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SOIL MICROBIAL BIOMASS CONTENT INTO LEACHED CHERNOZEM STRUCTURAL AGGREGATES IN DIFFERENT LANDS MANAGEMENT SYSTEMS

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Abstract

The paper aimed to present the relationships between soil microbial biomass content and the sizes of soil structural aggregates in the leached chernozem from central part of Moldova in three different lands management systems as the long-term arable chernozem with crop rotation without fertilizers, long-term arable land covered for nine years with cover crops (grass mixture ryegrass and lucerne) which are used each year as a green manure and chernozem under 60 year-old fallow. It is based on the research carried out in the experimental sites of "Nicolae Dimo" Institute of Pedology, Agrochemistry and Soil Protection from village Ivancea, Orhei District. The data have been processed into the following indicators: soil structure, organic carbon content, microbial biomass carbon. Carried out research show that fallow chernozem under the forest stripe has a significantly better structure than arable and phyto improved soils. In all three experimental sites carbon content have a uniform distribution regardless of the aggregates size. Microbial biomass carbon is concentrated in the smallest aggregates of fallow cernozem in the surface layer and has a polynomial distribution in below layer. Arable cernozem is characterized by fairly uniform distribution in all size soil aggregates but with a slightly higher concentration in the 0.5-0.25 mm aggregates. Phyto improved cernozem differs from the arable by microbial biomass carbon higher content in medium sized (the highest in 3-2 mm) aggregates in the first layer from the surface. As a conclusion, despite a uniform organic carbon distribution in different sized soil aggregates, microbial biomass carbon has some preferences due to the used agricultural practice and can be an indicator of soil health.

Key words: *carbon, soil biomass, soil structure, cernozem, Moldova.*

INTRODUCTION

Soil framing in the agricultural use is immediately followed by negative changes in its quality. Soil structure is a morphological and agronomical soil index which makes it different from the parental rock and confers its fertility. Unfortunately, in the last decades this soil feature of particular importance has been significantly degraded on arable lands resulting in soil compaction, crop yields decreasing and erosion processes on ever wider surfaces extending, not only in Moldova, but also worldwide. Restoring soil fertility and its sustainable use is the primary aim of modern agriculture. A very sensitive indicator used to determine changes in soil is microbial biomass content. Although microbial biomass represents less than 5% of the total organic matter in soils, it plays an essential role in soil life contributing to substances transformation, pesticides degradation, and soil aggregation. Previous research has established that soils framing is resulting in its biota degradation - a phenomenon found in close correlation with soil dehumification and destructuration processes (Senicovscaia, 2012). Conventional tillage system leads to structural aggregates destruction, and therefore of microorganisms habitat (Senicovscaia et al., 2010). Microorganisms' interaction with organic matter and soil structure is complex and represents a heterogeneous phenomenon that contributes to soils quality and high productivity establishment. Soils used under perennial grasses, which form biogenic layer at the soil surface, compared with fallow and arable are ideal ecosystems for investigations of these interactions. In this context, the paper present an analysis of organic and microbial carbon distribution on different size of soil structural aggregates in three different lands management systems from central part of Moldova, in order to put into evidence the changes that occur with the soil microorganisms along with the soil transforming under ploughing, farming and phytotechnical improving.

MATERIALS AND METHODS

The research where carried out in the Republic of Moldova at Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental field located in the center of the country, in the Ivancha village, Orhei district. The soil is the leached chernozem with humus content around 3.0% and pH ≈ 6.6 in the 0-25 cm layer.

For research was chosen three experimental sites with different lands management systems as: leached chernozem under 60 year-old fallow in the forest strip from the field edge (forest strip), the long-term arable land with crop rotation without fertilizers (conventional agriculture) and nine years phyto improved arable land with grass mixture ryegrass+lucerne (grass strip) (Figures 1, 8).

