Eurasian continent, is the main region of low-latitude frozen soil in the world (Wang et al., 2002). It is also the source of headwaters for the Yangtze, Yellow and Mekong Rivers, as well as several other inland rivers in Asia (Li et al., 2007b). However, the alpine grasslands in the QTP have suffered from severe degradation due to natural and anthropogenic actives (Zhou et al., 2005; Harris, 2010). Therefore, it is quite important to assess soil quality of alpine grasslands in QTP. The objectives of this study were: (1) to identify the appropriate indicators for assessing soil quality in alpine grasslands; (2) establish an integrated assessment system for the soil conditions of alpine grasslands; (3) quantify the soil conditions of alpine grasslands under different disturbances and stressors; and (4) reveal the best soil management practices for sustainable grassland development.

Material and Methods

To develop the integrated SQI, we took the following three steps: (1) selecting appropriate parameters, (2) transforming and weighting the indicators and (3) scoring the selected index.

Indicator selection

Given that the selected indicators should represent a wide range of soil characteristics (Qi et al., 2009),we applied a tool to identify the management goals for a specific site (Andrews et al., 2004). The lists were further narrowed down according to soil properties and assessment purposes. In total, fifteen indicators covering the physical, chemical and biological properties of the soil were selected in this study.

Table 1 A subset of indicators for each function

Indicators	Soil function	Reference for use as indicators
ABC	Biodiversity and Habitat/Nutrient cycling	(He et al., 2008)
BBC		(He et al., 2008)
SOC	Nutrient cycling/Resistance and resilience	(Sikora &Stott, 1996)
MBC/SOC	Nutrient cycling	(Liao &Boutton, 2008)
TN		(Yang et al., 2010)
MBC		(Gregorich et al., 1994)
MBN		(Iyyemperumal et al., 2007)
MBN/TN		(Li et al., 2010)
MBC/MBN		(Li et al., 2009a)
pH	Nutrient cycling/Resistance and resilience/Resistance and resilience/ Water relations	(Karlen et al., 1997)
proteinase	Nutrient cycling/Physical stability and support	(Alfredsson et al., 1998)
ureease		(Zhang et al., 2011)
Ca	Nutrient cycling	(Li et al., 2006)
K		(Li et al., 2006)
P	Filtering and buffering/Nutrient cycling/Physical stability and support	(Wu et al., 2009)

Quantifying soil quality requires a ‘minimum data set’ because of the complexity of the soil system and attributes regarding soil physical, chemical and biological properties should be selected (Griffiths et al., 2011). Therefore, after selecting the above fifteen indicators, MDS, which was a data reduction method, was employed to help select the most suitable indicators for assessing soil quality. Principal component (PCA) and correlation analyses were applied to select the representative MDS (Doran &Parkin, 1994). PCA can be applied as a data reduction tool to choose the most appropriate parameters from a panel of indicators (Govaerts et al., 2006; Qi et al., 2009).

Indication interpretation

After determining the variables for the MDS, each observation was transformed for inclusion in the SQI. Indicators were transformed using non-linear scoring functions constructed using CurveExpert (version 1.3 shareware, http:/www.ebicom.net/~dhyams/cvxpt.htm). The shape of each decision function, which was typically a variation of a sigmoid curve with a lower asymptote ('less is better') or a sigmoid curve with an upper asymptote ('more is better'), was determined by environmental function according to literature reviews (Andrews et al., 2002). In this study, we applied a sigmoidal-type curve developed by previous researchers(Bastida et al., 2006; Masto et al., 2008)to score the indicators, as follows:

$$S = a / (1 + (x / x_0)^b)$$

Where S represents the score of the indicator; a stands for the maximum value attained by the function and that we defined as a =1in our case; x is the value of the selected indicators and x_0 is the mean value of each indicator corresponding to the soils of the four experimental plots; and b is the value of the slope of the equation. In the PCA, there are two types of indicators; one is positive ("more is better"), and the other is negative ("less is better"); -2.5 and 2.5 were selected as the b values for positive and negative indicators, respectively (Zhang et al., 2011).

Establishing the soil quality index (SQI)

After scoring all of the selected indicators, the indicator scores were integrated from the previous interpretation step into an additive single-index value. The value can be viewed as an overall assessment of soil quality, reflecting management practices or land use effects on soil function (Andrews et al., 2004). We calculated the soil quality index (SQI) using the following equation:

$$SQI = \sum_{i=1}^{n} W_i S_i$$

Where W is the weighting factor for the indicators derived from the PCA. Each PC explains a certain amount of variance (%) in the total data set, which gives the weights for the indicators. Finally, the equation was normalized to yield a maximum SQI of 1 (Masto et al., 2008; Zhang et al., 2011).

Case study

We verified the feasibility of the SQI on data from a study examining four types of grasslands over different levels of degradation in the alpine region of the QTP, as described as below.

Study site

The study was conducted in Dawu village (34°28′11″N, 100°12′39″E), Maqin county, in the Glog Tibetan Autonomous Prefecture, Qinghai Province of China, from 2009 to 2010. The climate in this area is characterized by strong solar radiation with a short, cool summer and a long, cold winter. The mean annual precipitation is 513 mm and occurs primarily from May to September. The annual temperature is -0.6°C, ranging from -10°C in January to 11.7°C in July. There is no absolutely frost-free period. The grassland vegetation is typical alpine meadow dominated by *Kobresiaspp*, *Polygonumspp* and *Poaspps*. The soil is loam (termed "alpine meadow soil" in the Chinese Soil Classification System). Severely degraded grassland (SDG), heavily degraded grassland (HDG), moderately degraded grassland (MDG) and non-degraded grassland (NDG) were selected as our sampling sites. The indicators were measured using field survey and lab experiments.

Results and Discussion

Soil quality index (SQI)

According to the PCA, the soil indictors differed significantly across the grasslands. The first three principal components (PCs) had eigenvalues >1.0. The higher loadings under PC-1 were SOC, ABC, BBC, MBC, MBC/SOC, TN, MBN, MBN/TN, MBC/MBN, pH, urease, Ca, K and P. MBN/TN had a higher loading and was significantly correlated with other higher-loading indicators but less significantly correlated with urease. Therefore, urease and MBN/TN were retained for the SQI. The highest-loading property under PC-2 was proteinase, and therefore, proteinase was selected as one of the indicators for the SQI. Likewise, SOC was selected for the SQI due to its higher loading in PC-3. As a result, the indicators selected from the PCs for the SQI were: urease, MBN/TN, proteinase and SOC. The final normalized SQI can be formulated as:

$SQI = 0.46[1/(1+(x_1/0.02)^{-2.5})] + 0.46[1/(1+(x_2/0.81)^{-2.5})] + 0.06[1/(1+(x_3/1.29)^{-2.5})] + 0.02[1/(1+(x_4/6.45)^{-2.5})]$ where x_1, x_2, x_3, x_4 represent MBN/TN, urease, proteinase and SOC, respectively.

As shown in Fig.1, the SQI varied markedly among the different grasslands, from 0.60 in the NDG to 0.36 in the SDG. The four grasslands can be categorized into three groups: (1) high SQI [>0.60, NDG]; (2) medium SQI [0.40-0.60, MDG] and (3) low SQI [<0.40, HDG and SDG].

Table 2 Principal component analysis of soil indicators

Principal component	1	2	3
Eigenvalue	11.773	1.687	1.022
Variance(%)	78.484	11.25	3.919
Cumulative (%)	78.484	89.734	93.654
SOC	0.888	0.065	-0.506
ABC	0.865	-0.014	0.163
BBC	0.964	0.161	0.132
MBC	0.982	0.119	-0.102
MBC/SOC	0.866	0.302	0.314
TN	0.991	-0.101	0.061
MBN	0.942	-0.215	0.236
MBN/TN	-0.893	-0.318	0.174
MBC/MBN	0.883	0.387	-0.205
pH	-0.978	0.171	0.046
Proteinase	0.205	0.933	0.179
Urease	0.813	-0.377	0.275
Ca	0.934	-0.281	-0.093
K	-0.837	0.347	0.028
P	0.956	-0.7	-0.136

$SQI=0.78_{MBN/TN} + 0.78_{urease} + 0.11_{proteinase} + 0.04_{SOC}$

Normalized $SQI=SQI/1.71=0.46_{MBN/TN} + 0.46_{urease} + 0.06_{proteinase} + 0.02_{SOC}$

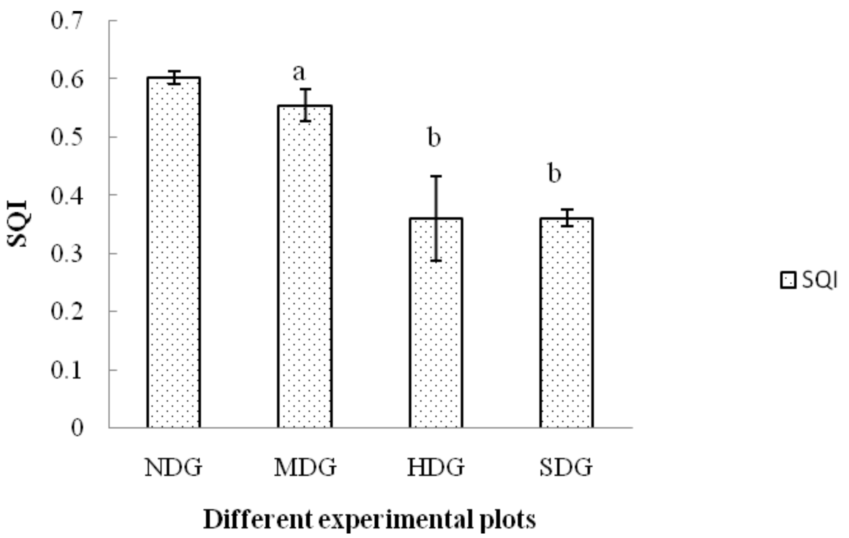

Fig. 1 Soil quality index in the different grasslands

Values are presented as the means±SD. Values with different letters are significantly different at the 0.05 level.

Soil quality is one of the most critical environment factors for sustaining the global biosphere (Fu et al., 2003). A better understanding of soil quality is important for developing sustainable land use management in that it can provide early warning signs of adverse trends, identify sources of problems and offer a valuable baseline against which to compare subsequent measurements (Qi et al., 2009). In our study, we had selected 15 indicators for assessing soil quality. Almost all previous soil quality indicators suggested by Gregorich et al. (1994), Jimenez et al. (2002) and Schoenholtz et al. (2000) were included in our list. MDS was also selected to minimum soil indicators, However, we cannot neglect one limitation in the MDS selection; only the PCs with eigenvalues ≥1 and indicators receiving weighted loading values within 10% of the highest value were selected for the MDS (Andrews et al., 2002). If the indicator with the highest loading was significantly correlated with other indicators, this indicator represented the other indicators in the PC. However, some information about soil quality is inevitably lost (Qi et al., 2009).

In our study, a modified SQI was applied in soil quality evaluation for alpine grasslands in the QTP under different intensities of disturbance. We found that the soil quality index decreased along the gradient of human disturbance, meaning that more intensive land use made it difficult to improve soil quality and led to irreversible consequences (Sparling &Schipper, 2004). Higher livestock numbers and greater human activities on grasslands can increase the likelihood of higher nutrient loading and soil compaction (Sparling &Schipper, 2004). In our study, we can categorize the grasslands into three groups, the non-degraded grasslands with high SQI, the moderately degraded grassland with medium SQI and the heavily and severely degraded grasslands with low SQI.

Conclusion

It can be concluded that the modified soil quality index in our study is a reasonable measure of soil quality in the QTP's alpine grasslands at different degradation levels. It can also be concluded that human disturbances and land use changes had a significant effect on the soil quality of alpine grasslands in the QTP. Urease, MBN/TN, proteinase and SOC could be most important indicators for assessing soil quality of the alpine grasslands in the QTP. The grasslands in good condition (NDG) can be used as a reference for restoring the degraded grasslands in the QTP.

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References

Alfredsson, H., Condron, L. M., Clarholm, M., Davis, M. R. (1998). Changes in soil acidity and organic matter following the establishment of conifers on former grassland in New Zealand Forest Ecology and Management, **112,** 245-252.

Andrews, S. A., Karlen, D. L., Cambardella, C. A. (2004) . The soil management assessment framework: a quantitative soil quality evaluation method. Soil Science Society of America, **68,** 1945-1962.

Andrews, S. S., Karlen, D. L., Mitchell, J. P. (2002). A comparision of soil quality indexing methods for vegetable systems in Norhtern California. Agriculture, Ecosystems & Environment, **90,** 25-45.

Bastida, F., Moreno, J. L., Hernández, T., Garcı´A, C. (2006). Microbiological degradation index of soils in a semiarid climate. Soil Biology & Biochemistry, **38,** 3463-3473.

Doran, J. W., & Parkin, B. T. (1994). Defining and assessing soil quality. In: Doran, J. W., Coleman, D. C., Bezdicek, D. F., Stewart, B. A. (Eds), Defining soil quality for a sustainable environment. Soil Science Society of America, Inc., Madsion, WI, USA, (pp. 3-21), Special Publication, Number 35.

Franzluebbers, A. J. (2002). Soil organic matter stratification ratio as an indicator of soil quality. Soil & Tillage Research, **66,** 95-106.

Fu, B. J., Liu, S. L., Lu, Y. H., Chen, L. D., Ma, K. M., Liu, G. H. (2003). Comparing the soil quality changes of different land uses determined by two quantitative methods. Journal of Environmental Sciences, **15,** 167-172.

Granatstein, D., & Bezdicek, D. F. (1992). The need for a soil quality index: local and regional perspectives. American Journal of Alternative Agriculture, **7,** 12-16.

Govaerts, B., Sayre, K. D., Deckers, J. (2006). A minimum data set for soil quality assessment of wheat and maize cropping in the highlands of Mexicao. Soil & Tillage Research, **87,** 163-174.

Gregorich, E. G., Carter, M. R., Angers, D. A., Monreal, C. M., Ellert, B. H. (1994). Towards a minimum data set to assess soil organic matter quality in agricultural soils. Canadian Journal of Soil Science, **74,** 367-385.

Harris, R. B. (2010). Rangeland degradation on the Qinghai-Tibetan plateau: a review of the evidence of its magnitude and causes. Journal of Arid Environments, **74,** 1-12.

He, N., Yu, Q., Wu, L., Wang, Y., Han, X. (2008). Carbon and nitrogen store and storage potential as affected by land-use in a Leymus chinensis grassland of northern China. Soil Biology & Biochemistry, **40,** 2952–2959.

Iyyemperumal, K., Israel, D. W., Shi, W. (2007). Soil microbial biomass, activity and potential nitrogen mineralization in a pasture: impact of stock camping activity. Soil Biology & Biochemistry, **39,** 149-157.

Jimenez, M. D. L. P., Hprra, A. D. L., Pruzzo, L., Palma, R. M. (2002). Soil quality: a new index based on microbiological and biochemical parameters. Biology and Fertility of Soils, **35,** 302-306.

Karlen, D. L., Mausbach, M. J., Doran, J. W., Cline, R. G., Harris, R. F., Schuman, G. E. (1997). Soil quality, a concept, defination, and framework for evaluation. Soil Science Society of America Journal, **61,** 4-10.

Li, W. J., Li, J. H., Knops, J. M. H., Wang, G., Jia, J. J., Qin, Y. Y. (2009a). Plant communities, soil carbon, and soil nitrogen properties in a successional gradient of sub-alpine meadows on the eastern Tibetan Plateau of China. Envrionmental Management, **44,** 755-765.

Li, W. J., Li, J. H., Lu, J. F., Zhang, R. Y., Wang, G. (2010). Legume-grass speices influnece plant productivity and soil nitrogen during grasslands succession in the eastern Tibet Plateau. Applied Soil Ecology, **44,** 164-169.

Li, X. G., Li, F. M., Zed, E., Zhan, Z. Y., Singh, B. (2007b). Soil physical properties and their relations to organic carbon pools as affected by land use in alpine pastureland. Geoderma, **139,** 98-105.

Li, X. R., Jia, X. H., Dong, G. R. (2006). Influence of desertification on vegetaion pattern variations in the cold semi-arid grasslands of Qinghai-Tibet Plateau, North-west China. Journal of Arid Environments, **64,** 505-522.

Liao, J. D., & Boutton, T. W. (2008). Soil microbial biomass response to woody plant invasion of grassland. Soil Biology & Biochemistry, **40,** 1207-1216.

Masto, R. E., Chhonkar, P. K., Singh, D., Patra, A. K. (2008). Alternative soil quality indices for evaluating the effect of intensive cropping, fertilisation and manuring for 31 years in the semi-arid soils of India. Environmental Monitoring and Assessment, **136,** 419-435.

Parisi, V., Menta, C., Gardi, C., Jacomini, C., Mozzanica, E. (2005). Microarthropod communities as a tool to assess soil quality and biodiversity: a new approach in Italy. Agriculture, Ecosystems & Environment, **105,** 323-333.

Qi, Y. B., Darilek, J. L., Huang, B., Zhao, Y. C., Sun, W. X., Gu, Z. Q. (2009). Evaluating soil quality indices in an agricultural region of Jiangsu Province, China. Geodema, **149,** 325-334.

Rapport, D. J., Mccullum, J., Miller, M. H. (1997). Soil heath: its relationship to ecosystem health. In: C E Pankurst, B M Doube, V V S R Gupta (Eds.), Biological Indicators of Soil Health, (pp. 29-47). CAB International, Oxon, UK.

Schoenholtz, S. H., Miegroet, H. V., Burger, J. A. (2000). A review of chemical and physical properties as indicators of forest soil quality: challenges and opportunities. Forest Ecology and Management, **138,** 335-356.

Sikora, L. J., & Stott, D. E. (1996). Soil organic carbon and nitrogen. . p. 157-167. In J W Doran and A J Jones (ed.) Methods for assessing soil quality. SSAA Spec. Publ. No. 49. SSAA, Madison, WI.

Sparling, G., & Schipper, L. (2004). Soil quality monitoring in New Zealand: trends and issues arising from a broad-scale survey. Agriculture, Ecosystems & Environment, **104,** 545-552.

Wang, G. X., Qian, J., Cheng, G. D., Lai, Y. M. (2002). Soil organic carbon pool of grassland soils on the Qinghai-Tibetan Plateau and its global implication. The Science of the Total Environment, **291,** 207-217.

Wu, G. L., Du, G. Z., Liu, Z. H., Thirgood, S. (2009). Effect of fencing and grazing on a Kobresia-domniated meadow in the Qinghai-Tibetan Plateau. Plant and Soil, **319,** 115-126.

Zhang, C., Liu, G. B., Xue, S., Song, Z. L. (2011). Rhizosphere soil microbial activity under different vegetation types on the Loess Plateau, China. Geoderma, **161,** 115-125.

Zhou, H. K., Zhao, X. Q., Tang, Y. H., Gu, S., Zhou, L. (2005). Alpine grassland degradation and its control in the source region of the Yangtze and Yellow Rivers, China. Grassland Science, **51,** 191-203.

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Influence of composts on agrochemical properties of soils of Zarafshan valley, salted with magnesium carbonates and yield-capacity of corn

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Abstract

Peculiar characteristics of soils of Zarafshan valley are salinity with carbonates. To improve of soil reclamation is recommended introduction large amount of manure or other organic fertilizers in these soils. But currently there is no possibility to collect so many organic fertilizers in Uzbekistan. That is why, we searched other ways production of organic fertilizers for improve of soil fertility. In the experiment was studied the influence of composts, prepared from tobacco wastes and manure on agrochemical properties of soils of Zarafshan valley, salted with magnesium carbonates and yield-capacity of corn. Through production of compost from these industrial wastes can be decided once two problems that exist in Uzbekistan. These include: problems of environmental contamination with wastes and problems ensuring with organic fertilizers in farmland soils. Introduction of composts in the doze of 30 t/ha separately and on the background of mineral fertilizers-NPK increased the humus content, total NPK and mobile nutritious substances in soil. It is proved that composts, prepared from tobacco wastes with their effect on the yield-capacity and quality of corn production can successfully substitute manure. Composts positively influence on the balance of nutritious substances in the system of soil–corn.

Keywords: Soils of Zarafshan valley, soils salted with magnesium carbonates, tobacco wastes, manure, mineral fertilizers, meadow soils, agrochemical properties, corn

Introduction

Soils of Zarafshan valley are salted with calcium and magnesium carbonates. In the case of increasing of calcium and magnesium carbonates above 18%, magnesium carbonates above 2%, becomes the soil type which salinity with carbonates (Kuguchkov, 1954). The total area of these soils on the right bank of the Zarafshan river is 42,6 thousand ha, on the left bank 10,75 thousand ha (Uzakov, 1963). One of main measures improving fertility of these soils is application of high amount of organic fertilizers, which is recommended by some researchers (Kuguchkov, 1954; Uzakov, 1963; Saidmurodov, 1973). Currently in soils of Uzbekistan luck of humus dominates. According to Holikulov & Ortikov (2007) over a period of last 20 years humus of soils in Uzbekistan decreased to 0,78%. It means if a meter of soil layer had 120 t/ha^{-1} humus reserve in 1971, at the beginning of 2000 it had only 62 t/ha^{-1} of humus. Reduction of humus reserve is 58 t/ha^{-1}. Reason of the reduction of humus content in these soils is application high amount of mineral, mainly nitrogen fertilizers without organic fertilizers to increase the yield capacity of cotton and other agricultural crops.

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Currently it is a major problem ensuring irrigated soils of Uzbekistan with manure or other organic fertilizers. To support the humus content in irrigated soils of Uzbekistan without deficits, there must be introduced 17-18 t/ha^{-1} manure or other organic fertilizers yearly (Sattarov, 1990). That is why, the introduction of other ways of production of organic fertilizers is one of very important tasks, that solves existing problems in agriculture. One of sources of organic substances for production of fertilizers is urban household and industrial organic wastes. Because, every year in Uzbekistan there are collected more than 30 million m^3 urban household (Holikulov & Pardaev, 2003) and 100 million ton industrial wastes (National lecture, 2006). More than 70 percent of these household wastes are biological. These wastes are stored in open place and are the sources of contamination of environment. Air, soil and ground waters are contaminated. However, so many of wastes stayed unused, in farmland soils of Uzbekistan is the luck of humus content dominated. Through compost production from these organic wastes can be decided two problems at once that exist in Uzbekistan. These include: problems of environmental contamination with organic wastes and problems of organic fertilizers in farmland soils.

We learned the influence of the compost prepared from tobacco wastes on chemical and agrochemical properties of soils, soil nutrition balance, growth and yield capacity of corn. The influence of compost prepared from tobacco wastes on activities of earthworms (Eisenia fetida) was studied in our previous works (Trautz et al., 2009). Application this compost in amount of 30 t/ha to soils doesn’t cause the toxic influence on earthworms of soil.

Material and Methods

Site and soil properties: Field experiments were conducted on meadow soils, salined with magnesium carbonates of the agricultural farm “Mamarasul Sohibkor” in Samarkand region, Taylak district in 2009-2011 years. This district is situated on the left bank of the Zarafshan river. Soil properties of field trials are following: average sandy, humus – 1,31%, total nitrogen – 0,145%, total phosphorus – 0,190%, total potassium - 2,8%, N-NH_4 – 7,3 mg/kg, N-NO_3 – 18,3 mg/kg, mobile phosphorus – 21,5 mg/kg, exchangeable potassium – 200 mg/kg, pH – 7,2.

Preparing of compost: For conducting of field trials were used tobacco wastes of the Samarkand cigarette factory. In the factory yearly are collected almost thousand tons (1 ton is 1000 kg) of tobacco wastes. For the preparation of composts were used in the depth of 1,5-1,75 meter. Into the depth components of the compost were inserted in sequence. For 1000 kg tobacco wastes was added 500 kg manure. Then humidity of substrate was leaded to 70-75% with water. The substrate was covered with 15-20 cm thickness soils. The compost ripened in 5-6 months.

Field treatment: As an object of field experiment there was taken a corn the sort “UzRos Kremnistaya”. The field experiment was conducted in 4 replicates. Variants were placed systematically in plots. The width of the plots was 5,6 meter, the length was 30 meter. There were 8 lines on the plot. 4 lines in the middle were calculating lines, 4 lines in two sides were protecting lines.

The schedule of field trials:

1. Control (without fertilizers)
2. 30 t/ha manure
3. 30 t/ha compost
4. $N_{200}P_{150}K_{100}$ (NPK)
5. NPK+30 t/ha manure
6. NPK+30 t/ha compost

Soil analysis: In the experiment humus analysis were carried out by method of Tyurin, Total NPK – method of Malzev-Gritsenko, N-NH_4 –in photo calorimeter with the help of reagent of Nessler, N-NO_3 – in photo calorimeter method of Grandwald-Lyaju, mobile phosphor – in photo calorimeter method of Machigin, exchangeable potassium – in flame calorimeter method of Machigin-Protasov, total and magnesium carbonates – in vinegar extract, humus reserve – calculating methods, pH – in water solution – potentiometer method (Yagodin et al., 1987; Radov et al., 1971).

Manure and compost analysis. Total N - organic substance of manure was combusted with concentrated sulfuric acid in the presence of phenol, catalysts and zinc dust. Nitrogen of the manure enters to form ammonia, with sulfuric acid forms ammonium sulfate. Ammonia was distilled with apparatus of Kjeldahl titrated with solution of sulfuric acid.

Phosphorus was determined in dry combustion method and potassium with wet combustion volumetric cobaltinitrite method (Yagodin et al., 1987; Radov et al., 1971).

Fertilizers: As a nitrogen fertilizer there was used ammonium nitrate: NH_4NO_3 (34,6% N), phosphorus fertilizer, complex fertilizer ammophos: $NH_4H_2PO_4$ (11% N and 46% P_2O_5), potassium fertilizer, potassium chloride: KCl (60% K_2O), organic fertilizer was introduced as rotted manure in soil. Manure content: 0,5% N, 0,25% P_2O_5, 0,6% K_2O. Compost content: 0,6-0,8% N, 0,25-0,40% P_2O_5, 0,63-1,0% K_2O. Content of tobacco wastes: 1,4-1,7% N, 0,4-0,6% P, 1,5-2,1 % K.

Statistical evaluation of results of the field experiment was conducted according to Dospexov (1985) in Excel-program.

Climate: Climate of Taylak district is similar to the climate of Zarafshan valley. There is a sharp continental temperature between seasons and day-night. The main precipitations are in autumn, winter and spring periods (average 300-350 mm). Winter of this climate is short, but very cold. Summer is dry and hot. That is why, crops must be always irrigated in summer. The coldest month is January (up to -27 °C), the hottest is July (up to 41 °C). The average annual air temperature according to perennial data is 14,9-15,1 °C, Average temperature of the hottest month is 26-27°C, the coldest is -1,5 + 2,6 °C.

Results and Discussion

The reason for the salinization of these soils with carbonates is the existing of high content of water dissolved carbonates: $Ca(HCO_3)_2$, $Mg(HCO_3)_2$ in subterranean waters. Total and magnesium carbonates in soils of field experiments is 27,1%, of that calcium and magnesium carbonates are respectively 21,4% and 5,7%. This soil salinization belongs to middle saline soils with carbonates (Kuguchkov, 1954). To the deeper layer down, the content of calcium carbonate is higher and magnesium carbonate is lower. Because, magnesium carbonate dissolves easily in water and rises with subterranean water up the surface of soils (Ortikov & Uzakov, 2013). That is why it’s content on the soil surface is higher than in deeper layers (table 1). In the consequences of soil mishandling, evaporation of redundant water from soil surface, non application of organic fertilizers and rising of subterranean waters bicarbonates will rise up to the soil surface through capillaries. Consequently it leads to the soil salinization with carbonates.

Table 1.The change of carbonates through soil profile in meadow soils (2009)

Soil profiles, cm	$CaCO_3$, %*	$MgCO_3$,%*
0-28	21,3±1,41	5,55±0,46
28-47	25,62±1,12	5,85±0,48
47-74	28,12±0,92	5,22±0,78
74-103	36,82±1,18	4,85±0,79
103-142	39,42±2,28	5,02±0,64
142-184	46,5±1,67	4,5±0,54
184-224	71,45±4,02	4,15±0,88

*Significant at 0.05 level

The results of the field experiments show that three years application of manure, compost and mineral fertilizers leads to the change of humus content in soils. The cultivation of crops without application of organic fertilizers leads to strengthening of humus mineralization. This process will intensive when the soil will be irrigated. During three years the humus content of the soil decreased to 0,03% or 1,08 t/ha in control. In the application of 30 t/ha manure and compost the humus content of soil increased significantly. Thereby in the variants of 30 t/ha manure and 30 t/ha compost, the humus content increased respectively to 2,16 and 1,44 t/ha. In the variant where were introduced only mineral fertilizers, humus content decreased to 2,52 t/ha. In the application of mineral fertilizers soil microbiological processes will very intensive. If there is very low content of organic substances in soil, microorganisms get organic carbon from soil humus for the formation of cell structure (Hoshimov & Ortikov, 1993). Consequently it leads to mineralization of humus. In experiments of Piraxunov (1977) with application of phosphorus fertilizer for ten years, especially in high doses in the condition of typical grey soils with continuous cropping of cotton humus and total nitrogen contents increase respectively to 0,20 and 0,015% versus control. According to this research high doses of phosphorus fertilizers

(100-150 kg/ha) has more positive effect than low doses. In our experiments application of phosphorus fertilizers with nitrogen and potassium didn't increase the humus content.

Application of manure and compost in the background of mineral fertilizers led to improving of humus content in the soil. But this significance was lower than the application of organic fertilizer without minerals. Thus, the compost prepared from tobacco wastes increases humus content in soil and substitute traditional organic fertilizer - manure (*table* 2).

Table 2. Influence of organic and mineral fertilizers on humus content and humus reserve of soil

Treatment	Soil layer	2009 autumn		2011 autumn		Relatively to the control
		%*	t/ha	%*	t/ha	t/ha
Control	0-30	1,21 ±0,033	43,56	1,18 ±0,058	42,48	-
30 t/ha manure	0-30	1,22 ±0,088	43,92	1,28 ±0,103	46,08	+3,24
30 t/ha compost	0-30	1,24 ±0,090	44,64	1,28 ±0,065	46,08	+2,52
$N_{200}P_{150}K_{100}$ (NPK)	0-30	1,22 ±0,142	43,92	1,15 ±0,119	41,40	-1,44
NPK+30 t/ha manure	0-30	1,19 ±0,069	42,82	1,23 ±0,110	44,28	+2,54
NPK+30 t/ha compost	0-30	1,20 ±0,059	43,20	1,24 ±0,089	44,64	+2,52

*Significant at 0.05 level

Ammonia nitrogen was defined in various dates from soil samples. In the control was the lowest ammonia nitrogen content. In the application of 30 t/ha manure and compost to the soil, ammonia nitrogen content was increased significantly. Mineral (nitrogen) fertilizers influenced more than organic fertilizers on the ammonia nitrogen content. Application of organic and mineral fertilizers together, led to the maximum content of ammonia nitrogen in soil, saline with carbonates. E.g. during intensive nutritional period of crops (5.07) in the control ammonia nitrogen was -5,9; in the variants of 30 t/ha manure -13,2; 30 t/ha compost - 10,06; $N_{200}P_{150}K_{100}$ -32,3; NPK+ 30 t/ha manure -35,6; NPK+30 t/ha compost -36,3 mg/kg (Figure 1).

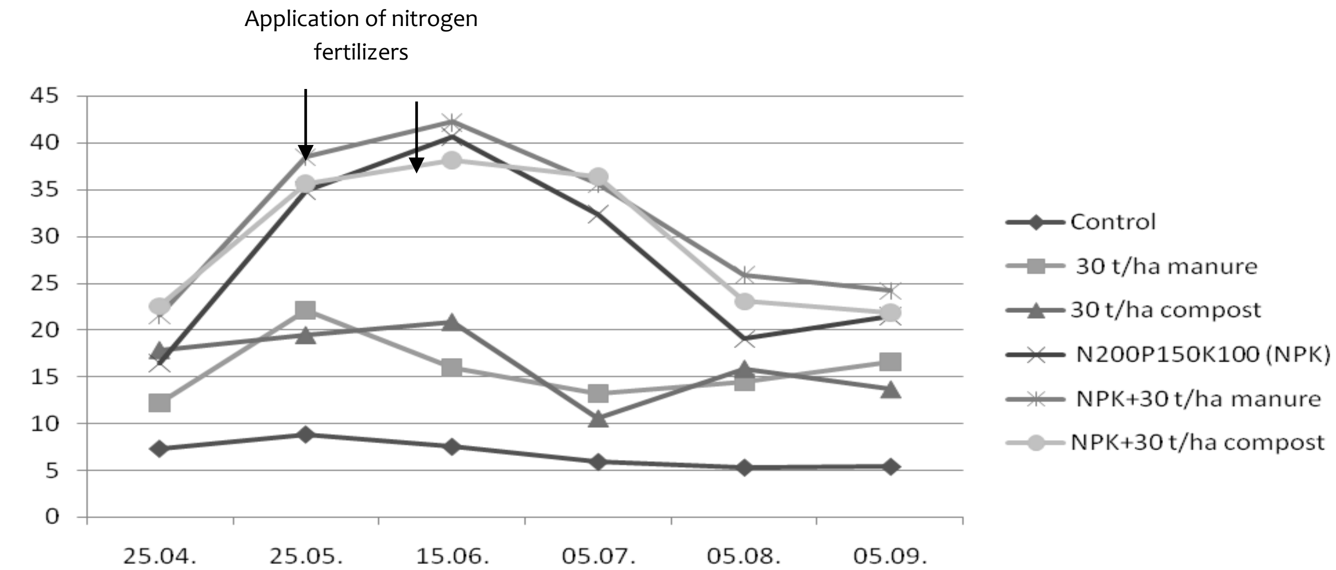

Figure 1. Influence of organic and mineral fertilizers on ammonia content in the soil, mg/kg (2011)

Nitrate nitrogen content also was very low in the control, but more than ammonia. Because, nitrification processes are more intensive in the soils than ammonification (Hoshimov & Ortikov, 1993). Change of nitrate content in soil was like ammonia nitrogen. In the date of 05.07 nitrate content in soil was in the control -15,2; in the variants of 30 t/ha manure -33,1; 30 t/ha compost -27,5; $N_{200}P_{150}K_{100}$ -47,1; NPK+30 t/ha manure and NPK+30 t/ha compost respectively -50,8 and 51,4 mg/kg (Figure 2).

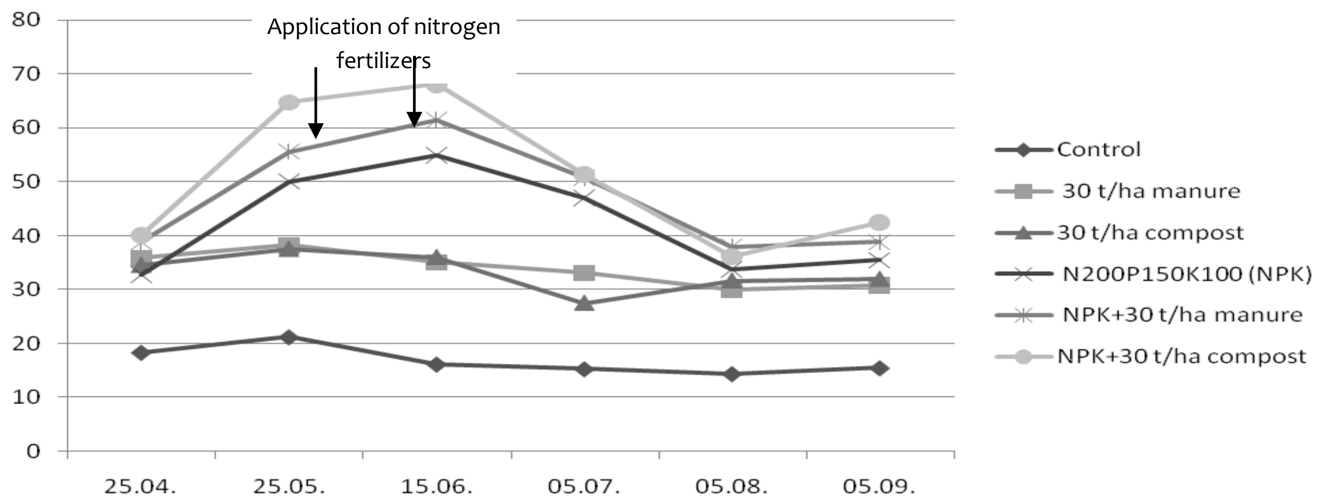

Figure 2. Influence of organic and mineral fertilizers on nitrate content in the soil, mg/kg (2011)

In carbonate saline soils mobile phosphor content is lower than in other soil types because of existing high content of calcium and magnesium carbonates. Carbonates lead the mobile phosphor to chemical absorption (Mashrabov et al., 2010). Consequently it decreases the nutrition efficiency of crops from phosphorus fertilizers in the soil. According to Hayitov (2013) in typical grey soils 93,5% of total phosphorus is in mineral form and 6,5% is in organic. For increasing of yield of agricultural crops, phosphoric fertilizers must be introduced to soil in mineral form. Soils of the field trials are supplied low with mobile phosphorus. In consequences with application of manure and compost mobile phosphorus content increases to middle supplied degree. In the application of phosphorus fertilizers mobile phosphor is increased abruptly. This increasing was observed notably in application of compost and manure in the background of mineral fertilizers (Figure 3).

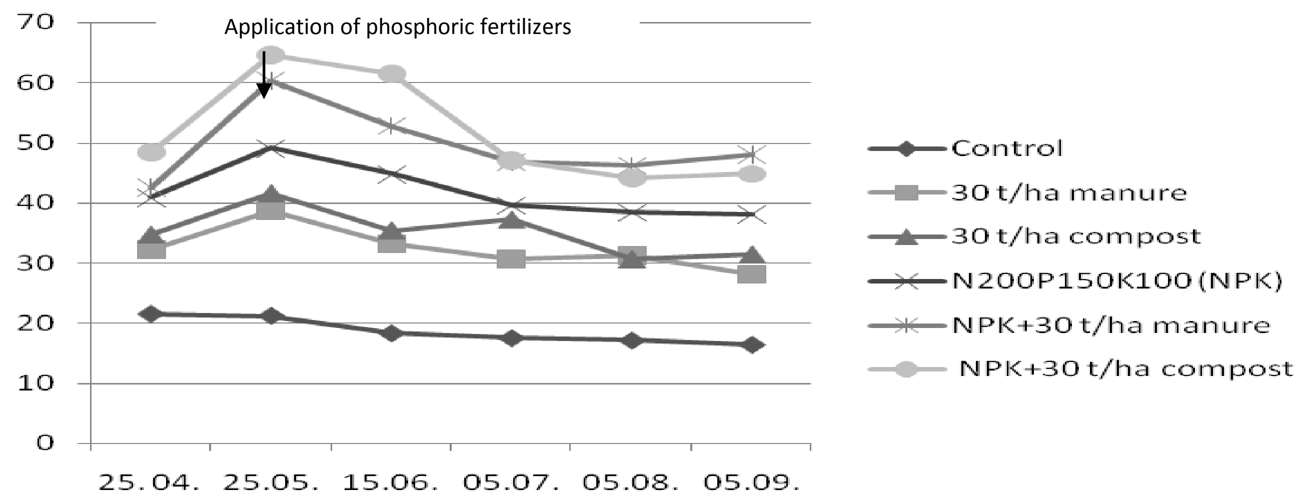

Figure 3. Influence of organic and mineral fertilizers on mobile phosphorus content in the soil, mg/kg (2011)

The content of exchangeable potassium is more than mobile phosphorus in grey (sierozem) soils. Application of manure and compost increases the content of exchangeable potassium in meadow grey soil, saline with carbonates. This alteration lasted till the end vegetation period of corn. Such change was observed also in application of mineral fertilizers. Application of manure and compost in the background of mineral fertilizers creates very optimal nutritional regime in the soil (Figure 4).

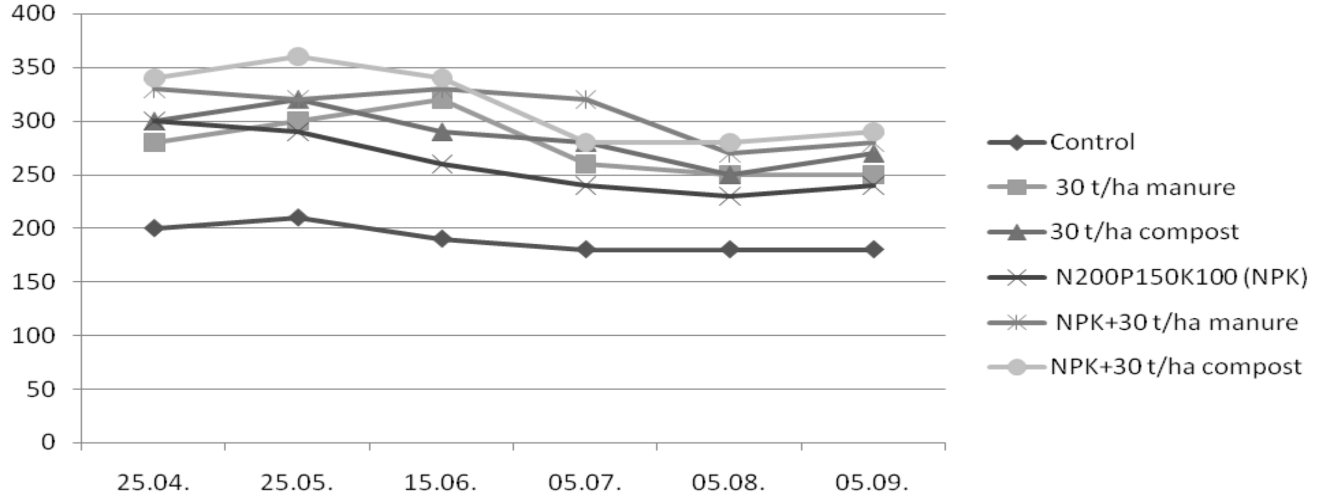

Figure 4. Influence of organic and mineral fertilizers on exchangeable potassium content in the soil, mg/kg (2011)

Improving of nutritional regime of the soil influenced positively on the growth and yield capacity of corn. Because of deficiency of nutrient substances in the control, yield capacity of corn was the lowest. Thereby yield capacity of corn has been decreased constantly from year to year.

In soils, saline with magnesium carbonates the content of soil nutrition substances was very low. It was not enough nutritional substances for normal growth of crops without fertilizers. Application of manure and compost improved the nutrition regime of soils, saline with carbonates. This led to improving of growth and yield capacity of corn substantive. Mineral fertilizers influence on the growth of crops sharply than organic fertilizers. In application of mineral fertilizers the yield capacity of corn was higher than application of manure and compost without minerals. Application of organic fertilizers in the background of mineral fertilizers led to maximal yield capacity of corn. Thereby nutrition substances of the soil were enough for the growth of corn-plant. In variants of application of manure and compost the increasing of corn grain was respectively -2,06 t/ha (85,5%) and 2,16 t/ha (89,6%); in mineral fertilizers -4,3 t/ha (178,4%); in application of manure and compost in the background of mineral fertilizers was -6,11 (253,5%) and 6,26 t/ha (259,7%) respectively (Figure 5).

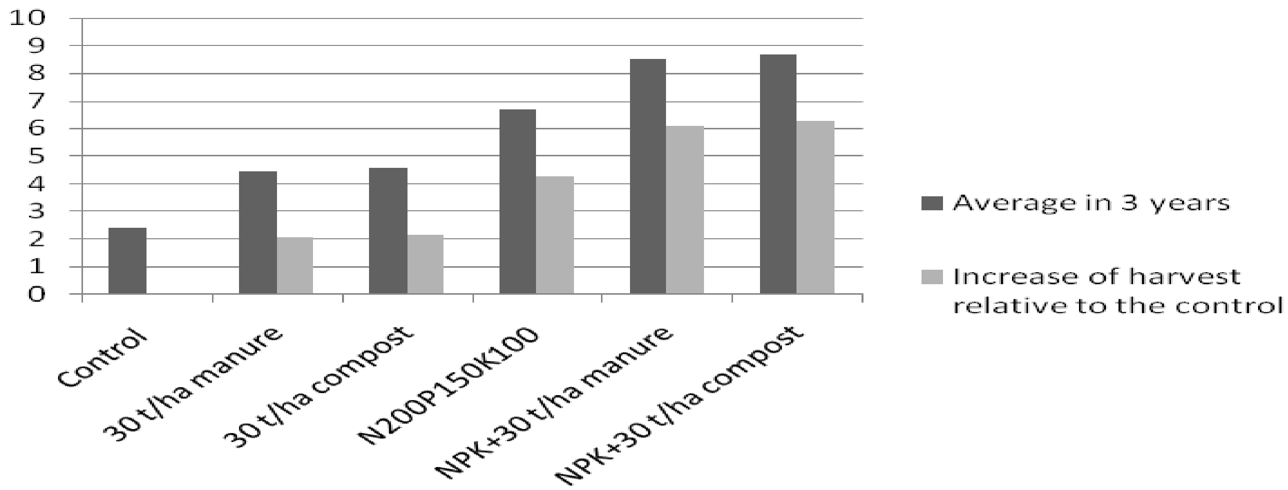

Figure 5. Influence of organic and mineral fertilizers on yield capacity of corn (2009-2011 years)

1st year significant: =0,405 t/ha, Sx % =4,49*

2nd year significant:=0,505 t/ha, Sx % = 5,28*

3rd year significant:=0,418 t/ha, Sx % = 4,52*

*Significant at 0.05 level

Conclusion

Thus, compost, prepared from tobacco wastes increases the humus content of soils, saline with carbonates, improves nutrition regime of soil substantive. In the application of this compost, content of mineral nitrogen, mobile phosphor and exchangeable potassium increased. Improving of the soil nutritional regime leads to improving corn growth and increasing the yield capacity. This compost doesn't concede the traditional organic fertilizer-manure and substitute it partly. Utilization of tobacco wastes through preparing of composts protects environmental pollution from wastes and decides the problem of deficiency of organic fertilizers in agriculture. Besides, increasing of soil organic matter through fixation of carbon dioxide in the soil is the topic of current interest for decreasing of carbon dioxide content in the atmosphere during the period of global climate change.

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References

Dospexov B.A. 1985. Methods of field trials. Agropromizdat. Moscow. 352p. (in Russian)

Hayitov M. 2013. Some properties of formation phosphoric regime in typical grey soils. Book of the conference "Integration of science and production is the important factor of efficiency of agriculture". Samarkand AI. Samarkand. 22-24 (in Uzbek)

Holikulov S. Pardaev S. 2003. Morphological content of urban hard wastes of the population of Samarkand city and ecological problems, dependent on it. Ecological Bulletin. Tashkent. 3. 39-41. (in Uzbek)

Holikulov S.T., Ortikov. T.K. 2007. Technological options to enhance humus content and conserve water in soils of the Zarafshan valley, Uzbekistan In: Lal R., Suleymanov B.A.,Stewart D.O., Hansen & Doraiswamy. Climate change and terrestrial carbon sequestration in Central Asia. Taylor & Francis Group London, UK. 512p.

Hoshimov F., Ortikov T. 1993. Some questions of the environmental consequences of application high doses of nitrogen fertilizers. Abstracts of the International Conference. Alma Ata-Istanbul. 85-86. (in Russian)

Kuguchkov D.M. 1954. About carbonate salt accumulation in soils of Uzbekistan. Synopsis of the dissertation for the doctoral degree. Samarkand AI. Samarkand. 19p. (in Russian)

Mashrabov M., Hayitov M., Hoshimov F. 2010. Influence of phosphoric fertilizers on the phosphorus regime in the condition of meadow grey soils of Miyonkol. Proceedings of the Delegate's Congress of Soil Scientists of Uzbekistan. Tashkent. 195-199 (in Uzbek)

National lecture for using of national sources and environmental situation in the Republic of Uzbekistan. 2006. Tashkent. Uzbekistan. 281p. (in Uzbek)

Ortikov T., Uzakov P. 2013. Efficiency of fertilizers on cotton growing in hydromorphic soils of Zarafshan valley which had various fertility and mastered degree. Proceedings of the conference of staffs. Samarkand AI. Samarkand. 17-21. (in Uzbek)

Piraxunov T.P. 1977. Phosphorus nutrition of cotton in various soil conditions. Tashkent. Fan. 164p. (in Russian)

Radov A.S., Pustavoy I.V., Korolkov A.V. 1971. Practical works on agro chemistry. Kolos. Moscow. 336p. (in Russian)

Saidmuodov O. 1973. Growth, development and yield of cotton, depending on the types and doses of fertilizers on soils, saline with calcium and magnesium carbonates. Synopsis of the dissertation for the doctoral degree. Samarkand AI. Samarkand. 20p. (in Russian)

Sattarov D.S., 1990. Main problems of improving of soil cover statement in Uzbekistan. Proceedings of the 1st Delegates' Congress of Soil Scientists of Uzbekistan. Tashkent, 3-10. (in Russian)

Trautz D., Hazratqulov S., Gremmes H. 2009. The influence of ecological properties of compost, prepared from tobacco leaves, phosphogypsum and manure on the activity of earthworms (Eisenia foetida). Agrarian Bulletin of Uzbekistan. Tashkent. 4. 96-102. (in Uzbek)

Uzakov P.U. 1963. Genesis, properties and dissemination of saline soil with carbonates in Zarafshan Valley and ways of their agricultural use. Synopsis of the dissertation for the doctoral degree. Samarkand AI. Samarkand. 24p. (in Russian)

Yagodin B.A., Deryugin I.P., Jukov Y.P., Demin V.A., Peterburgskiy A.V., Kidin V.V., Slinchik A.F., Kulyukin A.N., Sablina S.M. 1987. Practical works on agro chemistry. Agropromizdat. Moscow. 512 p. (in Russian)

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Influence of crop rotation and fertilization on the microbial activity in rhizospheric soil

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Abstract

Organic matter is the most important source of plant nutrients therefore the Increase of organic matter content in soil is a vital prerequisite for soil fertility and quality. Application of organic fertilizer are essential for the maintanence of soil natural fertility. The aim of this research was to investigate the unfluence of crop rotation and fertilization on soil biological properties. Soil samples for microbiological analises were taken from the following treatment:1. Monoculture of maize (MO), 2. Maize-wheat (without fertilization, NF2), 3. Maize-wheat (with fertilization, F2), 4. Maize-soy-wheat (with fertilization, F3S), 5. Pasture soil (P), 6. Forest soil under oak (F) from three depth: 0-10 cm, 10-20 cm and 20-30 cm in may and october of 2012. Microbiological analyses included the determination of total number of bacteria (TNB), number of fungi (FNG), actinomycetes (ACT), aminoheterotrophs (AMH) and azotobacter (AZB). Comparison of microbiological parameters by depth and different soil usage showed that certain statistically important changes did occur in soil. The number of investigated groups of microorganisms at to the beggining of the plant vegetation period were, in average higher in relation to the end of vegetation period. Crop rotation affected positively the TNB is soil under maize, especially at the beggining of vegetation, while fertilization treatments did not influence significantly the TNB. Statistically significant changes in the number of ACT and FNG were not achieved in maize rhizospheric soil. Crop rotation influenced the number of AZB and AMN. The number of all investigated groups of microorganisms decreased with the increase of soil depth though those changes were not in the range of statistical significance.

Keywords: crop rotation, monoculture, maize, microorganisms.

Introduction

Soil is a complex dynamic system comprised from solid, liquid and gaseous phase. Minerals and organic matter are parts of the solid phase (Molnar, 2004). Soil organic matter (SOM) makes only a few percentage of the soil total mass. However, the fast transformation and higher activity makes it very important due to its impact on overall soil dynamics and its properties (Jarak and Čolo, 2007). The highest percentage of SOM is humus. Microorganisms play a crucial role in the processes of humification as well as in the cycles of macro and micro nutrients (Cairney,2000; Klironomos et al., 2000).

Numerous physical and chemical properties of soil, tillage, plant species and other factors influence the diversity and abundance of microorganisms in soil (Jarak et al., 2003). According to Nannipieri et al. (2003) the number of certain groups of microorganisms and their enzymatic activity depended on the variability of soil properties as well as the level of antropogenisation. Many authors argued that the amount and the type of SOM had an significant impact on the microbial biomass in soil (Grayston et al., 2001). Vast majoroty of soil

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microorganisms use organic sources of nutrients and energy. Therefore, soils with higher SOM content have a more diverse and developed microbial population (Bo Liu et al., 2007).

The aim of this research was to investigate the unfluence of crop rotation and fertilization on soil biological properties.

Material and Methods

Soil samples for microbiological analises were taken from the following treatment: 1. Monoculture of maize (MO), 2. Maize-wheat (without fertilization, NF2), 3. Maize-wheat (fertilization pattern: 120 kg ha^{-1} N under maize and 100 kg ha^{-1} N under wheat, F2), 4. Maize-soy-wheat (fertilization pattern: 120 kg ha^{-1} N under maize, 100 kg ha^{-1} N under wheat, microbial fertlizer Nitragin under soy, manure-25 t ha^{-1}, F3S), 5. Pasture soil (P), 6. Forest soil under oak (F) from three depth: 0-10 cm, 10-20 cm and 20-30 cm in may and october of 2012.

The total number of microorganisms (TNB), the number of aminoheterotrophs (AMH), azotobacter(AZB), actinomycetes (ACT) and fungi (FNG) was determined by the method of agar plates (Trolldenier, 1996). Appropriate nutrient media were used (Hi Media Laboratories Pvt. Limited, Mumbai, India): nutrient agar for the total number of bacteria, synthetic agar for the number of actinomycetes, potato dextrose agar for the number of fungi, meat peptone agar for the number of aminoheterotrophs, and azotobacter medium with manitol for the number of azotobacter.

The data were statistically processed using STATISTICA 10 software.

Results and Discussion

Results of the research are presented in Tables 1. and 2. Fertilization did not affected the total number of microorganisms. Crop rotation had a stimulatory effect on the total number of microorganisms at the begining of the vegetation period. Statistically significant higher number of microorganisms were recorded in the treatment without fertilization in comparison to other investigated treatments at the end of vegetation period. Đurić et al., (2004) studied the same treatments and concluded that the highest microbial activity was determined after maize cultivation in system with three crops without fertilization. The highest total number of microorganisms was determined under maize monoculture at the depth from 20 to 30 cm in october.

Table 1. Number of microorganisms in soil – May 2012. (log No g^{-1} soil)

Treatments	Depth (cm)	TNB	FNG	ACT	AZB	AMH**
MO	0-10	8,7$^{e, f}$	5,2$^{a, b, c}$	5,3^{a}	3,2$^{a, b}$	8,6$^{c, d, e, f, g, h}$*
	10-20	8,5^{f}	4,8$^{b, c, d, e}$	5,0$^{a, b}$	3,3$^{a, b}$	8,9$^{b, c, d, e, f, g}$
	20-30	7,6^{g}	4,6$^{d, e, f, g}$	5,1$^{a, b}$	3,4^{a}	8,3$^{f, g, h}$
NF2	0-10	9,9^{a}	5,2$^{a, b}$	4,8$^{b, c}$	3,3$^{a, b}$	8,5$^{d, e, f, g, h}$
	10-20	9,8^{a}	5,2$^{a, b}$	4,6^{c}	3,3^{a,b}	7,7^{h}
	20-30	9,5^{a}	5,2$^{a, b}$	4,9$^{a, b, c}$	3,1^{b}	8,5$^{c, d, e, f, g, h}$
F2	0-10	9,8^{b}	5,2$^{a, b}$	4,8$^{b, c}$	3,3$^{a, b}$	10,2^{a}
	10-20	9,8^{a}	5,2$^{a, b}$	4,6$^{c, d}$	3,3$^{a, b}$	9,1$^{b, c, d, e, f}$
	20-30	9,5^{a}	5,2$^{a, b}$	4,9$^{a, b, c}$	3,4^{a}	9,7$^{a, b}$
F3S	0-10	9,5^{b}	5,3^{a}	4,9$^{a, b, c}$	3,3$^{a, b}$	9,0$^{b, c, d, e, f, g}$
	10-20	9,2^{c,d}	5,1$^{a, b, c}$	4,9$^{a, b, c}$	3,3^{a,b}	9,0$^{b, c, d, e, f, g}$
	20-30	8,7$^{e, f}$	5,1$^{a, b, c}$	5,0$^{a, b}$	3,4^{a}	8,4$^{e, f, g, h}$
P	0-10	9,4$^{b, c}$	5,1$^{a, b, c}$	5,2$^{a, b}$	2,7^{c}	8,1$^{e, g}$
	10-20	9,3$^{b, c}$	5,0$^{a, b, c, d}$	4,8$^{b, c}$	2,7^{c}	9,5$^{a, b, c, d}$
	20-30	8,9$^{d, e}$	4,8$^{c, d, e, f}$	4,6^{c}	2,5^{c}	9,7$^{a, b}$
F	0-10	9,3$^{b, c}$	4,4$^{e, f, g}$	4,5$^{c, d}$	0,8^{d}	9,5$^{a, b, c}$
	10-20	9,1$^{c, d}$	4,3$^{f, g}$	4,0^{d}	0,8^{d}	9,4$^{a, b, c, d, e}$
	20-30	8,8$^{e, f}$	4,2^{g}	4,2$^{e, d}$	0,8^{d}	9,3$^{a, b, c, d, e}$

* The different letter above the number indicates significant difference at P<0.05 according to Fisher`s test
**AMH -aminoheterotrophs; AZB – Azotobacter; TNB- total number; ACT- actinomycetes; FNG- fungi;

Results analysis showed that fertilization and crop rotation did not stimulate the increase of the microbial biomass, partcularaly fungi and actinomycetes in soil. Šeremešić (2012), also found that treatments without ferilization had much higher number of fungi in comparison to the treatments with fertlization. Number of fungi decreases with the increase of soil depth in treatments with maize monoculture, pasture and forest soil. Number of actinomycetes decreased in deeper soil layers and that decrease was statistically significant. Statistical analysis showed that fertlization did not exert a significant influence on the number of free-living nitrogen fixing bacterium *Azotobacter* sp. Its number in forest soil samples was less abundant which can be explained by low soil pH.

Table 2. Number of microorganisms in soil – October 2012. (log No g^{-1} soil)

Treatments	Depth (cm)	TNB	FNG	ACT	AZB	AMH**
MO	0-10	7,3 $^{e, f}$	3,9 $^{d, e, f}$	4,6 $^{c, d, e}$	2,9 $^{a, b}$	7,3 $^{g, f}$
	10-20	7,3 $^{e, f}$	5,3 ^{a}	4,5 $^{d, e}$	2,9 ^{b}	7,3 $^{g, f}$
	20-30	9,1 $^{a, b, c, d}$	5,1 $^{a, b}$	4,5 $^{d, e}$	2,9 $^{a, b}$	8,9 $^{a, b, c, d, e}$
NF2	0-10	9,2 $^{a, b, c, d}$	4,1 $^{c, d, e, f}$	4,1 ^{e}	2,9 ^{b}	9,4 $^{a, b}$
	10-20	9,1 $^{a, b, c, d}$	4,7 $^{a, b, c, d}$	4,6 $^{d, e}$	3,0 $^{a, b}$	9,4 $^{a, b}$
	20-30	9,5 $^{a, b}$	5,0 $^{a, b}$	4,1 ^{e}	3,2 $^{a, b}$	9,6 ^{a}
F2	0-10	8,2 $^{c, d, e}$	4,9 $^{a, b}$	5,4 $^{a, b, c}$	3,2 $^{a, b}$	9,0 $^{a, b, c, d}$
	10-20	7,0 ^{f}	4,6 $^{a, b, c, d}$	5,1 $^{a, b, c, d}$	2,9 $^{a, b}$	8,1 $^{f, e, d}$
	20-30	8,1 $^{d, e, f}$	4,9 $^{a, b}$	4,7 $^{b, c, d, e}$	3,0 $^{a, b}$	8,6 $^{a, b, c, d}$
F3S	0-10	7,3 $^{e, f}$	3,7 $^{a, f}$	5,1 $^{a, b, c, d}$	3,0 $^{a, b}$	9,4 $^{f, g}$
	10-20	7,3 $^{e, f}$	4,3 $^{b, c, d, e}$	5,1 $^{a, b, c, d}$	3,2 ^{a}	9,2 $^{c, d, e, f}$
	20-30	7,3 $^{e, f}$	4,0 $^{c, d, f}$	4,5 $^{d, e}$	3,3 ^{a}	9,0 ^{g}
P	0-10	8,6 $^{b, c, d}$	5,0 $^{a, b}$	5,1 $^{a, b, c, d}$	3,3 ^{c}	8,0 $^{f, g}$
	10-20	8,1 $^{d, e, f}$	4,6 $^{a, b, c, d}$	4,6 $^{d, e}$	1,9 ^{c}	8,2 $^{c, d, e,f}$
	20-30	8,3 $^{c, d, e}$	4,8 $^{a, b, c}$	4,6 $^{c,d, e}$	1,9 ^{d}	7,1 ^{g}
F	0-10	9,3 $^{a, b, c}$	4,0 $^{c, d, e, f}$	5,5 $^{a, b}$	0,7 ^{d}	8,5 $^{b, c, d, e}$
	10-20	9,8 ^{a}	3,3 ^{f}	5,5 ^{a}	0,7 ^{d}	8,9 $^{a, b, c, d, e}$
	20-30	9,7 $^{a, b}$	4,1 $^{c, d, e, f}$	4,9 $^{a, b, c, d}$	0,7 ^{d}	9,2 $^{a, b, c}$

* The different letter above the number indicates significant difference at P<0.05 according to Fisher`s test

**AMH -aminoheterotrophs; AZB – Azotobacter; TNB- total number; ACT- actinomycetes; FNG- fungi;

Results analysis showed that fertilization and crop rotation did not stimulate the increase of the microbial biomass, partcularaly fungi and actinomycetes in soil. Šeremešić (2012), also found that treatments without ferilization had much higher number of fungi in comparison to the treatments with fertlization. Number of fungi decreases with the increase of soil depth in treatments with maize monoculture, pasture and forest soil. Number of actinomycetes decreased in deeper soil layers and that decrease was statistically significant. Statistical analysis showed that fertlization did not exert a significant influence on the number of free-living nitrogen fixing bacterium *Azotobacter* sp. Its number in forest soil samples was less abundant which can be explained by low soil pH.

Our research showed that the introduction of crop rotation with different levels of fertilization affected positively the number of aminoheterotrophs in soil under maize during vegetation period. This is in accordance with the results of numerous scientists. Fertilizer treatments significantly ($P < 0.01$) increased microbial biomass nitrogen (MBN) and microbial biomass carbon (MBC) with the maximum increase in mixed application of farmyard manure and mineral fertilizers treatment both in surface and sub-surface soil (Ahmad et al., 2014). The authors concluded that the cropping patterns having cereal–legume rotation improved organic soil fertility by 25%, 11.4%, 13% and 44% increase in total N, mineral N, MBN and MBC after a 10 day incubation period over the cereal-cereal rotation, respectively. The increase of microorganisms from N cycle was expected since large amount of mineral N fertilizer and manure were applied.

The addition of organic and inorganic fertilizers in an integrated form increased soil organic matter content that provides a carbon source and other nutrients for microbes (Courtney and Mullen, 2008) and altered the biochemical properties of the soil by increasing potentially mineralizable N and microbial biomass C and N (Monaco et al., 2008).

Conclusion

The number of investigated groups of microorganisms at to the beggining of the plant vegetation period were, in average higher in relation to the end of vegetation period. Crop rotation affected positively the TNB in soil under maize, especially at the beggining of vegetation, while fertilization treatments did not influence significantly. Statistically significant changes in the number of ACT and FNG were not achieved in maize rhizospheric soil. Crop rotation influenced the number of AZB and AMN. The number of all investigated groups of microorganisms decreased with the increase of soil depth though those changes were not in the range of statistical significance.

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References

Ahmad W, Farmanullah , Zahir Shah , Muhammad Jamal, Kawsar Ali Shah 2014. Recovery of organic fertility in degraded soil through fertilization and crop rotation. Journal of the Saudi Society of Agricultural Science, http://dx.doi.org/10.1016/j.jssas.2013.01.007

Bo L., Gumpertz, M.L., Shuijin, H., Ristaino, J.B. 2007. Long-term effects of organic and synthetic soil fertility amendments on soil microbial communities and the development of southern blight. Soil Biology and Biochemistry 39, 2302-2316.

Cairney, J.W.G. 2000. Evolution of mycorriza systems, Naturwisenschaften 87, 467-475.

Courtney, R.G., Mullen, G.J., 2008. Soil quality and barley growth as influenced by the land application of two compost types. Bioresource Technol. 99 (8), 2913–2918.

Đurić, S., Jarak, M., Šeremešić, S., Milošev, D. 2004. Effects of crop rotation and fertilization on microbiological activity in soil. Proceedings of the ESNA XXXIV Annual meeting, 128-131.

Grayston, S.J., Griffith, G.S., Mawdsley, J.L., Campbell, C.D., Bardget, R.D. 2001. Aaccounting for variability in soil microbial communities of temperate upland grassland ecosystem. Soil Biology and Biochemistry, 33, 533-551.

Jarak, M., Čolo, M. 2007. Mikrobiologija zemljišta, Poljoprivredni fakultet, Novi Sad, 1-209.(in serbian)

Jarak, M., Đurić, S., Hajnal, T., Udovički, M. 2003. Mikrobiološka aktivnost kao pokazatelj sabijenosti zemljišta. Tractors and power machines, 8., 176-181. (in serbian)

Klironomos, J.N., McCune, J., Hart, M., Neville, J. 2000. The influence of arbuscular mycorrhizae on the relationship between plant diversity and productivity, Ecology Letters, 3, 137-141.

Molnar, I. 2004. Opšte ratarstvo, Poljoprivredni fakultet, Novi Sad. (in serbian)

Monaco, S., Hatch, D.J., Sacco, D., Bertora, C., Grignani, C., 2008. Changes in chemical and biochemical soil properties induced by 11 year repeated additions of different organic materials in maizebased forage systems. Soil Biol. Biochem. 40, 608–615.

Nannipieri, P., Ascher, J., Ceccherini, M.T., Landi, L., Pietramellara, G., Renella, G. 2003. Microbial diversity and soil functions, Eur.J.Soil Sci. 54, 665-670.

Šeremešić, S. 2012. Uticaj sistema ratarenja na svojstva organske materije černozema. Doktorska disertacija. Poljoprivredni fakultet, Novi Sad. (in serbian)

Trolldenier, G. 1996. Plate Count Technique. In Methods in Soil Biology. Ed.Franz Schinner, Ellen Kandeler, Richard Ohlinger, Rosa Margesin. Springer-Verlag Berlin Heildeberg., 20-26.

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The investigation of pathogenic situation of soil irrigated by treated waste water

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Abstract

The competition for the resources of clean water which allocated for agricultural purposes against drinking, domestic and industrial uses etc. is increasing each passing day. Because of this reason, nowadays, reuse of treated waste water in agriculture is considered as one of the most important and sustainable water resources. High cost investments are being made for reducing the negative environmental impact of the urban waste water and the operational costs of the facilities are also very high. However, the water treated to certain extends and generally suitable for agricultural irrigation is emptied into various water bodies such as the sea and rivers instead of reuse in agricultural. Many countries like Spain, Israel, Tunisia, USA, etc. use treated waste water for agricultural irrigation. Although pilot applications are carried out in Turkey, the main concern is the health risk stemming from microbiological contamination form agricultural products grown with treated water. The fact that use of treated waste water in irrigated agriculture by suitable irrigation methods and control applications has been proved to reduce the microbiological risk. Redirecting the treated water which is treated under costly processes and restored the quality features for a clean environment into agriculture provides a considerable amount of water supply for plant production. The Research was conducted at International Agricultural Research and Training Centre Menemen-İzmir-Turkey in the late summer period in 2013. In this research, lettuce were irrigated by 3 different irrigation methods, drip irrigation, subsurface drip irrigation and furrow irrigation, with domestic sourced treated waste water. The total viable bacteria, E. coli counts and salmonella test of treated waste water used for irrigation were run. The soil samples were taken from the depth of 0-20 cm, where is including the most intensive layer of microbiological activities, two times in a year, before irrigation and after harvest. Total viable bacteria, coliform bacteria and E. coli counts were determined. Helminth eggs and protozoa (*Giardia lamblia*) detection tests were run. According to the results of analysis, it was shown that, the total viable bacteria, fecal coliform and E. coli counts after irrigation were increased and helminth eggs and protozoa cysts were not detected. According to the analyses of soil samples before irrigation by treated waste water salmonella was also counted beforehand. It is thought that, this case can be a result of the feces of winged living around the trial area.

Keywords: waste water, reuse, soil, irrigation, pathogen

Introduction

The increasing population, contamination of surface and ground waters, irregular distribution of water resources and periodic droughts have led people to look for new and anticipatory water resources. Waste water has been used in irrigation for centuries. But today this application has become more and more important due to the limited water resources (Filibeli, Yüksel, 1994).

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The farmers in Menemen Plain, where irrigation water deficiency is an important issue, have been increasingly demanding and pressing for the use of waste water treated in Menemen Biological Waste Water Treating Facility for irrigation (Avcı et al. 2003; Bahri and Brissaud, 2004). However it is quite important for human and animal health to realize and constantly trace the possible changes in the ground water quality which is used both for drinking and irrigation in case of using treated waste water (Aşık et al 2004).

Menemen Biological Waste Water Treating Facility treats domestic waste water. Treated waste water is discharged to drainage channel and conveyed to Aegean Sea. But especially in July and August when irrigation is at maximum farmers use the treated water from this canal for irrigation. Thusly both industrial plants like cotton, maize and vegetables like tomato, pepper, lettuce are irrigated with this water. This case poses a serious risk for human health while nutrution elements such as N, P and K in treated waste water become nutrutions for the plants.

Material and Methods

The study was conducted in IARTC randomized blocks with 3 repetitions at the end of the summer and the beginning of autumn in 2013.

Domestic waste water treated by Menemen Biological Waste Water Treating Facility was used as irrigation water. As plant material Kassam lettuce variety was chosen. Trial subjects were subsurface drip irrigation, drip irrigarion and furrow irrigation.

Treated waste water was taken from the discharge canal of the facility and brought to trial area. Every week, samples were taken from the discharge canal into disinfected bottles with the help of rubber gloves. Standart irrigation water analysis, contamination analysis and some microbiological analysis were run on these samples. EC, pH and fecal coliform values were traced weekly. Soil samples were taken twice, once before plantation and once after harvest, from the depth of 0-20 cm where microbiological activity is at maximum. Soil samples were taken into sterilized containers with the help of rubber gloves.

Results and Discussion

Fecal coliform number in treated water used in irrigation was found unsuitable to the guideline in our country and also to the guideline of WHO for irrigation of fresh consumed vegetables.

Table 1. The weekly results of treated waste water (pH, EC, and fecal coliform) during 2013 irrigation season.

Date	pH	EC(dS/m)	Fecal coliform cfu/100ml
20.08.2013	7.82	2.856	3.26×10^3
26.08.2013	7.73	2.765	1.965×10^3
03.09.2013	7.69	3.005	2.667×10^3
10.09.2013	7.65	2.895	3.165×10^3
01.10.2013	7.56	2.450	1.955×10^3

BOD_5 analysis results varied between 15mg/l and 18/l. According to the Turkey standarts and guideline these values are acceptable and considered as 1st Class water. It is considered as 3rd Class water according to NO_3-N values and 1st and 2nd Class water within the suspended solid cleansed waters.

Table 2. The water pollution analyses results of treated waste water used for irrigation in 2013

Date	COD	BOD_5	SS	TN	NO_3-N	T P
03.09.2013	28	15	11.5	38	10.9	1.1
10.10.2013	29	15	24.3	60	24.5	5.3
22.10.2013	42	18	13.8	42	14.5	1.3

The potential toxic element concentration values of the treated water which was used in 2013 was analyzed and for the sample taken on 10th October 2013. Cr value was found to be higher than the reference value while the others were lower.

See Table 5 for the microbiological analysis results on the soil samples taken from 0-20 cm depth both at the beginning of the trial and at the end of 2013 irrigation season.

Table 3. The monthly values of anion and cation in treated waste water.

Date	EC (dS/m)	pH	B (ppm)	Na%	SAR	Cations, me/l				Anions, me/l			
						Na	K	Na	K	Na	K	Na	K
03.09.2013	2.409	7.52	1.21	55.02	5.75	12.72	0.60	4.80	5.00	7.95	3.70	11.47	23.12
10.10.2013	3.324	7.67	0.66	61.17	8.81	23.31	0.80	4.80	9.20	7.80	4.20	26.11	38.11
22.10.2013	2.752	7.62	0.48	49.18	5.36	14.13	0.70	5.70	8.20	8.00	2.50	18.23	28.73

Table 4. Potential toxic elements values in treated waste water (ppb)

Date	Fe	Cu	Zn	Mn	Pb	Cd	Cr	Co	Ni
03.09.2013	35.47	1.83	39.04	1.59	8.14	0.19	8.47	0.30	1.98
10.10.2013	1527.85	7.94	218.42	42.33	17.46	0.25	**116.36**	1.18	1.34
22.10.2013	29.75	1.53	30.20	0.87	15.54	0.25	4.88	0.67	1.19
Referance values in Turkey	5000	200	2000	200	5000	10	100	50	200

The total number of viable bacteria in the samples at the beginning of the trial varied between $1.3x10^6$ cfu/100g and $2,2x10^6$ cfu/100g while it varied between $1.2x10^7$cfu/100g and $1.9x10^7$cfu/100g in the samples taken after harvest. At the beginning of the season, thusly before irrigation with treated waste water, salmonella was encountered in the soil. It is considered that because of the feces of the birds. According to the analysis run both before planting and after harvest no helminth egg cysts or/and no protozoon (*Giardia lamblia*) was found.

Table 5. The results of microbiological analyses of the soil samples.

Time for soil samples	Subjects	Total viable bacteria (cfu/100g)	Coliform bacteria (cfu/100g)	E. Coli (cfu/100g)	*Salmonella spp.*	Helminth eggs and protozoon
Before Planting	Drip irrigation	$2.2x10^6$	$2.1x10^3$	$2.1 x10^3$	+	-
	Subsurface drip irrigation	$1.7 x10^6$	$2.7 x10^3$	$2.5 x10^3$	+	-
	Furrow irrigation	$1.3 x10^6$	$3.3 x10^3$	$3.3 x10^3$	+	-
After harvest	Drip irrigation	$1.2x10^7$	$3.8 x10^3$	$3.2 x10^3$	+	-
	Subsurface drip irrigation	$1.7 x10^7$	$3.5 x10^3$	$3.1 x10^3$	+	-
	Furrow irrigation	$1.9 x10^7$	$4.1 x10^3$	$3.9 x10^3$	+	-

Total viable bacteria, coliform bacteria and E. coli counts were determined. Helminth eggs and protozoa (*Giardia lamblia*) detection tests were run. According to the results of analysis, it was shown that, the total viable bacteria, fecal coliform and E. coli counts after irrigation were increased and helminth eggs and protozoa cysts were not detected.According to the analyses of soil samples before irrigation by treated waste water salmonella was also counted beforehand. It is thought that, this case can be a result of the feces of winged living around the trial area.

Conclusions

The competition for the resources of clean water allocated for agricultural purposes against drinking, domestic and industrial uses etc. is increasing day by day. Because of this reason, nowadays, reuse of treated waste water in agriculture is considered as one of the most important and sustainable water resources. Fecal coliform number in treated water used in irrigation was found unsuitable to the guideline in our country and also to the guideline of WHO for irrigation of fresh consumed vegetables. And The results of the microbiolocigal analysis run on the randomly taken lettuce samples from the trial subjects shows that, furrow irrigation subject has the highest pathogenic contamination values with 1123 cfu/100g E. Coli. Yet there is less pathogenic contamination with values such as 953 cfu/100 g for drip irrigation and 363cfu/100 g for sub-surface drip irrigation. It’s only shown one and very important advantages of subsurface irrigation.

References

Avcı, M., Aşık Ş., Ünal H.B., Akkuzu E., Kılıç M., ve. Karataş B.S. 2003. Menemen Ovasında su dağıtım performansı ve su dağıtımına çiftçi tepkileri üzerine bir araştırma, EÜ Bilimsel AraştırmaProjeRaporu (Proje No:2000-ZRF-035)

Blumenthal, U.J., Peasey, A., Ruiz-Palacios G. and Duncan Mara, D., 2000. Guidelines for Wastewater Reuse in Agriculture and Aquaculture: Recommended Revision Based on New Research Evidence. Water and Environmental Health at London and Loughborough (WELL) Study, Task No: 68, Part 1, Loughborough University, UK. http://www.lboro.ac.uk/well/ (12.06.2012

Bahri, A. andBrissaud, F., 1996. Waste water Reuse in Tunisia: Assessing a National Policy. Water Science and Technology, 33 (10-11), 87-94

Filibeli, A. ve N. Yüksel. 1994. Tarımsal sulama suyu ihtiyacı için atık su potansiyelinin değerlendirilmesi. Gökova Körfezi Çevre Sorunları ve Çevre Yönetimi Semp., 139-152. http://www.ldeo.columbia.edu /edu/dees /ees/lithosphere/haystutorial3/hydro.htm.Erişim:Aralık 2004

Karataş, B., Akkuzu E., Aşık Ş., 2005. İzmir Kentsel Arıtılmış Atık Sularının Sulamada Kullanım Olanaklarının İncelenmesi. Ege Üniv. Ziraat Fak. Derg., 2005,42(3):111-122. ISSN 1018-885.

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Automorphic soils of North Forest – Tundra subzone (North-East of European Russia)

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Abstract

Automorphic soils Gelic Cambisols and Spodi-Stagnic Cambisols on loamy deposits of North Forest – Tundra subzone were under study. In Gelic Cambisols accumulation and migration of organic compounds within the profile process, Al-Fe humic illuviation process, discovered by the analysis of sandy-silty coatings (skeletans) in the upper part of profile, and feebly expressed, diagnosed by the analysis of inner aggregate mass eluvial-illuvial profile differentiation, are fixed. Features' expression of cryogenic processes is shown. In Spodi-Stagnic Cambisols peculiarities of the contemporary cryogenic phase of evolution are observed: redox mobilization process, Fe-migration process in microprofile of podzol in the upper part of profile and forming of cryometamorthic horizons in the lower part of it. Features inherited from the former phases of development were discovered.

Keywords: Gelic Cambisols, Spodi-Stagnic Cambisols, mezo-, micromorphology, inherited features

Introduction

A contact position of ecoton is the reason for distinctiveness and complexity of pedogenesis in biogeocenosis of tundra and forest landscapes of forest-tundra subzone. Transitional zones are contrasting according to their nature, they are characterized by special dynamics of fluctuation and trends, variety of landscapes and soils, expression in a certain degree of relict and inherited features.

Podzols on sands in well drained conditions are discovered on the 280th km to the north from the border of forest in Quebec (Sanborn at al., 2011). Presence of podzolic soils and paleosoils in the Arctic tundra is connected with the vegetation of forests in the past (Bryson at al., 1965). This viewpoint is supported by a number of researches of peat lands (Bolykhovskaya at al., 1988; Krasovskaya, 1996) as well as remainders of wood (Kremenetskiy at al., 1996; Khantemirov, and Shyiatov, 1999; Kaakinen, and Eronen, 2000). Presence of typically tundra species (Moneses uniflora (L.), (Ramischia secunda (L.) on the islands of forest not far from the Barents seashore, in the basin of the More-U river (Tolmachev, and Tokarevskikh, 1966) points out spreading of taiga forests into warm Holocene phases. According to the data (Kaakinen, and Eronen, 2000), on the basis of bored tree stem and pollen in peat lands researches, maximum spreading of lignose (tree vegetation) on the north-west of Bolshezemelskaya tundra (68°02' NL and 54°08' EL) happened 5500-3000 years ago. Characteristics of inherited features preserved in the soils from the former phases of development and testifying to soil polygenesis are paid not much attention to. Polygenesis of loamy soils is interpreted in

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different ways. Preservation of eluvial-illuvial differentiation on granulometric and bulk composition is considered the result of pedogenesis of the Holocene Optimum (Targulyan at al., 1978; Ignatenko, 1979). At the same time, the possibility of soils forming on originally double layer deposits, defining profile differentiation, due to covering silt genesis on the north-east of the East European Plain. In compliance with the other statements, there was no substantial displacement of tree vegetation in the Holocene Optimum period. Complexity of finding solutions for such problems demands up-to-date methods and approaches.

The aim of this article is the characteristic of pedogenesis peculiarities, structural organization, expression of inherited features, cryogenic and pedogenic processes in automorphic soils of tundra boigeocenosis and forest-tundra islands.

Material and Methods

Integrated approach to the soils research includes analysis of structural organization and functioning products differentiation (clay and sandy-silty coatings complex) with the help of the method developed by V.O. Targulyan (1974). Monoliths of unbroken structure were selected as increased humidity and frequent thixotropy of tundra soils make the process of sampling preparation near the cut-off impossible. There is a description of mezomorphology that was done in a fivefold increase. Samples of inner aggregate mass (IAM) were received by cutting the surface layer of the aggregate. Sampling of concretions was done by wet sifting method. The description of cryogenesis features in soils took place, the content including chemical composition of concretions and structural components were defined. Physical chemical properties of soils were defined with the help of universal (generally accepted) methods (Theory and practice…, 2006). The rule of oxidogenesis is calculated by Vodyanitsky's formula (2003).

The researches took place in the basins of the Choseda-U and Seida rivers. Vegetation of spotty hummocky tundra landscapes is represented, in general, by shrub-moss-lichen vegetation. Rarified fur and fur-birchen forests with dwarf birches undergrowth and suffruticous-lichen ground cover are timed to well drained slopes of river valleys.

The territory under study is characterized by massive-island permafrost about 50 m, permafrost table is deeper than 0.5-8 m. Among soil forming species moraine loams, two layered deposits dominate, on the watershed covering loams are spread. As the object for research Gelic Cambisols and Spodi-Stagnic Cambisols, forming on silty loams in tundra and forest landscapes, were taken.

Results and Discussion

Gelic Cambisols is spread on a bulging surface of a ridge (67.02° NL; 63.03° EL). The cut is placed under dwarf birches, with dwarf shrub-hypnum tundra.

O 0-7 cm. Dark-greyish-brown, loose, damp bedding with a tough humic layer 2 cm thick on the border with the mineral thickness.

CRM1 7-11 cm. Greyish-brown with some brown-greyish-brown and greyish-brown-whitish spots in the upper part, middle silty loam, scatters into aggregates of round-angular form 3 -5 mm in size. Whitish thin skeletans (sandy-silty coatings) and brown matt membranes on the surface. In the fracture of light-brown ped thin inner aggregate tube pores about 1 mm in diameter, whitish spots of skeletans, can be noticed. Consistent, fresh, small ochre spots, numerous roots. Gradual transition.

CRM2 11-24 cm. Light greyish-brown with brown-greyish-brown and whitish-greyish-brown spots, middle silty loam of angular-grained structure, 5-7 mm in size and 5 mm thick; on a matt brown surface there are spots of whitish skeletans thicker than in a higher horizon (1-2 mm). The fracture of aggregate - light-brown, noticeable black dots and tube pores, and also separate brown spots (soaking with Fe-organic combinations). Subhorizontal deposition of skeletans, that take place in the intervals between aggregates are characterized by a stratified build, of smaller size, 1-2 mm thick, 7 mm – in a long axis, plate form of aggregates, abundance of skeletans. Skeletans on the upper surfaces of the aggregates are deposited as a complete layer 1-2 mm thick, on the lower layers – as separate areas. Consistent, fresh, the number of small ochre spots increases with the depth, many roots. Gradual transition.

CRM3 24-38 cm. Light greyish-brown with separate dark greyish-brown spots, sometimes like halos around pores, middle silty loam. Single roots. The size of the aggregate – 5x8 mm, thickness – 5 mm. Form – round-oval, round-angular. Skeletans, 1-3 mm thick on the upper surface, cover aggregate and fill pores within the ped. In some cases, there is a brown membrane on the pore walls. The inner aggregate mass is light greyish-brown, in some places with ferreous zones. Tube pores are about 1 mm in diameter. Stratified build, subhorizontal deposition of skeletans. Consistent, fresh, single roots. Gradual transition.

CRM4 38-70 cm. Light greyish-brown silty loam with dark greyish-brown areas, more compact. Roots. The structure is angular-grained; skeletans have greyish-brown colour, thinner and less widespread. Thin porosity. Dark greyish-brown areas are characterized by a distinct grainy structure. Small tube pores are penetrating into peds. The size of the primary ped is 5x3 mm, thickness – 2mm. The fracture has a light greyish-brown colour with small black and rusty dots. In the upper part of horizon there are concretions 3x4 mm in size hemmed by whitish membrane about 1 mm thick. Whitish skeletans are distinct near cracks. On the area between cracks – surfaces of aggregates have whitish spots. The lower part of horizon is more consistent, massive, darker in colour. No clarified whitish skeletans. Dark-brown hem of pores and brown spots appear on the surface of the aggregates. The size of the primary aggregates is a bit less. Tube pores are about 1 mm in diameter.

Frozen ground is at a depth of 1 m.

Gelic Cambisols are characterized by absence of gley horizons, cryogenic character of aggregations and presence of tough humic material over the mineral thickness. Structural organization promotes aeration of soil, that is also testified to a degree of oxidogenesis development (table 1), reduction of cryoturbation expression, as absence of overmoisture impedes cryogenic mass exchange. At the same time, a descending migration process of solutions actively develops; this fact is supported by content increase of C in skeletans deeper in profile (table 1).

Table 1. Content of mobile Fe and Al, C and N oxides in structural components of soils on the silty loams (%)

Horizon	Depth (cm)	Structural component	by Tamm		Fe_2O_3 by Mera-Jackson	C	N	C/N	Degree of oxidogenesis, total soil mass
			Fe_2O_3	Al_2O_3					
Gelic Cambisols									
CRM1	5-12	Skeletans	0.30	0.16	0.85	0.17	0.02	8	0.3
		IAM	0.32	0.18	0.75	0.20	0.03	7	
CRM2	12-27	Skeletans	0.22	0.10	0.43	0.22	0.02	11	0.4
		IAM	0.45	0.20	0.50	0.27	0.03	9	
CRM3	27-45	Skeletans	0.25	0.11	0.45	0.21	0.03	7	0.4
		IAM	0.42	0.18	0.79	0.21	0.03	7	
CRM4	45-70	Skeletans	0.23	0.11	0.33	0.18	0.02	9	0.4
		IAM	0.22	0.22	0.72	0.24	0.03	8	
Spodi-Stagnic Cambisols									
E	2,5-10	Skeletans	0.20	0.09	0.42	0.29	0.04	7	–
		IAM	0.34	0.15	0.58	0.51	0.05	10	
BF	10-17	Skeletans	0.33	0.15	0.61	0.60	0.06	10	–
		IAM	0.46	0.21	0.60	1.14	0.12	9	
CRMg	16-34	Skeletans	0.24	0.12	0.38	0.26	0.04	6	–
		IAM	0.36	0.17	0.37	0.38	0.05	8	
CRMi	34-67	Skeletans	0.26	0.11	0.30	0.12	0.02	6	–
		IAM	0.25	0.11	0.64	0.20	0.04	5	
CRMC	67-93	Skeletans	0.42	0.06	0.42	0.13	0.02	6	–
		IAM	0.65	0.11	0.65	0.19	0.03	6	

Footnote. IAM – inner aggregate mass, "–" – no data

Whitish spots of stratified build, discovered in the upper part of mineral layer, in the horizon CRM1, may be fragments of podzolic horizon. Whitish spots in the inner aggregate mass contribute to this idea.

The result of the fact that soils under study are being formed in regions with widespread permafrost is that cryohydration processes lead to an intensive rework of fragments of sandy-silty coatings (skeletans), which get cracks, alternation of deepenings on the surface, caverns (Konishchev, 1981). Unevenness on the surface of skeletan grains (sandy and silty) delay washed out from the upper horizons products of soil forming. The analysis of structural components has shown accumulation of oxalate and dithionitesoluble Fe and Al in skeletans of the horizon CRM1. Al-Fe-humic illuviation process (without forming horizon BHF under horizon O) as well as solutions going to the front of frozen ground.

Cyclical freezing and turning water into ice are accompanied by secretion of oxygen (Konishchev, 1981) and accumulation of Fe oxides on the surface of skeletons as well. Thus, pedogenic as well as cryogenic processes take part in the forming of tundra soils. Under O horizon brown-greyish-brown zones and matt brown cover on the aggregate surface, where Fe and Al oxides precipitate in the form of organo-mineral compounds, are observed. The same thing is about the description of microstructure of Gelic Cambisols, formed in the upper part of the profile near Vorkuta (Rusanova, 2013), with bored at the depth of 37-80 cm bisequia soddy podzolic soil in the lower layer. Produced in the process of bedding transformation mobile organic compounds, which are not connected with the Fe and Al oxides, migrate down in the profile, accumulating more in skeletans and inner aggregate mass of the lower horizon CRM2 (table 2). In the same horizon a certain accumulation of oxalatesoluble Fe and Al oxides in IAM soils takes place. Dark greyish-brown, brown spots in the inner aggregate mass of this horizon illustrate sedimentation of migrated, obviously, during the earlier phases of pedogenesis, fulvic acids and Fe and Al oxides. Product sedimentation of contemporary migration happens mostly in the intervals between aggregates.

Concentration of whitish spots, preserved in the upper part of horizon CRM1, with bulk Fe, Al oxides and some increase of their content in horizon CRM2, and also accumulation in clarified spots SiO_2 and its reduction with the depth (horizon CRM2) is observed in Gelic Cambisols (Tonkonogov, 2010). Analysis of mobile Fe, Al oxides and carbon in the inner aggregate mass of soil under study (table 1) also made evident eluvial-illuvial character of differentiation. Consequently, the process of Al-Fe-humic podzol forming (though poorly expressed) in Gelic Cambisols can be found by a bulk analysis of total mass and inner aggregate mass, a little bit changed under influence of descending migration process of soil forming products. Evidently, diagnostic horizon E, preserved in spots under horizon O, was destroyed during cryogenic reorganization of the profile, forming of cryometamorphic horizons in the middle and lower parts. The process of Al-Fe-humic illuviation is diagnosed by analysis of skeletans (table 1). As skeletans are timed to the border of phase division with the migration ways, we can suppose that this process takes place now as well.

Concretion neoformations are one of the sources of information concerning formation and development of soils. In Gelic Cambisols maximum content of concretions is found in the upper horizons. Here solid, brown, round (with the dominating fraction of 1-2 mm in size) neoformations are widespread. In the lower layers – loose, rusty-brown, round, with uneven edges, the composition of which includes large fractions (> 3mm) and tube fractions (1-12 mm of concretion) (table 2).

Table 2. Content and fractional composition of concretions

Horizon	Depth (cm)	Concretion content, soil mass (%)	Fractional composition, total concretion mass (%)			
			< 1 (mm)	1-2 (mm)	2-3 (mm)	> 3 (mm)
Gelic Cambisols						
CRM1	7-24	1.67	26	57	10	6
CRM2	24-38(45)	0.12	10	30	17	43
CRM3	38(45)-63(69)	0.29	32	31	13	24
CG	100-110	0.63	20	31	11	38
Spodi-Stagnic Cambisols						
O	2.5-4(5)	1.61	58	38	3	1
E-BF	4(5) -16(17)	3.20	76	22	2	0
CRMg	16(17)-34	0.10	44	45	11	0
CRMi	34-67	0.04	13	67	20	0
CRMC	67-93	0.08	24	50	15	11
C	93-112(113)	0.05	7	29	12	52

Large neoformations concentrate Fe 4-7, Mn – 14-34 times more in comparison with a containing mass (table 3). Maximum content of Fe in Gelic Cambisol is found in concretions of a large size. With the depth in profile the number of Fe is reducing and the size of concretions size is noticed, and in the lower part – on the contrary, concretions of a small size are poor in this element. The profile differentiation of fractional composition of concretions as well as of the elements' content in them might be suggestive of different redox conditions in the upper (0-40 cm) and lower (40-100 cm) parts of soil. Maximum accumulation of Fe and Mn in the horizon CRM1 points out frequent changes of redox conditions in this part of profile.

Table 3. Bulk chemical composition of Gelic Cambisols concretions (%)

Horizon	Depth (cm)	SiO_2	Fe_2O_3	MnO
		Concretions of 1-2 (mm) in size		
CRM1	7-24	54.70	27.16	1.00
CRM3	38(45)-63(69)	62.65	17.74	0.59
CG	100-110	71.10	10.11	0.15
		Concretions > 3 (mm) in size		
CRM1	7-24	51.62	31.40	0.71
CRM3	38(45)-63(69)	60.72	18.72	0.88
CG	100-110	64.97	15.56	0.31

Among soil processes we should pay attention to the accumulation and within the profile migration of mobile organic acids, feebly intensive Al-Fe-himic illuviation process and, evidently, inherited from the former phases of pedogenesis poorly expressed process of eluvial-illuvial profile differentiation. Inherited features, signs of the former phases of pedogenesis are preserved in other soils of the region as well (Rusanova, 2010, 2012). Nowadays they don't cause changes of the fundamental properties on the level of genetic type.

Spodi-Stagnic Cambisols is forming on a protected from the wind comb of a slope of a medium length under a birchen-fir thin forest (67.02° NL; 63.04° EL). Birches are of a bushy form 4-5 m high, fir trees – about 6 m. A shrubby layer is represented by dwarf birches and willow, shrubs – wild rosemary, blueberry, crowberry, cowberry, blackberry. In the soil cover – green and haircap mosses, lichen.

O 0-4(5) cm. Dark-brown, loose, heterogeneous on the degree of decomposition, with a black organo-mineral layer in the lower part. Bound by numerous roots, black fragments of plant remainders.

