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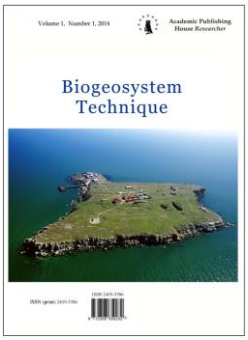

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Soil Processes in *Haplic Kastanozems* of Central Anatolia (Turkey, Ćumra Region): Bio- and Agrophysical Aspects

[1] E. V. Shein
[2] S. A. Erol
[1] E. Yu. Milanovskiy
[3] F. D. Mikailsoy
[1] N. V. Verhovtseva
[6] S.I. Zinchenko
[4] F. Er
[5] S. Ersahin

[1] Moscow State University, Russian Federation
Faculty of Soil Science, Leninskie gory, Moscow, 119191
[2] University of Selcuk, Turkey
Çumra Higher Educational College, 3umraa/Konya, 42500
[3] University of Igdır, Turkey
Department of Soil Science and Plant Nutrition, Konya, 76000
[4] University of Selcuk, Turkey
Çumra College of Applied Sciences, 3umra/Konya, 42500
[5] University of Cankiri Karatekin, Turkey
Department of Soil Science and Ecology, Cankiri, 18200
[6] Vladimir scientific institute of agronomy, Russian Federation
Suzdal, 601261

Abstract

Agrophysical properties and soil biota were studied in Haplic Kastanozems Chromic (calcareous soils) in Central Anatolia (Konya province, Ćumra region). These heavy textured (medium clay) soils with a low content of organic carbon (less than 1%) have favorable biophysical properties due to the stable structure of the pore space. The favorable structure of the pore space is suggested to be stipulated by the activity of the numerous and diverse representatives of soil biota. *Actinobacteria* is the dominant in four phyla in the microbiological composition of the soils studied. The composition of this phylum is dominated by the elevated number of both higher (*Streptomyces*) and lower (three species of *Rhodococcus*) actinobacteria. The high biodiversity of bacteria against the background of their great total number and the developed tropics interactions in the microbial community promote the well balanced production of specific metabolites, including gaseous ones (CO_2, H_2). This circumstance allows this clayey soil to function rather actively while protecting the pore space against compaction and maintaining the optimal density, porosity, and hydrological properties.

Keywords: Soil Ecology, Pore Space, Microbiological Composition, Biogeophysics.

Introduction

Agrolandscapes and soils of Central Anatolia are actively used in agriculture due to their high heat resources, natural fertility, and the availability of water for their additional irrigation. However, scientific works on the optimization of the water and heat regimes of these soils have not been carried out, although it is evident that such works are necessary to elaborate a strategy for the agricultural production and the rational use of the natural resources. Therefore, the agrophysical assessment of the soils in this region is very important. This work is aimed at studying the agrophysical properties and the soil microbiota of this calcareous soils in a special field experiment.

Objects and methods

The Ćumra region studied (about 172 thousand ha) is located in the central part of Turkey (Central Anatolia, Konya province) between 37° and 38° E and 33° and 34° N at an altitude of 1013 m a.s.l. It is mainly a mountain–hilly territory; in its plain area, agriculture has been maintained for a long time. The climate of the region has been formed under the influence of different factors, the main of which is its continentality: hot and dry summers and cold and dry winters. The mean annual temperature is 11.8°C; the minimal and maximal temperatures are –1.5 and +26.1°C, respectively. The mean annual precipitation is 306 mm. The soil profiles investigated were in the test area of the Agricultural Faculty of Selcuk University (Konya).

The particle size composition was determined using the laser diffraction method and a FRITSCH Analysette 22 device with the preliminary treatment of the samples with ultrasound in pure water [7]. The soil bulk density was determined by the method of a cutting ring [5, 7]; it was 1.03–1.10 g/cm3 in the upper plow layer and, from the depth of 40 cm, 1.35– 1.50 g/cm^3. The contents of C and N were measured using a CNHS analyzer (Vario EL III Elementar) for solid samples. The obtained values of the C/N ratio were very low (table), thus testifying to the high N saturation of the organic matter. Usually [3, 5], in the well_humified organic matter, these ratios reach 12–13. The values of C/N ration 5–7 in the calcareous alluvial soils were most likely related to the organic matter absorbed on the surface of the fine elementary mineral soil particles. This organic matter appears to be associated with the metabolic products of the soil biota.