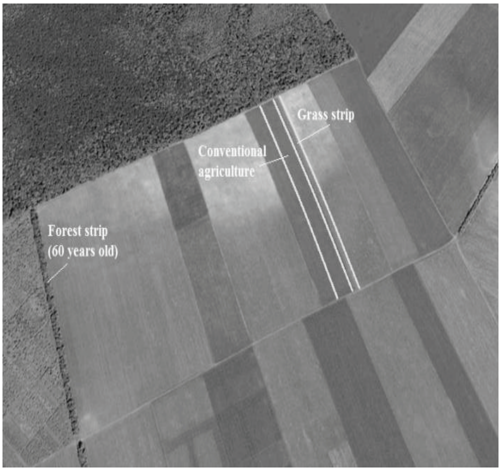

Figure 1. Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental field used for current research

Plots under mixtures of perennial grasses (ryegrass+lucerne) were founded in the autumn of 2007.

This study was performed in the period 2015-2016.

Soil samples were collected from the 0-10 and 10-25 cm layers in each experimental plot in five repetitions for statistical data processing.

In the middle of each experimental plot also was made a full profile to describe and analyse the soil in the deep.

In order to characterize the microbial biomass transformation under different lands management systems, the following indicators were used: soil structure, organic carbon content and microbial biomass carbon in soil structural aggregates with different size.

For soil structural composition or aggregate size distribution assessment was used the standard classical dry-sieving method (Savinov, 1936). Where is taken 500 g of air-dried, undisturbed soil which is sieved through a cluster of sieves having 10, 5, 3, 2, 1, 0.5, and 0.25 square mm from which results eight aggregate size classes (>10, 10-5, 5-3, 3-2, 2-1, 1-0.5, 0.5-0.25 and <0.25 mm).

Soil organic matter (%) or organic C was analyzed by the dichromate oxidation method (Arinushkina, 1970). The carbon content was calculated using the coefficient of 1.724.

The microbial biomass carbon was measured by the rehydratation method based on the difference between carbon extracted with 0.5 M K_2SO_4 from dried soil at 65-70^{0}C within 24 h and fresh soil samples with Kc coefficient of 0.25 (Blagodatsky et al., 1987). K_2SO_4 - extractable organic carbon concentrations in the dried and fresh soil samples were measured simultaneously by dichromate oxidation. K_2SO_4-extractable carbon was determined at 590 nm with СФ 103 spectrophotometer.

The obtained data have been statistically processed and interpreted. The microbial biomass index was evaluated statistically by the variance and correlation analysis.

RESULTS AND DISCUSSIONS

Leached chernozem under 60 year-old fallow from the forest strip is well structured in the entire profile. The main part of the soil is joined in agronomic precious aggregates (Figure 2). But after 60 years the effect of soil plowing can still be recognized in the layer 12-25 cm.

Arable chernozem is bad-structured (Figure 3). Less favourable for plant growth is exactly the layer of roots growth. First 0-10 cm from the surface is extremely dusty top layer. The underline layer 10 - 20 cm is so compacted, large aggregates greater than 10 cm predominate here as a result of soil compaction in this layer.

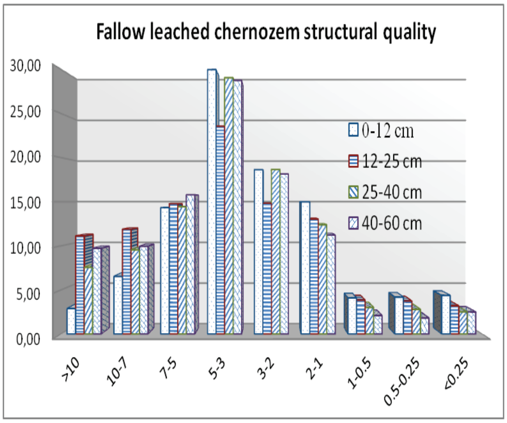

Figure 2. Fallow leached chernozem aggregate size distribution

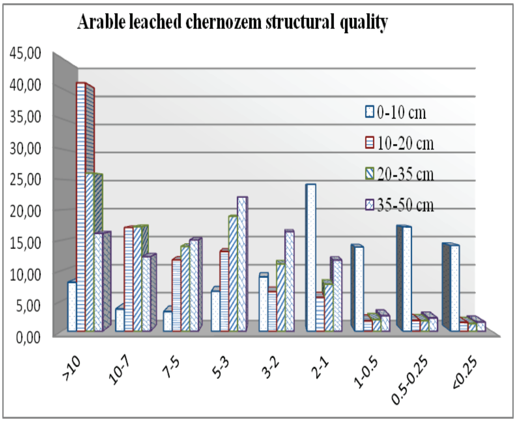

Figure 3. Arable leached chernozem aggregate size distribution

Cover crop into phyto improved leached chernozem experimental site help to destroy the big soil particles in the layer 10-20 cm (Figure 4).