E 4(5)-8(11) cm. Light, silty olive gray bleached loam, feebly marked horizontal divisibility, thickened, damp. Aggregates are round and plate-like, scaly, form a thin subparallel lamination with skeletans in the intervals. Thin tube pores aren't filled with skeletans. Brown-rusty round concretions about 1-2 mm in diameter. Boundary line is corrugated, transition is blurred. Horizon in some places lenses out.

BF 8(11)-14(19) cm. Rusty-ochre silty loam, of roe structure, thickened, damp, many roots. Sometimes alternation of thin whitish and greyish-brown layers, with small pores and ochre layers on the walls. Aggregates rounded are less than 1 mm in size, plate-like, thin tube pores with whitish membranes on the walls. The structure is solid. Concretions are about 1-2 mm in diameter. Gradual transition, noticeable in colour.

CRMg 14(19)-33 cm. Light, silty, bluish-greyish-brown loam, angular-grained, sometimes of a granular structure. The size of structural partings is seldom over 2-3 cm, horizontal divisibility is poor. Skeletans fill in the pores and interaggregate intervals. Concretions are about 1-2 mm and less than 1 mm in diameter. Solid, damp, some roots are present, transition is gradual, hardly noticeable in colour and thickness.

CRMi 33-58 cm. Light-greyish-brown silty loam, of lumpy structure, peds 7-10 mm in size, membranes on the edges of aggregates and skeletans in the intervals between aggregates. Very solid, damp, infrequent roots, gradual transition.

CRMC 58-85 cm. Light silty bluish-greyish-brown loam, of lumpy structure, thickened, damp.

Frozen condition of ground within the limits of 2 meters is absent.

In Spodi-Stagnic Cambisols, which are being formed under forest cenosis, a peculiar profile with evident podzol and Fe-illuvial horizons in a light loam of the upper part, spread under by a specifically structured cryometamorphic horizons of the loamy composition, develops. On the grounds of particle-size composition we conclude, that there is no lithologic dissimilarity on fraction amount change of fine sand and coarse silt in the upper and lower horizons, and the coefficient of clay differentiation is 1.3 at the depth of 20-50 cm, testifying to the formation of illuvial-clayish horizon. This horizon is characterized by presence of aggregates of a walnut form with clayish membranes on the edges. The soil belongs to the clay-illuvial subtype. Presence of microprofile (subprofile) of podzol in the upper part and formation of illuvial-clayish horizon in the lower part testify to similarity with the podzol soils of the north taiga subzone with the subprofile Al-Fe-humic podzol in the eluvial thickness. In forest-tundra soils under study the expression of pedogenic processes becomes weaker.

It is known, that during the late-atlantic period taiga soils spread to the north, right down to the Barents Sea (Ivanov at al., 1994). This fact is supported by bored soddy-podzol soils (6030±170 years ago, (IGRAS-2271), discovered in 5.5 km to the northeast from Vorkuta (Rusanova, 2003).

According to the literature sources (Tonkonogov, 2010), Spodi-Stagnic Cambisols are feebly or not differentiated on clay and bulk content of Al oxide. In accordance with our researches, bulk chemical composition of the soil inner aggregate mass (IAM) clearly illustrates eluvial character of the upper part of profile (up to 34 cm) in relation to the lower part in distribution of CaO and MgO, in a smaller degree Fe_2O_3, Al_2O_3, P_2O_5 and K_2O (table 4). The inner aggregate mass, which is a subject to the influence of corrosive solutions, demonstrates profile differentiation in a chemical composition, inherited from the former stages of pedogenesis. For podzol microprofile concentration in horizon E of bulk compounds SiO_2 and impoverishment of Fe_2O_3, Al_2O_3, eluvial-illuvial distribution of Fe and Al oxides in a total mass as well as in the inner aggregate mass (IAM) are typical.

Table 4. Bulk chemical composition of Spodi-Stagnic Cambisols (%)

Horizon	Depth (cm)	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	P_2O_5	Sum
Total mass (Tonkonogov, 2010)											
E	5-10	77.21	1.89	11.95	0.97	0.20	6.91	2.20	0.89	0.29	99.57
BF	10-20	76.18	3.68	12.46	0.67	0.23	5.39	1.81	0.62	0.01	101.07
CRMg	20-40	74.62	3.60	12.63	0.74	0.22	6.14	1.91	0.46	0.01	100.35
CRMi	40-50	73.43	3.38	12.13	0.73	0.28	7.43	1.95	0.74	0.02	100.11
CRMC	60-70	70.34	4.18	13.42	0.78	0.39	7.78	2.00	0.71	0.04	99.66
Inner aggregate mass											
E	2.5-10	75.3	4.40	12.36	0.91	0.99	0.89	2.11	–	0.13	–
BF	10-17	72.9	5.11	12.85	0.97	0.87	0.89	2.15	–	0.11	–
CRMg	16-34	75.3	4.62	12.09	0.90	0.91	0.87	2.10	–	0.12	–
CRMi	34-67	72.9	5.38	13.19	0.97	1.24	0.98	2.22	–	0.15	–
CRMC	67-93	72.6	5.35	13.56	0.90	1.20	1.10	2.17	–	0.18	–

Footnote. IAM – inner aggregate mass, "–" – no data

Profile distribution dithionite- and oxalatesoluble forms of Fe in IAM as well as in skeletans, reflects not only eluvial-illuvial differentiation in horizons E-BF, but also redox processes, accompanied by mobilization and removal of Fe oxide from the horizon E and accumulation in the horizon BF (table 1), in concretions as well. In the character of distribution in IAM and skeletans of oxalatesoluble Al we can also notice increasing in the horizon BF and translocation downwards in the profile.

Heritage of the lower part of profile illustrates (table 5) lithochemical indexes (Syso, 2007) of the weathering degree and material maturity of the upper and lower parts, showing the difference between them: minor weathering and maturity of the upper part. Lower horizons, reflecting higher degree of maturity, evidently, belong to earlier formed soils of taiga stage, experienced consequently a period of cryogenic structural metamorphism. The upper part of the profile has features of the contemporary cryogenic phase: redox-Al-Fe-humic podzol forming, which was defined by V.D. Tonkonogov (2010) for the soils of such type.

In Spodi-Stagnic Cambisols, with the numerical domination of concretions, formations of a smaller size (1-1.5 mm), concentrated in the horizon BF, are widespread. With the depth the number of concretions is decreasing (table 2). The content and profile distribution of neoformations are dependent on the location of soils in the landscape, periodicity of damping and redox processes, as well as on the history of soil formation.

Thus, for the first time detailed researches of structural organization and functioning products differentiation with the help of the mezomorphology method, analysis of the IAM chemical composition and skeletans, which let us define peculiarities of pedogenic and cryogenic processes development, were carried out. The presence of inherited eluvial-illuvial profile differentiation is proved by calculations of intensity of soil transformation.

Table 5. Signs of lithochemical indexes in soils

	Soil	Horizon	Depth, cm	CIA*	ICV**
Basin of the Seida river	Spodi-Stagnic Cambisols, 67°02'50''	E	4(5)–8(11)	91	0.91
		BF	8(11)–14(19)	93	0.84
		CRM	14(19)–33(40)	95	0.87
	Gelic Gleysols, 67°02'50''	Gox-Bf	5–12	79	–
		G	15–18	78	–
		CRMg1	20–30	80	–
		CRMg2	40–50	82	–
		CRMG	60–70	83	–
Basin of the Vorkuta river	Gelic Gleysols (virgin lands), 67°31'79''	B Bt Btc	14–46	71	0.78
		Bt	46–89	72	–
		Btc	89–137	76	0.64
		D1	137–158	79	0.55
		D2	158–170	76	0.60
	Dystric Gleysols (drilled meadow), 67°31'79''	B1	20–38	71	0.75
		B2	38–60	71	0.81
		B3	60–100	75	0.62
		BC1	100–140	75	0.70

Footnote. *CIA – lithochemical index of the lithomatrix weathering degree;
**ICV – lithochemical index of thin alumosilicoclastics degree

Conclusion

1. Gelic Cambisols, being formed on loamy deposits in more drained conditions of tundra landscapes, are characterized by accumulation and migration of mobile organic compounds within the profile. Thanks to new methods and approaches we can define Al-Fe-humic illuviation, diagnosed by the analysis of skeletans, timed to the ways of contemporary migration, and also a feeble eluvial-illuvial profile differentiation, discovered by analysis of the inner aggregate mass, blocked up with coatings against leaching and conserving properties, which is inherited from the former stages of development. Inherited processes don't lead to changes of the fundamental soil properties on the level of genetic type, but prove polygenetic character of these formations.
1. 2.Specific character of Spodi-Stagnic Cambisols forest landscapes of forest-tundra is defined by the presence of cryometamorphic horizons in the lower part, and also subprofile of micropodzol in the upper part. Typical for the micropodzols, according to the inner aggregate mass analysis, are podzolic process, expressed in concentration of SiO_2 in the horizon E, eluvial-illuvial differentiation of Fe and Al oxides (horizons E-BF), as well as redox process, responsible for mobilization, migration, and accumulation of Fe hydroxides. Middle and lower parts, where inherited features (presence of illuviation coatings on the edges of structural units) of the illuvial horizon of the taiga stage, experienced the period of cryogenic structural metamorphism.

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References

Bolikhovskaya, N.S., Bolikhovskiy, V.F and Klimanov, V.A., 1988. Climatic and cryogenic factors of peatland genesis in the European North-East of the USSR. In Khotinsky N. A. & V. A. Klimanov (eds), Paleoklimaty golotsena Evropeiskoi territorii SSSR. Institute of Geography, Academy of Sciences of the USSR, Moscow, 36-44 (in Russian).

Bryson, R.A., Irving, W.N., and Larsen, I.A. 1965. Radiocarbon and soil evidence of former forest in the southern Canadian tundra. Science 147:46-48.

Ignatenko, I.V., 1979.)Pochvy vostochno-evropeiskoi tundry i lesotundry (Soils of East-European Tundra and Forest Tundra). Nauka Pablishers, Moscow. 280pp (in Russian).

Ivanov, I.V., Velichko, A.A., Morozova, T.D. 1994. Osnovnye cherty pochvennogo pokrova Vostochnoy Evropy v atlantichesky period golotsena. Doklady. RAN, vol. 337, № 5, pp. 667-671 (in Russian).

Kaakinen, A., Eronen, M., 2000. Holocene pollen stratigraphy indicating climatic and tree-line changes derived from a peat section at Ortino, in Pechora lowland, northern Russia // The Holocene 10, 611-620.

Khantemirov, R.M., Shiyatov, S.G. 1999. Radiouglerodnie i dendrokhronologicheskie datirovki poluiskopaemoi drevesini na Yamale I ikh ispolzovanie dlya izhuchenia dinamiki lesotundrovih ecosystem // Biota Priuralskoy Subarktiki v posdnem pleystocene i golotcene. Ekaterinburg. B.I. pp. 3 -22. (in Russian).

Konishchev, V.N. 1981. Formirovanie sostava dispersnikh porod v kriolitosfere. Moskva, Nauka. P. 198. (in Russian).

Krasovskaya, T.M. 1996. Prostranstvenno-vremennie zakonomernosty nakopleniya tyazhelih metallov v ecosistemah Vorkutinskogo promishlennogo raiona// Bioindikatsiya sostoyaniya prirodnoy sredy Vorkutinskoy tundry: Trudi Komi nauchn.tsentra UrO RAN. Syktyvkar. № 143. pp. 42-48. (in Russian).

Kremenetskiy, K.V., Macdonalds, G.M., Galabala, R.O., 1996. i dr. Ob izmenenii severnoy granitsi arealov nekotorih vidov dereviev i kustarnikov v golotsene// Botan.zhurn. vol. 81. № 4. pp. 23-25. (in Russian).

Rusanova, G.V., Kuhry, P., 2003. Buried Soils and Pedorelicts in the Usa River Basin (Bol'shezemel'skaya Tundra). Pochvovedenie, No. 1, 23-34 (2003) [Eur. Soil Sci. 36 (1), 21-31 (2003)].

Rusanova, G.V., 2013. Buried loamy soils of southeast Bolshezemelskaya tundra. Pochvovedenie, No 10, 1206-1213 (2013) [Eur. Soil Sci., 9, 231-242, (2013)].

Rusanova, G.V. Lapteva, E.M., Pastukhov, A.V. Kaverin, D.A. 2000. Sovremennie protsessy i unasledovannie priznaki v pochvah na pokrovnih suglinkah uzhnoy tundra // Kriosfera Zemli. Vol. XIY. № 3. pp.52-60. (in Russian).

Rusanova, G.V. Shakhtarova, O.V. 2012. Strukturnaya organizatsiya i profilnaya differentsiatsiya veshchestv v avtomorfnih pochvah yugo-vostoka Bolshezhemelskoy tundra // Vestnik Tomskogo gosudarstvennogo universiteta. Biologiya. № 3 (19). pp.18-32. (in Russian).

Sanborn P., Lamontagne, L., Hendershot, W. 2011. Podzolic soils of Canada: genesis, distribution and classification. Canad. J. Soil Sci. V. 91. № 5. P. 843-880.

Sykhodrovskiy, V.L., Vilchek, G.E. 1993. Estestvennoe rasvitie geosistem Tazovskogo poluostrova. Izv. RAN. Ser. Geogr. № 1 pp.104-110. (in Russian).

Syso, A.I., 2007. Patterns of distribution of chemical elements in the soil-forming rocks and soils of Western Siberia. Novosibirsk: Publishing House of the Russian Academy of Sciences, 227.

Targulian, VO., Sokolova, T.A., Birina, A.G., Kuliko, A. V, Tselishcheva, L.K. 1974. Organization, composition and genesis of soddy-Pale-Podzolic soil on mantle Loams (An Analytical Study): X Int. Congr. of Soil Science, Moscow.

Targulian, VO., Tonkonogov, V.D., Alexandrovskiy, A.L. 1978. Gipoteza golotsenovoy evolutsii suglinistich tundrovikh i taezhno-lesnikh pochv Vostochno-Evropeyskoy ravnini / Voprosy genezisa I ratsionalnogo ispolzovania pochv RSFSR. Rostov na Donu. pp. 6-10. (in Russian).

Teoriia i praktika khimicheskogo analiza pochv / pod red. L.A. Vorob'evoi. [The theory and practice of chemical analysis of soil. Ed. L.A. Vorobeva]. Moscow, 2006, 400 p. (in Russian).

Tolmachev, A.I., Tokarevskiy, S.A. Issledovanie raiona "lesnogo ostrova" u r.More-Yu v Bolshezhemelskoy tundra // Botan. Zhurn. № 4. pp. 244-260. (in Russian).

Tonkonogov, V.D. 2010. Automorphic Pedogenesis in Tundra and Taiga Zones of the East European and West Siberian Plains (Pochv. inst. im. V.V. Dokuchaeva, Moscow). 304 p. (in Russian).

Vodyanitskiy, Y.N. 2003. Khimiya i mineralogiya pochvennogo zheleza. Soil Inst. Named V.V. Dokuchaev Publishers, Moscow. 238 p. (in Russian).

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Current ecological and agromeliorative condition of irrigated soils in Ukraine and ways of managing their fertility

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Abstract

In Ukraine, which large area is located in areas of unstable and insufficient moisture, food and resource supply is largely dependent on the availability, condition and use of irrigated lands. Irrigation is a significant factor of soil transformation, changes the main factors of soil formation and inherent in the original soil natural relationship with the environment, determines the subsequent evolution of the soil cover. Irrigated lands in Ukraine are concentrated mainly in the Steppe climatic zone. The total area of irrigated lands is 2.1 million hectares, actually 0.5 - 0.7 million hectares are being watered annually. Purpose - to characterize the current ecological and agromeliorative condition of irrigated soils in Ukraine and ways to manage their fertility. During long-term research the basic directions of the evolution of soils under irrigation have been established: cultivation of soils, increasing their natural and effective fertility by using suitable for irrigation water; development of degradation processes by using limited suitable or unsuitable for irrigation water and low farming culture. Basic complex characteristic of irrigated land, which determines the possibility, technological features and prospects for their further use is ecological and agromeliorative soil condition (measured by hydrogeological, soil - ameliorative, ecological - toxicological and agronomic criteria). Generally, in Ukraine about 20% of the total irrigated lands have good ecological and agromeliorative condition, satisfactory - about 65% and not satisfactory - about 15%. Areas with not satisfactory condition are lands which are used unsuitable for irrigation water, soils strongly or medium saline and / or solonetzic and waterlogged. By satisfactory conditions are the lands, which have a low level of salinity and solonetzicity, are irrigated limited suitability for irrigation waters and are in automorphic - hydromorphic conditions. In all other cases, ecological and agromeliorative soil condition is defined as good. For a more accurate assessment of ecological and agromeliorative soil condition it is created a series of electronic maps of irrigated lands. Fertility management of irrigated lands is aimed at models formation of sustainable, environmentally safe and cost-effective land use and should be based on the legislative, regulatory, legal, regulatory and methodological, informational, technological, scientific, financial security, using international experience of environmental activities.

Keywords: soil, irrigation water quality, processes, reclamation

Introduction

The irrigation is one of the most intensive and effective factors of anthropogenous loads on an environment as a whole and irrigated land in particular. With its beginning forming natural ambience, including occur

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change to velocities and directivities of soil processes. The results of these change can carry both positive (the improvement water supply, increasing of fertility, efficiency and etc.), and also negative character (salinization, appearance solonetz, alkalinization of soils, contamination and others). The intensity and direction of manifestation in irrigated soils of negative phenomena's to a considerable extent depends on qualities of irrigation waters and volumes water feeding. The main object of water ameliorations is soil cover of zones with insufficient and unstable moistening and with overmoistening. The application of irrigation is necessary for optimizing the water-air balance of soils for the purpose of considerable increase and stabilization of their fertility. At the same time large-scale building of drainage-and-irrigation systems can worsen ecological situation and cause the gradual degradation of soils because of the appearance and the developments of negative processes in the contemporary soil formation. Therefore the important task of drainage and irrigation is not only increassng of the productivity of the agricultural lands, but also conservation of inherent in ecological and social functions soil cover.

Material and Methods

The research were conducted in Forest-steppe and Steppe zones of Ukraine, where is disposed 98% irrigated lands. The Objects of our research were:

- irrigation water. For irrigation in Ukraine are used basically water of main river arteries and created on their base water storage's and ponds. In zones Forest-steppe and Steppe - waters of Dnieper's and cascade of Dnieper water storage, Dniester and others;
- irrigated soils. The area of irrigation in Ukraine forms 2,5 millions hectares. The structure of topsoil irrigated lands is presented basically by chernozems (typical, ordinary, southern and meadow-chernozemic) and dark-chestnut solonetz soils;
- agricultural plants, grown in conditions of irrigation (grains, vegetables, fodder's and technical cultures).

The main methods were field, model, analytical and statistical research.

Results and Discussion

The natural fertility of the soils of Ukraine (without amelioration and fertilization) is within the limits from 7-10 c/ha in soddy-podzolic to 34-38 c/ha in the dark gray podzolized, chernozem podzolized soils and the chernozems typical. Work on a steady improvement in the productive functions of soils provides for the creation of conditions for stable control of the soils regimes: hydrological, nutritive, thermal, biological, etc. The determining role in solution of this problem belongs to the amelioration methods, the need of their applying which in the entire territory of Ukraine is almost determined by natural climatic conditions and level of the natural fertility of soils. The dependence of agricultural production on the climatic factor is significantly reduced because of the application of irrigation the lands.

More than half of the territory of Ukraine is located in the zones of insufficient and unstable moistening, furthermore, the protracted periods of droughts are increased in frequency; therefore irrigated lands are located practically in all natural zones and subzones. The soil cover of the irrigated lands is extremely complex (table 1 - for the conveniences, the soil names accepted in Ukraine in this and following tables are harmonized with the international names according to the WRB classification). Practically all types of the soils of the Ukraine are represented in its structure, but chernozem and dark-chestnut soils predominate. The irrigated lands occupied the greatest area (2,6 mln. ha) at the beginning of the 90's of past century, which was 8 % of area of plowed land. During this period irrigated lands because of the sufficiently high level of their use performed the role of unique insurance fund in the food securitu of the country, especially in the dry years. During this period actual productivity of almost 80 % of area of the irrigated lands corresponded its project level, and the production of plant growing comprised to 30 % of its gross production in Ukraine [1].

Hydrotechnical ameliorations lead to the transformation of soils, correction of natural soil processes. Directivity, periodicity and alteration rate depend on the quality of irrigating waters, volume of water delivery, initial state of soils and degree of natural drainability of territory, technologies of irrigation, level of agriculture.

Table 1. Irrigated soils of Ukraine

	Soil		Area, thousands of the hectares
	In the national classification	In the international classification (WRB)	
1	Soddy-podzolic soils	Albeluvisols Umbric	7,9
2	Light grey forest soils	Albeluvisols Umbric	40,2
3	Dark grey podzolized soils	Phaeozems Albic	26,0
4	Podzolic chernozems	Chernozems Albic	50,0
5	Typical chernozems	Chernozems Chernic	230,0
6	Ordinary chernozems	Chernozems Chernic	720,0
7	Southern chernozems	Chernozems Chernic	566,0
8	Meadow chernozems	Phaeozems Haplic	99,0
9	Dark-chestnut soils	Kastanozems Haplic	384,6
10	Chestnut solonetzic soils	Kastanozems Luvic	10,0
11	Meadow-chestnut solonetzic soils	Phaeozems Sodic	54,7
12	Chestnut solonetz	Solonetz Humic	5,5

We have extended results of long-term observation by a composition of irrigation waters and direction of soil processes. It has allowed to us elaborating and puting into operation State standard 2730-94 "Quality of water for irrigation. Agronomical criterion's". It includes an evaluation of water on danger of:

- salinization, with provision for granulometrical composition of soils;
- alkalinization of soils, on base of complex estimation index pH, toxic alkalinity and alkalinity from normal carbonates;
- appearance solonetz, on size of correlation's (in %) into total alkaline cations sodium and potassium (milligram-equivalent (mg-eq)) to total all cations (mg-eq) with provision for antialcaline soil bufferity and granulometrical composition of soils; values of correlation in irrigation water a magnesium to calcium and class of water on dangers salinization or alkalinization of soils;
- toxic operating on plants.

The evaluation of water is conducted for several groups of soils upon their stability against degradation phenomena on the grounds of analytical concentrations of ions and thermodynamic indexes (the active concentrations of ions). On agronomical criterions we distinguish three classes of water: 1 class - «suitable», 2 classes - «bonded suitable», 3 classes - «unsuitable». 1 class of water is applied without limitations. 2 classes of water is applied under condition of conducting control (monitoring) behind their quality and complex of agroamelioration actions under the warning of rise of the negative phenomens in soils. 3 classes of water is not suitable for irrigation.

The main methodical approach to estimation of quality of natural water - experimental-expert estimation in system "water (irrigation) - soil - plant".

We have accumulated extensive material on two groups of quality indexes of irrigation water: 1) on characteristics of water and contents of materials, which in determined quantity required for normal functioning agroecosystems; 2) on characteristics of water and contents of materials, which negatively influence upon condition and functioning agroecosystems and components environment. Simultaneously the study of stability of soil systems and qualities of agricultural product was conducted. The complex analysis of data has allowed to proceed to standardization of irrigation water quality on ecological criterions for the reason warning the possible negative influence upon components of environment and on health of population. In the result of our work we received possibility to elaborate and to put into operation the State standard 7286 -2012 "Quality of water for irrigation. Ecological criterions". The standardization of contents in irrigation water is organized in this document :

- nitrogen, microelements, biological need for oxygen (general ecologicaly-hygienic indexes);
- heavy metals, pesticides, phenols, oils and others (ecologicaly-toxicological indexes);
- pathogenic microflora, bacteria's of group of intestine stick (sanitary-bacteriological indexes);
- radioactive materials (normative according to special document).

From the large number of soils evolution directions during the irrigation and the draining we separate 3: cultivation, without the changes and the degradation of soils.

Generally, in Ukraine about 20% of the total irrigated lands have good ecological and agromeliorative condition, satisfactory - about 65% and not satisfactory - about 15%. Areas with not satisfactory condition are lands which are used unsuitable for irrigation water, soils strongly or medium saline and / or solonetzic and waterlogged.

The direction of the evolution of soils depends on the joint influence of the natural and anthropogenic factors on their natural properties and regimes and of the direction of changes in the functions of soils and their fertility. Irrigation creates conditions for a considerable increase in the productivity of land-utilization. Nevertheless, amelioration frequently becomes the cause for appearance and development of a number of degradation phenomena. Finally, sharp reduction in the productivity of the ameliorated lands is not excluded. Therefore, to disregard the phenomena of degradation, as practice showed, is inadmissible. It is necessary to detect it in proper time, to forecast and to remove it. Thus, under "degradation of soils" we understand the natural and anthropogenic processes of worsening in the natural properties and regimes of the soils, which produce steady negative changes in their functions, decrease stability and fertility. The estimation of the degradation of soils is achieved by the method of comparison of the parameters of the soils, which are fixed in the initial period of observations, or standard soils with the same parameters after the corresponding periods of the soils using. The criteria of evaluation of the development of degradation processes are carried out on the basis of these observations, the levels of their ecological danger and unprofitability are determined, the preventive and straight anti-degradation methods of using the ameliorated soils are proposed.

Under "Irrigational degradation", we mean the degradation of soils, which can be developed under the effect of irrigating ameliorations and cause an increase in the expenditures for the restoration of the project production level. As the basis of the evaluation of the degradation of the irrigated soils, it is the most expedient, in our opinion, to use the degradation processes, which can occur to the soils under the effect of the irrigation and the degree of the manifestation of these processes.

We determine the degrees of irrigational degradation on the level of deviation from the optimum of the soil basic parameters of the, which are determined for the fertility formation:

- the soils without degradation: the soils, the properties and regimes of which are not worsened, which fulfill functions inherent in it, but productivity corresponds its natural fertility (deviation from the optimum to 5 %);
- the soils with low degree of degradation: deterioration of properties and regimes, negative changes in the functions, reduction in the productivity do not exceed 20 %;
- the soils with average degree of degradation: the average degree of the manifestation of negative changes in the soil properties and regimes, functions, reduction in the productivity in the range 20- 50 %;
- the soils with strong degree of degradation: the strong degree of the manifestation of unfavorable soil changes in the soil properties and regimes, functions, reduction in the productivity are more than 50 %.

The most common forms of the irrigational degradation of the soils are soil overcompaction, crustification; erosion; swamping and underflooding; pollution of soils with heavy metals, pesticides, radioactive nuclides; secondary salinization, solonetzization and alcalination. They are developed after using for the irrigation waters of the not proper quality (suitable for determined limit and not suitable for the irrigation) and/or because of the low level of agriculture and insufficient resource investments there are humus and nutritious elements losses. The application of a complex of agroameliorative measures serves to weakening the manifestation of these processes, but completely it can not to remove them.

Let us highlight at such forms of irrigational degradation as salinization, solonetzization and alkalinization.

Secondary salinization is accumulation in the soil of water-soluble salts, a change of the salt composition to increasing in sodium concentration and contraction is relation Ca:Na. The degree of salinization of soils is determined by the content of gross and/or toxic salts taking into account chemism of salinization (it's type). There are approximately 100 thousand ha of secondary salinized soils (content of salts in the layer 0-100 cm) among the irrigated lands.

Secondary solonetzization is accumulation of sodium and potassium in the soil absorbing complex, which gives to soils unfavorable physical properties. Secondary solonetzization is the most common degradation process on the irrigated lands. The area of the irrigated solonetzic soils is approximately 700-800 thousand ha.

Alkalinization is increase of the alkalinity of soil solution and the formation of soda, which occurs under the effect of secondary solonetzization, ground and irrigating waters, reducing of sulfates or other reasons. The regions in Ukraine, where there is a danger of the formation of soda, are geographically separated. The greatest danger exists in the regions of the cultivation of rice in Kherson region and in the Crimea over the area more than 60 thousand ha.

Integral estimation according to the degree of irrigational degradation is developed (table 2). With the carrying out of this estimation there were used data of ecological-amelioration monitoring and own results of long-term field, micro-field, greenhouse and model experiments, and previously obtained data, presented in a number of papers.

Table 2. The integral estimation of the irrigated soils according to the degree of the degradation

Indices	Soil without degradation	Degree of degradation		
		Low	Average	Strong
Salinization, 0-50 cm				
Toxic salts content, eCl^-, meqv/100 g of soil	less than 0,3	0,3-1,5	1,5-3,5	more than 3,5
Ca:Na in water extract	more than 2,5	2,5-1,0	1,0-0,5	less than 0,5
Solonetzization, 0-30 cm				
Na^++K^+, % from sum of cations, clay soils	less than 3	3-6	6-10	more than 10
Na^++K^+, % from sum of cations, sandy soils	less than 5	5-8	8-12	more than 12
$aNa/\sqrt{aCa}$	less than 1	1-3	3-7	more than 7
Factor of dispersivity by Kachinsky, %	less than 10	10-20	20-30	more than 30
Alkalinization, 0-30 cm				
pH_w.	less than 7,8	7,8-8,5	8,5-9,0	more than 9,0
HCO_3^--Ca^{2+}, meqv/100 g of soil	less than 0,5	0,5-1,0	1,0-2,0	more than 2,0
CO_3^{2-}, meqv/100 g of soil	less than 0,1	0,1-0,3	0,3-0,9	more than 0,9
pH-pNa	less than 4,0	4,0-5,0	5,0-5,5	more than 5,5
Humus state, 0-50 cm				
Decreasing of humus content, % from initial	0	0-10	10-20	more than 20
Agrophysical state, 0-30 cm				
Content of air-dry aggregates 0,25-10 mm	more than 70	60-70	40-60	less than 40
Content of water-proof aggregates > 0,25 mm	more than 45	35-45	25-35	less than 25
Equilibrium density of composition, g/sm³, clay soils	less than 1,3	1,3-1,4	1,4-1,6	more than 1,6
Equilibrium density of composition, g/sm³, sandy soils	less than 1,3	1,3-1,5	1,5-1,7	more than 1,7
Pollution, 0-100 cm				
Heavy metals content, in zinc equivalents, mg/kg of soil	less than 25	25-50	50-100	more than 100
Water-soluble fluorine, mg/kg of soil	less than 6	6-10	10-20	more than 20

For a more accurate assessment of ecological and agromeliorative soil condition it is created a series of electronic maps of irrigated lands.

The results of investigations concerning determination of criteria and parameters of the evaluation of the ameliorated soil degradation give the possibility to pass to the scientifically valid solution of the contemporary ecological problems of irrigation, the definition of opportunities and expediency of performing these works [2].

The estimation of the degree of the degradation of the ameliorated soils was executed on the basis the information input, combined from the following sources:

- Materials of large-scale land survey (1957-1961 yr.) and their correction;
- The Land cadastre;
- Materials of agrochemical certification of the agricultural lands;
- Information about the ameliorative state of the irrigated and drained lands and the data of ecological-ameliorative monitoring;
- Data of scientific organizations UAAS, higher educational institutions and others (field soil investigations, stationary field experiments).

During the second large-scale land survey and soil monitoring the controlling of degradation processes have to be performed on the base of the unified approaches with gradual harmonization to the European approaches by formation of the fixed set of the representative survey sites as an addition to the total fields survey, including all the categories of land and not only agriculture territories, along with building the databases and the information system. We proposed processes and indices of soil monitoring, the content of the control of technologies and the management of the territory organization.

The effective control (monitoring) of the soils degradation must include:

- the systematic observation of state, properties, regimes of soils;
- the analysis of the stability of soils to the diverse degradation processes;
- the evaluation of the different types of the human economic activity, its positive and negative influence on the soil cover - impact-analysis;
- the computer data bases creation and cartography;
- forecast and prevention of the degradation processes.

Control of the fertility of the irrigated lands, directed to the formation of the models of steady, ecologically safe and economically effective agriculture, is impossible without:

1. Legislative and normative support of soils protection. The laws and programs accepted as of today are inactive or act not sufficiently because of the absence of the mechanisms of their realization, financial guarantee. “National program of the soils fertility protection” and “State program of lands use and protection” are developed, but, until now are not accepted. The non- acceptance of these programs, the absence of the financial support of measures for the protection of soils lead to the aggravation of soil problems, the long-term development of degradation processes.
2. Creation of united soil-land service. The strategic and current national and regional tasks resolution concerning the soils protection and rational use are laid just on this service. Just this service must be responded for the soils protection, the use of soil resources, and the preservation of their fertility.
3. New large-scale land survey and monitoring the soils, which will give adequate information about the soils of the country. It corresponds the European experience, where state, but not departmental monitoring functions more than 10 years.
4. Increasing of the irrigation effectiveness due to the complex application of all kinds of amelioration and modern agro-technologies.
5. Essential certification of the agricultural lands, firstly, irrigated and drained, for the purpose of the investment of the land users’ resources for protection and amelioration of soils.

For the achievement of stated goal the normative-methodical base of soil investigations realization, agrochemical certification of the agricultural lands, ecological-ameliorative monitoring of the lands and monitoring of the soils is already created. It includes more than 200 normative documents concerning soil quality, methods of soil composition and quality analysis, system of indicators for assessing of soil condition, fertility and degradation. Principles are developed and offered for the ecological rationing of permissible anthropogenic impact on the soil cover and the scientific bases of soil degradation risks assessment are worked out and presented [3].

Conclusion

The general characteristic of irrigated land fund of Ukraine is given, current ecological and agromeliorative condition of irrigated soils in Ukraine and ways of managing their fertility, existing in Ukraine approaches to assessing the quality of irrigation water, approaches to monitoring and regulatory environment protection of irrigated land are characterized.

References

1. Baliuk,S., Medvedev, V., Tarariko O., (Eds.) 2010. National report "On the situation of soil fertility in Ukraine",Kiev, 111 p.
2. Stashuk,V., Baliuk,S., Romashchenko M., (Eds.) 2009. The scientific basis for the protection and management of irrigated land in Ukraine Kiev, Agricultural Science,619 p.
3. Stashuk,V., Baliuk,S., Romashchenko M., (Eds.) 2009. State monitoring of the use and protection of irrigated land, Kiev, Agricultural Science, P. 471-491.

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Potential environmental risks associated with sewage sludge application in agriculture and solution recommendations

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Abstract

Recently, sewage sludge production has significantly increased by the municipal and industrial waste water treatment plants. Therefore, disposal of sewage sludge generated from the waste water treatment plants has become an important environmental issue. The disposal of sludge products in landfills or by incineration are feasible options currently practiced in many parts of the world but both of these strategies are expensive and cause environmental problems. The application of stabilized sewage sludge to the cropland is therefore most attractive potential method because it can recycle valuable components, such as organic matter, N, P, and some other plant nutrients. Also, sewage sludge can improve physical and biological properties and agricultural productivity of soils. However, the environmental impact of this practice needs to be investigated carefully. Because, depending on the origin and composition, sludge may contain substantial amounts of toxic metals as well as beneficial nutrients. The addition of heavy metals to the soil and their subsequent transfer to the food chain is one of the major factors limiting the application of sewage sludge to agricultural land. However, knowing soil properties and heavy metals concentrations in sewage sludge are also important in order to utilize sewage sludge in appropriate doses in soil. The solubility or bioavailability of heavy metals from sewage sludge depends on soil pH, lime content, soil cation exchange capacity and soil organic matter. In this review potential risks associated with sewage sludge application in agricultural land and how we can determine the appropriate and safe sewage sludge doses are discussed.

Keywords: Sewage sludge, heavy metals, toxic elements, soil properties, soil pollution.

Introduction

Water resources are becoming contamined due to generating industrial and urban effluents, with drawel of water, agricultural runoff due to improper practices, etc that result in its pollution. Because of this reason in recent years, waste water treatment plants are increased sharply in the world due to the demand for the better quality water and imposition of more strict environmental laws.

Sewage sludge is a by-product obtained from urban waste water treatment process (Singh and Agrawal 2008). The production of municipal sewage sludge increases each year in the EU due to the implementation of the Urban Waste Water Treatment Directive (91/271/EEC), with about 10 million Mg y^{-1} being produced by 2005 (Ramirez et. al. 2008). The accumulation of these bio-wastes poses a growing environmental problem. Treatment and disposal of sewage sludge are the most costly phase of sewage treatment (Huang et. al. 2008). The disposal methods of sewage sludge include landfill, incineration and dumping (Metthes 1992;

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Zheng et. al. 2006) but these strategies are expensive and can cause important environmental problems. The application of sewage sludge to the agricultural land has therefore become an attractive option and common practice over the past decade. This practice is inexpensive, logical and easy to carry out.

Agricultural land application of the sewage sludge is suggested to be the most economical sludge disposal method (Metcalf and Eddy, 2003). Sewage sludge is an organic waste which usually contains high levels of nitrogen and phosphorous as well as significant concentrations of micronutrients (Epstein et. al. 1976; Sopper, 1993). For this reason sewage sludge is a perfect material for provides organic matter to soil and this addition may represent a good alternative to prevent degradation of soils (Rolden et. al. 1996; Angın and Yağanoğlu 2009) and to improve many physical properties of agricultural soils as water holding capacity, aeration, porosity and cation exchange capacity (Engelhart et. al. 2008).

However, sewage sludge addition always poses a risk to the environment resulting from nutrient imbalances and toxic element accumulation and leaching. Metal transfer from sewage sludge to soil and subsequently to groundwater and plants represents potential health and environmental risks (Mc Bride et. al. 1997: Bhogal et. al. 2003). Heavy metals are currently of much environmental concern. They are harmful to humans, animals and tend bioaccumulate in the food chain (Zhang and Ke 2004). Because of this reason the environmental impact of this practice needs to be investigated carefully. Because depending on the origin and composition, sludge may contain substantial amounts of toxic metals as well as beneficial nutrients (Cuningham et. al. 1975). And other limiting factor of sewage sludges useless is soil properties. And the other important factor is plant species. Because plants differ in their heavy metal uptake, accumulation and tolerance levels. Accumulation and availability to plants of heavy metals in agricultural soils largely depend on the composition of the sludge, rate of sludge application, soil properties and crop species and cultivar (Bozkurt and Yarılgaç 2003).

Characteristics of Sewage Sludge

The heterogeneous nature of sewage sludge produced at different treatment plants and the variations between seasons necessitates knowledge of the chemical composition of sewage sludge prior to the land application. Characteristics of sewage sludge depend on the waste water treatment processes and sludge treatment (Singh and Agrawal 2008). Generally sewage sludge is composed of organic compounds, macronutrients, a wide range of micronutrients, non-essential trace metals, organic micro pollutants and microorganisms (Kulling, 2001; Epstein et. al. 1976; Sopper, 1993). The use of sewage sludge in soil restoration has very beneficial effects on the quantity and availability of nutrients, on the structural stability of the soil, and on its resistance to erosion (Sort and Acaniz, 1996, 1999; Deposz et. al. 2002). Very rarely urban sewerage systems transport only domestic sewage to the treatment plants. Industrial effluents and storm-water runoff from roads and other paved areas are frequently discharged into the sewerage system (Singh and Agrawal 2008). Thus sewage sludge may also contain harmful components (heavy metals, organic compounds, salts and pathogens) in soil and crops (Jusle and Mench 1992; O'Riordan and Dadd 1994). Sewage sludge may also contain other harmful toxics such as detergents, pesticides due to effluents from municipal, industrial premises and hormone disruptors. Before application of stabilized sewage sludge to the cropland sewage sludge chemical properties investigated carefully. And the concentrations of heavy metals in the soil and sewage sludge must be lower than the limit values of Europen directive 86/278/EEC.

Effects of Soil Properties

Sewage sludge application may lead to the accumulation of number of potentially harmful components such as heavy metals in soil and crops. The presence of heavy metals in the applied sludge can result in phytotoxic effects, soil and water contamination and accumulation of heavy metal in food supplies (Keller et. al. 2002; Yinhming and Corey 1993). Real bioavaiability of many metals depends more on the type of soil organic compounds than on their quantity (Alloway and Jakson 1991). The solubility and bioavalibility of heavy metals from sewage sludge is based on soil pH, lime content, soil cation change capacity and soil organic material.

Low soil pH is limiting factor of sewage sludge useses (Table 1). The importance of pH in metal solubility is well known as it influences heavy metal adsorption, retention and movement (Sauue et. al. 1997). The use of sulphur containing waste in the soil with high pH, $CaCO_3$ and clay content did not create heavy metal build up or toxicity (Kaplan et. al. 2005). For this reason liming is a common practice in agriculture to maintain optimal soil pH and has also been used to reduce the solubility of heavy metals. Table 1 show that as result of sludge applications, and no sludge should be applied to any site where the soil concentration of any of the elements, with the exception of molybdenum, is at or above these values. In addition, the ten year average annual rates of application of these elements in sludge must not exceed those set out in Table 1. As seen on Table 1 sewage sludge uses doses were different at different soil pH. The combination of elevated soil pH and high organic matter may have played a role in the limited plant availability of heavy metals in the soil, resulting in low plant uptake of these metals (Jung and Thornton 1996; Rosselli et. al. 2003). Because of this reason soil chemical properties have important effect for sewage sludge application doses to soil.

Table 1. Maximum permissible concentrations of potentially toxic elements in soil after application of sewage sludge and maximum annual rates of addition

PTE	Maximum permissible concentration of PTE in soil (mg/kg dry solid)				Maximum permissible average annual rate of PTE addition over a 10 year period (Kg/ ha) (2)
	pH 5.0<5.5	pH 5.5<6.9	pH 6.0<7.0	pH(3) >7.0	
Zinc (1)	200	200	200	300	15
Copper (1)	80	100	135	200	7.5
Nickel	50	60	75	110	3
	For pH 5.0 and above				
Cadmium (1)	3				0.15
Lead (1)	300				15
Mercury	1				0.1
Chromium	400				15
Molybdenum (4)	4				0.2
Selenium	3				0.15
Arsenic	50				0.7
Fluoride	500				20

* These parameters are not subject to the provisions of Directive 86/278/EEC. (In 1993 the European Commission withdrew its 1988 proposal to set limits for addition of chromium from sewage sludge to agricultural land).

(1) The permitted concentrations of zinc, copper, cadmium and lead are provisional and will be reviewed when current research into their effects on soil fertility and livestock is completed. The pH qualification of limits will also be reviewed with the aim of setting one limit value for copper and one for nickel across pH range 5.0<7.0 and therefore ensuring consistency with the approach adopted for zinc in response to the recommendations from the Independent Scientific Committee (MAFF/DOE 1993).

(3) The increased permissible PTE concentrations in soils of pH greater than 7.0 apply only to soils containing more than 5% calcium carbonate.

(4) The accepted safe level of molybdenum in agricultural soils is 4 mglkg. However there are some areas in UK where, for geological reasons, the natural concentration of this element in the soil exceeds this level. ln such cases there may be no additional problems as a result of applying sludge, but this should not be done except in accordance with expert advice. This advice will take account of existing soil molybdenum levels and current arrangements to provide copper supplements to livestock.

Effect of plant

Plants differ in their heavy metal uptake, accumulation and tolerating ability. These parameters are affected by many factors. Davis and Carlton-Smith (1980) reported wide variations in heavy metal accumulation in crop grown on sludge-amended soil. In general, variations in plants species, the growth stage of the plants and element characteristics control absorption, accumulation and translocation of metals (Behbahaninia et. al. 2009). Under normal growing conditions, plants can potentially accumulate certain metal ions on order of magnitude greater than the surrounding medium (Kim et. al. 2003). But more than four hundreds plants are known as hyper accumulators of metals, which can accumulate high concentration of metals into their above ground biomass. A plant's ability to accumulate metals from soils can be estimated using the BCF, which is defined as the ratio of metal concentration in the roots to that in soil. A plant's ability to translocate metals from the roots to the shoots is measured using the TF, which is defined as the ratio of metal concentration in the shoots to the roots.

Cd accumulation was highest in different species with respect to species the trend of accumulation was tobacco > lettuce > spinach > celery > cabbage > for Cd; kale > rye grass > celery > for Pb; sugar beet > some varieties of barley for Cu; sugar beet > ryegrass > mangold > turnip for Ni; and sugarbeet > mangold > turnip for Zn (Davis and Carlton-Smith 1980). Alloway et. al. (1990) found a trend of Cd uptake as lettuce > cabbage > radish > carrots. Orman et. al. (2014) reported that Ni and Cr were accumulated in roots of alfalfa grown at the amendments of sewage sludge more than 40 ton ha^{-1} to soil. The consumption of such plants might pose a serious risk to human health. If we want to use sewage sludge on crop we have to know plants ability to accumulate and translocate heavy metals very well.

Conclusion

Sewage sludge is a by-product of sewage treatment processes, is composed of organic compounds, macro and micro nutrients. The beneficial effects of using sludge on agriculture have been proven by numerous researchers. But sewage sludge application on cropland may lead to the accumulation of a number of potentially harmful components such as heavy metals in soil and crops. The problem related to sewage sludge application arises when it contains high concentrations of potentially toxic heavy metals. Relatively high rates of sludge application to the cropland increase the toxicity risk. In recent years land application of sewage sludge for agricultural purpose has increased among farmers, primarily due to economic reasons. The application of sewage sludge to soil must obey the limited regulations. And after the analysis of sewage sludge and soil, permission to apply them must be obtained from the relevant officials.

References

Alloway, B.J., Jackson, A.P., 1991. The Behavior of Heavy Metals in Sewage Sludge-Amended Soils. Sci. Total Environ. 100: 151-176.

Angın, I., Yaganoglu, A.V., 2009. Application of sewage sludge as a soil physical and chemical amendment. Ekoloji 19 (73): 39-47.

Bhogal, A., Nicholson, F.A., Chambers B.J., Shepherd, M.A., 2003. Effects of past sewage sludge additions on heavy metals availability in light textured soils: implications for crop yields and metal uptakes. Environ. Pollut. 121: 413-423.

Bozkurt, M.A., Yarılgaç. T., 2003. The Effect of Sewage Sludge Applications on the Yield, Growth, Nutrition and Heavy Metal Accumulation in Apple Trees Growing in Dry Conditions. Turk J. Agric. For. 27: 285-292.

Cunningham, J.D., Ryan, J.A., Keeney, D.R.,1975. Phytotoxicity in and metal uptake from soil treated with metal-amended sewage sludge. Journal of Environmental Quality 4:455-460.

Debosz, K., Petersen, S.O., Kure, L.K., Ambus, P., 2002. Evaluating Effects of Sewage Sludge and Household Compost on Soil Physical, Chemical and Microbiological properties. Appl. Soil Ecol. 19: 237-248.

Engelhart, M., Kruger, M., Kopp, J., Dichtl, N., 2000. Effect of disintegration on anaerobic degradation of sewage excess sludge in downflown stationary fixed film digesters. Water Sci. Technol. 41: 171-179.

Epstein, E., Taylor, J.M., Chaney, R.L., 1976. Effects of sewage sludge and sludge compost applied to soil on some physical and chemical properties. J. Environ. Qual. 5 (4), 422-426.

Huang, X.L., Chen, Y., Shenker, M., 2008. Chemical fractionation of phosphorus in stabilized biosolids. J Environ. Qual. 37:1949-1958.

Jung, M.C., Thornton, I., 1996. Heavy Metal Contamination of soils and plants in the vicinity of a lead zinc mine, Korea. Appl. Geochem. 53: 9-11.

Juste, C., Mench, M., 1992. Leng-Term Application of Sewage Sludge and Its Effects on Metal Uptake by Crops. In: Domy CA, Editor. Biogeochemistry of Trace Elements. Advances in Trace Substances Research. Boca Raton, FL: Lewis, 93: 159-93.

Kaplan, M., Orman, S., Kadar, I., Konez, J., 2005. Heavy metal accumulation in calcareous soil and sorghum plants after addition of sulphur-containing waste as a soil amendment in Turkey. Agriculture, Ecosystem and environment 111: 41-46.

Keller, C., McGrath, S.P., Dunham, S.J., 2002. Trace metal leaching through a soil grassland system after sewage sludge application. J. Environ. Qual. 31: 1550-1560.

Kulling, D., Stadelmann, F., Herter, U., 2001. Sewage Sludge-Fertilizer or waste? UKWIR Conference, Brussels.

McBride, M.B., Richards, B.K., Steenhuis, T., Russo, J.J.,Sauve, S., 1997. Mobility and solubility of toxic metals and nutrients in soil fifteen years after sludge application. Soil Sci. 162: 487-500.

Metcalf, Eddy, 2003. Wastewater engineering: treatment, disposal, and reuse, fourth ed. McGraw-Hill Publishing Company Ltd., New York.

Metthews, P.J., 1992. Sewage sludge disposal in the UK: a new challenge for the next twenty years. Water Environ. J. 6: 551-559.

O'Riordan, E.G., Dodd, U.A., Fleming, G.A. Tunney, H. 1994. Repeated Application of a Metal-Rich Sewage Sludge to Grassland. 1. Effects on Metal Levels in Soil. Ir J. Agric. Food Res. 33:41-51.

Orman, S., OK, H., Kaplan, M., 2014. Application of Sewage Sludge for Growing Alfalfa, Its Effect on the Macro-Micronutrient Concentration, Heavy Metal Accumulation, and Translocation. Ekoloji 23(90): 10-19.

Oste, L.A., Temminghoff, E.J.M., Van Riemsdijk, W.H., 2002. Solid-solution portioning of organic matterin soils as influenced by an icrease in pH or Ca concentration. Environmental Science & Tecnology 36: 208-214.

Ramirez, W.A., Domene, X., Ortiz, O., Alcaniz, J.M., 2008. Toxic effects of digested, composted and thermally-dried sewage sludge on three plants. Bioresour. Technol. 99,7168-7175.

Roldan, A., Albadalejo, J., 1996. Aggregate stability changes in a semiarid soil after treatments with different organic amendments. Arid Soil Res. Rehabil. 10: 139-148.

Roselli, W., Keller, C., Boschi, K., 2003. Phytoextraction capacity of trees growing on metal contaminated soil. Plant Soil 72: 256-265.

Sauve, S., McBride, M.B., Henderhot, W.H., 1997. Speciation of Lead in Contaminated soils. Environmental Pollution 98: 149-155.

Singh, R.P., Agrawal, M., 2008. Potential Benefits and Risks of Land Application of Sewage Sludge. Waste Management 28: 347-358.

Sopper, W.E., 1993. Municipal Sludge Use in Land Reclamation. Lewis Publishers, Boca Raton.

Sort, X., Alcaniz, J.M., 1996. Contribution of Sewage Sludge to Erosion Control in the Rehabilitation of Limestone quarries. Land Degrad. Dev. 7: 69-76.

Sort, X., Alcaniz, J.M., 1999. Effects of Sewage Sludge amendment on Soil Aggregation. Land Degrad. Dev. 10: 3-12.

Yingming, L., Corey, R.B., 1993. Redistribution of Sludge Borne Cd, Cu and Zn in a Cultivated Plot. J. Environ. Qual. 22: 1-8.

Zhang, M.K., Ke, Z.X., 2004. Heavy metals, phosphorus and some other elements in urban soils of Hangzhou City, China. Pedosphere 14(2): 177-185.

Zheng, G.D., Gao, D., Chen, T.B., Luo, W., 2006. Stabilization of nickel and chromium in sewage sludge during aerobic composting. J. Hazardous Meterial 142:216-221.

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Role of wind erosion in dust-salt masses migration, soil salinization and degradation (in the coastal area of Azerbaijan)

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Abstract

In a global, including regional climate change, considering the impact of drought, desertification and land degradation, there is a need for detailed study of the role of deflationary process (obtaining quantitative and qualitative data) in the respective natural-anthropogenic conditions in the region of study. It is important to identify the dust and salts amounts taken away by winds, define dust salt accumulation areas and develop actions to counter these processes. In the studied region, all types of soils subject to potential deflation. To solve these problems, studies are carried out in the coastal zone with a variety of landscapes, saline soils, having a number of patterns spreading beyond the region of study. The studies are carried to establish the degree of deflation of soils, to identify areas of their expansion, to identify sources of eolian dust and salt migration. Summarizing the results of studies of soil deflation, it is shown that 18% of soil subject to wind erosion of varying degrees. The source areas of eolian dust-salt mass migration are established as well as their accumulation areas. Salinization of meadow gray saline and alkaline soils is high, thick residue in their upper horizon constitutes 1.42-1.50 % and 0.63 %, respectively. Mean total removal of salts from saline soils with the average 10% plant cover varies from 171 to 320 ton per km^2 per year, or 1.7 - 3.2 t / ha per year.That means the deflation rate is at 0.17 - 0.32 mm per year, which estimates the annual removal by wind of the dust-salt mass from across the region. The acquired data of eolian removal of dust salt mass per unit area are functional. These are averages for soil salinity of mainly hydromorphic, chloride-sulfate type. Loose constitution of the upper salt accumulation horizon (evaporite horizon) contributes to removal of dust-salt mass by wind. The thickness of evaporite layer reaches 2-2.5 cm. According to the value of the full aqueous extract the solid residue in the upper horizons of the crust-plump saline soil constitutes 8.7 %, and in the eolian mound near shrubs - more than 7.0%. Eolian dust-salt mass migration in the zone of active anthropogenic influence deterioratesthe geochemical environment.

Keywords: Wind erosion, land degradation, saline soil, deflation.

Introduction

Wind erosion is classified as one of the criteria for properties changes in the soil components or as one of the environmental factors influencing soil conditions and characteristics of species diversity of vegetation. Particularly acute problem of increasing activity and/or intensity of deflation processes is observed in the coastal zone of Azerbaijan. This is explained by the specifics of natural conditions of the coastal zone and increasing anthropogenic impact.

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The coastal area is exposed to the agricultural impact for long periods (over 80 years); these are vast expanses of cropland and grazing land for annual crops. As a result of continuous exposure the processes of secondary salinization and water-logging have developed, and projective cover of natural vegetation (also including artificial forest-shrub shelterbelts) and the soil surface covers were disturbed.

Material and Methods

The studied region is a trans-regional area that includes south-eastern parts of the main physiographic regions of Azerbaijan (Greater Caucasus, the Kura Basin, Lesser Caucasus, near-Araz elevation and depressions) (Museyibov, 2002). Taking into accounts the diversity of this region, we should consider the imposition of "sea factor" on the formation and dynamic development of geo-complexes that underwent significant changes in time and space. Formation of geo-complexes depends on physiographic processes specific for land and sea.

The absolute height of the terrain varies from zero and -4 meters above sea level to the -24m. Marine sediments are deposited on the surface and at depths 3-5m and deeper in different variations. Their upper part consists of marine sand, light-textured alluvium, deltaic sediments of various thickness, clays and heavy loams. The types of soils most widely used in agriculture under annual crops are the meadow-gray (low-humic and mediim-humic), primitive gray-meadow and mixed soils of coastal plains of the Kura-Araz lowland (Salyan plains and Southeastern Shirvan plain). The critical depth of groundwater level there varies from 1.0 m to 3.0 m. Groundwater mineralization ranges between 30-50 g/l and 50-80 g/l. The groundwater depth averages 150-170cm in August and the capillary rise of water in loamy soils is approximately 160 cm. In such circumstances there is an accumulation of salts ongoing in the upper layer (0 - 25 cm). Dominant salts are Na_2SO_4 and NaCl, with NaCL accumulating near the surface.

Anthropogenic processes of varying the size and intensity, forms and methods, superimposed on the natural environment contributed to the intense change of the soil surface and vegetation.

To assess the role of wind erosion in the migration of dust-salt mass, in salinization and degradation of soils and vegetation the field monitoring and reconnaissance surveys were arranged and conducted to observe and evaluate and removal of fine-grained dust-saline soil particles. The study included taking soil samples which were analyzed in the laboratory for chemical composition. These studies were carried out in the zone of secondary salinization, as well as in the less deflation-prone and less saline areas, and in the core areas of aeolian salt migration.

To determine the bulk weight of eolian removal of dust and salts from a unit area of salt marshes and soil landscapes the following methods were used: samples of reference points, visual observations, the sampling of soil and salt for laboratory analyzes, and others, including indirectly supplementing and referencing the received results on deflating soils.

Results and Discussion

The appearance of abandoned lands developed from the areas which are non-attractive for agriculture, especially with damaged projective cover of vegetation and soil cover, naturally leads to a degradation of all natural processes. Very rapid change occurs in structure-aggregate composition of soil cover, which leads to even faster deflation process, and area of deflated soil surface increases.

Based on the soil deflation studies it was found that on Salyan plain only 24 thousand hectares (18%) of the soil cover of the total area (129.4 hectares) are subject to varying degrees of wind erosion. On the territory of Southeastern Shirvan plain the topsoil affected by wind erosion are classified as: low deflated - 14.5 thous ha, medium-delfated - 27.6 thous ha and highly deflated - 16.8 thousand ha. Highly deflated are alkaline soils (solonchaks) and coastal sands. Our results demonstrated that all types of soils in the region are potentially deflation-prone. Analysis of numerous materials to establish the degree of soil deflation, the core areas of wind erosion and the intensity of their manifestations leads to conclusion that the soils of the study region are subject to wind erosion, and hence to a migration of eolian dust-salt mass. It is worth noting that of the common types and subtypes of soils in the region the most susceptible to wind erosion are meadow-gray saline and alkaline soils, solonchaks and sand.

The degree of soil salinization on Salyan plains varies widely. There are certain patterns detected in the spread of soil salinization across the area. Less saline soils are common in the western part of plains. Medium and highly saline soils are found in the central and eastern part of the region. Soils with the highest degree of salinization are concentrated mainly in the eastern part - the coastal zone and some adjacent areas. Such a pattern of soil salinization is explained by the topographic low resulting in closed drainage, high capillary action of overlying rocks, intense evaporation, and poor rock permeability. Large amounts of salt, particularly chlorides, enters the coastal zone as a result of impulverizaton (airborne salt move). Intensive sea salt intake covers only a narrow coastal strip. The regularity in sharp decline of salts at a distance from the coast was noted by Hutton (1976). Changes in the degree of salinity are also observed in the direction of the prevailing winds, which are the north-easterly winds the year round. A decrease in the degree of soil salinity is observed in the southern direction. Hence, there is another factor involved in the soil salinization of this part of the region - the influence of neighboring areas having pockets with dust-salt mass. The greatest influence on salinization and eolian transport of salts have the territories located north of Salyan plains – the Southeastern Shirvan plain and Gobustan. Under certian climatic conditions, these effects can be observed at a distance of 100-150 km and more (Photo 1)

Photo 1. Solonchak on South-Eastern Shirvan Plain

There are many hypotheses about the features of salinization in arid, sub-arid zones. It is noted that there is a discrepancy between the rate of income and actual inventory of salts. For example, Orlova (2009) states that one of saline areas in Kur-Araz lowland (South-Eastern Shirvan plain) receives 10 to 35 million m3 of brine annually from the deep layers. Such an amount of salts could cause salinization across the whole Kura lowland in 300-500 years. However, despite such a huge influx of salt, there is a wide spread of low-saline and non-saline soils. The loss of salts happens because of aeolian migration of salts.

The low, medium and highly saline soils in the study area are caused due to the above listed reasons, but not excluding the anthropogenic factors: the irrational use of land, absence of or poor condition of drainage channels in irrigated agriculture.

We would like to draw attention to the aeolian process, its role in the migration of salts and, on its role in the salinization of soils of the area and of adjacent territories.

Processing and summarizing the research shows typical values for saline soils and salt marshes. Salinization of the meadow gray saline soils and solonchaks is high, thick residue in the upper horizon reaches, respectively, 1,42-1,50% and 0.63%. According to the chemical composition the salts are of chloride-sulphate type. Salt marshes occupy almost 20% of the study area. They are presented here in wet, puffed, crusty-puffed and hummocky variations. The most dynamic are crusty-puffed solonchak (See Photo 2).

Photo 2. Solonchak on Salyan plain

Loose constitution of the upper salt accumulation horizon, that is evaporite horizon, promotes the removal of the dust-salt mass by wind. Critical wind rate of removal for puffed layer is 2.5-4.0 m/s according to Orlova (1983). The finest dust is easily removed by wind speed of 3-4 m/s, with larger particles removed under stronger winds. The finest dust rises even by intense convective motions during the summer day thermal depression. A slightest breeze can raise the mineral particles from the soil surface.

As a result of visual observations on the soloonchak, we can say that loose salt mass, devoid of lumpiness, can be easily blown off, even at high humidity, since it is a light loose layer. At night, as a result of condensation, this layer is deposited, in the day it dries and fluffes. Evaporite layer thickness reaches 2-2.5 cm.

On the surface layer of solonchaks large amounts of salt and water-soluble carbonates get accumulated. Average total removal of salts from 1 km^2 of alkaline soils with 10% of plant cover ranges from 171 to 320 ton/km^2/year. That means the wind removal of dust-salt mass at 0.17 - 0.32 mm per year. The result estimates the annual removal of dust-salt mass by wind from across the region.

The obtained values of eolian dust-salt removal from unit area are functional. In the studied case the data are averages for mainly hydromorphic, chloride-sulfate type of soil salinity.

Here are some of the morphological characteristics of the vertical profile cut #73, dug 4 km to the south of Neftchala town. This plain is used for winter pasture; vegetation is presented by occasional sporadic halophytes. Soil cut is made to a depth of 90 cm. The chemical analyzes show that mechanical composition of the solonchak is heavy- loam, the physical quantity of clay reaches 48,8% in the upper layer, while in the deeper layers lighter clays are found with physical clay content up to 61%. Results of mechanical and structural-aggregate analyses show that deflation and redeposition of material leads to fewer physical clay on the solonchak's surface and usually represented in less than 1 mm fractions. (see Table 1).

Eolian hummock near shrubs was also studied. It differs sharply from solonchak features by its light texture (28.4%). According to the full aqueous extract, the solid residue in the upper horizons of the crusty-puffed solonchak totals 8.7%, and in the eolian hummock near shrubs - more than 7.0%. Eolian migration of dust-salt mass in the zone of active anthropogenic influence deteriorates geochemical status of the environment.

Table 1. Full aqueous extract of solonchaks (%/mEq soil dried at 105°C).

Verti-cal cuts	Genetic horizon	Deflation degree	Depths, sm	CO_3	HCO_3	Cl	SO_4	Ca	Mg	Na+K (by difference)	Solid residue %
73	B1	Highly deflated (solonchak)	0-10	None	0.20 3,18	3,80 106,77	1,32 27,38	0.07 3,45	0.14 11,28	2.82 122.60	8.74
			10-35	-	0.10 1,68	1,23 34,91	1,22 25,34	0.08 3,86	0.07 5,38	1.21 52.69	6.86
			35-90	-	0.15 2,41	1,25 27,06	1,16 24,13	0.06 3,05	0.09 7,42	1,45 63,13	4.65
85		Accumu-lated (hummock near shrub)	0-20	None	0.15 0.21	0.30 0.72	0,52 0,03	10,15 0,20	2,11 0,03	103.50 2.38	7.06
			20-60	-	0.01 -	0.47 1,42	1,37 0,06	7,64 0.15	1,09 0,01	99.06 2.23	6.54

Conclusion

The processing and analysis of a series of field work studies leads to a conclusion that it is not only anthropogenic impact results in the land degradation. The natural processes, in our case soil migration, plays an important role accompanies and accelerates anthropogenic desertification, forming specific landscapes. These landscapes appear in concentric-focal, diffuse-widespread linearly-lane and sporadically-spotted forms. Deflated and eroded soil are unevenly distributed, which, of course, happen due to the influence of anthropogenic factors. The climate changes increases frequency of droughts, desertification and degradation processes, the value of wind erosion studies increases. It is important to assess the amounts of transported dust and salts, to identify their accumulation areas, and to develop measures to prevent and counteract these processes.

References

1. Belgibayev M.E. 1972 Бельгибаев М.Е. Природные условия дефляции почв и почвенно-эрозионное районирование Северо-Тургайской равнины// Автореф. дис. … канд. геогр. наук. [Natural conditions of soil deflation and soil erosion classification of North Turgau plain// published summary of a PhD thesis] Alma-Ata
2. Gahramanova T.M. 2011 Каграманова Т.М. Ветровая эрозия как один из факторов деградации почв прибрежной зоны Азербайджана. Вестник Бакинского Университета, №3, 2011, с.115-123. [Wind erosion as one of factors of soil degradation in coastal areas of Azerbaijan. In: Vestnik Bakinskogo Universiteta #3-2011, pp.115-123. Baku
3. Hutton J.T. 1976 Chloride in rainwater in relation to distance from the ocean. Reprint N 1162. Division of soil 8. Commonwealth scientific and industrial research organization// Search. Vol.7.N5,p.207-208
4. Kosnazarov K.A. 1990 Косназаров К.А. Роль эолового переноса в солевом режиме Южного Приаралья// Автореф.Дис. … канд. с-х наук. [Role of eolian transport in saline regime of South Aral sea region// // published summary of a PhD thesis] Tashkent
5. Orlova M.A. 1983 Орлова М.А Роль эолового фактора в солевом режиме территории. [Role of eolian factor in saline regime of an area] Alma-Ata
6. Orlova M.A., Saparov A.S. 2009 Орлова М.А. Сапаров А.С. Глобальный саморегулируемый круговорот солей в природе. [Global self-regulated circulation of salts in the nature] Almaty

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Application of green algae *Chlorella vulgaris* as microbial fertilizer

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Abstract

Green algae, *Chlorella vulgaris* stimulates plant growth by production of hormones, vitamines, improves soil structure, increases soil aeration, absorbs havy metals from soil. Microbial fertilizers with *Chlorella* sp. are used succesfully as monovalent inoculum and combined with rhizobacteria as mixed inocula. The aim of this research was to evaluate the effect of *Chlorella vulgaris* on the initial growth of wheat, maize, bean, onion and lettuce and microbiological activity of rhizospheric soil. The experiment was conducted in controlled conditions in three repetitions. The inocula was applied as foliar fertilizer by spraying. Plant material was taken 30 days after treatment which was followed by the measurment of plant growth parameters (stem length, stem fresh mass, root length and root fresh mass). Soil microbiological activity included the determination of total number of bacteria (TNB), number of actinomycetes (ACT), fungi (FNG), animoheterotrophs (AMH), azotobacter (AZB) and dehydrogenase activity (DHA). *Chlorella vulgaris* affected positively the length (28,5 % increase) and fresh mass (17,9 % increase) of maize root, stem length of wheat (24,2 % increase), stem mass of lettuce (56,34 % increase) and uniform increase of stem and root length of bean. *Chlorella vulgaris* increased the number of aminoheterotrophs in the maize rhizosphere while the number of other investigated groups of microorganisms did not change significantly.The influence of plant species was more significant. The activity of dehydrogenase enzyme was not affected by inoculation with green algae. *Chlorella vulgaris* produces biologically active substances, increases the level of photosynthesis. It is a source of macro and micronutrients, amino acids and hydrocarbons. The application of green algae is recommended for production of crops and vegetables on all soil types.

Keywords: green algae, stimulation of growth, foliar treatment

Introduction

Chlorella vulgaris stimulates plant growth by production of growth hormones, vitamins, macronutrients (N, P, K) and micronutrients (Fe) (Bajguz and Piotrowska-Niczyporuk, 2013). *Chlorella* sp. enhances soil structure, soil aeration, absorbs heavy metals. Mode of application varies from foliar treatment to seed coating or only algal extracts could be used (Faheed and Abd-El Fattah, 2008). Green algae based microbial fertilizers are used in Hungary, India, Egypt, Portugal and in Scandinavia. *Chlorella vulgaris* could be successfully used as single or combined with different rhizobacteria (Raposo and De Morais, 2011; Gonzales and Bashan, 2000).

The aim of this research was to investigate the influence of *Chlorella vulgaris* based microbial fertilizer on the initial growth of wheat, maize, been, onion and lettuce as well as the microbiological activity in the rhizospheric soil.

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Material and Methods

The experiment was set up in vegetation pots filled with humus substrate. Plant material was as follows: maize (NSSC6010), been (Žuta olovka), wheat (NSR-5), lettuce (Majska kraljica) and onion (Damascus/F1). The above ground plant parts were treated two times within 30 days with 1.6% water suspension of green algae microbial inocula (Natur Plasma - liquid fertilizer containing *Chlorella vulgaris*, $3x10^7$ CFU/ml, Hungary). The treatments were foliar. First application was carried out seven days after emergence, second treatment 25 days after emergence. Sampling of the plant material was performed five days after second treatment. Stem length (cm), stem fresh mass (g), root length (cm) and root fresh mass (g) were measured. In the rhizospheric soil the total number of bacteria, number of actinobacteria, fungi, aminoheterotrophs and azotobacter were determined. Standard method of agar plates was used (Trolldenier, 1996). Dehydrogenase activity was measured by spectrophotometric method (Lenhard, 1956 and Thalmann, 1968). Statistical analyses were performed using STATISTICA 10.0 (Hamburg, Germany).

Results and Discussion

Application of *Chlorella vulgaris* affected differently the initial growth of the plants. The initial maize growth parameters were increased 4.5 and 28.5% (Table 1). Maize root length was the highest regardless of the foliar treatment of *Chlorella vulgaris*. The highest stem length was obtained with wheat. Stem and root of bean plants grew uniformly, the increase in length was around 10%, respectively. *Chlorella vulgaris* affected positively the growth of lettuce which is of great importance because it is mainly grown for leaves and used as salads in human diet.

Table 1. Effect of *Chlorella vulgaris* on investigated plant growth parameters*

		Stem length	Root length	Stem fresh mass	Root fresh mass
Maize	Control	47.25	41.50	2.14	0.94
	Chlorella vulgaris	51.00	53.33	2.23	1.11
	% increase or decrease	7.9	28.5	4.5	17.9
Wheat	Control	29.62	14.0	130.0	31.0
	Chlorella vulgaris	36.8	16.6	174.0	38.4
	% increase or decrease	24.2	18.57	33.0	23.8
Bean	Control	33.5	32.0	4.25	0.791
	Chlorella vulgaris	37.0	35.5	4.40	1.11
	% increase or decrease	10.44	10.9	3.5	40.0
Lettuce	Control	17.25	14.25	5.85	0.816
	Chlorella vulgaris	18.75	19.12	9.14	1.46
	% increase or decrease	8.6	34.2	56.34	78.3

*Plant growth parameters: stem length (cm), root length (cm), stem fresh mass (g/plant), root fresh mass (g/plant)

Table.2. Effect of *Chlorella vulgaris* on microbiological activity in rhizospheric soil (log No)*

		UBB	ACT	FNG	AMN	AZB	DHA
Maize	Control	9.37^{bc}	6.21^{a}	5.07^{bd}	9.20^{ab}	4.84^{a}	474
	Chlorella vulgaris	9.95^{d}	6.35^{a}	5.66^{b}	9.63^{c}	4.83^{a}	440
Wheat	Control	9.41^{a}	6.35^{a}	4.76^{a}	9.36^{a}	4.72^{a}	1424
	Chlorella vulgaris	9.84^{b}	6.26^{ab}	5.38^{a}	9.88^{a}	4.77^{a}	674
Bean	Control	9.86^{d}	6.24^{a}	3.46^{a}	9.69^{c}	4.79^{a}	551
	Chlorella vulgaris	9.59^{be}	6.28^{a}	4.74^{cd}	9.44^{ac}	4.56^{a}	342
Lettuce	Control	9.19^{c}	6.28^{a}	4.42^{c}	9.14^{ab}	3.70^{b}	893
	Chlorella vulgaris	8.91^{a}	6.20^{a}	4.75^{cd}	8.93^{b}	3.57^{b}	2004
Onion	Control	9.64^{e}	6.27^{a}	4.53^{cd}	9.63^{c}	3.50^{b}	368
	Chlorella vulgaris	9.76^{de}	6.33^{a}	5.07^{d}	9.66^{c}	3.41^{b}	434

*Note: different letters in superscript indicate the statistically significant difference among investigated parameters; LSD test (p=0.05); DHA-µg TPF 10^{-1} g soil

Plants foliar treatment with *Chlorella vulgaris* led to the increase of total bacterial number in the rhizosphere of maize and wheat (Table 2). Actinomycetes and azotobacter were not affected significantly by algalization. Abundance of saprophytic fungi was increased only in the rhizosphere of bean. The number of aminoheterotrophic bacteria was increased in the rizosphere of maize. The dehydrogenase activity was negatively affected by algal inoculation.

Algalization or application of green algae as a soil-based inoculums influenced positively the plant growth. Significant increase of growth parameters recorded in this research is in accordance with the works of many authors worldwide. Faheed and Abd-El Fattah (2008) studied the effect of green algae on growth parameters and some physiological response of lettuce (*Lactuca sativa*) seed germination and growth. In general, microalgal treatment significantly increased the growth with a significant decrease in soluble carbohydrate, soluble protein and total free amino acids compared with those of the control (sterilized culture medium) of seed germination. Addition of *Chlorella vulgaris* (2 and 3 g dry alga kg^{-1} soil) to the culture medium or soil significantly increased fresh and dry weight of lettuce seedlings as well as pigments content. Our results states that the fresh mass of lettuce increased 56.34% after foliar treatment with *Chlorella vulgaris*. The stimulatory effects of alga as bio-fertilizer on some growth parameters of lettuce are also in accordance with the results obtained by Rani and Sathiamoorthy (1997). Mahmoud and Amara (2000) found that all treatments significantly increased plant growth parameters compared with un-treated plant. Strong stimulating effect of algae on growth of grapevine seedlings cv.“*Palieri*” test plants were observed in the variants with 0.5g and 1.0g *Chlorella* in comparison with the control variants (Bileva, 2013). *Chlorella vulgaris* cells improved the germination of cluster beans seeds (*Cyamopsis tetragonoloba*) tested, the total length was more by nearly 6% in microalgae-treated plants when compared with that of control (Hanumantha Rao et al., 2010). Furthermore, the stimulatory effect of green algae could be attributed to antimicrobial effects of *Chlorella vulgaris*. Pratt et al. (1944) isolated the first antibacterial compound from *Chlorella*; a mixture of fatty acids, viz. chlorellin. It was found to be responsible for that inhibitory activity against both Gram+ and Gram- bacteria. Since then many authors focused their research on antimicrobial substances produced by green algae (Ghasemi et al., 2004, 2007; Ordog et al., 2004).

In contrast to stimulated plant growth, algalization with *Chlorella vulgaris* did not influence significantly the microbiological activity in the rhizosphere of the investigated plants. That was an expected result since the algal inoculum was applied as foliar treatment. Few algal cells reached the soil surface and could not interact with soil microorganisms.

Green algae as biofertilizers are a promising alternative to avoid soil pollution caused by agrochemicals. Also, they recover the nutrients content to soil as they secrete exo-polysaccharides that improve soil structure and bio-active substances that enhance the plant growth. Algae are known to be one of the most promising sources as bio-control agents of any residues, thereby having positive impact on human health (Silva et al., 2000).

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References

Bajguz, A., Piotrowska-Niczyporuk, A., 2013. Synergistic effect of auxins and brassinosteroids on the growth and regulation of metabolite content in the green alga *Chlorella vulgaris* (Trebouxiophyceae). Plant Physiol Biochem. 71, 290-297.

Bileva, T., 2013. Influence of Green Algae *Chlorella vulgaris* on Infested with *Xiphinema index* Grape Seedlings, J Earth Sci Climate Change 2013, 4:2 http://dx.doi.org/10.4172/2157-7617.1000136

Faheed,F.A., El-Fattah,Z.A., 2008. Effect of *Chlorella vulgaris* as bio-fertilizer on growth parameters and metabolic aspects of lettuce plant. J. Agriculture Social Sci. 4, 165-169.

Ghasemi, Y., Moradian, A., Mohagheghzadeh, A., Shokravi, S., Morowvat, M.H., 2007. Antifungal and antibacterial activity of the microalgae collected from paddy fields of Iran: characterization of antimicrobial activity of *Chlorococcus dispersus*. J. Biol. Sci.7, 904-910.

Ghasemi, Y., Yazdi, M.T., Shafiee, A., Amini, M., Shokravi, S., Zarrini, G. Parsiguine, 2004. A novel antimicrobial substance from *Fischerella ambigua*. Pharmaceutical Biology 42, 318-322.

Gonzales, L.E., Bashan, Y., 2000. Increased Growth of the Microalga *Chlorella vulgaris* when Coimmobilized and Cocultured in Alginate Beads with the Plant-Growth-Promoting Bacterium *Azospirillum brasilense.* Appl. Environ. Microbiol. 66/4, 1527–1531.

Hanumantha Rao P., Ranjith Kumar, R., Subramanian, V. V., Sivasubramanian, V., 2010. Environmental impact assessment of *Chlorella vulgaris* employed in phycoremediation of effluent from a leather-processing chemical industry J. Algal Biomass Utln. 1 (2), 42-50.

Lenhard, G., 1956. Die dehydrogenase aktivitat das Bodeusald Mass fur die Mikroorganizmentatigk eit im Boden. Z. Pflansenern. Dung Bodenkude. 73, 1-11.

Mahmoud, H.A.F., Amara, M.A.T., 2000. Response of tomato to biological and mineral fertilizers under calcareous soil conditions. Bull. Fac. Agric. Cairo University 51, 151–74.

Ördög V, Stirk WA, Lenobel R, Bancírová M, Strand M and van Standen J 2004. Screening microalgae for some potentially useful agricultural and pharmaceutical secondary metabolites. J. Appl. Phycol. 16, 309-314.

Pratt, R., Daniels, T.C., Eiler, J.B., Gunnison, J.B., Kumler, W.D., 1944. Chlorellin, an antibacterial substance from *Chlorella*. Sci. 99, 351-352.

Raposo, M.F.D.J., De. Morais, R.M.S.C. 2011. *Chlorella vulgaris* as soil amendment: influence of encapsulation and enrichment with rhizobacteria. Int. J. Agric. Biol., 13, 719–724

Rani, M.S.A., Sathiamoorthy, S., 1997. Effect of organic and bio-fertilizers on root enzyme activity, nematode, total biomass and growth enhancement of Papaya cv. Co. 6. South India Hort. 45, 217–223.

Silva, J.A., Evensen, C.I., Bowen, R.L., Kirby, R., Tsuji, G.Y., Yost, R.S., 2000. Managing Fertilizer Nutrients to Protect the Environment and Human Health. In: Plant Nutrient Management in Hawaii's Soils, Approaches for Tropical and Subtropical Agriculture. J. A. Silva and R. Uchida, eds. College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa. Capter 1, 7-22.

Thalmann, A., 1968. Zur Methodik des Bestmmung des Dehydrogenase aktivitat im Bodenmittels TTC. Landiw. Forch. 21, 249-258.

Trolldenier, G., 1996. Plate Count Technique. In: Methods in Soil Biology. Ed. Franz Schinner, Ellen Kandeler, Richard Ohlinger, Rosa Margesin. Springer-Verlag Berlin Heideberg, 20-26.

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Shallot of Lembah Palu variety responses under different watering interval, puddling and liming in Palu Valley entisols

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Abstract

Shallot of LembahPalu variety is a priority commodity in Central Sulawesi Indonesia due to its unique flavor and texture. Its minimal management has lead to low productivity particularly in Bulubaseh watershed Central Sulawesi Indonesia. Water availability often becomes the main constraints for high yield. Farmers used to puddle the soil in order to preserve water. This practice along with lime and water interval applications was studied in small lysimeters within a glass house. Puddling was done by stirring the soil with a stick at 20 and 40 rotations minute^{-1}. Water was applied at four, eight and 12 day intervals and lime was added at 0, 10 and 20 t ha^{-1}. Plant evapotranspiration during growth period was highest in combination treatments of puddling, water interval of 12 days and with no lime application. Soil physical characteristic such as bulk density was significantly affected by the combination of puddling and lime treatments with lowest value were found in no puddling and lime 10 t ha^{-1}. Water interval and puddling combination treatments had significant effect on hydraulic conductivity. Liming at 10 t ha^{-1} and no puddling resulted in highest hydraulic conductivity. Other characteristic such as field capacity and soil penetration resistance were only significant under puddling treatment. Both were highest in twice puddling treatment. Root length was only significantly affected by single treatment of puddling in which longest root was found in no puddling while plant dry weight only by water interval with four day water intervals produced largest weight.

Keywords: Puddling, liming, water interval, evapotranspiration, shallot.

Introduction

Shallot of LembahPalu variety is increasingly becoming an important commodity in Palu of Central Sulawesi Indonesia. Its main product as fried shallot with its unique texture and flavor has lead to rapidly demand increases in the last several years. For this reason, the regional government of Central Sulawesi Province has issued a policy stating that the plant is one of priority commodities (Anshar, 2012). In the last decade the land area where shallot is grown has extended to more than 120%. However, sustaining constant supply of the fried shallot either for local or export needs has been facing many constrains; one of them is environmental condition where the plant is cultivated. Soil characteristic predominantly silty loam to sandy loam and dry climate with rainfall of 800 – 1.000 mm year^{-1} has lead to limited water supply for most agricultural land in Palu valley. This particular condition has prevented high productivity of this commodity. According to Widjajanto*et al.* (2007), land suitability and climate factors plays a main role in developing the plant cultivation to produce better quantity and quality of the fried shallot. One particular area where shallot has been cultivated for a long period of time in Palu valley is Guntarano village sited in Bulubaseh watershed (LaporanDesaGuntarano,

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2010). Farmers in this village have long practiced puddling their soil in order to preserve water. This practice alone has little influence on improving the shallot productivity. One strategy to increase it is through technology application suitable for the farmers including improving soil physical condition and plant water use efficiency (Widjajanto*et al*., 1997; and Widjajanto, 2006). According to Widjajanto (2002) soil puddling and liming can effectively improve soil aggregate stability and water holding capacity in early period of soil drying. Therefore, the objectives of the research were to determine the influence of watering interval, puddling and liming on the changes of soil physical characteristics, root length and plant dry weight, and evapotranspiration during its growth period of shallot of local Palu variety.

Material and Methods

Entisols sample from Guntarano village was taken compositely at a depth of 0 – 20 cm. The soil was air dried and sieved to obtain soils with diameter of less than 2 mm. The sieved soils were then filled into lysimeters for 10 kg each. The lysimeter had dimension of 30 cm in diameter and 30 cm in height with holes at the bottom for watering. The lysimeters were placed in the green house of Faculty of Agriculture, Tadulako University.

The experimental design was a split split plot with three factors imposed including watering interval (main plot) at a rate of 4, 8 and 12 d; puddling (sub plot) at a rate of 0, once and twice; and liming at a rate of 0, 10, and 20 t ha-1 $Ca_3(PO4)_2$. Watering was done by placing the lysimeter into a container filling with 15 cm water depth to avoid air entrapped. Saturated condition was reached after 2 – 3 d and then the soil was left to dry until the next watering session.Soil puddling according to Tranggono (1988) was carried out by manually stirring the soil clockwise and anti clockwise at saturated condition using a stick at 10 rpm. This is considered as puddling once. The following Table 1 shows the combinations of the treatments applied. Each treatment was replicated thrice; therefore, there were 81 experimental units.

Table 1. Treatment Combinations

		W0	W1	W2
P0	L0	W0P0L0	W1P0L0	W2P0L0
	L1	W0P0L1	W1P0L1	W2P0L1
	L2	W0P0L2	W1P0L2	W2P0L2
P1	L0	W0P1L0	W1P1L0	W2P1L0
	L1	W0P1L1	W1P1L1	W2P1L1
	L2	W0P1L2	W1P1L2	W2P1L2
P2	L0	W0P2L0	W1P2L0	W2P2L0
	L1	W0P2L1	W1P2L1	W2P2L1
	L2	W0P2L2	W1P2L2	W2P2L2

Notes: W0=watering at 4 d interval; W1=watering at 8 d interval; W2=Watering at 12 d interval; P0=no puddling; P1=puddling once; P2=puddling twice; L0=no liming; L1=liming 10 t ha^{-1}; and L2=liming 20 t ha^{-1}.

Soil sampleswere air dried for two weeks and screened through 2 mm sieve. Lime according to the treatment was uniformly mixed with the soil and packed into alysimeter with 30 cm in height and 30 cm in diameter. Each lysimeter was filled with 10 kg soil. A hole at the base of the lysimeter was opened for wetting the soil. Three seeds were planted at each lysimeter and allowed to grow for 10 – 20 d, then thinned to one seed left. Soil and plant variable observed is summarized in Table 2.

Table 2. Soil and Plant Variables Observed

Variable Observed	Time	Analyisis Methods
	SOIL	
Evapotranspiration (ET)	Onceevery two daysduring soil drying period	Gravimetric
Bulk Density (BD)	80 DAP*	Undisturbed Soil Sample
Hidraulic Conductivity (HC)	80 DAP	Constant Head Permeameter
Saturated Water Content (SWC)	80 DAP	Gravimetric
Field Capacity Water Content(FCC)	80 DAP	Gravimetric
Penetration Resistance (PR)	80 DAP	Hand Penetrometer
	PLANT	
Root Length (RL)	80 DAP	Grid (Tenant, 1975)
Top Dry weight (TDW)	80 DAP	Drying at 60°C for 3x24 h

*Days after planting

Data obtained was analyzed using F Test and proceeded with Least Significant Difference Test (LSD) if the differences between treatments were significant (Steel and Torrie, 1980).

Results and Discussion

Soil Characteristics

The result of Analysis of Variance of soil variable observed issummarized in Table 3.

Table 3. Analysis of Variance of various soil characteristics as affected by watering interval, puddling, liming and their interactions

Treatment	Analysis of variance					
	ET	BD	HC	SC	FCC	PR
W	**	*	**	ns#	ns	ns
P	*	**	**	**	**	**
L	*	*	ns	ns	ns	ns
W*P	*	ns	*	ns	ns	ns
W*L	*	ns	ns	ns	ns	ns
P*L	*	*	ns	ns	ns	ns
W*P*L	*	ns	ns	ns	ns	ns

Notes: *significant (P<0.05%); **very significant (P<0.01%); #not significant

Table 3 depicts that only the puddling treatment has significant effect on all soil variables observed whereas the watering intervalon ET, BD, and HC, and Liming on ET and BD. All treatment interactions significantly influence ET whereas the interaction between the watering interval and puddling only significantly affect HC and the interaction between the puddling and the liming significantly affect BD.

Evapotranspiration

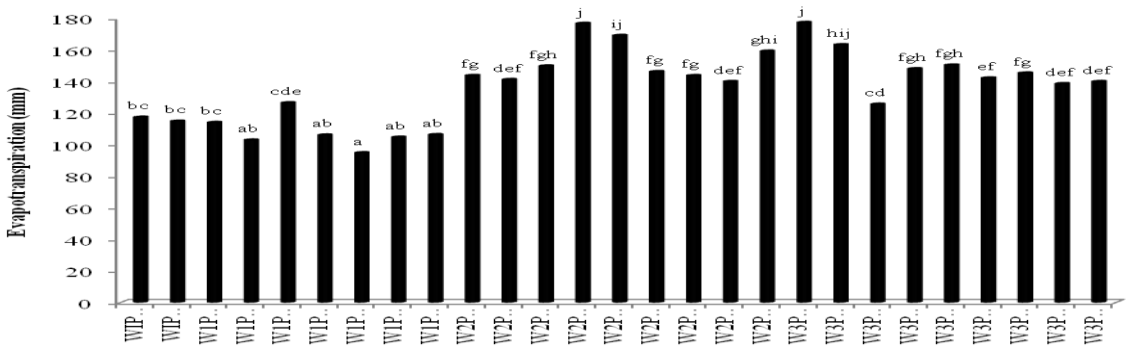


Figure 1. The effect of watering interval, puddling and liming on plant evapotranspiration
Note: *Different letter indicates significant difference at LSD 0.5%

Bulk density

Figure 2 shows soil bulk density as affected by puddling and liming. The largest bulk density was found in the P2L1 treatment. The bulk density tends to increase with increasing puddling and liming rate. This indicate that liming addition tend to stimulate more soil compaction. Sharma and de Datta (1985) and Tranggono (1988) stated that soil puddling conducted under saturated soil condition changes random clay particle orientation to more parallel orientation. Puddling also creates more cracks during drying which in turn could intensify soil compaction as shown by lower bulk density.

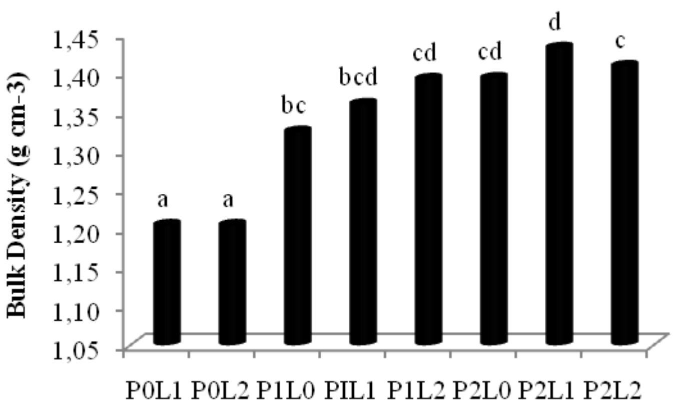


Figure 2. The effect of puddling and liming on soil bulk density
Note: *Different letter indicates significant difference at LSD 0.5%

Hydraulic conductivity

Soil hydraulic conductivity as affected by watering interval and puddling is depicted in Figure 3. Figure 3 shows that hydraulic conductivity of the soil tends to decrease with increasing watering interval and puddling. The largest hydraulic conductivity of 10.32 cm h^{-1} was found in the W1P0 treatment. Lime added at 2.5 – 5% simultaneously with puddling at soil contained high montmorillonite clay decreased crack formation during drying compared to no lime addition (Widjajanto, 1995).

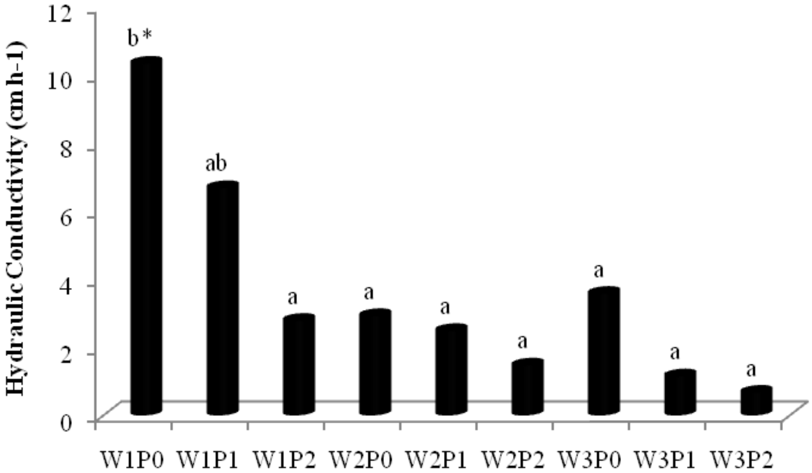
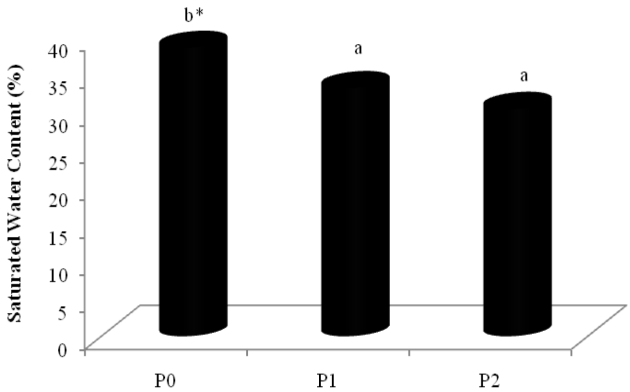


Figure 3. The effect of watering interval and puddling on soil hydraulic conductivity (Note:*Different letter indicates significant difference at LSD 0.5%

Water Content

Saturated water content significantly decrease with increasing puddling as shown in Figure 4. Puddling caused soil to become more compacted reducing soil porosity.



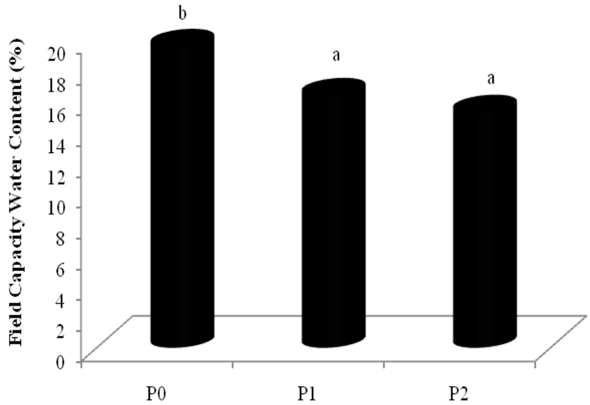


Figure 4. The effect of puddling on saturated water content   Figure 5.The effect of puddling on field capacity water content

Note: *Different letter indicates significant difference at LSD 0.5%

Water content at field capacity also shows similar trend to the water content at saturation as depicted in Figure 5. The largest soil water content at field capacity was found in no puddling treatment which is 19.56%. Puddling not only decreases the water content at saturation but also at field capacity indicating loss of both macro and meso pores.

Soil Penetration Resistance

Figure 6 shows soil penetration resistance as affected by puddling. Soil penetration resistance is significantly increased with increasing puddling. Puddling changes random clay orientation to become more oriented causing the soil to become more compact and stronger. Soil resistance increases from less than 1000 kPa to more than 2500 kPa when no puddling soil was puddled twice in magnitude. Soil penetration resistance of larger than 2000 kPa poses a great risk for plant root to explore soil.The rate of root growth is exponentially related to increasing soil penetration resistance (Bengough and Mullins, 1990). Soy bean root length decreased from 4.5 cm to only 2 cm when soil penetration increase from 400 kPa to 2000 kPa (Khalilian *et al.*, 1990).