Table 1: The content of organic carbon (C org, %), carbonates ($CaCO_3$, %) and nitrogen (N, %) in the alluvial soil at the beginning and end of the growing season. Above the line - data for June (vegetation period), below the line - for October (autumn, after vegetation)

Depth, cm	$CaCO_3$, %	Corg, %	N, %	C/N
0-10	2.40/2.27	0.88/0.85	0.14/0.12	6.3/7.1
10-20	2.36/2.29	1.00/0.89	0.13/0.13	7.6/6.8
20-30	2.35/2.23	0.69/0.7	0.13/0.1	5.3/7.0
30-40	2.43/2.21	0.51/0.58	0.10/0.08	5.1/7.3
40-50	2.49/2.49	0.42/0.42	0.07/0.07	6.0/6.0
0-10	2.38/2.35	0.86/0.77	0.15/0.12	5.7/6.4
10-20	2.39/2.29	0.81/0.77	0.13/0.12	6.2/6.4
20-30	2.32/2.31	0.72/0.65	0.11/0.11	6.5/5.9
30-40	2.32/2.28	0.62/0.57	0.08/0.10	7.8/5.7
40-50	2.32/2.26	0.45/0.57	0.08/0.09	5.6/6.3
50-60	2.39/2.27	0. 0.45/0.51	0.03/0.09	15/5.7

Results and discussion

The soils studied are heavy textured along their whole profile (Table 1) using the laser diffraction method of granulometric composition [4]. According to the international classification, their particle size composition is silty clay (44.8% clay, 54.2% coarse silt, and 1% sand); by the Kachinskiy classification, they are referred to medium clay. At the depth of 40 cm, the soil texture becomes heavier, and the soil density increases. Probably, these changes in density and texture are related to the agricultural practices (compacting of the subsoil by agricultural machines) or to the natural lessivage of fine particles into the deeper layers. It should be emphasized that, despite the

heavy texture and low organic matter content, these soils have high porosity and a stable porous structure. This fact is confirmed by numerous measurements of the filtration coefficient by the method of flood areas. The values of this coefficient are unusually high for heavy textured soils: they range from 250 to 360 cm/day. As a rule, the soils of the same texture (light clay–medium clay) are characterized by low (3–7 cm/day) filtration coefficients (saturation conductivity) if the soils do not have a well pronounced stable aggregate structure. In the soils studied, there were no agronomically valuable aggregates. At the same time, the results of studying the water permeability of the soils showed that, in the first and last hours of the observations, the rate of absorption weakly decreased testifying to stable water conducting ways.

The latter is an important and agrophysically valuable property. The reason for the stable favorable agrophysical status of the studied soil is not clear, but it appears to be related to the high content of carbonates and to some other processes that stabilize the porous space and soil structure under these conditions. Thus, Loveland and Webb [2] consider that the main factor limiting the agrophysical properties is the content of organic matter. They suggest a threshold at 2% organic carbon for loamy soils. An absolute agrophysical criterion is the porosity of the soils. In a very compact soil, it restricts the respiration of the microorganisms [5, 7]. Some authors note that the favorable agrophysical status of clayey soils may be related to the $CaCO_3$ content, the concentration of which should be in the range of 9–19% [7]. According to the criteria accepted in Russia, the soils studied belong to favorable ones in terms of their agrophysical status. However, the low organic carbon content (up to 1%), the low C/N ratios, and the low content of carbonates presuppose a low level of agrophysical conditions [1, 5, 7] (Table 1).

This fact is considered interesting and very important for understanding the agrophysical assessment of the soils. We suggested that the favorable agrophysical status of the alluvial soils in the Ćumra region is provided by their rich and diverse microbiota and its high activity in these well heated clayey soils. The results of the total microbiological characterization of the studied soils showed that four phyla predominated there. Among them, the *Actinobacteria* phylum is the dominant one (fig.1).