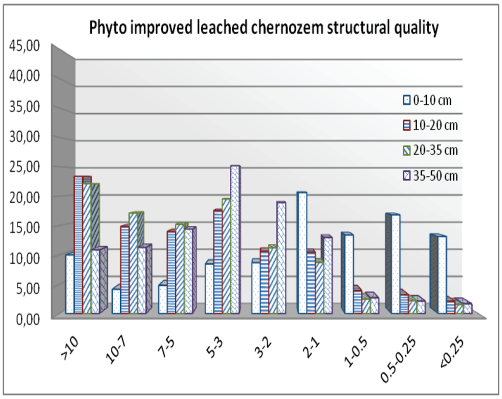

Figure 4. Phyto improved leached chernozem aggregate size distribution

This bad structural conditions affect to a large extent plants grow, but how it affect the organic carbon and soil microorganism distribution in various size aggregates?

The organic carbon values are higher in the fallow cernozem (3.0-3.5% in the top layer, 2.6- 2.9% in the 10-20 cm layer). Arable and phyto improved soils carbon content is in the range of 1.7-2.1%.

In all three experimental sites organic carbon content have an almost uniform distribution in all soil aggregates regardless of the aggregates size.

But a size of soil particles plays an important role in the distribution of microorganisms in the aggregate fractions of leached chernozem under 60 years-old fallow (Figure 5). The largest concentrations of microbial biomass carbon were found in the layer of 0-12 cm.

The highest amounts of the microbial biomass in the layer of 0-12 cm are localized in fractions of 0.5-0.25 mm (16.9%) and < 0.25 mm (13.5%). The lowest amounts of the microbial biomass have been recorded in the fraction of > 10 mm (6.4%).

All remaining biomass was distributed approximately equally among soil particles with the size of 10-7, 7-5, 5-3, 3-2, 2-1 and 1-0.5 mm, which is 63.2% of the total amount. The link between microorganisms and soil fractions is strongly positive.

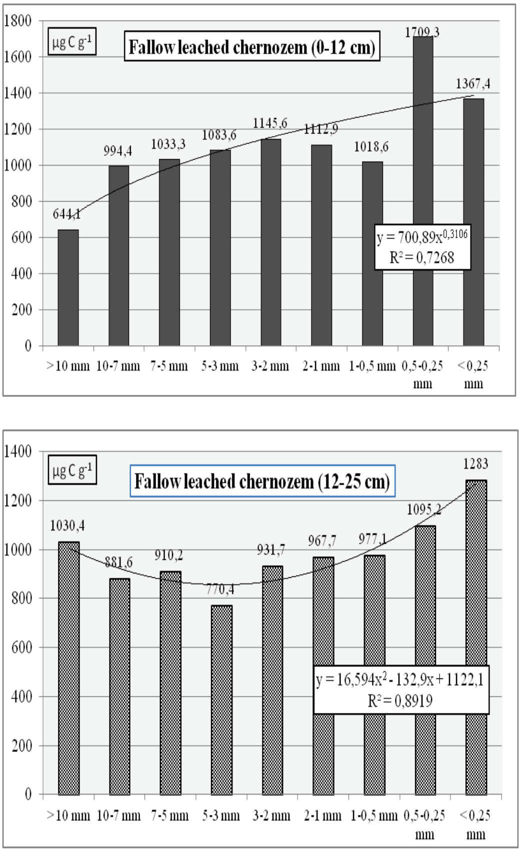

Figure 5. Distribution of microorganisms in soil aggregates of the fallow leached chernozem