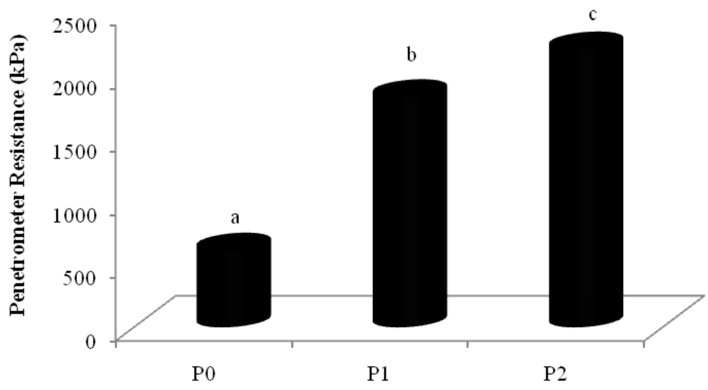


Figure 6. The effect of puddling on soil penetrometer resistance
Note:*Different letter indicates significant difference at LSD 0.5%

Plant Characteristics

Table 4 depicts the result of analysis of variance which shows that only puddling gives very significant effect on root length and plant dry weight and watering interval on root length.

Table 4. Analysis of Variance of plant characteristics as affected by watering interval, puddling, liming and their interactions

Treatment	Analysis of variance	
	Plant Root Length	Plant Dried Weight
W	ns	**
P	**	**
L	ns	ns
W*P	ns	ns
W*L	ns	ns
P*L	ns	ns
W*P*L	ns	ns

Notes: *significant (P<0.05%); **very significant (P<0.01%); #not significant

Plant Root Length

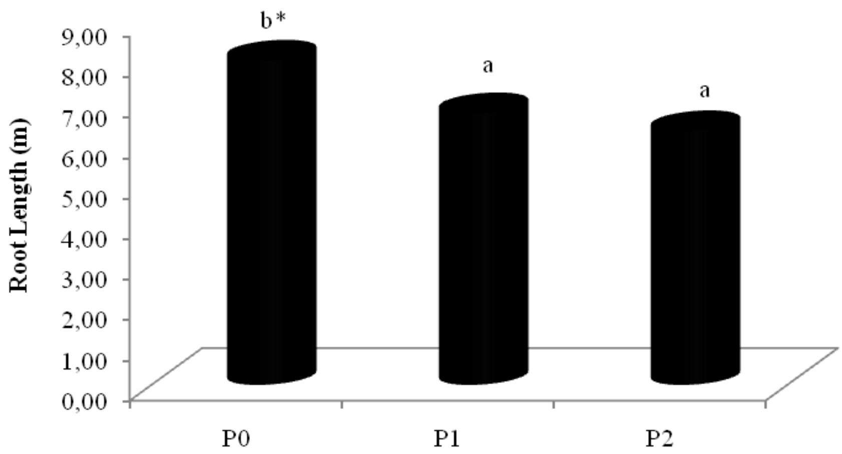


Figure 7. The effect of puddling on plant root length
Note:* Different letter indicates significant difference at LSD 0.5%

Figure 7 shows that root length significantly reduces with increasing puddling suggesting that this result is consistent with that of penetrometer resistance. The root length at the no puddling treatment was 8.02 m decreasing to only 6.82 m when puddling was twice in magnitude. Puddling creates soil physical condition unfavorable to plant growth during drying process as measured by penetrometer resistance (Figure 6). Root length development varied according to soil penetration resistance it endures (Bengough and Mullins, 1990; Bécel *et al*., 2012)

Plant Dry Weight

Puddling effect on plant dry weight was similar toroot length as depicted in Figure 8. As puddling increased to twice in magnitude plant dry weight significantly reduce from 4.32 g in no puddling treatment to only 3.10 g. Longer interval of watering significantly reduces plant dry weight as depicted in Figure 9. At four days of watering interval, the plant dry weight is 4.71 g which significantly reduce to only 2.99 g when the watering interval increased up to 12 days.

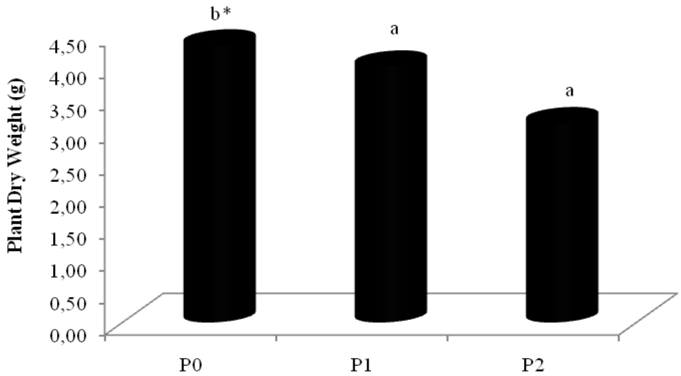


Figure 8. The effect of puddling on plant dry weight

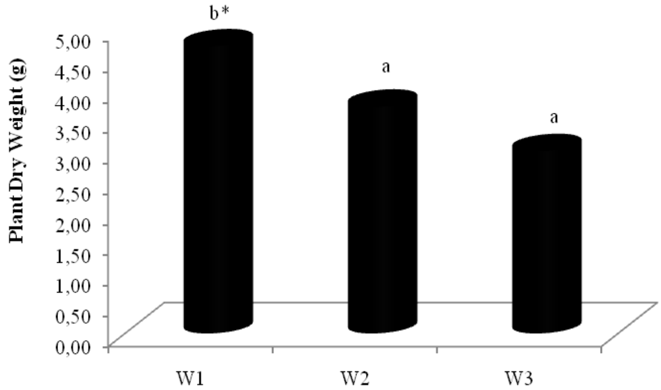


Figure 9.The effect of watering interval on plant dry weight

Note:*Different letter indicates significant difference at LSD 0.5%

Conclusion

This experiment suggests that the farmer practice of soil pudlling to preserve water actually has negative impact on plant growth decreasing both plant root length and dry weight with increasing puddling process.

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References

Anshar, M., 2012.Pertumbuhan dan Hasil Bawang Merah Pada Keragaman Ketinggian Tempat.Dissertation.Gadjah Mada University.

Bécel, C., Vercambre, G., Pagès, L., 2012. Soil penetration resistance, a suitable soil property to account for variations in root elongation and branching. Plant Soil 353:169–180

Bengough, A.G., Mullins,C.E., 1990. Mechanical impedance to root growth: A review of experimental techniques and root growth responses. J. Soil Sci. 41:341-358.

Khalilian, A., Hood, C.E., Palmer, J. H., Graner, T.H., Bathke, G. R., 1990. Soil compaction and crop response to wheat/soybean interseeding.Trans. Am. Soc. Agr. Eng 34, 2299-2303

Guntarano, L.D., 2010. ProduksiPertanian Di KelurahanGuntarano, KecamatanTanaNtovea, Palu. KelurahanGuntarano, TanaNtovea, Palu.

Sharma, P.K., De Datta, S.K., 1985. Effect of Puddling on Soil Physical Properties and Processes.In Soil Physics and Rice.IRRI, Los banos, Laguna, Philippines.p: 217 – 234.

Steel, R.G.D., Torrie, J.H., 1980.Principles and Procedures of Statistics. McGraw-Hill, Inc.

Tenant, D. 1975.A test of a modified line intersect method of estimating root length. J. Eco, 63, 995-1001

Tranggono, R., 1988. Puddling in 'Sawah' ant Its Effect on Soil Physical Properties.Ph.D Thesis.School of Agriculture, La Trobe University, Victoria, Australia.

Widjajanto, D., 1995. Studi Pembentukan Retakan Tanah pada Vertisol. J. Agroland 2(8): 42 – 46.

Widjajanto, D., Sahiri, N., Hasanah, U., 1997. Pertumbuhan Tanaman, Akar, dan Penggunaan Air pada Tanaman Kedelai (*Glycine max* L.) di Lahan Persawahan. Laporan Penelitian Program Berbagai Bidang Ilmu (BBI), Fakultas Pertanian, Universitas Tadulako. Palu.

Widjajanto, D., 2002. Pengaruh pengolahan tanah dan pemberian kapur terhadap perubahan ukuran bongkah dan kemantapan agregat tanah selama periode pengeringan. J. Agrisains 3(2): 104 – 111.

Widjajanto, D., 2006. Model Penggunaan Lahan untuk Pengembangan Pertanian Berkelanjutan. (Studi Kasus Daerah Aliran Sungai Gumbasa, Donggala). Disertasi. Intitut Pertanian Bogor.

Widjajanto, D., Hasanah, U., Pagiu, S., Golar, Rahman, A., Toknok, B., Taha, I., 2007. Identifikasi Karakteristik Daerah Tangkapan Gumbasa. Sulawesi Tengah. Kerjasama Fakultas Pertanian Universitas Tadulako dan Balai Pengelolaan DAS Palu-Poso.

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Fertility and productivityof soils in the Czech Republic

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Abstract

Soil as a principal production factor in agriculture has a number of specifics that require some detailed understanding of relation that exist between the production and soil characteristics, environment and food quality. Because of highly heterogeneous soil and climatic conditions, it is almost impossible to describe them accurately. For the identification of main relations, the systems of soil categorizationaredeveloped that contain the main specific features of individual groups of soils. Categorization of soil-climatic conditions provides sufficiently accurate definition of the soil productivity level for individual commodities and the need for production inputs. Crop yields and soil inputs were assigned to individual crops by the use of statistical methods based on the main parameters: soil texture, level of fertilization, weather and climate history, soil depth, slope, stoniness, exposure, technological way of tillage and other specific habitat-related conditions that are defined by the categorization of soil-climatic characteristics using so-called valued soil-ecological units (BPEJ). The level of individual yields and costs is attached to each of the main crops that arearranged according to their suitability to individual habitat-related conditions. Production costs are derived from the soil inputs according to operational surveys, applied processes and machinery costs. The system can also predict crop yields with respect to changing weather conditions on a statistically significant level. This paper presents results of the system and other possible use of related data for farms.

Keywords: Soil fertility, soil productivity, soil valuation, soil classification, advisory system, gross margin

Introduction

Soil as a most important production factor in agriculture and has a number of specifics that require some detailed understanding of relation that exist between the production and soil characteristics, environment and food quality. Results of the relations are realized in the complex system of coherent knowledge between natural and economic conditions. Because of highly heterogeneous soil and climatic conditions, there should be constructed enough detailed, but robust system for classification of soil-climatic conditions with regard to the basic needs of crops with economic character. The system of soil categorization isused that contains the main specific features of relations between individual groups of soils.The natural fertility of soil is defined by the physical characteristics of the soil together with the climate. In contrast, the productivity of the soil may be modelled using the same physical characteristics together with an assessment of those anthropogenic practises designed to enhance the natural soil fertility. In the Czech Republic, soil quality has been evaluated on the basis of genesis, moisture content, and partly on texture of soils. The system comprises seventy-eight groups, the so-called main soil units (HPJ). It is then divided into 557 main soil-climatic units (HPKJ). These are further divided according to the land configuration, soil thickness, and skeleton content into 2 199 soil-climatic units (BPEJ). The characteristics of HPJ and HPKJ enable the underlying of physical properties of the soil and

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climate to be quantified and the subsequent soil productivity modelling to be undertaken in relation to the basic soil fertility factors. The BPEJ are defined particularly for the purpose of taxes and state aid. They are, however, also utilised to quantify environmental issues (Voltr et al. 2011, 2012, Voltr 2012).

The valued soil-ecological units BPEJ is strictly based on natural conditions, properties and characteristics of the soil and habitats on which the land is located (Klecka, Korbini 1973). Code of BPEJ primarily and explicitly covers the whole climatic characteristics of the region (the first code number BPEJ), the characteristics of stoniness and soil depth, slope and exposure of the slope of the site (the fourth and fifth code number). Basic characteristics of the main soil units HPJ (second and third code number BPEJ) including taxonomic classification of soil classification and contain the main groups of soil-forming substrates such as grain, water and air regime, susceptibility to erosion and any other properties and characteristics of soils are supplemented by numerical and verbal assessment in the text and tables to the significant characteristics of HPJ.

Economic evaluation of soilcomes, from a long-term evaluation of inputs and outputs, which has been involved during implementation of the system of BPEJ to use (Klecka, Korbini, 1973; Nemecek, 2001; Mašát et al., 1985, 2002, others).The assessment of the soil is strictly based on natural conditions, properties and characteristics of the soil and habitats on which the land is located (Mašát et al., 2002). Code of BPEJ depends primarily on the characteristics of the climate of the region, the characteristics associated to the main soil units (hereinafter referred to HPJ), including the taxonomic evaluation of soil classification, major groups of soil-forming substrates, generally grain, the depth of soil, water regime, air arrangements, and further erosion depends on stoniness, slope and slope exposure.

The design of categorization of soil and economic context is developed with the help of crop production functions as a fundamental approach to define soil productivity. It was contended that production functions represent very important tool for analytical, descriptive, and predictive assertions.

Heady and Dillon (1961) described the application of crop production functions as a fundamental approach to define soil productivity, and this continues to underpin many ongoing applied research activities. It was contended that production functions represent a very important tool for analytical, descriptive, and predictive assertions. Possibility of use of regression functions described Efroymson(1960). Karlen et al. (1997) noted that as soil quality cannot be measured directly it serves as an umbrella concept for examining and integrating relationships and functions among the various biological, chemical, and physical parameters that are measured and important for sustainable agricultural and environmental systems. An international comparison of soil and climatic conditions, which focused on soil texture in combination with other factors (i.e. depth, slope, drainage, salinisation), has been undertaken in order to investigate soil fertility (Alterra& INRA 2005). It may also be possible to compare soil conditions by definition of certain groups of crops that are suitable for the specific soil type (Reinds and Van Lanen 1992), but with similar unifying criteria, primarily of content of clay particles.

Material and Methods

The method is based on complex formula of main indicators with respect to the soil productivity, used to define the complex interactions of soil productivity. Procedure of the main solved points in the paper is shown in the Fig. 1.

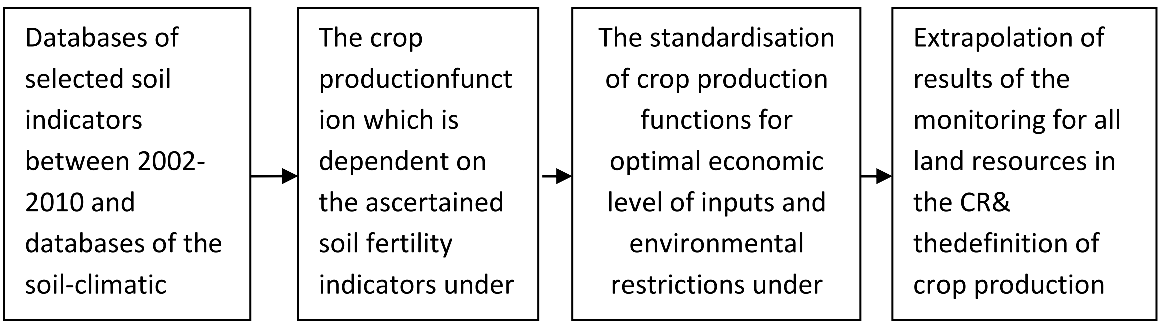


Fig. 1. Procedure of the main solved points

Dabbert (1994) demonstrated that the crop production function could result from a wide range of preparatory factors, defined by a primary formula (1):

$$Yt = f\ (Wt; St; At; Zt; Pt; Lt; T) \quad (1)$$

where: Y = crop yield; t = monitoring period (in years); W = climatic variables; S = type and condition of the soil; A = tillage; Z = plant nutrition; P = level of chemical protection of plants; L = soil preparation; T = technological progress.

The level of food crop nutrition may be defined in the same manner using function (2):

$$Xt = f\ (Wt\text{-}n; Ut\text{-}n; At\text{-}n; S; Pt\text{-}n; Lt\text{-}n; T) \quad (2)$$

where: X = the level of nutrition; t-n = the previous period t-n and variables; W = climatic factors; U = use of land for a particular crop; A = tillage; S = variables describing the soil type, nature, and condition of soil; P = chemical plant protection; L = soil preparation; T = technological progress.

Production functions were evaluated on the survey comprises approximately five hundred homogeneous plots of land covering a total area of 9 200 ha. It represents the 65 main soil units (HPJ) and the 127 most common soil-climatic units (BPEJ). The individual plots cover an area of at least 5 ha, with the main soil unit covering more than 80 % of the total area of the plot (Voltr 2011). In the period 2002-2010, production related data were collected on each of the monitored plots of land.

The basic indicators for determining soil fertility and soil productivity are defined by the physical characteristics of the soil and the climate supplemented with technological data related to crop production. The analysed soil characteristics are those of topsoil and subsoil texture, pH, chemical composition, humus content, soil absorption complex, and soil moisture during the vegetation period. Environmental characteristics of HPJ is evaluated in selected categories. The analysed climatic data relate to the average values of precipitation and soil temperature for a specific month at any given location, as collected by the Czech Hydrometeorological Institute. The analysed technological data relate to fertilisers, plant protection, and tillage as well as the penetrometric resistance of the soil.

Results and Discussion

A comprehensive list of all the variables based on statistical relationships from the underlying database needs the data to be prepared with regard to degree of correlation and their significance. For the selected agricultural crops, the yields depend on indicators with a high degree of significance but a lower correlation coefficient.

A three-stage model of yield dependency on operating conditions is used including the assessment of production factors´ significance and the introduction of other contexts reflecting particular climatic factors and environmental indicators that both relate to production yield. The quality of production functions depends primarily on the observed sample data and its variability. The best production function results in terms of stability are provided particularly for winter wheat, with the number of more than 1000 times/repetition.

Regression function was used in the first stepfor factors selected in the specific group with influence to the yield of main crops (without nitrogen), in the second step was used regression function based on predicted yield of each specific group. Regression function in the third step was create based on the nitrogen input.

The best predicative factors used for first stage of models are shown in tab 1. and 2.

The results presented in Table 1 and 2 show that soil fertility has a greater impact on winter wheat yield than the intensification factor given by the nitrogen dosage. As shown in Table 1, some of the variables have different importance for the yield of winter wheat. It may be possible to model linear functions using factors of soil fertility to obtain a complex function of soil productivity in the dataset. However, problems arise when attempting to specify the soil-climatic categorisation functions for different plants.

Evaluation of yield, nitrogen consumption and intensity of chemical protection primarily factors was carried out in each basic group: Weather, local conditions, fertilizers, technology, main soil units, soil texture. Statistical analysis was divided into groups because of the need of evaluation of the operational aspects of the production on a large number of factors influencing the yield of crops. The importance of individual groups of factors was evaluated by regression analysis for each crop.Results of the analysis are shown on Fig. 2.

Table 1. Factors with positive influence on the yields of winter wheat

Factors	Pearson Correlation
Soil texture of topsoil, percentage of particles 0.01 - 0.05 mm	0.416
Soil depth category by main soil unit (category)	0.399
Thickness of humus horizon by main soil unit (category)	0.367
Exchangeable pH of topsoil based on the Comprehensive Soil Survey	0.36
Total nitrogen rate (kg/ha)	0.332
Number of PPP applications	0.331
Subsoil structure by main soil unit (category)	0.328
Mineral nitrogen	0.316
Skeleton category	0.291
Vulnerability to water erosion by main soil unit (category)	0.268
Sum of dry days during the sowing period, wheat	0.258
Thickness of humus horizon by main soil unit (category)	0.256
Soil texture, percentage of particles smaller than 0.001 mm	0.211
Soil texture of subsoil, percentage of particles smaller than 0.001 mm	0.202
Ploughing resistance by main soil unit (category)	0.202
Topsoil structure by main soil unit (category)	0.188
Total phosphorus rate (kg/ha)	0.183
Year of harvest	0.176
Organic nitrogen rate (kg/ha)	0.171

Tab. 2. Factors with negative influence on the yields of winter wheat

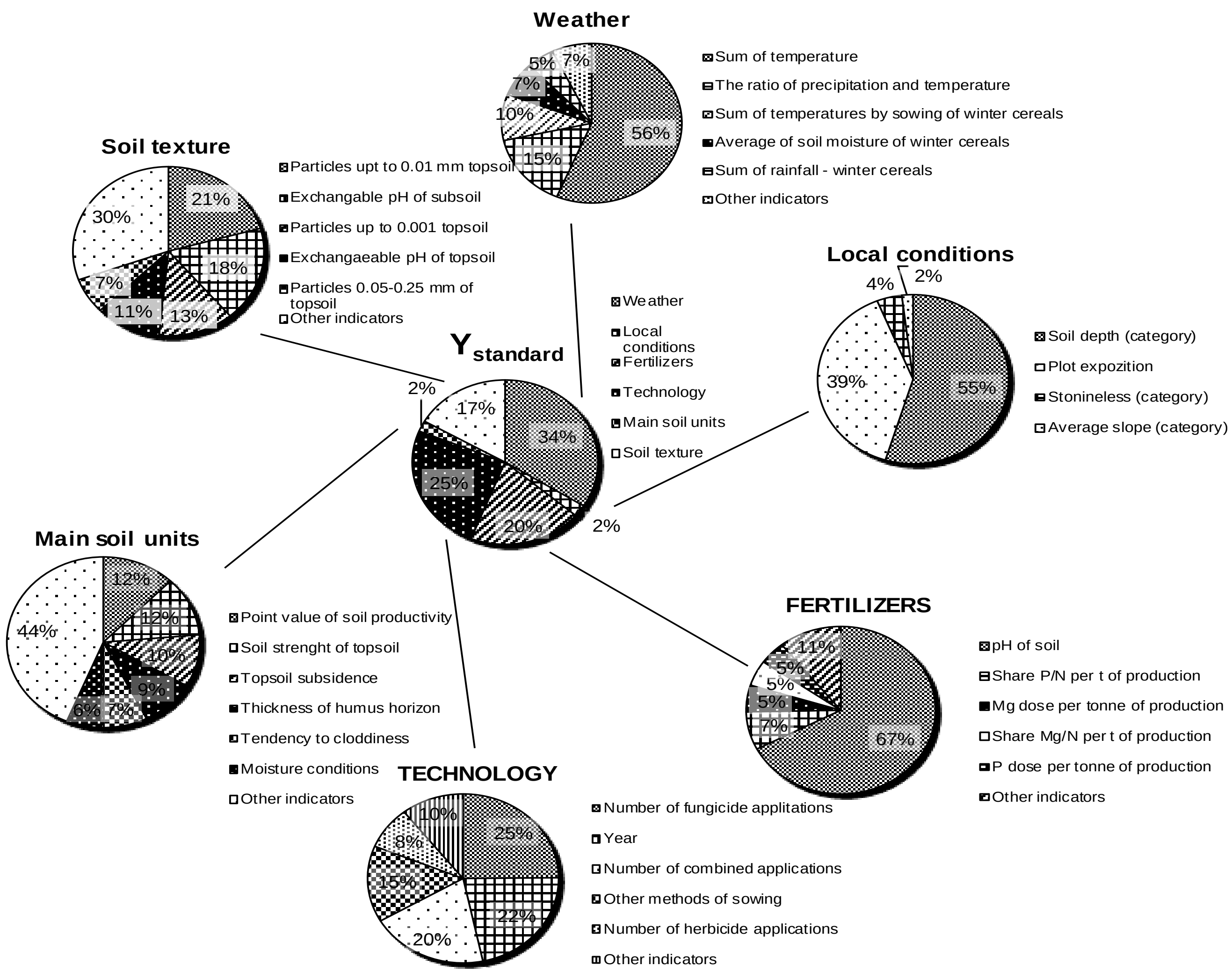
Factors	Pearson Correlation
Soil texture of topsoil, percentage of particles 0.25 - 2 mm	-0.399
Soil depth (category 1 best > 60 cm , 3 small < 30 cm)	-0.359
Vulnerability to acidification by main soil unit (category)	-0.354
Altitude (m)	-0.341
Skeleton category	-0.319
Total nitrogen rate per tonne of yield (kg/t)	-0.306
Soil texture of topsoil, percentage of particles 0.05 - 0.25 mm	-0.289
Mean moisture during the sowing period, winter cereals	-0.271
Mean soil penetration resistance 38-72 cm (MPa)	-0.257
Soil wetting by main soil unit (category)	-0.256
Mean moisture during the dry period (%) in previous autumn, wheat	-0.243
Sum of dry days during the sowing period, wheat	-0.238
Sum of dry days during the spring	-0.232
Precipitation/temperature ratio, winter cereals	-0.207
Mean moisture, winter cereals	-0.199
Sum of precipitation during the sowing period, winter cereals	-0.168

Each group is represented with the most important factors of the group. On the graph is described percentageof influence to the yield of most important factor from the 5%.

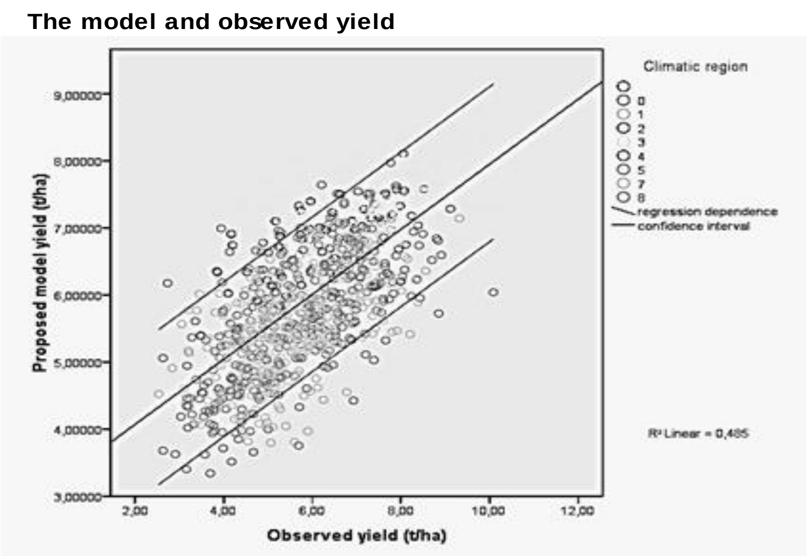
Importance of the whole basic model without influence of nitrogen is described in the equation above in figure. Weather has weight of 0.6295, soil texture 0.3096 and pH including share of fertilizers has weight of 0.3651 %. On the bottom is confidence interval of suggested results including statistical importance of model.

Different importance of the individual group of factors is observed across the main crops. Soil texture and climatic factors are most important (Fig. 3). Great impact has also technology of growing plants and pH of the soil and share of fertilizers.Environmental description of HPJ is only additional factor.

$$Y_{standard} = -4,663 + 0,4667 \cdot Y_{technology} + 0,0427 \cdot Y_{local\ conditions} + 0,6295 \cdot Y_{weather} + 0,3651 \cdot Y_{fertilizers} - 0,0393 \cdot Y_{main\ soil\ units} + 0,3096 \cdot Y_{soil\ texture}$$



The model and observed yield



statistical model

Indicator	Yield t/ha
R	0,654
R^2	0,43
N	1154
F	143,09
Sig.	0,000

Fig. 2. Statistical model of factors with the greatest importance of factors by the production of winter wheat

Another problem is the selection of appropriate indicators for the functional relationship. Linear functions for predicting the yield could be built on simple or aggregated variables. The large number of indicators has been combined using factor analysis for reasons of model stability. The instability of relationships between indicators has so far not made it possible to perform structural modelling.

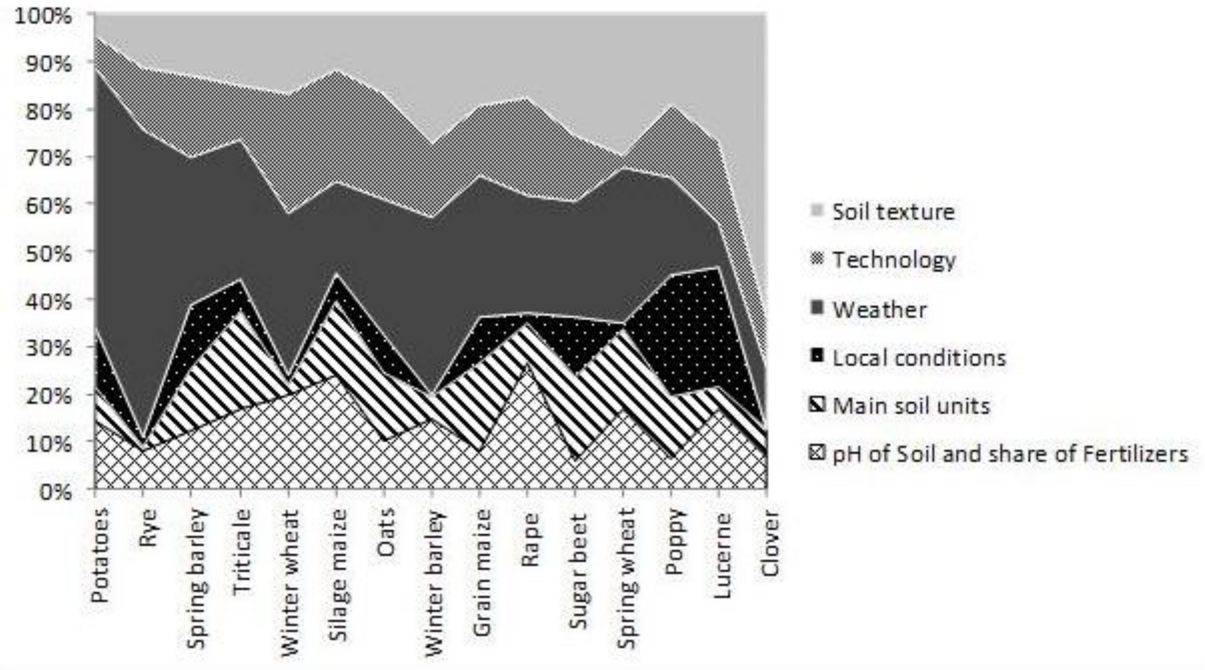


Fig. 3. The importance of individual groups of factors on yield formation (%)

From the model solution were build up standardized yields of crops, doses of nitrogen and frequency of plant protection operations on system of BPEJ. The estimation is made based on the empirically-derived form of the production function (PF), specific for every crop and different soil and climatic conditions. By using the standardized dose of nitrogen, we additionally include the corresponding standardized crop yield according to conditions of specific BPEJ into our calculation. The standardized yield is replaced by the estimated yield originated from the estimation of PF by using specific N inputs. The program can select the appropriate percentage of N reduction or even the increasing dose of nitrogen.

The main use of the system is considered to be in the advisory service on the level of enterprise. For the same purpose it may also be used for networks of advisors that can use the results for other proposals related to optimal crop composition on the level of an enterprise or individual units of LPIS, balance proposals of fertilizers and protective means. In accordance to results, it is able to calculate the yield values of the farm for the purpose of its market valuation. All the system of standardized data could be utilized for valuation of agricultural land or for knowledge expert system for farms or advisors. Relation of crops yield and other factors could be utilized for other technology with the impact on the yield or on the local conditions.

In the real world, crop production is affected by various conditions affecting both crop yields and production costs, depending on the technique of crop cultivation and the quality of land resources. Crop nutrition, soil compaction and subsequent soil erosion are significantly influenced by technological measures and selection of crops. These take place in the market environment characterized by real market possibilities and price conditions in the input market.

The findings demonstrate the importance of responsible and sustainable approach to agricultural land, including the consequences of non-compliance. Efficiency of production inputs is influenced by fertilization, crops representation and also maintenance of the correct soil pH. Organic nitrogen fertilization is an important factor in soil fertility particularly in terms of maintaining adequate soil structure. The humus content should be evaluated specifically in relation to its quality. The mere humus content (by Cox) leads to an erroneous conclusion; a negative dependence arises in the Cox content and the winter wheat yield. Higher quality humus is characteristic for most fertile soils.

The obtained and reported values present the foundation upon which future systems can be further developed and refined. We can say that the level of knowledge of living environment interactions with farm production processes is so complex that it can never be completely filled. Nevertheless, significant findings were identified which allow us to analyse agricultural production system in its fundamental aspects.

The proposed method of land unit evaluation allows the use of an economic analysis of agricultural production, valuation of inputs and outputs, and associated factors of production that are required on the national, regional or farm level. In terms of agricultural policy evaluation, the level of land units can become an interesting alternative for the assessment of economic and related environmental impacts. Possible scheme of the use of economic application is on the Fig.4. In the agricultural system could be standardized crop rotation on local soil-climatic conditions, or economic alternative to the rotation.

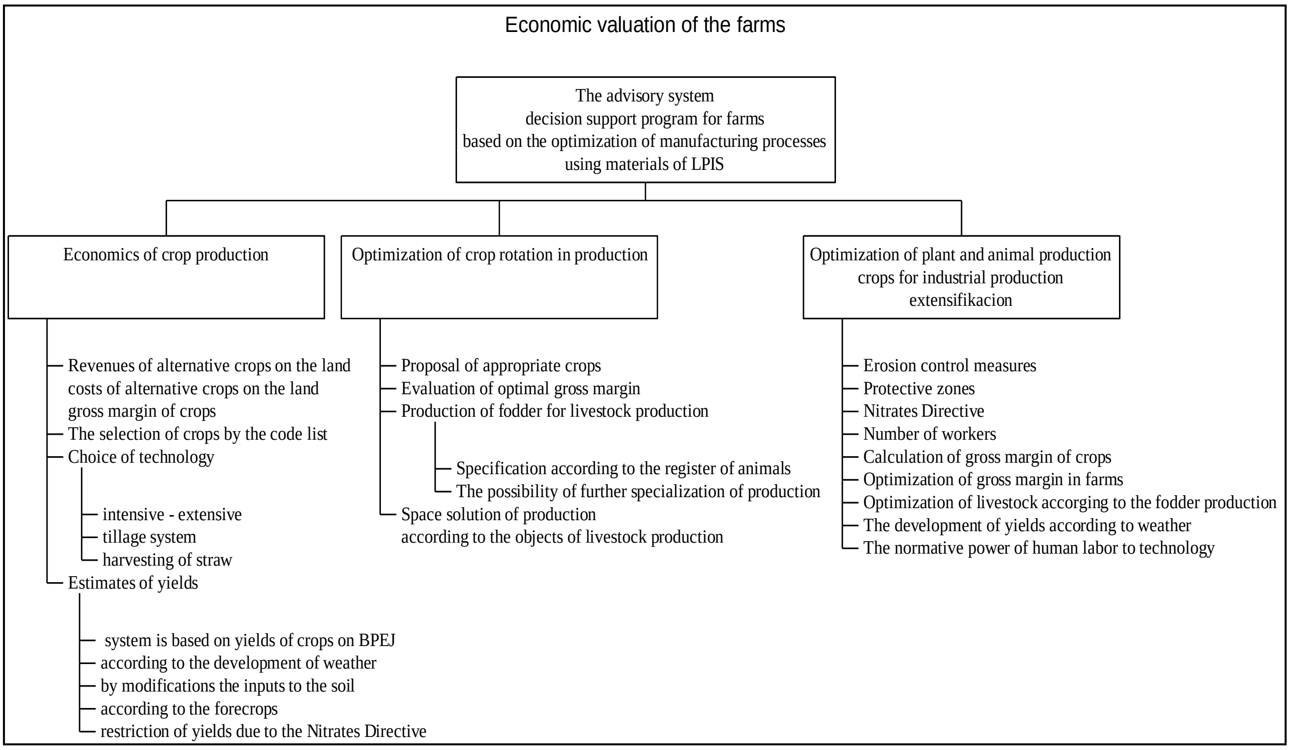


Fig. 4. Economic application of the soil classification and experts system

Costs of management practices are used to evaluate normative costs of the various field operations. The specific combination and the sequence of operations are set for every crop in the Czech Republic. The variability of cost of management practices is evaluated depending on the soil texture, slope of the land area and types of production. The components of the variable costs are maintenance costs, cost of fuel and labour costs.

Conclusion

The result of the system will be the complex of database information on soil blocks and farms. This information will be prepared for an optimal crop in the given natural and economic conditions and it will also assess economic results of other crops. Particular documents obtained for local conditions will be consistent with results of methodology for the valuation of BPEJ (Voltr 2012) and new relationships in feed evaluation for the need of animal production. This information may also be used for other applications, especially in advisory system and in the design of economic alternatives based on other programs of ÚZEI that focus on business economics.

In Czech Republic is value of BPEJ used for tax purposes and developed expert system can the database explore to the advisory system.

Technical aspect of the system security is dependent on operational conditions of LPIS and related databases. In present time, we expect the external management of outputs according to LPIS and its quarterly-updated data system on IAEI websites.

Results of the system are useful for the follow-up assessment of the economic efficiency of farms. This is mainly done by the assessment of, for example, environmental production requirements in accordance to erosion control measures and the Nitrates Directive, regional employment need, relationship between plant and animal production, evaluation of enterprise´s natural conditions and also alternative scenarios in relation to economic measures during the preparatory phase of the Rural Development Programme.

References

Voltr, V., Bartlova J., Brtnicky M., Denesova, O, Fronek P. Honz J, Hlavsa, T., Hruska M., Khel, T., Kohut M., Kren J., Kubat, J., Kucera J, Lang J., Lestina, J., Lipavsky J., Misa P., Novak P., Podesvová J., Pokorny E., Roznovsky J.,Stolbova M., Sarec O., Sarec, P., Trantinova M., Vigner J., Vilhelm V., Vopravil, J., 2011, Hodnocení půdy v podmínkách ochrany životního prostředí (Valuation of soil in the condition of environment), Praha, ÚZEI, 480 s. ISBN 978-80-86671-86-4

Voltr, V., Sarec, P., Hruska, M. 2012, Metodika ocenění půdy pro bonitované půdně-ekologické jednotky (BPEJ)(Methodology for land valuation on BPEJ). ÚZEI, Praha, 18 s., 21 annexs

Voltr V.: Concept of soil fertility and soil productivity evaluation of agricultural sites in the Czech Republic. Archives of Agronomy and Soil Science, 2012, 58, S1, ISSN 0365-0340, p. 243-251

Klecka, M., Korbini, J., 1973, Bonitace zemědělského půdního fondu ČSSR (Land valuation af agricultural soils in Czechoslovakia). Záv. zpráva VÚEZVž a VÚEPP, , Praha – Bratislava, 51 p.

Nemecek, J., Macku, J., Vokoun, J.,Vavricek, D., Novak, P. 2001, Taxonomický klasifikační systém půd České republiky (Taxonomic classification system of soils of Czech Republic), ČZU, Praha, 78 p., ISBN 80-238-8061-6

Masat, K., Klecka, M. a kol.: Bonitace čs. zemědělských půd a směry jejich využití. (Valuation of agricultural soils and the directions of their use) 1 part, Praha – Bratislava 1985, 130 p.

Masat, K., Nemecek, J., Tomiska, Z., 2002, Metodika vymezování a mapování BPEJ (Methodology for editing and mapping of BPEJ). MZe CR, VUMOP Praha, 114 p.

Heady, E.O., Dillon, J.L., 1961, Agricultural Production Functions. Ames, Iowa State University Press: 599 pp.

Efroymson, M.A., 1960, Multiple Regression Analysis. In: Ralston A, Wilf HS (Eds.). Mathematical Methods for Digital Karlen, DL. at all., 1997. Soil Quality: A Concept, Definition, and Framework for Evaluation

(A Guest Editorial). Soil Sci. Soc. Am. J. 61: 4-10.

Alterra & INRA 2005, New soil information for CGMS (Crop Growth Monitoring System) (SINFO). Wageningen, Alterra & INRA: 219 pp.

Reinds, G.J., Van Lanen H.A.J., 1992, Crop production potential of rural areas within the European Communities II: a physical land evaluation procedure. Technical Working Document. The Hague, Dutch Scientific Council for Government Policy: 26 pp.

Dabbert, S., 1994, Ekonomik der Fruchtbarkeit (Economic Fertility). Stuttgart: Ulmer; 201 pp.

Computers. New York, John Wiley and Sons.

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The experience of purposeful management of soil fertility and mineral nutrition optimization of grain and leguminous crops in the conditions of rain fed agriculture of the Northern Kazakhstan

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Abstract

The results of years research in solving the problem of diagnosis and optimization of the conditions of phosphorus and nitrogen nutrition of grain and leguminous crops in the Northern Kazakhstan are considered in this article. The estimation is given to the most widely used in the practice methods for determining doses of fertilizers on the basis of empirical data from field experiments (the best average dose) and balance method of calculating doses. Neither of these conditions in the Northern Kazakhstan has given satisfactory results. It is developed and proposed a new approach to the assessment of the phosphate status of soils and determination of crops' needs in phosphorus fertilizers taking into account the specifics of the zonal and the main factors determining their effectiveness, the initial state of the soil and crop to the individual requirements of P_2O_5 content in the soil. It is revealed a close correlation between the content of P_2O_5 in the soil and crop productivity, which allowed determining the optimal parameters of its content in the soil and providing a method for achieving an optimal level. Proposed a new approach to the diagnosis and optimization of nutrition allows accurately determine the element deficiency in the soil and purposefully manage soil fertility, creating an optimal diet and formation of potentially possible harvest, using optimization formula below

$$Dr.\ kg / ha = (P\ optimal - P\ actual) * 10$$

The methodological approach to crops evaluation and diagnosis of nitrogen nutrition conditions are offered. It is given the established diagnostic criteria for optimal performance and security crops with nitrogen. The new method of determining the needs and calculate doses of nitrogen fertilizer to the individual requirements of crops and 4 main factors determining their effectiveness are presented. The mathematical model for predicting the effectiveness of fertilizers is given. The developed technique allows controlling the nitrogen regime of soils, optimizing supply faiths and ensuring high efficiency and environmentally safety fertilizers. It is found that each crop imposes specific requirements for content and nutrients in soil.

Keywords: fertilizer, productivity, soil, diagnosis, interrelation, optimal parameters

Introduction

Kazakhstan is an agrarian country. It is among the largest countries in the world by the occupied area. Land Fund of the Republic makes up 272.5 million hectares among them agricultural land makes up 222.5 million including arable land which makes up 22.3 million hectares. From all of these about 60 % of arable land is in the

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North zone of the Republic where agriculture is a vital sector (Land balance of the Republic of Kazakhstan, 2013).

Arable land in the Northern Kazakhstan is represented mainly with chernozem (black soil) (ordinary and southern) and dark chestnut soils (Durassov and Tazabekov, 1981; Kurishbayev, 1996). They are characterized by relatively favorable physical and chemical properties but differ considerably in the humus content and gross forms of nutrition elements. Black soils are characterized with a high humus content: ordinary - 6-8%, south - 4.5-6.0 %, dark brown from 3.0 % to 4.5%.

Extensive farming led to a serious drop of soil fertility. Humus loss, according to agrochemical service of Kazakhstan reached 25-30%. Annually about 2.5 million tons of nutrients irrevocably alienated leading to deepening degradation and reduced fertility. Approximately 70 % of soils are characterized by high soil phosphorus deficiency and require about 50 % nitrogen. But if you can adjust the nitrogen by biological, agronomic and other methods, then increase the amount of phosphorus fertilizer can be done only with fertilizers application. Agricultural practices have virtually no effect on the mobility of phosphorus (Rylushkin, 1977). Reason for the decline, as an effective and potential fertility of soils is the low level of fertilizer application (Chernenok, 2010). But the formulaic application of fertilizers can lead to negative consequences - contamination of soil and environment (Ongley, 1996; Shmidt et al, 2011). It is very important to determine the most accurate method of diagnosis of their needs, taking into account all factors determining the efficiency that is the weakest link for efficient and environmentally safety application.

In practice, fertilizers are the most commonly used stereotyped, in the best case it is applied average, established empirically in a single dose of field experience, giving it the status of "universality" without taking into account the biological characteristics of crops and their requirements to the conditions of soil nutrition. Interpolation of the dose to the vast territory does not guarantee their effectiveness and often fraught with negative consequences and was mentioned above. Other methods, without checking their effectiveness in relation to zonal features are applied (Chernenok, 1996).

Long-term research goal is determining the most accurate method of diagnosing crop fertilizer needs and the way purposefully control soil properties.

Material and Methods

Objects: main arable soils of the Northern Kazakhstan (dark brown and black soil), cereals and legumes (wheat, barley, chickpeas, peas).

200-330 mm of rain falls on dark chestnut soils located in the dry steppe zone for the crop year and 350mm and above falls on the black soil in the forest-steppe zone. The average annual temperature in the area of research is 2.8 degree. The coldest month is January with the temperature of 14.8°. The absolute maximum temperature is in July month. The vegetation period makes up 140-150 days. The sum of temperatures during the growing season in average makes up 2300-2400° (Titov, Zaremba, 1971).

Methodological approach to the development of diagnostic methods and techniques targeted soil fertility management based on the results of years of research in the long stationary multivariate (18-20) experiments with fertilizers, which were created by different levels of nitrogen and phosphorus supply (potassium does not contribute due to excessively high natural content) in the grain steam rotations where phosphate fertilizers have been made in the fallow field once per crop rotation.

The following aspects were studied in the experiments: potential and effective soil fertility; regularities of their changes in crop rotations under the influence of climatic and agronomic factors and fertilizers; duration of the aftereffect of fertilizers, the main factors that determine their effectiveness; removal and utilization rates of nutrients from soil and fertilizers; relationship with agrochemical properties of soil productivity and efficiency of fertilizers; optimal parameters of agrochemical soil properties and methods of achieving them, providing formation maximum crop productivity in developing conditions with guaranteed efficiency and environmental safety (Chernenok, 1993).

Basic elements of nutrition in the soil were determined by conventional methods in agricultural chemistry for neutral and calcareous soils (Agrochemical research methods, 1975). Mobile phosphorus was determined by

Machigin's method that Rylushkin's research (1970) is acceptable not only to the carbonate but non-carbonate soils respectively.

Results and Discussion

Diagnosis of phosphorus

The most frequently used in practice - the results of field experience and balance method were tested in searching the most advanced methods of conditions diagnosis of phosphorus supply. But, unfortunately, none of them gave satisfactory results (Chernenok, 1997).

Studies in long stationary experiments showed that the results of field experience, not based on fundamental theoretical studies, are purely private, local, objectively reflects only that situation in which it is held. Any change in the experimental conditions (soil, moisture, etc.) entails a change in the results of the experiment, table 1. It is shown from the table that on one of the same soil in different years, the same dose of phosphate and nitrogen fertilizers has worked with different effect.

The average yield on the variants of the experiment reflects only the arithmetic mean value, but do not rule that the original content was determined by elements in the soil.

The most effective and cost-effective doses were arguments content of elements in the soil up to a required level for a given culture. Fertilizer efficiency in paired combinations indicates the importance of not only the content but also the ratio of elements in the soil.

This is one of the major reasons restricting broad interpretation of received findings and it is difficult to choose the best solution in reproducibility of the results of field experience in other conditions. Studies have shown that a single "universal" medium dose of fertilizer that would always provide the best result can't be in principle. And it is impossible to deliver experience in every field.

Table 1 Effect of fertilizer on peas and chickpeas productivity, dt/ha**

Applied, kg a.s./ha	Harvest on control and increment to it, dt/ha								
	2006	2007	2008	average	2005	2006	2007	2008	average
	peas				nut				
0	15,4	13,4	15,2	14,7	9,6	8,3	20,3	11,1	13,2
P_{60}	1,8	0,7	1,8	1,3	1,3	1,7	3,8	2,1	2,2
P_{90}	3,1	1,1	2,2	2,1	2,6	3,3	4,8	4,5	3,8
P_{120}	3,6	2,0	3,6	3,1	3,6	3,9	6,1	4,7	4,6
P_{150}	5,0	2,2	-2,6	0,6	4,8	4,1	4,0	4,2	4,3
P_{210}	6,0	2,7	-3,2	1,8	3,8	5,3	2,5	3,9	3,9
N_{30}	2,3	1,0	-0,6	0,9	3,7	1,6	4,8	1,2	2,8
N_{60}	-1,1	2,8	-1,2	0,5	5,3	2,6	5,9	1,1	3,7
$P_{90}N_{30}$	8,5	4,0	1,0	4,5	0,7	3,8	1,9	2,8	2,3
$P_{90}N_{60}$	3,6	1,9	0,4	2,0	1,8	3,7	2,7	5,4	3,4
HCP_{05}	1,5	1,0	1,0	1,2	1,21	1,06	1,68	1,14	1,27

a.s- active substance; dt/ha**-0, 1t

Balance methods for calculating doses of fertilizers on planned or programmable productivity, performance-based removal of harvest nutrients (HR), the coefficients using elements from the soil (CUS) and fertilizers (CUF) don't solve this problem (Mihailov N.N., Knipper V.B., 1971; Kayumov M.K., 1977; Shatilov I.S., 1978; Afendulov K.P., Lantuhova A.I., 1983).

The research showed that the balance method was completely unacceptable to the area of lack of unstable moistening of the Northern Kazakhstan, due to the high degree of variation of all parameters used in this method which are dependent on many factors very dynamic - hydrothermal conditions, soil properties and fertilizer content of the soil nutrient, agronomic techniques precursor doses and types of fertilizer forms.

How great is this relationship and to what extent this may affect the accuracy of determining the need for fertilizers can be judged from the data in Table 2

Table 2 Doses of NP fertilizers with different criteria in balance calculation

Indexes	Criteria (1970-1990) for spring wheat*, Chernenok V.		Reference data	Criteria (2006-2008), for peas***		Criteria (2006-2008), for nut**	
	Experimental data	average		Experimental data	average	Experimental data	average
Output 1c N	1.8-5.6	3.4	3.0	4.6-6.6			
P	0.4-1.3	0.7	1.1	0.8-1.8	1.3	0.8-1.9	1.4
URS: N	10-50	30	30	66-90	78		
P	10-30	20	10	26-62	44	19.1-66	38.3
URF: N	20-50	35	60	1.2-76.	38.6		
P	0.4-9.3	5	15	4-26	13.2	1.8-13.2	6.5
Calculated dose N	104-120	91	40	59-412	86		
and P fertilizers, kg a.s /ha	89-500	40	106	2-168	10	20.9-322	116

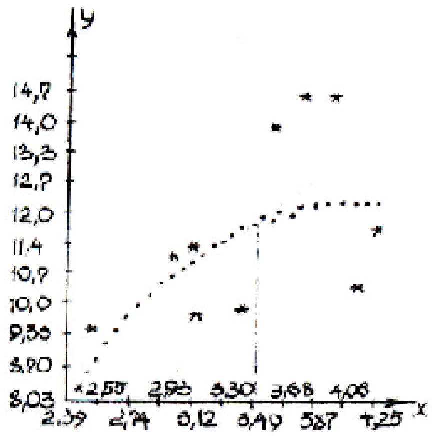
* Background: the planned yield of 20 dt / ha; N hydrolysable - 40 mg / kg soil, P2O5 - 20 mg / kg
** Nute dose designed to harvest 20 dt which was obtained in experiments on the control containing 17.8 mg P2O5 without fertilizers.
*** Doses were calculated on the pea harvest 15 dt/ha, which was obtained by the same control, containing 12.8 mg without fertilizers.

As it can be seen from the table, removal of nutrition elements of 1 dt/ha of wheat depending on growing conditions varies in 3-2 times, instrumentation CUS 2.5 – 3, CUF 2.5 (nitrogen) to 20 -fold that of phosphorus, calculated doses - 3 nitrogen, phosphorus and 12.5 times (40 to 500 kg/ha) based on which indicators are used - the minimum, maximum or average variation within. In reality, however, a need in this field of wheat in nitrogen was 30 kg, and the phosphor 150 kg/ha a.s. (Chernenok, 1997).

Similarly the same can be pointed in bean crops. The research showed that that in low and unsustainable use of wetting balance calculations is unacceptable due to the high variation of all parameters of its components.

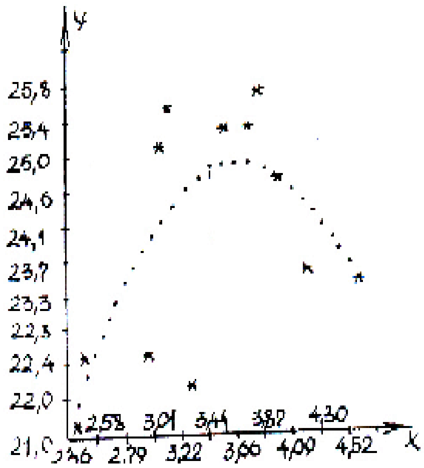
In this connection, in the search for new solutions for a long time, we have studied the full range of issues relating to both soil fertility and fertilizer efficiency in order to establish patterns of action fertilizer and establish a quantitative relationship between the indicators of soil fertility, efficiency of fertilizers and crop productivity.

Based on the correlation regression analysis it is revealed a close correlation and quantitative relationship between the content of available phosphorus in the soil (Machigin's method) and crop yields of grain steam rotation, figures 1-4.



$Y=3,2*3,5x^2*EXP(0,876x)$, $r=0,73$

Fig. 1 Relations of yield (Y) with the content of P_2O_5 (X), in sharp dry year.



$Y=2,09+14,9x-2,05x^2$, $r=0,70$

Fig. 2: Relation of yield (Y) with original content of P_2O_5 (X) in average with moisture year.

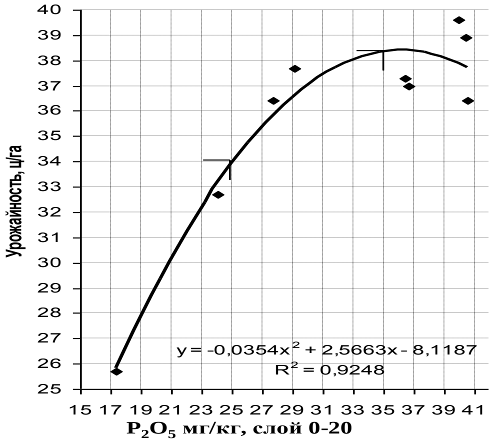


Fig. 3. Interrelation of yield of spring wheat with the content of P_2O_5 on ordinary black soil, 2001, R=0,96

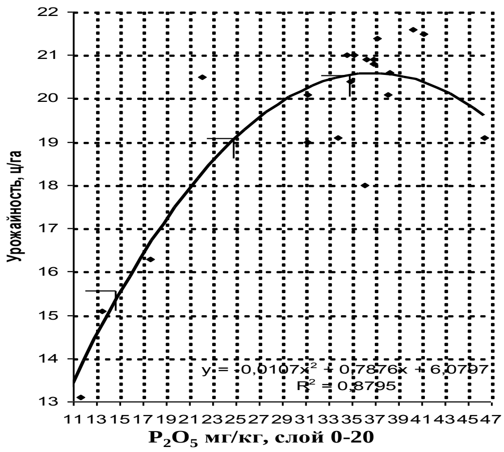


Fig. 4. Interrelation of yield of spring wheat with the content of P_2O_5 on ordinary black soil, 2002, R=0,93

It is evident from the figures that in a very dry year (Fig. 1) and in a more humid (Fig. 2) the greatest yield of spring wheat was formed from the very beginning (before sowing) and content of P_2O_5 35 mg per kg was in the soil. But it is important to note that different humidification years formed a different level of spring wheat - from 8.0 to 25.8 dt/ha (0.8-2.5 t/ha). This is due to the fact that during the formation of crop in sharp dry year mainly soluble forms of phosphorus are involved. In the more favorable years, with the improvement of water regime and phosphates of the second group are included.

Studies conducted on ordinary black soils confirmed the same relationship, figures 3.4 . Different, but the highest yield in the wet 2001 - 40 dt/ha (4t/ha) and 22 t/ha (2.2 tons) in arid 2002 formed on the background of 35 mg P_2O_5/kg soil, which casts doubt on competence and ability to program crop in rain fed agriculture in the conditions of low and unstable moistening.

P_2O_5 35 mg/kg of soil, it is the optimum level of phosphorus for spring wheat to which it is desirable to bring its concentration in the soil.

According to figures it is clearly traced the role of moisture and nutritional levels established by the application of fertilizer. Upon reaching the optimal level of phosphorus in the soil, yield is a linear function of moisture conditions.

Studies have shown that different biology and culture require different levels of soil phosphorus saturation. Thus, according to figures 5.6 shows that for chickpeas and peas optimum ranges of 28-30 mg P_2O_5 / kg of soil.

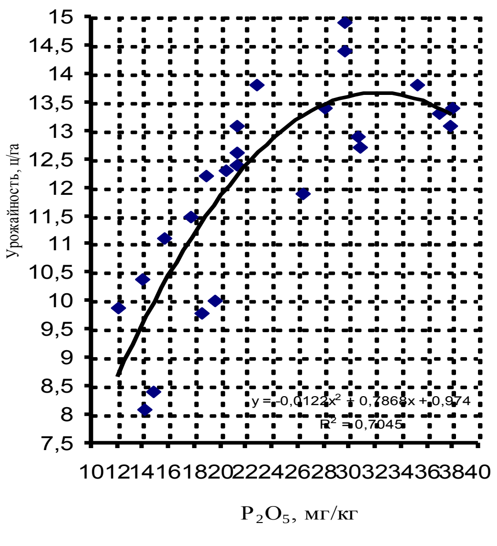


Figure 5 - Relation of nut yield with P_2O_5 in soil, R =0,84

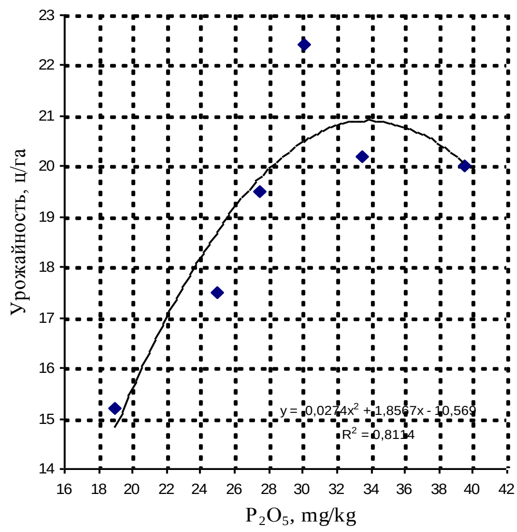


Fig. 6 - Relation of pea yield with P_2O_5 R =0,91

Knowing the optimum level of available phosphorus content of the crop and the actual content on this field in mg/kg soil as well as equivalent kg of fertilizers on soil 1 mg P_2O_5 (K), which is not difficult to determine experimentally, it is possible to accurately determine the element deficiency in soil mg/kg and calculate the amount of fertilizer needed to create optimal conditions for supply of phosphorus, using the above formula below optimization (Chernenok, 1987).

$$Dp.\ kg\ a.s./ha = (Popt. - P\ fact.)^{*}\ K \quad (1)$$

K - for soils of the Northern Kazakhstan is 10 kg of fertilizers

In this formula is taken into account more fully the biological requirements to culture conditions phosphorus nutrition and original content of mobile phosphorus in this field, which allows extremely accurately determine the need for fertilizers.

Creating an optimal level allows culture to realize their potential and build the best possible harvest any moisture conditions.

Optimal diet provides the most efficient and economical fuel moisture per unit of output. Thus, at low power levels on average 20 years old wheat moisture ratio of water consumption by 20 mm, with an average -12 and optimum of 8 mm.

To quantify the relationship between the content of P_2O_5 and yield defined flow mg P_2O_5 per 1 quintal of grain for different humidification years, тable 3.

It can be determined by the table:

- What crop can be obtained by knowing the content of P_2O_5 in the soil;
- To what level should bring the contents of P_2O_5 in the soil to get the planned harvest;

Table 3 Relation of the yield of spring wheat with the content of P_2O_5 вin soil in different by wet conditions years

Content of P_2O_5, мg/кg soil	Yield, dt/ha in years		
	very dry	average	damp
10	3-4	7-8	10-12
15	5-6	10-12	17-20
20	6-7	14-16	22-25
25	8-9	17-20	28-30
30	10	21-25	33-37
35	11-12	25-30	38-40
Expenditure of мгP_2O_5 per 1 c of harvest	3.0	1.2-1.4	0.8-1.2

*by the results of 20 years studies

- Calculate the dose to the planned increase in yield from the formula or the equivalent cost mg P_2O_5 per 1 center of products based equivalent for medium and wet years 1,2).

For example: to increase yields by 5 dt with initial content of 15 mg P_2O_5 should increase the amount of phosphorus in the soil at 6 mg (5dt 1.2 mg P_2O_5), and this need to be 60 kg a.s. fertilizers (6*10), or to bring the content of phosphorus in the soil for up to 20 mg, substituting the formula P opt. 20 instead of 35 mg. Finally Dp = 50 kg.

In this manner it is advisable to use at high phosphorus deficiency in soil and are unable to resolve the deficit bullet making.

The method allows purposefully manage soil phosphorus regime with the account of individual requirements of crops.

Diagnosis and method for optimizing of nitrogen nutrition of crops.

Nitrogen is the second most important element of nutrient, determines the size and quality of the crop. Variety of forms of nitrogen in the soil complicates the determination of the diagnostic indicator security crops and nitrogen requirements for nitrogen fertilizers without which it is impossible to solve the problem of effective targeted soil fertility management.

In the literature, a large number of known methods recommended as diagnostic indicators of soils with nitrogen: the sum of mineral and soluble organic compounds (Koenig and Hasenbaumer, 1924; Tyurin and Kononov, 1935), by the sum of ammonia and nitrate nitrogen (Nemeth, 1932), nitrifying ability (Waxman, 1922; Kravkov, 1931), the content in the soil $N\text{-}NO_3$ in the layer 0-40 cm in autumn or pre-period A.E.Kochergin.

(1956), a method of alkaline hydrolysis (AV Petersburg, 1971). Studies have shown that all of these methods in terms of Northern Kazakhstan only with the content of N-NO_3 in soil established correlation yield figures 7-8 (Chernenok, 1970).

From the figures it is clear that productivity growth with an increase in the nitrogen content of nitrates in the soil goes up to a certain limit, beyond which productivity is reduced, which allowed to determine the optimal level of nitrogen for culture. As it can be seen, for spring wheat the upper limit of the saturation level is 15 mg N-NO_3 per kg of soil layer 0-40 cm in all types of soil, figures 8-9. The lower limit is 12-mg. Increasing N-NO_3 from 12 to 15 mg (1 quintal increase) does not guarantee economic efficiency.

Different cultures require different levels of saturation of soil nitrogen. So, legumes peas and chickpeas, Figure 9, maximum productivity in all the years was formed when the content of nitrate nitrogen makes up 10-12 mg per kg of soil in the 0-40 cm layer of soil.

Correlation curve, Figure 7, reflecting the results of the connection of 42 field experiments allowed us to determine the zonal scale security and regulatory allowances. Elevated levels of N-NO_3 mg/kg soil (very low supply) increased yield by 5 dt; from 6 to 9 mg (low) gain 3 dt/ha, from 9 to 12 at 2 dt and from 12 to 15 mg per 1 dt, which is confirmed by Figure 10.

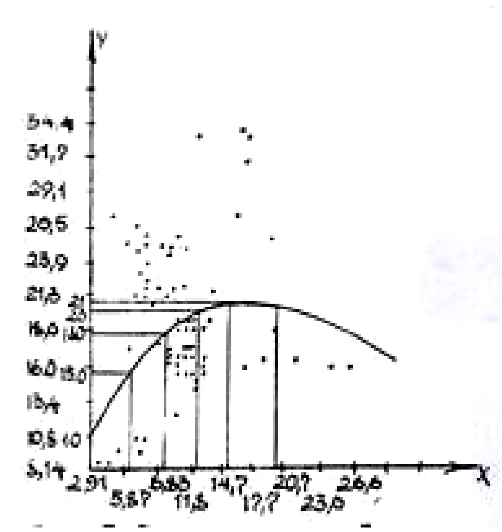
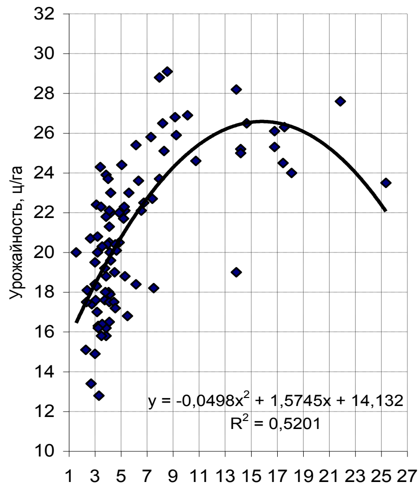
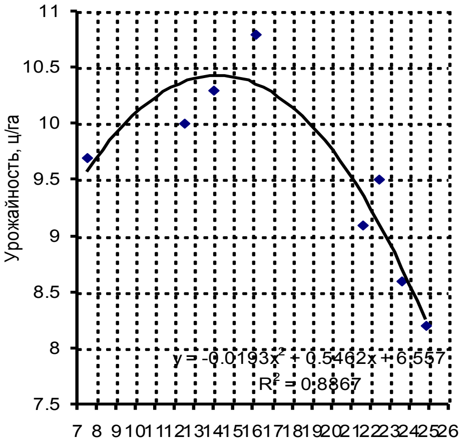


Figure 7 - Relation of wheat yield with N-NO_3 mg/kg in 0-40 cm, at dark chestnut soils n 90, r=0.46 Y=5.34 * 0.76x^2 * EXP (-0.049x)



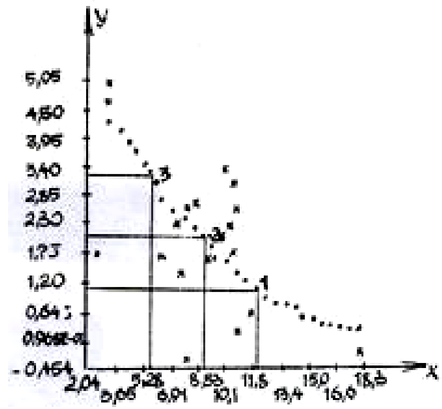
N-NO_3 mg/кg, level 0-40

Figure 8. Interrelation of wheat yield with N-NO_3 (for crop rotation) on ordinary black soils, 2003



N-NO_3 mg/kg, layer 0-40 cm

Figure 9- Relation of nut yield with -NO_3 , 2003 г., R =0,94



N-NO_3 mg/kg, layer 0-40

Figure 10 – Relation of wheat yield (y) with N-NO_3 mg/kg at P_2O_5>25 mg/kg, n 20 , r=0.64; У =-1.86 + 40.9/x - 70.1/x^2

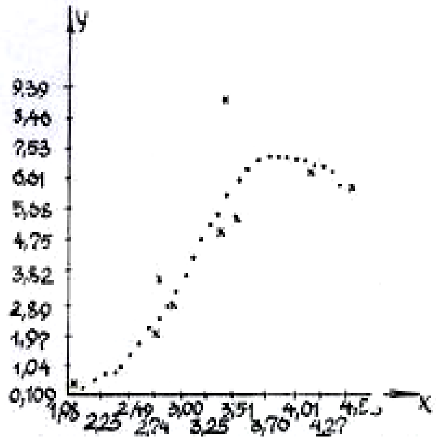


Figure 11 – Efficacy of N_{30} (y) in dependence on the content of P_2O_5 in soil (x), r=0.98; У=0.0562*19.3x*УХР (-4.9)

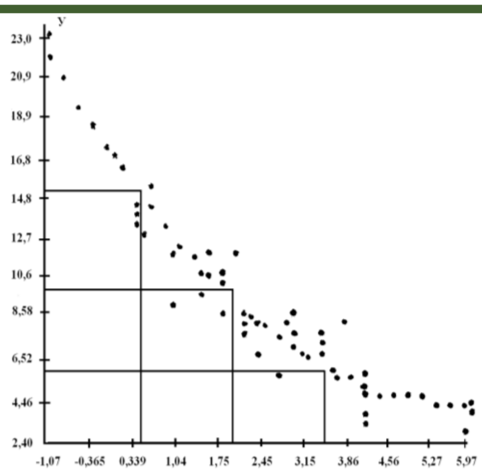


Figure 12 – Relation of predicted gain (x) with PK increasing from N- NO_3 (y). r = 0,93,
У = A+B*X+C*X2,
where A = 16,6; B =4,67, C=0,427

Excess nitrogen saturation of soils, as well as a lack leads to the reduction of spring wheat production. Determination of optimal levels of nitrate nitrogen in the soil is essentially important for evaluating and justifying the economic and environmental viability of fertilizers use. Studies have shown a high dependence of the efficiency of nitrogen fertilizer not only on the content of mineral nitrogen in the soil, but also to cultural phosphorus, Figure 11, where the maximum effect is obtained from the N30 on the optimal phosphorus background - 35 mg/kg soil. Excess and deficiency of phosphorus reduces the efficiency of nitrogen fertilizer, which is important to consider when determining the deficit and doses of nitrogen fertilizer and is accounted for in the zonal scale security indices (Chernenok V.G., 1997).

It is known that the most important factor determining the efficiency of fertilizers is the moisture content of crops. It is clear, that in terms of higher wet, the gain within the class will be much higher and in dry zones it will be lower.

To clarify the dose and adjustments of regulatory gain in moisture conditions it is introduced a correction factor (PKwet.) based on the ratio of projected rainfall for crop year to regulatory (275) adopted by probation for one. This gives the ratio > or <1, and multiplying by which should be.

PKwet.=Precipitation forecast / Precipitation regulations (275mm) (2)

This approach stems from the fact that it was with rainfall for crop year set the highest relationship (r = 0.60), while, as with spring moisture reserves total r 0.37, with precipitation of the vegetation period r 0.46.

Predicted precipitation for the current year is calculated on the actual rainfall prevailing in September and May and then rainfall for June-August months is added on the basis of the forecast. If rainfall is below normal in June it is added 0.5 standards-term averages by the forecast if higher, then 1.5 from the norm, and if it is in the normal range, the average annual rate. This reduces to a minimum the error calculation of PKwet. In the worst outcome of error does not exceed 10%, but usually it is within 3%.

Introducing the correction factor for moisture at times, the accuracy of dose determination and prediction of fertilizer efficiency are increased, by reducing the dose step from 15-30 to 3-6 kg/ha, Table 4.

This gives a great cost savings and fertilizers. The range of variation is due to increases of dose and class performance security in accordance with graduation.

This table is convenient to use the art. Focusing precipitation, class of security (eg, low), and knowing the price of fertilizer and grain, you can calculate how profitable or not in a given situation to apply nitrogen fertilizer.

More precisely, with respect to each element in the soil mg, one can calculate the need for nitrogen fertilizers by formula 3 (Chernenok)

DN kg a.s. = (Nopt - Nfact) * 7.5 * PKwet. (3)

where DN - dose of nitrogen fertilizers, kg/ha ai;
Nopt - the optimum nitrogen content of nitrates (N-NO_3) of soil, mg/kg in a layer 0-40 sm;
Nfact. - The actual N-NO_3 content in the soil, mg/kg;
7.5 - equivalent to 1 mg of nitrogen fertilizer N-NO_3 soil established experimentally.

Table 4 Doses of nitrogen fertilizers and crop increment (dt/ha) depending on N-NO_3 content in the soil and PKwet.

RainfallO for agricultural year, mm	PK wet	Provision with nitrogen					
		Very low		Low		Average	
		dose, kg a. s.	Gain of yield	Dose N, kg	Addition to the yield	Dose of N, кg	Addition to the yield
200	0.7	42	2.1-3.5	32	1.4-2.1	21	0.7-1.4
225	0.8	48	2.4-4.0	36	1.6-2.4	24	0.8-1.6
250	0.9	54	2.7-4.5	40	1.8-2.7	27	0.9-1.8
275	1.0	60	3.0-5.0	45	2.0-3.0	30	1.0-2.0
300	1.1	66	3.3-5.5	50	2.2-3.3	33	1.1-2.2
325	1.2	72	3.6-6.0	54	2.4-3.6	36	1.2-2.4
350	1.3	78	3.9-6.5	58	2.6-3.9	40	1.3-2.8
375	1.36	82	4.2-6.8	61	2.7-4.1	41	1.4-2.7

Formula with high accuracy to bring the nitrogen content of nitrates in the soil to the optimum level. In calculating the dose must be based on expediency bring nitrate nitrogen content and the lower limit of the optimum, i.e. to 12 mg/kg soil of wheat and 10 mg/kg of pea and chickpea. Bring to 15 mg is not advisable, as it is not accompanied by a significant increase in productivity. In determining the doses of nitrogen fertilizer it is necessary to consider the security of soil phosphorus. Equation 3, it is advisable to calculate the dose of fertilizer with phosphorus content in soil below the average level, ie, at least 25 mg/kg soil. If a significant deficiency of phosphorus, is based on the need to preserve the optimal ratio of phosphorus and nitrogen in the soil, which is 2.5-3 P2O5-in the 0-20 cm layer to the N-NO_3 content in the layer of 0-40 cm, the dose of nitrogen fertilizer should be calculated by the formula 4:

$$DN \text{ kg a.s.} = (1/3 \text{ Ropt} - \text{Nfact}) * 7.5 * \text{PKwet}. \quad (4)$$

where: 1/3 means that the amount of nitrogen that is a must have for the actual content of hosphorus. Identified quantitative relationships between agrochemical parameters of soil fertility and fertilizer efficiency allow to predict the increase of nitrogen fertilizer, using the formula 5 (Chernenok)

$$I_N = 1{,}24 - 0.14*\text{N-NO}_3 + 1.62*\text{PKwet} + 0.06*\text{P/N}, \quad (5)$$

where: I_N - an increase of nitrogen fertilizer, dt/ha;
N-NO_3 - content in the soil, mg/kg in a layer 0-40 sm;
P/N - ratio of the actual content of P_2O_5 mg/kg soil in a layer 0-20 cm to N-NO_3, mg/kg in a layer 0-40 cm
The equation includes all the factors that determine the efficiency of nitrogen fertilizer and allows to predict the increase in yield with high accuracy, (R = 0.93), Figure 12.
Developed a range of issues related to establishing the main factors determining the formation of yield diagnostic indicators of conditions of soil food crops, quantitative relationships with productivity, to determine the optimal parameters and ratios of batteries, development of methods to achieve them allow purposefully control fertility.

Conclusion

The proposed method of calculation and optimization of the power needs of crops in phosphorus and nitrogen fertilizers, taking into account their biological requirements of crops and original content element in this field is brand new, scientifically sound, the most accurate and appropriate for the targeted fertility management in precision farming system.

They allow not to exclude efficient and environmentally dangerous pattern in fertilizer application, provide the most accurate way of determining element deficiency in soil and fertilizer requirements calculation, based on a certain culture for each optimal level, thus providing targeted management of soil fertility and crop productivity, creating the necessary power mode to realize its potential in the emerging conditions of moisture, with guaranteed high payback and environmental safety.

References

Agrochemical methods of soil investigation (1975). Moscow, p 655

Bokaryov VG (1999) Determining's method of content for available phosphorus in the soil, method of diagnostic and regulation of phosphorus plants' nutrition and a method of estimating of system phosphorus fertilization. RU2133465 1999.07.20 A01C21/00 G01N33/24

Waksman SA (1925) Microbiological analysis of soil as an indicator of soil fertility. The accumulation of ammonium (cited by Scientific and Agronomic Journal, 1)

Durassov AM, Tazabekov TT (1981) Soils in Kazakhstan. Kainar, Almaty, p149

Land balance the Republic of Kazakhstan (2013). Almaty

Zvereva EA (1990) Diagnostic nutrition of crops by irrigation. Chemicalization of agriculture, №3, 18-20. RU2133465 C1, 20.07.1999. RU2193836 C2, 10.12.2002. SU934346, 15.06.1982. SU968067, 23.10.1982

Kayumov MK (1977) Programming Reference for crops. Russian agricultural publishing. Moscow, pp 98-99

Konig S and Hasenbaumer S (1924) Determination of requirements for the soil. Journal PflD n Part III, 497

(1956) Conditions of nitrogen nutrition of grain crops on black earth in Siberia. Agrobiology, №2.

Kochergin AE , Gamzikov GP (1972) Effectiveness of nitrogenous fertilizers in the black earth zone of Western Siberia. Agrochemistry. № 6, 3-10

Kravkov S P (1931) The course of general agriculture. Moscow, p 332

Kurishbayev AK (1996) The monograph «Theorganic substance of arable soils in Kazakhstan» , Kazakh Research Institute of agriculture . Village Ushkonyr. Almaty region

Makarikova RP, Barsukov PA (2005) Method of diagnosing and regulation of phosphorus nutrition of plants.RU2244922 2005/01/20 G01N33/24 Institute of Soil Science and Agricultural Chemistry of SB RAS

Mikhailov NN, Knipper VP, (1971) Definition of requirement in fertilizers of plants. Kolos, Moscow, p 255

Journal Nemes (1932) Fur Planz. Dung. Und Bodenkunde. A. 23, 14, ¾

Nurmanov ET, Chernenok VG (2010) Diagnostics and optimization of nutrition and fertilization for chickpeas. Proceedings of the IV International scientific conference of young scientists dedicated to the 40th anniversary of the Russian Agricultural Academy, 348-352

Ongley ED (1996) Control of water pollution from agriculture- FAO irrigation and drainage paper 55, food and Agriculture Organization of the United Nation.Rome.

Petersburgskiy AV (1971) Agrochemistry and Plant Physiology. Russian agricultural publishing, Moscow, p 334

Postnikov AV, Shafran SA (1982) Temporary standards of fertilizers costs for work on KAHOP, Moscow

Rylushkin VI (1970) The Phosphatic regime of dark chestnut soils in Tselinograd area with connection of using of mineral fertilizers for spring wheat. Dissertation's auto abstract of candidate of agricultural sciences, Tashkent, p 24

OV Sdobnikova (1969) Using of fertilizers in the steppe regions in Western Siberia and Northern Kazakhstan. Moscow

Smidt GA, Parks A, Pokharel R, Landes F, Schnug E, Koschsky A (2011). Indications for phosphorus fertilizer derived uranium mobilization from arable soils to groundwater. Berichte der DBG

Titov RN, Zarembo ES (1971). Agroclimatic resources in Tselinograd area. Almaty, p172

I.V. Tyurin, M.M. Kononova , 1935. The method of determining nitrogen's requirements. In the boo: The chemical method for soil 's requirements for mineral fertilizers. USSR Academy of Sciences, Moscow-Leningrad.

Chernenok VG (1970) Nitrogen regime of dark chestnut soils in connection with the application of fertilizers. Dissertation of candidate of agricultural sciences. Tselinograd, p 24.

Chernenok VG (1993) Theoretical basis of optimization and diagnostic of grain crops' mineral nutrition in the dry steppe zone in Northern Kazakhstan. Dissertation of candidate of agricultural sciences, Omsk,54 p.

Chernenok VG (1996) On the issue of balance methods for determining doses of fertilizers in conditions of insufficient and unreliable moistening. Journal of Science of Akmola Agricultural Institute

Chernenok VG (1997) Nitrogen's regime of soils in Northern Kazakhstan and using of fertilizers. AAU. Akmola

Chernenok VG (2010) Targeted management of soil fertility - the key to efficient economy and competitive agricultural products. Achievements and prospects of agriculture, biology and breeding of crops. Almalybak, p 442-445.

Chernenok VG, AB Kudashev (2010) Utilization's coefficients by peas from soil and fertilizers. / Journal of Science. S.Seifullin azakh Agro Technical University. № 1 (56). Astana, p 28-35.

Shatilov IS and others (1978) Organization of scientific research on programming of agricultural crops. Scientific works VASHNIL. Kolos, Moscow, p 5-7

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Transporting capacity of small depth flows as the prerequisite of eroded soil formation

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Abstract

The objective of this work – by the example of soddy-podzolic soil of different degree of wash off quantitatively assess the ability of small depth flows at the system level "flow-soil" to transfer certain mass of soil material. The results of model experiments used for verification of theoretical equation of sediment transport. Determination of quantities transfer and deposition of soddy-podzolic soil of different degree of wash off spend on a large erosive tray. The tray had artificial channel (length 5 m, width 0.1 m, bump height of roughness of the bottom – 0.35 mm), which was set different velocity of the water flow and streams of water artificially loaded soil in dry or pre-humid condition. The range of velocities varied from 0.20 to 0.62 m/s. The flow depth was 8-13 mm. In the experiments yielded the following indicators: the average velocity (V, m/s) and water turbidity, the radius (r_i, m) of the transported and deposited in the stream bed of aggregates and other. These indicators are used for verification of the theoretical equation transporting capacity (β, kg/m^3):

$$\beta=\frac{C}{(gH)^{1/\gamma}}\left(V^2-V_k^2\right)^{1/\gamma}, \tag{1}$$

where g is the acceleration of free fall, m/s^2; H is flow depth, m; C and $1/\gamma$ are empirical indicators. Calculation of V_k was held by the equation:

$$V_k=\sqrt{\frac{\frac{4}{3}\left(\frac{\rho_i}{\rho_w}-1\right)g r_i+\frac{f_i}{r_i\rho_w}}{K_d}}, \tag{2}$$

where ρ_i is density of the soil solid phase, kg/m^3; ρ_w is water density, kg/m^3; f_i is coefficient of surface strength for transported or deposited aggregates, N/m; K_d is lift coefficient (c-vortex). On the basis of the obtained experimental data was found the following regularities. The average diameter transported flow aggregates increases with the velocity of water flow, and the diameter of the aggregates, deposited in the stream bed decreases with increasing velocity. It is established, that it depends not only on the flow velocity, but also on the extent washed of soil, humus content and water resistance of aggregates. The obtained experimental data will allow to making the conclusion on the applicability of the model's transporting capacity flow in relation to the soil material. Comparison of the experimentally obtained values of portable soil material and calculated the dependence (1) showed that the average error in module amounted to 18.4%, and the correlation coefficient is 0.86.

Keywords: Soil, erosion, modeling, transporting capacity, water flow

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Introduction

Detachment of soil particles by water flows, their transfer or deposition are the main processes taking place in the period of formation of surface runoff and soil wash-off. The intensity of soil wash-off by water flows depends on a number of factors. Many researchers attribute to them climate, topography, soil, lithology, etc. Thus, evaluating the processes of erosion is necessary to consider not only the flow velocity (average, scouring or bottom), but also the transport capacity of the flow.

Under the transport capacity is understood the largest possible sediment discharge at a given hydraulic flow regime (Kuznetsov, Glazunov, 2004). By definition hydrological dictionary, the transport capacity of the flow – limiting sediment discharge, which is able to transport flow (Chebotarev, 1978). That is, transporting capacity is numerically equal to the sediment discharge, which flow able to transfer under specified hydraulic conditions (Alekseevsky, Chalov, 1997). Sediment transport problem in many papers. In the vast majority of research were conducted in relation to large stream flow. Meanwhile, the sediment transportation is one of the important components streaming soil erosion.

Therefore, considering the mechanism of detachment and transport of soil material by water flows necessary to consider it from the point of view of this process at the system level "water flow and soil". The interaction of water flow with soil, the degree of saturation of the soil material, transfer or accumulation, all it will determine the intensity of erosion processes. And, consequently, the formation washed away and over washed soils on the slopes. It is known that the basic amount of the soil material is wash away by forming of the slope flows depth of 10-15 mm. In this regard, there is a need to develop different methods for the assessment of transport of soil material flows of small depth.

The aim was to quantify the ability slope flows small depth at the system level, "water flow and soil" to transfer a certain mass of soil material different degrees washed away and over washed soddy-podzolic soil.

Material and Methods

Model experiments were carried out on a large erosion tray. For experiments it was necessary to have the samples are not washed away, over washed, weekly and middle washed away soils.

On the territory of the Solnechnogorsk district of the Moscow region (Educational and Experimental Station MSU "Chashnikovo") was selected Catena, where the samples were taken from plowing horizon not washed away, middle over washed, weekly and middle washed away soddy-podzolic soil. Definition of the degree of soil erosion and over washed and highlighting their borders were determined by descriptions of soil profiles in different relief elements (Classification..., 1977). In selected samples was determined water resistance macrostructure of soil by the method of N.I. Savvinov. Fractionation of soil samples was carried out on the sieves in the air-dry (dry sieving) and fractionation in water (wet sieving). In the first case, the fixed number of aggregates of different sizes, in the second – determines the amount of water-stable aggregates, i.e. give a qualitative assessment of water-resistant structures (Vadyunina, Korchagin, 1986). The critical flow velocity and, consequently, the amount of soil transported will depend on the predominant fraction of the aggregates.

Carbon content in soil was determined by the method Nikitin with colorimetric ending on Orlov-Grendel with subsequent recalculation on the humus content (Praktikum..., 2001).

The determination of water flow velocity, the quantity of transported soil material and diameter carried and deposited in channel aggregates was determined on the "large" erosive tray. Erosion tray is a device for model experiments in the laboratory conditions with the purpose of studying and forecasting of various processes of water erosion of soils. In our experiments on a bed tray was created artificial channel (length 5 m, width 0.1 m), in which, by means of the pump was supplied different amounts of water. Soil into the stream was served with the help batcher and belt conveyor (the speed of movement of conveyor can vary from 25 to 250 mm/s). The height of the projections of roughness bed is 0.7d=0.35 mm. The tray also has a device for changing the angle of inclination of the bed. The flow of water loaded with soil in air-dry and capillary-wetted condition. Transported by the flow of water the soil was admitted to a series of sieves that allowed determining its aggregate composition. Flow depth and velocity were regulated by changing the angle of the tray.

Method of calculating the transport capacity of the flow

Experimentally on a large erosion tray was determined: the depth of the flow (m), the slope of the tray (deg.), the water discharge in the experiment (l/s), the time of the experiment (s), the average flow velocity (m/s), the mass carried of soil (g) and average diameter of aggregate (mm) carried by the flow and deposited in channel. Calculation of transport capacity of flow was carried out by the equation (1), developed at the Department of erosion and soil conservation (Gendugov et al, 2007).

$$\beta = \frac{C}{(gH)^{\frac{1}{\gamma}}}(V^2 - V_k^2)^{\frac{1}{\gamma}}, \quad (1)$$

where β is the transport capacity of the flow, kg/m^3; g is acceleration of gravity, m/s^2; H is depth of flow, m; V and V_k are respectively the average and critical flow velocity, m/s; C is empirical coefficient, kg/m^3; $1/\gamma$ is empirical exponent.

The critical flow velocity calculated for transported or deposited in the flow of aggregates by the equation (Gendugov, Glazunov, 2009):

$$V_k = \sqrt{\frac{\frac{4}{3}\left(\frac{\rho_i}{\rho_B}-1\right)g r_i + \frac{f_i}{r_i \rho_B}}{K_d}}, \quad (2)$$

where f_i is coefficient of surface strength for transported or deposited aggregates, N/m; K_d is lift coefficient (c-vortex); r_i is the radius carried or deposited in channel aggregates, m; ρ_i is density of the soil solid phase, kg/m^3; ρ_w is water density, kg/m^3; other symbols as before.

Calculation of the coefficient of surface strength (f_i) was carried out by the equation (Gendugov, Glazunov, 2009):

$$f_i = \frac{4}{3} r_i^2 g(\rho_i - \rho_B), \quad (3)$$

Results and Discussion

The analysis of the aggregate composition of the investigated soils in the original, air-dry state (before the experiments), showed that the highest weighted average diameter of aggregates was determined in the sample of middle over washed soil – 4.44 mm. In samples of the not washed away, weekly and middle washed away soils observed are the regular decrease of the weighted average diameter of the aggregates with increasing degree of erosion – from 4.08 mm in not washed away to 3.34 mm in middle washed away soil (Table 1). At the same time the determination of the weighted average diameter of water-stable aggregates (wet sieving of air-dry soil) observed a slightly different pattern. The smallest diameter of water-stable aggregates was obtained in the middle over washed soil (0.88 mm), while the highest (2.25 mm) in the not washed away the soil. When wet sieving capillary-wetted weekly and middle washed away soils weighted average diameter of water-stable aggregates respectively 1.44 and 1.55 mm (Table 1). Larger diameter water-stable aggregates at middle washed away compared with weekly wash away soil can be explained by the fact that in its arable horizon large role in the formation of water-resistant structure belongs granulometric composition, and not the content of humus. This is due to the involvement in the arable horizon eluvial and the transition between eluvial and illuvial horizons as a result of plowing.

When wet sieving capillary-wetted soil was detected pattern similar to the one that was found in the dry sieving air-dry soil. First, a fairly high value weighted average diameter of the aggregates for middle over washed soil (3.90 mm), and secondly, to decrease the value of this parameter with increasing degree of erosion of the soil from 4.14 to 2.86 mm (Table 1).

Table 1. Weighted average diameter of aggregates depending on the type of fractionation

Soil	Type of fractionation / Aggregate diameter (mm)		
	dry sieving air-dry soil	wet sieving air-dry soil	wet sieving capillary-wetted soil
not washed away	4.08	2.25	4.14
weekly washed away	3.97	1.44	3.36
middle washed away	3.34	1.55	2.86
middle over washed	4.44	0.88	3.90

Analysis of the results wet sieving of air-dry and capillary-wetted soils showed that the weighted average diameter of water-stable aggregates more with prior capillary moisture sample.

This phenomenon can be explained by the fact that at the capillary moisture pores inside soil aggregates are gradually filled with water, and the subsequent submersion of the sample in the water is no sharp remove air from long-destroying machines, which occurs during the wet sieving air-dried samples.

Thus, when analyzing the data in the aggregate structure of soil investigation, it was found that it depends on the degree of the soil erosion. The greater the degree of erosion, the less the weighted average diameter aggregates. The exception is when middle over washed soil fractionated air-dry and capillary-wetted condition.

The relationship between the humus content in the studied soils and their aggregate composition

It is known that the content of humus in the soil depends on the degree of erosion. Determination of the content of humus in the investigated soil samples showed that increasing the degree of erosion, this indicator decreased from 2.37% in not washed soil to 1.96% in medium washed soil. At the same time, the maximum content of humus (2.56%) was discovered in middle over washed soil (Table 2).

Table 2. Weighted average diameter of aggregates in different types fractionation depending on the content of humus in the soil

Soil	The average humus content in the layer of 0-30 cm (%)	Type of fractionation / Aggregate diameter (mm)	
		dry sieving air-dry soil	wet sieving capillary-wetted soil
not washed away	2.37	4.08	4.14
weekly washed away	1.97	3.97	3.36
middle washed away	1.96	3.34	2.86
middle over washed	2.56	4.44	3.90

The relationship between the humus content and the weighted average diameter of the aggregates was found at two types of fractionation of the investigated soils – sieving of samples in the air-dry and wet sieving capillary-wetted soil samples. The results of the analysis showed the following. With increasing total humus content in the studied soils weighted average diameter of aggregates for different types of fractionation increases. For example, in not washed away soil with the content of humus 2.37%, weighted average diameter of aggregates by the dry sieving of air-dry soil was 4.08 mm and wet sieving capillary-wetted soils was 4.14 mm. In the middle washed away soil with humus content 1.96% weighted average diameter of aggregates by sieving air-dried samples was 3.34 mm and for wet sieving capillary-wetted samples was 2.86 mm (Table 2).

The relationship between the degree of soil erodibility, the content of humus and the weighted average diameter of water-stable aggregates is determined by the wet sieving of air-dry soil, has not been detected.

Thus, it is established, humus content decreases with increasing degree of erosion. In middle over washed soil humus content is high enough. The relation between the content of humus and weighted average diameter of the aggregates of fractionating as air-dry soil, and wet sieving in capillary-wetted condition.

Analysis of the influence of flow velocity to the changing diameter of the transported and deposited aggregates

Model experiments at the large erosion tray with samples not washed away soil was carried out in the range of flow velocities from 0.28 m/s to 0.62 m/s. Thus values of diameter of the transported the flow of aggregates of air-dry soil increased with increase of velocity from 0,13 mm to 0,79 mm, and deposited in the channel was decreased from 0.48 mm to 0.10 mm (Fig. 1).

In experiments with capillary-wetted soil in the same range of velocities was observed a slight increase in the diameter transported by the flow of aggregates (from 0.10 mm to 0.20 mm) and diameters deposited in the channel practically did not change and fluctuate within the range of 1.00-0.93 mm (Fig. 2).

The analysis of experiments results with air-dry not washed away soil shows that there is regularity in the changing diameters of the transported and deposited aggregates with increase in average flow velocity, while for capillary-wetted soils this dependence is weak (Figs. 1, 2). This can be explained by the fact that the soil being no eroded and being formed on the part of a gentle slope with a gradient of not more than 0.0192, has not previously been subjected to intense erosion processes. Consequently, in the capillary-wetted soil is much more resistant to these processes than air-dry.