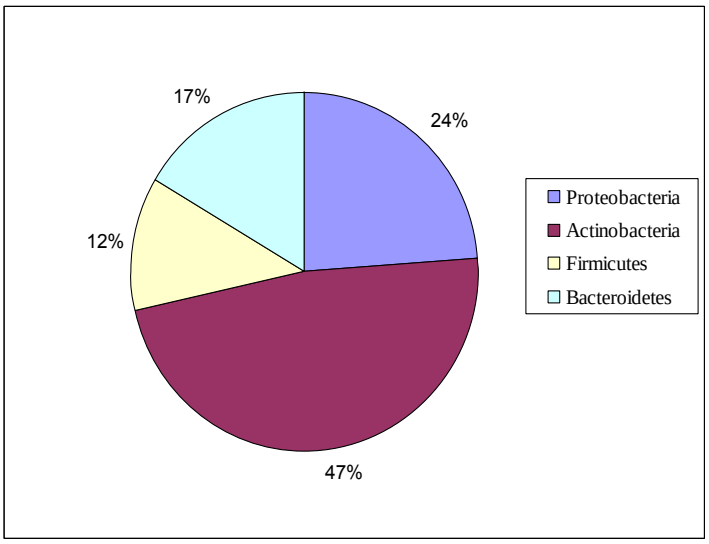

Fig. 1. Composition and structure of the soil microbial community
(reconstructed by chemical markers by gas chromatography-mass spectrometry [8])

In the *Actinobacteria* phylum, both higher (*Streptomyces* forming mycelium) and lower (three species of *Rhodococcus*) actinobacteria were found in elevated amounts. These species are actinobacteria, for which the main ecological niche is the anaerobic zone of the soil, where they perform the hydrolysis of complex substrates, for instance, the hydrolysis of cellulose and even carbohydrates. In addition, the antibiotic activity of *Streptomyces* is important in the formation of the microbial community, where *Streptomyces* act as a factor regulating the composition of the cenosis, which inhibits the development of one species and provides conditions for the reproduction of other ones. *Rhodococcus* is able to produce bioactive steroids and acrylic acid.

Anaerobic hydrolytics of this phylum are no less important. We found *Bifidobacterium* sp., which was not observed in the control soil, in the soil of plot 1, probably, due to the exudates of sugar beets cultivated on this soil. This genus is useful for soil fertility, since it has the ability to excrete some enzymes, aminoacids, and regulators of the plant growth [3, 8]. On the whole, the diversity of microorganisms is rather high—47 species of bacteria from 35 genera. The total number is 107 cell/g soils. It is worth noting that, at the humus content of 1%, this number of bacteria and their diversity are considered rather high. The C/N ratio in the soil is close to that characteristic of microbial cells (6.2) [3], thus showing favorable soil conditions for the development of microorganisms. Probably, the high biodiversity at the great number of bacteria and the developed trophic interrelations in the microbial community promote the balanced production of specific metabolites, including gaseous ones (CO_2, H_2). This fact allows the clayey soil studied to actively protect the porous space against consolidation and to maintain the optimal density, porosity, and hydrological properties. This conclusion is preliminary, and a detailed study of the structure of the microbial communities and numerous tests are needed. It points to the necessity to continue research on the determination of the relations between the physical properties and the agrophysical processes and the composition, properties, and functioning of the soil biota. But production of gaseous metabolites allows this clayey soil to function rather actively while protecting the pore space against compaction and maintaining the optimal density, porosity, and hydrological properties.

Conclusions

The favorable density and structure of the pore space in alluvial clay soils in Central Anatolia is suggested to be stipulated by the active activity of the numerous and diverse representatives of soil biota. The values of C/N ratio about 5–7 in the calcareous alluvial soils were most likely related to the organic matter absorbed on the surface of the fine elementary mineral soil particles. This organic matter appears to be associated with the metabolic products of the soil biota. Four phyla predominate in the microbiological composition of the soils studied; among them, *Actinobacteria* is the dominant. The composition of this phylum is dominated by the elevated number of both higher (*Streptomyces*) and lower (three species of *Rhodococcus*) actinobacteria. The high biodiversity of bacteria against the background of their great total number and the developed tropic interactions in the microbial community promote the well balanced production of specific metabolites. Soil agrophysical properties are rather good and stable because of the microbial activity.

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