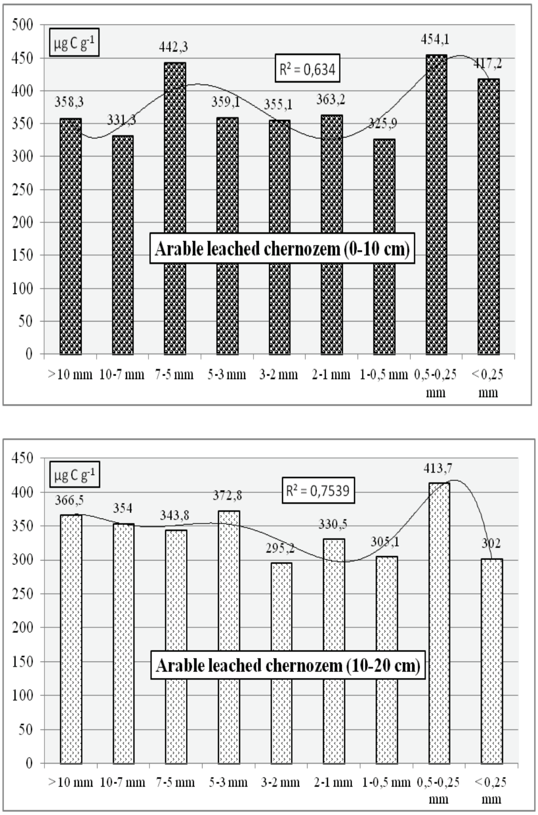

Figure 6. Distribution of microorganisms in soil aggregates of the arable leached chernozem

Trend of the microbial biomass content in soil aggregates in the layer of 0-12 cm is described by the power function. Correlation coefficient constitutes $R^2 = 0.73$.

The highest amounts of the microbial biomass in the fallow chernozem (layer of 12-25 cm) are localized in the fractions of < 0.25 mm (14.5 %), 0.5-0.25 mm (12.4 %) and > 10 mm (11.7 %). The lowest amounts of the microbial biomass have been recorded in the fraction of 5-3 mm (8.7 %). Fractions with the particles size of 10-7, 7-5, 3-2, 2-1 and 1-0.5 mm contained approximately the same number of microorganisms (881.6-977.1 μg C g^{-1} soil). Trends are described by the polynomial function with the high correlation coefficient ($R^2 = 0.89$).

Soil matrix under arable chernozem contains significantly lower amounts of microorganisms in comparison with fallow chernozem in 0-12 cm layer and as well as in the layer of 12-25 cm (Figure 6). Enrichment of soil fractions with microbes was reduced by several times. It should be noted the decrease in the microorganisms abundance in the 10-20 cm layer.

The trend of the microbial biomass and particles size in the arable chernozem is described by polynomial function of 6 degrees and reveals moderate and strong links (R^2 = 0.63 and 0.75).

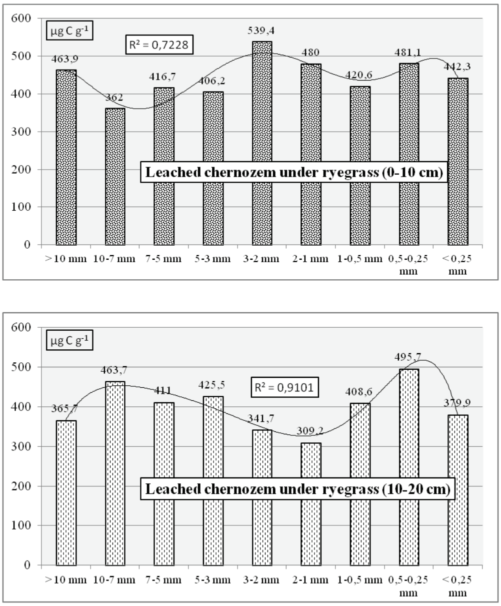

Figure 7. Distribution of microorganisms in soil aggregates of the leached chernozem under ryegrass

The highest numbers of the microbes in the arable chernozem (0-10 cm layer) are localized in fractions of 7-5, 0.5-0.25 and < 0.25 mm (38.5%).

The maximal amount of microorganisms in the 10-20 cm layer of arable chernozem were recorded in the fraction of 0.5-0.25 mm, their number reached 413.7 µg C g^{-1} soil.

Statistically, all other factions of the chernozem under arable were not different from each other.