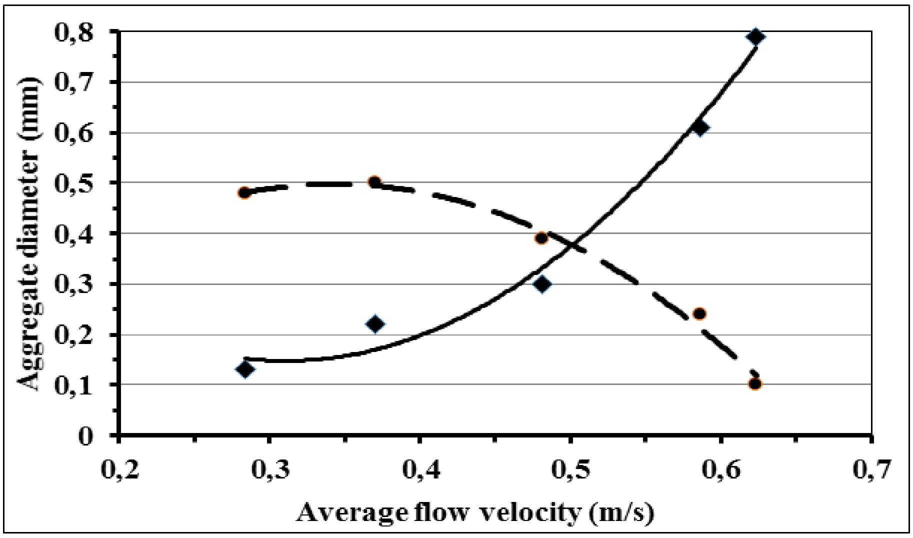

Figure 1. The change in diameter of the transported and deposited aggregates not washed away soil of the flow velocity (air-dry condition)

Legend in figures 1-4: ♦—♦ is transportable aggregates; • – – • is deposited aggregates

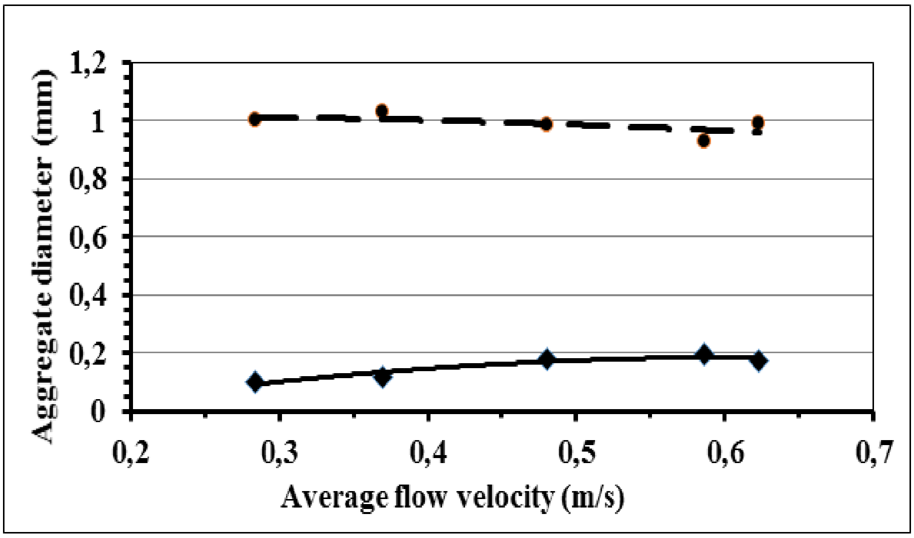

Figure 2. The change in diameter of the transported and deposited aggregates not washed away soil of the flow velocity (capillary-wetted condition)

Model experiments with samples weekly washed away soil was carried out in the range of flow velocities from 0.28 m/s to 0.53 m/s. The weighted average diameters transported aggregates ranged from 0.09 mm to 0.59 mm in the study of air-dried samples and from 0.10 mm to 0.71 mm for capillary- wetted. Diameters deposited aggregates for air-dry soil ranged from 0.35 mm to 0.09 mm and capillary-wetted was 2.17-1.53 mm.

Analysis of the results of changes in the diameter of the transported and deposited aggregates weekly washed out air-dry and capillary-wetted soils showed that there is a pattern, close to the results obtained in the experiments with samples not washed away soil.

Analysis of the results of the diameter transported and deposited aggregates middle washed away soil in air-dry conditions shows that the general pattern identified for not washed away and weekly washed away soil from the degree of erosion is independent. The range of average flow velocities established for this soil has not changed significantly compared to earlier investigated soils (0.20-0.54 m/s). The diameter of the transported aggregates of air-dry soil with increasing flow velocity has increased from 0.08 mm to 1.37 mm, and deposited on the contrary, decreased from 0.49 mm to 0.02 mm (Fig. 3).

Figure 4 shows the change in diameter of the transported and deposited aggregates in the study of middle washed away soil in capillary-wetted condition. Figure 4 shows that this degree of soil erosion regularity, identified earlier for not washed away and weekly washed away the soils has a slightly different view. The distribution of points similar dependencies are detected in the study of air-dried samples not washed away, weekly and middle washed away soils. Diameter transportable aggregates increased from 0.07 mm to 1.92 mm and the deposition decreased from 1.13 mm to 0.38 mm.

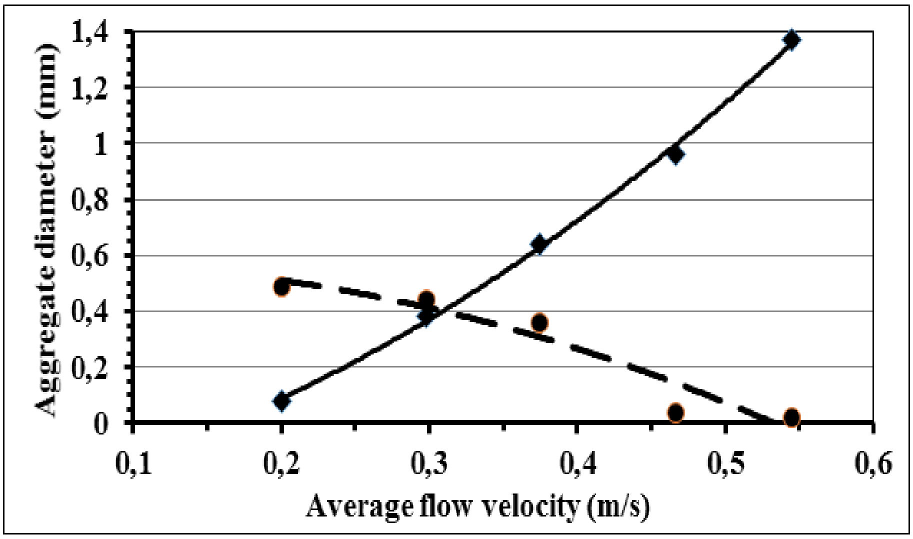

Figure 3. The change in diameter of the transported and deposited aggregates middle washed away soil of the flow velocity (air-dry condition)

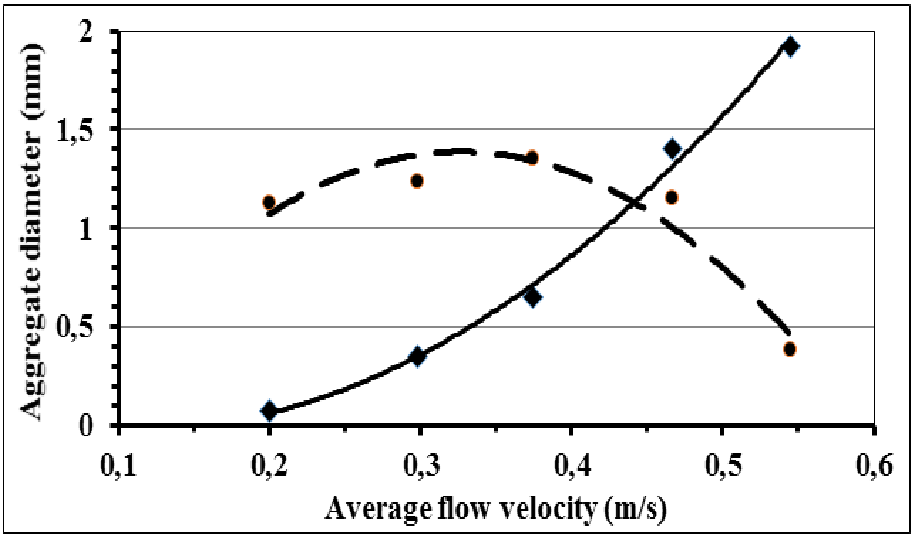

Figure 4. The change in diameter of the transported and deposited aggregates middle washed away soil of the flow velocity (capillary-wetted condition)

When carrying out model experiments with middle washed away soil average flow velocity was varied from 0.22 to 0.58 m/s. In experiments with soil in the air-dry condition diameters transported aggregates has increased from 0.08 to 0.39 mm increase in average flow velocity, and the diameters of the deposited aggregates decreased from 0.33 to 0.01 mm.

In model experiments with middle over washed capillary-wetted soil the diameter transported aggregates increased with the increasing flow velocity from 0.09 to 1.19 mm, and deposited was decreased with 1.42 to

0.17 mm. The character of changes in the diameter as transported and deposited aggregates in both variants of the experiment is close to middle washed away soil.

The analysis of changes in the diameter of the transported by the flow of water and deposited in bed of soil aggregates, coming into the flow as in the air-dry, and in capillary-wetted condition, have shown, that with increase of velocity of the water flow the diameter of the transported aggregates increases, while deposited aggregates become smaller, than the flow velocity is greater.

Verification of the equation transport capacity depth depths flows (on the example, soddy-podzolic soil)

Verification equation 1 was conducted in the following way. On the basis of experimental data obtained from model experiments with samples of the studied soils were derived actual values of turbidity flow (B, kg/m^3) and the average velocity of flow (V, m/s). Calculation of the critical flow velocity for transportable aggregates (V_k, m/s) was performed using equations 2 and 3. For the finding of the empirical exponent $1/\gamma$ and the empirical coefficient C, built graphs of the lnB from $\ln(V^2\text{-}V^2_k)/gH$ for the studied soils in air-dry and capillary-wetted condition. Methods of determining the coefficients of $1/\gamma$ and C as an example is shown in Figures 5 and 6. The equation of the linear trend of the form y=kx+b for each variant of model experiments found empirical exponent $1/\gamma$, as an indicator of the slope of the line and the empirical coefficient C is natural antilogarithm from a free member in the equation of the trend line.

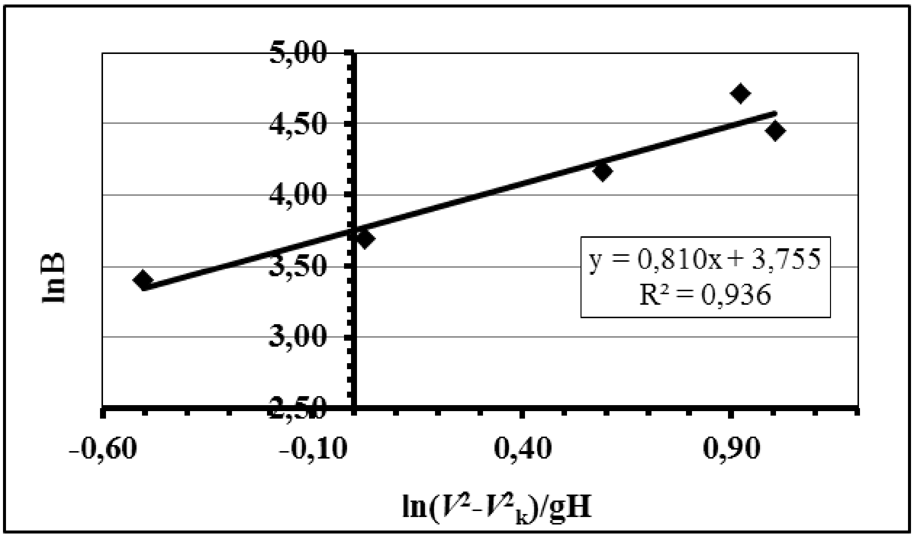

Figure 5. Dependence lnB from $\ln(V^2\text{-}V^2_k)/gH$ for not washed away soil (air-dry condition).

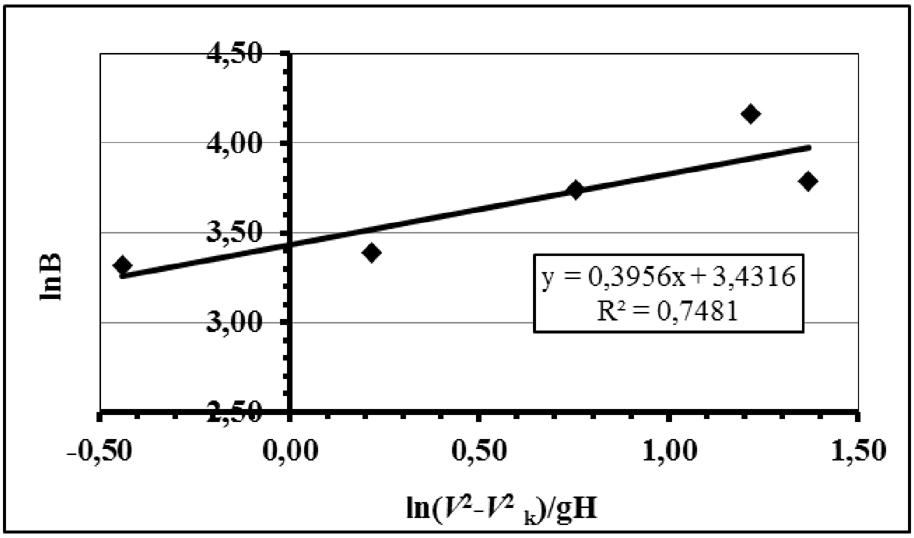

Figure 6. Dependence lnB from $\ln(V^2\text{-}V^2_k)/gH$ for not washed away soil (capillary-wetted condition).

Graphical analysis has shown that in the linear approximation dependences lnB from ln(V^2–V^2_k)/gH coefficients of approximation (R^2) were quite high (from 0.72 to weekly washed away capillary-wetted soils to 0.98 for middle washed away air-dry soil). This means that the approximation is performed sufficiently satisfactory certainty. Having values of *C* and $1/\gamma$, according to equation 1 was calculated of transportation capacity flow *β* (kg/m^3) and found relative error in module (|P|, %) between the experimentally obtained values of turbidity (B), and calculated according to equation.

Analysis of the logarithm of the results obtained for not washed away soil entering the tray in air-dry and capillary-wetted condition shows the following. There is more close correlative connection data with the soil in air-dry conditions (*r*=0.81) compared with capillary-wetted where *r*=0.69 (Table 3).

Correlative relationship in experiments with weekly washed away soil in both variants entering of soil in water flow, showed high precision (*r*=0.88-0.83), but the relative error is made, respectively, 31.6 and 16.4%.

The results of experiments with middle washed soddy-podzolic soil, also showed rather high correlative relationship. The correlation coefficient *r*=0.99-0.80 (Table 3). The results of the logarithm of the data obtained middle over washed soil also showed high correlation (*r*=0.92).

The analysis of the obtained values *β* and available data on experimentally defined turbidity flow (B, kg/m^3) showed that the relative error of these calculations varies from 12.9% to 31.6% its average value is 18.4% (Table 3). This suggests that the comparison of these values established experimental and calculation methods, shows their satisfactory compliance.

Table 3. The parameters defined in the model experiment

Soil	C (kg/m^3)	$1/\gamma$	|P| (%)	r
		not washed away		
air-dry	42,73	0,81	20,7	0,81
capillary-wetted	30,93	0,40	16,2	0,69
		weekly washed away		
air-dry	48,13	1,27	31,6	0,88
capillary-wetted	19,14	0,50	16,4	0,83
		middle washed away		
air-dry	42,18	0,66	13,8	0,99
capillary-wetted	78,34	0,73	18,8	0,80
		middle over washed		
air-dry	12,76	0,36	12,9	0,92
capillary-wetted	31,25	0,51	16,7	0,92
Average			18,4	0,86

Note. *C* is empirical coefficient; $1/\gamma$ is empirical exponent; |P| is relative error in module; *r* is correlation coefficient.

Thus, on the example of soddy-podzolic soils of different degree of erosion and inwashed during our studies have shown that for the calculation of transport capacity of flows small depth of acting on these soils, you can use the equation developed at the Department of erosion and soil conservation of Soil Science Faculty of Lomonosov Moscow state University (Gendugov et al, 2007).

Conclusion

The aggregate analysis of the composition of the soil in the initial state showed that the average diameter of the aggregates depends on the degree of erosion. The decrease in the weighted average diameter aggregates from not washed away to middle washed away soils are observed.

The content of humus in soddy-podzolic soil influences its aggregate composition. Weighted average diameter in the fractionation aggregates of air-dry and capillary-wetted soddy-podzolic soils decreases with decreasing humus content.

In model experiments on a large erosion tray established that the average diameter of the transported aggregates increased with the increase of the flow velocity, and the diameter of the deposited aggregates decreased.

On the basis of data obtained in the model experiments, the values of empirical coefficient (C) and empirical exponent ($1/\gamma$) necessary for verification of previously developed experimentally-theoretical equations transport capacity of the water flow.

The verification equation applied to the soddy-podzolic soils of varying degrees of erosion and inwashed. The comparison of obtained experimentally and calculated by the equation values of turbidity showed satisfactory compliance. The average relative error in module was 18.4%, and the correlation coefficient was 0.86.

Acknowledgements

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References

Alexeevsky, N.I., Chalov, R.S., 1997. Movement of sediments and channel processes. Moscow, Moscow State University (in Russian)

Chebotarev, A.I., 1978. Hydrological dictionary. Leningrad. Gidrometeoizdat. (in Russian)

Classification and diagnostics of soils of the USSR, 1977. Moscow, Kolos. (in Russian)

Gendugov, V.M., Glazunov, G.P., 2009. About the unity of mechanisms of water and wind erosion of soil. Soil science. 5, 29-44. (in Russian)

Gendugov, V.M., Kuznetsov, M.S., Abdulfanova, D.R., Larionov, G. A., 2007. Model of sediment transport slope flows. Vestnik Moscow State University. Soil science. Ser.17. 1, 35-40. (in Russian)

Kuznetsov, M.S., Glazunov, G.P., 2004. Erosion and soil conservation. Textbook, Moscow, Moscow State University, ColosC". (in Russian)

Praktikum on Agrochemistry. Textbook, 2001. Moscow, Moscow State University. (in Russian)

Vadyunina, A.F., Korchagina, Z.A., 1986. Methods of research of physical properties of soils. Moscow, Agropromizdat. (in Russian)

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Effects of different soil amendment on total phosphorus availability

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Abstract

Phosphorus (P), is a vital macro element for plant growth. Due to heavy addition of P fertilizer, amount of total P in soils increased while plant available P decreased year to year. In recent years, environmental pollution, especially phosphorus, which is an affiliate Phosphorus fertilizer use in limiting the reduction of eutrophication, is one of the main purposes. In this study, the effects of different soil amendment (cattle and chicken manure, sulfur) application on soil total P availability were investigated. The study was carried out under the greenhouse conditions as a pot experiment. Soil was collected from the 0-20 cm depth of İkizce series in Harran Plain soils at the Harran University research area in Eyyubiye Campus. Treatments were 0, 4 and 8 t/ha for chicken manure, 0, 20 and 40 t/ha for cattle manure and 0, 0.75 and 1.5 t/ha for Sulfur. Cattle and chicken manure applications increased available P in soil.

Keywords: Total Phosphorus, Available Phosphorus, Soil amendment

Introduction

Phosphorus is one of the most important elements for plant growth. Plant available P in soils is low and P use has increased day to day, to grow plants in required reserves is decreased (Gahooni et al., 1999). In our country, in the extreme of the effect of the applied chemical phosphorous fertilizer, despite soil total P content an increase in the amount of Plant available is very small level. Phosphorus in the soil is low and a large portion of usefulness in the soil in the form of plants can not assume the presence useless, is further increasing the value of these nutrients. Less of phosphorus, alkaline calcareous soils limits crop production efficiency is one of the most important factors. Despite adding phosphorus to soil, pH due to lime that phosphorus do not benefit sufficiently for plants. Such features P soils significantly limit the usefulness of the plants (Mengel and Kirby, 1987, Rodriguez et al., 2000; Galletti et al., 2003; Franson et al., 2003). In our country, in an unconscious way too extreme and phosphorous fertilizers are applied. This country's economy as well as pose problems in terms of environmental pollution. In recent years, environmental pollution, especially phosphorus, which is an affiliate Phosphorus fertilizer use in limiting the reduction of eutrophication is one of the main purpose. In this study, which is present in the soil by increasing the availability of Total Phosphorus, every year continuously added to the soil in excess of phosphorous fertilizer consumption is to be reduced.

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Material and Methods

The study area is loated in the Harran Plain, Sanliurfa, Turkey. Soil was collected from the 0-20 cm depth of İkizce series in Harran Plain soils at the Harran University research area in Eyyubiye Campus. The soils used in the experiment include the following features.

Table 1. Physical and chemical properties of Experiment Soil

Horizon	pH	OM (%)	CEC (me/100gr)	Total P (mg kg -1)	Available P (mg kg -1)	CaCo3 (%)	Sand (%)	Loam (%)	Clay (%)
Ap	7.85	0.9	49	429	41.51	11.5	24	26	50

Incubation Study

In the study, elemental S amount pots how applied to determine which five different S-dose (25, 50, 75, 100, 150) kg / da from each of three replications including 2 mm was sieved off from land 110g health taking samples was performed. These samples at room temperature at a humidity of 20% intimately mixed with the soil particles after 1 week, 15 days, 1 month after 10 g of each sample taken from the pH of the soil was measured. The results are then compared to 0.75 t / ha and 1.5 t / ha was applied

Greenhouse Study

In this study, manure, sulfur and chicken manure doses was applied. The used plants in the experiment, which is common wheat plant cultivation in the Harran Plain is selected. Harran Plain Campus İkizce Eyyubiye series of soil samples taken from the 0-20 cm, after drying, 2 mM steel sieve and a 1-liter 1000 g of soil in each pot was filled. In this study, 3 (Sulfur) x 3 (manure) x 3 (chicken manure) x 3 (recurrence) was used for a total of 81 pots. In a randomized block design was established under greenhouse conditions. Before cultivation soil moisture was adjusted to 20%. Each pot was applied, and the soil must be applied to each pot and each pot was seeded in 12, 6 dilutions were made so as to be exhausted. Hoagland nutrient solution to the plants and were watered with distilled water if necessary. In pots cleaned of weeds and pests by hand if there is way drugs were made. Plants were harvested after 50 days. Harvest; The plants in each pot until the point where the ground contact portion green parts i.e., cut with scissors after washing with pure water with paper towels paper bags were put in drying and labeled. Likewise the plant roots in the soil of each pot removed and washed with plenty of water drying and placed into paper bags, green herbage yield based on the wet weight to determine the dry weight at 65 ° C was placed in the oven. Dry weight samples were taken from the plant were made by wet digestion. Soil, before planting and after harvest in order to compare the status of each soil sample was taken from the pot is 150g. After drying the soil samples were prepared for analysis.

Statistical analysis

This study was carried out according to plan factorial experiment with three replications. Statistical analyzes were performed using SAS program. In comparison of the mean value (LSD) were used in different minimum value.

Results and Discussion

Effects of Applications on Available Phosphorus and Total Phosphorus

Application of chicken manure (CM) applied at different doses of each of the three doses of the impact on the available phosphorus (AV) and total phosphorus (TP) was statistically insignificant. Applications of manure were significant at the 0.01 level on the available phosphorus and total phosphorus. Eraslan, F (1998), applied different doses of manure increases the uptake of soil available phosphorus have been reported.

Table 2. Effects of Application on Available Phosphorus and Total Phosphorus

CM	YP	AP	**AG**	AP(gr/L)	TP(gr/L)	**S**	AP(gr/L)	TP(gr/L)
0	49.864	74.724	0	42.050b	56.479b	0	51.629	69.061
1	51.331	66.239	1	52.786ab	72.143ab	1	52.741	72.137
2	57.636	74.766	2	63.995a	87.007a	2	54.46	74.431
F Test	SD	SD	F Test	**	**	F Test	SD	SD

Effects of Applications on Available Phosphorus and Total Phosphorus

Chicken manure effect on pH and EC of the application is not important. S application on the Potts both pH and EC effect was significant at 0.01 level. Manure application is negligible effect on pH and EC. Chicken manure and manure when applied with together effects on both pH and EC is not important.

Table 3. Effects of Application pH and EC

CM	pH	EC	Manure	pH	EC	S	pH	EC
0	7.903	1024.56	0	7.913	964.67	0	7.9706a	801.63c
1	7.912	945.81	1	7.914	973.85	1	7.9037b	992.15b
2	7.906	992.85	2	7.895	1024.7	2	7.8491c	1169.44a
F Test	ÖD	ÖD	F Test	ÖD	ÖD	F Test	**	**

Conclusion

In Conclusion, increasing applied chicken manure doses and sulfur application doses did not make a significant impact on total phosphorus and available phosphorus. Furthermore, increasing manure application doses increased amount of available and total phosphorus. In general, increasing the dosage manure, chicken manure and S practices have a positive impact on the root of the P. Ca ratio in the plant 3.93 - 5.15 mg / kg was found to the amount of Ca in the root 5.15 to 8.12 mg / kg was found. The amount of Fe in the plant 0.05 1.81 mg / kg of the root of the amount of Fe in the 0.20 to 1.25 mg / kg was found.

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References

Eraslan F, 1998. Different Organic Materials (Humic Acid, AG, Rose of Posada, apple pomace) Effect of Some Chemical Properties of Soil Ranch. Suleyman Demirel University Institute of Science and Master of Science Thesis. Isparta

Franson, A., Aarle, I.M., Olsson, P.A., Tyler, G., 2003. Plantago Lanceolata L. And Rumex Acetosella L. differ in Their Utilization of Soil Phosphorus Fractions. Plant and Soil 248: 285-295.

Gahoonia, T.S., Nielsen, E.N. and Ole, B.L., 1999. Phosphorus (P) Acquisiti on of Cereal Cultivars in the Field at Three Levels of P Fertilization. Plant and 211: 269-281.

Gallet, A., Flish, R., Ryser, J., Nosberger, J., Frossard, E. and Sinaj,S., 2003. Uptake of Residual Phosphate and Freshly Diammonium Phosphate by Lolium Perenne and Trifolium Repens. J. Plant Nutr. Sci. 166: 557-567

Mengel, K., Kirkby, E.A., 1987.Principles of Plant Nutrition 4.ed.Int.potash Inst.Bern, Switzerland pp. 665

Rodriguez, D., Andrade, F. H., Goudriaan, J., 2000. Does Assimilat Supply Limit Leaf Expansion in Wheat Grown in The Field Under Low Phosphorus Availability. Field Crops Research 67: 227-238

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Effects of plant essential oils on some soil microbial properties

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Abstract

Plant oils and their components, and extracts of the world, using the saprophytic and pathogenic micro-organisms have been many studies for the control. Essential oils for their antimicrobial activities direct effects on soil microbial fauna and physical and chemical nature and on plant productivity. *Achillea millefolium* (Y_1), *Artemisia dracunculus* (Y_2) and *Salvia officinalis* (Y_3) plant species are well known for their high contents in aromatic compounds, and essential oils. This study focused on the impacts of essential oils of *Achillea*, *Artemisia* and *Salvia* plants on; (a) soil reaction, (b) soil bacteria and fungi population and (c) soil respiration. Soils were collected from the research farm of Ataturk University, Erzurum, Turkey and 0-20 cm depth. We used four different essential oil doses (0, 100, 1000 and 10.000 ppm). Soils were potted and incubated for several weeks and taken soil samples for analysis of bacteria, fungi and soil respiration in different incubation days (0, 15, 30, 45, 60 days). In this study, we concluded that soil pH level, bacteria populations and soil respiration decreased with increasing essential oil concentration and the lowest pH level has been obtained in 60 days incubation periods, but opposite effect has been observed on fungi populations at the 60 days incubation period. Among different essential oils Y_1 applications has been shown low effect, and Y3 application shown high effect on soil reaction, soil bacteria and fungi populations and soil respiration in the soil.

Keywords: achillea, artemisia, salvia, essential oils, bacteria and fungi population, soil respiration

Introduction

This is horticultural crop grown for production of seeds used as spice or the essential oil for industrial application in perfumery, cosmetic, pharmaceutics and vegetative parts used in salad.

Oils may also be extracted from plants by dissolving parts of plants in water or another solvent. The solution may be separated from the plant material and concentrated, giving an extracted or leached oil. The mixture may also be separated by distilling the oil away from the plant material. Oils extracted by this latter method are called essential oils. Essential oils often have different properties and uses than pressed or leached vegetable oils (Anon., 2014).

Essential oils of largely different chemical composition from both indigenous and nonindigenous aromatic plants on soil samples of different origin. The essential oils tested were rich in phenols, carvacrol, and/or thymol, carvone–dihydrocarvone, 1,8-cineol–camphor, and linalool–linalyl acetate (Vokuo and Liotiri, 1999).

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The constituents of some essential oil, including trans-anethole, d-fenchone, camphene and methylchavicol are paramount importance in the pharmaceutical industries and in confectionary (Wealth of India, 1978; Abdallah *et al*., 1998). Some essential oils has camphor, 1,8-cineole,, chamazulene, nuciferol propionate, nuciferol butanoate, caryophyllene oxide, borneol, R-terpineol, spathulenol, cubenol, â-eudesmol, and terpinen-4-ol (Kordali et al., 2005).

In spite of their different chemical composition, all of the essential oils (1-15 µl) activated soil respiration. Moreover, soils not previously exposed to essential oils responded similarly to those supporting aromatic plants (Vokuo and Liotiri, 1999).

In previous researches showed that soil respiration was activated in the presence of *Coridothymus capitatus* and *Satureja thymbra* essential oils. The increase of soil respiration was found to be a primary rather than secondary effect. The essential oils from these plants did not kill some soil microorganisms, thereby providing substrate easily decomposable to others (Vokuo et al., 1984) but directly activated soil bacteria.

The content of essential oil was significantly increased on increasing the soil exchangeable sodium percentage in present study. An increase in trans-anethole content in fennel essential oil might be attributed to decline in the primary metabolites due to the effect of sodicity, causing intermediary products to become available for secondary metabolite synthesis (Singh et al., 2014).

The aims of this work are to examine effects of essential oils (1) on soil pH level, (2) on soil microbial population and (3) on soil respiration.

Material and Methods

Experimental site

Achillea millefolium, Artemisia dracunculus and *Salvia officinalis* plants species were collected from Turkish tarragon. The experiment was conducted at greenhouses. Soils were collected from the research farm of Ataturk University (39° 54' N and 41°13' E, altitude 1883 m), Erzurum, Turkey and the 0-20 cm depth.

Experimental sites soils were classified as Ustorthents according to the United States Department of Agriculture (USDA) soil taxonomy (Soil Survey Staff, 1999). Some climatic data relating to the experimental area are provided in Table 1.

Table 1. Monthly rainfall, mean temperature and average relative humidity for 2014.

Month	Monthly rainfall (mm)	Mean temperature (°C)	Average relative humidity (%)
January	17.8	-11.2	81.6
February	10.9	-5.6	77.0
March	13.4	1.2	73.5
April	77.4	7.2	74.4
May	41.6	11.4	67.3
June	19.2	18.4	56.7
July	20.7	20.3	62.5
August	3.5	22.6	50.9
September	29.2	14.1	60.2
October	90.1	8.6	76.0
November	25.3	-0.1	70.9
December	8.3	-9.8	75.4
Average	29.8	6.4	68.9

Soil sampling and laboratory analysis techniques

Soil samples were collected from Ap horizon and sieved through a 2-mm mesh opening on the field and brought to the laboratory for initial chemical, physical and microbial analysis. Soil organic C was determined by the Smith-Weldon method (Tiessen and Moir, 1993), $CaCO_3$ content was determined using a Schleibler calcimeter (Tee et al., 1993), total nitrogen (N) was determined by using the micro Kjeldahl method (McGill and Figueiredo, 1993), soil pH was determined by using a glass electrode pH meter (1:2.5, soil: water), exchangeable cations and cation exchange capacity were determined by Perkin-Elmer, 2100 DV, ICP/OES spectrophotometer (Mertens, 2005), available P was determined by the Na2CO3 extraction method (Olsen and Sommers, 1982), soil texture was determined by the Bouyoucus hydrometer method (Shieldrick and

Wang, 1993), electrical conductivity (EC) was determined by using an EC meter according to the method of Janzen (1993). Measured chemical and physical properties of the experimental site soil are shown in Table 2.

Table 2. Some initial chemical, physical and microbiological properties of the experimental soil.

Soil properties		
pH (1:2.5)		6.71
Organic matter, g kg^{-1}		3,49
Lime (CaCO3), g kg^{-1}		1.01
Total N, g kg^{-1}		0.17
Available P mg kg^{-1}		13.95
Salt, %		0.016
Electrical conductivity, dS m^{-1}		0.65 x 10^3
Cation exchange capacity, cmol kg^{-1}		34.15
Exchangeable cations, cmol kg^{-1} soil	Ca	16.17
	Mg	14.64
	K	2.25
	Na	0.35
Microelements, mg kg^{-1}	Fe	12.41
	Cu	3.59
	Zn	0.59
	Mn	9.52
Particle size distribution, g kg^{-1}	Sand	52.44
	Silt	27.60
	Clay	19.96
	Texture Class	LOAM
Number of bacteria, CFU* g^{-1} soil		6.69 x 10^7
Number of fungi, CFU g^{-1} soil		1.93 x 10^5
Total C respired as CO_2, mg m^{-2} h^{-1} (CO_2-C)		1.70 Mg C ha^{-1} y^{-1}

*CFU, Colony-forming units.

Microbial population analysis

Determinations of viable microbial bacteria and fungi counts were carried out at five different incubation periods (0, 15, 30, 45 and 60 days) of soils and was analyzed the same day.

Culturable bacteria and fungi (colony forming units, CFU) were enumerated by the spread soil dilution plate method. For this method, each 10 g soil sample was homogenized in 100 ml phosphate-buffered saline solution (PBS, 0.15 M potassium phosphate, 0.85% NaCl, pH 7.0). The sample was centrifuged for 7 min at 250 ×g and the supernatant decanted into a sterile flask. The pellet was resuspended and washed twice by centrifugation in sterile PBS. All fractions were pooled in a sterile flask and serially diluted (10^6 – 10^7) in PBS (McDermott, 1997). For bacteria, 0.1 ml of each dilution of the series was placed onto a Petri dish with soil extract agar (SEA) (Ogram and Feng, 1997), for fungi, 0.1 ml of each dilution was placed onto a Petri dish with dextrose-peptone agar (DPA). To inhibit fungal growth during bacterial measurements, 30 mg l^{-1} cycloheximide was added to the SEA. To inhibit bacterial growth during fungi measurements, 30 mg l^{-1} streptomycin were added to the DPA. (Alef, 1995). Three replicate dishes were made for each dilution. The agar plates were aerobically incubated at 30°C for 7 days to obtain bacterial counts and at 25°C for 7 days for fungi counts. After the incubation period, the CFU of the bacteria and fungi developed on the respective agar plates were enumerated using an automated colony counter. The averaged CFU per gram of oven-dried soil was calculated for each soil sample (Canbolat at al., 2006; Madigon and Martinko, 2006) and results are reported in Table 2.

Basal respiration

Basal respiration (BR), as a measure of soil biological activity, was determined by using *in vitro* static incubation of unamended field moist soil (Islam and Weil, 2000). About 20 g ODE of field-moist soil adjusted at 70% water-filled porosity (WFP) was taken in 25 ml glass beakers. Each soil sample was placed in a 1 L mason jar along with a glass vial containing 10 mL of distilled deionized water to maintain humidity and a plastic vial containing 10 ml of 0.5 M NaOH to trap CO_2 evolved from the incubated soil. The mason jars were sealed airtight and incubated in the dark at 25 ± 1°C for 20 days. The CO_2 evolved over time was absorbed in the 0.5 M NaOH followed by precipitation as $BaCO_3$ by the addition of excess 1 M $BaCl_2$. The remaining NaOH in each vial was then titrated to the phenolphthalein endpoint with a standardized 0.5 M HCl solution (Table 2). The BR rate was calculated as:

$$\text{BR rates (mg } CO_2\text{/kg soil)} = (CO_2\text{soil} - CO_2\text{air})/20 \text{ days}$$

Plant leaves collection

The leaves of *Achillea*, *Artemisia* and *Salvia* plants were collected from the research farm of Ataturk University (39° 54' N and 41°13' E, altitude 1883 m), Erzurum, Turkey in May-June 2012. Freshly collected plant parts were shade-dried at room temperature for 10–15 days. Dried leaves samples were separately crushed and ground into fine powder with mortar and pestle.

Isolation and doses of essential oil

Shaded dried leaves (50 g) were ground and subjected to hydrodistillation for 3 h in 500 ml water (Langenau, 1948), using a Clevenger type apparatus (Clevenger, 1928) for 4 h.

We prepared three different plant essential oil doses (0, 100, 1000 and 10.000 ppm). Soils were potted and incubated for several weeks (0, 30, 45, 60 days).

Statistical analysis

Analysis of variance (ANOVA) was used to evaluate the significance of each treatment on soil properties and CO_2 fluxes and on bacterial and fungal populations. Comparison of means was performed, when the F-test for treatment was significant at the 5% level, using Duncan's multiple means tests.

Results and Discussion

Soil Reaction

Soil reaction were shoved significant ($p<0.01$) difference between different essential oil doses, different incubation day periods and different plant species as statistically.

According to obtained results in this research, the highest pH were observed at 15 days incubation period and 100 ppm essential oil concentration (6.70±0.7, 6.70±0.5 and 6.68±0.4, respectively). The lowest pH from soils in applying essential oils of *Achillea, Artemisia* and *Salvia* plants were observed at 60 days incubation periods and 10.000 ppm essential oil concentration (6.43±0.6, 6.48±0.4 and 6.45±0.5, respectively). The pH value generally decreased with increasing essential oil concentration. Among the essential oils, the highest soil pH was observed for the *Artemisia* (Y_1) essential oil application and the lowest for the *Salvia* (Y_3) essential oil application. Obtained soil pH value from the Y_1, Y_2 and Y_3 essential oil treatments were shoved significant ($p<0.01$) differences as statistically in different incubation day periods (Figure 1).

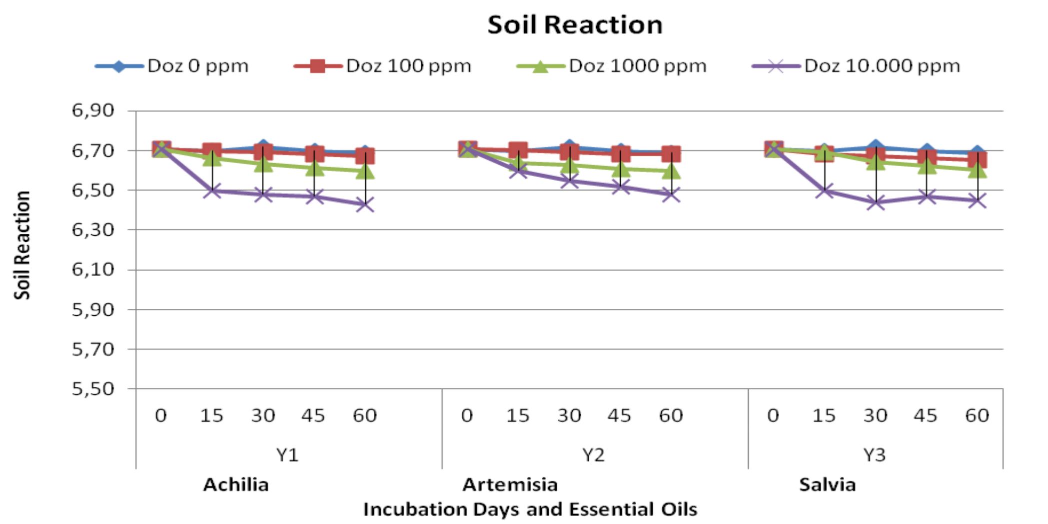

Figure 1. Effect of different essential oil doses on soil reaction at different incubation day periods.

At the 60 days period, adding essential oils has been contributed increase acidic compounds in the soil and these increases contribute to increased soil reaction Essential oils are usually highly acidic (Vincent, 2009). Increasing essential oil concentration in the soil has resulted in significant decreases in soil pH level because of the acidic chemical composition of essential oils (Singh et al., 2014). Similar results were obtained in this study.

Bacterial and fungi population

Bacterial and fungal population of the soil were shoved significant ($p<0.01$) difference between different essential oil doses, different incubation days and different plant species as statistically.

The highest bacteria populations were observed at 15 days incubation periods and 100 ppm essential oil doses in all essential oil applications (6.65±0.7, 5.51±0.8 and 5.18±0.6 CFU g^{-1} dry soil, respectively). The lowest bacteria populations were observed at 60 days incubation periods and 10.000 ppm essential oil doses in all essential oil applications (5.04±0.5, 4.04±0.7 and 3.63±0.6 CFU g^{-1} dry soil, respectively).

Among the essential oil applications, Y_1 application supported the highest bacteria population (6.65±0.7 CFU g^{-1} dry soil) at 15 days incubation periods and Y_3 application supported the lowest bacteria population (3.63±0.6 CFU g^{-1} dry soil) at 60 days incubation periods, respectively (Figure 2).

The highest fungi populations were observed at 60 days incubation periods and 1000 ppm essential oil doses in all essential oil applications (2.12±0.4, 2.03±0.5 and 2.17±0.5 CFU g^{-1} dry soil, respectively). The lowest fungi populations were observed at 15 days incubation periods and 10.000 ppm essential oil doses in all essential oil applications (1.92±0.5, 1.81±0.5 and 1.82±0.5 CFU g^{-1} dry soil, respectively).

Y_1 application supported the highest fungi population (2.32±0.5 CFU g-1 dry soil) at 60 days incubation periods and Y_2 application supported the lowest fungi population (1.81±0.5 CFU g-1 dry soil) at 15 days incubation periods, respectively when compared to initial soil treatments (0 days incubation) (Figure 2).

In this research, the essential oil application to the soil decreased bacteria populations with increasing essential oil concentrations and increased fungi populations up to 1.000 ppm essential oil concentration when compared to initial soil treatments. Although, microbial activity is strongly dependent on plant, soil and climatic conditions, soil reaction level has a definite effect on microbial activity.

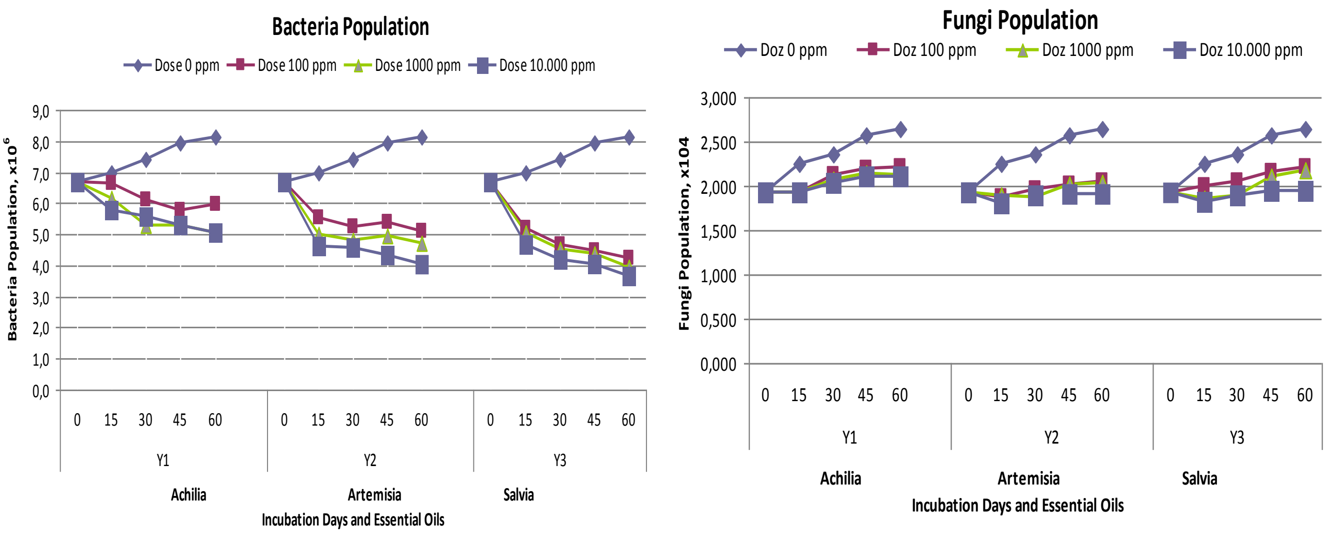

Figure 2. Effect of different essential oil doses on bacteria and fungi populations at different incubation days periods.

Some of research has shown positive effects of plant essential oils (especially in low concentration) on bacteria and fungi population in soils. However, some of them have opposite idea. In a research, the effect of the essential oil and its main constituents on soil metabolism and microbial growth has been examined. In the results of research, addition of the essential oil to soil samples (1, 5, 10, and 15 μl) induced a remarkable increase in soil bacterial population (Vokou et al., 2002).

L. nobilis essential oils presented the highest inhibition against bacterial colonies (44.9%) when compared to control soils. In contrast, *M. comunnis* and *L. stoechas* essential oils were found to augment bacterial activity by 85.9% and 63.8 when compared to control soil samples (Hassiotis and Dina, 2010).

Soil Respiration

According to obtained results in this research, soil respirations were shoved significant ($p<0.01$) difference between different essential oil doses, different incubation days and different plant essential oils species as statistically.

The highest soil respirations were observed at 15 days incubation periods and 100 ppm essential oil doses in all essential oil applications (17.57±1.8 18.53±1.2 and 19.38±1.4 mg CO_2-C m^{-2} h^{-1}, respectively). The lowest soil respirations were observed at 60 days incubation periods and 10.000 ppm essential oil doses in all essential oil applications (14.24±1.6, 13.05±1.5 and 11.59±1.3 CFU mg CO_2-C m^{-2} h^{-1}, respectively).

Among the essential oil applications, Y_1 essential oil aplication supported the highest soil respirations (19.38±1.4 mg CO_2-C m^{-2} h^{-1}) at 15 days incubation periods and Y_2 application supported the lowest soil respirations (11.59±1.3 CFU mg CO_2-C m^{-2} h^{-1}) at 60 days incubation periods, respectively. The soil respirations generally decreased with increasing incubation day periods. Among the different incubation days, the highest soil respirations were observed at 15 days incubation period and the lowest for 60 days incubation period (Figure 3).

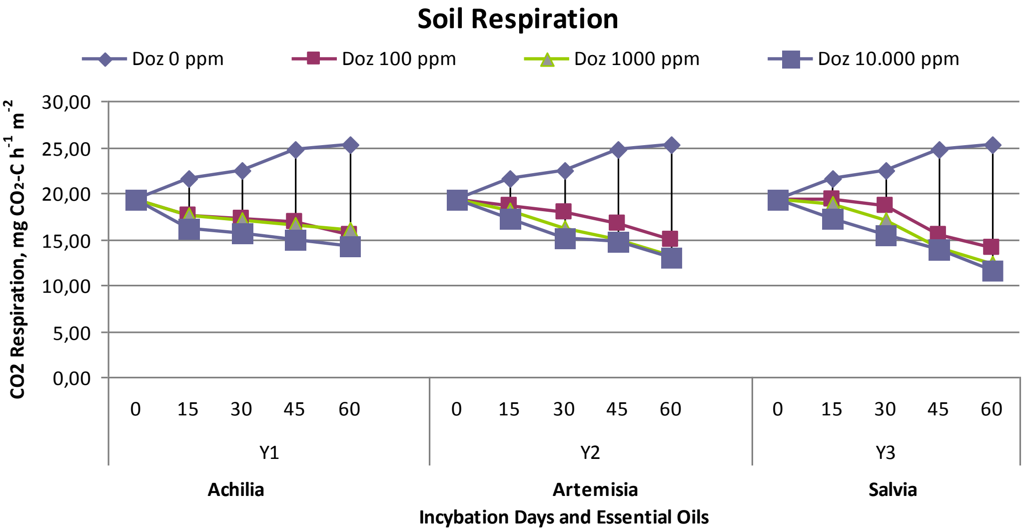

Figure 3. Effect of different essential oil doses on soil respiration at different incubation day periods.

In a research, addition of the essential oil to soils (1, 5, 10, and 15 µl) induced a remarkable increase in soil respiration. This was accompanied by an increase in the soil bacterial population of three orders of magnitude (Vokou et al., 2002). *L. nobilis* essential oils presented the highest inhibition against bacterial colonies (44.9%) and lowered soil respiration when compared to control soils. In contrast, *M. comunnis* and *L. stoechas* essential oils were found to augment bacterial activity by 85.9% and 63.8%, respectively, and to increase soil respiration (1.5-fold) when compared to control soil samples (Hassiotis and Dina, 2010).

Conclusion

In this study, we examined the effects of different essential oil doses on average soil pH, bacteria and fungi population and soil respirations in soils.

- Soil pH level of the soil in different incubation periods were the highest in 15 days incubation periods among all incubation day periods and the lowest in 60 days incubation periods.
- The highest soil pH level were observed in Y_3 applications in 15 days incubation periods and the lowest pH level were observed in Y_1 applications in 60 days incubation periods among different essential oils
- The highest bacteria populations were observed in 15 days incubation among all incubation day periods, the highest fungi population were observed in 60 days incubation among all incubation day periods.
- The highest bacteria populations were observed in Y_3 application and the lowest in Y_1 applications among different essential oils. The highest fungi populations were observed in Y_1 application and the lowest in Y_3 applications among different essential oils.
- Soil respirations in different incubation periods were the highest in 15 days incubation days and the lowest in 60 days incubation periods among all incubation day periods.
- The highest soil respirations were observed in Y_3 application in 15 days incubation periods and the lowest soil respirations were observed in Y_1 applications in 60 days incubation periods among different essential oils.

Future Research;

- Need to research essential oils uses in agriculture as antifungal or antibacterial preparat.
- Need to research further examine the effect of a number of individual essential oil constituents on plant growth and soil physical, chemical and microbial properties in different soils and in soil samples collected from the area where these aromatic plants grow and in the greenhouse and in the field conditions.

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References

Abdallah, N., El-Gengaihi, Sedrak, E., 1998. The effect of fertilizer treatment on yield of seed and volatile oil of fennel (*Foeniculum vulgare* Mill). Pharmazie, 33: 607-608.

Alef, K., 1995. Enrichment, isolation and counting of soil microorganisms. Methods in Applied Soil Microbiology and Biochemistry. Kassem Alef, Paolo Nanninpieri (Ed.). Academic Press, Harcourt Brace and Company Publishers, pp. 145-146.

Anon., 2014. List of vegetable oils. From Wikipedia, the free encyclopedia. http://en.wikipedia.org/wiki/List_of_vegetable_oils

Canbolat, M.Y., Bilen, S., Cakmakci, R., Sahin, F., Aydin, A., 2006. Effect of plant growth-promoting bacteria and soil compaction on barley seedling growth, nutrient uptake, soil properties and rhizosphere microflora. Biol. Fertil. Soils, 42(4): 350-357.

Clevenger, J.F., 1928. Apparatus for the determination of volatile oil. J. Am. Pharm. Assoc., 17: 345-349.

Hassiotis, C.N., Dina, E.I., 2010. The influence of aromatic plants on microbial biomass and respiration in a natural ecosystem. Israel Journal of Ecology and Evolution. Volume 56, Issue 2, 1 December 2010, Pages 181-196.

Islam, K.R., Weil R.R., 2000. Land use effect on soil quality in tropical forest ecosystem of Bangladesh. Agric. Ecosystems Environ., 79: 9-16.

Janzen, H.H., 1993. Soluble Salt. Soil Sampling and Methods of Analysis. Martin R. Carter (Ed.), Canadian Soil Sci. Soc. Lewis Publi. Boca Raton, FL, USA., p: 161-167.

Kordali, S., Cakir, A., Mavi, A., Kilic, H., Yildirim, A., 2005. Screening of Chemical Composition and Antifungal and Antioxidant Activities of the Essential Oils from Three Turkish Artemisia Species. J. Agric. Food Chem. 53, 1408-1416

Langenau, E.E., 1948. The Examination and Analysis of Essential Oils, Synthetics and Isolates. In: The Essential Oils, Volume 1, Guenther, E. (Ed.). Van Nostrand Co., New York, pp: 229-367.

Madigon MT, Martinko JM (2006). Biology of Microorganisms. 11th Edition. Upper Saddle River, NJ: Pearson Prentice Hall.

McDermott, T.R., 1997. Use of fluorescent antibodies for studying the ecology of soil and plant associated microbes In: Hurst CJ, Knudsen GH, McInerney MJ, Stetzenbach LD and Walter MV, Editors. Manual Environ. Microbiol. ASM Press, Washington, DC, pp. 473-481.

McGill W.B, Figueiredo C.T., 1993. Total nitrogen. Soil Sampling and Methods of Analysis. Martin R. Carter (Ed.), Canadian Society of Soil Science. Lewis Publishers. Boca Raton, Florida, USA., pp. 201-213.

Mertens, D., 2005. AOAC Official Method 975.03. Metal in Plants and Pet Foods. Official Methods of Analysis, 18th edn. Horwitz, W., and G.W. Latimer, (Eds). Chapter 3, pp 3-4, AOAC-International Suite 500, 481. North Frederick Avenue, Gaitherburg, Maryland 20877-2417, USA

Ogram, A., Feng, X., 1997. Methods of soil microbial community analysis In: Hurst CJ, Knudsen GH, McInerney MJ, Stetzenbach LD and Walter MV, Editors, Manual Environ. Microbiol. ASM Press, Washington, DC, pp. 422-430.

Olsen S.R., Sommers L.E., 1982. Phosphorus. In: Page AL, Miller RH, Keeney DR (Eds). Methods of soil analysis part 2. ASA-SSSA, Madison, WI, pp. 403-427.

Shieldrick, B.H, Wang, C., 1993. Particle Size Distribution. Soil Sampling and Methods of Analysis. Martin R. Carter (Ed.). Canadian Society of Soil Science. Lewis Publishers. Boca Raton, Florida, USA., pp: 499- 513.

Singh, P.K., Kumar, P., Tandon, P.K.., 2014. Soil Sodicity Alters Antioxidative Enzymes, Photosynthetic Pigments, Water Content and Essential Oil Quality of Fennel (*Foeniculum vulgare* Mill.). *Research Journal of Soil Biology, 6: 1-16.*

Soil Survey Staff., 1999. Soil Taxonomy a Basic System of Soil Classification for Making and Interpreting Soil Surveys 2nd ed. US Dept. of Agric. Soil Conservation Service Washington.

Tee B.G., Arnaud RJ.St., Mermut A.R., 1993. Carbonates. Soil Sampling and Methods of Analysis. Martin R. Carter (Ed.). Canadian Society of Soil Science. Lewis Publishers. Boca Raton, Florida, USA., p: 177- 187.

Tiessen H, Moir J.O., 1993. Total and Organic Carbon. Soil Sampling and Methods of Analysis. Martin R. Carter (Ed.). Canadian Society of Soil Science. Lewis Publishers. Boca Raton, Florida, USA., pp: 187- 201.

Vincent, E., 2009. Tips and techniques for using Young Living therapeutic-grade essential oils. https://aromatherapy4u.wordpress.com/category/acidic-alkaline/

Vokou., D., Chalkos, D., Karamanlidou., G., Yiangou, M., 2002. Activation of soil respiration and shift of the microbial population balance in soil as a response to *Lavandula stoechas* essential oil. J Chemical Ecology. Apr; 28(4):755-68.

Vokuo, D., Liotiri, S. 1999. Stimulation of microbial activity by essential oils. *Chemoecology* 9:41–45.

Vokuo, D., Margaris, N.S., Lynch, J.M., 1984. Effects of volatile oils from aromatic shrubs on soil microorganisms. *Soil Biol. Biochem*. 5:509–513.

Wealth of India, 1978. Fennel. Vol. 4, CSIR Publication, New Delhi, India.

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Preservation of soil resources at development of fields

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Abstract

At intensive development of fields the speed of formation of the disturbed lands is rather high and rehabilitation works can't be carried out before completion of the development Therefore at the mining enterprises the big areas of the disturbed lands and considerable stocks of the removed fertile soil are formed; these layers should be used for soil rehabilitation. The fertile layer is stored in clamps and kept until appearance of the areas for soil rehabilitation. Thus the period of storage can exceed several decades. In the course of removal and storage the degradation of the main agrophysical and agrochemical properties of the fertile layer takes place. The fertile layer is strongly compacted practically to critical values for vegetation development, and as a result of intermixing of different soil layers and active oxidation of soil mass the decrease in humus content occurs by 2-3%. Therefore at the expiration of the period of storage more than 10-15 years we receive, for the most part, a poor material which is required to be reclamated in order to rehabilitate soil fertility. Additional investments are also required in this case which at existing approach to carrying out of rehabilitation and under contemporary conditions practically could not be ever recompensated. Therefore it is necessary to look for new possibilities of use of this valuable material. In order to keep and rationally use the removed fertile layer it is necessary to place it at once on the surface of the disturbed land. It isn't difficult to make it at the mining enterprises where the internal dump formation prevails. It is enough to correct only logistics of movement of rocks and to place the fertile soil layer at once on the top, final ledge of dumps. But for all that one can increase the thickness of the dump up to 2 m. It will permit to place large volumes of the fertile layer on the smaller areas. At the same time high-fertile artificial soil-like formations appear which can efficiently be used. This will lead to preservation of fertility and later on, in case of need, this material can be repeatedly used for soil rehabilitation. Thus, the experience of application in Russia of the main rehabilitation technologies testifies to the need of their essential adjustment taking into account the obtained knowledge and modern social and economic conditions. It is necessary to carry out essential modernization of existing technologies of recultivation, taking into account their soil and ecological efficiency and orientation on further purposeful use of the territories under rehabilitation. Now the main objective of soil rehabilitation should consist in the localization of technogenic landscapes and reduction of negative influence on adjacent territories.

Keywords: Recultivation, fertile soil layer, disturbed lands.

Introduction

At present the problem of rational use of land resources takes on special significance, in particular in the regions of intensive development of coal fields. As a result of open working, the radical transformation of natural landscape and practically complete destruction of plant and soil cover occurs. By influence on environment the coal-mining industry exceeds considerably natural exogenous processes. As a result, they

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become a leading geological force in coal bearing area and affect the whole complex of environmental conditions.

The formation of man-made relief forms is a specific feature of open working. Absolutely a new type of area is formed such as crater (pits), dumping grounds and anthropogenic reservoirs. Besides, the speed of formation of such landscapes is rather high and implementation of rehabilitation works drops behind new disturbances. Low soil and environmental efficiency of rehabilitation works does not permit to regenerate adequately the disturbed lands. The research conducted on the disturbed territories show that initial landscape is not possible to be regenerated (Chaikina, Obiedkova, 2003; Androkhanov, Kurachev, 2010; Kupriyanov, Manakov, Barannik, 2010). Considerable resource and financial costs are required in order to regenerate the disturbed landscapes.

About 20 soil types and more than 50 soil subtypes are spread at the territory of Western Siberia. Such soil diversity secures sustainable functioning of natural ecosystems. In this connection one can easily imagine the scale and diversity of ecological consequences as a result of disturbance of natural soil cover. The formation of anthropogenic relief leads to a sharp decrease in soil diversity expressed in limited set of soil types which arise at the disturbed territories. Therefore, the conservation and rational use of land resources is an important general environmental task. At intensive development of fields the speed of formation of the disturbed lands is rather high and rehabilitation works can't be carried out before completion of the development Therefore at the mining enterprises the big areas of the disturbed lands and considerable stocks of the removed fertile soil are formed; these layers should be used for soil rehabilitation. The fertile layer is stored in clamps and kept until appearance of the areas for soil rehabilitation. Thus the period of storage can exceed several decades.

As a result of implementation of regenerative works or by natural means of natural rehabilitation the soil cover is formed with contours of various soil types. This fact takes place on the surface of disturbed man-made landscape in post-anthropogenic stage. At present, according to classification of soils of anthropogenic landscapes (Kurachev, Androkhanov, 2002) two soil classes are distinguished on the surface of man-disturbed lands. These classes are subdivided into 4 soil types. The first class unifies artificial soils created as a result of implementation of regenerative works, i.e. soil-like formations tekhnozems. The second class includes soils – enbryozems and eluviozems - of naturally regenerated disturbed landscapes which are in different stages of rehabilitation. Each type of new soils is characterized by its own level of life support of biocenoses. Therefore, further use of regenerated and self-rehabilitating territories of anthropogenic landscapes is determined by level of rehabilitation of soils and soil-environmental functions.

Long-term research of man-disturbed lands and generalization of experience of the works on soil rehabilitation showed close dependence of efficiency of rehabilitation in Siberia on quantity and quality of natural resources of rehabilitation kept in the process of development of fields and rationally used at subsequent rehabilitation (Gadzhiev, Kurachev, 2001). It is explained by display in the rocks of piles and other anthropogenic substrates of factors which limit the regeneration of vegetation and soil-environmental functions. Among basic natural lithogenic resources of soil regeneration in Siberia are fertile soil layer (FSL) and subaerial loess-like loams which are considered as being potentially fertile rocks (PFR). It is connected with the fact that only such substrates contain optimal ratios of elementary soil particles (from 0.05 to 0.001 mm) which promote the development of zonal processes of soil formation on the disturbed lands. Besides, it is necessary to take into account that soil-environmental success of is mainly (60-65%) dependent on the amount of fractions of physical clay (particles more than 0.01 mm) in the rock. The content of physical clay in the dumps rarely exceeds 20%; furthermore, there is high amount of stony fraction. Stony fragments complicate to a considerable degree the development of the disturbed areas. At such ratios of fractions one cannot achieve a high efficiency of rehabilitation. Therefore, in order to restore safe ecological functioning of the disturbed lands and their further economic use one should use the technologies with application of FSL and PFR. The existing practice, however, leads to complete absolute destruction of these resources in the process of development of coal deposits.

In the first place it was provoked by outdated technologies although technical equipment of mining industry was essentially improved that permits to raise considerably the efficiency of mining work (Potapov,et al., 2005). At the same time, the existing schemes of openwork which mainly provide total dump formation of mixture of stripping and accommodating rocks do not favor to conservation of FSL and PFR. The upper parts of stripping rocks which are presented by loess-like loams are mixed at dump formation with stripping rocks. These rocks are metamorphosed to a certain extent by ancient sedimentary deposits such as sandstones, siltstones and argillite; this fact leads to essential deterioration of the properties of arising soil-forming substrate. Besides, there is an opinion that fragmentary rocks which compose the rocks of dumps (sandstones, siltstones and argillite) are conductive to increase in amount of physical clay in the process of weathering.

In general theoretical sense this is really so, however, in practical respect such an idea does not favor to efficient restoration of the disturbed areas if to take into account the duration of the weathering processes and their connection with biological, chemical, physical and chemical conditions in the dumps, however, in practical respect. The accumulation of physical clay fractions is impossible without intensive biological processes. In its turn, the intensity of biological, more exactly, biochemical processes, is limited by the lack of physical clay. But mechanical destruction of argillites, siltstones and, moreover, sandstones leads only to accumulation of silty and sandy fractions, which are not capable to maintain water-supplying function of embryozems at the level to be optimal for phytocenoses.

Recently great amounts of the removed FSL have been accumulated at many mining enterprises of Siberia. According to state standard 17.4.3.02-85 the removed and conserved FSL is necessary to be mainly used for regeneration and in some cases it can be used for earthing of the low productive lands when they are available at the area of mining industry. If such lands are not available the FSL is stored in clamps and is kept until appear the plots suitable for regeneration. The period of storage may exceed several decades. Besides, considerable degradation of fertile properties of FSL takes place. (Androkhanov, |Ovsyannikova, Kurachev, 2000). The fertile layer is strongly compacted practically to critical values for vegetation development, and as a result of intermixing of different soil layers and active oxidation of soil mass the decrease in humus content occurs by 2-3%. In 10-15 years of storage we mainly obtain low-productive FSL, for the regeneration of basic elements of the fertility of this layer the reclamative measures and additional investments are required. These measures never can be compensated at existing approach to the execution of agricultural amelioration under contemporary economic conditions. Nevertheless, one should look for new possibilities to use this material or to correct the technology of rehabilitation, as a such.

In order to keep and rationally use the removed fertile layer it is necessary to place it at once on the surface of the disturbed land. It isn't difficult to make it at the mining enterprises where the internal dump formation prevails. It is enough to correct only logistics of movement of rocks and to place the fertile soil layer at once on the top, final ledge of dumps. But for all that one can increase the thickness of the dump up to 2 m. It will permit to place large volumes of the fertile layer on the smaller areas. At the same time high-fertile artificial soil-like formations appear which can efficiently be used. This will lead to preservation of fertility and later on, in case of need, this material can be repeatedly used for soil rehabilitation. In order to keep and use this material in KATEC (Kansk-Achinsk Fuel Economic Complex) it was supposed, to the extent possible, as FSL being used directly after removal for location on the surface of the dumps or on unsuitable lands in order to improve them and maintain biological processes in the FSL. It can be also recommended to pour out FSL in the process of rehabilitation up to 1.5 m in thickness, rather than 20-30 cm as it is foreseen in many projects. Besides, FSL will be required in more amounts, but as it useful at least to some extent, and so that may be conserved to be used in future. This material is also used for pouring of every unsuitable location, for example, small layers in the dumps. In order to conserve soil profile one can jointly remove FSL and PFR and place as well on the surface of the dumps as thick as more than 2 m. At the same time one can achieve decrease in expenditures for removal of FSL and formation of the clamps, and the level of efficiency of rehabilitation may be even higher. Moreover, at present time everywhere the preference is practically given to forest reclamation, and for this approach the pouring out is not required. At present, forest reclamation is conducted without creation of favorable root zone. Therefore, the efficiency of such reclamation is not high. The use of mixture of FSL and PFR permits to increase considerably the efficiency practically of any approach of rehabilitation.

Thus, the analysis of experience of application of principal active technologies testifies to the necessity of their essential correction taking into account the available knowledge and contemporary social and economic conditions. The results of generalization of scientific studies show as well the crucial necessity of implementation of modernization of existing technologies of the rehabilitation; in this case soil and environmental efficiency and orientation to the further targeted use of the areas under rehabilitation are taken into account. The main task of the restoration of the disturbed territories should be the localization of anthropogenic landscapes and decrease in negative influence on adjacent territories. At the same time, in the areas of mining industry one should take measures on monitoring transformation of soils and other compounds of ecosystems.

References

1. Androkhanov V.A., Kurachev V.M. Soil-environmental state of anthropogenic landscapes: dynamica and assessment. Novosibirsk: "Nauka" 2010. (In Russian).
2. Androkhanov V.A., Ovsyannikova S.V., Kurachev V.M. The tekhnozems: properties, regimes, functioning. – Novosibirsk: Nauka Publisher of SB RAS, 2000. (In Russian)
3. Gadzhiev I.M., Kurachev V.M., Androkhanov V.A. Strategy and prospects for solution of the problem of the rehabilitation of the disturbed land. Novosibirsk: Publisher "Tseris". (In Russian).
4. Kupriyanov A.N., Manakov Yu. A, Barannik L.P. Restoration of the ecosystems on the dumps of mining industry of Kuzbass. – Novosibirsk: Academy Publisher "Geo", 2010. (In Russian).
5. Kurachev V.M., Androkhanov V.A. Classification of soils of anthropogenic landscapes. – Siberian Ecological Journal, - 2002. – No. 3. (In Russian).
6. Potapov V.P, Mazikin V.P., Schastlivtsev Ye.L.,, Vashlayeva N.Yu. Geoecology of coal fields of Kuzbass. – Novosibirsk: "Nauka" Publisher, 2005. (In Russian).
7.Chaikina G.V., Obiedkova V.A. The rehabilitation of the disturbed lands in mining areas of Urals. – Yekaterinburg, 2003 (In Russian).

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Changes of seed yield and quality of maize (Zea mays l.) fertilized with sulphur in early and late sowing date

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Abstract

Appropriate sulphur supply can lead to markedly improvements in yield and quality of crop production because of having affects the availability of essential plant nutrients. The objective of the study was to determination the influence of sulphur application on seed yield, yield components, quality and mineral nutrients of maize grain in early (30.04.2013) and delay (26.05.2013) sowing date. The experiment was carried out with randomized block design in Aydın province in 2013. 31D24 was used as a material of the study. Three different sulphur (S) fertilization levels (0 (control), 400 and 800 kg S ha-1) were applied in 03.03.2013 both planting period. Sulphur application and sowing date did not affect directly K, Mg, Cu concentration of grain. Generally, Ca, Fe, Zn and Mn concentration of grain were decreased with delaying sowing date. The result of the study showed that yield and yield component of maize such as grain yield, cob length, thousand grain weight and grain number per cob in S fertilized were higher than control group, because of increased grain size under S-fertilization conditions. In addition to the effects on yields, sulphur application increased the grain protein and starch concentration more than without sulphur treatment, on the other hand the highest S (800 kg ha-1) application had negatively affected on the ash and oil concentration in grain in both sowing date. It was revealed that grain yield, cob length, thousand grain weight, grain number per cob, ash and oil content of seed were consistently decreased with delaying sowing date. The findings suggested that the decrease of grain yield of maize plant with delaying sowing date may be overcome by yield increased with S application.

Keywords: Maize (Zea mays L.), sulphur application, sowing date, protein, oil, starch, mineral content

Introduction

The biological importance of S has been well known since early days of agriculture. Numerous studies have investigated interactive effects of fertilizer S, N and the other elements on crop growth and metabolism. S is necessary for protein and enzyme synthesis, it is important that the relation of S to the other mineral elements be examined, since nitrate reductase and ATP-sulphurylase enzymes catalyse the first steps of the nitrate and sulphate assimilation pathways (Brunold 1990) and chlorophyll formation (Tirasoglu et al., 2005). Sulphur is accumulated in plants in low concentrations but is an essential element as a constituent of proteins, Cysteine-containing peptides such as glutathione, or numerous secondary metabolites (Scherer et al., 2008; Abdallah et al., 2010).Rabufetti and Kamprath (1977) reported that S applications increased yield of maize grown on sandy soils, if high rates of N were used. In contrast, Daigger and Fox (1971) reported a response to fertilizer S with only low rates of fertilizer N because the maize crop was able to develop a more extensive root system and

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extract subsoil S when high rates of fertilizer N were used. Sulphur deficiencies are often associated with sandy soils. However, in the past few years there has been increasing evidence of sulphur problems on mineral-organic and even on heavy muck or organic soils. This is especially the case when young plants with limited root systems show sulphur deficiency. Especially, in the Aegean region of Turkey, there may be sometimes extreme and irregular rainfall days at the April and May months, in which maize seed is generally sown. Therefore, sowing date of maize seeds may be done sometimes very late for first crop production in this area. Thus, maize plant, which is grown at late sowing date (last may), has small root system and low yield at the end of growing period because of having very quick root elongation (shallow) and exposed to abiotic stress during growing period (Dobermann et al. 2003). These seminal roots are initially very shallow (1/2 inch or less) at the late sowing date. Therefore, during the period when the plant switches from the radicle to the seminal root the lack of nutrients in the upper becomes a severe problem. Variation in sowing date in maize modifies the radiative and thermal conditions during growth (Cirilo and Andrade 1994). Especially, they identified that delays in sowing date hastened development between seedling emergence and silking, decreasing cumulative incident radiation on the crop during the vegetative period. Dobermann et al. (2003) pointed out that yield gaps may vary widely and understanding their causes is at the heart of improving crop management. However, many management decisions are often based on relative assessment of the attainable yield, with little use of tools that allow quantifying the yield potential as well as the attainable water and nutrient limited yields.

Considerable information has been reported on the effect of various environmental factors on grain quality (Cloninger et al. 1975), who explained that oil content of the grain was changed little by seasonal growing conditions and did not appear to be correlated with total rain yield. But protein content wasnot effected by the environment. Canavar and Kaynak (2008) emphasized that in the late planting dates in peanut growth when there was a shorter period for the production of pods and a slightly lower rate of pod production due to reduced growth, and exposure of plants to a warmer and longer photoperiod (long day) in the Aeagean region of Turkey.

The overall objective of this investigation was to study the influence of sulphur application on soil pH, mineral plant nutrients of maize grain in early and delay sowing date.

Material and Methods

Plant material and experiment establishment

The field experiments were conducted in the research area at the Adnan Menderes University in Aydın, located in the Western Turkey at 37° 44' N 27° 44' E at 65 m above sea level in the 2013. The field experiments were carried out using split plot design with 4 replications. The experiment's planting dates were 30.04.2013 and 26.05.2013 and the emerging dates were observed in 07.05.2013 and 01.06.2013. Therefore two different sowing dates (early and delay) were provided.31D24, which are maize hybrid, were used as experiment material. Standard fertilization applied two stage. The first one which before being planted was involved in 80 kg ha^{-1} nitrogen (N), 80 kg ha^{-1} phosphate (P_2O_5), and 80 kg ha^{-1} potassium (K_2O) provided by applying 533 kg ha^{-1} of 15-15-15 fertilizer in the field. Second application (120 kg ha^{-1} pure nitrogen) was provided by 261 kg ha^{-1} of urea (46%) when the plants were in the 6 – 8 leave stage. The harvest area for each parcel in all treatments was 9.8 m^2.

Sulphur levels treatment

Powdered elemental sulphur was used to sulphur application material. The sulphur levels composed of 0 (S1), 400 (S2) and800 (S3) kg S ha^{-1}and application date for all levels were noted as 03.03.2013.

The properties of experiment's area soil and climate

The results of soil analysis of the experiment field are given in Table 1. It is observed from the soil analysis results that experiment field has loamy sand content, its reaction had alkaline characteristics and it has low levels of organic matter. It was seen that the P is high, K is low. Besides, Ca is high, Na is moderate, Fe is high and Mn is sufficient.

Table 1. Soil texture and chemical analysis of soil

Soil texture (%)			pH	Organic matter	P	K	Ca	Na	Fe	Mn
Sand	Silt	Clay		(%)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
72.0	16.7	11.3	8.4	1.2	2978	101	19	5.6	594	21

The temperature and rainfall values during the time of the experiment (2013) and long-term mean (1975–2012) are presented in Table 2. January, February and March of average temperature in 2013 were cooler than long term average temperature. And during maize growth period in 2013, monthly mean temperatures were higher than long term average temperatures until September. Moreover the precipitation values of the 2013 from January to Julyhigher than long term precipitation values expect for March, June and July (Table 2).

Table 2. Monthly mean temperature and total rainfall and long-term mean (1975–2013) during the growing seasons of 2013 at the study site in Aydin Province, Turkey

Months	Temperature (°C)		Precipitation (mm)	
	2013	Long term	2013	Long term
January	5.6	8.2	160.0	121.0
February	6.8	8.9	154.0	95.5
March	10.6	11.7	38.6	71.1
April	16.3	15.7	83.8	45.5
May	20.1	20.9	43.6	33.5
June	27.0	25.9	2.4	14.0
July	29.6	28.4	3.2	3.5
August	27.9	27.2	0.0	2.2
September	22.7	23.2	0.0	14.4
October	19.9	18.4	60.4	43.8
November	14.5	13.0	45.6	87.5
December	9.7	9.4	202.0	110.2

The traits studied in this research were determined in the following ways:

Cob length: Cob length was measured 10 cobwhich wereprovided from each plot.

Seed number per cob: The number of kernels in 10 cobs was counted after they had been shelled, and was divided by the number of cobs.

Thousand kernel weight: Thousand kernel weights was calculated by taking four different samples of 100 grains from the grain yield per plot and by weighing and averaging these samples.

Per cob yield: Per cob yield was measured by taking their average of 20 cobs from each parcel of all treatments.

Protein, starch, ash and oil content: Seed quality characteristics were analyzed by using NIRS-FT (Bruker MPA) (Gislum et al., 2004). The samples were packed (90 g) as uniformly as possible in mini sample cups with a depth of approximately 2.8 cm and a diameter of 9 cm.

Seed nutrients analysis: All seed samples were dried at 70 0C for 48 h in an oven. Dry seed materials were ground in a Wiley mill and weighed (0.5 g). The mineral composition (P, K, Ca, Mg, Na, Fe, Zn, Cu, Mn,) of the seeds was digested by dry ashing method (Kacar and İnal, 2008). The digested sample was filtered and used for the determination of nutrients. Phosphorus (P) was analyzed by spectrophotometer (Shimadzu, UV-160A), (Jackson, 1958). K, Na and Ca were determined by flame photometer (Jenway, PFP-7) and Mg, Fe, Zn, Cu and Mn was determined by atomic absorption spectrophotometer (Varian, 220FS) (Kacar and İnal, 2008).

Statistical analysis

All data collected from experiment was statistically analyzed using the TARİST package software (Açıkgöz et al., 1994) as a split plot design with four replications using analysis of variance to evaluate the effect of different sulphur levels on the maize. Means among treatments were compared using Least Significant Difference (LSD) at $P \leq 0.05$ probability.

Results and Discussion

Per cob yield is the major parameter to estimating yield per unit area. Sulphur application (SA) levels and delaying sowing date (SD) were significantly effected per cob yield in 31D24 hybrid. The highest per cob yield was obtained from average of early sowing date (282.44 g). Delaying sowing date decreasedper cob yield (205.16 g) (Table 3). The highest average of per cob yield from S application is S2 (281.67 g) level (Table 3). Average of per cob yield from S1 (240.39 g) and control (209.34 g) levels were followed. Result of the data, it can be said that increasing S applications is increased grain yield and delaying sowing date is decreased grain yield (Table 3).

Sulphur application (SA) levels and delaying sowing date (SD) were significantly effected cob length. The highest cob length value was obtained from average of S2 level (21.82 cm) (Table 3). This value was followed by S1 (19.99 cm) and control (19.43 cm) levels. The result has been shown that increasing S applications is also increased cob length. Otherwise delaying sowing date was effected cob length negatively. Average of early sowing date (21.18 cm) was higher than late (19.65 cm) (Table 3).

Sulphur application and sowing date interaction (SA*SD) were significantly effected seed number per cob. The highest seed number per cob value was obtained from early sowing date S2 level (792.33) (Table 3). This value was followed by control (736.33) and S1 (732.67) levels in early sowing date. The lowest value obtained from late sowing date S1 (603.00) application level (Table 3).

Sulphur application (SA) levels and delaying sowing date (SD) were significantly effected thousand kernel weight. The highest value was obtained from average of S2 level (365.42 g) (Table 3). This value was followed by S1 (339.88 g) and control (332.22 g) levels (Table 3). The result has been shown that increasing S applications is also effected thousand kernel weight positively. However average of early sowing date (359.79 g) was higher than late (331.88 g). Result of this data delaying sowing date was effected negatively (Table 3).

Sulphur application and sowing date interaction (SA*SD) were significantly effected protein content of maize seed. The highest value was obtained from late sowing date S2 level (7.98 %) (Table 3). This value was followed by S1 (7.94 %) and control (7.90 %) levels in late sowing date. The lowest value obtained from early sowing date control (7.13 %) application level (Table 3). The control values in two sowing date shown lower than S1 and S2 applications. Sulphur assimilation is highly active in growing tissues where high levels of Cys and Met are required for protein synthesis (Rotte and Leustek, 2000).S is necessary for protein and enzyme synthesis, since nitrate reductase and ATP-sulphurylase enzymes catalyse the first steps of the nitrate and sulphate assimilation pathways (Brunold, 1990) and chlorophyll formation (Tirasoglu et al., 2005).Therefore it is said that supplying sulphur might be effected protein rate positively. Our results suitable for these results.

Sulphur application (SA) levels and delaying sowing date (SD) were significantly effected starch content of maize seed. In contrast to protein content, the highest starch content was obtained from average of late sawing date (73.58 %) and S1 (73.43 %) application (Table 3). The rate of starch was strongly correlated withthe protein content (Gibon et al., 2009) and germination significantly increases protein content anddecreases starch level in seed (Abu et al., 2007). Moreover it also serves important structural, regulatory and catalytic functions in the context of proteins, and as a major cellular redox buffer in the form of the tripeptide glutathione and certain proteins such as thioredoxin, glutaredoxin and protein disulfide isomerase (Jamal et al., 2010).Therefore protein and starch rates of seed are inversely related.Our results suitable for these results.

Sulphur application (SA) and sowing date (SD) were significantly effected ash content of maize seed. The highest value was obtained from early sowing date (1.35 %) (Table 3). This value was higher than late sowing date value (1.27 %). S1 and control applications have almost same effect on ash content of seed. The lowest ash content was obtained from S2 (1.25 %) application (Table 3).

Response of seed oil content was different the other seed quality characteristics against sulphur levels and delay sowing date. Only sulphur application (SA) were significantly effected oil content of maize seed. The highest value was obtained from average of S1 application (3.59 %). Average of S2 (3.47 %) lower than S1 and the lowest value was determined average of control (3.35 %) (Table 3).

Sowing date (SD), S application levels (SA) and their interaction (SD*SA) effected insignificantly on K, Mg and Cu contents of maize seed (Table 4). Ca and Mn content of maize seed were effected significantly by SA*SD interactions. P and Fe contents of maize seed were affected significantly by S application levels, Zn was effected significantly by only sowing date. The highest Mn content was obtained from early sowing date control (46 ppm) (Table 4). This value was followed by late sowing date S2 (44 ppm) levels. The lowest Mn value obtained from early sowing date S1 (24 ppm) application level (Table 4). The highest Ca content was obtained from late sowing date control (0.92 %). This value was followed by early sowing date control (0.67 %) application (Table 4). The lowest Ca value obtained from late sowing date S2 (0.22 %) application level (Table 4).

Table 3. Change of per cob yield, yield component (cob length, seed number per cob, thousand kernel weight) and seed quality characteristics (protein, starch, ash and oil content) against different sowing date and different S application levels

Sowing date	S application	Per cob yield (g)	Cob length (cm)	Seed number per cob	Thousand kernel weight (g)	Protein content (%)	Starch content (%)	Ash content (%)	Oil content (%)
Early	Control	261.00	20.13	736.33	354.03	7.13	71.61	1.36	3.33
	S1	266.33	20.33	732.67	350.00	8.11	72.30	1.39	3.64
	S2	320.00	23.07	792.33	375.33	7.70	73.15	1.29	3.48
	Average	282.44	21.18	753.78	359.79	7.65	72.35	1.35	3.49
Late	Control	157.69	18.73	694.00	310.40	7.90	72.75	1.29	3.36
	S1	214.45	19.65	603.00	329.75	7.94	74.56	1.30	3.54
	S2	243.33	20.57	687.07	355.50	7.98	73.44	1.21	3.45
	Average	205.16	19.65	661.36	331.88	7.94	73.58	1.27	3.45
	Control (Average)	209.34	19.43	715.17	332.22	7.52	72.18	1.33	3.35
	S1 (Average)	240.39	19.99	667.83	339.88	8.03	73.43	1.34	3.59
	S2 (Average)	281.67	21.82	739.70	365.42	7.84	73.29	1.25	3.47
LSD	Sowing date (SD)	*26.06	*0.67	*	*11.22	*	*0.87	*0.03	ns
	S application (SA)	*31.91	*0.82	*	*13.74	*	*1.06	*0.04	*0.17
	SA*SD	ns	ns	*45.16	ns	*0.36	ns	ns	ns

Table 4. Change of mineral content of corn seed against different sowing date and different S application levels

Sowing date	S application	P	K	Ca	Mg	Fe	Zn	Cu	Mn
		(%)				(ppm)			
Early	Control	0.20	0.27	0.67	0.08	274.00	42.00	10.00	46.00
	S1	0.17	0.25	0.61	0.09	305.00	37.00	17.00	24.00
	S2	0.20	0.27	0.55	0.11	604.00	30.00	14.00	37.00
	Average	0.19	0.26	0.61	0.09	395.00	36.00	14.00	36.00
Late	Control	0.22	0.27	0.92	0.08	255.00	34.00	13.00	30.00
	S1	0.18	0.27	0.24	0.09	277.00	24.00	17.00	29.00
	S2	0.21	0.29	0.22	0.11	548.00	20.00	15.00	44.00
	Average	0.21	0.28	0.46	0.09	360.00	26.00	15.00	34.00
	Control (Average)	0.21	0.27	0.80	0.08	265.00	38.00	11.00	38.00
	S1 (Average)	0.18	0.26	0.42	0.09	291.00	30.00	17.00	27.00
	S2 (Average)	0.21	0.28	0.38	0.11	576.00	25.00	15.00	40.00
LSD	Sowing date (SD)	ns	ns	**	ns	ns	*8.00	ns	ns
	S application (SA)	*0.02	ns	**	ns	**112.00	ns	ns	*
	SA*SD	ns	ns	**0.11	ns	ns	ns	ns	*12.00

Conclusions

The Aegean region of Turkey, there may be sometimes extreme and irregular rainfall days at the April and May months, in which maize seed is generally sowing period. Therefore, sometimes sowing date of maize may be delayed very late for first crop production in this area. Thus, maize plant emergency date, which is grown at last May, has small root system and low yield at the end of growing period because of having very quick root elongation (shallow). Seedling period (last May – early June) is usually very hot day and sometimes hot night temperature. Moreover some abiotic stress factors such as hot weather, insects and weedsmay beexposed to during seedling period. Thus some year maize yield isdecreasedin this region. These results show that decisions regarding need for fertilizer S should be based on potential for improved maize yield in this region. There appears to be no benefit for using fertilizer S to improve seed and yield quality.In this experiment, the findings suggested that the decrease of grain yield of maize plant with delaying sowing date may be overcome by yield increased with S application.

References

Abdallah M., Dubousset L., Meuriot F., Etienne P., Avice J.C., Ourry A., 2010. Effect of mineral sulphur availability on nitrogen and sulphur uptake and remobilization during the vegetative growth of *Brassica napus* L. J. Expt. Bot. 61(10): 2335-2346.

Abu EG, Ahmed Y., Abdalla Abdelsamad A., 2007. Effect ofdomestic processing methods on chemical composition,in vitro digestibility of protein and starch and functionalproperties of Bambara groundnut (Voandzeia subterra- nea). Seed Res J Agric Biol Sci 3, 1, 24–34.

Açıkgöz, N., Aktaş, M.E., Mokhaddam, A.F., Özcan, K., 1994. TARİST an Agrostatistical Packageprogramme for Personel Computer. E.Ü.Z.F. Tarla Bitkileri Kongresi, 1994. İzmir. Turkey.

Brunold, C., 1990. Reduction of sulphate to sulphide. Sulphur Nutrition and Sulphur Assimilation in Higher Plants, SPB Academic Publishing, The Hauge. pp. 13-31.

Canavar, Ö.,Kaynak, M.A., 2008. Effect of Different Planting Dates on Yield and Yield Components of Peanut (Arachis hypogaea L.). Turk J Agric For. 32: 521-528.

Cirilo, A.G., Andrade, F.H., 1994. Sowing Date and Maize Productivity: I. Crop Growth and Dry Matter Partitioning. Crop Sci. 34:1039-1043.

Cloninger, F. D., Horrocks, R.D., Zuber, M.S., 1975. Effects of Harvest Date, Plant Density, and Hybrid on Corn Grain Quality. Agron. J. 67: 693-695.

Daigger, L.A., Fox, R.H., 1971. Nitrogen and Sulfur nutrition of sweet corn in relation to fertilization and water composition. Agron. J. 3:729-730.

Dobermann, A., Arkebauer, T., Cassman, K., Drijber, R., Lindquist, J., Specht, J., Walters, D., Yang, H., Miller, D., Binder, D., Teichmeier, G., Ferguson, R., Wortmann, C., 2003. 2003 Annual Report to the Fluid Fertilizer Foundation on grant "Yield potential and optimal soil productivity in irrigated corn systems of the north-central USA".

Gibon Y., Pyl E.T., Sulpice R., Lunn J.E., Höhne M., Günther M., Stitt M., 2009. Adjustment of growth, starch turnover, protein content and central metabolism to a decrease of the carbon supplywhen Arabidopsis is grown in very short photoperiods. Plant, Cell and Environment 32, 859–874.

Jackson, M.L., 1958. Soil Chemical Analysis, Prentice-Hall, Inc. Englewood Cliffs, N.J. Newyork.

Jamal A,. Moon Y.S., Abdin M.Z., 2010. Enzyme activity assessment of peanut (Arachis hypogea) under slow-release sulphur fertilization. Aust J Crop Sci 4(3):169-174.

Kacar, B., İnal, A., 2008. Plant analysis. Nobel Press. No=1241(63). ISBN 978-605-395-036-3.

Rabuffetti, A., Kamprath, E.J., 1977. Yield, N and S content as affected by N and S fertilization on coastal plain soils. Agron. J. 69:785-788.

Rotte C, Leustek T., 2000. Differential subcellular localization and expression of ATP sulfurylase and APS reductase during ontogenesis ofArabidopsis thaliana leaves indicates that cytosolic and plastid forms ofATP sulfurylase may have specialized functions. Plant Physiol 124: 715–724.

Scherer H.W., Pacyna S., Spoth K., Schulz M., 2008. Low levels of ferredoxin, ATP and leghemoglobin contribute to limited N2 fixation of peas (Pisum sativum L.) and alfalfa (Medicago sativa L.) under S deficiency conditions. Biol Fert Soil 44:909–916.

Tirasoglu, E., Cevik, U., Ertugral, B., Apaydin, G., Baltas, H., Ertugrul, M., 2005. Determination of trace elements in cole (Brassica oleraceae var. acephale) at Trabzon region in Turkey Journal of Quantitative Spectroscopy & Radiative Transfer. 94: 181–187.

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Influence of pyrolysis temperature on chemical and physical properties of sewage sludge biochar

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Abstract

Pyrolysis of sewage sludge to biochar is an effective way to sludge management, besides mitigation of CO_2 input to atmosphere and positive effects on soil properties. The aim of this study was to evaluate the effects of pyrolysis temperatures from 300 to 700 °C, on physical and chemical properties of a secondary anaerobically-digested urban sewage sludge biochar. Biochar yield significantly decreased with increasing pyrolysis temperature, whereas gas yield increased with rising temperature. Biochar pH and EC had a rising trend with increasing temperature. Biochar produced at low temperature had higher concentration of total nitrogen and total organic carbon (TOC) but lower C/N, P, K and Na content. Iron, Zn, Cu, Mn, Ni, Cr and Pb concentrations increased with temperature. Lower DTPA extractable concentration of Fe, Zn, Cu, Mn, Ni, and Pb was found in biochars compared to the sewage sludge. Particle density was greater in biochars produced at high temperatures. Biochar production decreased bulk density, although it had no significant difference between temperatures. Pyrolysis decreased sewage sludge water repellency and the lowest water repellency rating was found for the biochar produced at 700 °C.

Keywords: Pyrolysis, Sewage sludge biochar, Nutrients, Bulk density, Water repellency

Introduction

Over the last few decades, population growth and economical development has resulted in increasing sewage sludge production. Application of sewage sludge to agricultural lands as a fertilizer enables the recycling of valuable components such as organic matter and many plant nutrients including N, P, K and micronutrients [25]. However sewage sludge is characterized by high concentration of heavy metals such as Zn, Cu, Cr, Ni, Cd and appreciable amounts of pathogens which have raised some concerns regarding the soils and groundwater pollution [7, 31]. In addition high concentration of nitrogen and phosphorous in sewage sludge could have adverse environmental effects [27]. Therefore safe and beneficial use of sewage sludge is a subject of considerable interest for the society.

Pyrolysis of waste biomass such as sewage sludge, crop residues or wood involves the thermal transformation of biomass with little or no oxygen to solid (charcoal, or biochar), liquid (bio-oil) and gas phases [17]. Biochar is a carbon rich matter that is more resistant to microbial decomposition than the original organic materials used to its product [18]. Polycyclic aromatic structure of biochar is the reason of its stability and carbon sequestration in the soil [30]. Biochar application to soil may provide benefits for the physical, chemical and biological properties of the soil and sustainable agriculture [19]. Biochar applications to soil increase soil

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aeration [17], soil porosity and specific area [16], water holding capacity and drainage [13], soil fertility and following plant yield responses [21].
Pyrolysis conditions and feedstock characteristics largely affect the physical and chemical properties (e.g. particle and pore size distribution) of the produced biochar, which, determine the suitability for a given application [4]. It is reported that increasing pyrolysis temperature, decreases biochar and liquid yield but raises gas yield.

Therefore pyrolysis of sewage sludge can potentially be a method of choice for its management, particularly compared to the current methods of landfilling and direct agricultural utilization [12]. Pyrolysis eliminates pathogens and organic compounds of concern, that present in the sewage sludge, reduces the volume of the solid residue and transport costs [3] and has positive effects on soil properties and agricultural outputs. Different studies have been conducted on pyrolysis of biomass as a potential carbon sequestrater [17, 30]. Less attention has been given to the effect of pyrolysis on sewage sludge biochar properties especially physical characteristics such as bulk density, water repellency.

The objective of this study was to investigate the effects of pyrolysis temperature on chemical and physical properties of sewage sludge biochar.

Material and Methods

Pyrolysis Experimental Setup and Procedure

Secondary anaerobically-digested sewage sludge sample was collected from an urban waste water treatment plant (32° 48' 21" N 51° 35' 21" E). The sewage sludge was air dried then put in oven at 40 °C for 24 hours to reduce water content. The sewage sludge was then grind, sieved to obtain particle sizes equal 2 mm and stored in air tied plastic bags until pyrolyzed. The sample was pyrolyzed under limiting oxygen condition using a modified electrical furnace. Pyrolysis process was done by increasing the temperature to 300, 400, 500, 600 and 700 °C at a rate of 3°C min^{-1} and using an argon flow. Produced liquid phase (effluent) was collected. The percentage of biochar yield at various temperatures was calculated using bellow relation:

$$\text{Biochar yield} = (\text{mass of produced biochar/ mass of original sludge}) \times 100 \qquad (1)$$

Liquid phase yield was calculated similar to biochar yield. The gas yield percentage was obtained with subtraction of biochar and liquid yield from 100.

Chemical Analysis

The pH and Electrical conductivity (EC) of sewage sludge and biochars were measured in 0.01 M $CaCl_2$ (1:10 ratio) and 1:10 biochar:deionized water ratio, respectively, using the method of of Blakemore et al. (1987) [2]. Total organic carbon and total nitrogen were determined with TOC analyser (CS22 SKALAR) and Kjeldahl method respectively. To determine total phosphorous, total potassium and sodium, sewage sludge and biochar were first incinerated at 550 °C. Extraction was done with 2 M HCl. Then the total P in the solution was determined using ascorbic acid–NH_4–molybdate blue colorimetry at 880 nm. Total potassium and sodium were measured by flame photometry. Total concentration of Fe, Zn, Cu, Mn, Ni, Cr, Pb, Co, and Cd was measured according to USEPA 3050B [29]. In order to determine the available form of trace elements, extraction was done with 0.005 M DTPA (diethylene triamine pentaacetic acid). Trace elements concentrations in extracts were measured using atomic absorption (AA, model Perkin Elmer A200).

Physical Analysis

Particle density of sewage sludge and biochar was defined using the method of Gupta et al., (2002) [10]. In this method the volume of oven–dried biochar was determined using a conventional pycnometer (density bottle) by volume displacement with kerosene. Bulk density of sewage sludge and biochars was determined using core method [8]. The samples were poured in the stainless cylinder with diameter of 5 cm and height of 7.8 cm, and then the bulk density of sewage sludge and biochars was calculated. Water Repellency of sewage sludge and biochars was determined according to the molarity of etanol droplet (MED) test [15]. The MED test determines the etanol concentration at which a droplet will infiltrate the surface of the sample within 10 seconds, which provides an index of water repellence for sample. A series of ethanol concentration with 0.2 M increment was prepared from a 96% ethanol stock solution. Since water repellency depends on the media wetness, temperature and surface roughness, all the water repellency tests were done on oven-dry samples with flat surface at 25 °C [22].

Statistical analysis

All the measurements were set up in a randomized design (organic material type or pyrolysis temperature) with three replicates. Results were analyzed using ANOVA procedures and means were separated using protected LSD at the 0.05 probability level [23].

Results and Discussion

Products Yield

Biochar yield significantly decreased with increasing pyrolysis temperature from 72.5% at 300 °C to 52.9% at 700 °C (Fig.1). The decrease in the biochar yield could be due to greater decomposition of row materials at higher temperatures [6]. The gas yield significantly increased from 9.7% at 300 °C to 27.5% at 700 °C (Fig. 1). Liquid yield increased with increasing pyrolysis temperature, but its change was less than those for solid and gas phases. The minimum of liquid yield was determined at at 300 °C and there was no significant change between 500 and 600°C.

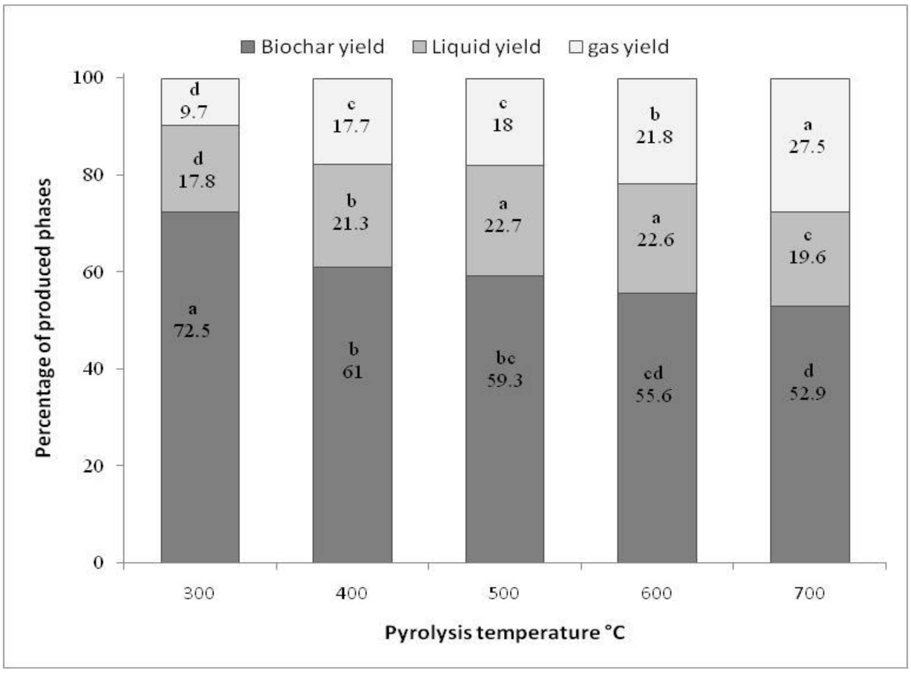

Fig 1. Yield of produced phases at different pyrolysis temperature.

Table 1. pH and electrical conductivity (EC) in sewage sludge, biochar and liquid phase at different temperatures.

Phase	Property	Sewage sludge	Pyrolysis temperature (°C)				
			300	400	500	600	700
biochar	pH	6.8[††]	8.2[e]	9.2[d]	9.7[c]	11.0[b]	12.0[a]
	EC (dS m^{-1})	2.2[a]	0.5[e]	0.8[c]	0.7[d]	0.6[d]	1.9[b]
Liquid phase	pH	–	7.8[e]	8.5[c]	9.0[a]	8.7[b]	8.3[d]
	EC (dS m^{-1})	–	43.2[e]	48.0[d]	50.5[c]	55.5[b]	63.6[a]

† In each row, figures with different letters are significantly different ($LSD_{0.05}$).

Decomposition of char at higher temperatures may produce non-condensable gaseous products, which would also contribute to the increase in the gas yield with elevating temperature [6].

Table 2. Chemical properties of sewage sludge and its biochars produced at different pyrolysis temperatures.*

	Unit	Sewage sludge	Biochar produced at temperature (°C)				
			300	400	500	600	700
TN	g 100g^{-1}	3.3^{a†}	2.7^{b}	2.1^{c}	2.0^{d}	1.7^{e}	1.1^{f}
TOC	g 100g^{-1}	40.8^{a}	34.0^{b}	33.0^{c}	32.7^{c}	26.9^{d}	25.1^{e}
C/N	–	12.4^{c}	12. 8^{c}	15.4^{b}	16.0^{b}	15.6^{b}	23.2^{a}
P	g 100g^{-1}	1.1^{c}	1.7^{b}	1.8^{b}	2.2^{a}	2.1^{a}	2.3^{a}
K	g 100g^{-1}	0.20^{d}	0.26^{c}	0.29^{c}	0.36^{b}	0.41^{b}	0.47^{a}
Na	g 100g^{-1}	0.20^{e}	0.24^{d}	0.27^{c}	0.30^{b}	0.32^{b}	0.35^{a}

* TN: Total nitrogen content. TOC: Total organic carbon content. C/N: carbon/ nitrogen ratio. P: Total phosphorous content. K: Total potassium content. Na: Total sodium content.
† In each row, figures with different letters are significantly different ($LSD_{0.05}$).

pH and EC

The sewage sludge pH was 6.8 and increased with biochar production (Table 1). The biochar pH significantly increased with increasing pyrolysis temperature, suggesting that higher pyrolysis temperature led to the higher pH of the biochars. The liquid phase pH was increased from 7.8 at 300 °C to 9 at 500 °C, and then decreased to 8.3 at 700 °C. The sewage sludge Electrical Conductivity (EC) was 2.2 (dS m^{-1}) and significantly decreased with biochar production (Table 1). The EC increased with increasing temperature and biochar produced at 300 °C had the lowest EC among pyrolysis temperatures. The liquid phase EC increased with increasing pyrolysis temperature (Table 1).

Chemical Analysis

The amount of total N was 3.29% in sewage sludge and significantly decreased with biochar production and increasing pyrolysis temperature (Table 2).The total N content of sewage sludge biochar decreased by 59.7% with increasing temperature from 300 to 700 °C. This reduction may be due to the volatilization of different nitrogen groups such as NH_4–N and NO_3–N or volatile matter containing N at low temperatures or pyridine like structures at high temperatures (>600°C) [[1]].

Pyrolysis process decreased the total organic carbon content (TOC) of sewage sludge (Table 2). TOC of biochars decreased with increasing pyrolysis temperature, however there wasn't significant difference between TOC content of biochar produced at 400 and 500 °C. There was no significant difference in C/N ratio of sewage sludge and biochar produced at 300 °C. As the pyrolysis temperature rose, C/N ratio increased and the maximum of C/N ratio was found at 700 °C. Although there wasn't significant difference in C/N ratio of produced biochars at 400 °C, 500 °C and 600 °C. Pyrolysis increased the amount of total P in the produced biochars compared to the sewage sludge (Table 2), but there were not significant differences between 500, 600 and 700 °C Greater content of total P in high temperatures produced biochars indicated phosphorous is associated with the inorganic fraction of sewage sludge. The concentration of total K and total Na increased with increasing temperature indicating inorganic association of K and Na with the sewage sludge [[11]].

Table 3 shows the total and DTPA extractable concentration of heavy metals (HMs) in sewage sludge and biochars. The HMs concentration in the sewage sludge was below the upper critical limits suggested by the USEPA [[28]]. Total concentration of Fe, Zn, Cu, Mn, Ni, Cr and Pb increased with biochar production (Table 3). Probably dissociation of organic compounds and some minerals like carbonates with pyrolysis temperature participated in the increased HMs concentrations. The greatest concentration of Mn and Cr in biochar was found at 500 °C. Concentration of Cr was significantly decreased with increasing temperature above 500 °C. In the case of Ni and Pb the highest concentration obtained at 700 °C. The concentration of Co and Cd in the sewage sludge and all biochars was below the detection limit of atomic absorption. The DTPA extractable concentration of heavy metals was regarded as the available form of them for plant uptake. The DTPA extractable concentration of Fe, Zn, Cu, Mn, Ni, and Pb decreased with biochar production (Table 3).

However, rising pyrolysis temperature increased the DTPA-extractable concentrations of Fe, Zn, Cu, Mn, Ni, and Pb. The highest availability of Pb in biochars was found at 600 °C. The DTPA extractable concentration of Cr increased with biochar production and increasing pyrolysis temperature, but the increase was only significant at 700 °C (Table 3). There was no significant difference in available concentration of Fe, Zn, Mn, and Ni between 400, 500 and 600 °C. DTPA extractable concentration of Cu didn't differ significantly between 300, 400 and 500 °C.

Table 3. Total and DTPA-extractable concentrations of heavy metals in sewage sludge and its biochars produced at different temperatures.

Heavy metal	Sewage sludge	Biochars produced at temperature (°C)				
		300	400	500	600	700
	Total concentration (mg kg–¹)					
Fe	12210^{f†}	16330^{e}	17730^{d}	18890^{c}	19490^{b}	20930^{a}
Zn	910^{d}	1150^{c}	1350^{ab}	1430^{a}	1470^{a}	1470^{a}
Cu	256^{c}	352^{b}	362^{ab}	396^{a}	386^{a}	414^{a}
Mn	298^{c}	386^{a}	380^{ab}	400^{a}	364^{b}	392^{a}
Ni	60^{b}	72^{a}	62^{b}	68^{ab}	70^{a}	76^{a}
Cr	92^{b}	88^{b}	100^{b}	178^{a}	96^{b}	104^{b}
Pb	107^{c}	107^{c}	116^{bc}	142^{ab}	132^{b}	152^{a}
Co	ND *	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND
	DTPA-extractable concentration (mg kg–¹)					
Fe	288.0^{a}	27.6^{d}	54.6^{c}	53.2^{c}	68.0^{c}	248.0^{b}
Zn	130.0^{a}	2.5^{d}	7.0^{c}	6.7^{c}	8.0^{c}	13.3^{b}
Cu	20.5^{a}	0.5^{d}	0.8^{d}	1.6^{d}	6.2^{c}	15.3^{b}
Mn	23.3^{a}	2.0^{d}	6.7^{c}	5.5^{c}	5.7^{c}	11.5^{b}
Ni	3.6^{a}	ND	0.3^{c}	0.3^{c}	0.3^{c}	1.2^{b}
Cr	1.2^{b}	1. 3^{b}	1.3^{b}	1.3^{b}	1.5^{ab}	1.8^{a}
Pb	13.2^{a}	1.4^{e}	6.2^{d}	6.2^{d}	10.9^{b}	8.6^{c}
Co	ND	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND

† In each row, figures with different letters are significantly different ($LSD_{0.05}$).
* ND: Non-detectable by atomic absorption spectrophotometer.

Table 4. Particle density, bulk density and water repellency of sewage sludge and its biochars at different pyrolysis temperatures.

Property	Unit	Sewage sludge	Biochars produced at temperature (°C)				
			300	400	500	600	700
PD	Mg m^{-3}	1.53^{e†}	1.81^{d}	1.96^{c}	1.99^{bc}	2.07^{ab}	2.16^{a}
BD	Mg m^{-3}	0.62^{a}	0.56^{ab}	0.58^{ab}	0.56^{ab}	0.53^{b}	0.52^{b}
MED	M	5.4	5.2	2.2	0.5	0.5	0.2
WRR	–	12	12	8	4	4	2
WRS	–	Very sever	Very sever	medium	low	low	low

PD: Particle density, BD: Bulk density, MED: Molarity of ethanol droplet, WRR: Water repellency rating, WRS: Water repellency severity.
† In each row, figures with different letters are significantly different ($LSD_{0.05}$).

Physical Analysis

Particle density (PD) of biochars was significantly higher than sewage sludge (Table 4). The PD of biochar increased significantly with increasing temperature. Kercher and Nagle (2002) found that biochar PD increases with increasing pyrolysis temperature because low-density disordered C convert to high-density turbostratic C [14].

Bulk density (BD) of sewage sludge decreased with biochar production, but biochar BD values at 600 and 700 °C were significantly lower than that of original sewage sludge (Table 4). Since plenty of pores were formed during the pyrolysis process particularly at high temperatures, bulk density was decreased within biochar production [5]. Depending on the original matter of biochar and production condition, biochar bulk density ranges from 0.08 [9] to 1.7 g cm^{-3} [20]. Scheffer and Schachtschabe, (2002) reported that common BD values of mineral soils range from 1.16 to 2.00 g cm^{-3}, therefore biochar addition to soil has a positive effect on bulk density decline and porosity increase [24].

As shown in table 4 the water repellency (WRS) of sewage sludge and biochar produced at 300 °C was very sever with water repellency rating (WRR) equal 12. Increasing pyrolysis temperature decreased water repellency of biochars, as water repellency rating (WRR) equal 2 was found for biochar produced at 700 °C. Water repellency severity (WRS) didn't differ between biochar produced at 500 and 600 °C.

Probably high water repellency of sewage sludge can be due to presence of hydrophobic organic materials/groups such as lipids and detergents.Biochars formed at lower temperatures (i.e. 300°C to 400°C) still contain the characteristics of the original feedstock. It seems that conversion of aliphatic C to aromatic C and decomposition of hydrophobic groups at high temperatures would decrease the water repellency [26].

Conclusion

1) Biochar yield significantly decreased with increasing pyrolysis temperature, whereas gas yield increased with elevating temperature. Pyrolysis increased pH of sewage sludge but decreased its EC. Biochar pH and EC increased with temperature. The EC of biochar's liquid phase was higher than the EC of biochar's solid suspension and increased significantly with rising the temperature.

2) The biochars had higher concentration of P, K and Na compared to sewage sludge but possess lower TN content. Therefore N fertilizers may be required when sewage sludge biochar is applied to agricultural soils. Pyrolysis of sewage sludge lowered the biochar TOC content. The C/N ratio significantly rose in biochars with increasing temperature.

3) Total concentration of Fe, Zn, Cu, Mn, Ni, Cr and Pb increased with biochar production and rising pyrolysis temperature. Biochars had lower DTPA extractable concentration of Fe, Zn, Cu, Mn, Ni, and Pb compared to sewage sludge.

4) Particle density was found to be higher in biochars produced at high temperatures. Pyrolysis process decreased bulk density, but it did not differ significantly between temperatures. Water repellency rating of sewage sludge was 12 which declined to 2 for produced biochar at 700 °C. This reduction indicates decomposition of hydrophobic groups at high temperatures.

5) Based on the overall assessment of chemical and physical properties and energy consumption, pyrolysis temperature in the range of 300–400 °C is suggested for biochar production from urban sewage sludge.

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References

[1] Bagreev, A., Bandosz, T.J., & Locke, D.C., 2001. Pore structure and surface chemistry of adsorbents obtained by pyrolysis of sewage derived fertilizer. Carbon, 39, 1971–1979.

[2] Blakemore, L.C., Searle, P.L., & Daly, B.K., 1987. Methods for Chemical Analysis for Soils: NZ Soil Bureau Scientific Report 80, pp. 78–79.

[3] Caballero, J.A., Front, R., Marcilla, A., & Conesa, J.A., 1997. Characterization of sewage sludges by primary and secondary pyrolysis. J. Analyt. Appl. Pyrolysis. 40–41, 433–450.

[4] Chan, K.Y., & Xu, Z., 2009. Biochar: nutrient properties and their enhancement. In: Lehmann J, & Joseph S (Eds) Biochar for Environmental Management: Science and Technology, pp. 67–84. Earthscan, London.

[5] Ding, Y., Liu, Y.X., Wu, W.X., Shi, D.Z., Yang, M., & Zhong, Z.K., 2010. Evaluation of biochar effects on nitrogen retention and leaching in multi-layered soil columns. Water Air Soil Pollut. 213, 47–55.

[6] Fu, P., Yi. W., Xueyuan. B., Li. Z., Hu. S., & Xiang. J., 2011. Effect of temperature on gas composition and char structural features of pyrolized agricultural residues. Bioresour. Technol. 102, 8211–8219.

[7] Gascó, G., Lobo, M.C., Guerrero, F., 2005. Land application of sewage sludge: a soil columns study. Water SA. 31 (3), 309–318.

[8] Grossman, R.B., & Reinsch, T.G., 2002. Bulk density and linear extensibility. In: J.H. Dane and G.C. Topp (Eds.) Methods of Soil Analysis, Part 4. Physical Methods. Soil Sci. Am. Book Series No. 5. pp. 202–228. ASA and SSSA, Madison, WI.

[9] Gundale, M., & DeLuca, T., 2006. Temperature and source material influence ecological attributes of ponderosa pine and Douglas-fir charcoal. For. Ecol. Manage. 231(1–3), 86–93.

[10] Gupta, M., Yang, J., & Roy, C., 2002. Density of softwood bark and softwood char: procedural calibration and measurement by water soaking and kerosene immersion method. Fuel. 81, 1379–1384.

[11] Hossain, M.K., Strezov, V., Yin Chan, K., Ziolkowski, A., & Nelson, P.F., 2011. Influence of pyrolysis temperature on production and nutrient properties of wastewater sludge biochar. J. Environ. Manage. 92, 223–228.

[12] Hwang, I.H., Ouchi, Y., & Matsuto, T., 2007. Characteristics of leachate from pyrolysis residue of sewage sludge. Chemosph. 68, 1913–1919.

[13] Ibrahim, H.M., Al-Wabel, M.I., Usman, A.R.A., & Al-Omran, A., 2013. Effect of Conocarpus biochar application on the hydraulic properties of a sandy loam soil. Soil Sci. 178, 165–173.

[14] Kercher, A.K., & Nagle, D.C., 2002. Evaluation of carbonized medium-density fiberboard for electrical applications. Carbon, 40, 1321–1330.

[15] King, P.M., 1981. Comparison of methods for measuring severity of water repellence of sandy soils and assessment of some factors that affect its measurement. Aust. J. Soil Res. 19, 275–286.

[16] Laird, D.A., Fleming, P., Davis, D.D., Horton, R., Wang, B.Q., & Karlen, D.L., 2010. Impact of biochar amendments on the quality of a typical Midwestern agricultural soil. Geoderma, 158, 443–449.

[17] Laird, D.A. (2008) The charcoal vision: A win-win-win scenario for simultaneously producing bioenergy, permanently sequestering carbon, while improving soil and water quality. Agron. J. 100(1), 178–181.

[18] Lehmann, J., Gaunt, J., & Rondon, M., 2006. Biochar sequestration in terrestrial ecosystems – a review, Mitigation and Adaptation Strategies for Global Change, 11, 403–427.

[19] Lehmann, J., & Joseph, S., (Eds.). (2009) Biochar for environmental management: Science and Technology. London, Sterling, VA: Earthscan.

[20] Oberlin, A., 2002. Pyrocarbons. Carbon, 40(1), 7–24.

[21] Park, J.H., Choppala, G.K., Bolan, N.S., Chung, J.W., & Chuasavathi, T., 2011. Biochar reduces the bioavailability and phytotoxicity of heavy metals. Plant Soil. 348, 439–451.

[22] Roy, J.L., & McGill W.B., 2002. Assessing soil water repellency using the molarity of ethanol droplet (MED) test. Soil Sci. 167, 83–97.

[23] SAS Institute., 2000. SAS/STAT User's Guide, Release 8. Cary, NC: SAS Institute.

[24] Scheffer, F., & Schachtschabel, P., 2002. Lehrbuch der Bodenkunde, (ed. 15). Ferdinand Enke, Stuttgart.

[25] Singh, R.P., & Agrawal, M., 2007. Effects of sewage sludge amendment on heavy metal accumulation and consequent responses of *Beta vulgaris* plants. Chemosph. 67, 2229–2240.

[26] Spokas, K. A., 2010. Review of the stability of biochar in soils: predictability of O:C molar ratios. Carbon Manage. 1, 289–303.

[27] Sumner, M.E., 2000. Beneficial use of effluents, wastes and biosolids. Commun. Soil Sci. Plant Analy. 31, 1701–1715.

[28] U. S. Environmental Protection Agency ., 1993. Clean water act. Section 503. Vol 58, No. 32. USEPA, Washington, DC.

[29] USEPA, Method 3050B., 1996. Acid Digestion of Sediments, Sludges, and Soils. U.S. Govt. Printing Office. Washington, DC.

[30] Verheijen, F., Jeffery, S., Bastos, A., C. van der Velde, M &. Diafas, I., 2010. Biochar Application to Soils. JRC Scientific and Technical Reports.

[31] Wang, X., Chen, T., Ge, Y., & Jia, Y., 2008. Studies on land application of sewage sludge and its limiting factors. J. Hazard. Mater. 160, 554–558.

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Agricultural grouping of soils
(On the area of north-east slope of small caucasus in Azerbaijan)

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Abstract
We grouping agricultural soils, so any plant or plant group that is not take into account, only on the basis of genetic-productivity properties and fertility of the land. Our republic`s soils are divided into 5 agricultural groups which depending on their features of natural fertility, the level of contemporaneity, their agromeliorative and meliorative measures. According to our research average bonitet of examined area equal to 41. We have calculated comparative the quality of being valuable ratios of soils by adopting the numbers which we got equal to one. Comparing the numbers which we got of soil`s comparative valuation ratios (CVRS >1), we saw that there is no need to additional measures for increasing the fertility of I, II, III group of soils, but there is a need to necessary complex improving (agromeliorative, fitomeliorative so the measures against the erosion and improving) measures and additional charge for arriving the fertility of IV and V group to average level on this area. Development of agriculture and from the point of view productivity of the land carrying out of the registering measures is one of the necessary measures of the day.
Keywords: Agricultural grouping of soil, bonitirovka, erosion, soil fertility, mountainous terrain.

Introduction

In recent years agricultural grouping of soils are preferred much more on the basis of the bonitet scores in our republic. So that, in the area of soil`s bonitirovka, while scientific research works are developing the soils which scores are alike were included, taking into account soil`s fertility characteristics and agro technical measures and then this grouping concret charactered much more. From this point, on the area of soil`s valuation training the soil which bonitet scores are alike to agricultural grouping, their taxonomic units were considered such as grouping with in groups. Some investigators said such idea that, the agricultural grouping on the basis of soil`s bonitet scores have an advantage much more, in comparision the grouping on the basis their genetic – productivity properties.
The agricultural grouping of soils is one of the important mean for the solution of different problems which is related to using soil effectively and improving their fertility. The agricultural grouping of soils is the combination of classification of alike soils group according to some agricultural plants which having certain property, plants group or agronomic property at attitude to general planting quality. Such grouping must be group taking account of soils genetic-productivity character and bonitet score at agricultural productivity. The agricultural grouping of soils is devided two half type: complex and specialized.

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Material and Methods

According to agricultural grouping of soils works analysis which took place in the country show that it was mainly taken into account the relation natural condition and soils genetic properties which influence soils fertility during their windings up. In our republic the grouping of soils are grouped three types.

a. According to separate requirements of agricultural plants.
b. According to certain ecological`s groups of agricultural plants or requirements of using soils types.
c. For being considered for any particular plants, general grouping based on soils fertility which defined as on environmental for cultural plants.

According to Q.S.Mammadov, the agricultural grouping of soil, the soil which provide agrosenoz, fodder and bioproductivity of forest areas is the combination of taxonomic units according to similar score [1,3]. Unlike the previous works which carried out in this plan, these groupings mainly don’t get away from genetic-productivity base. Whereas, at the time of previous grouping, homogeneity’s level of groups which allows to identity them, their concrete quantity’s indicators don’t shown. Such approach don’t reflect real situation, because at this time there is no exact criterion during the combination of soil’s types. While agricultural grouping of soils, bonitet scores which was created according to indicators of soils fertility act from the genetic similarity of soils type as the most important values indicators agriculture [1,2,3]. At the time of bonitet score’s detection, the granulometric content which defermine the soil’s contemporaneity, fysical and water –to-air features of soil and the erosion taken into account as an potential and effective indicators of fertility.

Results and Discussion

We grouped the north-east slope of Small Caucasus soil’s agricultural grouping base to there types, so taking into consideration any plant or plant groups, only on the basis of genetic productivity properties and the level of fertility of the land. Our republic’s soils are devided into five agricultural grouping which depending on their features of natural fertility, the level of contemporaneity, their agromeliorative and meliorative measures which is in accordance.

For this reason, correction coeffients in the previous section, taking into account the relevant principles were arawn up on the basis of land typevariety`s open bonitet scale of the north-east slope of the Small Caucasus’s soils which we merged them in five groups. As a continuation of the work which carried out, the agricultural grouping’s map (1:10000 scale) of the area has been developed. It is reflected on the pelvic of the cartogram the followings: the number of soils type variety, the name of soils which included to every group, bonitet scale, area, the areas of agro group, the average score for the group, and estimated area’s total average score. Agricultural grouping of soil’s appraisal is as well as continuation of very important group of sail, using soil and improve efficiency, increase productivity of plants in terms of scientific principles is considered to be a significant event. Let’s have a look at the analysis of the above pelvic. I group- high quality soils. It is included to this group high quality soils which growing of agricultural crosps with favorable natural properties and regimes. High quality soils usually don’t require large financial resources and major meliorative measures. They are differ with thick layer of humus, suitable granulometric composition, structure, and water-to-air modes. When we used correctly from agrotechnic, these soils which are from agricultural grouping have high productivity capable. It is included to this group according to north-east slope of Small Caucasus, average clayey, thick, carbonate, black rock: average clayey, thick, fatty mountin meadow, middle clayey, thick, scoured mountin black: heavy clayey, thick, carbonate mountin – black: heavy clayey, thick, fatty mountin-meadow: light clayey, thick, fatty mountin meadow, heavy clayey, thick, scoured mountin-black soils. The total area of this group is 13787,93 hectares or 3,45%. The average bonitet scale of high quality soils which included to first group was 86 scale.

II group – Good qualitative soils. The soils which included to this group are differ comparatively with their suitable structure, water-to-air regime and humus. In comparison with the first group’s soil’s their bonitet figures is low, because their indicators is relatively low (80-61). It is required to attend to the agro technical rules which increase the fertility and field safety while using them. It is possible to reduct the limiting factors of soil’s fertility of this group and put them to the first group by applying some agricultural rules. It is dominated mainly clayey granulometric composition. It is observed some slow erosion. The total area of group is 46797 hectars or 11,73% average bonitet scale is 68.

III group – average quality soils. These soils differ with it's disadvantage composition and properties in comparison with I and II group's soils. Also restrict to get high productivity without agro technical and meliorative measure's opportunity. The total area of group is 106806,98 hectars or 26,77%.

The average bonitet score of soils which included to third group is 50. it is dominated mainly light and heavy clayey granulmetric, and low, average erased and thin soils.

IV group – low quality soils. It is included to this group the soils which much more eroded. Despite the unfavorable composition and properties, it is possible to use a number of agricultural crops with complex and meliorative and agro technical measures which require more resources. So that, the soils which included to this group cover a large part of area. It is due to deterioration properties and modes as the result of the influence of anthropogenic factors and area's mountainous. It is dominated heavy and, light clayey granulometric soils in this group. Low and average erased soils dominate more. The thickness of soil's soft layer is average and thin. The area of group is very large, nearly it contains half of area. So that, total area is 203819,22 hectars or 51,08%. The average bonitet score of group valuated 31 points.

V group – it is consist of the soil which conventionally unfit to agricultural production. The soils which are not used in agriculture connected to this group according to the signs which lowering the fertility. It is included to this group too, surfaced rocks and bare rocks as a result of the strong influence of the erosion process, which is typical for the area. This is low quality land that their evaluation score was 0-20 points. A Great part of this soil may be used as the agricultural purposes at the future after long-term erosion protection, forest reclamation, taking of drying process. The total area of group 27821,47 hectars or 6,97%.

Conventionally unfit soil's average bonitet score is 17. it is dominate in this group sandy and clayey granulometric composition, average and much more strong erased soils and thin soils.

So that, it is possible to identify the average bonitet score of soils, calculating of comparative valuation ratios, the areas of quality groups according to soil's agricultural grouping of the north-east slope of the Small Caucasus.

Conclusion

According to our research average bonitet of examined area equal to 41. We have calculated comparative the quality of being valuable rations of soils by adopting the numbers which we got equal to one. Comparing the numbers which we got of soil's comparative valuation rations (CVRS>1), we saw that, there is no need to additional measures for increasing the fertility of I, II, III group of soils, but there is a need to necessary complex improving (agromeliorative, fitomeliorative, so the measures against the erosion and improving) measures and additional charge for arriving the fertility of IV and V group to average level on this area. Development of agriculture and from the point of view productivity of the land carrying out of the registering measures is one of the necessary measures of the day

References

G.Sh.Mammadov, M.Y.Khalilov, S.Z.Mammadova, Azerbaijan Republic "Ecological atlas" p.176,Baku Cartography Factory – 2010

Г.Ш.Мамедов, М.П.Бабаев, З.Р.Мовсумов , Ч.М.Джафарова, В.Г.Гасанов, «Поцвенный атлас» с.127 Баку – 2007

Бадалов Ш.А. Агроэкологическая характеристика и бонитировка виногродопригодных почв горной Ширвани с целью их рационального использование: Автореф. дис. .... канд. с.-х. наук. Баку, 1981, 22 с.

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Study of erosion mechanism meeting water of Pisha sandstone

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Abstract

The rock and soil erosion in Pisha sandstone area of Zhungeer Qi Inner Mongolia was very serious; the main reason is that once meeting water, the Pisha Sandstone as solid as rocks would turn into mud. In this paper, the intrinsic cause for the erosion of Pisha sandstone has been tentatively analyzed in the light of minerals, chemical compositions and grain size distribution.

Keywords: Pisha Sandstone; minerals; chemical composition; erosion

Introduction

Pisha Sandstone looks like a rock, but its structure is loose and breakable, so it is called the cancer of the earth. The erosion condition of Pisha Sandstone area is severe, and the Pisha Sandstone erosion is the main source of the Yellow Riversediment, which blocking the middle and lower reaches of the Yellow River and increasing its river bed[1,2]. The Pisha Sandstone area erosion would also cause the deterioration of the ecological environment, and make the vegetation coverage reduce seriously and desertification.

Sampling area condition

Fig. 1. Sampling sites and sample appearance of Pisha Sandstone in Zhungeer Qi

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According to the soil cover degree of Pisha Sandstone, the area can be divided into three types, namely bare Pisha rock area, soil covered area and sand covered area, the total area of 16700 km^2. Sampling location is in Zhungeer Qi area of Northern Loess Plateau Erdosplateau, at present, Inner Mongolia sandstone scenic area and science center has been built, mainly for scientific research, popularization of knowledge and tour[3]. Pisha Sandstone in Zhungeer Qi is mainly distributed in the western, the total area is 5915km^2, seriously exposed sandstone area is 915 km^2, and the potential sandstone area is more than 5000 km^2. Its average soil erosion modulus is up to 30000 tons/km^2, the average annual sediment transport to the Yellow River amounted to 100 million tons. Severe soil and water loss in Pisha Sandstone areas seriously deteriorate Zhungeer Qi's ecological, agricultural and animal husbandry production environment. Fig. 1 is the sampling sites and sample appearance, and our samples conclude grey, white and red.

Pisha Sandstone characteristics and its erosion mechanism meeting water

The chemical composition

Table 1 Chemical compositions of Pisha Sandstone /wt. %

Compositions	SiO_2	Al_2O_3	CO_2	CaO	Fe_2O_3	MgO	K_2O	Na_2O	IL
Gray sample	44.90	13.26	13.47	12.66	4.76	4.46	3.36	1.38	1.79
White sample	58.91	13.31	7.79	4.81	4.12	2.42	2.23	1.92	4.49
Red sample	56.29	17.73	7.90	5.47	4.23	2.99	2.59	0.78	4.49

Table 1 shows the chemical compositions of Pisha Sandstone. The main difference among three samples is the carbon dioxide content. Carbon dioxide content of gray sample is higher than other two samples, mainly because it exposed in the outermost. The iron oxide content of three samples is similar, so the color and the iron oxide content have no direct relation. Unstable components Na_2O, K_2O in Pisha Sandstone for about 4%, although far less than stable components such as SiO_2 and Al_2O_3, but they are unusually lively, prone to chemical changes, so that it is easy to cause the rock mass structure failure, and the rock and soil erosion resistance weakened[4].

The mineral composition

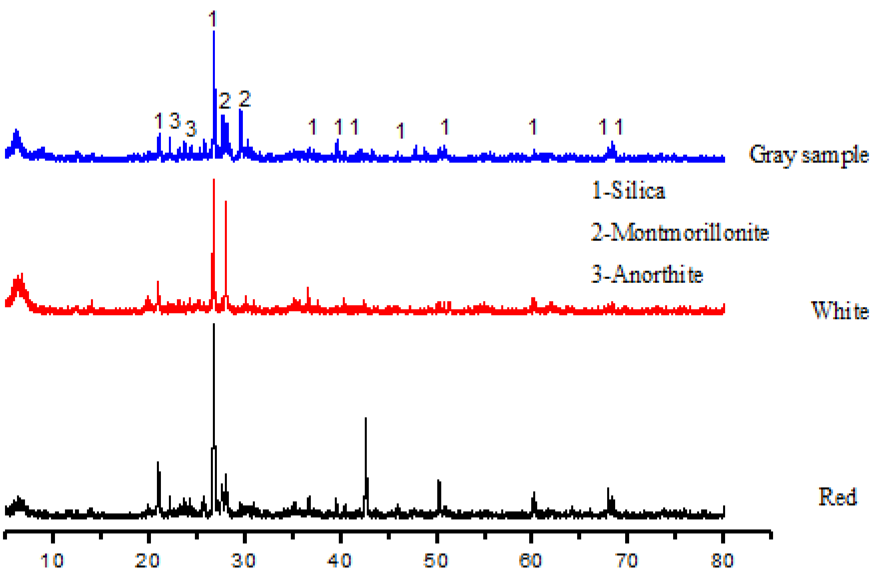

Fig. 2. XRD patterns of different Pisha Sandstone samples

The XRD patterns of different Pisha Sandstone samples are shown in Fig. 2. XRD spectra of three Samples were nearly unchanged, which indicates that the basic phases of different Pisha Sandstone samples were nearly unchanged. It can be seen that three samples contains large amounts of quartz, potassium feldspar, dolomite, calcite, smectite and kaolinite[5]. Quartz is a relatively stable material, so it can not cause poor ability of Pisha Sandstone. Potassium feldspar weathering will become kaolinite, kaolinite's resistance ability is poor, this is one reason why Pisha Sandstone's erosion resistance capacity is poor. Calcite is not stable, which makes its anti weathering ability is poor, and when meeting water, it will interact with CO_2. And this will decrease its cementation. Cementation decrease of Pisha Sandstone will be washed away by the water current. Montmorillonite is easily swell in water, the volume can be expanded to 1.5times the dry state, thus destroying the structure within the Pisha Sandstone will be destroyed and become loose, so that the antierosion ability of Pisha Sandstone decrease greatly.

The grain size composition and permeability

Table 2 Permeability ratio of Pisha Sandstone /wt. %

No.	A	B	C	D	E
Permeability ratio	1.19×10^{-4}	2.08×10^{-4}	1.15×10^{-4}	0.69×10^{-4}	0.61×10^{-4}

Permeability ratios of samples in different sites are showed in Table 2. There is large difference of permeability ratio among different sampling sites. The magnitude of permeability ratio of Pisha Sandstone is 10^{-4}, which is bigger than 5-7 orders of magnitude of concrete. Compared with the concrete, Pisha Sandstone is easy to water seepage, thus water can quickly penetrate into the Pisha Sandstone and make it erosion.

The binding between sandstone particles is completely depends on the combination of physical keys, so that the binding force between the particles is very weak[6]. On one hand, the water can make Pisha Sandstone expand, when the expansion occurs, it easily exceeds the binding force, so that the structure becomes loose. on the other hand, the water can form water film on the particle gap, and make the displacement between particles of Pisha Sandstone easy.

Conclusion

Erosion in sandstone area, and mineral composition, chemical composition of the rock itself, the litho logy, grain size composition, structural characteristics and engineering properties are inseparable, weak cementation and mineral calcite plays is the direct cause of anti erosion ability of rock, easy to weathering of feldspar and montmorillonite, water the expansion of the different litho logy combination and different grain size played a tremendous role in promoting the weakened ability to resist.

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References

[1] Gao Ke, Ren Yuyou, et al, 2001. Study on causes of wind and water erosion and dynamic state in Horqin sandy land. Research of Soil and Water Conservation. 8(3), 110-115 (in Chinese).
[2] Liu Zhi, Jiang Zhongshan, 1994. Study on the effect of natural rainfall factors and slopes on sheet erosion. Bulletin of Soil and Water Conservation. 14(2), 19-23 (in Chinese).
[3] Tang Zhihong, Cai Qiangguo, et al, 2001. Study on interaction among wind erosion, hydraulic erosion and gravity erosion in sediment-rock region of Inner Mongolia. Journal of Soil and Water Conservation. 15(2), 25-29 (in Chinese).
[4] Zhao Guoji, 2001. Research on the laws of soil and water loss in sand rock region, Inner Mongolia. Research of Soil and Water Conservation. 8(4), 158-160 (in Chinese).
[5] Bi Cifen, Wang Fugui, 2008. Research on soil erosion mechanism in soft rock regions. Journal of Sediment Research. (1), 70-73 (in Chinese).
[6] Ye Hao, Shi Jiansheng, et al, 2006. The effect of soft rock lithology upon its anti erodibility. Acta Geoscientica Sinica. 27(2), 145-150 (in Chinese).

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Effect of herbicide's ingredients on soil microbiological processes in a small plot experiment

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Abstract

Pesticides play a very important role in the regulation system of weeds, but have to be counted with the secondary effect of chemicals on soil life and on the so called "not purposed" soil organisms. In this paper the objective of study was to examine the effect of two various herbicide's ingredients on some microbiological parameters of a chernozem soil (Chernozems in WRB) with loam texture. The active ingredients of herbicides are the acetochlor (Acenit A 880 EC) and isoxaflutole (Merlin 480 SC), applied in maize culture to the soil surface. The effect of the herbicides was investigated on the sensitivity and quantity change of soil microorganism and biological parameters of soil in small plot experiment. In the experiment the single, double and five time doses of the recommended herbicide doses were applied and examined on the number of total bacteria and microscopic fungi, on the quantitative changes of aerobic cellulose decomposing and nitrifying bacteria, on soil respiration, on quantity of microbial biomass carbon (MBC) and nitrogen (MBN) for four years. The laboratory examinations were carried out in the soil chemical and microbiological laboratories of Institute of Agrochemistry and Soil Science, Debrecen University. Data analysis was performed using Microsoft Excel 2003 (mean values and standard deviation). Two factors variance analysis was used to get significant effect on measured parameters. The significant differences were accepted at the level 1%, but the evaluation was calculating by the LSD5% values as accepted in the agricultural research. The various microbial groups had different sensitivity on the increasing doses of herbicides, the number of total bacteria decreased significantly, while the number of microscopic fungi and cellulose decomposing bacteria increased. The MBC and MBN increased in most of the treatments of acetochlor, but the isoxaflutole had negative effect on these two parameter. Close correlation was found between some microbial soil parameters. Both herbicides had inhibiting effect on the total soil bacteria. The quantity of microscopic fungi and cellulose decomposing bacteria increased significantly by the various doses of herbicides. CO_2-production was stimulated by each treatment, except by the basic doses of herbicides. In order to choose the suitable herbicide for agricultural practice, comparative evaluation would be necessary. In summary those chemicals may be recommended for agricultural use, which cause less inhibition effect on soil microbiological parameters.

Keywords: herbicides, soil microbes, C- and N cycle of soil, MBC, CO_2-production

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Introduction

Maize is now the world's fastest developing sector in grain industry, in the past fifteen years it has increased by nearly 70%, (BOROS et al., 2008). The worldwide application of pesticides guarantees production capabilities, but their heavy use, persistence and transfer cross-ecosystems and into trophic food webs all cause major environmental contaminations (ACKERMAN, 2007). Our country, Hungary has one of the largest crop fields in Europe, it was about 1,2 million hectares in 2008 (NAGY, 2009) and the position of the corn production per inhabitants is also ranks high in the world leader board. Plant protection is an essential parameter in the cultivation of maize, which determine the control of pests and pathogen, and get an important role in weed control. Along the chemical weed control, the pesticides are in direct contact with the soil (KÁDÁR, 2001). Pesticides sprayed to the soil surface get in touch immediately direct contact with soil, while pesticides spraying on plants –weather permitting- have effect only a shorter or shorter time on soil and organisms living in soil (LENGYEL, 2002).

Plant protection based on chemical pesticides is widespread in agricultural production. Herbicides are among the most important non-point source pollutants in Europe. The objectives fixed by the EU Water Framework Directive (Directive 2000/60/CE) to prevent and control groundwater pollution by herbicides involve a better assessment of environmental impacts of agricultural practices. In Hungary 292 different pesticides were used in 1976, while in the 1990s the number of products was about 900 and 45% of the pesticides was herbicide. The number of authorised products for plant protection decreased from 765 in 2008, of which 41% of herbicides, 21% insecticides, and 37% fungicides share respectively.

The use of herbicides is an integral part of crop production, and when using these products we have to count an additional "secondary effect" on the soil life and as well as on the so called "non-target" organisms (KECSKÉS, 1976). Among non-target organisms, soil microorganisms are extremely important, since they are a key component in soil ecosystems, dominating cycling of nutrient element and playing a major role in maintaining soil quality (Wang et al. 2008.) The sensitive organisms are killed after using herbicides and their remains can be easily decomposed by the survivor microorganisms (CERVELLI et al., 1978).

Some organisms are able to utilize herbicides for growing. In addition those organisms show a quantitative growth, which consume the degraded metabolites and residues of herbicides. Soil biological point of view it is not to use either the long-term stimulant or the inhibitor quality of plant protection products, because both groups influences the life of microbial community and changes the biological balance. Those herbicides should be used for plant protection which has minimum secondary effect on the soil biological community. Changes in quantitative and qualitative ratio of soil microorganisms are due to change of biodiversity. As a result the sensitive species is reduced to a minimum; some species may disappear, while the herbicide resistant species can accumulate (KAPUR et. al., 1981). The applied herbicides also could have adverse effect; the results are the loss of soil fertility and deterioration of crops (VESTER, 1982). According to MÜLLER (1991) on the basis of herbicides' effect on the soil life, four groups can be distinguished: a. stimulant effect, b. neutral (the effect is not or hardly noticeable), c. inhibitory effect, d. when the effect is not obvious. It is therefore essential to assess the fate and impact of newly marketed xenobiotics. Following recent European bans on compounds like atrazine, "new generation" active ingredients have hit the market (MITCHELL et al., 2001).

Nowadays the selectivity of the applied chemicals is better than in the past, and they can be used in smaller concentration (INUI et al., 2001). Among non-target organisms, soil microorganisms are extremely important, since they are a key component in soil ecosystems, dominating cycling of nutrient element and playing a major role in maintaining soil quality (WANG et al. 2008.)

BIRÓ et al. (2005) emphasized the importance to investigate microorganisms of the maize rhisosphere taking part in the nutrient uptake. According to SZILI-KOVÁCS et al. (2006, 2008) the quantitative changes in the microbial biomass is often used as a good method for describing the great changes in the environment. TAYLOR-LOVELL et al. (2002) showed that the degradation of isoxaflutole was accelerated by the microorganisms living in the soil.

ANGERER et.al. (2004) examined in model experiment the effect of different doses of the new generation of herbicides applied in agricultural practice on soil microorganisms, Different sensitivity of the culturable microbial groups was proved against the specific herbicide doses and types. The Acenit herbicide can cause a significant change in the quantity of soil microorganisms and enzyme activities during the growing season, according to an examination taking place in Chernozems. The ecetochlor – atrazine herbicide combination generally increased the number of bacteria and microscopic fungi, as well as the CO_2-production (KÁTAI, 1998; 2003). In order to have a god practice for the herbicide application, it is advisable to conduct a specific crop and soil test.

In this paper the effect of two herbicides' ingredients was examined on some microbiological parameters of C-cycle in a chernozem soil. The active ingredients of herbicides are the ecetochlor (Acenit A 880 EC) and isoxaflutole (Merlin 480 SC), applied in maize culture to the soil surface.

In this paper the simple, double and five time dosages of the mentioned herbicides were examined in small plot experiment on the number of total bacteria and microscopic fungi, on the quantitative changes of aerobic cellulose decomposing bacteria, on soil respiration and on quantity of microbial biomass carbon (MBC) studied for four year. The examination was carried out in the laboratories of the Institute of Agricultural Chemistry and Soil Science of Debrecen University.

Material and Methods

The small plot field experiment was set up at the experimental site of Debrecen University, Faculty of Agriculture, Department of Plant Protection on calcareous chernozem. The soil microbiological effects of herbicides were investigated under maize culture. The laboratory examinations were carried out in the soil chemical and soil microbiological laboratories of Institute of Agrochemistry and Soil Science, from 2005-to 2008. The plots were set up in three repetitions. In this paper the results of 1x, 2x and 5x dosages of two herbicides (Acenit A 880EC and Merlin480 SC) applying in maize culture are investigated and evaluated from homogenous average soil samples. Soil samples were taken two times in a year, in Jun and July, six and twelve weeks after the application of the herbicides. In the evaluation the average of the four-year results are discussed and shown. In Table 1. the active ingredients and the generally applied normal doses are shown.

The two applied herbicides, their active ingradients and the applied dosages are in the Table 1.

The soil of experiment has loam texture, according to the pH_{H2O} (7,9) it is slightly alkaline. Among the chemical properties of soil, moderate amount of $CaCO_3$ content was measured. The humus content was 2,65%, according to nitrogen and phosphorus content the soil is middle supplied, in potassium the supplement of soil is good category. According to the international classification of soils (WRB), the soil of experiment was Calcic Endofluvic Chernozem (Endosceletic).

Table *1.* Characteristics and doses of herbicides used in the small plot experiment with maize culture on calcareous chernozem soil

Name of herbicides	Active ingredients	Content of active ingredient	Normal dose kg ha^{-1}
Acenit A 880 EC	Acetochlor+AD 67 anthydotum	800 g * l^{-1}+ 80 g * l^{-1}	2,0 - 2,6
Frontier 900 EC	dimethenamide	900 g * l^{-1}	1,2 - 1,6

Among the soil microbiological parameters the total numbers of bacteria, and the number of microscopic fungi was determined by plate dilution methods on meat and peptone-glucose agar.

The number of aerobic cellulose decomposing bacteria was determined according to POCHON et al. (1962) with the MPN (Most Probable Number) method in liquid culture media. The basic condition of this MPN-method is the distribution of germs in the basic suspension should be equal. The intensity of soil respiration (CO_2-production of soil) can be measured by oxygen uptake of soil and the CO_2-production. Along the measurement of soil respiration the CO_2 production was measured by absorption of CO_2 by NaOH (HU et al 1997).

The quantity of microbial biomass-C was determined according to JENKINSON et al.(1988) by fumigation-incubation method. The biomass-N was measured by fumigation-extraction methods. Soil samples were fumigated by chloroform (kill the living microorganisms of soil), and the *extraction* was made by K_2SO_4.

Data analysis was performed using Microsoft Excel 2003 (mean values and standard deviation). Two factors variance analysis was used to get significant effect on measured parameters. The significant differences were accepted at the level 1%, but the evaluation was calculating by the LSD5% values as accepted in the agricultural research.

In the small plot field experiment, the simple, double and five time dosages of herbicides (1x, 2x, 5x) were examined on the number of total bacteria and microscopic fungi, on the quantitative changes of aerobic cellulose decomposing bacteria, on soil respiration, on quantity microbial biomass carbon (MBC) studied for four year.

Results and Discussion

The results of total bacteria and microscopic fungi number, the quantitative changes of aerobic cellulose decomposing bacteria, soil respiration, and quantity of microbial biomass carbon (MBC) were evaluated in the field experiment used three increasing doses of two herbicides. The results of the soil microbial properties are shown in the Table 2.

It can be stated that the number of total soil bacteria decreased significantly by the effect of the each dose of the two herbicides. The largest inhibiting effect were measured in soil samples from treatments with soil Acenit 5x, and Merlin 1x doses.

Concerning the number of microscopic fungi, there was no negative effect of herbicides on the soil fungi, what is more, in totally the number of fungi increased in the soils of the herbicide treatments. The highest doses of herbicides caused the highest positive changes in the fungi number, but in all treatments the fungi number was increased significantly.

It can be stated that number of microscopic fungi was influenced positively by the examined herbicides.

Table 2. Effect of increasing doses of two herbicides on some microbial parameter in small plot field experiment with corn culture on calcareous chernozem soil (average values of four years)

Number of treatments	Total bacteria number x 10^6	Number of microscopic fungi x 10^3	Cellulose decomposing bacteria x 10^3	CO_2 mg 100g soil^{-1} 10day^{-1}	MBC (μg g^{-1})
Control	32,25	20,01	11,44	16,01	339,08
Acenit 1x	15,74*	40,14*	28,35	15,27	352,67
Acenit 2x	16,68*	30,69*	30,33	16,31	361,69
Acenit 5x	11,02*	41,24*	67,61	19,31*	346,63
Merlin 1x	10,08*	24,18*	15,57	15,57	367,84
Merlin 2x	20,46*	30,27*	19,07	19,07*	262,29*
Merlin 5x	10,84*	36,16*	20,34	20,34*	341,29
$LSD_{5\%}$	12,14	2,95	1,73	1,73	28,83
$LSD_{1\%}$	16,19	3,94	2,30	2,30	38,45

Regarding the aerobic cellulose decomposing bacteria the same was experienced than in case of microscopic fungi. Increased the bacteria number significantly in all treatments, the highest doses of herbicides caused the highest positive changes in this parameter, in case of Acenit six-fold, in case of Merlin four-fold bacteria number were detected compare to control. It seems that the 5x-dose of Acenit A 880 EC had the largest stimulating effect on the number of cellulose decomposing bacteria.

Concerning the CO_2–production, the effects of increasing doses of herbicide, the results were variable. The positive and negative effects are nearly the same regarding to the different dosages of herbicides and among the effect of herbicides too. In case of Acenit only the 5x-doses increased significantly this parameter, while the 2x and 5x-doses of Merlin also increased significantly the CO_2–production. In the other treatments did not change significantly this parameter.

The microbial biomass carbon slightly increased in the herbicides' treatments but not significantly. Only one exception has to be mentioned, it was the 2x dose of Merlin where this microbial parameter was decreased by treatment significantly. Compare to the content of microbial biomass-carbon and microbial biomass-nitrogen of soils, it may be concluded that the herbicides caused bigger changes in the microbial biomass-nitrogen, than in the microbial biomass-carbon of soil.

According to correlation analyzes close positive correlation was proved between the microscopic fungi and cellulose decomposing bacteria (r = 0,810) in Acenit and (r = 0,834) in case of Merlin treatments, while middle correlation was measured between the number of aerobic cellulose decomposing bacteria and CO_2– production regarding to Acenit treatment r = 0,509; in Merlin r = 0,679. We did not find any relations among the MBC and other soil biological parameters. In the Acenite treatments there was close negative correlation between the total bacteria number, and number of microscopic fungi and cellulose decomposing bacteria (r = – 0,846) and (r = – 0,884) respectively. In the treatments of Merlin, the total bacteria number was middle scale negative correlation with the mentioned two soil microbial parameter r = – 0,524; and r = – 0,686 respectively.

Conclusion

The effect of herbicides on the important microbial properties of soil depending on the properties and application of the doses of herbicide and can vary strongly in time on the examined soil type. The special responses of the different physiological groups of soil microorganisms can give a more detailed answer how to influence the microbial processes by the herbicides. In the selection of proper herbicides a lot of soil parameters should be taken account. The growth of plant, and quantity of resulted plant biomass would be helped by comparative assessment on the microbial properties of soil.

The various microbial groups had different sensitivity on the increasing doses of herbicides, the number of total bacteria decreased significantly, while the number of microscopic fungi and cellulose decomposing bacteria increased. The MBC increased in most of the treatments of acetochlor, but the isoxaflutole had negative effect on this parameter. Close and middle correlation was found between some microbial soil parameters. In summary those chemicals may be recommended for agricultural use, which cause less inhibition effect on soil microbiological parameters**.**

On the bases of results it may be concluded that among the soil microorganisms there were microorganisms, which might be use the herbicides and products of mineralization as carbon sources, this could be the reason of the increased number of cellulose decomposing bacteria and microscopic fungi, as well as the increased soil respiration in the majority of treatments.

References

Ackerman F. 2007. The economics of atrazin. International Journal of Occupational and Environmental Health, 13, 441–449

Angerer P.I., Köböcz L., Bíró B. 2004. Mikrobacsoportok herbicid-szennyvíz kombinációkkal szembeni érzékenységének vizsgálata modellkísérletben. Agrokémia és Talajtan, 53(/3-4), 331-342.

Bending G.D.,. Rodriguez-Cruz M.S,. Lincoln S.D 2007. Fungicide impacts on microbial communities in soils with contrasting management histories. Chemosphere, 69, 82–88

Biró B. 2005. A talaj, mint a mikroszervezetek élettere. In: A talajok jelentősége a 21. században. Magyarország az ezredfordulón. Stratégiai Kutatások a Magyar Tudományos Akadémián. II. Az agrárium helyzete és jövője. Szerk.: Stefanovits P. & Micheli E. p. 141-173. MTA Társadalomkutató Központ, Budapest.

Brookes, P. C., Landman, A., Pruden, G., Jenkinson, D. S. 1985. Chloroform fumigation and the release of soil nitrogen: rapid direct extraction method to measure microbial biomass nitrogen is soil. Soil Biology and Biochemistry 17. 837-842.

Boros B., Sárvári M. 2008. Újdonságok a kukoricatermesztésben. Agrárunió 9, (2). 32-33.

Cervelli, S., Mannipieri, P., Sequi, P. 1978. Interaction between agrochemicals and soil enzymes. In: Soil Enzymes, (ed. Burns) London, Acad. Press. 252-293.

Felföldy L. 1987. A biológiai vízminősítés. Vízgazdálkodási Intézet, Budapest, 172-174.

Bruggen Hu, S., Van A.H.C. 1997. Microbial dynamics associated with multiphasic decomposition of 14C-labeled cellulose in soil. Microbial Ecology. 33, (2) 134-143.

Inui, H., Shiota, N., Motoi, Y., Ido, Y., Inoue, T., Kodama, T. 2001. Metabolism of herbicides and other chemicals in human cytochrome P450 species and in transgenic potato plants co-expressing human CYP1A1, CYP2B6 and CYP2C19. Journal Pesticide Sciences 26. 28–40.

Jenkinson, D.S. 1988. Determination of microbial biomass carbon and nitrogen in soil. In: Advances in Nitrogen Cycling in Agricultural Ecosystems. Szerk. J.R. WILSON. CAB International, Wallingford, UK 368–386.

Kádár A. (2001): Vegyszeres gyomirtás és gyomszabályozás. Factum Bt. Kiadó, Budapest, 376.

Kapur, S., Belfield, W., Gibson, N. H. S. 1981. The effects of fungicides of soil fungi with special reference to nematophages species. Pedobiologia, Jena 21/3., 172-181.

Kátai J. 1998. The effect of herbicides on the amount and activity of microbes in the soil. In: Soil Pollution. Szerk.: Filep, Gy., Debrecen, 169-177.

Kátai J., Veres E. 2003. The effects of herbicides used in maize culture ont he microbial activity in soil. 2nd International Symposium. „Natural Resources and Sustainable Development". May 22-25, 2003. Nagyvárad, Románia. 114-115.

Kecskés, M. 1976. Xenogén anyagok, mikroorganizmusok és magasabb rendű növények közötti kölcsönhatások talajmikrobiológiai értékelése. Akadémiai doktori értekezés. MTA. Budapest. pp. 225.

Kiers, E.T., Leakey, R.R.B., Izac, A.J., Heinemann, A., Rosenthal, E., Nathan, D., Jiggins, J., 2008. Agriculture at a crossroads. Science Vol. 320 no. 5874 pp. 320-321

Lengyel ZS. 2002. Klór-acetanilid típusú herbicidek adszorpciójának vizsgálata talajokon. Doktori (PhD) értekezés Veszprém, pp.115.

G. Mitchell, D.W. Bartlett, T.E.M. Fraser, T.R. Hawkes, D.C. Holt, J.K. Townson, R.A. Wichert Mesotrione 2001. A new selective herbicide for use in maize. Pest Management Science, 57, 120–128

Müller G. 1991.Az agroökológia talajmikrobiológiai kérdései és az intenzív mezőgazdasági termelés. Agrokémia és Talajtan, 40/1-2., 263-272.

Nagy J. 2009. A kukorica ágazat esélyei és lehetıségei. Debreceni álláspont az agrárium jelenérıl, jövıjérıl. Szerk.: Nagy J., Jávor A. Magyar Mezőgazdaság Kft, Budapest, 127-146.

Pochon, J., Tardieux, P. 1962. Techniques D' Analyse en Micobiologie du Sol. Collection „Technivues de Base", 102.

Szili-Kovács T., Takács T 2008. A talajminőség mikrobiológia indikációja: lehetőségek és korlátok. Talajvédelem, p. 321-328.

Szili-Kovács T. – Tóth J. A. 2006. A talaj mikrobiális biomassza meghatározása kloroform fumigációs módszerrel. Agrokémia és Talajtan, 55, (2) 515-530.

Taylor-Lovell, S., Sims, G.K., Wax, L.M. 2002. Effects of moisture, temperature, and biological activity on the degradation of isoxaflutole in soil. Journal of Agricultural and Food Chemistry 50, 5626-5633.

Vester, F. 1982. Az életben maradás programja. Gondolat Könyvkiadó, Budapest 361.

M.C. Wang, Y.H. Liu, Q. Wang, M. Gong, X.M. Hua, Y.J. Pang, S.J. Hu, Y.H. Yang 2008.Impacts of methamidophos on the biochemical, catabolic, and genetic characteristics of soil microbial communities. Soil Biology and Biochemistry, 40, 778–788.

Bending G.D., Rodriguez-Cruz M.S., Lincoln S.D. 2007. Fungicide impacts on microbial communities in soils with contrasting management histories. Chemosphere, 69, 82–88.

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Biological activity of soils in sporadic permafrost zone of Western Siberia

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Abstract

Unique Nadym site (north Western Siberia) consists of different types of ecosystems which function in different geocryological conditions. On the key sites were assessed some parameters of soil biological activity: carbon dioxide emission (non-steady-state non-through-flow chamber method), carbon dioxide concentration in soil profile (tube method), carbon of microbial biomass (chloroform fumigation-extraction method). In general soils carbon dioxide emission is low (140 ± 25) $mgCO_2m^{-2}h^{-1}$. Research soils are characterized with high variation of labile organic carbon (WEOC) and the microbial carbon (MC) (WEOC=0,35-1,10% of TOC and MC=0,30-1,60 mg g^{-1} soil in Histosols; WEOC=0,50-1,10% of TOC and MC= 3,90-8,40 mg g^{-1} soil in Cryosols; WEOC=2,50% of TOC and MC= 6,20-10,15 mg g^{-1} soil in Podzols) in organic profile of the soils. The values of microbial biomass are high, but geocryological and hydrothermal conditions low down all soil processes. Based on the regression analysis was revealed a high and significant correlation carbon dioxide emission with content of carbon of microbial biomass (MC) in the upper 10 cm soil layer *(beta=0,965; p-level=0,00)*; with content of water-extractable organic carbon (WEOC) in the upper 20 cm soil layer *(beta=0,899; p-level=0,00)* and with the depth of permafrost table *(beta=0,993; p-level=0,00).* So the main factors which determine the soil carbon dioxide production and carbon fluxes is the depth of permafrost table and composition of soil organic matter. Permafrost-affected soils are characterized by the low biological activity which leads to the preservation of organic matter, so these ecosystems are sink of CO_2.

Keywords: soil microbial biomass, sporadic permafrost, carbon, peatland, CO_2 emission

Introduction

Global warming is enhanced at northern latitudes (Serreze, 2006) and leads to widespread changes in soil and permafrost (Romanovsky et al., 2010), altered vegetation structure and composition, changes in biodiversity and ecosystem function (Elmendorf et al., 2012), and changing landscapes as a whole (Hinzman et al., 2005; Jorgenson et al., 2013; Raynolds et al., 2013).

Particular attention is now being given to the investigation of the function of permafrost-affected soils in a changing climate and their parameters of soil biological activity (Walker et al., 2008; Ping et al., 2008).

Permafrost and soils in permafrost zone are considered the most significant terrestrial carbon pools on the planet. Soil organic matter in permafrost plays an important role in the global carbon dynamics, because its degradation under climate warming could lead to the release of significant amounts of greenhouse gases. Although permafrost soils occupy only 16% of the soil area, they contain about 40% of the total soil organic carbon (Tarnocai et al., 2009).

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The additional carbon emission into the atmosphere in the form of greenhouse gases will strengthen the greenhouse effect in the future based on the feedback effect and can become comparable with the annual technogenic increase in these gases in the atmosphere (Karelin et al., 2008). In addition to the accelerated decomposition of surface soil carbon, carbon from the permafrost horizons can also be released into the atmosphere.

The soil biological activity is a complex of biological processes taking place in the soil. About soil biological activity is judged by the intensity of the soil respiration (oxygen consumption and carbon dioxide evolution), enzymatic activity and other factors (Stepanov, 2011).

It is well known that about half of the total CO_2 flux from the soil of terrestrial ecosystems of Russia is formed by microbial soil respiration (Stepanov, 2009). Carbon of soil microbial biomass is an important part and status indicator of soil carbon, which sensitive to environmental conditions and its associated with ecosystem productivity (Ananeva et al., 2009).

A significant part of the organic matter in soils of northern ecosystems is concentrated in peat deposits. Northern peatlands are estimated to store up to a third of all the terrestrial carbon as peat, the partially decomposed organic matter (Vitt et al., 2000; Andersen et al, 2013). Under natural conditions peatlands are natural storage of organic carbon, existing without significant changes for a long time. Soil respiration, on the one hand, characterizes the total metabolism of the soil animals, microorganisms and underground plant organs and, on the other hand, it reflects the specific features of the physical and physic-chemical processes in the organo-mineral substrate mass (Naumov, 2009).

The main objective of this research proposal is to investigate the soil biological activity: flux of carbon dioxide of permafrost-affected soil, soil microbial biomass as well as identifying the main factors which determine the temporal dynamics and spatial variation of this indicator.

Our goals: 1) general characteristics of soil biological activity of different cryogenic landscapes, 2) detailed characteristics of the temporal dynamics of carbon dioxide production on the most common areas, 3) detailed characteristics of the spatial variation of parameter of soil biological activity. The main task at this work is to determine the correlation carbon dioxide flux with soil properties, organic matter content, microbial biomass carbon and microbial activity.

Material and Methods

Site description

The research area is located in north Western Siberia (Nadym region, Russia) within the north taiga and within the zone of sporadic permafrost. Permafrost is absent under forest sites, and exists under peatlands. The climate is characterized as mid-continental with very cold winters. According to the Nadym Weather Station , located 30 km north of the research sites, the mean annual temperature from 2004 to 2013 was -4,5°C (ranging from -2,4 to -6,8°C), annual precipitation was 550 mm, (ranging from 466 to 687 mm).

We analyzed the soil biological activity at three sites with different vegetation, topographic, and geocryological conditions (all sites located within several hectares): 1) forest site (N65°18'52.8'' E72°52'54.2''), 2) young frozen peatland (N65°18'54.4'' E72°52'10.0''), and 3) old frozen peatland (N65°18'55.1'' E72°52'33.9''). The forest site represents lichen-pine forest without permafrost. The vegetation mostly consists of *Pinus sibirica*, *Larix sibirica*, *Betula* sp. in the overstorey; representatives of the Ericaceae family, namely *Vaccinium uliginosum*, *Vaccinium myrtillus*, *Vaccinium vitisidaea*, *Ledum* sp. – in the middle storey; *Polytrichum strictum*, *Cladonia rangiferina*, *Sphagnum* sp. – in the lower storey. The soil was classified as Folic Podzol (World reference base for soil resources, 2006). The frozen peatland represents flat and slightly inclined surfaces of peatlands with cloudberry-Sphagnum cover. The vegetation of the young frozen peatland is represented in the ground cover by different lichens and mosses (*Cladonia rangiferina*, *Cladonia stellaris*, *Cladonia sylvatica*, *Sphagnum* sp.), in the subshrub layer – by *Betula nana*, *Rubus chamaemorus*, *Ledum* sp., *Vaccinium uliginosum*, *Vaccinium myrtillus*; for the grass layer, the most typical plants are the representatives of the Cyperaceae family – *Eriophorum* sp., *Carex* sp. The active layer is a peaty horizon with an underlying mineral stratum. Permafrost occurs below 60 cm. The soil here was identified as Turbic Cryosol. The old frozen peatland is characterized with locally bare peat spots, sparse vegetation, and permafrost from 40 cm in the peat layer. Vegetation on the overgrown areas is represented by *Ledum* sp., *Betula nana*, and in depressions by *Cladonia* sp. The soil was classified as Cryic Histosol. Soils described for key sites (Table 1) are representative of the common soils within the investigated territory (Vasilyevskaya, 1986; Matyshak, 2009).

Table 1. Soil properties

Active layer	Horizons	Depth, cm	Total Carbon, %	pH H_2O	Field H_2O, % wt	Bulk density, g/cm^3
			Folic Podzol (forest)			
-	Organic layer	0-8	46	3,8	80	0,1
	Mineral layers	8-12	1	4,3	14	1,3
		12-23	<1	4,4	18	1,2
		23-48	<1	4,5	20	1,5
		48-100	<1	4,5	20	1,5
			Turbic Cryosol (young frozen peatland)			
60 cm	Organic layers	0-5	38	4,3	170	0,1
		5-10	43	3,5	180	0,1
		10-40	38	4,7	200	0,3
	Mineral layer	40-60	<1	5,5	14	1,5
			Cryic Histosol (old frozen peatland)			
40 cm	Organic layers	0-3	52	3,7	110	0,3
		3-12	51	3,8	160	0,3
		12-22	50	3,8	160	0,3
		22-40	52	3,6	200	0,3

Carbon dioxide emission and concentration

Carbon dioxide emission from the soil surface was measured by the closed chamber method (non-steady-state non-through-flow chambers) (Orlov et al., 1987; Reth et al., 2005; Pumpanen et al., 2004) in a fivefold series, several times a day in August – September, 2010–2013 (the total number of probes exceeding 100 for each site). Soil CO_2 concentration is an important component of the terrestrial carbon budget and site specific information on the spatial and temporal variability (Bekele et al., 2007). To measure carbon dioxide concentrations at different depths, sealed tubes were placed in the soil, 1 cm in diameter and perforated on the bottom part Sampling was conducted with a rubber stopper several times a day. CO_2 concentrations were measured with a portable gas analyzer RMT DX6210.

Soil microbial biomass and water-extractable organic matter

It is well known soil microbial biomass (SMB) is important component for the functioning of an ecosystem and one of the main parameter of soil biological activity. SMB contributes to atmospheric CO_2 from respiration. Due to a lack of sufficiently standardized methods in soil microbiology, soil microbial biomass is estimated by different way: fumigation-incubation (FI) method (Jenkinson et al., 1976), substrate-induced respiration (SIR) (Anderson et al., 1978), fumigation-extraction (FE) method (Brooks et al., 1985; Vance et al., 1987; Cheng et al., 1993; Beck et al., 1997; Joergensen et al., 2011).

In our research microbial biomass C was estimated by chloroform fumigation-extraction (FE) method. Briefly, 5 g of fresh, moist, homogenized soil samples were fumigated with $CHCl_3$ for 24 hours (5 g for mineral soil samples, 1 g for peat and litter samples). After removal of residual CHCl3 from fumigated soils 25 ml of 0.05 M K_2SO_4 solution was added, and then shaken for 1 h on shaker. The shaken mixture was then filtered through filter paper. The concentration of organic carbon of each extract was analyzed on Analyzer TOC-VCPN (Makarov et al., 2013). There is a further correction, usually termed Kec, based on the fact that about 45% of the killed biomass C is evolved i.e. Kec=0.45 by (Wu et al., 1990) or Kec=0.35 by (Sparling et al., 1990). Finally, an estimate of the initial soil microbial biomass C (MC) is calculated from:

MC = [(C evolved from $CHCl_3$ fumigated soil in 24 h) - (C evolved from non-fumigated soil)]/Kec.

Carbon of water-extractable organic matter was determined by shaking 25 ml 0.005M K_2SO_4 solution with soil samples (1g for peat and litter, 5 g for mineral soils), then filtration through filter paper, extract was analyzed on Analyzer TOC-VCPN. Our method was modified from original (Chantigny et al., 2003; Embacher et al., 2007).

Also for all soils were estimated common chemical properties (total carbon, total nitrogen, pH), temperature of soil surface, the depth of permafrost. Statistical processing of the data was carried out using the Statistica 6.0 software program.

Results and Discussion

Carbon dioxide production

It was found during the study that emission of carbon dioxide by the soils of the ecosystems is low to amount on average for all the sites to (138 ± 24) mg $m^{-2}h^{-1}$.The values of CO_2 obtained significantly differ at the sites investigated: from (65 ± 15) mg $m^{-2}h^{-1}$on old frozen peatland to (246 ± 30) mg $m^{-2}h^{-1}$on the forest site. Young frozen peatland occupies an intermediate position, where CO_2 emission is (107 ± 11) mg $m^{-2}h^{-1}$. The high values of standard deviation are accounted for, on the hand, by high variability of the parameter by sites and years, and, on the other hand, by the fact that the measurements were taken considering daily temperature fluctuations. It is to be noted that, by the results of statistical processing, the sites reliably differ for the carbon dioxide emission, and the confidence intervals practically coincide for the two years of measurements (Fig. 1). The data obtained suggest low biological activity of soils in the region, although, as mentioned previously, the studies were conducted in the peak of the vegetation season.

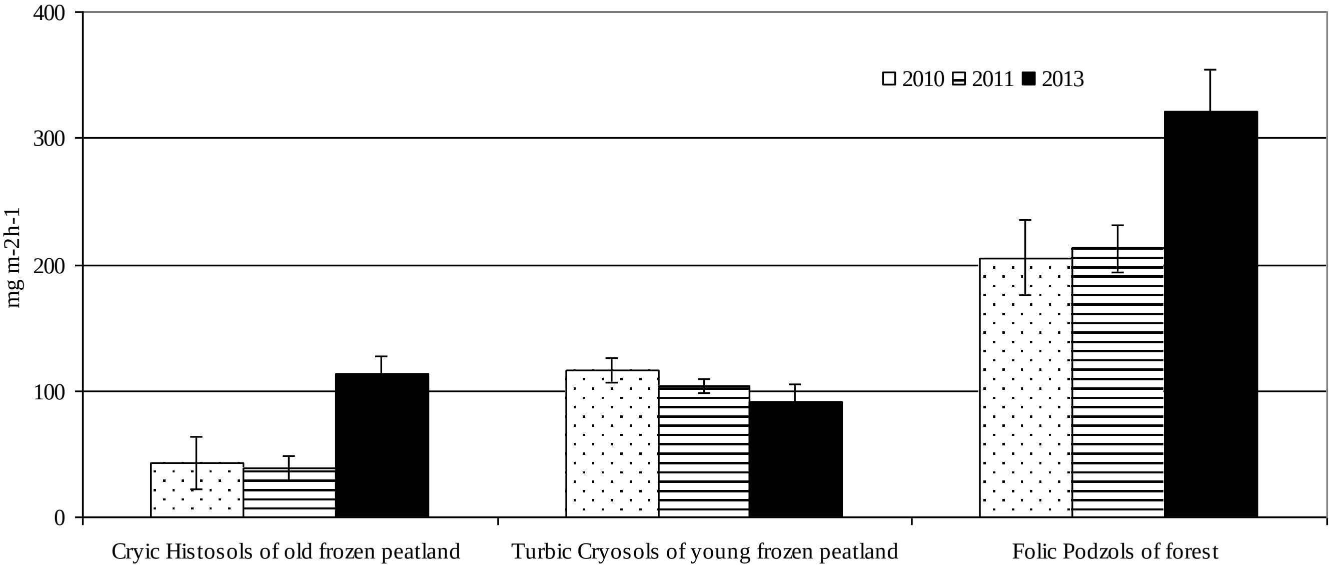

Fig. 1. Emission carbon dioxide from soil

Carbon dioxide concentration in soil

The emission value does not fully reflect biological activity in the soil, as it is the function of not only the biological processes going on in the soil, primarily physical processes. The processes of gas diffusion are related to soil humidity, temperature, climatic characteristics of the near-surface air, etc. Evaluation of the gas function only by the amount of emission may be underrated, as part of the gas gets accumulated and redistributed in the soil (Smagin, 2005).

To ensure more detailed evaluation of carbon dioxide production and to compare the sites based on this characteristic, we measured the gas concentration values immediately in the soil at different depths, using the method described above. Simultaneously with measurements of CO_2 concentrations, soil temperatures were measured at the same depths.

The general trend for all the soils investigated is gradual increase in the concentration of carbon dioxide from 0.1 to 0.2–0.5 %, related to its movement down the profile. This type of a curve (belt-like) describing changes in carbon dioxide concentration is characteristic of most amorphous soils.

Podzol of forest ecosystems is characterized by the maximum averaged values of CO_2 concentrations (0.18–0.50 % – in 2011), despite the small organic horizon thickness, where gas is mostly generated. Concentrations of carbon dioxide in permafrost soils are similar: from 0.1 % in the upper horizons to 0.2–0.3 % directly beside permafrost. To take an example, at the depth of 20 cm, the differences in the CO_2 concentrations are less than 0.1 %, while at the depth of 60 cm they reach 0.3 % (Fig. 2).

Peatland soils are characterized by much smaller increases in CO_2 concentrations as the depth increases, compared to forest soils. The authors assume that this is related to dissolution of carbon dioxide in cold solution formed when the seasonally frozen layer of the soil gets frozen. At the level of top permafrost, activity of aerobic microbes may be inhibited due to low temperatures approaching 0 °C and increased humidity, despite availability of substrate required for microbe viability: in the soil of old frozen peatland, this is peat, while in the soil of young frozen peatland, it is organic matter accumulated directly above the permafrost.
Thus, the general trend for the changes in the carbon dioxide concentration in soil profiles of the sites investigated remains, just like in the case of carbon dioxide emissions. It is to be emphasized that the differences in carbon dioxide emissions from the surface of forest soil and of the soils of peatlands are much more essential and reliable than the differences in the concentrations of this gas in the soil air (Fig.1, 2). This seems to be related to the major role of the thermal factor inside the soil profile and the leading role of permafrost. The presence and proximity of permafrost rocks determine both the values of carbon dioxide production in soils and the processes of its diffusion and fixation in the soil profile (Goncharova et al., 2014).

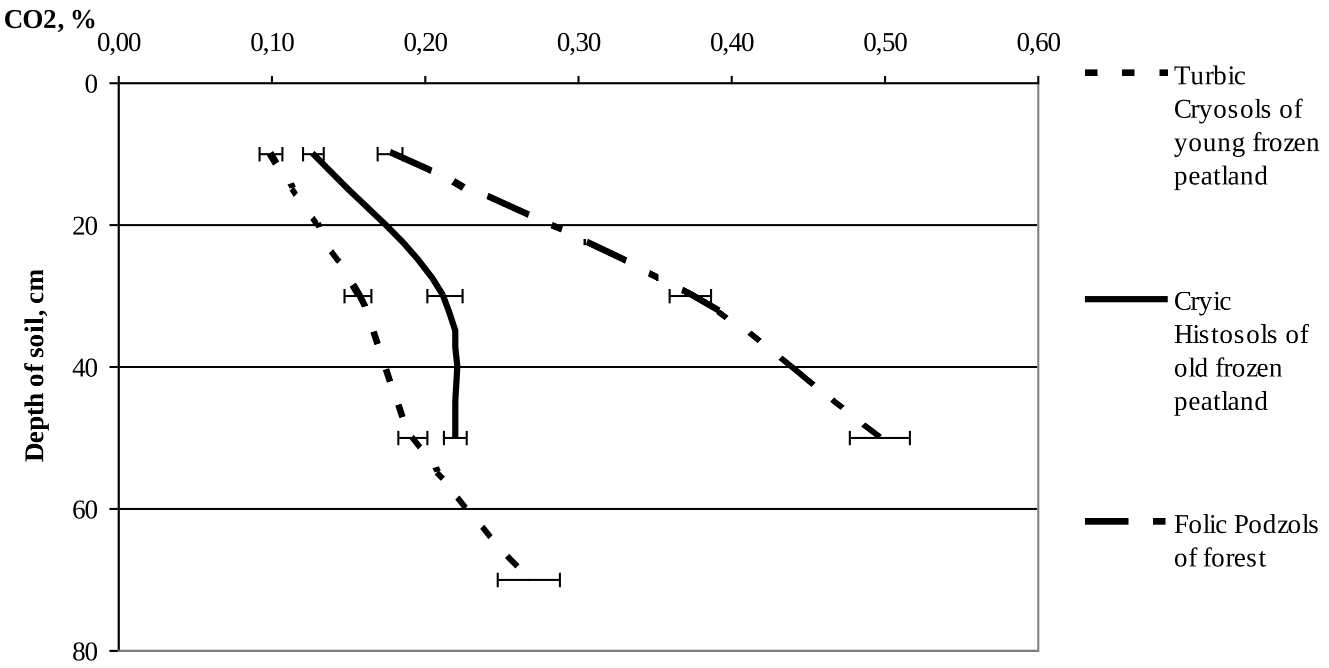

Fig. 2. Concentration of carbon dioxide in soil horizons

Microbial biomass and water-extractable organic matter

Research soils are characterized with high variation of labile organic carbon (WEOC) and the microbial carbon (MC) in organic profile of the soils.
Podzol of forest ecosystems is characterized by the maximum averaged values of MC: it varies from 6,18-10,14 mg g^{-1}soil in organic horizons to 0,01 mg g^{-1}soil in mineral stratum (Fig. 3). Forest soils are characterized by big increases in WEOC content with the depth from 2,50 to 13,10% of TC (Fig.4).
Soil of old frozen peatlands is characterized by the smallest value of MC in all soil profile, it varies from 0,28 to 1,59 mg g^{-1}soil. Content of WEOC varies from 1,10 to 0,35 % of TC with the depth.
The content of MC varies from 0,27 to 8.40 mg g^{-1}soil in peat horizons of young frozen peatland soil. Also WEOC varies significantly from 0,54% of TC in upper peat horizons to 6% of TC in mineral stratum.

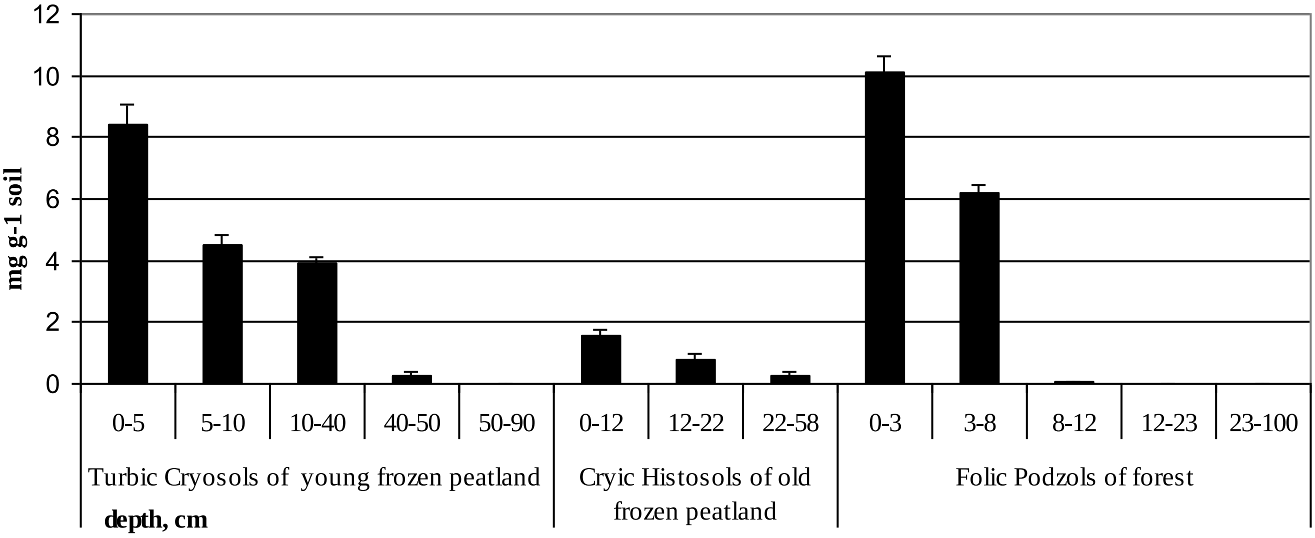

Fig. 3. Carbon of microbial biomass

Our results of soil microbial biomass carbon are typical for north taiga and tundra ecosystems (Cheng et al., 1993; Fisk et al., 2003; Polita et al., 2004; Edwards et al,, 2013). Thus, the general trend for the changes in the content of MC and WEOC of the sites investigated remains, just like in the case of carbon dioxide emissions and concentration in soil profiles. Folic Podzols of forest are characterized with highest content of MC and WEOC in organic horizons, and Cryic Histosols of old frozen peatland are characterized with lowest content of these parameters. It is related with chemical composition of peat, hydrothermal and geocryological conditions. The values of microbial biomass are high, but geocryological and hydrothermal conditions low down all soil processes. Close proximity of permafrost leads to a significant decrease of average annual temperatures and an increase of soil moisture (Goncharova et al., 2015). Permafrost-affected soils of peatlands are characterized by the low biological activity which leads to the preservation of organic matter, so these ecosystems are sink of CO_2.

Based on the regression analysis among more than 20 characteristics (hydrothermal, geocryological, soil) for key sites we reveal a high and significant correlation carbon dioxide emission with content of carbon of microbial biomass (MC) in the upper 10 cm soil layer *(beta=0,965; p-level=0,00)*; with content of water-extractable organic carbon (WEOC) in the upper 20 cm soil layer *(beta=0,899; p-level=0,00)* and with the depth of permafrost table *(beta=0,993; p-level=0,00).* So the main factors which determine the soil carbon dioxide production and carbon fluxes is the depth of permafrost table and composition of soil organic matter.

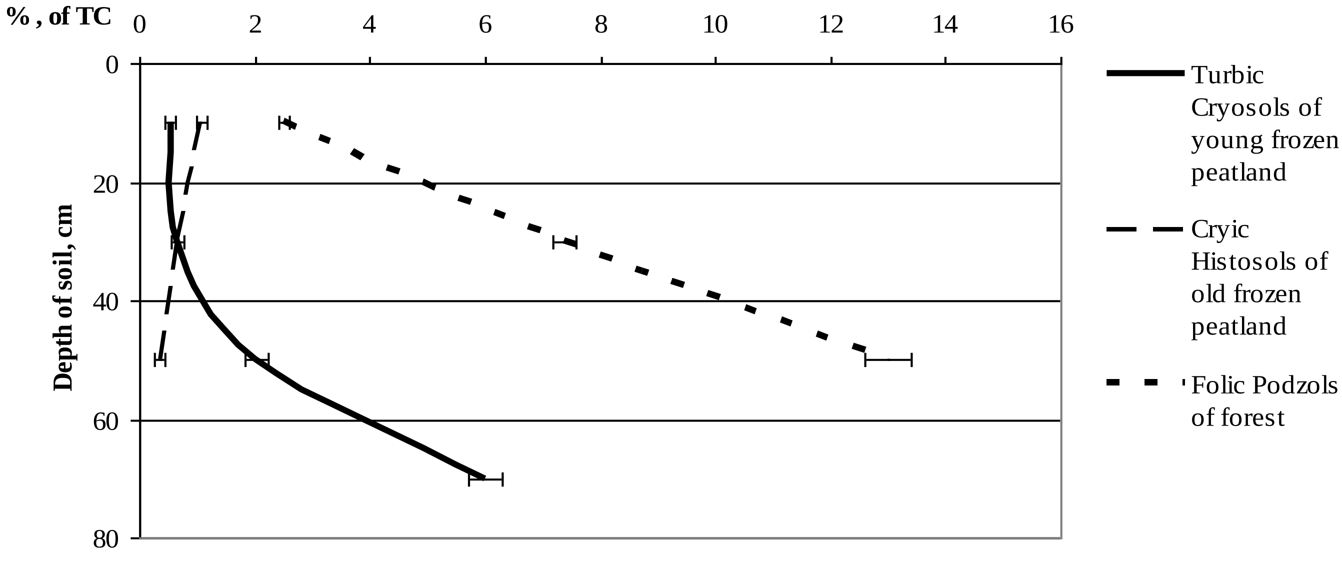

Fig. 4. Soil water-extractable organic carbon

Conclusion

Unique Nadym site consists of different types of ecosystems which function in different geocryological conditions. It's characterized by low soil biological activity. The content of microbial biomass are high, but geocryological and hydrothermal conditions low down soil biological processes. Permafrost-affected soils are characterized by the low biological activity which leads to the preservation of organic matter, so these ecosystems are the sink of carbon.

On the base of field and laboratory data we consider the main factor, which determines the soil carbon dioxide production and carbon fluxes, is the depth of permafrost table, it determines the type of ecosystem in such transitional landscapes, soil temperature regimes and organic matter transformation processes. Underestimation of the spatial heterogeneity of soil and vegetation cover in the region of discontinuous permafrost can lead to substantial distortion of estimates of the total emissions.

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References

1. Ananieva, N.D., Sysiyan, E.A., Rizhova, I.M., Bocharnikova, E.O., Stol'nikova, E.V., 2009. Carbon of microbial biomass and microbial production of carbon dioxide of podzolic soils of postagrogenic ecosystems and indigenous spruce forests of the southern taiga (Kostroma region). Eurasian Soil science. 9, 1108-1116.
2. Anderson, J.P.E., Domsch, K.H., 1978. A physiological method for the quantitative measurement of microbial biomass in soils. Soil Biology and Biochemistry. 10, 215-221.
3. Andersen, R., Chapman, S.J., Artz, R.R.E., 2013. Microbial communities in natural and disturbed peatlands: A review. Soil Biology and Biochemistry. 57, 979-994.
4. Beck, T., Joergensen, R.G., et al., 1997. An inter-laboratory comparison of ten different ways of measuring soil microbial biomass C. Soil Biology and Biochemistry. 7, 1023-1032.
5. Bekele, A., Kellman, L., Beltrami, H., 2007. Soil Profile CO2 concentrations in forested and clear cut sites in Nova Scotia, Canada. Forest Ecology and Management. 242, 587–597.
6. Brookes, P.C., Landman, A., Pruden, G., Jenkinson, D.S., 1985. Chloroform fumigation and release of soil nitrogen: a rapid direct extraction method to measure microbial biomass nitrogen in soils. Soil Biology and Biochemistry. 17, 837–842.
7. Chantigny, M. H., 2003. Dissolved and water – extractable organic matter in soils: a review on the influence of land use and management practices. Geoderma, 113, 357-380.
8. Cheng, W., Ross, A.V., 1993. Measurement of microbial biomass in arctic tundra soils using fumigation-extraction and substrate-induced respiration procedures. Soil Biology and Biochemistry. Vol. 25, No. 1, 135-141.
9. Edwards, K.A., Jefferies, R.L., 2013. Inter-annual and seasonal dynamics of soil microbial biomass and nutrients in wet and dry low-Arctic sedge meadows. Soil Biology and Biochemistry. 57, 83-90.
10. Elmendorf, S.C., Henry, G.H.R., Hollister, R.D., Björk, R.G., Bjorkman, A.D. et al., 2012. Global assessment of experimental climate warming on tundra vegetation: heterogeneity over space and time. Ecology Letters. 15, Issue 2, 164-175.
11. Embacher, A., Zsolnay, A., Gattinger, A., Munch, J.C., 2007. The dynamics of water extractable organic matter (WEOM) in common arable topsoils: 1. Quantity, quality and function over a three year period. Geoderma. 139, 412-419.
12. Fisk, M.C., Ruether, K.F., Yavitt, J.B., 2003. Microbial activity and functional composition among northern peatland ecosystems. Soil Biology and Biochemistry. 35, 591-602.
13. Goncharova, O.Yu, Matyshak, G.V., Bobrik, A.A., Moskalenko, N.G., 2014. Carbon dioxide production by northern taiga soils of Western Siberia (Nadym site). *Earth Cryosphere*, 18, 66–71.
14. Goncharova, O. Yu., Matyshak, G.V., Bobrik, A.A., Moskalenko, N.G., Ponomareva, O.E., 2015. Soils thermal regime in sporadic permafrost areas (Western Siberia, Russia). Eurasian Soil Science, In Press.
15. Hinzman, L.D., Bettez, N., Bolton, W.R., Chapin, F.S., Dyurgerov, M., Fastie, C., Griffith, B., Hollister, R.D., Hope, A., Huntington, H.P. et al., 2005. Evidence and implications of recent climate change in terrestrial regions of the Arctic. Climate Change. 72, 251-298.

16. IUSS Working Group WRB. World reference base for soil resources. 2006. 2nd edition. World Soil Resources Reports No. 103. FAO, Rome.
17. Jenkinson, D.S., Powlson, D., 1976. The effects of biocidal treatments on metabolism in soil V. A method for measuring soil biomass. Soil Biology and Biochemistry. 8, 209–213.
18. Joergensen, R.G., Wu, J., Brookes, P.C., 2011. Measuring soil microbial biomass using an automated procedure. Soil Biology and Biochemistry. 43, 873-876.
19. Jorgenson, M.T., Harden, J., Kanevskiy, M., et al., 2013. Reorganization of vegetation, hydrology and soil carbon after permafrost degradation across heterogeneous boreal landscapes. Environmental Research Letters. 8, 035017.
20. Karelin, D.V., Zamolodchikov, D.G., 2008. Carbon cycle in cryogenic ecosystems. Science Publishing House, Moscow.
21. Makarov, M.I., Malysheva, T.I., Shyleva, M.S., Meniaylo, O.V., 2013. Solubility of labile forms of soil carbon and nitrogen In K_2SO_4 solution with different concentrations. Eurasian Soil Science. 4, 408-413.
22. Matyshak, G.V., 2009. The specific features of formation of soils in the north of western Siberia under conditions of permafrost. Thesis, candidate of biological sciences, Moscow.
23. Naumov, A.V., 2009. Soil respiration: components, environmental functions, geographic regularities. Siberian Branch of the Russian Academy of Sciences Publishing House, Novosibirsk.
24. Orlov, D.S., Minko, O.I., Ammosova, Ya.M., 1987. The methods of investigating the gas function of soil. Modern Physical and Chemical Methods of Soil Study, Moscow University Publishing House, Moscow.
25. Ping, C.-L., Michaelson, G.J., Jorgenson, M.T., Kimble, J.M., Epstein, H., Romanovsky, V.E., Walker, D.A., 2008. High stocks of soil organic carbon in North American Arctic region. Nature Geoscience. 1, 615-619.
26. Potila, H., Sarjala, T., 2004. Seasonal fluctuation in microbial biomass and activity along a natural nitrogen gradient in a drained peatland. Soil Biology and Biochemistry. 36, 1047-1055.
27. Pumpanen, J., Kolari, P. et al., 2004. Comparison of different chamber techniques for measuring soil CO2 efflux. Agricultural and Forest Meteorology. 123, 159-176.
28. Raynolds, M. K., Walker, D.A., Verbyla, D., Munger, C.A., 2013. Patterns of change within a tundra landscape: 22-year Landsat NDVI trends in an area of the northern foothills of the Brooks Range. Alaska Arct. Antarct. Alp. Res. 45, 249–60.
29. Reth, S., Reichstein, M., Falge, E., 2005. The effect of soil water content, soil temperature, soil pH value and the root mass on soil CO_2 efflux – A modified model. Plant and Soil. 268, 21–33.
30. Romanovsky, V.E., Smith, S.L., Christiansen, H.H., 2010. Permafrost thermal state in the polar Northern Hemisphere during the international polar year 2007-2009: a synthesis. Permafrost and Periglacial Processes. 21, 106-116.
31. Serreze, M. C., Francis, J. A., 2006. The Arctic on the fast track of change. Weather. 61, 65-69.
32. Smagin, A.B., 2005. The gas phase of soils. Moscow University Publishing House, Moscow.
33. Sparling, G.P., Feltham, C.W., et al., 1990. Estimation of soil microbial C by a fumigation-extraction method: use on soil of high organic matter content, and a reassessment of the Kec-factor. Soil Biology and Biochemistry. Vol. 22, No. 3, 301-307.
34. Stepanov, A.L., 2009. Microbial formation and absorption of greenhouse gases in soil. MSU Publishing House, Moscow.
35. Stepanov, A.L., 2011. Microbial transformation of greenhouse gases in soil. GEOS, Moscow.
36. Tarnocai, C., Canadell, J.G., et al., 2009. Soil organic carbon pools in the northern circumpolar permafrost region. Global Biogeochemical Cycles. 23, GB2023
37. Vance, E.D., Brookes, P.C., Jenkinson, D.S., 1987. An extraction method for measuring soil microbial biomass C. Soil Biol. Biochem. 19, 703–707.
38. Vasilyevskaya, V.D., Ivanov, V.V., Bogatirev, L.G., 1986. Soils of north Western Siberia. Moscow State University Press, Moscow.
39. Vitt, D.H., Halsey, L.A., Bauer, I.E., 2000. Spatial and temporal trends in carbon storage of peatlands of continental western Canada through the Holocene. Canadian Journal of Earth Sciences. 37, 683-693.
40. Walker, D.A., Epstein, H.E., Romanovsky, V.E., Ping, C.L., Michaelson, G.J., Daanen, R.P., Shur, Y., Peterson, R.A., Krantz, W.B., Raynolds, M.K., Gould, W.A., Gonzalez, G., Nicolsky, D.J., Vonlanthen, C.M., Kade, A.N., Kuss, P., Kelley, A.M., Munger, C.A., Tarnocai, C.T., Matveyeva, N.V., Daniëls, F.J.A., 2008. Arctic patterned-ground ecosystems: A synthesis of field studies and models along a North American Arctic Transect.
41. Wu, J., Joergensen, R.G., Pommerening, B., Chaussod, R., Brookes, P.C., 1990. Measurement of soil microbial biomass C by fumigation-extraction - an automated procedure. Soil Biology and Biochemistry. 22, 1167-1169.