Microbial biomass in the leached chernozem under ryegrass in the 0-10 cm layer is localized mainly in fractions of 3-2, 2-1, 0.5-0.25 mm and > 10 mm fraction, in the 10-20 cm - in 10-7 mm and 0.5-0.25 mm fractions (Figure 7). The number of microbes in 10-20 cm layer is less by 10.2% in comparison with the 0-10 cm layer.

The link between the microorganisms and the size of fractions in the leached chernozem under ryegrass is positive and shows the strong correlation (R^2 = 0.72 and 0.91). The trend is described by polynomial function of 6 degrees.

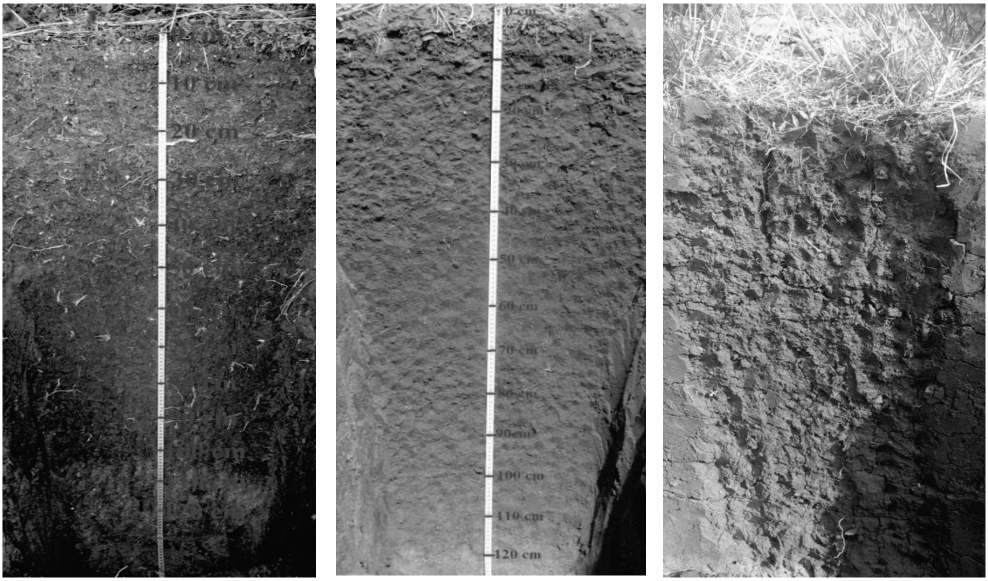

Figure 8. Studied soil profiles from Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" experimental field. Fallow leached chernozem - in the right, arable leached chernozem - in the middle and phyto improved leached chernozem - in the left

CONCLUSIONS

Conventional agricultural management practices lead to leached cernozem agronomically valuable aggregates destroying (soil dusting) in 0-10 cm toplayer and their hardening in big sized soil particles (soil compaction) in underlying 10-20 cm layer. It almost doesn't affect organic carbon content which is distributed evenly throughout all soil aggregates. But it affects microbes and soil organisms' habitat, so their content in soil and in its different size particles. The interaction between microbial components and the soil structure in the leached chernozem under different land management is very close and can be described by the complex equations of power and polynomial functions with high correlation coefficients. The microbial biomass content in soil aggregates decrease in the sequence: 60 years-old fallow land → arable land under ryegrass → arable land. The number of microbes in the aggregates in the topsoil is always higher than in the lower.

The largest amount of microorganisms in the soil under fallow are concentrated in soil particles with a smaller size – 0.5-0.25 mm and < 0.25 mm. As a result, resistance of natural soil matrix to natural and anthropogenic negative impacts is higher than in the soils from agricultural ecosystems.

The microbial biomass in arable chernozem is lower by 2.9-3.0 times than in the fallow chernozem. The microorganisms' distribution in the arable chernozem has more or less uniform character. The soil structure destruction and the significant deterioration of microorganisms in arable chernozems aggregates lead to their natural stability decrease and to the degradation processes development.

The use of ryegrass for the long-term arable chernozem quality restoration contributed to the microbes content increase then in the soil aggregates with 14.4-15.1%. These values do not achieve the level of the soil under natural vegetation.

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