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Removal of metals and arsenic from aqueous solutions using Fe- and Mn-oxide nanocomposite

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Abstract

Treatment of As(Ⅲ) can be a challenging task due its high mobility and small affinity to mineral surfaces and that pre-oxidation step to As(V) is necessary for enhancing removal efficiency. In this study, Fe-Mn oxide was synthesized through chemical precipitation in solutions with varying concentrations of $FeCl_3{\cdot}4H_2O$ and $MnCl_2{\cdot}4H_2O$ for oxidative adsorption of As(Ⅲ) in aqueous solution. The synthesized Fe-Mn oxide mineral possessed oxidation property rendered from manganese dioxide phases and adsorption capacity from iron oxide phases. The Fe-Mn oxide was characterized for surface area, morphology, composition, and magnetic property and bench scale laboratory experiments were carried out to investigate potential utility of the mineral in treating As(III) under the mineral dose of 1 g/L and 1 mg/L As(III). The results of kinetic experiments revealed the oxidation of As(III) occurred in very short period time (less than 30 min), followed by adsorption to iron oxide phase, with its removal efficiency being the highest for the mineral synthesized under 1:0.25 Fe:Mn condition. The maximum adsorption capacity determined from isotherm experiments was found to be 200 mg/g. The removal of As(Ⅴ) remained relatively constant in pH 3-6 at around 60 % removal but dramatically decreased when pH was raised to 10. The ionic strength in the range of 0.001-0.1 M $NaNO_3$ and the presence of competing anion (0.1-1 mM PO_4^{3-}) had little effect on the As(Ⅲ) removal. The overall results of this study demonstrated the potential utility of the Fe-Mn oxide for treatment of As(III) in field applications for high removal capacity and magnetic property that enables better separation of reacted material after treatment process.

Keywords: Arsenite, Fe-Mn oxide, Oxidation, Adsorption, Synthetic Material

Introduction

Arsenic, which is one of the most toxic chemical elements, has resulted in serious problem in water environment. U.S. Environmental Protection Agency (USEPA) and World Health Organization (WHO) have established the standard concentration for arsenic in drinking water at 10 μg L^{-1} because arsenic can cause severe problems in health and human body. Arsenic species exist in natural waters as trivalent and pentavalent arsenic speciation, and arsenite is generally more toxic than arsenate.

Several methods have been applied to remove arsenite from aqueous system, such as immobilization by plant, electro-ultrafiltration, electrocoagulation, adsorption and precipitation, biofilter. It is reported that the pretreatment for arsenite oxidation to arsenate through oxidants such as ozone, hydrogen peroxide,

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hypochlorite, potassium permanganate and monochloramine can enhance arsenic removal in water (Sorlini and Gialdini, 2010). Many studies proposed that Mn-oxides are effective for oxidation of arsenite and Fe-oxides are known as an effective adsorbents for arsenate. We tested the oxidation and adsorption capacity of composite of Fe and Mn oxides for aresnite.

Material and Methods

The composite of Mn-Fe oxides was synthesized by chemical precipitation using following procedure at different Fe : Mn ratio: 1) Precipitation of magnetite with the oxidation of Fe^{2+} at alkaline condition, 2) Adsorption of Mn^{2+} on magnetite surface, and 3) Precipitation birnessite by oxidation of Mn^{2+} at alkaline condition.

Mineralogical composition of the composite was determined using X-ray diffractometer (XRD) with Cu Kα radiation at 40 kV and 30 mA. The morphology was examined with transmission scanning electron microscopy (TEM). The surface area was determined from N_2 adsorption. Point of zero charge (pH_{pzc}) was determined with zeta-potential measurement of particle suspension in 0.01 M NaCl at pH 3-10.

Adsorption kinetic and adsorption isotherm experiments for arsenite and arsenate with the composite with 1 : 1 ration of Fe and Mn were conducted using 20 mL high density polyethylene vials. The concentration of As(III) was measured after removal of As(V) with passing the acidified sample (pH 3-5) through an anion-exchange resin in the acetate form (SAX, Alltech, USA) and The concentration of As(V) was determined by difference between total dissolved As(V+III) and As(III). The concentration of As including As(III) and As(V) in solution was determined with an ICP-AES. The effect of pH on adsorption of arsenate was investigated by running adsorption experiments at initial pH range between 3 and 10. The effect of anions on the adsorption of arsenate was investigated with PO_4^{3-}, SO_4^{2-}, CO_3^{2-}, Cl^-.

Results and Discussion

The XRD and morphology indicate that the composite consists of magnetite and birnessite. The surface area increased with increasing magnetite content ranging from 24 to 103 $m^2\ g^{-1}$. The point of zero charge increased with increasing Mn content ranging pH from 3.5 to 8. The removal capacity of As by the composite increased with increasing the Fe content and decreased with increasing the solution pH. The removal of As(III) by the composite occurred via the oxidation As(III) to As(V) by birnessite and then adsorption of the oxidized As(V) by magnetite. Phosphate showed a negative effect on the adsorption of As(III) by the composite.

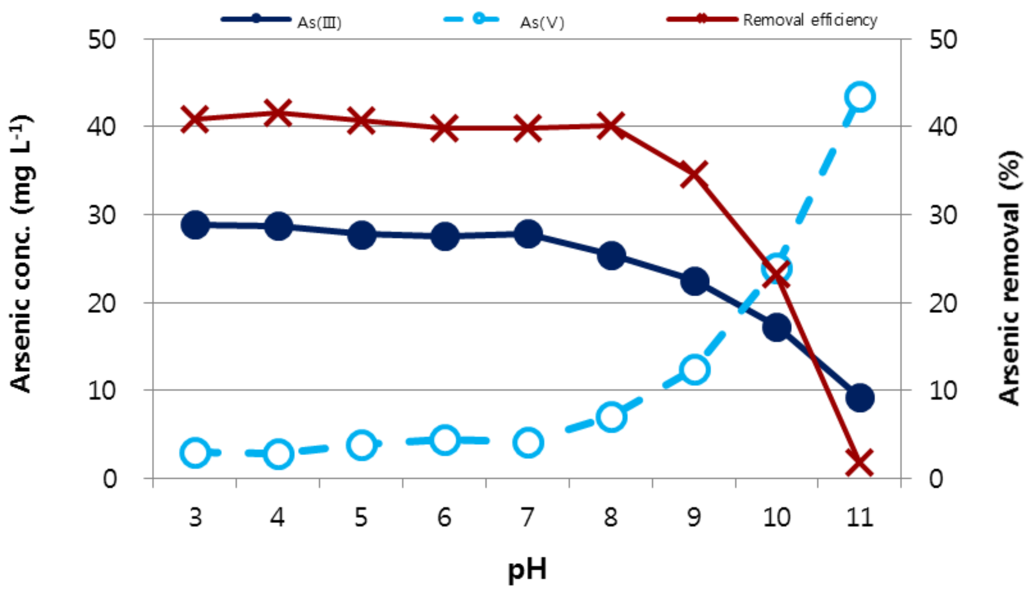

Fig. 1. The effect of pH on removal of As(III) by the composite at initial As(III) concentration of 50 mg L^{-1} and composite concentration of 1g L^{-1}.

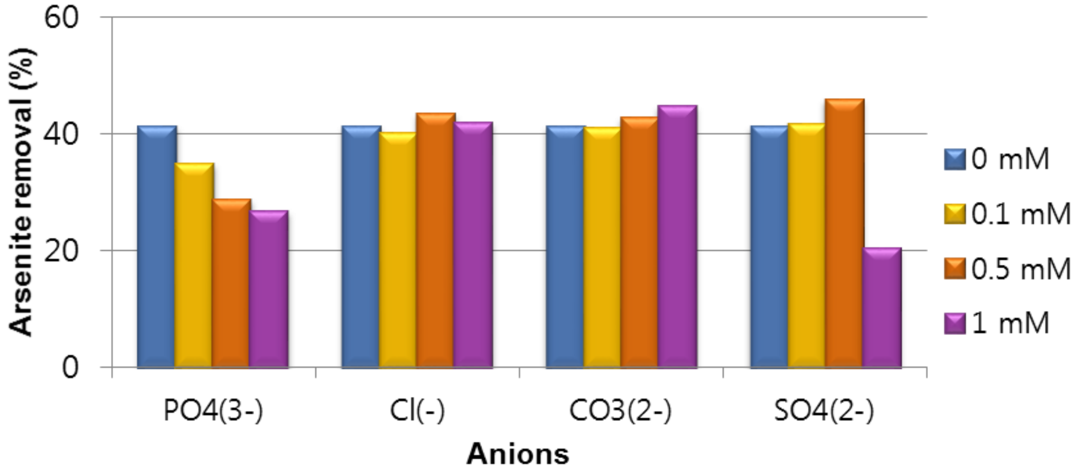

Fig. 2. The effect of anions on adsorption of As(V) by the composite.

Conclusion

The nano-composite of magnetite and birnessite had a high adsorption capacity for As. Arsenite removed by the composite via oxidation by birnessite and adsorption by magnetite. Phosphate showed a negative effect on the adsorption of As on the composite but sulfate, chloride and carbonate showed a little effect. The adsorption of As decreased with increasing solution pH.

References

Sorlini, S., Gialdini, 2010. Conventional oxidation treatments for the removal of arsenic with chlorine dioxide, hypochlorite, potassium permanganate and monochloramine. Water Research. 44, 5653-5659.

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Phytoextraction of sunflower and maize on the Pb contaminated soils exposing to EDTA and DTPA: An example of Yahyalı region of Kayseri in Turkey

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Abstract

Phytoextraction is proposed as an effective method to remove dangerous elements like heavy metals from contaminated soil using high biomass plants. The aim of this study is to determine the effect of EDTA and DTPA applications with increasing concentrations (0, 4, 8 mmol kg-1) on the phytoextraction of maize (*Zea mays*) and sunflower (*Helianthus annuus*) grown in Pb contaminated soil. It is also aimed to determine the quantity of Pb on the surface of soil and the cleaned part of contaminated soil from Pb. Experiment soil was provided from the Pb-Zn carbonate mines, which are located near Kayseri, Yahyalı in Turkey. Plants were grown in controlled greenhouse conditions during 10 weeks. EDTA (ethylenediaminetetraacetic acid) and DTPA (diethylenetriaminepentaacetic acid) were applied to contaminated soil 2 weeks before harvest. At the end of the experiment, total and extractable Pb concentrations of soil and plant have been determined for the purpose of determining the contents of Pb in the sample soil and plants. As a result of EDTA and DTPA applications with increasing doses to the soil, which is, contained total Pb of 448.64 mg kg-1, the increase of Pb concentration on the bodies of maize and sunflower has been observed. The surge of Pb accumulation in these plants was associated with the surge of Pb level in the soil solution due to the addition of chelates to the soil. It was observed that maize and sunflower was not affected by Pb concentration of high level. Soil pH, EDTA and DTPA were found to have an important influence on the potential capacity of plants to absorb Pb and extractable Pb from soil.

Keywords: EDTA, DTPA, lead, maize *(Zea mays)*, phytoextraction, sunflower *(Helianhus annuus)*

Introduction

Heavy metal pollution on soil has been a global problem through the progression of industry and mining activities. It has been estimated that oil and oil products are accounted for 80 per cent of total Pb quantity in atmosphere (Haktanır, et. al. 1995).

Phytoextraction, which is enable to remove the polluters from soil by plants is one of the techniques in recent years in prevent of soil contamination. This process is described as uptake and accumulation of metals into plant shoots, which can be harvested and removed from the site. There have been more than four hundreds plants include trees, vegetable crops, grasses and weeds known as hyperaccumulators of metals, which can accumulate high concentration of metals into their aboveground biomass. Using native plants is of great

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importance for the process because of the fact that these plants are often better in terms of survival, growth and reproduction under environmental stress than plants introduced from other environment (Yoon, et. al. 2006).

The objectives of this study are to determine the effect of EDTA and DTPA applications with increasing concentrations (0, 4, 8 mmol kg-1) on the phytoextraction of maize (*Zea mays*) and sunflower (*Helianthus annuus*) grown in Pb contaminated soil and the quantity of Pb on the surface of soil and the cleaned part of contaminated soil from Pb.

Material and Methods

The soil samples used in this study were collected from the agricultural land cultivating maize (*Zea mays*) and sunflower (*Helianthus annuus*) located in Yahyalı region near the Pb mines of Kayseri, Turkey. Native plants were used in the experiment. Cultivar of maize and sunflower were called "BORA" and "TEKİRDAĞ YERLİ" respectively. Sample soil was putted into the 5 kg pots then after detecting the quantities of azote (nitrogen), phosphor and potassium, the soil was fertilized by calculating according to the needs of plants (Table 1).

Table 1. Forms and quantities of fertilizer on soil

Azot (100 mg kg^{-1})	**Phosphor (60 mg kg^{-1})**	**Potassium (75 mg kg^{-1})**
10 ml NH_4 NO_3 /pot *	10 ml KH_2PO_4/pot**	

* NH4 NO3 fertilizer was given before cultivation and on fourth week.
** KH_2PO_4 fertilizer was given only before cultivation.

Plants were grown in controlled greenhouse conditions during 10 weeks. EDTA (ethylenediaminetetraacetic acid) and DTPA (diethylenetriaminepentaacetic acid) were applied to contaminated soil 2 weeks before harvest. After 2 weeks, the plants were harvested and their wet weights were determined. After the washing of plants, they were dried at 65 °C and they were also weighted for the chemical analyses.

Results and Discussion

The effect of soil reactions on the phytoextraction of sunflower (H. annuus) and maize (Z. mays) on the soils exposing to the EDTA and DTPA.

The soil reactions were diminished, whilst the level of EDTA and DTPA were rising. The difference between dose of the highest degree and the control soils was 0.9 units. The reason of this could be explained that the pH of exposed DTPA was between 2.1-2.5. Pb concentration in soil and Pb accumulation on the plant stem increased related to the diminishing of soil pH. Pb is more beneficial in terms of acid. The concentration of hydrogen ions is one of the prominent features of soils and it effects the beneficial of Pb positively. Usta (1995) stated that the solubility of toxic metal cations and their concentrations on soil raised with acidification. Chlopecka et. al. (1996) also pointed out that low pH soils had better potentials to uptake Pb from plant roots to stems and optimum pH level was about 5.0 then low levels of pH could slow the growth of plants. According to the result of correlation analysis, substantial negative relationship has been found between pH and Pb on plant significance at 5% level (stem: r=-0.925; leaf: r=-0.902) (figure 1).

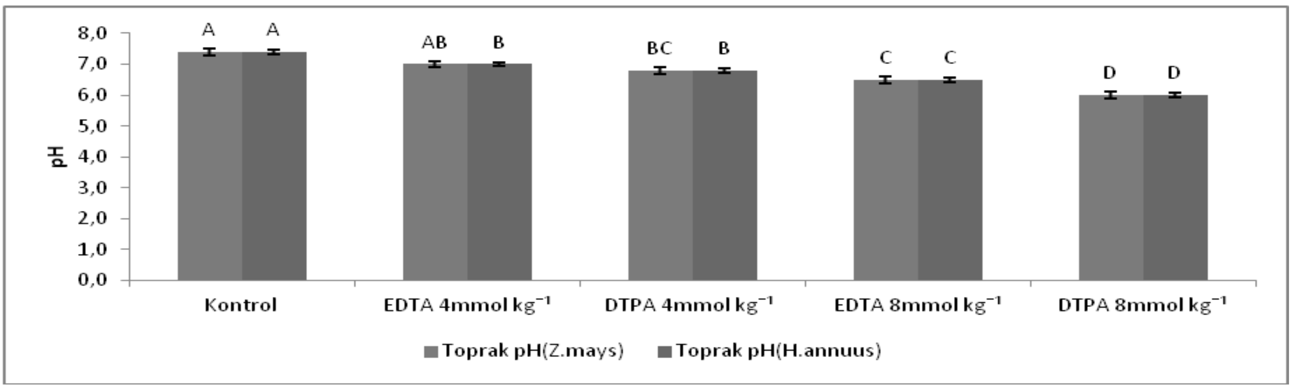

Figure 1. Effect of EDTA and DTPA applications on soil pH.

The effect of Pb contaminated soil exposing to EDTA and DTPA with increasing doses on the total and available Pb concentrations on soil

On the soil cultivating maize (*Z. mays*) exposing to EDTA 8 mmol kg^{-1}, total quantity of Pb on soil decreased 1.9 times and the quantity of Pb on plant also decreased 10.7 times in comparison with the control. Similarly, on the soil cultivating sunflower (*H. annuus*) exposing to EDTA 8 mmol kg^{-1}, total quantity of Pb on soil decreased 1.9 times and the quantity of Pb on plant also decreased 19.2 times in comparison with the control (Table 2). The reason of this was considered that at the highest dose of EDTA (8 mmol kg^{-1}), there was a considerable decrease of soil pH and this increased the available quantity of Pb and uptake of Pb from roots of plant to stem then concordantly total quantity of Pb was diminished in the final position. Besides, high value of the stability constant of Pb^{+2} ion with EDTA (LOG K = 18.0) increases the uptake of Pb on plant (Bucheli-Witshel and Egli 2001).

Table 2. Effects of adding EDTA and DTPA on total, beneficial and embedded Pb of *Z. mays* and *H. annuus**

Implementations	Soil (mg kg^{-1})	Maize (mg kg^{-1})		Soil (mg kg^{-1})	Sunflower (mg kg^{-1})	
(mmol kg^{-1})	Total Pb	Available Pb	Plant Pb	Total Pb	Available Pb	Plant Pb
Control	428.0 A	45.0 A	21.0 D	439.0 A	46.0 A	11.0 D
DTPA 4	380.0 AB	41.0 AB	66.0 C	394.0 AB	43.0 A	54.0 C
DTPA 8	358.0 BC	39.0 AB	90.0 BC	372.0 BC	41.0 A	77.0 C
EDTA 4	313.0 C	34.0 BC	135.0 AB	327.0 C	36.0 AB	122.0 B
EDTA 8	224.0 D	25.0 C	224.0 A	237.0 D	27.0 B	211.0 A

$P < 0.01$

* Table 2, shows the comparisons among vertical doses.

Available Pb and the quantity of Pb, which plant pulled from soil raised related to the decrease of total Pb quantity. According to the result of correlation analysis, the negative relationship has been found between total Pb and available Pb significance at 1% level (r=-0.999, r=-0.997). It is stated that synthetic chelates are used to raise the solubility of metal cations and transportation of Pb in stem (Wallace et. al. 1977, Checka et. al. 1987).

Exposing to EDTA and DTPA concentration in increasing doses raised the available Pb concentration in soil solution at first then it transported the available Pb concentration to the plant stem in 2 weeks process by increasing the mobility of available Pb. This situation caused to decrease the quantity of available Pb in soil solution (Table 2).

According to this experiment, the quantity of Pb removed from soil on the leaf and stem of plant was increased depending on the decrease of Pb quantity in soil solution (Table 2). According to the result of correlation analysis, the negative relationship has been found between the available Pb in soil solution and Pb at maize significance at 1% level (stem r=-0.993; leaf r=-0.972) then the negative relationship has also been found between the available Pb in soil solution and Pb at sunflower significance at 1% level (r=-0.973).

Lombi et. al. (2001) stated that exposing to 10 mmol kg^{-1} EDTA into soil, available Zn and Pb concentrations in the soil solution had approximately doubled along 21 days and compared with the control, they were 31 times bigger than control.

The effects of exposing EDTA and DTPA to contaminated (Pb-Zn) soils cultivating maize (Z. mays) and sunflower (H. annuus) on the quantity of stem and root dry materials of plants

Plant growth was adversely affected and a decrease was seen in the plant weights, whilst the levels of exposing to EDTA and DTPA were rising. All the control plants, which were not exposed to EDTA and DTPA, were seen to continue their normal growth procedure without exposing to the metal toxicity (Table 3).

In this experiment, stem dry weights decreased depending on decrease stem wet weights for both of two plants. Similarly, depending on decrease root wet weights, root dry weights decreased. According to the result of correlation analysis, the significant positive relationship has been found between the wet and dry weights of the stem of maize significance at 1% level (r=0.972). In a similar way, there was a significant positive relationship between wet and dry weights of the root of maize significance at 1% level (r=0.990). For sunflower, the significant positive relationship has been found between the wet and dry weights of the stem significance at 1% level (r=0.994). Similarly, the significant positive relationship has been also found between wet and dry weights of the root significance at 1% level (r=0.998). Hovsepyan and Greipsson (2005) pointed out that after 5 mmol kg EDTA exposing to maize (*Z. mays*), Pb concentration on plant stem increased but concordantly plant weight decreased.

Table 3. Effects of EDTA and DTPA applications on the quantities of dry and wet materials of maize (*Z. mays*) and sunflower (*H. annuus**

Implemen-tations (mmol kg^{-1})	Maize				Sunflower			
	stem		root		stem		root	
	wet weight, g plant $^{-1}$	dry weight, g plant $^{-1}$	wet weight, g plant $^{-1}$	dry weight, g plant $^{-1}$	wet weight, g plant $^{-1}$	dry weight, g plant $^{-1}$	wet weight, g plant $^{-1}$	dry weight, g plant $^{-1}$
Control	231.00 A	34.00 A	22.00 A	4.08 A	228.00 A	20.00 A	14.00 A	2.60 A
DTPA 4	209.00 B	31.00 B	21.00 A	3.91 AB	211.00 AB	18.00 AB	12.00 AB	2.25 AB
DTPA 8	193.25 BC	29.00 BC	18 AB	3.42 AB	206.00 AB	17.00 B	10.00 BC	1.98 BC
EDTA 4	190.25 C	30.00 BC	16.00 BC	3.33 B	200.00 BC	16.00 BC	10.00 BC	2.00 BC
EDTA 8	175.00 C	28.00 C	12.00 C	2.54 C	180.00 C	14.00 C	8.00 C	1.66 C

P< 0.01

* Table 3, shows the comparisons among vertical doses.

Biomass production of the plants exposed to toxic metals is generally reduced. This rule is peculiar to the high-accumulated plants (Hammer and Keller, 2003; Vervaekea, et. al. 2003; Mc Grath, et. al. 2006; Zhuang, et.al. 2007). Cooper et. al. (1999) stated that sunflower had lower dry matter accumulation but the highest Pb concentration compared to the grass and pea. Furthermore, in the light of experimental agricultural studies, sunflower had been found to be a proper plant for the object of phytoextraction and it was also pointed out that sunflower tolerated to metal and obtained higher yields.

The Pb contents of maize (Z. mays) and sunflower (H. annuus)

Pb concentrations on the plants (stem, leaf, and root) increased, whilst exposing levels to EDTA and DTPA were rising. This study showed that the most proper chelate compound for increasing phytoextraction of Pb was EDTA and in increasing doses of EDTA, the relationship between EDTA and DTPA was occurred as EDTA>DTPA. The transition factor is the ratio of element concentration on leaf to element concentration on root and it can be used to evaluate the accumulation of heavy metals on a plant. Transition factor, which is greater than 1, means to transport metals from root to leaf. The transition factor of maize (*Z. mays*) in EDTA 8 mmol kg^{-1} dose was 2.38 and the transition factor of sunflower (H. annuus) in EDTA 8 mmol kg^{-1} dose was 1.92. These showed the transportation of Pb from root to leaf. In rest of the doses, transition factor was less than 1.

At the beginning, the plant cells of maize and sunflower absorbed Pb expeditiously and at the end of a certain process, Pb concentration inside of the cell was much higher with respect to the solution of outside. This important phenomenon is called the Pb accumulation. Similarly, Kacar et. al. (2009) defined the accumulation of metal as the rate of metal concentration inside of the cell to outside of that.

The most substantial increase of Pb quantity on plant stem occurred at the highest dose (8 mmol kg^{-1}) of exposing to EDTA. Pb accumulated on plant in the form of root<stem<leaf. This showed that the phytoextraction occurred successfully. According to the studies regarding this issue, after exposing to EDTA, Pb was reported in the form of beneficial Pb-EDTA compound for uptake of the plant (Vassil, et. al. 1998). Maize (*Z. mays*), clover/lucerne (*Medicago sativa*) and sorghum (*Sorghum bicolor*) were found the effective crops in phytoremediation due to their fast growth rates and large amount of biomass (USEPA, 2000).

The most substantial increase of Pb quantity on plant leaf occurred at the highest dose (8 mmol kg^{-1}) of exposing to EDTA. Maize and sunflower are the fast growing and high biomass producing plants. In this research, it was observed that the Pb accumulation on plant stem was increasing. According to the control, Pb quantity on plant root increased in parallel with the increasing doses. The highest increase of Pb quantity on plant root occurred statistically at the 4 mmol kg^{-1} dose of exposing to EDTA (Table 3-4). EDTA was influential significantly in entering Pb^{+2} into the stem cell of plant and transmission of Pb^{+2} from cell to cell and transporting Pb^{+2} to the stem and leaf. Karczewska et. al. (2009) pointed out that as a result of exposing EDTA to soil for maize, Pb concentration raised, by extension, Pb transportation on xylem was facilitated and the bonding of Pb by root tissues and the transportation of Pb from root to stem increased. While the chelates were assimilated, it was stated that almost all of them were carried from root to shoots and the metal-EDTA complexes, which were carried to xylem juice after the classification of carbon fraction of EDTA, might be taken by the plant (Vassil, et. al. 1998; Heidari, et. al. 2005).

Lin, et. al. (2009) stated that Pb concentration for sunflower (*H. annuus*) were raised in the form of leaf>stem>root and best result was given by exposing EDTA in 3.2 mmol kg $^{-1}$. Besides, Huang, et. al (1997) detected that sunflower (*H. annuus*) accumulated 3000 mg kg^{-1} Pb in its stem, additionally the most effective chelate was EDTA in the mobility of Pb and exposing EDTA in maize raised the transportation of Pb from root to xylems. On the other hand, Shen, et. al (2002) determined the sequence of chelates raises uptake of Pb in the form of EDTA>HEDTA>DTPA>NTA>citric acid.

Table 4. Effects of EDTA and DTPA on plant extraction of Pb by maize *(Z. mays)* and sunflower *(H. annuus)* ($mgkg^{-1}$)*

Implementations	maize			sunflower		
(mmol kg^{-1})	root Pb	stem Pb	leaf Pb	root Pb	stem Pb	leaf Pb
Control	13.0 C	5.0 D	3.0 C	6.0 C	3.0 D	2.0 C
DTPA 4	40.0 B	14.0 CD	12.3 BC	34.0 B	11.0 CD	9.0 BC
DTPA 8	36.0 B	27.0 BC	27.0 BC	33.0 B	23.0 BC	21.0 BC
EDTA 4	61.0 A	36.8 B	37.0 B	58.0 A	33.0 B	31.0 B
EDTA 8	45.0 B	72.0 A	107.0 A	48.0 A	71.0 A	92.0 A

$P< 0.01$

* Table 4, shows the comparisons among vertical doses.

Conclusion

This study aimed the effects of exposing EDTA and DTPA to Pb contaminated soils (0, 4, 8 mmol kg^{-1}) on the growth of maize (*Z. mays*) and sunflower (*H. annuus*), pH on soil, total and beneficial Pb contents and available Pb form taken by plants (metal-EDTA, metal-DTPA). The metal concentrations of plants in their cultivated biomass are directly proportionate to the plant biomass. Generally, it is observed that maize (Z. mays) and sunflower (H. annuus) tolerate to high Pb concentration and EDTA and TPA concentrations with increasing doses due to their high biomass.

According to the result of this study, despite maize (*Z. mays*) and sunflower (*H. annuus*) were not hyper accumulator plants, no significant toxic buffering effect and no mortality of plant were observed with increasing Pb quantity caused by exposing EDTA and DTPA. Maize (Z. mays) and sunflower (H. annuus) was considered particularly as an annual plants in the research. Because annual plants are more convenient to increase the efficiency of phytoextraction than perennial plants.

EDTA was found to be the best desorb tool and it was also observed that the Pb-EDTA complex enabled this element (EDTA) usable in the large biomass, which contains 1% Pb with dry weight base and is not an accumulator like maize. It was determined that DTPA caused to increase the extractable Pb quantity significantly in the potting soils. Because of the longer biodegradation period of DTPA than EDTA, EDTA is recommended to use for the phytoremediation of Pb contaminated sites.

Recent researches has stated that the possibility on the linkages of extractable Pb into underground water has been rising. Because of the environmental concerns, minimizing the usage of EDTA and cultivating of plant after the end of implementation are highly recommended in phytoextraction of maize and sunflower on the Pb contaminated soils.

References

Bucheli-Witschel M, Egli T (2001) Environmental fate and microbial degradation of aminopolycarboxylic acids. FEMS Microbiology Reviews 25: 69–106

Checka RT, Corey RB, Helmke PA (1987) Effects of ionic and complexed metal concentrations on plant uptake of cadmium and micronutrient metals from solution. Plant and Soil 99: 335-345

Chlopecka A, Bacon JR, Wilson MJ, Kay J (1996) Forms of cadmium, lead, and zinc in contaminated soils from southwest Poland. Journal of Environmental Quality 25: 69-79

Cooper EM, Sims JT, Cunningham SD, Huang JW, Berti WR (1999) Chelate-assisted phytoextraction of lead from contaminated soils. Journal of Environmental Quality 28: 1709-1719

Haktanır K, Arcak S, Erpul G, Tan A (1995) Yol kenarındaki topraklarda trafikten kaynaklanan ağır metallerin birikimi. Journal of Engineering and Environmental Sciences 19: 423-431

Hammer D, Keller C (2003) Phytoextraction of Cd and Zn with Thlaspi caerulescens in field trials. Soil Use and Management 19: 144–149

Heidari R, Khayami M, Farboodnia T (2005) Effect of pH and EDTA on Pb Accumulation in Zea mays seedlins. Journal of Agronomy 4: 49-54

Hovsepyan A, Greıpsson S (2005) EDTA-enhanced phytoremediation of lead contaminated soil by corn. Journal of Plant Nutrition 28: 2037-2048

Huang JW, Chen J, Berti WR, Cunningham SD (1997) Phytoremediation of lead-contaminated soils: role of synthetic chelates in lead phytoextraction, Environmental Science and Technology 31: 800-805

Kacar B, Katkat V, Öztürk Ş (2009) Bitki fizyolojisi. Nobel Bilim ve Araştırma Merkezi Yayınları, 46: 524-535

Karczewska A, Galka B, Kabala C, Szopka K, Kocan K, Dziamba K (2009) Effects of various chelators on the uptake of Cu, Pb, Zn and Fe by Maize and Indian mustard from silty loam soil polluted by the emissions from copper smelter. Fresenius Environmental Bulletin 10: 1967-1974

Lin C, Liu J, Liu L, Zhu T, Sheng L, Wang D (2009) Soil amendment application frequency contributes to phytoextraction of lead by sunflower at different nutrient levels. Environmental and Experimental Botany 65: 410-416

Lombi E, Zhao FJ, Dunham SJ McGrath SP (2001) Phytoremediation of heavy metal-contaminated soils: Natural hyperaccumulation versus chemically enhanced phytoextraction. Journal of Environmental Quality 30: 1919–1926

McGrath SP, Lombi E, Gray CW, Caille N, Dunham SJ, Zhao FJ (2006) Field evaluation of Cd and Zn phytoextraction potential by the hyperaccumulators Thlaspicaerulescens and Arabidopsis. Environmental Pollution 141: 115–125

United States Environmental Protection Agency (2000) Introduction to Phytoremediation. 600/R-99/107: 14-18

Usta S (1995) Ankara Üniversitesi Ziraat Fakültesi Yayınları No:1387, Ders Kitabı No:401: 186-191

Vassil AD, Kapulnik Y, Raskin I, Salt DE (1998) The role of EDTA in lead transport and accumulation in Indian mustard. Plant Physiology 117: 447–453

Vervaekea P, Luyssaerta S, Mertensa J, Meersb E, Tackb FMG, Lusta N (2003) Phytoremediation prospects of willow stands on contaminated sediment: a field trial. Environmental Pollution 126: 275–282

Wallace A, Romney E, Alexander G, Kınnear J (1977) Phytotoxicity and some interactions of the essential trace metals iron, manganese, molybdenum, zinc, copper, and boron. Communications in Soil Science and Plant Analysis 8: 741-750

Yoon J, Cao X, Zhou Q, Ma LQ (2006) Accumulation of Pb, Cu, and Zn in native plants growing on a contaminated Florida site. Science of the Total Environment 368: 456–464

Zhuang P, Yang QW, Wang HB, Shu WS (2007) Phytoextraction of Heavy Metals by Eight Plant Species in the Field.Water Air and Soil Pollution 184: 235-242

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Critical level of boron and its relationship to relative yield of shoot dry matter, leaf and grain in wheat in eastern littoral soils of Caspian Sea

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Abstract

This research has been studied in northwest and southwest of Gorgan river in eastern littoral soils of Caspian Sea. The Boron concentration in plant samples had range between 24.65 to 141.73 mg/Kg. B concentration in plants had positive correlation with soil pH and soil EC (α=0.01). The soil B critical level was 3 mg/Kg, for shoot dry matter was 15 mg/Kg, for shoot dry matter relative yield was 3 mg/Kg, and for relative uptake was 4 mg/Kg. boron critical level of grain relative yield was 3 mg/Kg .

Keywords: Boron, Critical level, Relative yield, shoot dry matter, Caspian Sea

Introduction

Boron is one of the seven essential micronutrients required for normal growth of the most plants. The range of B concentrations in the soil solution causing neither deficiency nor toxicity symptoms in plants is narrow (Keren&Bingham1985). Boron uptake by plants is generally controlled by the B level in soil solution rather than total B content in the soil (Keren1985,Yermiahu 2001).The average value of soil solution B has range between 30-200 mg/Kg. The B concentration in plants has range between 5-50 mg/Kg , but this value is different in various soils and plants(Salardini 1382). The widespread role of Boron within the plants includes: Cell-wall synthesis, sugar transport, Cell division, membrance functioning , root elongation, regulation of plant hormone level, and generative growth of plants (Marschner 1995). Fleming 1980 reported that range of total B in soils is between 21.5 to 96.3 mg/Kg. the critical level of B in soils is about 5 mg/Kg (Mortvedet 1972, Mengel 1987). The average concentration of Hot water extractable boron is 30 mg/Kg but sometimes it reaches about 200 mg/Kg that lead to toxicity in some plants (Tsadilas 1994). The optimum concentration of plant B is 25 to 50 mg/Kg(Conforth&Sinkler 1982). Chapman 1960 reported that critical level of B in wheat shoot dry matter is 20 mg/Kg and deficiency symptoms appear in less than 20 mg/Kg. Adriano 1960 reported that critical level of B in wheat is 15 mg/Kg and deficiency symptoms appear in less than 15 mg/Kg. Ross 1997 reported that the critical level of B in wheat and barley has range between 10 -13 mg/Kg.

Material and Methods

22 soil samples from cultivated sites ranging widely physical-chemical properties were sampled from surface horizon (0-30 cm) of northern and southern Gorgan river fields. Soil samples were ground and passed from 1mm sieve.

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Results and Discussion

Relationship between available soil B and soil properties

The results of correlation between soil B and soil pH , soil EC is shown in table 1 that indicates the Hot water extractable Boron has positive correlation with soil EC , soil pH(α=0.01) and there is no correlation between HWS-B and soil organic matter. Jin 1987, Mendal 1993, Hou 1994, Yermiyahu1995 reported that Hot water extractable boron is controlled by various factors such as pH, OM,clay minerals and tillage management. Tsadilas 1994 and Gu&Lowe 1990 reported that the soil solution B tend to increase with pH increasing. In this research Hot water extractable B concentration increased with pH increasing (fig1).

Table1: Correlation Coefficient between soil B and soil properties

	EC(ds/m)	PH	HWS-B
HWS-B	0.39**	0.93**	1

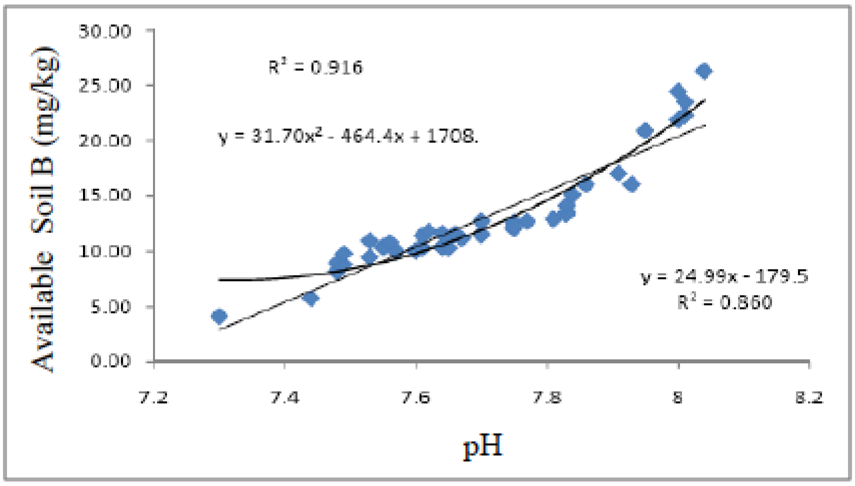

Fig 1. Relationship between Soil B and pH

Relationship between plant B and available soil B and soil properties

The result of correlation test between plant B concentration and available soil B and soil properties is shown in table 2. that indicate there is a positive correlation between plant B and available soil B(α=0.01) fig2 and soil EC(α=0.05) and with soil pH(α=0.01)fig3 . the plant B increased with increase of soil B. Hot water extractable boron is a suitable index for available boron(Bingham 1982). Boron uptake by plants is generally controlled by the B level in soil solution rather than total B content in soil (Keren1985).

Table 2. Correlation Coefficient between plant B and soil properties

	EC(ds/m)	pH	Soil B(mg/Kg)	Plant B(mg/Kg)
Plant B(mg/Kg)	0.36*	0.91**	0.97**	1

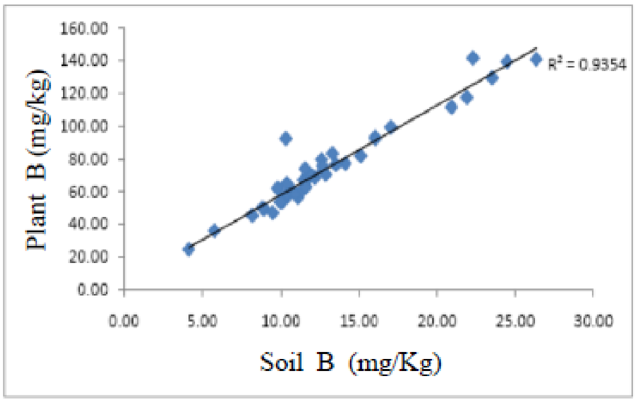

Fig 2. Relationship between soil B and plant B

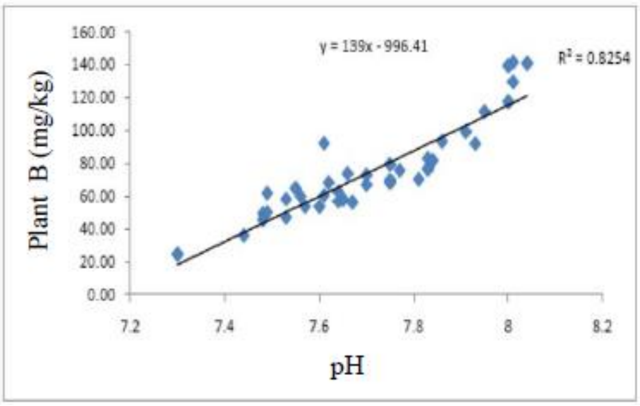

Fig 3. Relationship between pH and plant B

Boron critical level in wheat shoots dry matter

The plant Boron concentration had range between 24.65 to 141.73 mg/Kg. the critical level of soil B for wheat shoot dry matter by Kate-Nelson Method was 15 mg/Kg.(fig4). Adriano 1986 reported that the optimum B content in plants has range between 5-50 mg/Kg , but this value is different in various soils and plants. Chapman 1967 said the critical level of soil boron for plant is 15 mg/Kg and deficiency level is less than 15 mg/Kg. Martin 1965 reported that the critical level of soil B for wheat has range between 10-20 mg/Kg and deficiency level is less than 15 mg/Kg. Conforth and Sinkler 1982 said the critical level of soil B in Wheat has range between 20-24 mg/Kg anddeficiency level is less than 20 mg/Kg . Adriano 1986 said the toxicity level is upper than 16 mg/Kg . Martin 1965 said toxicity level is upper than 200 mg/Kg and Conforth 1982 said toxicity level is upper than 35 mg/Kg. Critical B concentration values showed great variation , such as 10-130 ppm in plant dry matter for wheat and barley ,Although 5 ppm soil boron (HWS-B) is considered the critical level by many researchers , this quantity didn't reflect the response of many plant species cultivated under arid and semi-arid conditions. (Ross etal 1997).

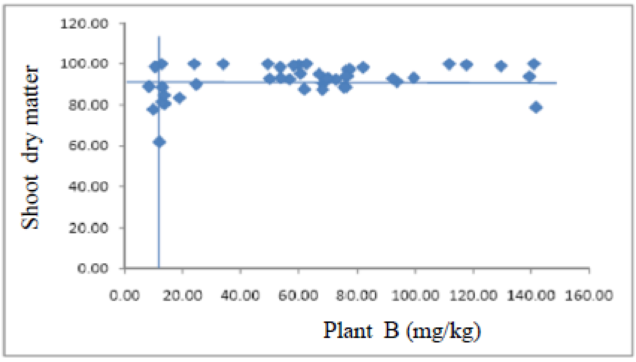

Fig 4. Critical level of soil B for Wheat shoot dry matter

Critical level of Boron in Wheat dry matter Relative yield and relative uptake

Dry matter relative yield Vs Hot water extractable B is shown in Fig5. The critical level of soil B for Relative yield of plant dry matter was 3 mg/Kg. shoot dry matter in Wheat decrease with increase of soil B and soil salinity (Bingham 1987). Mortvedett 1972 and Mengel 1987 reported that critical level of soil B for relative yield of plant dry matter is 5 mg/Kg. Mahler and Shafiee 2007 said the critical level of soil B for Legumes in 30 cm depth is 0.5µg/g and also said Legumes need higher B requirement than Cereals. Smith and Witton 1975 reported that applying 7-10 mg/Kg B lead to decrease 10% relative yield of Noble. but there is no decreasing in relative yield with applying 35 mg/Kg B in saturated extract(Showman 1969). Adriano 1986 reported that the critical level of soil B for relative yield in Wheat is 2.1-5 mg/Kg and sufficient groundnut yield increase in 54% ,but applying 3 Kg/hac B lead to decreasing groundnut relative yield. Aitken and Mccullum 1988 said there is a linear relation between soil solution B and relative yield of Sun flower in toxicity range of B.

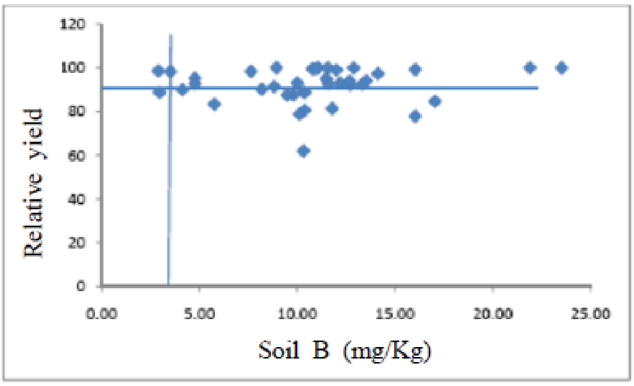

Fig 5. Critical level of Boron in Wheat dry matter Relative yield

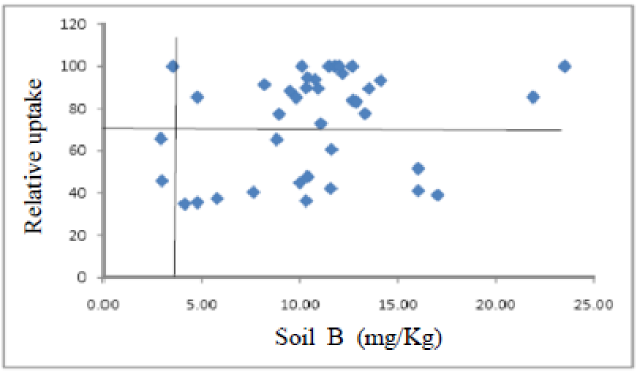

Fig 6. Critical level of Boron in Wheat relative uptake

Relationship between soil B and Grain relative yield

Critical level of soil B for Grain relative yield was 3 mg/Kg. Fig 7.

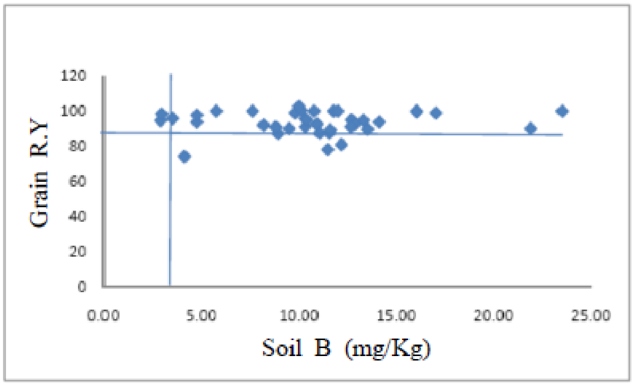

Fig 7. Critical level of soil B for Grain relative yield

Conclusion

1-In these soils plant B concentration had positive correlation with soil B(α=0.01). soil EC(α=0.05) and soil pH(α=0.01)

2-Critical level of soil B for Wheat shoot dry matter was 15 mg/Kg.

3-Critical level of soil boron for Wheat relative yield and for Grain relative yield were 3 mg/Kg .

References

Adriano, D. C. 1986. Trace Elements in the Terrestrial Environments. PP,73-105.Springer-Verlag, New York.

Chesworth, W., 1991. Geochemistry of micronutrients. Micronutrients in Agriculture. Eds. J. J. Mortvdet., F. R. cox., L. M. Shumman and R. M. Welch., pp 1-30 . Soil Sci. Soc .A m. Madison, WI, USA

Elrashidi, M. A., Oconner, G.A., 1982. Boron sorption and desorption in soils. Soil Sci. Soc. Am .J. 46, 27-31

Gupta, U. C., 1993. Boron and its Role in crop production. CRC Press, 137-145.

Gu, B., Lowe, L. E., 1990. Studies on the adsorption of boron on humic acids. Can. J. Soli Sci. 70, 305 – 311.

Jin, J., Martens, D. C., 1987. Distribution and plant availability of soil boron fractions. Soil . Sci. Soc. Am. J. 51, 1228-1231.

Keren, R., Bingham, F.T., 1985. Plant uptake of Boron as affected by boron distribution between liquid and solid phases in soil. Soil . Sci. Soc. Am. J. 49, 297-302

Mahler, R. L., Shafii, B. 2007. Relationship between soil test boron and lentil yields in the England pacific North west Commun. Soil . Sci . Plant. Anal. 38,1193-1202

Mandal, B., Adbikari, T. K., and De, D. K., 1993. Effect of lime and organic matter application on the availability of added boron in acidic alluvial soils. Commun. Soil Sci. Plant Anal. 24, 1925-1935.

Mengel, D. B., Barber, S. A., 1974. Rate of nutrient uptake per unit of corn root under field conditions. Agron. J. 66,399-402.

Nable, R. O., Gary, N., Banuelos, S. 1997. Boron toxicity . Plant and Soil . 193, 181-198.

Nicholaichuk, W. A., Leyshon, J., Jame, Y. W., and Campbell , C. A. 1988. Boron and Salinity Survey of irrigation projects and the Boron adsorption characteristic of sum S. Saskatchewan soils. Can. J. Soil Sci. 68,77-90.

Onder, E. C. 2007. Response of chickpea cultivars to application of Boron in boron deficient calcareous soils. Communication in Soil Science and plant Anal. 38, 2381-2399

Schuman, G. E. 1969. Boron Tolerance of tall Wheat grass. Agron. J. 61,445-447.

Simard, R. R., Charron, G. 1996. Field calibration of boron soil tests for barley . Commun. Soil Sci. Plant Anal. 27,1631-1646.

Wiliam, D. D. 2004. Macro benefits from micro nutrients for grey to green revolution in agriculture in: Response of chickpea cultivars to application of Boron in boron deficient calcareous soils. Communication in Soil Science and plant Anal. 38, 2381-2399.

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Fractionations of Boron and its relationship with soil properties in Eastern littoral soils of Caspian Sea

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Abstract

The various forms of Boron in Eastern littoral Soils of Caspian Sea in Golestan province were investigated. The dominant forms of Boron in these soils were in order Hot water extractable B> Nonspecific adsorbed B(NSA-B)> Specific adsorbed B(SPA-B)> Mn oxy Hydroxy B(MOH-B)> Amorphous Fe-Al B(AMO-B).the Hot water extractable Boron had positive correlation with SPA-B(α=0.01) and NSA-B had positive correlation with MOH-B and also SPA-B(α=0.01).SPA-B had significant positive correlation with pH in(α=0.01) and had significant positive correlation with clay percentage (α=0.05).

Keywords: Boron fractions, Soil properties, Caspian Sea

Introduction

Boron is one of the seven essential micronutrients required for normal growth of most plants (Ganter 2003). However, the range of B concentrations in the soil solution causing neither deficiency nor toxicity symptoms in plants is narrow(Keren, Bingham 1985).the primary source of boron in most soils are tourmaline and the volatile emanations of volcanoes (Chesworth1991). Tourmaline from high temperature rocks is very resistance to chemical breakdown in the weathering zone and thus accumulates in the clastic fractions of sediment and sedimentary rocks. In igneous, metamorphic, sedimentary rocks, B occurs as Borosilicate, which are resistant to weathering and not readily available to plants. Mobilization of immobile forms of rock B occurs by weathering in the pedosphere, which include soil reaction of acid-base, oxidation-reduction and dissolution precipitation. The dominant species in soil when B from primary silicates goes into solution is $B(OH)_3$ boric acid. This form of B is mobile and easily lost by leaching. In soils, this form of B can be taken up by vegetation, held by organic matter or temporarily adsorbed on fine mineral fractions(Nable1997). Boron is disturbed in various soil components including, soil solution, organic matter and minerals. Boron in soil solution is readily available for plant uptake, but this source constitutes is less than 3% of soil B(Jin etal 1987, Tsadilas 1994). Maintaining in soil solution is important for plant nutrition (Keren,Bingham 1985).It controlled by pools of B in other soil components and their equilibration with the soil solution (Xu,Wang 2001). The factors influencing B adsorption and desorption from soil constituents are: i)B concentration in soil solution, ii)PH, iii)type of exchangeable ions, iv)ionic composition of the soil solution, v) wetting and drying cycles(Keren 1985). A variety factors such as pH, OM, clay minerals, Fe, Al oxides, Carbonates and tillage management may change

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the content of extractable B, and transformed among different soil B fractions(Jin etal 1987.,Mandal etal 1993, Hou etal 1994). The content of water soluble B in soils tend to increase with soil pH increasing, but not always in consistent manner(Tsadilas 1994, Xu etal 2001). Probably because B adsorption by soil components also increased with the increase of pH and reaches to maximum level in alkaline pH range(Gu&Lowe 1990, Xu&Wang2001). Hot water extractable B is suitable index of plant available B (Bingham 1982) but in some studies Hot water extractable B have not been correlated with plant response (Simard&Johnson 1991). Fleming 1980 reported that the total B content in soil had range between 21.5- 96.3 mg/Kg. Total B content in soil had range between 2-100 mg/Kg (Mengel1987). The average content of Hot water extractable B in soils is 30 mg/Kg but sometimes reaches to 200 mg/Kg (Tsadilas 1994). Elrashidi and Oconnor 1982 indicated positive correlation between organic matter content and boron uptake. Gupta 1968 found a positive correlation between organic matter and Hot water extractable B. Boron uptake in soil is an important phenomenon (Arora& Kahal 2007). Jin etal 1987 separated soil Boron to Nonspecific adsorbed B, Specific adsorbed B, Mn oxy hydroxy B, Residual B, Amorphous Fe-Al B and also reported that the Maize Boron content had positive correlation with Hot water extractable B but did not have correlation with NSA-B and SPA-B.

Material and Methods

Soil samples

22 soil samples from cultivated sites ranging widely physical-chemical properties were sampled from surface horizon (0-30 cm) of northern and southern Gorgan river fields. Soil samples were ground and passed from 1mm sieve.

Fractions of soil Boron

Methods and procedures for separated of soil B fractions were based on the sequential fractionation procedure of Jin 1987. The extraction methods are summarized in table 1. Soil B was divided into Nonspecific adsorbed Boron(NSA-B), Specific adsorbed Boron(SPA-B), B occluded in Mn oxyhydroxides (MOH-B), B occluded in amorphous Fe-Al oxides(AMO-B) and residual B. Boron concentration in the extracted solutions were determined by inductively coupled plasma-atomic emission spectrometry. and boron were determined with Azomethyn H procedure. Simple correlation analysis was used to calculate the correlation coefficients between soil B fractions and soil properties.

Table 1 .Summary of extraction procedures of various B fractions in soil (based on Jin etal 1987)

B fractions	Extraction procedures
Nonspecifically adsorbed Boron (NSA-B)	10g soil,20ml Cacl2,shaking for 24h,at25C
Specifically adsorbed Boron (SPA-B)	6g soil,20ml 0.02 M mannitol in 0.02 M Cacl2,shaking for 24h,at 25C
B occluded in Mn oxyhydroxides (MOH-B)	4g soil, 40ml HNO3, shaking for 30 min ,at 25 C
B occluded in Amorphous Fe-Al oxides (AMO-B)	1g soil, 50ml 0.2 M NH4-oxalate, shaking for 2h in dark ,at25C
Residual B (RES-B)	Digestion with HCL+HNO3+HF mixture

Results and Discussion

Fractionations of soil Boron

Various content of soil B including: NSA-B had range between 0.17 to 4.1 mg/Kg and SPA-B had range between 0.64 to 4 mg/Kg , MOH-B had range between 0.11 to 1.45 mg/Kg, AMO-B had range between 0.32 to 1.31 mg/Kg., Hot water extractable B had range between 4.1 to 24.46 mg/Kg and RES-B + B contact OM had 8.54-19.87 mg/Kg. in the 13 Chinese soils examined, 87.4 to 99.7% of soil B was in the residual fraction(RES-B), which generally doesn’t relate well to plant –available B. in Jin etal 1987 research boron fractions content had range between, NSA-B 0.02 - 0.26 mg/Kg, SPA-B 0.01 – 0.05 mg/Kg, MOH-B 0.02 – 0.55mg/Kg, RES-B 7 – 39.9 mg/Kg and AMO-B 0.01 – 0.7 mg/Kg. Hou etal1996 found slightly lower proportions of RES-B in soils of Ontario but presented no data on clay levels of soils. Tsadilas etal 1994 found higher proportions of RES-B in all 20 Greek soils tested the contents of B followed the order of RES-B>> CRO-B=MOH-B>NSA-B>SPA-B=AMO-B. The NSA-B fraction is mainly in solution or weakly adsorbed by soil particles, and is believed to be the most readily available fraction of B for plant uptake(Keren & Bingham 1985). The SPA-B fraction may be specifically adsorbed on to clay surfaces or associated with OM in soil (Jin etal 1987).

Correlation between various soil fractions

Hot water extractable B had positive correlation with SPA-B(α=0.01) and NSA-B had positive correlation with MOH-B and SPA-B(α=0.01). results has shown in table 2. Similar results has proved in Xu etal 2001 and Hou etal 1996. Xu etal 2001 reported that The NSA-B fraction was positively correlated with both MOH-B and CRO-B fractions. There was also a close relationship (α=0.01) between SPA-B and MOH-B fractions. Tsadilas etal 1994 reported that there isn't correlation between the MOH-B fraction and either SPA-B or NSA-B in Greek soils. Yermiahu 1988 and Xu etal 2001 reported that there is a positive correlation between SPA-B and MOH-B(α=0.01). There is no relation between RES-B and AMO-B with another forms of B (Jin etal1987).in this research similar results received.

Table 2. Correlation Coefficient between soil B fractions

B fractions	HWS-B	NSA-B	AMO-B	SPA-B	MOH-B	RES-B
HWS-B	1					
NSA-B	0.22	1				
AMO-B	-0.38	0.13	1			
SPA-B	0.52**	0.57**	0.03	1		
MOH-B	0.2	0.98**	0.13	0.57**	1	
RES-B	-0.56	0.11	-.002	-0.11	0.095	1

Relationship between B fractions and soil properties

Results of correlation test has shown that SPA-B had positive correlation with soil pH (α=0.01) and had positive correlation with clay percentage (α=0.05). Table 3. Hot water extractable B had positive correlation with soil pH (α=0.01), and had positive correlation with EC (α=0.01).There were no correlation between soil OM and soil boron fractions. Elrashidi & Oconnor 1982 said there is positive correlation between soil OM and soil boron . Gupta 1986 found a positive correlation between Hot water extractable B and soil OM. Hue 1988 said deficiency of boron occurred in high OM soils. In our research AMO-B had negative correlation with soil pH (α=-0.01). Xu 2001 reported that there is a negative correlation between AMO-B and soil pH and soil clay percentage. Gu & Lowe 1990 had proved similar results. Bingham 1971 found a positive correlation with soil pH and MOH-B increasing solution pH would enhance the oxyhydroxides on the surface of Mn oxyhydroxides which retain B through ligand exchange mechanisms. Xu 2001 said that NSA-B tend to increase with pH increasing .and also said SPA-B had no correlation with any soil properties .There were no correlation between RES-B and any soil components .Hou etal 1996 found that RES-B had significant correlation with the content of clay mica. Tsadilas 1994 found that the SPA-B was correlated with soil pH, and negatively correlated with Fe, Al amorphous and crystalline oxyhydroxides.

Table 3. Relationship between B fractions and soil properties

Soil B fractions	%clay	EC	pH	%OM
HWS-B	-0.12	0.39**	0.94**	0.05
AMO-B	0.39	-0.09	−0.43**	0.22
NSA-B	0.13	0.11	0.27	0.02
SPA-B	0.42*	0.27	0.63**	0.08
MOH-B	0.1	0.16	0.26	-0.04
RES-B	-0.12	-.011	-0.12	0.19

Conclusion

1-The dominant forms of boron in these soils were in order :Hot water extractable B> NSA-B> SPA-B> MOH-B>AMO-B.

2- Hot water extractable B had positive correlation with SPA-B(α=0.01). NSA-B had positive correlation MOH-B and SPA-B (α=0.01).

3- Hot water boron had significant positive correlation with soil EC and soil pH(α=0.01) and with clay percentage(α=0.05).SPA-B had positive correlation with clay percentage in (α=0.05) and with soil pH in(α=0.01).AMO-B had negative correlation with soil pH(α= - 0.01).

References

Arora, S., Chahal, D.C., 2007. Comparison of kinetic models for boron adsorption in alluvium –derived soils of Punjab, india. Commun. Soil Sci. Plant Anal. 38, 523-532.

Chesworth, W., 1991. Geochemistry of micronutrients. Micronutrients in Agriculture. Eds. J. J. Mortvdet., F. R. cox., L. M. Shumman and R. M. Welch., pp 1-30 . Soil Sci. Soc .A m. Madison, WI, USA

Elrashidi, M. A., Oconner, G.A., 1982. Boron sorption and desorption in soils. Soil Sci. Soc. Am .J. 46, 27-31

Gupta, U. C., 1993. Boron and its Role in crop production. CRC Press, 137-145.

Gu, B., Lowe, L. E., 1990. Studies on the adsorption of boron on humic acids. Can. J. Soli Sci. 70, 305 – 311.

Jin, J., Martens, D. C., 1987. Distribution and plant availability of soil boron fractions. Soil . Sci. Soc. Am. J. 51, 1228-1231.

Keren, R., Bingham, F.T., 1985. Plant uptake of Boron as affected by boron distribution between liquid and solid phases in soil. Soil . Sci. Soc. Am. J. 49, 297-302.

Mandal, B., Adbikari, T. K., and De, D. K., 1993. Effect of lime and organic matter application on the availability of added boron in acidic alluvial soils. Commun. Soil Sci. Plant Anal. 24, 1925-1935.

Mengel, D. B., Barber, S. A., 1974. Rate of nutrient uptake per unit of corn root under field conditions. Agron. J. 66,399-402.

Nable, R. O., Gary, N., Banuelos, S. 1997. Boron toxicity . Plant and Soil . 193, 181-198.

Simard, R. R., Charron, G. 1996. Field calibration of boron soil tests for barley . Commun. Soil Sci. Plant Anal. 27,1631-1646.

Tsadilas, C. D., Yassoglou, N. 1994. The availability of soil boron fractions to olive trees and barley and the relationship to soil properties. Plant Soil. 162, 211-217.

Xu, J, M., Wang, K., Bell, R. W. 2001. Soil boron fractions and their relationship to soil properties. Soil . Sci. Soc. Am. J. 65, 133-138.

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Technogenic impact of motorways on adjoined agrocenosis in the black soil zone of Russian South

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Abstract

Wide areas of industrial crops in black soil zone are situated along large motorways. There is an unfavorable ecological situation here due to heavy metals entering the soil and plants. Goal of research: evaluation of the role role of windbreaks in restraining of heavy metals entering the soil and plants in agrocoenosis located near large motorways. Farther from the motorway, beginning from a distance of 50 m the increase of potential stock of lead mobile forms in the soil is recorded, as for current stock it is recorded at a distance of 50 m and 100 m from the motorway. The excessive amount of lead in winter wheat grain was found at a distance of 10m, 50 m and 100m from the motorway. Consequently, windbreaks as a land reclamation factor are not able to control it.

Keywords: black soil zone, heavy metals, agro-forestry

The significant areas of soils in the south of Russia are presented by black soils. Wide areas of industrial crops in black soil zone are situated along large motorways. There is an unfavorable ecological situation here due to heavy metals entering the soil and plants. Numerous investigations have showed that lead is the most important contaminant entering the soil from motorways.

V.M. Ivonin and G.E.Shumakova (1)noted in their research work a positive role of windbreaks in restraining of heavy metals entering the soil and plants in agrocoenosis located near large motorways. The authors investigated 3 agrocoenosis located near the federal motorway "Don":

1. 742 km-Voronez region;
2. 983km-Rostov region;
3. 1045 km-Rostov region.

Agrocoenosis is situated at the wind side from the motorway and closed by windbreaks with thick construction. We conducted reinvestigations of these plots after 15 years ago. During this period of time traffic pressure on the motorway had greatly increased and as a result ecological situation of the agrocoenosis became worse. Selection of soil and plants were conducted in points: 1) 10m, 2) 50m, 3) 100m, 4) 150m, 5) 200m far from the motorway. Soil examples were taken in the layer 0-20cm. The content of lead mobile forms was determined during the analysis:

1. Current stock- with help of acetate-ammonium buffer with pH 4,8;
2. Potential stock-with help of 1% EDTA solution in acetate-ammonium buffer.

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Lead content in plant examples was determined according to the standard procedure.
During our investigations the content of lead mobile forms was determined in soil examples:

1. Current stock- with help of the standard acetate-ammonium buffer with ph 4,8;
2. Potential stock-with help of 1% EDTA solution in acetate-ammonium buffer with ph 4,8.

Advantages of this standard procedure are described in details in researchers of N.V.Nikituyk. (2)
Analysing the investigation of agrocoenosis located at 742 km of the motorway it should be noted that there is no marked impact of windbreaks on control of lead entering the agrocoenosis. Data of our investigation concerning both current and potential stock of lead in soil prove it. According to the data of our investigation the content of potential stock of lead mobile forms decreases only at a distance of 220 m from the motorway. According to the data of our investigation the content of current stock of lead mobile forms decreases only at a distance of 150 m from the motorway. Its greatest amount is recorded at a distance of 220 m from the motorway (fig. 1).

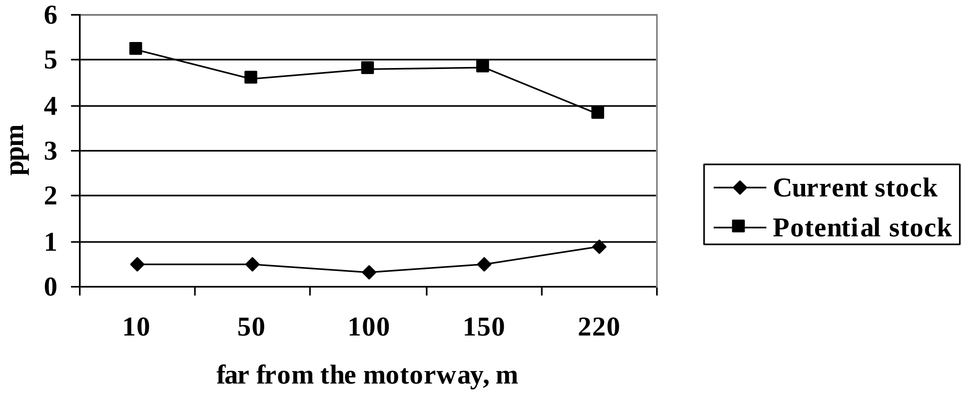

Figure 1. The contents of mobile forms of Pb in the soil (742 km)

The allocation of lead in the soil of agrocoenosis located at 983 km of the motorway also demonstrates its technogenic impact. (fig.2).

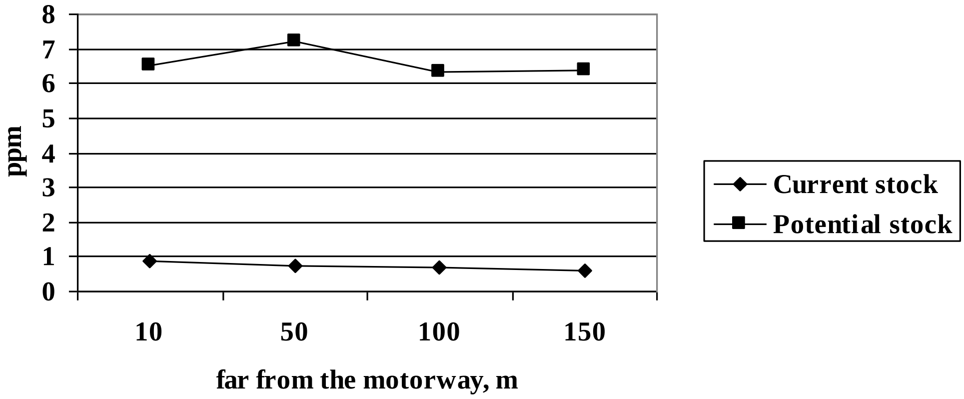

Figure 2. The contents of mobile forms of Pb in the soil (983 km)

The decrease of lead current stock in the soil is recorded at a distance of 150 m from the motorway and potential stock at a distance of 220 m. Besides according to the data of our investigation of lead potential stock there is an increase of its mobile forms amount at a distance of 50 m from the motorway.
The same tendency toward lead allocation in the soil is recorded also during the investigation of agrocoenosis located at 1045 km of the motorway (fig. 3).

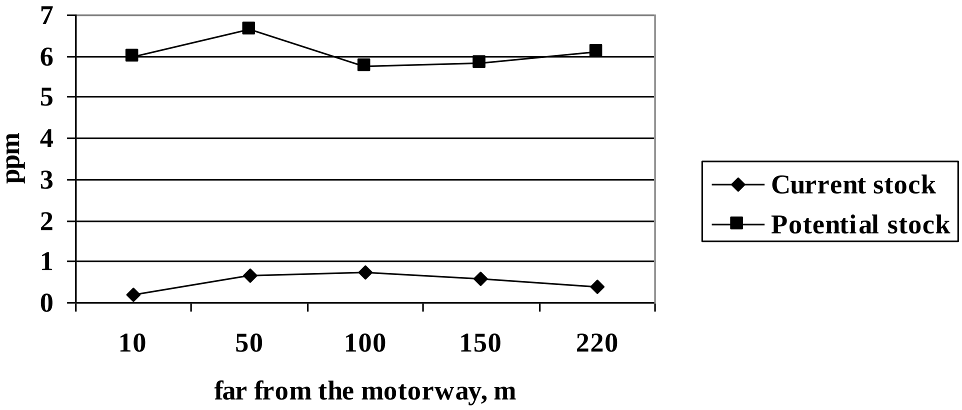

Figure 3. The contents of mobile forms of Pb in the soil (1045 km)

According to the data of V.M. Ivonin and G.E.Shumakova the maximum amount of both current and potential stock of lead in soil was found at a distance of 10 m from the motorway, farther these data decrease greatly. According to the authors such result is caused by forest amelioration factor. It is noted in the research work that technogenic lead entering from the motorway is restrained by trees and settled mainly in the windbreak.
According to the data of our investigation the least amount of mobile lead in both current and potential stock was found at a distance of 10 m from the motorway. Farther from the motorway, beginning from a distance of 50 m the increase of potential stock of lead mobile forms in the soil is recorded, as for current stock it is recorded at a distance of 50 m and 100 m from the motorway. Consequently, windbreaks as a land reclamation factor are not able to control it.
It should be noted that traffic pressure on the motorway is higher at 1045 km and the result is greater technogenic impact on soils in the investigated agrocoenosis.
Chemical analysis of heavy metals content in crops growing in the agrocoenosis should not be excluded from the investigation. During the investigation conducted by V.M. Ivonin and G.E.Shumakova summer barley was grown in the agrocoenosis located at 1045 km of the motorway. The authors noted that the excessive amount of heavy metals in barley grain and straw had not been found.
Winter wheat was grown here during our investigation. The content of lead in winter wheat grain characterizes a clear pattern of its allocation due to a distance from the motorway. The data of investigations are presented in table 1.

Table 1. The content of lead in winter wheat grain, ppm

Variant of experiment	Distance from the motorway,m					Max.Perm.Con.
	10	50	100	150	220	
742 km	0,7	0,2	-	0,2	0,04	0,3
983 km	-	0,3	0,8	0,1	0,3	
1045 km	0,1	0,5	0,5	0,1	0,2	

The excessive amount of lead in winter wheat grain was found at a distance of 10 m from the motorway in the agrocoenosis located at 742 km of the motorway. The grain contained such lead amount must not be used in food. The excessive amount of lead was found at a distance of 100m from the motorway in the agrocoenosis located at 983km of the motorway. The excessive amount of lead in winter wheat grain was found at a distance of 50 m and 100m from the motorway in the agrocoenosis located at 1045km of the motorway. To our mind, increasing of traffic pressure on the motorway has given us the following results lately: the existing windbreaks are not able to manage their reclamation function in agrocoenosis located near large motorways. Consequently, it is necessary to search for other ways of solving this problem.

References

1. Ivonin V.M., 1995. Land improvement/V. Ivonin. Monograph. -Novocherkassk,. -196 with.
2. Nikityuk N.V., 1998. Mobility of heavy metals in chernozem ordinary calcareous and its evaluation: Ab-toref. DIS. ... Cand. c.-h. Sciences. -Krasnodar, -18 with.

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Mapping of saline soils from processed satellite images and agro-ameliorative measures against salinisation

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Abstract

The article deals with the mapping of the saline soils in the Kur-Araz lowland, prepared on the basis of the electronic maps of the agricultural lands and made by the digital processing of the images taken from the artificial satellites of the Earth "LANDSAT-TM" in 1998 and "IKONOS" in 2008. The aim of the work is the definition of the area of saline soils of the Kur-Araz lowland according to the maps of agricultural lands, made in 1998 and 2008 due to the results of the processed satellite images and due to the suggestions on the agro-ameliorative measures preventing the salinisation process. It was ascertained that for the past 10 years, from 1998 to 2008, the area of the saline soils increased by 66.5 thousand hectares as a result of not following the agrotechnical and agro-ameliorative measures, and also of the poor state of the collector-drainage network in the investigated farmlands. For the improvement of the ameliorative conditions of soils, the alternation of crops on the arable lands and the supervision of the proper operation of the drainage-collector network are necessary.

Keywords: the Kur-Araz lowland, saline soils, the artificial satellites of the Earth "LANDSAT-TM", "IKONOS", digital processing, satellite images

Introduction

Saline soils, that are located mainly in the Kur-Araz lowland, have widely spread in irrigated lands of Azerbaijan. The lands of the lowland are 21.532 km² or 24.5 percent of the whole territory of the Azerbaijan Republic.

The Kur-Araz lowland is considered as "geocynclinal intermontane flexure, closed between the elevations of Greater and Lesser Caucasus and Talysh mountains". Its surface was covered with alluvial sediments of the Kur and Araz Rivers and proluvial and dealluvial sediments of the rivers flowing down from the Caucasian ridge.

For their age, the deposits, covering the lowland, refer to the Mesozoic and Cenozoic eras. The top five - ten meters thickness of the modern deposits is the basic and underlying soil. Material and object of reclamation consist of a wide variety of sediments (clay, loam, sandy loam, sand and gravel).

The climate of the Kur-Araz lowland is subtropical dry, warm and continental. Summer is dry and hot, winter is relatively warm and it snows a little. The average annual temperature in the lowland ranges from +14°C to +16°C.

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The vegetation cover of the Kur-Araz lowland refers to a botanical and geographical region of the semi-deserts of the Eastern Transcaucasian plain. At the territory of the lowland, the following types of vegetation are observed: desert, semi-desert, meadow-grass etc.
Depending on the genetical and geographical features of the Kur-Araz lowland, brownish gray soils have spread here. In the conditions of the valley-deltaic hydrogeological regime and under the influence of various moisture intensity, meadow-brownish gray, brownish gray-meadow, meadow and meadow-marshy soils have formed.
In the Kur-Araz lowland, continental delta salt accumulations have widely spread as a coastal delta with its arid climate. Saline soils are characterised by high salinity. Their surface layer contains more than 1% of easily soluble salts. They are formed in the presence of saline groundwater lying at a small depth. One of the essential conditions of groundwater formation in the Kur-Araz lowland is the water saturation of the soil strata lying above the horizon of downstream water. To the factors of formation of groundwater belong all kinds of surface and subterranean nutrition of groundwater. And among them the filteration of water from the irrigation network and also poor condition of collector-drainage network in the investigated territory have essential sense.
In connection with the salinity of soils, the development of irrigated agriculture in the Kur-Araz lowland confronted with the necessity of carrying out many land reclamations.
Depending on soil and ground conditions and ameliorative situations, in 1934-35, the construction of deep collectors and drainage was started in the territory. The construction was carried out on an integrated way: together with the construction of the collector-drainage network, the fundamental planning and production leaching of irrigational and preparatory lands were also realised.
Nowadays, the length of collector-drainage network is about 25.000 km. The total area from the used collector-drainage network is more than 600.000 hectares. The area of saline soils is about 30%-35% of the total territory of the lowland. The reason for such a distribution of saline soils is both the initial salinisation of soil, ground and groundwaters and their secondary salinisation as a result of intensive evaporation of closely located (to the surface) highly mineralised groundwaters with intangible amount of atmospheric precipitations.
To work out the methods of struggle with saline soils, it is necessary to determine their spatial location first.

Material and Methods

The paper presents mapping of saline soils of the Kur-Araz lowland from processed space images taken from the artificial satellites of the Earth "LANDSAT-TM" in 1998 and "IKONOS" in 2008.

Results and Discussion

In 1998, "LANDSAT-TM" was removed from the territory of Azerbaijan in the range of 0.45-0.52; 0.52-0.60; 0.63-0.69; 0.76-0.90; 1.55-1.75; 2.08-2.35; 10.45-12.50 micrometers and was held digital processing, using GIS technology and an electronic map of agricultural lands of the Republic was made at scale 1:50.000.
While processing the multi-channel Earth images, software ERDAS, IMAGINE and ENVI was used. The processing of satelitte images includes more than 100 actions. The basic actions are as follows:

- visualization of images;
- geometric changes;
- radiometric changes;
- filteration of images.

While processing the satelitte images, the methods were used on the basis of cluster analysis of algorithm ERDAS-Isodata for the mapping of agricultural lands and other lands. On this purpose, the spectral channels TM3, TM4 and TM5 were selected.
Note that, as a result of digital processing not only individual farmlands - arable lands, vineyards, forests, pastures, but also saline soils were identified. On the basis of this map, the Kur - Araz lowland was allocated (Fig. 1).

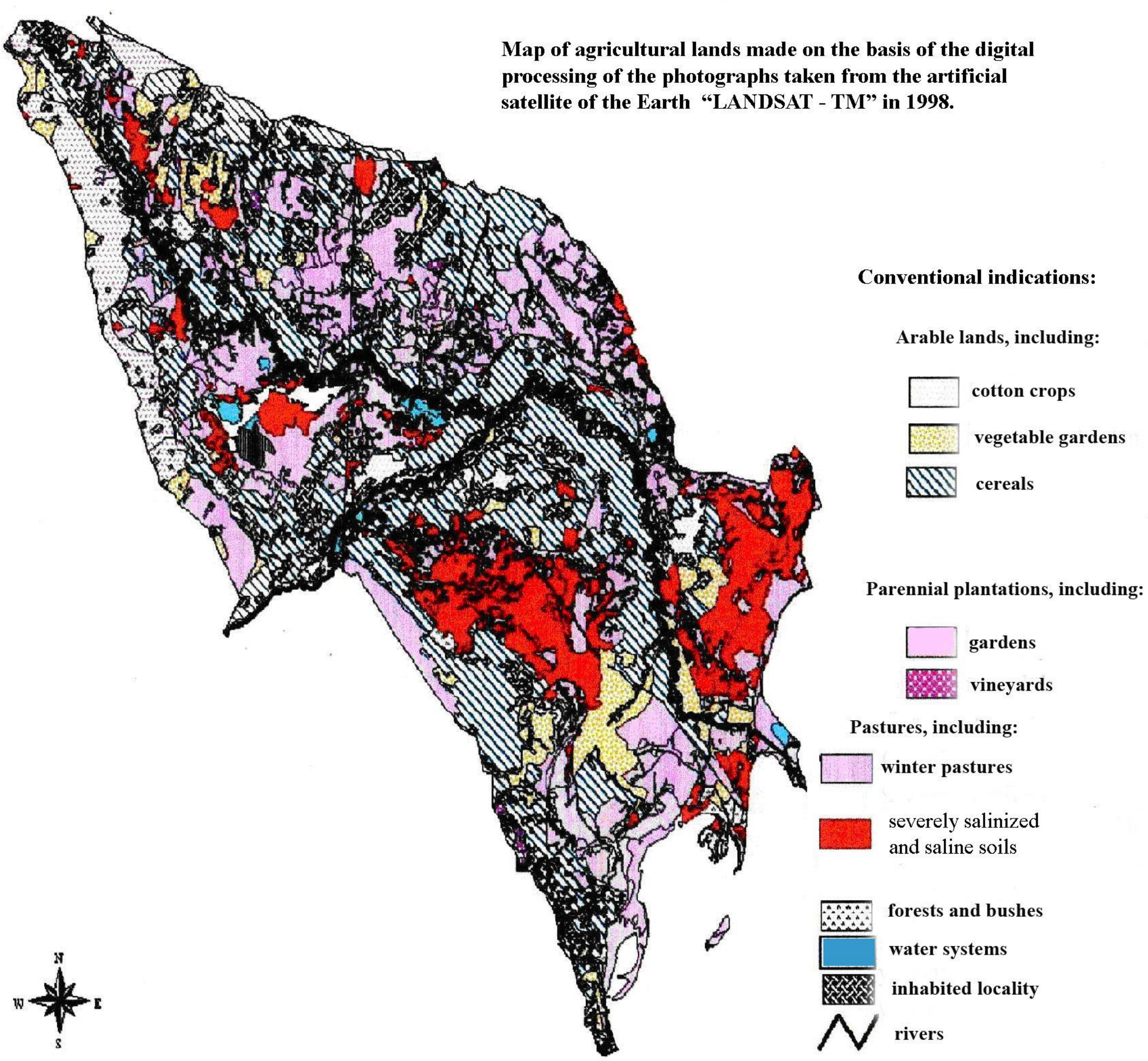

Fig. 1. Map of the agricultural lands and other lands of the Kur-Araz lowland, made as a result of digital processing of satelitte images "LANDSAT-TM" in 1998.

Fig. 1. states that saline soils occupy a large area in the investigated territory. They are mainly located in the south-western part of the Kur-Araz lowland in the Mugan-Salyan massif as well as in the territory of the Shirvan steppe.

In 2008, photographs of the Kur-Araz lowland were taken from the artificial satelitte of the Earth "IKONOS" in the range of 0.45-0.72 and 0.77-0.88 micrometers. On the basis of the digital processing of the space images, a map of farmlands was made and the area of the highly salinized soils and salt-marshes were defined in the investigated territory (Fig. 2.).

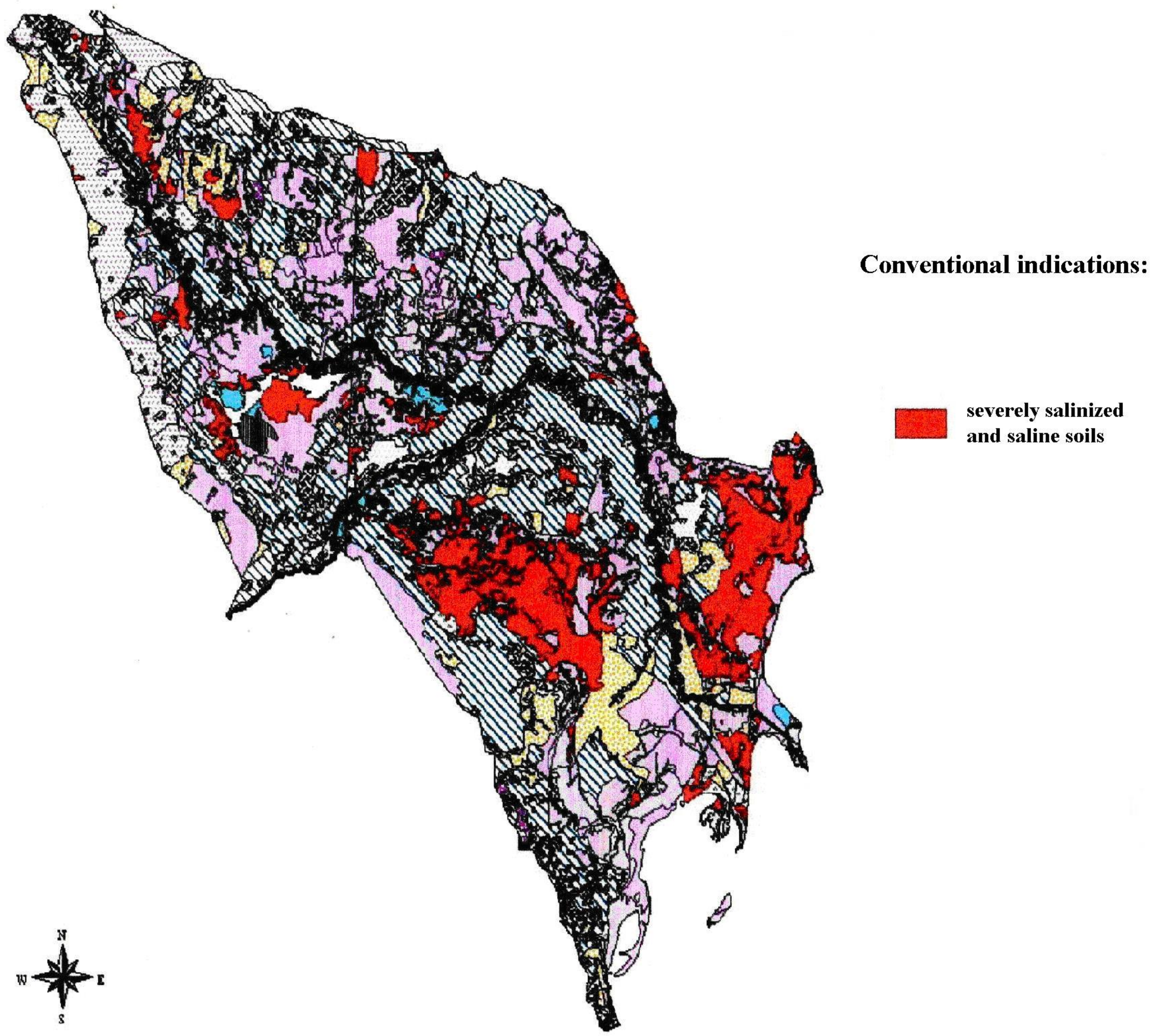

Fig. 2. Map of saline soils of the Kur-Araz lowland, made as a result of digital processing of satelitte images "IKONOS" in 2008.

Fig. 2. states that the area of the saline soils has significantly increased in the investigated territory. It should be noted that according to the accepted standards, the usage term of the built irrigation canals and collector-drainage network is about 35-50 years. Note that, in the period from 1951 to 1975, in the most part of the built collector-drainage network of the Kur-Araz lowland, the side walls collapsed, and the bottom was covered with cane brushwoods and other water plants. We can say that the usage period of the built irrigation canals and collector-drainage network of the Kur-Araz lowland has almost expired.

Conclusion

Over the last 20-25 years, in the survey area, the volume of the construction and reclamation work has decreased sharply and water loss increased in irrigation systems; besides, a large part of collector-drainage system became worse.

Digital processing of the images taken from "IKONOS" in 2008 stated that the area of the highly salinized soils and salt-marshes in the investigated territory increased by 66.5 thousand hectares compared to 1998. The existence of the highly salinized soils in the Kur-Araz lowland prevents the development of the irrigation and reclamation of soils here.

Final Remarks :
It should be noted that the extension of the salt-marshes of the Kur-Araz lowland in the mentioned period is basically related to poor conditions of the collector-drainage system. To prevent salinisation in the investigated territory, the following measures and recommendations are necessary.
Cleaning is necessary inside the weedy collector-drainage network, whereas fundamental repairs or new construction work should be done in the areas of the close drainage.
To preserve moisture resistance of soil, well growing trees should be planted on both sides of the irrigation canals. One of the main reasons of the process of salinisation of irrigated lands is high capillarity of unstructured soil. The experiments and researches state that the alternation of crops is required for the prevention of salinisation of irrigated and cultivated areas and for the improvement of their crop yields.
In addition to all the above agro-ameliorative measures, it is necessary to periodically observe the proper operation system of the built collector-drainage network of the Kur-Araz lowland.

References

1. Abduyev M.R., 1968. Soils with dealluvial salinisation and their amelioration problems. Publication of the Academy of Sciences of the Azerbaijan SSR, Baku.
2. Volobuyev V.R., 1965. Genetical salinisation forms of soils of the Kur-Araz lowland. Baku.
3. Morozov A.T., 1962. Drainage in the irrigated soils as a result of water-salt regime. In: Melioration of soils of the Kur-Araz lowland. Moscow, pp. 4-106
4. Heydarova R.M., 2012. Ecological estimation of soils of the Mil steppe from the processed satellite images. In: International Scientific Conference on Soils of Azerbaijan: genesis, geography, melioration, rational use and ecology. Gabala, pp. 233-236
5. Naghiyev P.Y., Heydarova R.M., 2013. Investigation of the soil salinity alteration of the Kur-Araz lowland. Earth from the Space - a more efficient decision. 16, 78-83

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Applying a 'regional' focus to the 'universal' principles of erosion and sediment control

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Abstract

Australia is an old continent with a patchwork of mostly erodible and low-nutrient soils, and climatic zones varying from alpine, tropical and desert. Erosion and sediment controls (ESC) have been used for many years to limit soil loss and to mitigate sedimentation problems. In the last two decades ESC guidelines have evolved significantly, though still based on universally accepted principles. These guidelines however, have primarily been developed from experiences gained from coastal city soils and weather, rather than those conditions typically found across the country. This paper provides a brief historical account of ESC in the USA, Europe, Australia and specifically Queensland, explains some of the problems in adapting ESC and drainage controls along a 2000 km transect from Queensland's coast to the arid centre, and explores the opportunities and difficulties for regionalisation in terms of technical parameters, cost/ benefits and institutional drivers for five Queensland regions. It concludes that effective and cost efficient ESC outcomes will only be achieved when guidelines adequately reflect the local conditions in which they are applied. The same is likely to apply elsewhere, e.g. Turkey.

Keywords: drainage, erosion, sediment, control

Introduction

Australia is an aging continent often thought of as a vast arid landscape. It has a wide range of climatic conditions, soil types, vegetation and receiving waterways. The environmental mantra of 'think global, act local' resonates well with business and private activities in Australia.

This paper overviews the regional application of the 'universally accepted' principles of erosion and sediment control (ESC) to the state of Queensland, Australia. The paper focuses on the application of erosion and sediment control principles to 'civil construction' activities that include urban subdivisions, mining, pipeline and utility installation, instream work practices and building sites. Though not specifically addressed within this paper, current rural and farming practices typically mimic the lessons learnt within the 'civil construction' industry.

ESC practices are said to be at the cutting edge of common sense. Unfortunately, this statement is often followed by the sarcastic comment that where ESC is used, 'common sense' is not so common. What the statement is really saying is that the practice of erosion and sediment control is not 'rocket science'. Its

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application does not require a tertiary degree; however, many of the applications require explanation by trained professionals before their 'simplicity' becomes fully realised.

Historical evolution of ESC practices within Queensland

As is the case in most countries, the practice of soil erosion control in Australia primarily originated from the activities of two industries: farming practices and road works. In both cases the primary objective was to protect the asset that was being eroded.

The initial focus of farming practices was the retention of a minimum 40 per cent cover of open soil (through stubble retention) and the introduction of contour banks for drainage control. The purpose of the stubble retention was to protect the soil from the effects of raindrop impact and sheet erosion. The purpose of the land contouring was to prevent rill erosion caused by the concentration of surface runoff.

In essence, these early farming practices were focused on the now-recognised tasks of 'erosion control' and 'drainage control'. The practice of 'sediment control' was often limited to the sediment-retention capabilities of farm dams. Over time, constructed wetlands have been introduced into many rural properties as both sediment traps and water quality improvement devices.

It should be noted that the primary motive for these rural practices was the protection of the land on which the soil erosion was occurring. The protection of receiving waters or even up-slope properties was seen as a secondary benefit.

The historic focus of soil erosion practices within road construction and maintenance was again on the protection of the asset, the road, and the maintenance of suitable trafficable conditions along the roadway. Once again little consideration was placed on potential impacts up-slope or downstream of the roadway; however, consideration was given to the potential impacts of road works on upstream flood levels.

Road work activities also focused on the early establishment of the permanent (operational) drainage system and the 'natural' control of soil erosion through site revegetation. It was road works funding that allowed the introduction and development of many of the hydraulically-applied erosion control measures, such as hydro-mulching, bonded fibre matrix, flexible growth media and composite blankets.

In the late 1980s, Australia's National Soil Conservation Program funded a research project *'Towards an Evaluation of the Off-Site Costs of Soil Erosion in Queensland'*. Based on the outcomes of this report, Grant Witheridge (the author) on behalf of the Institution of Engineers Australia Queensland (IEAust Qld) prepared an industry-based erosion and sediment control guideline for Queensland construction sites (IEAust Qld, 1996). This became known as the White Book. It should be noted that within Australia, erosion and sediment control guidelines are often referred to by the colour of their cover; hence the Green, Black, Blue, White, Maroon and Rainbow Books.

Development of the IEAust Qld guideline was influenced by a New South Wales guideline (the Black Book) and the author's tour of eastern USA construction site practices (and later European experiences). These areas are low to medium rainfall temperate climates. So, upon its release, immediate experience showed that the guideline did not suit the high-rainfall conditions commonly found along the coastal regions of Queensland.

Based on feedback received from users of the White Book, and the knowledge gained from several site inspections, the author immediately commenced a rewrite of the guidelines. The adaptation of the universally accepted principles of erosion and sediment control to Queensland conditions took another 11 years and resulted in the initial rollout of revised guidelines (IECA, 2008), called the Rainbow Book. Ultimately, the final suite of six best practice documents was not completed until 2010.

Over recent years, an increase in soil-disturbing activities within the more arid regions of western Queensland and adaptation to climate change has highlighted the need for further revisions to these best practice documents.

Problems experienced in adapting ESC principles to Queensland

In simple terms, the problems experienced during the adaptation of the universally accepted ESC principles to Queensland conditions are centred around the treatment of 'drainage control' as a separate tool box within the erosion and sediment control framework. Within the United States, and most other regions of Australia, the traditional focus has been on presenting ESC practices as a set of two tool boxes; 'erosion control measures' and 'sediment control measures'. Drainage control was initially considered just a component of erosion control.

It quickly became apparent that most of the early site failures experienced in Queensland were the result of inadequate drainage control. When site supervisors were asked why they did not have adequate erosion control (the term used to describe drainage practices during the mid 1990s) they pointed out that either they didn't need erosion control because it was the 'dry season', or they did have erosion control measures in the form of mulch and erosion control blankets.

Not surprising, ESC practices worked best when it was not raining! Once Queensland's tropical wet season arrived, mulch simply washed off the site and sediment fences folded to the ground.

For those readers that have not experienced tropical rainfall, the best way to describe the conditions is to point out that during heavy rainfall , such as a once in ten year storm of 200 mm/hr, windscreen wipers on a car become almost useless

The solution to this dilemma was to introduce 'drainage control' as a separate toolbox within the Queensland ESC industry. It is worth noting that the IEAust Qld guideline had already presented drainage control as a separate toolbox, but the concept was not fully explained. Figure 1 demonstrates the concept of the three toolboxes.

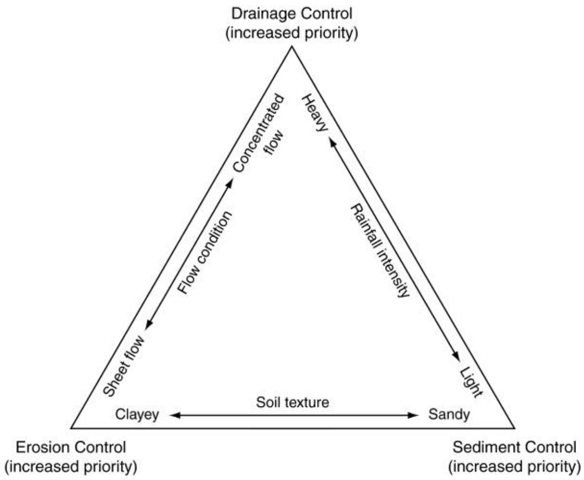

Figure 1 Relative importance of drainage, erosion and sediment control measures for different site conditions (IECA, 2008).

The following points outline some of the lessons learnt between the 1996 IEAust and 2008 IECA guidelines:

- Without effective drainage control measures, most ESC measures would fail during the severe weather conditions typically experienced within the tropics.
- Changing legislation changed ESC focus. Originally, 'pollution control' legislation focussed on the use of sediment control practices and limiting mass soil loss. As legislation matured to 'environmental protection' of downstream water quality, soil fertility etc; the focus shifted to erosion control measures.
- Sediment was initially viewed as a single pollutant, instead of being seen in its constituent parts consisting of clays, silts, sands and contaminants such as salts, cement, metals and nutrients.
- Soil particle size is important to distinguish between those impacts caused to minor waterways (creeks) by sand-sized particles, those cause to large freshwater habitats (rivers) by silt-sized particles, and those caused to estuaries by clay-sized particles.
- Drainage control measures gain increasing importance within tropical regions, while erosion control measures usually take priority within temperate regions.
- Within coastal regions, sediment control measures primarily benefit minor waterways such as creeks, while the environmental protection of major waterways and estuaries can only be achieved through the effective application of erosion control measures.

- Sediment basins, though effective in controlling turbidity during the nominated 'design storm', cannot be relied upon to protect estuaries and major waterways. Basin design storm (for reasons of cost and spatial practicality) is set well below the 1 in 1 year storm event resulting in these basins overtopping several times during a typical year.

- Capturing sediment close to the source of the erosion is an admirable objective but not practical. It is usually better to place sediment traps in locations that optimise their performance and minimise their interference with earthwork activities, i.e. to direct sediment-laden water to an appropriately placed sediment trap rather than to move the sediment trap closer to the source of the soil erosion.

- Sediment traps were classified using risk assessment to avoid an 'all or nothing' approach to sediment control. A sub-catchment based risk assessment procedure was developed that classified sediment control measures as Type 1, Type 2, Type 3 and Supplementary sediment traps. Cost and efficiency is based on the assessed environmental hazard within a given sub-catchment. The adopted system is defined in Table 1.

Table 1 Classification of sediment traps based on particle size.

Classification	Minimum particle size	Targeted sediment particles
Type 1	<0.045 mm	clay, silt and sand
Type 2	0.045 to 0.14 mm	silt and sand
Type 3	>0.14 mm	sand
Supplementary	>0.42 mm	coarse sand

- Sediment fences may appear to be a cheap and highly visible solution, but are generally ineffective if the critical pollutant is clay-sized particles. They are a Type 3 sediment trap that does not capture sufficient quantities of the fine-grained (clay/silt) particles.
- Topsoil, essential to prevent erosion and as a valuable growing medium, is no longer simply stripped and stockpiled for reuse. It now plays a greater role in forming temporary flow diversion banks (drainage control).
- Vegetation, once burnt, milled or mulched, now plays a greater role in the formation of filter berms (sediment control) down-slope of soil disturbances.
- Competency in ESC practice has evolved. In the past, ESC officers were trained to become experts in all areas of ESC. Today, it is more usual to have a team of experts (soils, drainage, water quality, revegetation and construction) involved in the preparation of Erosion and Sediment Control Plans (ESCPs).

Developing a regional focus on erosion and sediment control

There are several key elements to the development of regionally-based erosion and sediment control practices, including:

- Local climatic conditions (e.g. type of seasons)
- Soil conditions
- Vegetation conditions
- Ecosystem health
- Nature of receiving waters (e.g. coastal or inland waterways)

Considering these elements, and along an east-west transect, Queensland has potentially five specific regional conditions (seen broadly in Figure 2): northern coastal tropics, southern coastal waterways, hinterland, semi-arid (250–375 mm rainfall), and arid (<250 mm rainfall).

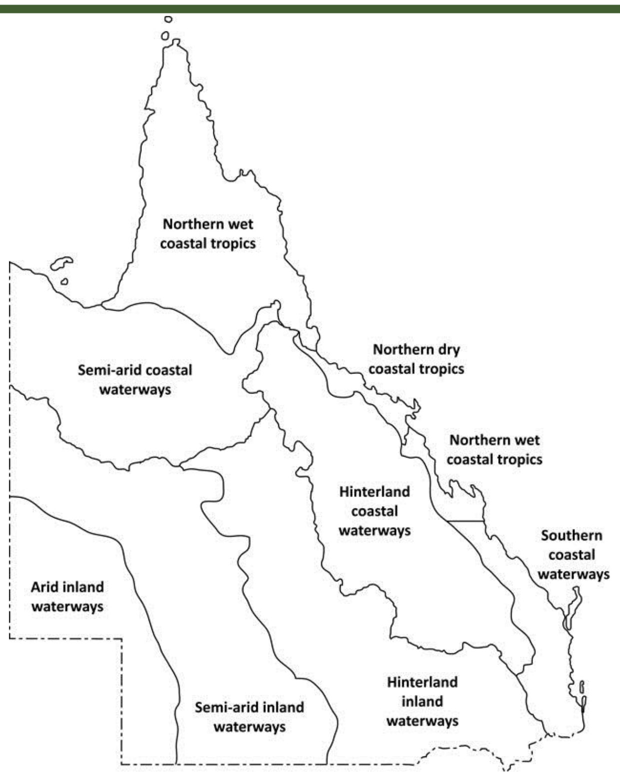

Figure 2 Proposed ESC management regions in Queensland

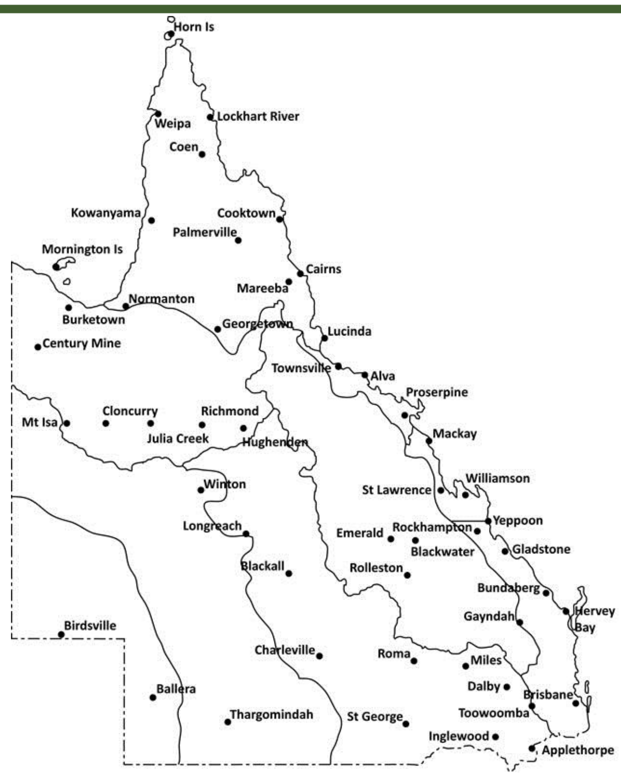

Figure 3 Town locations with the Proposed ESC management regions

Proposed ESC management regions in Queensland (Figure 2) can be further refined by weather patterns in the northern coastal tropics. The tropics have higher wet season rainfall quantities and rainfall intensity as compared to the southern coastal region and are divided into 'wet' and 'dry' tropic regions. The southern coastal region has a higher risk of unseasonal (winter) rainfall compared to the tropics. Climate change is likely to change regional boundaries.

Waterway flow directions of eastern Australia are dominated by the existence of the Great Dividing Range—a mountain range that runs parallel with the coastline from Victoria to North Queensland. Both the northern and southern coastal tropics flow into coastal waterways. In the northern Gulf country some semi arid catchments also flow into coastal waterways. However, the majority of semi arid and arid catchments flow into inland waterways. Due to the existence of the Great Dividing Range, the 'Hinterland' region can either flow into coastal or inland waterways.

In Australia coastal waterways are generally physically, chemically and ecologically sensitive to turbidity, while many of the inland waterways are naturally turbid during the wet season. Typically, these inland waterways are less sensitive to turbidity.

Table 2 provides a general guide to the ranking of drainage, erosion and sediment control (coarse-fraction and fine-fraction) for both coastal and inland waterways. It shows the importance of:

- Erosion control throughout the year
- Drainage control during the wet season
- Turbidity control along the coast.

Table 2 Ranking of ESC measures for coastal and inland waterways.

ESC priority system	Drainage control	Erosion control	Coarse sediment	Turbidity control
Coastal waterways – dry season	4th	Priority	3rd	2nd
Coastal waterways – wet season	Priority	2nd	4th	3rd
Inland waterways – dry season	3rd	Priority	2nd	4th
Inland waterways – wet season	Priority	2nd	3rd	4th

In coastal regions the primary focus of ESC is to minimise the risk of sediment impacts within waterways downstream of the soil disturbance. By contrast, in arid regions the focus is often directed towards minimising the risk of erosion on upstream or up-slope properties. In the flat arid landscapes typically found in far western Queensland vegetation is very sparse and the formation of small rill erosion on a road or earthworks site can result in the formation of extensive gully erosion up-slope of the soil disturbance.

In these arid regions natural surface gravels should be considered a component of the 'topsoil' and should be returned to the surface of the soil during site rehabilitation wherever practical. All reasonable and practicable efforts must also be taken to minimise the concentration or diversion of overland flows where such flows could initiate rill erosion.

Key elements of the erosion and sediment control measures for seven regional areas of Queensland are outlined in Tables 3 and 4.

Table 3 Key ESC elements for Queensland's coastal and hinterland areas.

	Northern tropics	Southern coastal waterways	Hinterland coastal waterways	Hinterland inland waterways
Water quality objectives (WQO)	Post storm discharge limit of 50 mg/L		WQO based on receiving water quality	
Critical sediment particle size	Clay-sized particles		Variable	Depends on receiving water
Critical sediment control activity	Turbidity control			Coarse sediment
Relaxed ESC conditions allowed during the dry season	Yes	Limited	As per Table 4	
Separate ESC plans required for the wet and dry seasons	Yes	As per Table 4		
Desirable minimum ground cover upon completion of earthworks	80%	70%	Minimum ground cover depends on local natural conditions	
Timing of site rehabilitation linked to the timing of wet season	No		Yes	

Table 4 Key ESC elements for Queensland's arid and semi-arid areas.

	Semi-arid coastal waterways	Semi-arid inland waterways	Arid inland waterways
Water quality objectives (WQO)	WQO based on receiving water quality	WQO may not be critical	
Critical sediment particle size	Depends on the type of receiving waterway		Sand
Critical sediment control activity	Capture of coarse sediment (silts & sands)		
Relaxed ESC conditions allowed during the dry season	During the dry season, greater areas of land can be disturbed at any given time, site rehabilitation times can be extended, and erosion control measures require lower shear stress limits		
Separate ESC plans required for the wet and dry seasons	Generally the same ESCPs are used for both wet and dry seasons, but technical notes are included that identify additional measures required during periods of wet weather		
Desirable minimum ground cover upon completion of earthworks	Minimum ground cover depends on local natural conditions		
Timing of site rehabilitation linked to the timing of wet season	Yes		

Interaction of current political issues into the development of regional guidelines

The evolution of ESC guidelines has matched legislation that, in turn, has matched Queensland's concerns about its fragile soils and their impacts on water quality and ecology. However, it has been mostly a southern coastal and urban view that does not work for approximately 90% of the land area of the Queensland.

Current politics favour that 90% of the land area. But a difficult economic climate and a lack of powerful regional structures will make funding and use of regional guidelines difficult to prepare and implement.

What the future might look like

If the gas industry and mining continue to grow in the Hinterland and Semi-arid regions, and if rural lands and associated infrastructure are likely to serve Asia's growing agricultural food needs, it is likely that regional guidelines will be required. Undoubtedly, the benefits would far outweigh the costs.

And at a smaller scale, even today the construction industry continues to confuse the need for temporary 'erosion control' (applied by the principal contractor) with the contracted application of permanent 'site revegetation' (often applied by a sub-contractor)—this needs to change.

Anticipating the future and learning from the development of ESC guidelines will serve potential regionalisation and limit adverse impacts on Queensland's fragile natural resources.

Conclusion

Erosion and sediment control requirements prescribed for civil construction activities are often dictated by the soil and weather conditions of the capital city of a given state or region because these are the conditions that the government regulators most closely associate with. However, in those regions of the world where the soil and weather conditions can vary significantly across a given jurisdiction, both the water quality objectives and the technical guidelines should reflect the true variation of site conditions. Adjusting the water quality objectives to match the site conditions can result in significant cost savings for the civil construction industry and result in better outcomes for society.

Using Queensland, Australia as an example, this paper has outlined how erosion and sediment control requirements can vary across climatic conditions varying from tropical to arid, and inland to coastal regions.

References

International Erosion Control Association, 2008, Best Practice Erosion and Sediment Control

Institution of Engineers Australia Queensland, 1996, Soil Erosion and Sediment Control Engineering Guideline

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Estimating soil dispersivity coefficient by Artificial Neural Network

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Abstract

Soil dispersivity coefficient (α) is a required input parameter in solute-transport models based on the Advection-Dispersion Equation (ADE). Soil dispersivity coefficient is typically difficult to model due to the complexity of the phenomenon. With respect to importance of this parameter, this paper presents the MLP- Artificial Neural Network (ANN) approach to predict the soil dispersivity coefficient. For training and testing of MLP model, the experimental data which measured in the rectangular tank with 1550mm length, 100mm width and 600mm height, were used. The collected data related to sandy soil with five sizes of very coarse, coarse, medium, fine and very fine and five distances of 25, 50, 75, 100 and 125 cm. NaCl was used as persistent pollutants with five velocities. The measured data such as transport distance (L), bulk density (ρ_b), porosity (n), hydraulic conductivity (K), average diameter of particles (D_{50}), the pollutant velocity (V_c) were used as input data for predicting soil dispersivity coefficient (α). For comparison of results statistical criteria such as R^2, RMSE and MAE were used. The ANN model was performed by different structures to minimize the prediction error and determine the optimum network configuration. The results show that the best architecture for the MLP model is comprised of 4 neurons with two hidden layers and transfer function of hyperbolic Tangent. The proposed MLP/ANN approach produced excellent results (R^2 = 0.987, RMSE = 0.00036m and MAE= 0.00047m) compared to the MLR model (R^2 = 0.943, RMSE = 0.00063m and MAE= 0.00043m) in testing set. Results show that the performance of ANN model was better than MLR model.

Keywords: Longitudinal dispersion coefficient; Multi-Layer Perceptron neural network; Multiple Linear Regression Method (MLR); soil

Introduction

More recently, concern for the quality of the soil and possible contamination of groundwater has provided a major impetus for studying solute transport in soils. The movement and fate of solutes in the subsurface is affected by large number of physical, chemical and microbiological processes requiring a broad array of mathematical and physical sciences to study and describe solute transport [10]. Solute movement in soil is a complex process, numerous mathematic models have been developed to simulate the movement of solute in soils. Of these, the Advection-Dispersion Equation (ADE) is the most widely used for steady state, one dimensional water flow with a nonreactive solute and is given by [7]:

$$dc/_{dt} = D_L \, d^2c/_{dl^2} - V \, dc/_{dl} \qquad (1)$$

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Where c is concentration of solute in the soil water (ML^{-3}), t is time (T), l is distance (L), D_L is the longitudinal dispersion coefficient (L^2T^{-1}), and V is the mean pore-water velocity (LT^{-1}). The longitudinal dispersion coefficient and the initial and boundary conditions are required to solve the Eq. (1). The initial and boundary conditions are obtainable to conduct tracer studies but dispersion coefficient is not directly measurable. Longitudinal dispersion coefficient defined by[6]:

$$D_L = \alpha v + D^* \quad (2)$$

Where α is the dispersion coefficient at porous media (m) and D* is molecular diffusion coefficient (L^2/T). At velocity more than 10^{-5} cm/s D* is negligible. Therefore, $D_L = \alpha v$ [8]. So in the ADE, the soil dispersivity coefficient is considered to be the most important parameter to be determined [15]. Direct estimation (by experimental means) of the soil dispersivity coefficient needs expensive and time consuming tracer studies. As a result, demand for a coefficient prediction tool still exists. Therefore, this study presents an intelligent model named Artificial Neural Network (ANN) which is able to learn and to generalize from a few specific examples and is capable of recognizing patterns and signal characteristics in the presence of noise. ANNs are inherently nonlinear and therefore, capable of modeling nonlinear systems [2,4,5].

Estimation of the longitudinal dispersion coefficient using soft computing techniques has been received considerable attention for a long period of time. For instance Rowinski et al (2005) used ANN techniques for the estimation of longitudinal dispersion coefficient in rivers, they found that although the results obtained using ANN are not fully satisfying, they are more accurate and far less costly than physically-based models allowing for the prediction of longitudinal dispersion coefficient.

Tayfour and Singh (2005) used ANN model to predict longitudinal dispersion coefficient in rivers. They found that the ANN model was superior in predicting the dispersion coefficient. Toprak and Cigizoglu (2008) used three artificial neural network methods, i.e. feed forward back propagation, the radial basis function neural network and the generalized regression neural network to compute the longitudinal dispersion coefficient in natural streams. They compared the results of ANN models with results of traditional methods. Their results show that ANN models are more accurate than the traditional methods. Piotrowski (2005) used two kinds of ANN models (MLP and RBF) for estimation of dispersion coefficient and then compared the results with linear regression method. The results show that the MLP model gives the best results.

No investigation has been made to use non-linear and intelligent models to predict the dispersion coefficient in soil. Therefore, the main scope of this paper is to develop a versatile tool for estimating the dispersion coefficient in soil.

Material and Methods

Artificial Neural Network (ANN)

ANNs provide a method to characterize synthetic neurons to solve complex problems in the same manner as the human brain does. ANN is able to learn and generalize from experimental data even if they are noisy, imperfect or non-linear in nature. This ability allows this computational system to learn constitutive relationships materials directly from the result experiments [1]. There are a variety of ANN methods, i.e. the Multi-Layer Perceptron network (MLP), Radial Basis Function-based neural networks (RBF), Generalized Regression Neural Networks (GRNN). The MLP is one of artificial neural networks that are extensively used to solve a number of different problems, including pattern recognition and interpolation. Artificial neural networks comprise of several simple units (or nodes or neurons) arranged in a parallel and cascade fashion, i.e. in input, hidden and output layers. Neurons are interconnected with each other in a previous layer by weights. In each neuron, a specific mathematical function called the activation function accepts a weighted sum of the outputs from a previous layer as the function's input and generates the function's output [9]. The neurons in the input layer include the input values (four neurons in this study). The pattern of hidden layers to be applied in the modeling can be either multiple layers or a single layer. The number of hidden neurons should be found "as optimal" for the solution of a given problem and the number of output nodes is equal to the number of output variables (one output variable, namely soil dispersivity coefficient was considered in this study).

The most widely used training algorithm for neural networks is the back-propagation algorithm [5], which is also used in this study. The topology of the neural network used in this study is presented in Fig.1.

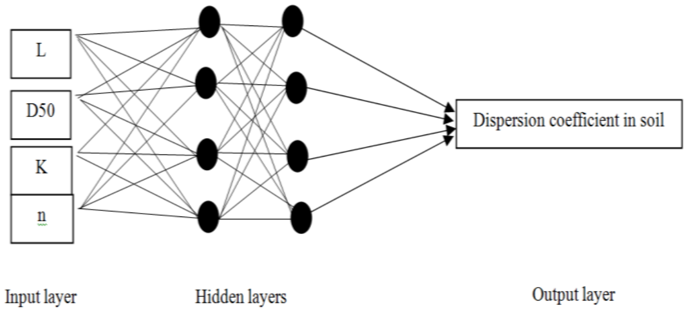

Fig. 1. Multi-layer perceptron neural network used for the estimation of soil dispersivity coefficient

Multiple Linear Regression (MLR)

Linear regression is a math concept statisticians use frequently to estimate the equation of a line among a set of data points thought to be linearly related. It uses several explanatory variables to predict the outcome of a response variable. The goal of multiple linear regression (MLR) is to model the relationship between the explanatory and response variables. The model expresses the value of a response variable as a linear function of one or more predictor variables and an error term:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_p x_{ip} + e_i \quad \text{where} \quad i = 1,2, \ldots, n \tag{3}$$

Where β0 is called the regression constant, the β_p are called slopes or coefficients and e is error term [7].

Data Set

The applications were carried out using 125 data sets which obtained from a physical model in lab. The physical model was filled with homogeneous sandy soil with different five sizes of very coarse, coarse, medium, fine and very fine. Nacl with a concentration of 9 g/l was used as a nonreactive contaminant. Every experiment was performed with five flow velocities. The point sampling was also taken at travel distances of 25, 50, 75, 100 and 125 cm. Descriptive statistics such as means, minimum, maximum, coefficient of variation (CV) and standard deviation (SD) are presented in Table 1.

Table 1. Range of collected data set

Symbol	Variable definition	Variable range	Mean value	SD	CV (%)
L (m)	travel distance	0.2500-1.2500	0.7500	0.3549	16.801
D_{50} (m)	average diameter of particles	0.0003-0.0017	0.0009	0.0004	0.0219
n	Porosity	0.3800-0.4000	0.3900	0.0063	0.0103
K (m/s)	hydraulic conductivity	0.0009-0.0097	0.0051	0.0032	0.2124
α (m)	soil dispersivity coefficient	0.0031-0.0168	0.0083	0.0029	0.1032

Data were subdivided into two sets: Around 80 % (100 data set) were used for training (chosen randomly), while the remaining about 20% (25 data set) were used for testing stage. The scenarios considered in building the ANN and MLR models, inputs (travel distance (*L*), porosity (*n*), hydraulic conductivity (*K*), average diameter of particles (D_{50}) and output (soil dispersivity coefficient (*α*)).

Modeling performance criteria

In order to evaluate and compare the forecasting performance, it is necessary to introduce forecasting evaluation criteria. In this study, three criteria include: coefficient of determination (R^2), Root Mean Square Error (RMSE), Mean Absolute Error (MAE) are used. Table 2 shows the R^2, RMSE and MAE formulation.

Table 2. Forecasting evaluation criteria

Criteria	Formulation
Coefficient of determination (R^2)	$R^2 = \left[\sum_{i=1}^{N}(P_i - \bar{P})(O_i - \bar{O})\right]^2 \left[\sum_{i=1}^{N}(P_i - \bar{P})^2(O_i - \bar{O})^2\right]^{-1}$
Root Mean Square Error (RMSE)	$RMSE = \left[\sum_{i=1}^{N}\frac{(P_i - O_i)^2}{N}\right]^{0.5}$
Mean Absolute Error (MAE)	$MAE = \frac{1}{N}\sum_{i=1}^{N}\lvert O_i - P_i\rvert$

Where N is the number of observations, P_i is the estimated values, O_i is the observed data, while $\bar{P}$ and $\bar{O}$ are the mean values for P_i and O_i, respectively.

Results and Discussion

Development of the neural network model

Since the MLP neural network is the most commonly used network in engineering problems relative to non-linear mapping [9], in this research, the multi-layer perceptron network, i.e. one of supervised feed-forward networks, was selected from a large variety of neural networks. After randomizing and splitting of data set into training and testing data, various ANN structures were constructed to specify the optimal structure. The number of neurons in input and output layers is depended on the independent and dependent variables, respectively. So the network was designed with 4 parameters (i.e. travel distance (L), porosity (n), hydraulic conductivity (K), average diameter of particles (D_{50})) as input and soil dispersivity coefficient (α) as the output parameter. The number of hidden layers was selected by calibration through several test runs and trial and error. In this study different hidden layers were tried, it was found that two hidden layers were the most suited. Selecting the number of neurons in the hidden layers is a very important part of deciding the overall neural network architecture. There is a method for determining the correct number of neurons to use in the hidden layers which say the number of hidden neurons should be 2/3 the size of the input layer plus the size of the output layer. Therefore, in the present study, 4 neurons in both hidden layers were used. Moreover, various activation functions were tested for MLP neural network. As shown in Table 3, Hyperbolic Tangent function with RMSE=0.00036 and MAE=0.00047 and value of R^2= 0.987 in testing stage was the best. The scatter plot of the measured values versus predicted values of soil dispersion coefficients for the train and test data set are given in Fig.2 for the best ANN structure. So that according to this figure, the best fitted line has the angle of near to 45° that shows the high accuracy of estimation by the ANN model.

Table 3. The best performance of MLP/ANN model.

Transfer Function	Stages	R^2	RMSE	MAE
Hyperbolic Tangent	Training	0.991	0.00026	0.00040
	Testing	0.987	0.00036	0.00047

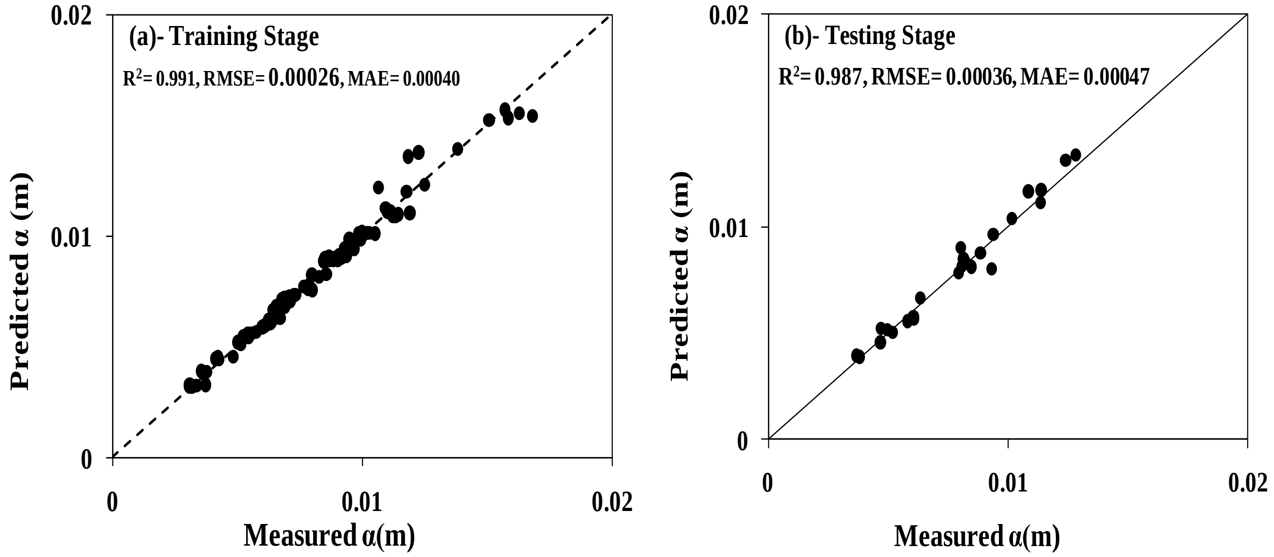

Figure 2. Comparison between the measured and predicted soil dispersivity coefficient (α) by MLP/ANN model in the (a) training and (b) testing stages.

Multiple Linear Regression Analysis (MLR)

The regression model was applied for the same inputs and output data which used for MLP-ANN model. The coefficients were obtained that are presented in Table 4.

Table4. Model summaries of multiple regression for prediction of soil dispersivity coefficient (α)

Independent variables	Coefficients	Std. Error	t-Value
(Constant)	0.053	0.013	4.193
L	0.003	0.000	9.718
D_{50}	8.921	2.240	3.982
n	-0.137	0.034	-4.078
K	-0.396	0.304	-1.303

Based on MLR model the following equation can be used to estimate soil dispersion coefficient as follow:

$$\alpha = 0.053 + (0.003)L + (8.921)D_{50} - (0.137)n - (0.396)k \tag{4}$$

As shown in Eq.4, the porosity (n) and hydraulic conductivity (K) have negative effects on the soil dispersivity coefficient (α) and the effects of travel distance (L) and average diameter of particles (D_{50}) on α are positive. The results of MLR model are presented in Fig.3 for training and testing data sets. It can be seen that the MLR model gives worse results than ANN model (independent of the statistical measure considered, R^2 = 0.995, RMSE = 0.00042 m and MAE = 0.00063 m for training stage and R^2 = 0.943, RMSE = 0.00043 m and MAE= 0.00063 m for testing stage.

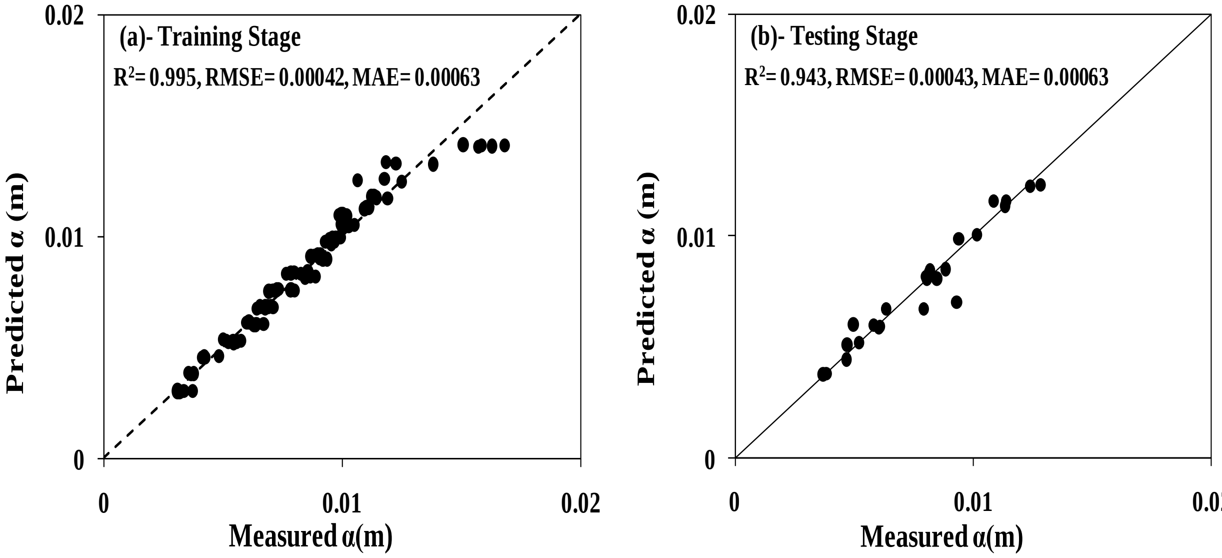

Fig. 3. Comparison between the measured and predicted soil dispersivity coefficient (α) by MLR model in the (a) training and (b) testing stages.

Conclusion

In this paper the application of Artificial Neural Network (ANN) as a soft computing technique and Multiple Linear Regression (MLR) as a linear model are investigated for predicting longitudinal dispersion coefficient in soil. The performance of the ANN model is compared with MLR model. Four independent variables namely, travel distance (L), porosity (n), hydraulic conductivity (K), average diameter of particles (D_{50}) were used as input to predict soil dispersivity coefficient (α). The ANN modeling results showed that there was excellent agreement between the experimental data and the predicted values, with (R^2 =0.987, RMSE= 0.00036 m and MAE= 0.00047 m in testing period) establishing that the developed model was able to analyze non-linear multivariate data with very good performance, fewer parameters, and shorter calculation time. Results using two models showed that ANN model is more accurate than the MLR method with (R^2 =0.943, RMSE= 0.00043 m and MAE= 0.00063 m in testing period). Results demonstrate that in the ANN technique the relative error of estimation significantly was less than MLR method. So the ANN model might be an alternative low cost and less time consuming method for estimating dispersion coefficient in soil.

References

[1]. Banimahd, M., Yasrobi, SS., Woodward, PK., 2005. Artificial neural network for stress-strain behavior of sandy soils: Knowledge based verification. Comput. Geotech. 32, 377-386.
[2]. Basheer, A.I. Najjar, Y.M., 1996. Predicting Dynamic Response of Adsorption Columns with Neural Nets., Journal of Compu.Civ. Eng. 10 (1), 31- 39.
[3]. Emamgholizadeh, S., Bateni, S.M., Jeng, D.S. 2013a. Artificial intelligence-basedestimationof flushing half-conegeometry. Engi. Appli. Arti. Intell. 26, 2551–2558.
[4]. Emamgholizadeh, S., Kashi, H., Marofpoor, I., Zalaghi, E. 2013b. Prediction of water quality parameters of Karoon River (Iran) by artificial intelligence-based models. Int. J. Environ. Sci. Technol. 11, 645–656.
[5]. Civelekoglu, G., Yigit, N.O., Diamadopoulos, E., Kitis, M., 2007. Prediction of Bromate Formation Using Multi-Linear Regression and Artificial Neural Networks. Jour.Ozo. Scie. Eng., Taylor & Francis. 5(5), 353-362.
[6]. Freeze, R. A., and Cherry, J. A. 1979. Groundwater. Prentice-Hall, Englewood Cliffs, NJ.
[7]. Fried, J.J., Combarnous M.A. 1971. Dispersion in porous media. Adv. Hydrosci. 7, 169-282.
[8]. Gillham, RW., Cherry, JA., 1982. Contaminant migration in saturated unconsolidated geological deposits, Geological Society of America, 189p.
[9]. Haykin, S., 1994. Neural Networks. Macmillan College Publishing Company, Inc: New York.
[10]. Leij, F.J., Dane J.H. 1989. A review of physical and chemical processes pertaining to solute transport. Alabama Agric. Exp. Stn. Agron. Soils Dep. Ser. No. 132.
[11]. Piotrowski, A., 2005. Application of Neural Networks for longitudinal dispersion coefficient assessment. Geophysical research abstracts. 7, 00976.
[12]. Rowinski, PM., Piotrowski, A., Napiorkowski, JJ., 2005. Are artificial neural network techniques relevant for the estimation of longitudinal dispersion coefficient in rivers? Hydr. Scie. Jour. 50(1), 175-187.
[13]. Tayfur, G., Singh, VP., 2005. Predicting longitudinal dispersion coefficient in natural streams by artificial neural network, J. Hydr. Engi., ASCE, 131(11), 991-1000.
[14]. Toprak, Z. F.,Cigizoglu, HK. 2008. Predicting longitudinal dispersion coefficient in natural streams by artificial intelligence methods, Hydro. Proce. 22, 4106-4129.
[15]. Zheng, C., and GD. Bennett. 1995. Applied contaminant transportmodeling. Van Nostrand Reinhold, New York.

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Anthropogenic loading on soil and impact of land use on surface and groundwater quality

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Abstract

The anthropogenic loading of soils and the water pollution are one of the most significant problems, associated with agriculture. The basic factors, which influence nitrate and chemical elements leaching through the soil profile, nitrogen accumulation in the profile, movement through the geological profile and pollution of shallow aquifers with different components are: hydrogeological characteristics of the terrains, soil type, geomorphology, climate, management of agricultural lands (anthropogenic impact from fertilizers, septic systems and livestock wastes) and etc. The aim of this investigation is to present results on surface and ground water quality monitoring on the territory of a small watershed at the pilot site (near V. Tarnovo) in Northern Bulgaria. Fluctuation of the groundwater table was monitoring at permanently build pipe wells, home wells and springs. The simples for chemical analysis of surface water were taken at different sites of the Yantra River in the area of the pilot site. The influence of different land use activities on the content of chemical elements in surface and ground water has been studied in 2013 year. It was established that surface and ground water sampled from monitoring watershed has neutral to alkaline reaction and hydrocarbonate-calcium chemical composition.

Keywords: anthropogenic loading, land use activities, monitoring, surface and ground water, chemical elements, environment protection

Introduction

The groundwater chemical composition depends on the natural factors such as hydrological haracteristics of the terrains, the type of soils, geology profile and climate, as well as the anthropogenic loading of the watershed (Stoichev et al., 1998; Stoichev et al., 2001b; Shaffer and Ma, 2001). A lot of groundwater quality monitoring programs is developed in order to prevent water contamination due to intensive anthropogenic loading of the catchments (Nitrate Directive (91/676/EEC); Council Directive 98/83/EEC and Water Framework Directive 2000/60/EEC).

Many attempts have been done for assessing the influence of different land use on the groundwater quality at field experiments and natural conditions on a watershed level (Stoicheva et al., 1993; Stoicheva et al., 2013). Agricultural practice is considered to be one of the main non-point sources of surface and groundwater contamination by nitrate and other chemical elements (Ramos, 1996; Stoichev et al., 2001a; Raikova B., 2003;

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Stoicheva et al., 2008). However, it is not correct to charge all agricultural activities without determining the vulnerable components of the biological cycle of nitrogen in plant-soil-groundwater system. It is important to evaluate the factors which lead to nitrates accumulation in the root zone and their movements to the surface water and groundwater.

The objective of this study is to assess, on a watershed level, the impact of different land use activities and natural factors on the surface and groundwater quality.

Material and Methods

The study is part of surface and groundwater quality monitoring in the region of Parvomaitsi village, V. Tarnovo district (Bulgaria). The site is situated in the central part of the Yantra river basin (42° 40' and 43° 40'N and 24° 40' and 26° 30' E and 94-110 m above the sea-level) on a well defined small watershed with climate, soils, municipal economy activities and habits representative for this part of the country. The pilot site is situated on the first flooded terrace in the middle part of the Yantra river's catchment basin. The scheme of this investigation was designed to obtain information for the different components of the agro-ecosystem along a transect across the selected watershed perpendicular to the Yantra River in the area of village. The details of surface and groundwater monitoring scheme and some soil characteristics of the pilot site are presented in our earlier publications (Stoichev et al., 1997, 1998a, 2001a; Stoicheva et al. 2013). The distribution of nitrogen and other chemical elements in the underlying vadoze zone of the studied soils in the pilot site determined in disturbed soil samples taken when the reference wells were drilled (Stoichev et al., 1998c; Stoicheva et al., 2006).

Main agricultural practices at this region included intensive vegetable rotation, irrigation manuring and frequent soil cultivation are described in publication of Stoichev et al. (2001b).

The pH values and chemical composition (NO_3-N, Na^+, K^+, Ca^{2+}, Mg^{2+}, PO_4^-, SO_4^-, HCO_3^-, Cl^-) of surface and ground water are determined using the following methods: pH – potentiometrically (Arinushkina, 1970); nitrogen analysis in water samples were carried out by direct distillation with 10 % Fe_2SO_4 and 0.5%Ag_2SO_4 reducing agents (Mettodenbuch, 1955); potassium and sodium were determined by flame photometer, calcium and magnesium – by atomic absorption spectrometry – AAS (Page et al., 1982), hydrocarbonate by titration with 0.02nH_2SO_4 to pH 4.4 and chloride by Moor method (Arinushkina, 1970). As maximum permissible concentration level (MPCL) for nitrate was used the accepted in Europe and Bulgaria drinking water standard for NO_3 -50 mg.l^{-1} (Council Directive 98/83/EC).

Results and Discussion

The pH values of the groundwater from the monitoring wells (Table 1) show that in all cases they have neutral to alkaline reaction despite the fact that soil on the territory of the watershed has neutral reaction depending on the different land-use type.

Table 1. Monitoring of pH values of Groundwater (Wr and Wh), Yantra River and Central Water Supply System (CWSS) in the area of Parvomaitsi village (V. Tarnovo district)

Source	No of wells	Depth,m	pH values
CWSS	1		8.05
Wr	5, 6	11-12	8.15
Wh	11, 15	5-12	8.35
Wh	16,17,18,19,20,21	2-5	8.25
Yantra River	23-25	-	8.25

Wr – reference pipe wells; Wh – home wells.

The average pH values in surface (N 24-25) and ground water in monitoring well (N 5-21) varies from 8,05 to 8,35. It was not found any influence of the anthropogenic loading on the pH values of the groundwater with the exception of home wells (Wh) N 16 and 17 where the pH values are higher.

Potassium content in the surface and groundwater is presented on fig. 1.The data show that the potassium concentration is higher in surface water (4,45 - 5,45 mg.l^{-1}) . In the groundwater K^+ content of all monitored wells of the pilot site varies in large limits from 0,56 to 10,27 mg.l $^{-1}$. During the 2013 year the highest concentration of potassium was observed in the groundwater sampled from deep well N 6 (10,27 mg.l $^{-1}$). Shallow groundwater from home wells has the lower K^+ concentrations compared with studied deep wells in the pilot watershed. In general, potassium is an element, which is characterized with very low mobility coefficient, because of its physico-chemical fixation in the soil.

Sodium is an element with high geochemical mobility and transitional status in the geochemical cycle of the elements and due to this reason is highly influenced by the changing in anthropogenic loading.

The concentrations of Na^+ in the surface and groundwater varies from 23,57 to 50,82 mg.l $^{-1}$ (Fig.1). The dynamics of sodium content in the groundwater is close to that of the potassium (Fig.1).

Calcium concentrations (Fig.1) varies from 48,50 to 143,50 mg.l $^{-1}$ in all wells from the monitored 2013 year and do not exceed the maximum permissible contaminant level in the standard for drinking water (MPCL=150 mg.l $^{-1}$).

The magnesium content in the groundwater (Fig. 1) show three time lower concentration in comparison with the absolute calcium values.The concentrations of Mg^+ in the groundwater varies from 33,00 to 54,00 mg.l $^{-1}$ (Fig.1). The magnesium content in the surface water (Yantra River) from the three points, which is located at the lower part of the watershed varies from 11,50 to 13,50 mg.l $^{-1}$. Values for Mg^{2+} content, as calcium do not exceed the MPCL for this element for drinking water (50 mg.l $^{-1}$). The data show that the magnesium content in surface and ground water varies in close limits.

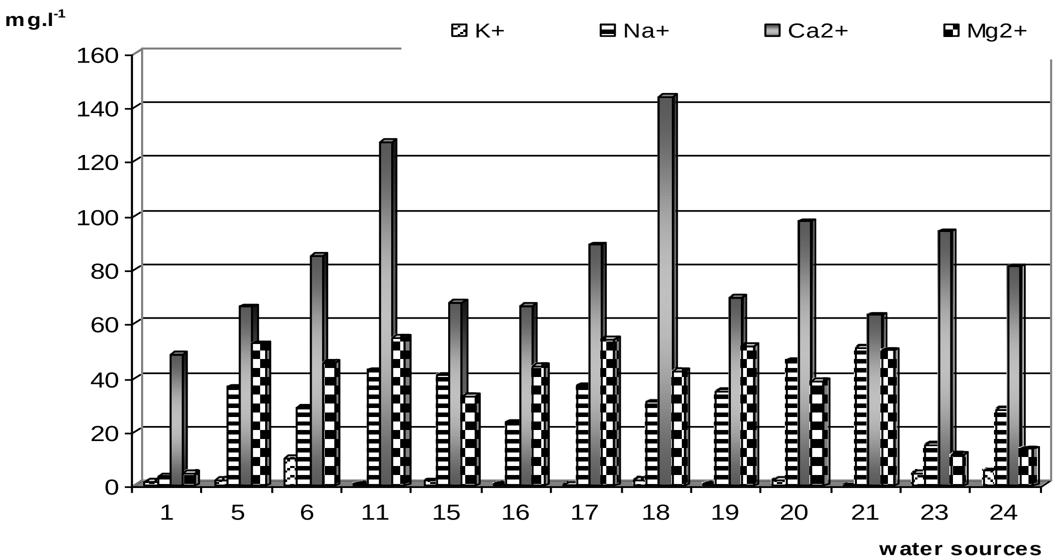

Fig.1. Potassium, sodium, calcium and magnesium contents in surface and groundwater (v. Parvomaitsii, near V. Tarnovo), 2013 year

Data received for the pilot site show that nitrate nitrogen concentration in the shallow groundwater varies in a large range between 7,30 - 27,80 mg.l $^{-1}$ depending on the observation wells location. Almost in several cases the measured nitrate nitrogen concentrations were higher than the maximum concentration levels for $N\text{-}NO_3$ for drinking water – 11,3 mg.l $^{-1}$ (Standard for drinking water, 1983).

It was established that the household gardens are a subject of high nitrogen loading, creating potential sources for nitrate nitrogen pollution of shallow groundwater. Data on nitrate nitrogen content for 2013 year (Fig. 2) confirm the tendency of decreasing the nitrate concentration in average with values around and a bit higher up the maximum permissible contamination levels (MPCL). The lowest nitrate concentration – 1,97-4,90 mg.l $^{-1}$ was measured in the samples taken from Yantra River.

The PO_4^- concentration in the groundwater varies from 1,50 to 16,10 mg.l $^{-1}$. It could be expected a direct relationship between the applied phosphorus and its content in the groundwater, taking into account the high chemical fixation and biological absorption of this element in the soil root zone.

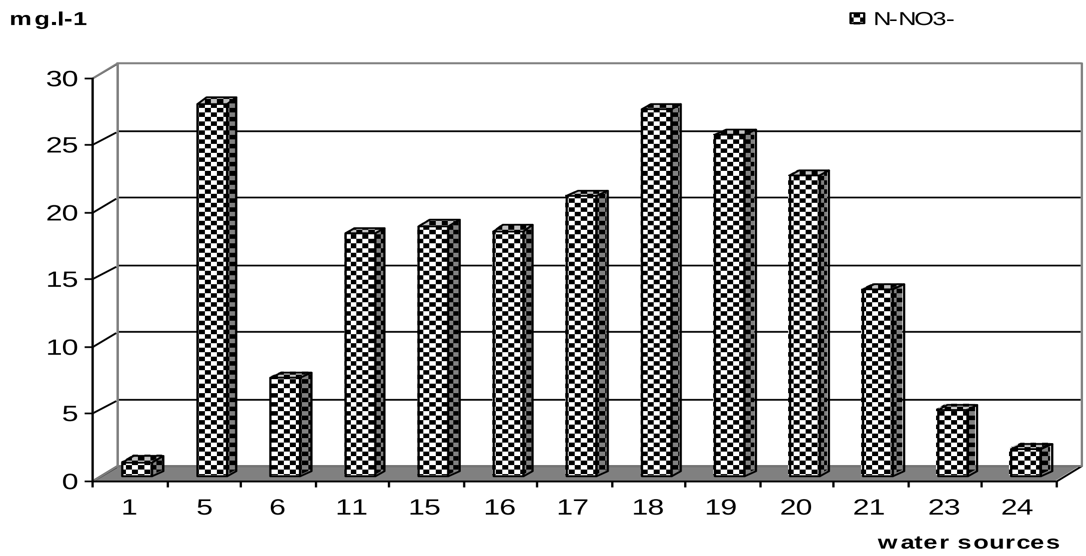

Fig.2.Nitrate nitrogen content in surface and groundwater (v. Parvomaitsi, near V. Tarnovo), 2013 year

The content of hydrocarbonates in the groundwater (Fig. 3) is characterized with significant dynamic. However, almost all wells are presented as a whole according to this parameter, which is a proof that the high dynamic has a background character and is less influenced by the type of land use. The high contents of hydrocarbonates in the ground water of the pilot watershed determine its hardness, which in the more monitored wells exceeds the standard level for drinking water. The sulfate content in the groundwater varies from 36,00 to 173,00 mg.l $^{-1}$.

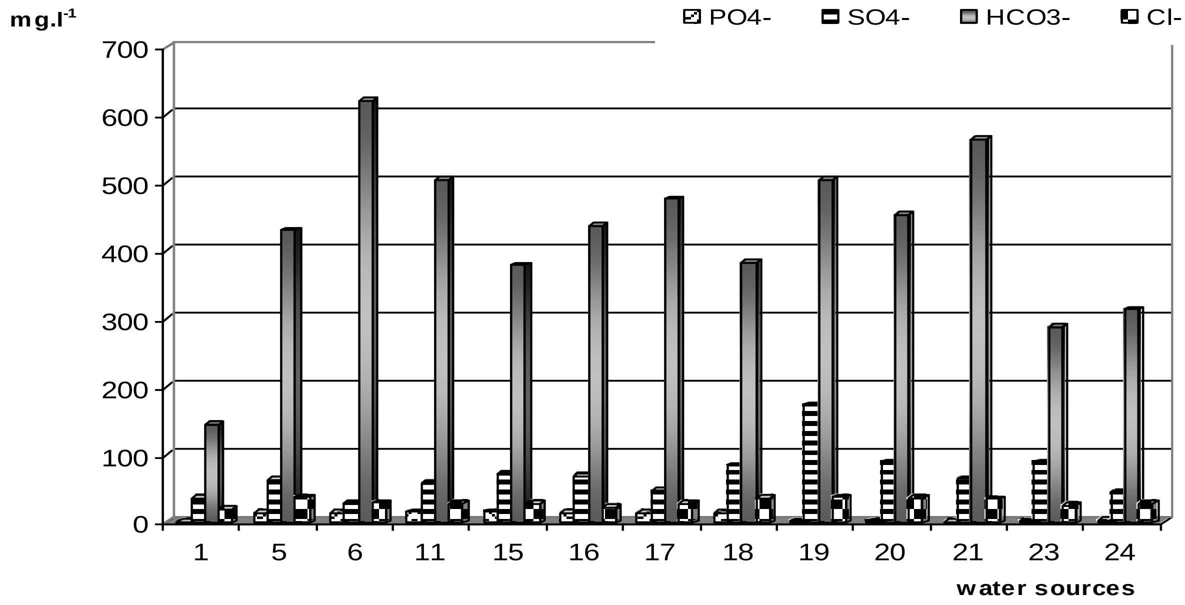

Fig. 3. Phosphate, sulfate, hydrocarbonates and chlorine contents in surface and groundwater (v. Parvomaitsi, near V. Tarnovo), 2013 year

Chlorine content (Fig.3) in the groundwater could be characterised with considerably low variation in space and time. The observed data are in close limits, which is not typical for this element due to its high mobility and status in the geochemical cycle of elements. The chlorine concentrations in monitored wells do not exceed the MPCL in the standard for drinking water (250,00 mg.l $^{-1}$). Chlorine has a transitional status in the biological cycle of nutrients.

Conclusion

It was established that surface and groundwater samples in the studied watershed has neutral to alkaline reaction and hydrocarbonate-calcium-magnesium chemical composition.

The dynamics of the processes, which determine the enrichment of groundwater with nitrates and their redistribution in the space, requires a periodic monitoring of their chemical composition to update the information of the status of the groundwater.

The calcium and magnesium concentrations in groundwater do not exceed the maximum permissible contaminate level in the standard for drinking water. It was monitored a significant variation in the data for hydro-carbonates content in the groundwater, slightly influenced by the anthropogenic loading. Chlorine and sulphate contents in the groundwater could be characterised with considerably low variation.

Solving the problem of water quality protection from nitrate pollution of agricultural sources requires the determination of the maximum permissible loading with nitrogen of arable lands in order to preserve the sustainability of the agroecosystem. The received information will be used as a methodological approach in further environmental impact assessment on a watershed level.

Acknowledgement

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References

Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrate from agricultural sources. European Councel, 1991.

Directive 2000/60/EC of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy. European Councel, 2000.

Standard for drinking water, 1983. Governamental Agency on Standards and Metrology, Ministry of Environment and Waters- N 2823-83.

Arinushkina, E., 1970. Guidelines in Chemical Soil Analysis, Izd. MGU, Moskow, p. 487.

Mettondenbuch, 1955. Band 2. Die Untersuchung for Bond, Aufange, Neuman. Verlag, Berlin.

Page, A.L., Miller, R.H.& Keeney, D.R. (Eds.), 1982. Methods of Soil Analysis, Part 2. Chemical and microbiological properties.2nd edition , ASA and SSSA, Madison, Wisconsin, USA, p.1159.

Raikova, B., 2003. Some issues on groundwater protection in the country, Journal "Ecology and Industry", v. 5, No1-3, 137-138.

Ramos, C., 1996. Effect of agricultural practices on nitrogen losses to the environment, C. Rodriguez-Barrueco (Eds), Fertilizer and Environment, Kluwer Academic Publisher, The Netherlands, 355–361.

Shaffer, M J. and Ma, Liwang, 2001. Carbon and nitrogen dynamics in upland soils. In: M.J. Shaffer, Liwang Ma, S. Hansen (Eds) Modeling Carbon and Nitrogen Dynamics for Soil Management, Chapter 2, CRC Press LLC Publisher , 11-26.

Stoichev, D., D. Stoicheva, M. Kercheva, A. Lazarov, S. Marinova, G. Angelov, P. Alexandrova, E. Filcheva, T. Mitova, E. Tzvetkova, M. Stoimenova , V. Koleva, 1997. Assessment of the agricultural pollution sources in the Yantra River Basin, Chimia and industry, v. 68, No 1-3, 51-53.

Stoichev, D., D. Stoicheva, M. Kercheva, 1998 a. Impact of land-use on groundwater quality on watershed level. I. Nitrate-nitrogen contamination, Journal of Balkan Ecology, vol.1, No 2, 98-104.

Stoichev, D., D. Stoicheva, M. Kercheva, 1998 b. Impact of land-use on groundwater quality on watershed level. II. Chemical characteristics. Journal of Balkan Ecology, vol.1, No 2, 104-112.

Stoichev, D., D. Stoicheva, M. Kercheva, A. Lazarov, K. Dervenkov, 1998 c. Distribution of nitrogen in the intermediate vadose zone of watershed. Bulgarian Journal of Agricultural Science, No 5, 384-393.

Stoichev D., M. Shaffer, J. Starr, J. Lemunyon, D. Stoicheva, M. Kercheva, V. Koleva, 2001a. Cooperation between USDA and Bulgaria in agro-environmental water quality programme. In: Stott D.E., Mohtar R.H., Steinhart G.S. (eds) Sustaining the Global Farm.. Selected papers from the 10th ISCO Meeting held May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory, 1106-1111.

Stoichev D., M. Kercheva, D. Stoicheva, 2001b. "NLEAP water quality applications in Bulgaria". Chapter 9, In: Shaffer, M., Ma L., Hansen S. (eds) Modeling Carbon and Nitrogen Dynamics for Soil Management, Lewis Publishers, Boca Raton, FL, pp. 333-354.

Stoicheva, D., Stoichev, D., Angelov, G. and Dimitrova, K., 1993. Effect of some land use activities on ground water quality, International conference "Integrated arable farming systems", Nitra, 332 – 339.

Stoicheva D., M. Kercheva, D. Stoichev, 2006. Nitrogen distribution in vadose zone under some Bulgarian soils, Proceeding of 5th International Congress on Environmental Geotechnics, II, 1256-1263.

Stoicheva, D., M. Kercheva, V. Koleva, P. Alexandrova, Ts. Simeonova. 2008. Good agricultural practices for the protection of groundwater by nitrates pollution from agricultural practices. Sofia, Brochure, p. 32.

Stoicheva D., Ts. Simeonova, M. Kercheva, M. Benkova, L. Nenova, Sv. Marinova, V. Petrova, 2013. Nitrates in water monitoring under different anthropogenic loading at pilot site in Northern Bulgaria, Journal of Balkan Ecology, v. 16, No 3, 313-319.

Stoicheva D., Ts. Simeonova, M. Kercheva, M. Benkova, L. Nenova, Sv. Marinova, V. Petrova, 2013. Influence of land use on water chemical composition at watershed scale, Journal of Balkan Ecology, v. 16, No 4, 403-4012.

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Determine the influence of bio-slime on yield and quality of crop production

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Abstract

Interest in the production of biogas from organic waste has intensified in recent years. Anaerobic fermentation during biogas production is associated with obtaining of bio-slime. Several studies have found that bio-slime is rich in micro and macro nutrients and can be used as an organic reserve in agricultural practice. The aim of this study is to determine the effect of bio-slime on yield and quality of crop production at the ratio of raw materials in biogas installation - pig manure and markets waste 70:30. As an indicator crop is planted lettuce. The studies were carried out on two soil types. Different percentage of bio-slime was tested in compared with untreated soils use as a control. The results show that agrochemical and chemical characteristics define bio-slime as a biomass rich in macro and micronutrients that can be used in agriculture for increasing of soil fertility. It was define that the lettuce at increasing doses of biomass indicates that plants have the best development and quality options with 15% bio-slime involving 70% pig manure.
Keywords: bio-slime, biogas, anaerobic fermentation.

Introduction

The shortage of electricity in Bulgaria requires demand for renewable energy sources. In recent years there has been increased the interest for biogas production from organic waste (Zaharinov, 2011). Currently, potential raw materials for biogas production are not used properly. Their improper processing or storage leads to environmental pollution. In our country, there are still no installations for biogas production.

Anaerobic fermentation (AF) is a microbiological process of decomposition of organic matter in the absence of oxygen and is typical of many natural environments (Galabova et al., 2003). Nowadays AF is used mainly for the production of biogas in airtight tanks-reactor, usually called bioreactors (Schink, 2001). Wide range of microorganisms is involved in the anaerobic process- as main end products are biogas and bio-slime. Biogas is a combustible gas containing methane, carbon dioxide and small amounts of other gases as well as small amount of other elements (Simeonov, 2012; Zaharinov, 2013; Rychtera et al., 1983).

During anaerobic fermentation for biogas production it is obtained secondary biomass also known as bio-slime. This requires seeking of its realization. Several studies have found that bio-slime is rich in micro and macro nutrients and can be used as an organic reserve in agricultural practice (Shaffer et al., 2001; Marinova et al., 2012; Baykov, et al., 2007).

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The interest of farmers associated with utilization of bio-slime is related to the lack of organic sources, imbalance of organic matter in Bulgarian soils and the availability of large quantities of organic waste.
The aim of this study is: To establish the effect of bio-slime for use in agricultural practice and its impact on yield and quality of crop production at the ratio of the raw materials into biogas pilot plant - 70:30 pig manure and market wastes.

Material and Methods

Conducting the vegetation experiment

Experimenting with amount of different variants and establishment of the most optimal require conducting of greenhouse experiments. Pots experiments were conducted using bio-slime from model installation for biogas production with raw material comprising pig manure: wastes from market in ratio 70%: 30%. Experiments are carried out on two soil types: Fluvisols from the area of Kubratovo and Vertisols from Bojurishte. The following variants were tested: Control - clean soil, control - soil with mineral fertilization and variants with 5%, 15%, 25% and 35% of bio-slime by soil weight. The variants with mineral fertilization are included to compare the used bio-slime, which is organic matter (gradually mineralized) and mineral fertilization (easily assimilated form). The lettuce (Lactuca sativa L.) was planted as a test crop. For establishment of content of macro and micro nutrients and cation exchange capacity bio-slime and soil types were analyzed before experiment.

Determination of the yield and analysis of crop production and soil

Post-harvest crop yield was recorded and the information was subjected to mathematical and statistical analysis. The plant production is analyzed for basic content of macro and micro elements and some heavy metals according to standard methodologies:
- Total nitrogen – *BNS EN 13342:2003 ISO 11261:2002*
- Ammonium and nitrate nitrogen – *BNS ISO 14255:2002*
- Mobile forms of phosphorus - *BNS ISO11263:2002*
- Mobile forms of potassium – *with a flame photometer*
- Total content of heavy metals - aqua regia method *BNS EN-13346:2000, BM-1:2007*
- Mobile forms of microelements (heavy metals) - according to EDTA method
- pH- *BNS EN12176:2004*
- Cation exchange capacity- *Ganev and Arsova method (1980).*
- Mechanical composition – *ISO 11277:2009*
- Hygroscopic humidity – *BNS EN 12880:2003*
- Electrical conductivity – conductometrically.

Results and Discussion

Characterization and evaluation of bio-slime used in vegetation experiments.

Agronomic and environmental characteristics of bio-slime obtained from 70% pig manure: 30% fruit and vegetable waste (Simeonov et al, 2012) is shown on table 1.
The data show that bio-slime is rich in macro and microelements and can be used in agricultural practices to improve soil properties and crops yield.
The content of the common forms of nutrients - nitrogen, phosphorus and potassium are respectively 10,80%; 7,67% and 9,02% in absolute dry matter. Based on the dry matter content, the real values of total nitrogen were 0,11%; 0,08% total phosphorus and 0,099% total potassium. The pH activity is slightly alkaline - 7,62.
The content of heavy metals (table 1) shows that values are under Maximum Available Concentration (MAC) and bio-slime is not hazard for use in agriculture.
The data on chemical composition and physicochemical properties of bio-slime shows that it can be a source of important plant nutrients such as nitrogen, phosphorus, potassium, magnesium, calcium, iron, sodium, etc.

Table 1. Chemical and agrochemical characteristics of bio-slime from vegetative experiments

Elements	70:30 pig manure: markets waste	Elements	70:30 pig manure: markets waste
pH in H_2O	7,62	Mobile P %	0,54
Moisture %	98,9	Mobile K %	1,25
Dry residue %	1,1	S (as SO_4) %	0,1
Organic C %	24,88	As mg/kg	< 5,0
Total P_2O_5 %	7,67	Cd mg/kg	< 1,0
Total N %	10,8	Cr mg/kg	13
Total K_2O %	9,02	Ni mg/kg	26
Total CaO %	7,6	Cu mg/kg	411
Total MgO %	2,89	Zn mg/kg	1409
Mobile N–NH_4 %	5,48	Pb mg/kg	8
Mobile N–NO_3 %	0,53	Hg mg/kg	<1

Characterization and evaluation of experimental soils types

Agrochemical physical-chemical characteristics of Fluvisol from Kubratovo.

Data from agrochemical analysis show that the soil is very well supplied with mobile phosphorus (23,2 mg P_2O_5/100g soil) well preserved with mobile potassium (27,4 mg K_2O/100g soil) and mineral nitrogen in dominant ammonium form. Conductivity is low and amount of soluble salts is also very low. The total amount of heavy metals in the soil is below MAC (table 2).

Table 2. Chemical analysis of Vertisol and Fluvisol of the vegetation experiments

Elements	Vertisols	Alluvial-meadow	Elements	Vertisols	Alluvial-meadow
pH –H_2O	6,1	5,5	Exchange Mg mg/100g	108	57
Total N %	0,12	0,21	Conductivity mS/cm	0,042	0,077
Total Ca%	-	0,14	Water soluble salts g/100g	0,013	0,024
Total Mg %	-	0,58	As mg/100g	<1	< 1
Total Fe %	2,77	3,51	Cd mg/100g	<1	< 1
Total P %	-	0,14	Cu mg/100g	185	210
N – NH_4 mg/kg	8,2	11,8	Pb mg/100g	2	42
N –NO_3 mg/kg	5,8	7,1	Ni mg/100g	22	18
Mobile P_2O_5 mg/100g	0,22	23,2	Zn mg/100g	1170	132
Mobile K_2O mg/100g	36,9	27,4	Cr mg/100g	7	11
Exchange Ca mg/100g	696	430	Humus %	3,36	-

A physicochemical characterization of soils, used in vegetation experiments was also made. Data on Fluvisols is presented in Table 3. According to the constitution bases, when the bases are <T_{CA} ($T_{8.2}$%) and pH <6 the soil is podzolic. According to the buffer systems the soil is medium acid and the ion exchange capacity ($T_{8.2}$ = 35 meqv. /100 g soil) define it as medium colloidal. The predominant clay minerals determine soil as montmorillonite-illite (T_{CA} = 81,43%) with evolution to Illite-montmorillonite (base = 80,29%).

Table 3. Cation exchange capacity and base saturation in studied Fluvisol

Materials	pH/ H_2O	$T_{8,2}$	T_{CA}	T_A	Exch. $H_{8,2}$	Exch. Al+H	Exch. Ca	Exch. Mg
		meqv/ 100 g.						
Soil	5,5	35,0	28,5	6,5	6,9	0,4	24,0	3,9

T_{CA}	T_A	Exch. $H_{8,2}$	Exch. Al	Exch. Ca	Exch. Mg	Base saturation %
% $T_{8,2}$						
81,43	18,57	19,71	1,43	68,57	10,86	80,29

Physical and mechanical properties of Fluvisol (Table.4) show that fraction <0,001 dominates.

Table 4. Mechanical composition of Fluvisol from the vegetation experiments

Variants	Particle size (mm)						
	Amount > 1	1 – 0.025	0.25 – 0.05	0.05 – 0.01	0.01 – 0.005	0.005 – 0.001	<0.001	Amount < 0.01
Soil	0.0	16,7	19,73	13,72	15,04	6,71	28,10	49,85

Agrochemical and physical-chemical characteristics of Vertisols in the region of Bojurishte.

Soil from Bojurishte region - Sofia provided for vegetation experiment is, classified as Smolnitsa according to the Bulgarian Soil Classification, which correspond to Vertisol in the World Reference Base for Soil Resources (IUSS Working Group WRB, 2006).

Data from agrochemical analysis of the soil shows that it is very well supplied with mobile potassium- 36,92 mg K_2O / 100 g soil, and very low, almost poor in the plants absorbable phosphorus- 0,22 mg P_2O_5 /100 g soil.

Mineral nitrogen is in predominance of ammonium form. The amount of soluble salts is very small due to the low conductivity. The total amount of heavy metals is below the limit (table 2).

Data for physical and chemical characteristics of the soil is presented in table 5. The ranges of variation of the magnitude of cation sorption capacity ($T_{8,2}$) and the average percentage of strong (T_{CA}) and weak (T_A) atsidoid is determined using the Ganev and Arsova method.

Table 5. Cation exchange capacity and base saturation in studied Vertisol

Materials	pH/ H_2O	$T_{8,2}$	T_{CA}	T_A	Exch. $H_{8,2}$	Exch. Al+H	Exch. Ca	Exch. Mg
		meqv/ 100 g.						
Soil	6,1	50,7	43,86	6.9	3,9	0,0	34,7	9,04

T_{CA}	T_A	Exch. $H_{8,2}$	Exch. Al	Exch. Ca	Exch. Mg	Base saturation %
% $T_{8,2}$						
86,39	13,61	7,69	0,0	72,39	17,89	92,31

Constitution bases soil (A horizon) with pH = 6.1, bases = T_{CA} confirms that the soil is leached. According to the acid and buffer systems, Vertisol is a weak acid (A horizon). Colloidal reactivity ($T_{8,2}$ = 44, meqv/100g) shows that the soil is poorly colloid. The prevalent clay mineralogy (T_{CA} = 43.86 meqv/100g) determine soil as montmorillonite ilite. It was also determined the mechanical composition of the Vertisol. The results are presented in table 6. The data shows that dominated fraction have a size less than 0,001 (finest fraction).

Table 6. Mechanical composition of Vertisols for vegetation experiments

Variants	Particle size (mm)						
	Amount > 1	1 – 0.025	0.25 – 0.05	0.05 – 0.01	0.01 – 0.005	0.005 – 0.001	<0.001	Amount < 0.01
Soil	0.0	1,8	9,8	13,0	11,5	8,8	53,3	73,6

Development of plants during vegetation

Pots experiments are set on 31 October 2011 on already mentioned two soil types (Fluvisols and Vertisols). Sowing of lettuce was carried out. Plants germinated normal on 10 November 2011. 20 days later lettuce was thinned. The plants are watering according to field capacity (FC) requirements. Forty six days after sowing the plants in different variants were photographed.

Lettuce

Yield and chemical analysis of lettuce plant production

Vegetation experiments show that lettuce develops normally on both soil types. The obtained data from lettuce yield on Fluvisol (fig.1) and leaching Vertisol (fig. 2) show that quantity of biomass is higher on the first soil type for all variants.

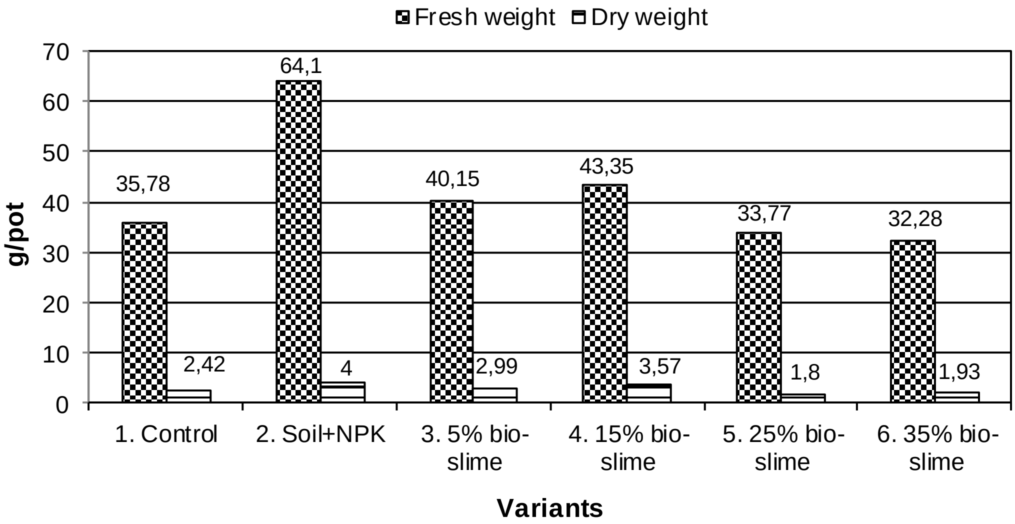

Fig.1. Yield of lettuce from Fluvisol on experiments with bio-slime

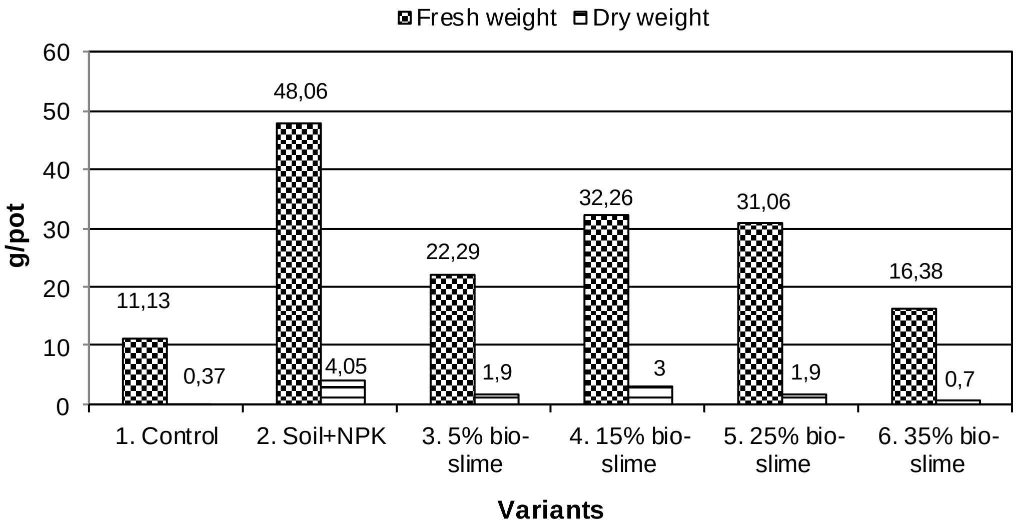

Fig. 2. Yield of lettuce from Vertisol on experiments with bio-slime

The high value of lettuce yield on Fluvisol is probably due to the very good soil preservation with N, P and K. The trend in yield by increasing the amount of bio-slime for both soil types is similar. The best lettuce developing is observed in variants with mineral fertilization and the yield is highest. Biomass of lettuce in control variant (clean soil) remains low compared to other variants and it is similar in both soil types. For variants with bio-slime the largest biomass was measured in variants with 15% bio-slime compared to control variant. High rates of bio-slime have suppressive effects on plant development and yield probably due to excessive high levels of digestible nitrogen, phosphorus and potassium. Higher rates of bio-slime obtain the soil compaction, which affects the optimal development of lettuce root system. On the other hand bio-slime values larger than 15% are not environmentally friendly and cost effective. The highest yield of lettuce in both soils was obtained with mineral fertilization variants – 4g / pot in Fluvisol and 4,05 g / pot - Vertisols. The differences between each variant are greater than less permissible difference (LPD) 0.1%. In bio-slime variants, the maximum of yield is in 15% bio-slime by weight of soil. The difference between yields from variants of Fluvisol is statistically proven (LPD 1%), and the Vertisols - in (LPD 0,1%). There is a tendency to reduce yield at further increasing the amount of introduces bio-slime (with LPD 0,1%).

After lettuce harvesting some analyses for content of basic macro and microelements and heavy metals were made. The results of chemical analysis of plant production are presented in table 7 and table 8.

Table 7. Chemical characteristic of plant production by lettuce grown on Fluvisol

Variants	N %	P %	K%	Ca %	Mg %	Zn mg/kg	Cu mg/kg	Mn mg/kg	Fe mg/kg
1. Control	1,40	0,46	6,80	1,22	0,32	46	10	78	800
2. Soil+NPK	2,20	0,72	7,40	1,53	0,42	53	11	95	1200
3. 5% bio-slime	1,20	0,49	7,40	1,19	0,31	39	11	92	1650
4. 15% bio-slime	1,30	0,46	6,40	1,44	0,45	42	6	98	1050
5. 25% bio-slime	2,30	0,45	8,60	1,43	0,38	50	10	48	1000
6. 35% bio-slime	2,40	0,43	9,00	1,50	0,40	51	13	63	1400

Table 8. Chemical characteristic of plant production by lettuce grown on Vertisols

Variants	N%	P %	K%	Ca %	Mg %	Zn mg/kg	Cu mg/kg	Mn mg/kg	Fe mg/kg
1. Control	0,83	0.18	5.80	1.00	0.25	35	7	65	850
2. Soil+NPK	1,40	0,43	7,50	1,18	0,28	41	9	67	950
3. 5% bio-slime	1,20	0,25	6,00	0,92	0,23	36	7	71	900
4. 15% bio-slime	1,40	0,18	6,80	0,84	0,30	48	11	103	2000
5. 25% bio-slime	1,20	0, 27	8,40	1,07	0,39	54	10	104	2500
6. 35% bio-slime	1,40	0,26	7,50	2,40	0,47	66	13	120	2300

The content of total nitrogen in plants varies between 1,40% and 2,40% on Fluvisol and from 0,83% to 1,40% on Vertisols. These values are comparable with data from studies of Mitova and Marinova, (2012) with enriched vermiculite on the same soil types and the same variety of lettuce.

In Fluvisol with increasing bio-slime amount, the phosphorus in plants is not changed, potassium increased slightly, while calcium and magnesium is varying (table 7).

Nutrients content in Vertisols expressed no clear trend with increasing amount of bio-slime. The concentrations in different variants slight vary (table 8).

Analyses for content of microelements Cu, Zn and Mn in plant production show that they are in optimal range for the species.

The iron content in plant tissues at the end of the study have high values in Vertisols (from 850 to 2400 mg / kg), and from 800 to 1400 mg / kg in Fluvisol. Regardless of increased amounts of iron visible depression in lettuce is not noticeable.

Chemical and agrochemical characteristic of Fluvisol from Kubratovo after lettuce harvesting.

Agrochemical analysis of soil, after harvest lettuce show that increasing of bio-slime amount leads to significantly increase of plant absorbable phosphorus (table 9).

Table 9. Agrochemical characteristic of Fluvisol with variant post-harvest vegetation experiments with lettuce

Variants	pH H_2O	Mineral nitrogen mg/kg NH_4	NO_3	P_2O_5 mg/100g	K_2O mg/100g
1. Control	5,8	66,70	16,80	23,20	28,40
2. Soil+NPK	5,3	62,10	44,70	76,60	39,20
3. 5% bio-slime	5,8	66,70	28,40	26,70	32,90
4. 15% bio-slime	5,9	60,90	38,90	32,30	34,00
5. 25% bio-slime	5,9	70,20	43,50	42,10	43,20
6. 35% bio-slime	6,0	52,80	45,80	50,30	45,20

Higher level of supply absorb phosphorus has the variant with 35% added bio-slime, which causes a decrease in yield. The degree of mobile potassium increases with increasing of bio-slime amount in variants. In 35% bio-slime the potassium content reaches 45, 2 mg K_2O / 100 g soil and it shows very high degree of supply with this nutrient. The amount of mineral nitrogen was also increased with increasing dose of bio-slime. This is at the expense of a large increase of nitrogen from 16, 83 mg / kg N-NO_3 var.1 up to 45, 8 mg / kg N-NO_3 for var.6. The change of ammonia form of mineral nitrogen is weak and variable, but generally mineral nitrogen has very high values (table 9).

Table 10. Assessment salinity of Fluvisol from vegetation experiments with lettuce with different variants of bio-slime

Variants	Conductivity mS/cm	Water soluble salts g/100g
1. Control	0,098	0,030
2. Soil+NPK	0,308	0,100
3. 5% bio-slime	0,084	0,027
4. 15% bio-slime	0,098	0,031
5. 25% bio-slime	0,116	0,037
6. 35% bio-slime	0,135	0,043

After harvesting the lettuce analyses of conductivity and presence of soluble salts in variants, show increasing amount of added bio-slime gradually increasing conductivity and the amount of water-soluble salts, but they are within the limits of not salty soils. The highest values have variant 2, with incorporated mineral N, P, K fertilizers (table 10).

Chemical and agrochemical characteristic of Vertisols in the region of Bojurishte after lettuce harvesting.
Studies on agrochemical characteristics of soil after harvesting the lettuce found that increasing of bio-slime rates leads to smoothly increasing of absorbable phosphorus for plants. The highest dose of bio-slime is P_2O_5/100 14,16 mg g soil (table 11). In variant with 35% bio-slime is achieved moderate supply of absorbable phosphorus. The degree of mobile potassium in Vertisols is very good. In the variants with the highest amount of bio-slime content reaches 10, 1 mg K_2O / 100 g soil and it can lead to depression in yield. As noted above the amount of mineral nitrogen in non treated soil is high with prevalence of the ammonia form. Significantly increasing of the bio-slime rates, lead to increasing the amount of nitrate form of mineral nitrogen (table 11).

Table 11. Agrochemical characteristics of Vertisols after lettuce harvesting

Variants	pH H_2O	Mineral nitrogen mg/kg		P_2O_5 mg/100g	K_2O mg/100g
		NH_4	NO_3		
1. Control	6,1	49,3	13,3	0,75	45,0
2. Soil+NPK	5,6	101,5	124,7	66,13	105,0
3. 5% bio-slime	6,1	63,2	33,1	3,13	46,0
4. 15% bio-slime	6,0	58,6	55,1	6,38	51,0
5. 25% bio-slime	5,9	71,3	80,6	11,63	59,0
6. 35% bio-slime	6,1	53,9	94,5	14,16	101,1

Table 12. Evaluation of Vertisols salinity after lettuce harvesting

Variants	pH, H_2O	Conductivity,mS/cm	Water soluble salts g/100g
1. Control	6,1	0,042	0,013
2. Soil+NPK	5,6	0,406	0,130
3. 5% bio-slime	6,1	0,084	0,027
4. 15% bio-slime	6,0	0,098	0,031
5. 25% bio-slime	5,9	0,116	0,037
6. 35% bio-slime	6,1	0,135	0,043

Analyses were conducted for the electrical conductivity and the presence of soluble salts on all variants after lettuce harvesting. It is found that with increasing amount of imported bio-slime slightly increases conductivity and quantity of water-soluble salts, but these rates not lead to salinisation (table. 12). The highest values have both indicators, measured for variants with chemical fertilization (table 12).

Conclusion

As a result of conducted experiments and the obtained results it was found:

1. Agrochemical and chemical characteristics define bio-slime as a biomass rich in macro and micronutrients that can be used in agriculture for increasing of soil fertility. The content of heavy metals in initial bio-slime is below maximum allowable concentration and soil is not burdened with these elements.
2. A positive effect of bio-slime utilization was established in vegetation experiments on the yield and quality of crop production. The results of lettuce at increasing doses of biomass indicates that plants have the best development and quality options with 15% bio-slime involving 70% pig manure.

3. The results for total nitrogen, phosphorus, potassium, calcium, magnesium and microelements copper, zinc and manganese in plant production of lettuce are within the normal range for the species. The values of iron content are higher in lettuce grown on Vertisols.

It is found that increasing of bio-slime rates significantly increased plants absorbable phosphorus and potassium in both soil types. The quantity of mineral nitrogen (nitrate form) also increases. The amount of soluble salts in the soil increases slightly, but there is no danger of salinization.

Acknowledgement

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References

1. Baykov, B., J. Petkov, K. Kirov, B. Zaharinov, N. Marinova, I. Popova, 2007. Exploring the quality of compost as a natural replacement for high energy chemical fertilizers. Environmental assessment of the amount of toxic elements in compost. Ecological engineering and environment protection. № 2, 33-36.
2. Galabova,D., I. Simeonov, D. Dalev, D. Karakashev. 2003. Research and optimization of the anaerobic digestion of organic wastes. *Ecological Engineering and Environment Protection* 2: 37-43.
3. Ganev S., A. Arsova, 1980. Methods of determining the strongly acid and the slightly acid cation exchange in soil. Soil Science and Agrochemistry, 3, 22-33.
4. Marinova S., S. Mihaylova, E. Zlatareva, R. Toncheva, H. Pchelarova, I. Simeonov. 2012. Effect of Digestate from Anaerobic Co-degistation of Wasted Fruits and Vegetables and Swine Manure on Development of Lettuce. Proceedings Intern. *Conference "Ecology- Interdisciplinary Science and Practice* ", Sofia, 25-26 oct. Part 2, 493-497.
5. Mitova, I., Marinova, S., 2012. Effects of enriched vermiculite on the formation of yield and quality in lettuce. Soil Science and Agricultural Chemistry and Ecology. Year XLVI, Book 2, Sofia, Agricultural Academy
6. Rychtera, M., J. Ionas, 1983. Biotechnological aspects of biogas production from agricultural wastes. Proc. *Biotechnology symp. of Socialist countries Bratislava*. 25-29 Apr. 1983. Pt 2. 455-473.
7. Shaffer, M J. and Ma, Liwang, 2001. Carbon and nitrogen dynamics in upland soils. In: M.J. Shaffer, Liwang Ma, S. Hansen (Eds) *Modeling Carbon and Nitrogen Dynamics for Soil Management*, Chapter 2, CRC Press LLC Publisher, 11-26.
8. Simeonov I, Sn. Mihaylova. B. Kalchev. E.Chorukova, S.Marinova, 2012, Study on the anaerobic co-digestion of waster fruits and vegetables, BALWOIS – 2012, Ohrid, 5-th Intern. *Conference on Water, Climate and Environment,* 28 May - 2 June.
9. Zaharinov, B., 2011. Waste management through their use of organic matter as a source of energy - conversion of established industry boundaries. *NBU collection of articles, Ecology* 2011.
10. Zaharinov, B., 2013. "Biomass, biogas, compost energy of anthropogenic ecosystems". *Environmental biotechnology for the production of biogas and compost utilization*. New Bulgarian university Sofia.
11. Schink, B., 2001. Anaerobic digestion concepts, limits and perspectives, 9-th World Congress "Anaerobic digestion", 2-6 Sept, Antverpen, Belgium, 15-21.
12. IUSS Working Group WRB. 2006. *World reference base for soil resources 2006*. 2nd edition. World Soil Resources Reports No. 103. FAO, Rome. p. 128

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Soil and crop management effects on soil organic carbon

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Abstract

At present the major environmental problem is the carbon dioxide (CO_2) axis climate change. Climate changes basically stems from human activities. In recent years there has been a severe drought in the Mediterranean ecosystem. Most people cannot predict the exact cause of the drought. Even the scientific community is not sure about effect of soil-crop management on atmospheric CO_2 increase and climate change. In order to get high yield and production farmers are using high inputs such as chemical fertilizers, pesticides, tillage, irrigation and improved seed. Last 15 years effect of crop and soil management on soil organic carbon has been studied. Under the high temperatures and less water conditions and burning of straw after harvest for the next crop, reduce soil organic carbon (SOC) and elevated CO_2 concentrations and climate change is expected to increase as well. Soil can be a sink for atmospheric carbon, thus reducing the net CO_2 emissions normally associated with agricultural ecosystems, and mitigating the 'greenhouse effect'. Atmospheric CO_2 can be fixed to soil thought photosynthesis. Since plant root and mycorrhizal fungi are demanding more carbon, plants are capturing more atmospheric CO_2 and accumulated in plant tissue. Carbon sequestration and saving carbon in the aggregate has recently been the burgeoning topic in soil science with an increasing interest on the effect of mycorrhizal hyphae (glomaline as the by-product), together with humic substances enhancing aggregate stability. Arbuscular mycorrhizal fungi (AMF) are obligate symbioses of nearly %95 of plants species. The effects of mycorrhizal colonization on nutrient uptake and root growth were studied extensively. However recently it has been indicated that mycrrhizae hyphae may have significant effect on soil aggregate size and development. Mycorrhizae fungi are the major component of soil microbial biomass, and AMF hyphae produce glomalin, a recalcitrant glycoproteinaceous substance highly correlated with soil aggregate water stability as well. Long term mycorrhiza inoculation or indigenous mycorrhizae management also has effect on aggregate development. And also under long term field experiment there is a relationship between SOC content and yield increases.

Keywords: soil management, carbon sequestration, plant root, mychorriza, glomalin, aggregation.

Introduction

Since the onset of industrial revolution around 1850, the concentration of carbon dioxide (CO2) has increased by 31% from 280 ppm to 380 ppm year in 2005, and is presently increasing at 1.7 ppm year or 0.46% yr−1 (IPCC 2007 http://www.ipcc.ch/), presently is 398 ppm. The green revolution enhanced the agricultural production as a result of the increased agricultural inputs such as chemical fertilizers, pesticides, heavy tillage, irrigation and improved seed use. However after a certain period of time, the increase in the agricultural inputs does not increase the yield. Because of high temperature, high $CaCO_3$, clay content and heavy tillage, the soil organic matter content decreases and productivity is low in the Eastern part of the Mediterranean regions. Singh *et al.*

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(2009) reported that loss of organic matter and the degradation of soil structure can have a detrimental effect on soil fertility and crop productivity. Since, root C has longer residence time in soil than shoot C (Gale and Cambardella, 2000; Gale *et al.*, 2000, 2002; Rasse *et al.*, 2005) it is important to manage the plant roots in soil depth for the carbon pool. At the same time Lal and Kimble (1997) indicated that agricultural soils, being depleted of large amount of organic C due to cultivation, have significant potentials to sequester atmospheric CO_2. There is a strong interest in stabilizing the atmospheric abundance of CO_2 in order to reduce it effect on the risks of global warming.

There are three strategies of lowering CO_2 emissions to mitigate climate change (Schrag, 2007):

1) reducing the global energy use,

2) developing low or no-carbon fuel, and

3) sequestering CO_2 from point sources or atmosphere through natural (photosynthesis) and engineering techniques.

The most efficient method of carbon mitigation is photosets mechanism which can download the atmospheric carbon to the surface. The basic processes of the carbon cycle are: CO_2 in through photosynthesis, and CO_2 out through decomposition. The net gain of C in the soil is a function of the balance between inputs (i.e., net primary productivity plus any external inputs) and losses (i.e.,decomposition, erosion, leaching).

Fixing CO2 from atmosphere to soil through photosynthesis is one of the powerful natural mechanisms. Through the process of photosynthesis, plants absorb CO_2 from the atmosphere, transform it into plant carbon, and sequester it in either above- or below-ground biomass and/or soil carbon. Agricultural soils can be both a sink and source of atmospheric CO_2 and can be managed to moderate CO2 emissions. Soil organic matter (SOM) is an important component of soil fertility, productivity and quality because of its crucial role in soil chemical, physical and biological properties. SOC is considered as the most important agent for aggregate formation with mycorrhizal fungi.

Although the SOC pool and accompanying relationships with climate and vegetation are poorly understood (Lorenz and Lal, 2005), numerous field experiments revealed the direct relations between soil management and the C pool and SOM content.

The types of land use and soil cultivation are important factors controlling organic carbon storage in soils and they may also change the relative importance of different mechanisms of soil organic matter stabilization Figure 1. As can be seen in the Figure 1. Deferent fertilizer inputs have significant effects on soil OM concentration. Plant species and soil management is important for long term carbon sequestration in the soil as well. Previously (Ortas and Lal (2012); Ortas *et al.*, 2013) indicated that since with organic and inorganic fertilizer addition plant biomass is increasing consequence residue material increase soil organic matter content.

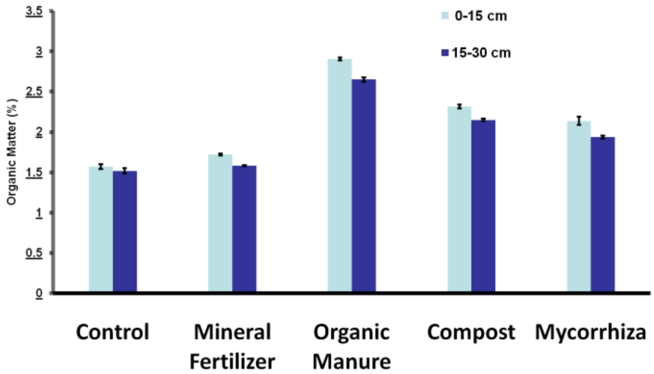


Figure 1. Effect of mineral and organic fertilizer on organic matter (Ortas unpublished)

Soil Keep Carbon for Long Term

In many ecosystems the C pools and SOC stock changes are strongly associated with C input rate to soils. It has been calculated that the total amount of carbon stored in terrestrial ecosystem is about 2000 +/- 500 Pg and about 75% of this occurs in the soil profile. It has been estimated by Lala (2004) that soil is storing up to 1,550 Pg C to one m depth and twice the amount of Carbon in the atmosphere. Also according to Lal (2004)'s calculation approximately 78 Pg (10^{15})C has been lost from the global soil pool due to land-use conversion for agriculture with approximately 26 Pg attributed to erosion and 52 Pg attributed to mineralization. Keeping or enhancing the storage of carbon long term in soil call carbon sequestration. Carbon capture can occur at the point of atmospheric emission through natural processes photosynthesis, which remove carbon dioxide from the atmosphere to plant and then to soil. Simply sequestered is the difference between carbon 'gained' by photosynthesis and carbon 'lost' or 'released' by respiration. Enhancing C in the soil is an appropriate management practices which is ecologically and economically important.

Since plant are decomposed in a several years most of the carbon is losses. C losses associated with conventional treatments which agree with our previous findings. It is important to keep carbon in soil rather than biomass. Carbon remain in biomass for 10 years, remain in soil is about 35 years. The aggregation process is one of the important soil properties keep C in the soil for long term. The soil organic carbon is very important in arid and semi-arid regions of Mediterranean region, where soils have several structural problems such as high clay, high $CaCO_2$ level, shrinking water, severe erosion, periodic drought, low biological productivity all have effect on SOC.

Soil Management Carbon and the Aggregate

Soil organic matter (SOM) is an important indicator of soil fertility, productivity and quality because of its crucial role in soil chemical, physical and biological properties. Since soil aggregates are blockading C and N, it is going to be a good agricultural strategy to developed soil aggregation for more carbon sequestration. The disturbance of surface land in agricultural practices distributes the dynamic equilibrium of organic matter inputs and outputs creating a new soil environment. Macro aggregates exhibited a significant positive relationship with SOC and particular organic matter (POM) (Mikha *et al.*, 2010).

Blanco-Canqui and Lal (2007) compared differences in soil physical properties and SOC concentrations in aggregates among tree species after 7 years of plantation and their results show that differences in aggregate physical properties and aggregate-associated SOC concentration among tree species were relatively small and depended on the soil property. Also they indicated increases in SOC concentration reduced soil aggregate straight and increased soil water retention. Shrestha and Lal (2007) shown that the aggregate-size distribution and stability are important indicators of soil physical quality (e.g. soil structure, aggregation and degradation) parameters. Soil aggregation also plays a dominant and central role in SOC sequestration by physically protecting SOM through its incorporation (Golchin *et al.*, 1994).

The aggregates encapsulate SOC, reducing the rate of SOC decomposition (Lal, 2008). It has been reported in various studies that plant roots and mycorrhizal hyphae can physically protect the soil carbon from microbial decomposers through aggregation (Golchin *et al.*, 1994; Jastrow *et al.*, 1998).

Soil structural stabilization is related to organic matter inputs (Caravaca *et al.*, 2002). There is a strong direct relationship between soil aggregation and SOC concentration (Mikha *et al.*, 2010). The SOC encapsulated within soil aggregates has lower decomposition rate than that located outside of aggregates (Golchin *et al.*, 1994; Six *et al.*, 2000). One important source of organic compounds on aggregation is polysaccharides, carbohydrates, lignin and lipids

Effect of Soil Till on Aggregation

In order to understand the effect of management on soil carbon (C) sink capacity, budget and sequestration long-term soil management experiments and data are required. Soil management exerts a strong influence on the formation and stabilization of aggregates and SOC sequestration (Tisdall *et al.*, 1997; Jastrow *et al.*, 1998; Six *et al.*, 1998).

Rimal and Lal (2009) indicated that land management practices influence structural properties of soil aggregates, its size and stability, and the stabilization effect of SOC and other cementing agents. Soil organic C (SOC) is an important component of soil quality and productivity.

It has been frequently indicated that various tillage systems have a strong effect on SOC and soil aggregation. Tillage disrupts the macro aggregates and breaks them into micro aggregates by letting in oxygen and releasing carbon dioxide (Pendell *et al.*, 2007). It has been shown that land use and soil management especially non-till and conservation tillage affects SOC pools. Puget and Lal, (2005) showed that the effects of tillage on soil aggregation and SOC varied depending on regional climate, soil type, residue management practice, and crop rotation. A recommended management practice is especially the no-till treatment which reduces soil losses and increases SOC and also increases the C sequestration through aggregate development.

In many field studies, the soil organic matter quantity and quality as well as soil aggregation were significantly affected (Celik *et al.*, 2004) in the top soil rather than the deep soil especially under conventional tillage systems.

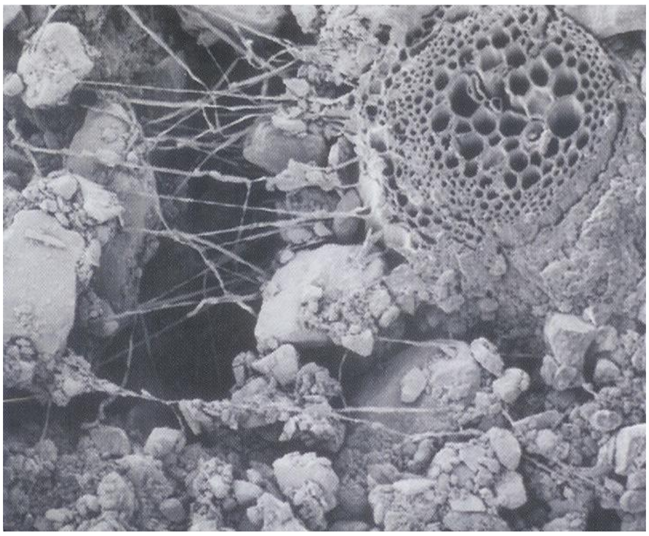
Arbucular Mycorrhiza Develops Aggregation

Arbuscular mycorrhizal fungi (AMF) as soil microorganisms appear to play a predominant effect on aggregates formation because the symbiosis significantly changes the root functioning (Rillig, 2004). AMF are the largest symbiotic associations between plants and fungi that can make significant contribution on soil physical fertility through AM fungal hyphae extending into the rhizosphere and thereby improve the absorption of phosphate and nitrogen, which are the two major nutrients (Ortas, 2003; Karandashov and Bucher, 2005; Smith and Read, 2008). It has been demonstrated that the mycorrhizae mycelia network can have a binding action on the soil and improve soil structure (Tisdall *et al.*, 1997; Caravaca *et al.*, 2006; Rillig *et al.*, 2010b). Organic amendment and mycorrhiza are the well-known aggregate building agents (Celik *et al.*, 2004). Extensive soil based mycelium of fungus around roots can help soil aggregation processes (Picture 1).

Picture 1. Mycorrhizal hyphae through soil profile (Ortas, 2008)

It has been indicated that (AM) fungi are key organisms of the soil/plant system, influencing and contributing to soil aggregation and soil structure stability by the combined action of extra radical hyphae and of an insoluble, hydrophobic proteinaceous substance named glomalin-related soil protein (Bedini *et al.*, 2009).

The strength of the mycorrhizal association and its relationship with soil structure depend on root morphology (Miller and Jastrow, 1990) and mycorrhizal hyphae.AM improves soil structure, as a consequence of the contribution of mycorrhiza in the formation of stable aggregates. The establishment of mycorrhiza causes changes in the physiology of the host plant. This enables mycorrhizal plants to develop better and to respond better to environmental stresses than non-mycorrhizal plants.Functions of AM in soil physical development depend on several factors and have a significant effect on ecosystem service(s). These ecosystem service(s) provided by AM are based on the modification of the root morphology and development of a complex ramified mycelia network in soil, which increases plant/soil adherence and soil stability (binding action and improvement of soil structure) (Picture 2) in turn increasing mineral nutrient and water uptake by plants.



Picture 2. Binding actions such as root, hyphae and microorganisms improvement of soil structure. Roots, microbes and particles of soil (Luoma, 1998).

Soil C addition has significant effect on plant and soil development through direct and indirect effects. Less soil C not only limits plant growth through a reduction in available nutrients, but also reduces mycorrhizal colonization of plant roots. When the mycorrhizal hyphae not developed soil quality and aggregation is not developed as well. The contribution of mycorrhizal inoculation to the SOC pool and aggregate depends on root and hyphae productivity, root and hyphae turnover rates and exudation. Abiven *et al.* (2007) indicated that aggregate stability seemed to be influenced by fungal hyphal length. Roots and mycorrhizae (Figure 3), improve aggregation by enmeshing soil particles together and through exudates which increase microbial biomass and produce polymers that serve as aggregates binding agents (Jastrow *et al.*, 1998). Wilson *et al.*

(2009) reported that AMF abundance was a surprisingly dominant factor explaining the vast majority of variability in soil aggregation.

The results of (Bedini *et al.*, 2009) showed that MWD values of soil aggregates were positively correlated with values of total hyphal length and hyphal density of the AM fungi utilized. They also showed that the mean weight diameter (MWD) of macro aggregates of 1-2 mm diameter, was significantly higher in mycorrhizal soils compared to the non-mycorrhizal soil. Mycorrhizas enhanced >2 mm, 1-2 mm and >0.25 mm water-stable aggregate fractions but reduced 0.25-0.5 mm water-stable aggregates (Wu *et al.*, 2008). Similarly (Caravaca *et al.*, 2006) reported that the combination of *G. intraradices* with both organic amendments had significantly enhanced the structural stability.

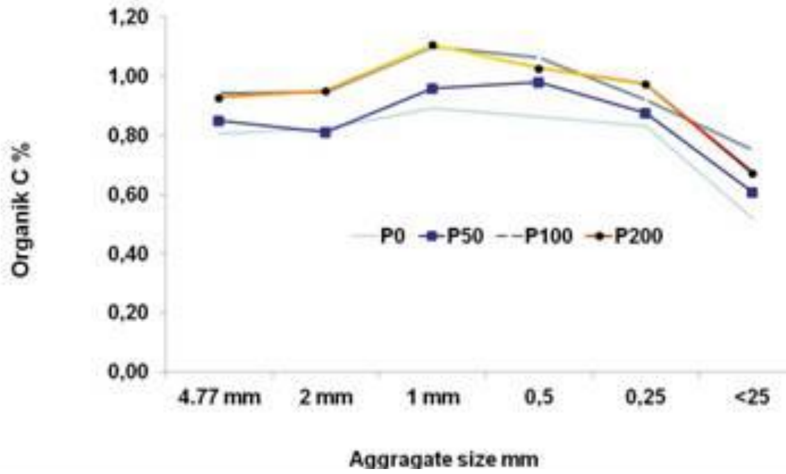


Figure 2. Effect of long term P fertilizer on aggregate fraction carbon concentration (Ortas and Lal, 2012).

There was more C concentration in 0.5-1 mm aggregate sizes than in <0.25 mm size range. Also soil physical properties MWD were affected with high organic carbon addition (Ortas and Lal, 2012).

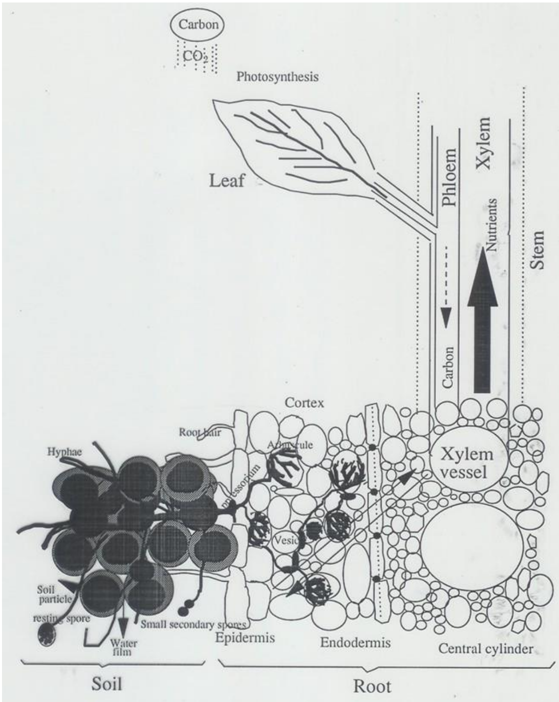
Zhang *et al.* (2014), searched effect of different organic amendment on aggregate distribution and that found that macro aggregates were a major aggregate size class in the organic amendment treatments, comprising 43–52% of the total soil aggregates. Macro aggregates are very important to keep carbon in the soil.

Also aggregation is significantly related with the SOM content. Borie *et al.* (2008) reported that soil structure stability is strongly influenced by the nature and content of soil organic matter. And also they indicated that land use and management practices influencing SOM will be determinant in soil aggregation. Macro and micro aggregates exhibited a significant positive relationship with SOC and POM (Mikha *et al.*, 2010). More C is generally returned to the soil through root growth and mycorrhizal hyphae and turnover than through aboveground biomass in many ecosystems. Preferential preservation of root C in soils has been attributed to:

(1) higher chemical recalcitrance of root C (Rasse *et al.*, 2005);

(2) reduced decomposition in deeper soil layers due to prevailing environmental conditions, which are detrimental to the decomposition of plant tissues (Gill *et al.*, 2002);

(3) physicochemical protection of root exudates and decomposition by-products through interactions with minerals (Jones and Edwards, 1998; Rillig *et al.*, 2010a) and metal ions, such as Al and Fe, which inhibit microbial degradation (Kinraide and Sweeney, 2003).



Picture 3. Root and rhizosphere (Ortas, 1994)

(4) the secretion by AM fungi such as glomalin (Rillig *et al.*, 2002) contributes to soil stability (Bedini *et al.*, 2009). The combination of an extensive hyphal network and the secretion of glomalin is considered to be an important element in helping to stabilize soil aggregates (Andrade *et al.*, 1998; Rillig and Mummey, 2006), thereby leading to increased soil structural stability and quality (Caravaca *et al.*, 2002; Bedini *et al.*, 2009).

(5) physical protection from microbial decomposers through aggregation by root and hyphae (Golchin *et al.*, 1994; Jastrow *et al.*, 1998; Bearden, 2001).

Plant Root and Aggregation

Soil aggregation also influences the seedling emergence and root growth. Soil physical fertility is important for root development and mycorrhizal development as well. Nadian *et al.* (2009) demonstrated that colonized Berseem clover (*Trifolium alexandrinum* L.) root length was improved by 20% as soil aggregate diameter increased. The adherence of soil particles and sand grains on the root via AM mycelia were shown by the conceptual diagram of soil aggregation Picture 3 drawn by Miller and Jastrow (2000).

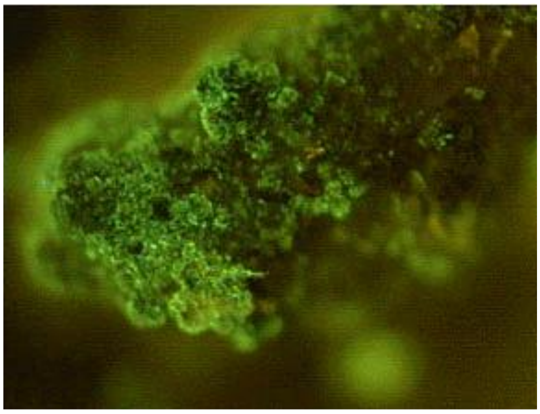
Mycorrhiza inoculated root also have mycorrhizospher. Mycorrhizosfer expended rhizosphere volume which may affect soil aggregate formation. It is expected that most of the rhizosphere components are formed in this area.

Plant roots are excreted nearly 5–21 % of photosynthesis as root exudates and Leake *et al.* (2006) indicated that 6.6–8.9 % of the released C was supplied to AMF. Root exudates have significant contribution on soil development.

Glomalin and Aggregation

Glomalin, a brown to red-brown colored glycoprotein produced by AM fungi, is a major component of soil organic matter that currently is defined operationally by the extraction method (Nichols and Wright, 2005). Glomalin is an abundant component of soil organic matter and has been linked to aggregate stability (Wright and Upadhyaya, 1998). Also it has been indicated that higher levels of glomalin give greater water infiltration, more permeability to air, better root development, higher microbial activity, resistance to surface sealing and erosion. Wright and Upadhyaya (1996) indicated that increased aggregate stability which leads to better soil structure, in turn, leads to better plant production.

Although so much work has been conducted on the effect of glomaline on soil development very recently Treseder and Turner (2007) postulated that the role of glomalin in the ecosystem is still unclear and should be studied under several management systems. Glomalin as a strong glue is produced by a beneficial fungus that grows on plant roots (Picture4). A laboratory procedure reveals glomalin on soil aggregates as the green material shown here. Zhang *et al.* (2014) indicated that total glomalin-related soil protein and easily extracted glomalin-related soil protein within aggregate sizes were affected by organic carbon treatments.



Picture 4. Colure of glomalin under microscope (Nichols, 2010)

Mycorrhizal Hyphea On Glomaline and Aggregation

Bedini *et al.* (2009) showed that the secretion by AM fungi glomalin contributes to soil stability and water retention. It has been reported that the combination of an extensive hyphal network and the secretion of glomalin is considered to be an important element in helping to stabilize soil aggregates (Andrade *et al.*, 1998; Rillig and Mummey, 2006), thereby leading to increased soil structural stability and quality (Caravaca *et al.*, 2006; Bedini *et al.*, 2009).

Rillig *et al.* (2002) indicated that the secretion by AM fungi referred to as glomalin contributes to soil stability and water retention (Bedini *et al.*, 2009). It is supposed that glomalin appears on the outside of the hyphae, and the hyphae seal themselves so they can carry water and nutrients. When hyphae stop transporting water, their protective glomalin sloughs off into the soil, where it helps soil build defenses against degradation and erosion, and boosts its productivity. Glomalin is reported to be a non-water soluble, highly persistent glycoproteinaceous substance (Wright and Upadhyaya, 1998) produced in mycorrhizal fungal cell walls, and remains in soil after hyphal death (Driver *et al.*, 2005). AMF, fed on carbon, found living on plant roots, appear to be the only producer of glomalin.

Conclusion

Soils have different C storage capacity and aggregate size. Generally carbon is kept in soil aggregates. Also the aggregates protect SOC against mineralization. The aggregates are very important soil properties for soil quality and provide physical fertility. The aggregates also play an important role in stabilizing SOC and act and play a significant role to storage more carbon in soil. The aggregates are made by mycorrhizal hyphae and hyphae produced glomaline. Also plant roots are different and have significant effect on aggregation. Crop and soil management are very important to keep soil organic carbon into soil and mitigate the atmospheric CO_2 and climate change. More research is needed to work under semi-arid soil conditions to increase soil organic carbon and increase soil quality.

References

Abiven, S., Menasseri, S., Angers, D.A., Leterme, P., 2007. Dynamics of aggregate stability and biological binding agents during decomposition of organic materials. European Journal of Soil Science 58, 239-247.

Andrade, G., Mihara, K.L., Linderman, R.G., Bethlenfalvay, G.J., 1998. Soil aggregation status and rhizobacteria in the mycorrhizosphere. Plant and Soil 202, 89-96.

Bearden, B.N., 2001. Influence of arbuscular mycorrhizal fungi on soil structure and soil water characteristics of vertisols. Plant and Soil 229, 245-258.

Bedini, S., Pellegrino, E., Avio, L., Pellegrini, S., Bazzoffi, P., Argese, E., Giovannetti, M., 2009. Changes in soil aggregation and glomalin-related soil protein content as affected by the arbuscular mycorrhizal fungal species Glomus mosseae and Glomus intraradices. Soil Biology & Biochemistry 41, 1491-1496.

Blanco-Canqui, H., Lal, R., 2007. Soil structure and organic carbon relationships following 10 years of wheat straw management in no-till. Soil & Tillage Research 95, 240-254.

Borie, F., Rubio, R., Morales, A., 2008. Arbuscular mycorrhizal fungi and soil aggregation. Rev. Cienc. Suelo Nutr. 8, 9-18.

Caravaca, F., Alguacil, M.M., Azcon, R., Roldan, A., 2006. Formation of stable aggregates in rhizosphere soil of Juniperus oxycedrus: Effect of AM fungi and organic amendments. Applied Soil Ecology 33, 30-38.

Caravaca, F., Garcia, C., Hernandez, M.T., Roldan, A., 2002. Aggregate stability changes after organic amendment and mycorrhizal inoculation in the afforestation of a semiarid site with Pinus halepensis. Applied Soil Ecology 19, 199-208.

Celik, I., Ortas, I., Kilic, S., 2004. Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a Chromoxerert soil. Soil & Tillage Research 78, 59-67.

Driver, J.D., Holben, W.E., Rillig, M.C., 2005. Characterization of glomalin as a hyphal wall component of arbuscular mycorrhizal fungi. Soil Biology & Biochemistry 37, 101-106.

Gale, W.J., Cambardella, C.A., 2000. Carbon dynamics of surface residue- and root-derived organic matter under simulated no-till. Soil Science Society of America Journal 64, 190-195.

Gale, W.J., Cambardella, C.A., Bailey, T.B., 2000. Root-derived carbon and the formation and stabilization of aggregates. Soil Science Society of America Journal 64, 201-207.

Gale, W.J., Cambardella, C.A., Bailey, T.B., 2002. Root-derived carbon and the formation and stabilization of aggregates. (vol 64, pg 201, 2000). Soil Science Society of America Journal 66, 2040-2040.

Gill, R.A., Kelly, R.H., Parton, W.J., Day, K.A., Jackson, R.B., Morgan, J.A., Scurlock, J.M.O., Tieszen, L.L., Castle, J.V., Ojima, D.S., Zhang, X.S., 2002. Using simple environmental variables to estimate below-ground productivity in grasslands. Global Ecology and Biogeography 11, 79-86.

Golchin, A., Oades, J.M., Skjemstad, J.O., Clarke, P., 1994. Soil-structure and carbon cycling. Australian Journal of Soil Research 32, 1043-1068.

Jastrow, J.D., Miller, R.M., Lussenhop, J., 1998. Contributions of interacting biological mechanisms to soil aggregate stabilization in restored prairie. Soil Biology & Biochemistry 30, 905-916.

Jones, D.L., Edwards, A.C., 1998. Influence of sorption on the biological utilization of two simple carbon substrates. Soil Biology & Biochemistry 30, 1895-1902.

Karandashov, V., Bucher, M., 2005. Symbiotic phosphate transport in arbuscular mycorrhizas. Trends in Plant Science 10, 22-29.

Kinraide, T.B., Sweeney, B.K., 2003. Proton alleviation of growth inhibition by toxic metals (Al, La, Cu) in rhizobia. Soil Biology & Biochemistry 35, 199-205.

Lal, R., 2004. Soil carbon sequestration to mitigate climate change. Geoderma 123, 1-22.

Lal, R., 2008. Soil carbon stocks under present and future climate with specific reference to European ecoregions. Nutrient Cycling in Agroecosystems 81, 113-127.

Lal, R., Kimble, J.M., 1997. Conservation tillage for carbon sequestration. Nutrient Cycling in Agroecosystems 49, 243-253.

Leake, J.R., Ostle, N.J., Rangel-Castro, J.I., Johnson, D., 2006. Carbon fluxes from plants through soil organisms determined by field (CO2)-C-13 pulse-labelling in an upland grassland. Applied Soil Ecology 33, 152-175.

Lorenz, K., Lal, R., 2005. The depth distribution of soil organic carbon in relation to land use and management and the potential of carbon sequestration in subsoil horizons. Advances in Agronomy, Vol 88 88, 35-66.

Mikha, M.M., Benjamin, J.G., Vigil, M.F., Nielson, D.C., 2010. Cropping Intensity Impacts on Soil Aggregation and Carbon Sequestration in the Central Great Plains. Soil Science Society of America Journal 74, 1712-1719.

Miller, R.M., Jastrow, J.D., 1990. Hierarchy of root and mycorrhizal fungal interactions with soil aggregation. Soil Biology & Biochemistry 22, 579-584.

Miller, R.M., Jastrow, J.D., 2000. Mycorrhizal fungi influence soil structure In: Kapulnik, Y., Douds, J.D.D. (Eds.), Arbuscular Mycorrhizas: Physiology and Function. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 3-18.

Nadian, H., Hashemi, M., Herbert, S.J., 2009. Soil Aggregate Size and Mycorrhizal Colonization Effect on Root Growth and Phosphorus Accumulation by Berseem Clover. Communications in Soil Science and Plant Analysis 40, 2413-2425.

Nichols, K.A., 2010. Glomalin production and accumulation in soilless pot cultures. Canadian Journal of Soil Science 90, 567-570.

Nichols, K.A., Wright, S.F., 2005. Comparison of glomalin and humic acid in eight native US soils. Soil Science 170, 985-997.

Ortas, I., 2003. Effect of selected mycorrhizal inoculation on phosphorus sustainability in sterile and non-sterile soils in the Harran Plain in South Anatolia. Journal of Plant Nutrition 26, 1-17.

Ortas, I., Akpinar, C., Lal, R., 2013. Long-Term Impacts of Organic and Inorganic Fertilizers on Carbon Sequestration in Aggregates of an Entisol in Mediterranean Turkey. Soil Science 178, 12-23.

Ortas, I., Lal, R., 2012. Long-Term Phosphorus Application Impacts on Aggregate-Associated Carbon and Nitrogen Sequestration in a Vertisol in the Mediterranean Turkey. Soil Science 177, 241-250.

Pendell, D.L., Williams, J.R., Boyles, S.B., Rice, C.W., Nelson, R.G., 2007. Soil carbon sequestration strategies with alternative tillage and nitrogen sources under risk. Rev. Agric. Econ. 29, 247-268.

Rasse, D.P., Rumpel, C., Dignac, M.F., 2005. Is soil carbon mostly root carbon? Mechanisms for a specific stabilisation. Plant and Soil 269, 341-356.

Rillig, M.C., 2004. Arbuscular mycorrhizae, glomalin, and soil aggregation. Canadian Journal of Soil Science 84, 355-363.

Rillig, M.C., Mardatin, N.F., Leifheit, E.F., Antunes, P.M., 2010a. Mycelium of arbuscular mycorrhizal fungi increases soil water repellency and is sufficient to maintain water-stable soil aggregates. Soil Biology & Biochemistry 42, 1189-1191.

Rillig, M.C., Mummey, D.L., 2006. Mycorrhizas and soil structure. New Phytologist 171, 41-53.

Rillig, M.C., Wagner, M., Salem, M., Antunes, P.M., George, C., Ramke, H.G., Titirici, M.M., Antonietti, M., 2010b. Material derived from hydrothermal carbonization: Effects on plant growth and arbuscular mycorrhiza. Applied Soil Ecology 45, 238-242.

Rillig, M.C., Wright, S.F., Eviner, V.T., 2002. The role of arbuscular mycorrhizal fungi and glomalin in soil aggregation: comparing effects of five plant species. Plant and Soil 238, 325-333.

Schrag, D.P., 2007. About climate change - Reply. Elements 3, 375-375.

Shrestha, R.K., Lal, R., 2007. Soil carbon and nitrogen in 28-year-old land uses in reclaimed coal mine soils of Ohio. Journal of Environmental Quality 36, 1775-1783.

Singh, S., Mishra, R., Singh, A., Ghoshal, N., Singh, K.P., 2009. Soil Physicochemical Properties in a Grassland and Agroecosystem Receiving Varying Organic Inputs. Soil Science Society of America Journal 73, 1530-1538.

Six, J., Elliott, E.T., Paustian, K., 2000. Soil macroaggregate turnover and microaggregate formation: a mechanism for C sequestration under no-tillage agriculture. Soil Biology & Biochemistry 32, 2099-2103.

Six, J., Elliott, E.T., Paustian, K., Doran, J.W., 1998. Aggregation and soil organic matter accumulation in cultivated and native grassland soils. Soil Science Society of America Journal 62, 1367-1377.

Smith, S.E., Read, D.J., 2008. Mycorrhizal Symbiosis. Academic Press, San Diego, CA.

Tisdall, J.M., Smith, S.E., Rengasamy, P., 1997. Aggregation of soil by fungal hyphae. Australian Journal of Soil Research 35, 55-60.

Treseder, K.K., Turner, K.M., 2007. Glomalin in ecosystems. Soil Science Society of America Journal 71, 1257-1266.

Wilson, G.W.T., Rice, C.W., Rillig, M.C., Springer, A., Hartnett, D.C., 2009. Soil aggregation and carbon sequestration are tightly correlated with the abundance of arbuscular mycorrhizal fungi: results from long-term field experiments. Ecology Letters 12, 452-461.

Wright, S.F., Upadhyaya, A., 1996. Extraction of an abundant and unusual protein from soil and comparison with hyphal protein of arbuscular mycorrhizal fungi. Soil Science 161, 575-586.

Wright, S.F., Upadhyaya, A., 1998. A survey of soils for aggregate stability and glomalin, a glycoprotein produced by hyphae of arbuscular mycorrhizal fungi. Plant and Soil 198, 97-107.

Wu, Q.S., Xia, R.X., Zou, Y.N., 2008. Improved soil structure and citrus growth after inoculation with three arbuscular mycorrhizal fungi under drought stress. European Journal of Soil Biology 44, 122-128.

Zhang, X.K., Wu, X., Zhang, S.X., Xing, Y.H., Wang, R., Liang, W.J., 2014. Organic amendment effects on aggregate-associated organic C, microbial biomass C and glomalin in agricultural soils. Catena 123, 188-194.

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Do major crops grown in Turkish soils respond to potassium fertilization?

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Abstract

The supply of potassium to the plant during its growth stages is an important factor that enhances the plant growth and the crop yield. Potassium has several positive effects on the crop physiological processes such as protein synthesis and translocation as well as the color development of the fruit. In addition, potassium plays a big role in enhancing crop tolerance to biotic and abiotic stress conditions such as resistance to diseases, and tolerance to salinity and drought stress conditions. During the 2012-2013 growing season, several field experiments were conducted at the Cotton Research Institution, Nazili-Aydın, Çukurova University, Adana and the Giresun Hazelnut Research Institution, Giresun. The main objective of these studies was to evaluate the effect of different rates of two K fertilizer sources (KCl and K_2SO_4) application on yield and quality of maize, melon, cotton and hazelnut grown under field conditions. The results of the experiments indicated that yield increases with K application mostly when applied under conditions of low soil K level. Results from the maize experiment in Adana during the 2012 indicated that the highest maize grain yield (12.8 t/ha) was obtained with the application of 60 kg K_2O/ha as KCl, while a similar application of K_2SO_4 produced maize grain yield of 11 t/ha. In 2013, the results showed that the highest maize grain yield (14.5 t/ha) was obtained with the application of 60 kg K_2O/ha as KCl, while a similar application rate of K_2SO_4 produced maize grain yield of 12.0 t/ha. The potassium applies as KCL produced 13.6 % more yield than when applied as K_2SO_4. The results from the watermelon field experiment at the same site, indicated that the highest watermelon fruit yield of 55 t/ha was obtained with the application of 120 kg K_2O/ha as KCl, while a similar application rate of K_2SO_4 produced 41.6 t/ha of watermelon fruit. The results from the cotton experiment at Cotton Research Station indicated no significant differences among all treatments including the control on any of the cotton yield. On the other hand, the hazelnut plant responded positively to potassium application from both K fertilizer sources. Compared to the control treatment where no potassium was applied, the hazelnut yield obtained was 2275 kg/ha, while the rate of 480 kg K_2O /ha resulted in a higher yield (3566 kg/ha). It can be concluded from the results obtained for different crops that potassium application from the both sources enhances the crop yields and improve the quality of the products.

Keywords: Potassium fertilization, Potassium uptake, Maize, Watermelon, Cotton, Hazelnut.

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Introduction

Turkey is located in the east part of the Mediterranean area. The population of Turkey is over 70 million. Nearly 35 % is still live in country side area and earn their income from the agriculture sector. At present Turkey has nearly 22.4 Mha of agricultural land including 6 Mha of irrigated area. Nearly 60 % of the total agricultural land used in Turkey is used for production of cereals, the largest share of which, about 69 %, occupied by wheat and barley. Also recently in Çukurova area maize production is expanding. In cost of Mediterranean area citrus, vineyards and olive plantations is getting increase. Recently in the Mediterranean area also banana production under cover is being practiced to a limited extent. Nearly 42000 ha land is used for protected agriculture (plastic houses and glass greenhouses) for vegetables (90 %) and ornamental production. Turkey provides 70 % of the world hazelnut production with planted area of 690.000 hectares and the average annual production 580.000 tons (FAO, 2012).

Generally in Turkey, the soils are divers in soil fertility levels. These soils are low in organic matter with a clayey texture and a slightly alkaline reaction, excluding the soils of Eastern Black Sea region, which have a lower pH. Most of the soils are very low in plant available concentration of N, P, Zn, Fe and Mn. Zinc and iron deficiency in plants is the most common in this region. Nearly 50 % of arable soils with an area of 14 Mha are deficient in zinc. N and P fertilizers are commonly used especially in irrigated agriculture. This lead to nutrient imbalance with respect to K. Therefore, there is a need to enhance the use of K fertilizers.

In generally, soils are believed to be rich in K. K constitutes about 2.1–2.3 % of the earth's crust (Wedepohl, 1995). However, it has been reported by Mengel and Kirkby, (2001); Römheld and Kirkby, (2010) that large agricultural areas of the world are to be deficient in plant available forms of soil K, including 3/4 of the paddy soils of China, and 2⁄3 of the wheat belt of Southern Australia. Smil (1999) reported that, in contrast to nitrogen (N) and phosphorus (P), K fertilizers are applied at lower level and less than 50 % of K removed by plants.

In some cases regardless of the soil K level there is no strong relationship between extractable K_2O level and plant K uptake. It may be related to the fact that plant differences in K uptake are in part due to mobilization of non-exchangeable K by root exudates. Zorb et al. (2014) indicated that plants such as ryegrass and sugar beet are 3 to 6 times more efficient in mobilizing K than wheat and barley. Also Zorb et al. (2014) reported that soil microorganisms are able to release K from geologic minerals by excreting organic acids. These organic acids may dissolve rock K or chelate the associated silicon (Si) mineral and bringing the K into soil solution. However so far there is less information and research under the field conditions.

The Role of Potassium on Plant Growth and Quality

Potassium (K) is one of the 17 essential elements for plant growth and development (Ortas et al., 1999). Plants need large quantities of K, as much as, or even more than nitrogen (N). K constitutes about 2.1–2.3% of the earth's crust and thus is the seventh or eighth most abundant element (Wedepohl, 1995). Therefore, soil K reserves are generally large (Schroeder, 1978). Plants deficient in K become susceptible to stress such as drought, excess of water, high and low temperature, as well as to pests, diseases, and nematodes (Timsina et al, 2013). Also potassium has a significant role to play in the plant energy status for storage of assimilates and tissue water relation. (Romheld and Kirkby 2010) reported that K in most plant physiological processes is now well understood including the important role of K in re-translocation of photo assimilates needed for good crop quality. The stress-mitigating role of K is important in plants, particularly under drought, salinity, and upon pathogenic infection (Amtmann et al., 2008).

A high K supply is believed to reduce the reactive oxygen species (ROS) load of cold-stressed plants (Zorb et al. (2014). There is evidence that K has further benefit in freezing stress conditions. Freezing the internal water within a plant causes severe damage under cold temperature areas. Plant species or genotypes within species have been reported to differ in their capacity to use nutrient resource (Wang et al., 2012). Zorb et al. (2014) indicated that ryegrass and sugar beet are more efficient in mobilizing K than wheat and barley. Since plant species have different root development that may have on K uptake.

Potassium is probably the second most important nutrient for hazelnut and adequate supply of potassium is required for the maximum yield and nuts with high quality. Özenç, (2014) reported that 400 kg ha^{-1} and 600 kg ha^{-1} K_2O doses were recommended in hazelnut agriculture. The results of Akat et al. (2005) shown that the rooted smart variety of cutting rose plant give high response to K fertilizer and data obtained from the experiments have clearly shown that, 200 ppm K dose increased all quality characteristics such as length and thickness of flower steams, length and diameter of buds and number of leaves. Also Taban et al. (2005) have shown that 40 kg ha^{-1} K_2O increased the garlic yield at the rate of 1.7 % while 80 kg ha^{-1} K_2O increased at the rate of 10 % compare to the control treatment.

Content of Extractable K in Turkish Soils

Özyazıcı et al. (2013) in Eastern Black Sea Region has collected and analyzed total of 370 samples for physical, chemical and fertility properties. The results of this study indicated that the soil samples generally have low or insignificant calcium carbonate content and they had no salinity problem. Also they have determined that the extractable K contents of the soils were generally at inadequate level (Table 1). Özyazıcı et al. (2013) reported that the content of extracted K in red-yellow Podzolik soil was on the level of 11-971 mg kg^{-1}. In generally 63.52 % of soil has low, 14.32 % has sufficient and 22.17 % has high and very high levels of extractable K (Pizer, 1967).

Table 1. Critical soil K levels

Soil Properties	Critical value	Evaluation	Number of Sample	%
K (mg kg^{-1})	<100	Very low	141	38.11
	100-150	Low	94	25.41
	150-200	Medium	53	14.32
	200-250	Good	30	8.11
	250-320	high	21	5.68
	>320	Very high	31	8.38

TARIS Cotton Farm Sales Company in order to develop fertilizer recommendations for cotton producers has conducted a soil survey in Aegean region (Table 2). Results obtained during the period of 2001-2005 years have shown that 39-47% of regional soils need in K fertilization (Hüner and Ersan 2005).

Table 2. Potassium content in soils under cotton production in Aegean region during 2001 -2005 years.

Soil K Level (mg kg)	2001	2002	2003	2004	2005
0-100	29	20	30	26	22
101-150	18	20	13	18	17
151-190	11	9	13	12	12
191-250	11	14	15	14	17
251-321	12	13	13	10	12
>321	19	24	16	20	20
Number of soil samples	1769	1404	1467	1765	3390

Elmacı (1989) indicated that in Demre-Antalya Provence nearly 50 % of greenhouse soils have K deficiency. Sönmez et al., (1999) and Çakıcı (1989) searched greenhouse soil K level in Gazipaşa, Kumluca and Kale-Antalya and they found that soil K_2O level is nearly 664 ppm, and 68 % of soil has sufficient and high K levels. Tümsavaş and Aksoy (2009) indicated that soils in Bursa Provence have sufficient level of extractable K. Ari et al. (2002) analyzed the greenhouse soil in Antalya region and found that 25, 6 % of soil has low level of K (<200 mg K_2O ha^{-1}). During 1957-1992 years Turkish national sugar company has analyzed more than 200,000 soil samples all over the Turkey and found that in sugar beet grown areas 8 % of arable soils had the content of soil extractable K at very low level (> 60 ppm), 16,7% had low level (60-99 ppm), 37.9 % had the medium (100-199 ppm) level, 18.6 % had the high (200-299 ppm) level and 18.8 % had the very high (> 300 ppm) level of extractable K (Turhan and Pişkin 2005). In the period of 1995-1998 on-field research was carried out at Ilgın Experiment Station of Sugar Institute, Ilgın Uşak, by Turhan and Pişkin, (2005). Obtained results showed that the most appropriate rates of K fertilizers were between 40-80 kg K_2O ha^{-1}. Applications of these rates had increased both root yield and sugar yield as well resulted in increase of sugar beet quality.

Use of Fertilizers in Turkey and in the Middle East Region

K fertilizers used in Turkey are mainly K_2SO_4 and KNO_3. In addition, compound fertilizer containing K (15:15:15) where the K source is KCl. Some factories are producing other grades of compound fertilizers such as 20:20:20. Statistical data shows that current fertilizer use in Turkey and other Middle East (ME) countries is highly unbalanced (Table 3). For example the current N: P: K ratio in the fertilizers used is highly negative with respect to K. Such negative nutrient balances indicate soil nutrient mining in particular P and K and thus loss in soil fertility and productivity.

Several on-field trials in different ME countries have proved the benefits of balanced fertilization in terms of yield, quality and stress tolerance. However, dissemination of these results to the farmers, company dealers, extension agents and decision makers has not been achieved yet.

Table 3. NPK ratio in the ME countries

Countries	$N-P_2O_5-K_2O$ Ratio
Egypt	1 - 0.12 - 0.04
Jordan	1 - 0.75 - 0.64
Lebanon	1 - 0.42 - 0.43
Morocco	1 - 0.40 - 0.20
Saudi Arabia	1 - 0.59 - 0.11
Sudan	1 - 0.04 - 0.06
Syria	1 - 0.48 - 0.03
Turkey	1 - 0.40 - 0.06

NPK ratio is generally similar in other Middle East countries. In general, the use of nitrogen is the most, while that of K is the least. This may be related to the misconception that the soils are rich in potassium. In Turkey for example, K fertilizer consumption from 2005 to 2012 has not been changed (Table 4).

Table 4.Turkey: Consumption in nutrients tones of nutrient (FAOSTAT 2014)

Items	2002	2005	2009	2012
N Fertilizers (N total nutrients)	1198855	1372053	1529581	1474048
P Fertilizers (P205 total nutrients)	474244	601606	633258	612825
K Fertilizers (K20 total nutrients)	73567	93816	69753	97161

Therefore, the objective of the proposed International Plant Nutrition Institute IPNI activities in Turkey is to promote balanced fertilization with emphasis on K and to disseminate and transfer the results and obtained knowledge to the farmers, extension agents and to the decision and policy-makers in the sectors of agriculture and fertilizer use. This will be achieved through conducting field experiments and at a later stages on-farm demonstrations; field days; training workshops and conferences; publications (leaflets, brochures, papers etc.) (Table 4-5).

Table 5. Consumption of potash fertilizers in Turkey (tones of nutrient (FAOSTAT, 2014)

K fertilizer, tons	2002	2005	2009	2012
Potassium nitrate	20223.00	33607.00	17758.00	0.00
Potassium chloride	111803.00	135193.00	0.00	0.00
Potassium sulphate	36743.00	39156.00	10396.00	0.00
NPK complex <=10kg	0.00	1357.00	0.00	0.00
NPK complex >10kg	0.00	18636.00	0.00	0.00
PK compounds	0.00	2113.00	0.00	0.00
NPK complex	0.00	787384.00	212595.00	0.00

Strategic Aim/Goal of The Project

The strategic goal of this experiment was to promote the use of K as KCl and K_2SO_4 in agriculture production in Turkey. This can be achieved through demonstrating the positive impact of KCl and K_2SO_4 on improving plant growth and crop production both in term of the quantity and quality. The objective of this proposal is to study the effect of different K sources and levels on yield and some quality components of watermelon, maize, cotton and hazelnut grown under field conditions.

Maize Response to K

Maize is very commonly cultivated in Turkey especially in Cukurova region part of the Mediterranean. Since in Cukurova region there is few field research on the effect of K fertilizers on maize yield and quality, the recommended K fertilizer rates are not known. In different regions of the world the maize yield is lower than expected since farmers are not using K and possibly other fertilizers sources. Soil K level is depend on the parent material and varies with locations. However the response to K fertilizers application has been observed and reported in many parts of the world. Dai et al. (2013) indicated that in North China under long-term experiment, omission of K fertilizer reduced maize yield significantly compared to the maize yield of the NPK-treated plot. Murell (2014) indicated that K deficiency can also delay corn development. Tan et al. (2012) also found that the effect of K-fertilizer application on maize yield varied widely. Niu et al. (2011) reported that production practices directly affected maize-yield response to K fertilizer. Rurinda et al. (2013) on farm experiment have shown that N, P and K fertilizer application increased maize yield. During 2012 and 2013 we have two field experiment using KCl an K_2SO_4 with several K_2O levels and we have found that up to 60 kg ha K_2O application increase the maize yield. Kovacevic et al (2008) had done field experiment with three rates of KCl such as; 150 (control), 650 and 1400 kg K_2O/ha application and they found that maize yield increased from 13 to 16 % in comparison to the control treatment.

Maize Response to K in Trials Conducted in 2012 in Turkey

In general, applied K_2SO_4 fertilizer produced similar maize yield as the application of KCl fertilizer. In KCl fertilizer treatments maize yield ranged from 7.92 ton ha^{-1} to 12.84 ton ha^{-1}. The control plots resulted in 7.92 ton ha^{-1} maize, while the 60 kg K_2O per ha produced 12.84 ton ha^{-1}(Table 6). However K_2SO_4 applied maize yield ranged from 8.75 ton ha^{-1} to 10.96 ton ha^{-1} .

Table 6. Effect of different rates of KCl and K_2SO_4 on maize yield.

Treatments	Rates (kg/ha)	Yield ton/ha		Total Yield ton/ha	Mean ton/ha
KCL	0 K_2O	7.92	±1.8 e		
	30 K_2O	9.45	±0.8 c-e		
	60 K_2O	12.84	±0.4 a		
	120 K_2O	8.22	±0.7 e		
	240 K_2O	10.43	±0.2 bc	48.86	9.77
K_2SO_4	0 K_2O	8.75	±0.7 de		
	30 K_2O	10.96	±1.4 b		
	60 K_2O	10.12	±1.2 b-d		
	120 K_2O	9.29	±0.7 c-e		
	240 K_2O	9.90	±0.8 b-d	49.01	9.80

Finally application of K fertilizers in the rates up to 60 kg K_2O ha^{-1} has increased maize yield. Also their nutrient content and root dry weight has increased. There is a not significant difference in between KCl and K_2SO_4 fertilizers (data's are not shown).

Maize Response to K in Trials Conducted in 2013 in Turkey

The fertilizer treatments significantly affected the grain yields. Generally, KCl produced more maize yield than K_2SO_4 fertilizer application. Data presented in Table 7 show that plots received KCl plots produced totally 69,56 ton ha^{-1}maize. In KCl fertilizer treatments maize yield ranged from 13.03 ton ha^{-1} to 15.50 ton ha^{-1}. When fertilizer sources is KCl, the lowest yield (13.0 t/ha) was obtained when no K was applied. The highest yield 15.5 t/ha was obtained with the application of 240 kg K_2O/ha. The average yield for plots with KCl applied was 13.91 t/ha (Table 7).

Table 7. Effect of KCl and K_2SO_4fertilizer application on maize yield.

	Yield ton/hectare	
Doses (kg/ha)	K2SO4	KCL
0 K_2O	10,91 ±0,51e	13,03 ±0,55cd
30 K_2O	11,22 ±0,95e	13,24 ±1,16b-d
60 K_2O	11,99 ±0,69de	14,50 ±0,82ab
120 K_2O	13,79 ±1,41bc	13,30 ±0,27b-d
240 K_2O	13,33 ±0,73b-d	15,50 ±0,76a
Mean	12,25	13,91

Mean of three replicates and ± is standard error

Columns with different letters are significantly different (P<0.05), according to LSD's test.

In K_2SO_4 fertilizer application the lowest yield (10.9 t/ha) was obtained when no K was applied. In K_2SO_4 fertilizer treatments maize yield ranged from 10.91 ton ha^{-1} to 13.79 ton ha^{-1}.The highest yield (13.8 t/ha) was obtained with the application of 120 kg K2O/ha. The average yield for plots with K_2SO_4 applied was 12.25 t/ha. K_2SO_4 fertilizer applied plots produce totally 61,25ton ha^{-1}maize.

Watermelon Response to K in Trials Conducted in 2012-13 in Turkey

Çukurova plane is located in costal of Mediterranean region. Watermelon is an important and commonly cultivated in Cukurova region part of the Mediterranean. And it is the most important cash crop in the region. Nearly 80 % of Turkish watermelon is produced in the region. Behind Chine, with over 4 million watermelon productions Turkey is the second largest producer of melons all over the world (Sari et al. 2007). In globe there is a rich genetic diversity of melons (Sari et al. 2008). But, there is little knowledge about genetic variations in K efficiency in watermelon.

Watermelon requires much higher potassium than other elements. It has been shown by de Lucena et al. (2011) that under salinity irrigation watermelon plant extracted nutrients order was K > N > Ca > Mg > P. A field experiment was conducted in Brazil with three K fertilize sources and doses. And it was found that the biggest number of fruits for plant was achieved with 190 and 300 K_2O ha^{-1} of KNO_3 and KCl, respectively (Cecilio and Grangeiro 2004). Also they found that among K fertilizer sources the greater weight of fruit was determined with KCl fertilizer sources. However maximum yield were obtained with doses of 132, 193 and 205 kg K_2O ha^{-1}, respectively from K_2SO_4, KNO_3 and KCl sources. During 2012 and 2013 two field experiment by using several level of KCl and K_2SO_4 fertilizers have been conducted.

Year 2012

For the year 2012 water melon yield increased up to 120 kg ha with K fertilizers application. It seems KCl have more effects on yield than K_2SO_4 fertilizer. Melon fruits were collected six times from all the plots and the total yield was reported as ton ha^{-1}. In KCl fertilizer treatments ranged from 36.0 ton ha^{-1} to 55.0 ton ha^{-1} and in K_2SO_4 treatments ranged from 31.6 ton $ha^{-1}$to 41.6 ton ha^{-1}, respectively. In KCl treatments, the mean yields in control were 36.0 ton ha^{-1} and in 120 kg ha^{-1} K_2O treatments were 55.0 ton ha^{-1} (Figure 1).

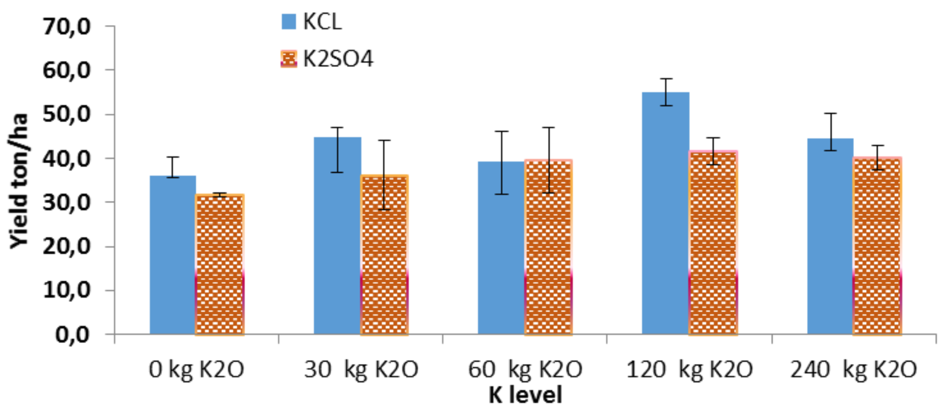

Figure 1. Effect of KCl and K_2SO_4 fertilizer application on watermelon (yield 2012)

At high doses of K fertilizer application yield was lower. For example in the case of KCl as a fertilizer sources the yield at plot received 240 kgK_2O ha^{-1} the was lower than at plot with 120 kg ha^{-1} K_2O treatments.

Both K fertilizer sources have increased the yield of watermelon with application of up to 120 kg ha^{-1} K_2O. It can be concluded that, the highest amount of fruit weight and yield was found at 120 kg ha^{-1} K_20 with KCl potassium fertilizer sources.

Year 2013

In KCl applied plots average yield of water melon was 84,71 ton ha^{-1}. On the other hand, K_2SO_4 applied plot produced 90,18 ton ha^{-1} (Figure 2). For KCl, increasing the rate of K application up to 120 kg ha^{-1} K_2O, significantly increased the yield. For K_2SO_4 sources up to 240 kg ha^{-1} K_2O application increased watermelon yield. It can be concluded that, the highest amount of fruit weight and yield was obtained with application of 120 kg ha^{-1} K_20 as KCl potassium fertilizer sources.

Okur and Yagmur (2004) reported that 240kg/ha of K_2O application yielded the highest yield of watermelon as 54,32 ton/ha. It seems that our results are in harmony with found of Okur and Yagmur (2004). Number of fruits, fruit weight and width were also the maximum. Song et al. (2007) reported that K at 480kg/hm^2 significantly increased fruit weight and yield of watermelon.

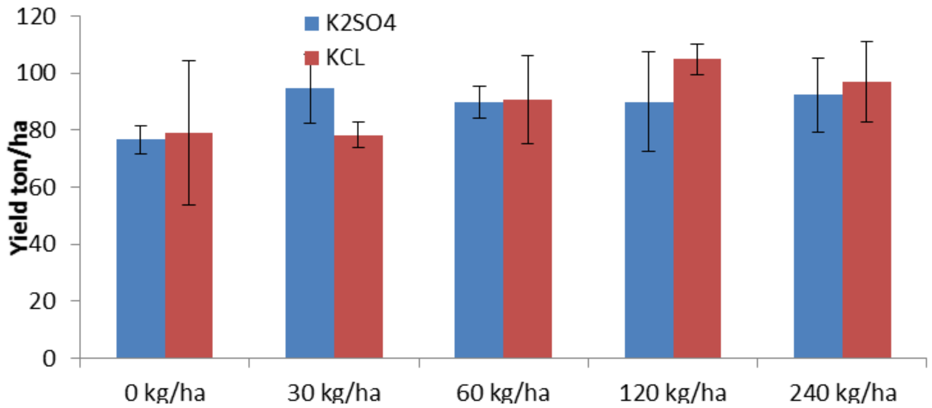

Figure 2. Effect of KCl and K_2SO_4fertilizer application on watermelon yield (year 2013)

The Role of Fertilizer in Hazelnut Orchards

Application of K fertilizers significantly increased the hazelnut yield, protein ratio and oil content but not the kernel weight (Table 8). The highest yield value was obtained with application of 480 K_2O kg/ha. All rates similarly increased the protein ratio compared to the control treatment. However, the oil content was the highest with the application of 60 kg K_2O/ha the most

Table 8. Marketable Hazelnut Yield (kg/ha)

Fertilizer Application kg/ha	Yield kg/ha	Kernel weight/ nut weight ratio of hazelnuts (%)	Protein ratio %	Oil Content %
K (control)	2275.70 E	55.26 A	13.39 B	63.42 C
K-0	2464.90 DE	54.40 A	14.77 A	64.29 B
K-1 (60 K20)	2686.10 CD	54.94 A	15.12 A	65.50 A
K-2 (120 K20)	2784.10 CD	54.64 A	14.93 A	63.59 C
K-3 (240 K20)	2955.40 BC	54.37 A	15.23 A	64.46 B
K-4 (480 K20)	3566.60 A	54.84 A	15.20 A	64.54 B
K-5 (720 K20)	3232.50 B	54.37 A	15.15 A	64.53 B
CV	5.16 **	2.50	2.50 **	0.24 **
Std Dev	441.79	1.13	0.69	0.68

Cerutti and Beccaro (2012) indicated that the quantity of fertilizing material required was calculated in order to reach the optimum nutrient value for all the treatments for organic and in organic fertilizer is 80 kg N/ha, 30 kg P_2O_5/ha, 80 kg K_2O/ha. Under the Italian hazelnut orchard conditions Roversi (2010) suggested that mineral fertilizers should be supply yearly.

Finally according to our results during 2012 K level (as KCl) applied to a hazelnut orchard has a significant effect on yield and oil content of hazelnut.

Also increasing K fertilizer increased plant leaves K concentration. Up to 480 kg ha^{-1} K_2O application is sufficient for hazelnut plant healthy nutrient content. Increasing KCL application to soil increased, residue of K concentration and 720 kg/ha K_2O applied soil have 550,6 ppm K residue (datas are not shown)

Cotton

Cotton is more sensitive to low K availability than most other major field crops, and often shows signs of K deficiency on soils not considered K-deficient (Cassman et al., 1989). Potassium chloride (KCl), commonly referred to as muriate of potash, is the most common source of fertilizer K due to its lower cost and high K content (IPNI, 2011). Also according to Wang et al. (2012), K significantly affects yield and biomass production. Also K affects plant root and tissue development and increase plant resistant against disease and pest. K can also increase the water use efficiency. During 2012 and 2013 two K fertilize sources with several rates has been applied in Nazili-Aydın filed.

Table 9. Cotton Yields in K Experiment in 2012 and 2013

Treatments	Seed Yields (Kg ha^{-1})		seed Yields (Kg ha^{-1})
	2012		2013
K0 (control)	4492,3	A	3652
K1 (62,5 Kg/ha KCL)	3991,3	A	4115
K2 (125,0 Kg/ha KCL)	4372,0	A	4624
K3 (187,5 Kg/ha KCL)	4097,3	A	4379
K4 (250,0 Kg/ha KCL)	3930,7	A	3898
K5 (62,5 Kg/ha K_2SO_4)	4138,0	A	3888
K6 (125,0 Kg/ha K_2SO_4)	3892,0	A	4491
K7 (187,5 Kg/ ha K_2SO_4)	4053,7	A	4591
K8 (250,0 Kg/ ha K_2SO_4)	4097,3	A	4241
Average	4118,3		4052

The yields of seed cotton per hectare obtained ranged between 3930.7 Kg ha^{-1} to 4492.3 Kg ha^{-1} in KCl fertilizer treated treatments, while for K_2SO_4 fertilizer treated treatments the yield ranged between 3892.0 – 41380 Kg ha^{-1}. The cotton yield was not affected significantly neither by the source or rate of K application (Table 9). This could be due to high soil initial K concentration and/or due to genotypical differences. Zia ul, et al., (2011) reported that cotton genotypes are different in term of K uptake. Some genotypes are accumulating more biomass due to higher K uptake. Previously under Australian sodic soil conditions, addition of K fertilizer did not increase cotton yield and K uptake (Rochester 2010). In addition, soil and plant management systems may have effect on yield component.

Conclusion

It can be concluded from the results of this study that, maize, watermelon and hazelnut responded positively to the application of potassium. The response was higher when the potassium was applied as KCl compared to K_2SO_4. Therefore, it is recommended to apply more balanced fertilization by including the k application to the conventional NP fertilization recommendation. On the other hand, the cotton under the prevailing soil conditions did not significantly responded to the potassium application due to the higher initial soil K level.

References

Akat, H., Yokaş, I., Özzambak, E., and Kılınç, R., 2005. Kesme gülde potasyum dozlarının gelişme üzerine etkileri. “Tarımda potasyumun yeri ve önemi” Çalıştayı, 3-4 Ekim 2005, Eskişehir.

Arı N., Ateş T., Özkan C. F., Arpacıoğlu A. E., 2002. Antalya bölgesi’nde domates yetiştiriciliği yapılan seraların toprak verimlilik durumlarının incelenmesi. VI. Sebze Tarımı Sempozyumu 17-20 Eylül 2002. Bursa.

Amtmann, A., S. Troufflard, and P. Armengaud. 2008. The effect of potassium nutrition on pest and disease resistance in plants. *Physiologia Plantarum* 133 (4):682-691.

Cassman, K.G., Roberts, B.A. Kerby, T.A. Bryant, D.C. and D.C. Higashi, D.C. 1989. Soil potassium balance and cumulative cotton response to annual potassium additions on a vermiculitic soil. *Soil Science Society of America Journal* 53: 805-812.

Cecilio, A. B., and L. C. Grangeiro. 2004. Yield of watermelon fruits as a function of sources and doses of potassium. *Ciencia E Agrotecnologia* 28 (3):561-569.

Cerutti, A. K., and G. L. Beccaro. 2012. Short Term Effects of Manure Fertilization in a Hazelnut Orchard in Northern Italy. In *Xxviii International Horticultural Congress on Science and Horticulture for People, eds.* I. Mourao and U. Aksoy, 245-252. Leuven 1: Int Soc Horticultural Science.

Çakıcı, H., 1989. Sera Sebze yetiştiriciliğinde (Gazipaşa) toprakların mineral besin m addesi durumunun tesbiti. E.Ü. Fen Bil. Ens. Toprak A.B. Dalı. Yüksek Lisans Tezi, Bornova-İzmir.

Dai, X. Q., Z. Ouyang, Y. S. Li, and H. M. Wang. 2013. Variation in Yield Gap Induced by Nitrogen, Phosphorus and Potassium Fertilizer in North China Plain. *Plos One* 8 (12):8.

de Lucena, R. R. M., M. Z. de Negreiros, J. F. de Medeiros, L. C. Grangeiro, and S. D. P. Marrocos. 2011. Growth And Accumulation Of Nutrients In Watermelon 'Quetzale' Grown Under Different Levels Of Salinity Of Irrigation Water. *Revista Caatinga* 24 (1):34-42.

Elmacı, Ö. L., 1989. Antalya yöresinde (kale) sebze yetiştirilen seralardaki toprakların ve bitkilerin besin maddesi durumunun tesbiti. Ege.Ü. Fen Bil.Enstitüsü Toprak Ana Bilim Dalı.Yüksek Lisans Tezi, Bornova-İzmir.

FAO, 2012. Agricultural statistics. Food and Agricultural Organization of the United Nations, http://www.fao-stat.fao.org.

FAOSTAT. 2014. http://faostat.fao.org/site/677/DesktopDefault.aspx?PageID=677#ancor

Hüner, H., and Ersan, Y., 2005. Ege Bölgesi pamuk topraklarının potasyum düzeyi. "tarımda potasyumun yeri ve önemi" Çalıştayı, 3-4 Ekim 2005, Eskişehir.

Kovacevic, V., Rastija, M., Simic, B., Andric, L., Kaucic, D., 2008 Phosphorus and potassıum fertilization impacts on yıield and nutritional status of maize. Cereal Research Communicatıons. 36:43-46.

IPNI (International Plant Nutrition Institute) 2011. Nutrient source specifics, No. 3. Potassium chloride. IPNI Publication No. 11-10063.Norcross, Georgia, USA.

Mengel K, Kirkby E.A., 2001. Principles of plant nutrition. Dordrecht, NL: Kluwer AcademicPublishers.

Murrell, T. S., 2014. Is Potassium fertilizer really necessary? IPNI Northcentral Director, PO Box 2539 West Lafayette, Indiana 47996. http://www.ipni.net/article/IPNI-3348.

Niu, J. F., Zhang, W. F., Chen, X. P., Li, C. J., Zhang, F. S., Jiang, L. H., Liu, Z. H., Xiao, K., Assaraf, M., Imas, P., 2011. Potassium fertilization on maize under different production practices in the North China Plain. Agron. J. 103, 822–829.

Okur, B., and Yagmur, B., 2004. Effects of enhanced potassium doses on yield, quality and nutrient uptake of watermelon. IPI regional workshop on potassium and Fertigation Development in West Asia and North Africa; Rabat, Morocco, 24-28Nov., 36-43.

Ortas, I., Guzel, N., Ibrikci, H., 1999. Determination of potassium and magnesium status of soils using different soil extraction procedures in the upper part of Mesopotamia (in the Harran Plain). Comm. Soil Sci. Plant Anal. 30(19-20):2607-2625.

Özenç, N., 2014. The Modelling study for potassium fertilizer requirements in hazelnut (*Corylus avellana* L.). Not. Bot.Horti. Agrobo. 42(1):263-269.

Özyazıcı, M.A. , M. Aydoğan, B. Bayraklı, and O. Dengiz. 2013. Basic characteristic properties and fertility conditions of the red-yellow podzolic soils in eastern black sea region. *Anadolu J Agr Sci* 28 (1):24-32.

Rochester, I. J. 2010. Phosphorus and potassium nutrition of cotton: interaction with sodium. *Crop & Pasture Science* 61 (10):825-834.

Romheld, V., and E. A. Kirkby. 2010. Research on potassium in agriculture: needs and prospects. *Plant and Soil* 335 (1-2):155-180.

Roversi, A. 2010. Nutrients Uptakes in Hazelnut Orchards. In *Vi International Symposium on Mineral Nutrition of Fruit Crops, eds.* M. Pestana and P. J. Correia, 439-444. Leuven 1: Int Soc Horticultural Science.

Rurinda, J., P. Mapfumo, M. T. van Wijk, F. Mtambanengwe, M. C. Rufino, R. Chikowo, and K. E. Giller. 2013. Managing soil fertility to adapt to rainfall variability in smallholder cropping systems in Zimbabwe. *Field Crops Research* 154:211-225.

Sari, N., I. Solmaz, H. Yetisir, and H. Unlu. 2007. Watermelon genetic resources in Turkey and their characteristics. In *Proceedings of the IIIrd International Symposium on Cucurbits, eds.* R. McConchie and G. Rogers, 433-438.

Sari, N., A. Tan, R. Yanmaz, H. Yetisir, A. Balkaya, I. Solmaz, and L. Aykas. 2008. *General status of cucurbit genetic resources in Turkey*.

Schroeder, D., 1978. Structure and weathering of potassium containing minerals. In: Proc.11th Congr. Int. Potash Inst.

Smil, V., 1999. Crop residues: agriculture's largest harvest. Bioscience, 49:299–308.

Song, Q.,Chen, G.,,Wu, L.,Yı Y.,Dıng M., Lı, Y.,Sun, Y.,2007. Effect of Different Potassium Supply Levels on Yield and Quality of Watermelon. Hubei Agricultural Sciences.

Sönmez, S., Uz İ., Kaplan M., Aksoy T., 1999. Kumluca ve kale yörelerindeki seralarda yetiştirilen biberlerin beslenme durumlarının belirlenmesi. Tr. J .of Agric. and Forest. 23. Ek sayı 2, 365-373.

Taban S., Çıkılı, Y., Kebeci, F., Sezer, S., Konuşkani, R., Taban, N., Çevik, N., and Topoğlu, E., 2005. Taşköprü yöresinde sarımsak tarımı yapılan toprakların potasyum durumu ve potasyumlu gübrelemenin sarımsakta verim üzerine etkisi. "Tarımda Potasyumun Yeri ve Önemi" Çalıştayı, 3-4 Ekim 2005, Eskişehir.

Tan, D. S., Jin, J. Y., Jiang, L. H., Huang, S. W., Liu, Z. H., 2012. Potassium assessment of grain producing soils in North China. Agric. Ecosyst. Environ. 148, 65–71.

Timsina, J., Singh, V.K., and Majumdar, K., 2013. Potassium management in rice–maize systems in South Asia. J. Plant Nutr. Soil Sci. 176, 317–330

Turhan, M., and Pişkin, A., 2005. Farklı dozlarda uygulanan potasyumun şeker pancarının verim ve kalitesine etkisi. "Tarımda Potasyumun Yeri ve Önemi" Çalıştayı, 3-4 Ekim, Eskişehir.

Tümsavaş, Z., and E. Aksoy. 2009. Kahverengi orman büyük toprak grubu topraklarının verimlilik durumlarının belirlenmesi. *Uludağ Üniv. Zir. Fak. Dergisi* 23 (1):93-104.

Wang, N., H. B. Hua, A. E. Eneji, Z. H. Li, L. S. Duan, and X. L. Tian. 2012. Genotypic variations in photosynthetic and physiological adjustment to potassium deficiency in cotton (Gossypium hirsutum). *Journal of Photochemistry and Photobiology B-Biology* 110:1-8.

Wedepohl, KH. 1995. The composition of the continental crust. Geochim Cosmochim Acta.59:1217–32.

Zia ul, hassan, M. Arshad, and A. Khalid. 2011. Evaluating potassium-use-efficient cotton genotypes using different ranking methods. *Journal of Plant Nutrition* 34 (13):1957-1972.

Zorb, C., Senbayram, M., and Peiter, E., 2014. Potassium in agriculture: Status and Perspectives. Better Crops/Vol. 98 No. 2, p. 29-31.

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The effect of using different percent of vermicomposts on some of chemical properties of calcareous soil

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Abstract

To study the effect of using different percent of vermicomposts on some of chemical properties of calcareous soil an experiment with nine treatments was conducted using a complete block design and tree replications. Nine different vermicomposts including, vermicomposted rice hull cow manure, azolla residues and cow manure. Mixed with soil at the rates of zero (blank), 10 and 20% w/w were used. The results of analysis of variance showed that there are significant differences between all tested chemical factors in different rates. The highest and lowest electrical conductivity were respectively, 20% of cow manure vermicompost and 10% azolla residues vermicompost. The highest pH of treatments was observed in treatment with 10% cow manure vermicompost, and lowest pH observed in treatment with 20% vermicompost of azolla residues.The highest concentration of N was measured in treatment with 20% vermicompost of azolla residues and the control treatment had the lowest concentration of this element. The highest P concentration in treatment 20% vermicompost of rice hull cow manure was observed and the lowest this element was observed in control treatment. The highest concentration of K, Fe, and Cu were measured for vermicomposts in the treatment with 20% vermicompost of cow manure. The treatment of 20% vermicompost of azolla residueshad highest concentration of Mn and Cu elements, and the lowest concentration of these elements were observed in control treatment. The highest of organic carbon was observed in 20% vermicompost of azolla residues.

Keywords: Vermicompost, Chemical properties, Soil calcareous

Introduction

The use of vermicompost Leads to improve soil. Product of vermicompost with organic waste and adding it to soil Cause the reduce of environmental pollution and increased activity of microorganisms in soil (3). The main cause of the positive effects of compost and vermicompost on the growth of crops, increased soil organic matter, improve soil chemical properties and increasing the supply of available macro and micronutrients for plant (1). The purpose of this research is the using different percent of vermicomposts on some of chemical properties of calcareous soil.

Material and Methods

In this research the soil was selected from a field of Faculty of Agriculture of Zanjan University. To study the effect of using different percent of vermicomposts on some of chemical properties of calcareous soil an experiment with nine treatments was conducted using a complete block design and tree replications. Nine

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different vermicomposts including, vermicomposted rice hull cow manure, azolla residues and cow manure. Mixed with soil at the rates of zero (blank), 10 and 20% w/w were used. After mixed vermicomposts with the soil, and after the incubation period, Chemical analysis was performed on the treatments. Statistical analysis was made with MSTAT-C and Excel. Means were compared with LSD test at 5 % probability level.

Results and Discussion

The results of analysis of variance showed that there are significant differences between all tested chemical factors in different rates. The highest and lowest electrical conductivity were respectively treatment control and 10% vermicompost. The highest pH of treatments was observed in treatment with blank and lowest pH observed in treatment with 20% vermicompost. The amount of soil macro and micro elements, including nitrogen, phosphorus, potassium, iron, copper, zinc and manganese, in 20% vermicompost treatments were highest and in the control treatment were lowest. The hieghest and lowest amount of Ec, pH and p were obtained in vermicomposts of cow manure and rice+hull manure. The hieghest and lowest concentration of N, Cu and Mn were measured respectively in vermicomposts of azolla residues and ricehull+cow manure. So, the amount of K, Fe and Zn in vermicomposts of cow manure and rice+hull manure were measured respectively, highest and lowest. The hieghest and lowest electrical conductivity were measured respectively in vermicomposts of 20%cow manure and 10%azolla residues. So, the amount of pH in vermicomposts of 10% cow manure and 20%azolla residues were measured respectively, highest and lowest. Another important feature of organic fertilizer effects on soil acidification. That reduces the acidity of soil (2). The hieghest and lowest amount of N were obtained respectively in vermicomposts of 20%azolla residues and control treatment. Werner and et all (1988) also found similar results (5). The hieghest and lowest concentration of P were obtained respectively in vermicomposts of ricehull+ cow manure and control treatment. The hieghest amount of K, Fe and Zn were observed in vermicomposts of 20% cow manure and lowest K observed in control treatment. The hieghest and lowest amount of Cu and Mn were obtained in vermicomposts of 20%azolla residues and control treatment. Fertilize with vermicompost increased their morphological and chemical propertise compared with control treatment (4). The hieghest and lowest amount of OC were obtained respectively in vermicomposts of 20%azolla residues and control treatment

Table 1 - Effect of different percentages of vermicompost on soil chemical properties

Oc%	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	K (mg/kg)	P (mg/kg)	N%	pH	Ec (ds/m)	vermicompost
16.22b	4.808b	2.267b	1.378b	10.55b	239.3b	25.99b	0.158b	6.87b	0.744b	10%
21.09a	6.010a	2.521a	1.883a	14.45a	316.8a	47.31a	0.370a	6.310c	0.994a	20%
0.560c	2.910c	2.0c	0.450c	2.680c	123c	16c	0.04c	7.320a	1.020a	blank
0.89%	0.2177%	0.0278%	0.246%	1.335%	23.49%	2.281%	0.027%	0.061%	0.087%	LSD

Table2 – Effect of deffrent vermicomposts on soil chemical properties

Oc%	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	K (mg/kg)	P (mg/kg)	N%	pH	Ec (ds/m)	vermicompost
9.571c	4.418b	2.50a	1.40a	11.43a	240.9a	32.67a	0.163b	6.960a	0.975a	Cow manure
12.68b	4.142c	2.098b	0.90b	5.524b	218.5b	34.53a	0.104c	6.92a	0.901ab	Cow manure + Rice hull
15.62a	4.750a	2.190b	1.41a	10.73a	219.8b	22.11b	0.301a	6.62b	0.881b	Azolla
0.889%	0.217%	0.115%	0.246%	1.335%	17.05%	2.281%	0.027%	0.061%	0.087%	LSD

References

1. Rajaei, M. and N. carimian. 1378. Effect of compost and nitrogen on the growth of tomato, nitrogen availability, and some soil characteristics under greenhouse conditions. Articles sixth Congress of Soil Science, pp. 152.
2. Malakooti, M. j. 1379. Role of micro nutrients in increasing agricultural production in Iran. Soil and Water Research Institute, Technical Journal 70.
3. Arnaud, C., M. Saint-Denis, J. F. Narbonne, P. Solerand and D. Ribera, 2000. Influences of different standardised test methods on biochemical responses in the earthworm Eisenia fetida andrei. Soil Biol. Biochem. 32: 67-73.
4. Tejada, M., J. L. Gonzalez, A. M. Martinez and J. Parrado, 2007. Application of a green manure and green manure composted with beet vinasse on soil restora. Bioresour Technol. 9:10-11.
5. Werner, W., H. W. S. Scherer and H. W. Olfs, 1988. Influence of long-term application of sewage sludge and compost from garbage with sewage sludge on soil fertility criteria. Z. Acker.Pflanzenbau. 160(3):173-178.

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Changes of microbiological properties and yield response of wheat in different microbial strains inoculated soils

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Abstract

The purpose of this study was to assess the affected by inoculation of different microbial strains on wheat yield and soil in greenhouse conditions, as well as explore the relationships between microbial biomass C, organic C, enzyme activities i.e. urease activity (UA), alkaline phosphotase activity (APA), dehydrogenase activity (DHA), catalase (CA), and soil parameters were studied in soils under wheat (Triticum aestivum L.) in the Black sea region of northern Turkey, Bafra Plain in Samsun, Turkey. We used microbial strains taken from Molecular Microbiology unit, Department of Biology, Faculty of Science and Art, Ondokuz Mayıs University, Samsun, Turkey. Seeds of wheat were inoculated with 5 bacterial strains such as *Amycolatopsis magusensis, Amycolatopsis orientalis, Streptomyces sp, Actinomadura geliboluensis, Amycolatopsis azurea*. Plants harvested and soil samples taken were after 124 days sowing. Research result showed that all treatments with additional microbial strains had positive effect on the yield, N concentrations of wheat, especially in *Actinomadura geliboluensis* treatment. Also, microbial strain *Actinomadura geliboluensis* had the highest effects on yield and increased the production of grain yield by 13.8 %, while its application with wheat straw resulted in a 83.2 % decrease in straw weight relative to the control (without microbe and wheat straw) treatment. Based on the research results, it was suggested that the use of indigenous *Actinomadura geliboluensis* strains might be suitable when producing and using bio-fertilizer.

Keywords: wheat, soil, enzyme activities, microbial strains.

Introduction

Wheat (Triticum aestivum L.) is one of the most important food crops of the world and a member of the family Poaceae that includes major cereal crops of the world such as maize, wheat and rice. Among the food crops, wheat is one of the most abundant sources of energy and proteins for the world population and its increased production is essential for food security (Chhokar RS, 2006). Also, the largest crop area is devoted to wheat and the quantity produced is more than that of any other crop. This occupies about 17 % of the world's cropped land and contributes 35% of the staple food. This means that will be used by a large number of chemical fertilizer. Extensive use of chemical fertilizers caused to occur in environmental pollution and ecological damage, and increased production cost (Ghost and Bhat, 1998, Gerber et al., 2005 and Mitsch and Day, 2006).

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To reduce pollution, restoration of land and wetlands, and excessive use of our non-renewable resources such as petroleum, which are used in the chemical fertilizers production, an alternative method must be developed. For this reason, environmental friendly product such as biofertilizer should be used when realizing agro-ecological restoration and sustainable ecosystem, which are the component of ecological engineering (Mitsch 1998) defined the ecological engineering as "the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both". Therefore, using biofertilizer and selection of the best microorganism strains have vital role when integrating human society with vulnerable ecosystems. Biological fertilizers, which are called bio-fertilizers, may be used in a way of to maintain soil fertility and soil improvement (Döbereiner, 1997). Biofertilizers are products containing living cells of different types of microorganisms, which have an ability to convert nutrionally important elements (N, P, K…) from unavailable to available from through biological process such as N fixation and solubilization of rock phosphate (Narula et al., 2000, Sahu and Jana, 2000, Çakmakçı et al., 2001 and Vessey, 2003).

Among the microbial strains used there and Actinomadura *geliboluensis.* Is a rare genus of actinomycetes. The first representatives of this genus (A. madurae and A. pelletieri) were isolated from clinical sources. In the tropical and subtropical regions of Africa and America, actinomaduras are known as the causal agents of human actinomycetoma. The natural habitat of actinomaduras is superficial soil horizons, from which they can get onto human lower limbs and then into wounds (Balows, A. et al.,1991).

The purpose of this study was to assess the affected by inoculation of different microbial strains such as *Amycolatopsis magusensis, Amycolatopsis orientalis, Streptomyces sp, Actinomadura geliboluensis, Amycolatopsis azurea* on wheat yield and soil in greenhouse conditions, as well as explore the relationships between microbial biomass C, organic C, enzyme activities i.e. urease activity (UA), alkaline phosphotase activity (APA), dehydrogenase activity (DHA), catalase (CA), and soil parameters were studied in soils under wheat (Triticum aestivum L.) in the Black sea region of northern Turkey, Bafra Plain in Samsun.

Material and Methods

Soil sampling

In our research, soil samples were collected from agricultural soils of Bafra Plain in Samsun, Turkey. The Bafra is located in the Kizilirmak Delta in the province of Samsun (Figure 1). The sampled soil site had been under arable agriculture for a long time. The site is located in the Black Sea Region, Northern Turkey (Latitude, 41021'N; longitude, 36015'W). This area is characterized by brown forest soils and has conglomerate, clay rock, and marn units and is gently sloping with a moderately well drained clay soil (Yüksel and Dengiz, 1996). The climate is semi humid, (Rf=47,21) with temperatures ranging from 6.6 °C in February to 23 °C in August. The annual mean temperature is 14.2 °C and annual mean precipitation in 670 mm.

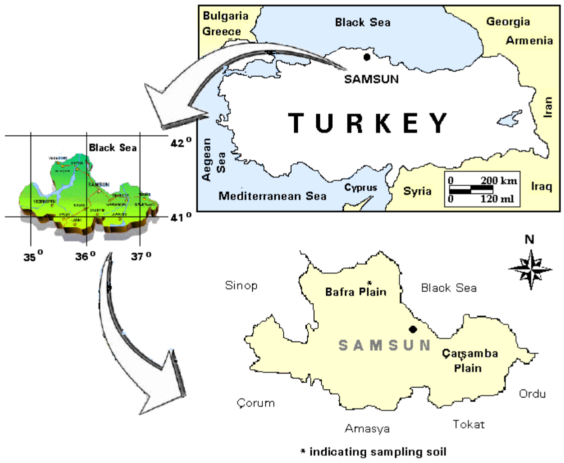


Figure 1. Location of the soil sampling point

Soil, wheat straw and microorganisms description

In March 2012, soil samples were collected to a dept ranging from 0 to 20 cm. Bulk soil samples were air dried at room temperature, sieved through 2 mm grids to remove root material, and saved until analysis. The soil contained 29,55% clay, 43,06% silt and 27,39% sand. The pH in water was 7.1 (notr), the oxidizable organic matter content 1.73%.

Wheat straw was obtained from the experimental farm of Agricultural Faculty, Ondokuz Mayıs University, Samsun, Turkey. The straw, with no diseases or contaminating insects, was oven dried at 65 °C. Whole plants, including stalks and leaves, were cut into 10-cm long pieces, then sieved to less than 0.50 mm. The properties of the straw is expressed on a moisture-free basis and analyzed by standard procedures, given in Ryan, Estefan, and Rashid (2001). The wheat straw is composed of approximately 79 % weight of oxidizable organic matter. The organic fraction comprises 45,9 % C and 0,89 % N while the inorganic fraction contains 2,60% P and 5,01 % K by weight.

Microbial strains taken from Molecular Microbiology unit, Department of Biology, Faculty of Science and Art, Ondokuz Mayıs University, Samsun, Turkey. These names are given in below: *Amycolatopsis magusensis, Amycolatopsis orientalis, Streptomyces sp, Actinomadura geliboluensis, Amycolatopsis azurea.*

Soil treatment and incubation

A pot experiment was carried out in the greenhouse with the spring wheat (*Triticum aestivum*) PANDAS in order to investigate the effects of inoculation with indigenous five different microbial strains. The experiment consisted of 12 treatments with 3 replications, and the pots were distributed in completely randomized design.

The samples (4 kg air-dried soil) were placed in 5 L plastic pots (length 19.5 cm and diameter 18 cm). The wheat straws were thoroughly mixed with the soil at a rate equivalent to 5% on an air-dried weight basis. Thirty seeds were sown in each pot and thinned to 15 plants per pot after the full emergence of the first leaf.

For all microbial strains was used Nitrogen-free medium. The pots were regularly irrigated to maintain a proper moisture level. The moisture contents in the soils were adjusted to 60% water holding capacity (WHC) throughout the experiment and the containers were incubated in greenhouse for 124 days after sowing.

Experimental design

Soil without wheat straw addition and microbial strain inoculation was used as a control. A randomized complete plot design with three replicates per treatment and soil was used. This greenhouse experiment was total 36 pots. The experiment was performed with the following 12 treatment:

(1) Control (without wheat straw, without microbial strain inoculation)
(2) With addition wheat straw, without microbial strain inoculation
(3) *Streptomyces sp.*, without addition of wheat straw
(4) *Streptomyces sp*., + 50 g kg^{-1} wheat straw
(5) *Amycolatopsis magusensis*, without addition of wheat straw
(6) *Amycolatopsis magusensis* + 50 g kg^{-1} wheat straw
(7) *Amycolatopsis orientalis*, without addition of wheat straw
(8) *Amycolatopsis orientalis*, + 50 g kg^{-1} wheat straw
(9) *Actinomadura geliboluensis*, without addition of wheat straw
(10) *Actinomadura geliboluensis*, + 50 g kg^{-1} wheat straw
(11) *Amycolatopsis azurea*, without addition of wheat straw
(12) *Amycolatopsis azurea*, + 50 g kg^{-1} wheat straw

Soil physico-chemical analysis

Selected soil physico-chemical properties were determined by the folowing methods: soil particle size distribution by the hydrometer method, pH and EC in 1:1 (w/v) in soil: water suspension by pH and EC meter, $CaCO_3$ content by Scheibler calsimeter, and soil samples were sieved through a 150 μm mesh to determine the total organic carbon content by the wet oxidation method (Walkley-Black) with dipotassium chromate $K_2Cr_2O_7$ (Rowell 1996). Total N in soil was determined by digestion and sequent measurement by the Kjedahl method (Bremner 1965).

Soil microbiological analysis

Microbial biomass carbon (Cmic) was determined by the substrate-induced respiration method of Anderson and Domsch [Anderson J.P.E., 1978].A moist soil sample equivalent to 100 g oven-dry soil was amended with a powder mixture containing 400 mg glucose. The CO2 production rate was measured hourly using the method described by Anderson [Anderson J.P.E.,1982]. The pattern of respiratory response was recorded for 4 h. Microbial biomass carbon (Cmic) was calculated from the maximum initial respiratory response in terms of mg C g–1 soil as 40.04 mg CO2 g–1 + 3.75. Three replicates of each sample were tested. Data are expressed as mg CO2–C 100 g–1 dry soil.

Basal soil respiration (BSR) at field capacity (CO_2 production at 22 °C without addition of glucose) was measured, as reported by Isermayer [Isermayer H.,1952]; by alkali ($Ba(OH)_2.8H_2O$ +$BaCl_2$) absorption of the CO_2 produced during the 24 h incubation period, followed by titration of the residual OH^- with standardized hydrochloric acid, after adding three drops of phenolphthalein as an indicator. Three replicates of each sample were tested. Data are expressed as µg CO_2 g^{-1} dry soil.

Dehydrogenase activity (DHA) was determined according to Thalmann [Thalmann A., 1968]. Moist soil (10 g) was treated with 10 ml of 0.8 % TTC (2,3,5-triphenyltetrazolium chloride) in Tris buffer (pH, 7.6) for 24 h in darkness at 30 °C. The triphenylformazan (TPF) formed was extracted with a 50 ml extraction solution (90 % (v/v) acetone + 10 % (v/v) CCl_4) by vigorous shaking for 1 min and then filtering through a Whatman 42 filter paper. TPF was measured spectrophotometrically at 485 nm, using the extracting solution as a blank. Triplicate tubes were set up for each soil sample along with an autoclaved control of each sample. Data are expressed as µg TPF g^{-1} dry soil.

Catalase activity (CA) was measured by the Beck method [Beck T.H., 1971]. Ten milliliter of phosphate buffer (pH, 7) and 5 ml of a 3% H_2O_2 substrate solution were added to 5 g of soil. The volume (ml) of O_2 released within 3 min at 20 °C was determined. Three replicates of each sample and controls were tested in the same way, but with the addition of 2 ml of 6.5% (w/v) NaN_3. Results were expressed as ml O_2 $5g^{-1}$ dry soil.

Urease activity (UA) was measured by the method of Hoffmann and Teicher [Hoffmann G.G., 1961].A 7.5 ml citrate buffer (pH, 6.7) and 10 ml of 10% urea substrate solution were added to 10 g of dry soil, and subsequently the samples were incubated for 3 h at 37 °C. The volume was made up to 100 ml with distilled water at 37 °C. Following filtration through Whatman No.42 filter papers, 1 ml of filtrate was diluted to 10 ml with distilled water, and 4 ml of sodium phenolate (12.5% (w/v) phenol + 5.4% (w/v) NaOH) and 3 ml of 0.9% sodium hypochloride were added. The released ammonium was determined spectrophotometrically at 578 nm. Three replicates of each sample were tested, and a control sample without urea was prepared. Results were expressed as µg N g^{-1} dry soil.

Results and Discussion

Soil physico-chemical properties

The soils were clay loam in texture, neutral in soil reaction, low in organic matter content (1,73 %), $CaCO_3$, % (11,74 %), and low in electrical conductivity (0,94 dS m^{-1}) [Soil Survey Staff, 1993] (table 1).

Table 1 Soil physico-chemical properties

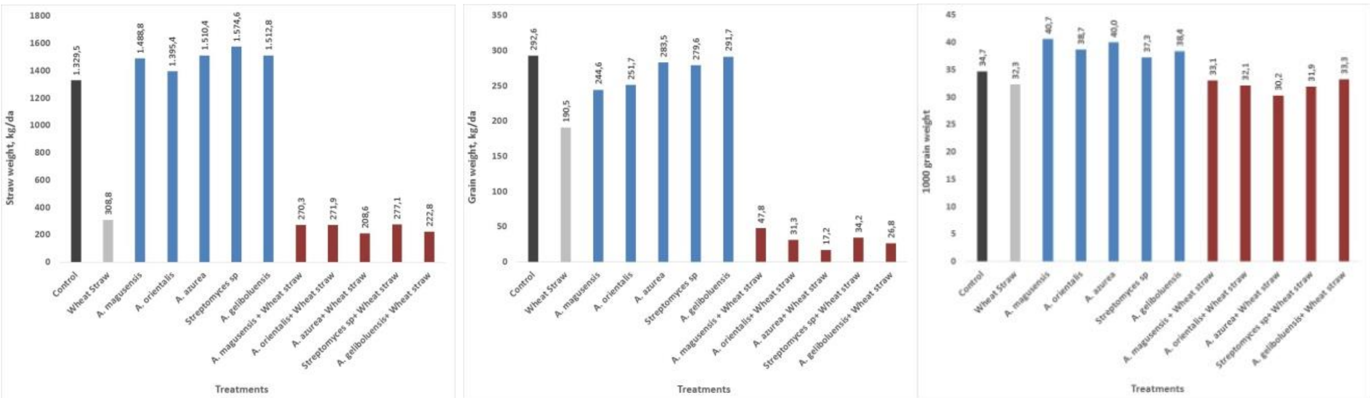
Clay, %	:	29,55
Silt, %	:	43,06
Sand, %	:	27,39
Texture class	:	Clay loam
pH	:	7,10
Electrical conductivity, dSm^{-1}	:	0,94
$CaCO_3$, %	:	11,74
Organic matter content, %	:	1,73
Total N, %	:	0,18

Grain and straw yield

Treatment effects on wheat straw weight, wheat grain weight and 1000 grain weight are shown in Figure 4.1., 4.2 and 4.3. (detailed in figure 2 and table 2) Sole application of microorganism application increased straw weight and 1000 grain weight significantly relative to the control while sole wheat straw application or its application with microorganisms, resulted in straw weight, grain weight and 1000 grain weight decreases. For example, the sole application of *Actinomadura geliboluensis* resulted in a 13.8 % increase in straw weight relative to the control while its application with wheat straw resulted in a 83.2 % decrease in straw weight relative to the control (without microbe and wheat straw) treatment. The sole wheat straw application decreased straw weight by 76.8 % relative to the control treatment and a 34.9 % decrease in grain weight was observed relative to the control treatment. Application of sole microorganisms and microorganisms with wheat straw did not result in a significant increment in grain weight.

Table 2 The effects of sole microorganisms and with wheat straw on straw weight, grain weight and 1000 grain weight

Treatments	straw weight, kg/da	grain weight, kg/da	1000 grain weight
Control	1329,46 ± 330,74	292,64 ± 8,70	34,71 ± 3,88
Wheat straw	308,75 ± 35,28	190,50 ± 12,04	32,32 ± 12,30
Amycolatopsis magusensis	1488,76 ± 78,61	244,59 ± 43,06	40,67 ± 0,28
Amycolatopsis orientalis	1395,43 ± 18,61	251,67 ± 11,94	38,72 ± 0,18
Amycolatopsis azurea	1510,43 ± 40,56	283,47 ± 21,76	40,02 ± 0,21
Streptomyces sp.	1574,60 ± 127,22	279,59 ± 20,00	37,28 ± 2,80
Actinomadura geliboluensis	1512,79 ± 71,76	291,67 ± 5,83	38,39 ± 1,01
Amycolatopsis magusensis + wheat straw	270,28 ± 133,15	47,78 ± 23,43	33,08 ± 1,06
Amycolatopsis orientalis + wheat straw	271,95 ± 93,52	31,25 ± 20,00	32,14 ± 0,99
Amycolatopsis azurea + wheat straw	208,61 ± 31,57	17,22 ± 2,69	30,24 ± 3,28
Streptomyces sp. + wheat straw	277,09 ± 90,56	34,17 ± 21,94	31,95 ± 0,86
Actinomadura geliboluensis + wheat straw	222,78 ± 62,04	26,81 ± 15,74	33,28 ± 1,64



A B C

Figure 2: A - The effects of sole microorganisms and with wheat straw on straw weight, B - The effects of sole microorganisms and with wheat straw on grain weight, C - The effects of sole microorganisms and with wheat straw on 1000 grain weight

Microbiological properties

It was determined that treatments with *Actinomadura geliboluensis* compare with control in microbial biomass-C, basal soil respiration, dehydrogenase, catalase, urease and alkaline phosphatase activity, and were 3,53 – 9,37 mg CO_2-C 1 g^{-1} dry soil, 0.86 – 1.16 mg CO_2-C 1 g^{-1} dry soil $24h^{-1}$, 2,26 – 18,18 µg TPF g^{-1} dry soil 24h, 29,13 – 72,55 ml O_2 g^{-1} dry soil 3 min, 52,57 – 234,58 µg N g^{-1} dry soil h^{-1} and 191,00 – 269,94 µg p-NP g^{-1} dry soil h^{-1} in all variations, respectively. Biological properties such as microbial biomass-C, catalase, urease and alkaline phosphatase activity in soils increased with inoculation of all microbial strain + wheat straw compared the control. In contrast with inoculation of microbial strain + wheat straw, dehydrogenase activity in soil was lower than the control and sole microbial strain inoculation. Basal soil respiration levels were consistently higher in sole microbial strain inoculation than in control.

Conclusion

In this research, which were aimed at establishing the usefulness of some microbial strains, consisted of the most popular crop, wheat, in Turkey. The studies encompassed the evaluation of the effects of different microbial strains on the yield of wheat and nutrient concentrations under greenhouse condition; and the relations between microbial inoculation into the soil and soil biological properties.

Microbial inoculation in the presence of the wheat straw additions, showed significant differences in dehydrogenase, urease, catalase, alkaline phosphatase activities, as well as in biomass, basal soil respiration and organic carbon content. Just of the effects on the dehydrogenase activities were the opposite to those

seen with microbial inoculation without the wheat straw addition, i.e. lower, but at that, other enzimes, such as urease, catalase, alkaline phosphatase activities were significantly higher with the inoculation in the presence of wheat straw additions than without inoculation, whereas urease activity was significantly higher.
Some of the agricultural management systems studied showed clear short-term effects on microbial biomass carbon and their activities, mainly due to the changes in organic matter inputs to soil. In particular, the addition of wheat straw to soil can be considered an effective soil management, because it produced an important increase of the different fractions of organic carbon and microbial activity, that it will be translated into a rapid improvement of soil biological properties.

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References

Anderson J.P.E., Soil respiration, in: A.L. Page (Ed.), Methods of Soil Analysis. Part 2, Chemical and Microbiological Properties, second ed., vol. 9, ASA-SSAA, Madison, Wisconsin, USA, 1982, pp. 831–871.

Anderson J.P.E., Domsch K.H., A physiological method for the quantative measurement ofmicrobial biomass in soils, Soil Biol. Biochem. 10 (1978) 215–221.

Bremner, J.M., Mulvaney, R.L. 1978. Urease activity in soils. In Soil enzymes, ed. R.G. Burns, 149-196. New York: Academic Press.

Rowell, D.L., 1996. Soil Science: methods an applications. Longman, UK.

Ryan, J., Estefan, G., Rashid, A., 2001. Soil and plant analysis laboratory manual. International Center for Agricultural Research in the Dry Areas (ICARDA). Syria.

Chhokar RS; Sharma RK; Chauhan DS; Mongia AD. *Weed Research*, 2006, 46, 40.

Pingali PL. World Wheat Facts and Trends. Mexico D F, 1999, CIMMYT. PL Pingali. World Wheat Facts and Trends. Mexico D F, 1999, CIMMYT.

Yüksel, M., Dengiz, O. 1996. Bafra Ovası Sağ Sahili Topraklarının Sınıflandırılması. Ankara Üniversitesi Ziraat Fakültesi Tarım Bilimleri Dergisi. 2 (2), 95-101, ANKARA.

Isermayer H., Eine einpache Methode zur Bestimmung der Pflanzenatmung und der Karbonate in Boden, Z. Pflanzenernähr. Düng, Bodenk. 56 (1952) 26–28.

Thalmann A., ZurMethodik der Bestimmung der Dehydrogenaseaktivität im Boden mittels Triphenyltetrazoliumchlorid, Landw. Forsch. 21 (1968) 249–259.

Beck T.H., Die Messung derkKatalasen aktivität Von Böden, Z. Pflanzenernähr, Bodenkd. 130 (1971) 68–81.

Hoffmann G.G., Teicher K., Ein kolorimetrisches Verfahren zur Bestimmung der Urease Aktivitat in Böden, Z. Pflanzenernähr. Düng, Bodenk. 91 (1961) 55–63

Balows, A. *et al., The Prokaryotes. A Handbook on the Biology of Bacteria: Ecophysiology, Isolation, Identification, Applications*, 2nd ed., , Eds., New York: Springer, 1991.

Soil Survey Staff Soil Survey Manual. USDA Handbook No. 18 US Government Printing Office, Washington, DC, USA (1993)

Ghost B.C., Bhat R. Environmental hazards of nitrogen loading in wetland rice fields Environ. Pollut., 102 (1998), pp. 123–126

Gerber P., Chilonda P., Franceschini G., Menzi H. Geographical determinants and environmental implications of livestock production intensification in Asia Bioresour. Technol., 96 (2005), pp. 263–276

Mitsch W.J., Day J.W. Restoration of wetlands in the Mississipi–Ohio–Missouri (MOM) river basin: experience and needed research Ecol. Eng., 26 (2006), pp. 55–69

Mitsch W.J. Ecological engineering – the 7 year itch Ecol. Eng., 10 (1998), pp. 119–138

Döbereiner J. Biological nitrogen fixation in the tropics: social and economic contributions Soil Biol. Biochem., 29 (1997), pp. 771–774

Narula N., Kumar V., Behl R.K., Deubel A., Gransee A., Merbach W. Effect of P-solubilizing Azotobacter chroococcum on N, P, K uptake in P-responsive wheat genotypes grown under greenhouse conditions J. Plant Nutr. Soil Sci., 163 (2000), pp. 393–398

Sahu S.N., Jana B.B. Enhancement of the fertilizer value of rock phosphate engineered through phosphate-solubilizing bacteria, Ecol. Eng., 15 (2000), pp. 27–39

Çakmakçı R., Kantar F., Sahin F. Effect of N2-fixing bacterial inoculations on yield of sugar beet and barley, J. Plant Nutr. Soil Sci., 164 (2001), pp. 527–531

Vessey J.K. Plant growth promoting rhizobacteria as biofertilizer. Plant Soil, 255 (2003), pp. 571–586

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