BIOTA OF XEROPHYTE-FOREST CHERNOZEM UNDER DIFFERENT LAND USES

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Abstract

The influence of different land use management on the modification of biological properties of the xerophyte-forest chernozem located in the southern zone of the Republic of Moldova has been investigated. The long-term arable chernozem was compared to the virgin soil under forest. The xerophyte-forest chernozem in the natural ecosystem is characterized by the favorable physical and chemical properties and is ideal standards in regard to the composition, biomass and activity of the biota. A characteristic feature of the natural xerophyte-forest chernozem is the high concentration of invertebrates and *Lumbricidae* family in the upper layers of soils and in the litter. Saprophages prevail in the composition of the edaphic fauna in the virgin chernozem under forest, accounting for 90.8% of the total abundence. Six families and seven species of invertebrates were found in the virgin chernozem. The concentration of microorganisms in the top layer reaches 521.1 µ C g^{-1} soil. The abundance and reserves of biota and the humus content in soil profiles decreased with its depth. The microbial biomass was connected with the humus content and amounts of agronomic valuable aggregates. Prolonged use of the chernozem in the agricultural production led to the destruction of soil structure, reduction of humus content and contributed to the degradation and decrease of soil biota stability. The negative effects on soil biota were observed as a result of mineralization processes and long-term land management practices without of organic fertilizers. A land management with the fallow areas is recommended for the regeneration of the edaphic fauna and microorganisms and the natural restoration of the quality of xerophyte-forest chernozems.

Key words: soil biota, xerophyte-forest chernozem, land management, degradation

The degradation of soils in the Republic of Moldova is the most threatening problem for agriculture, for environment and people's habitat.

Dehymification of the arable soils is one of the main forms of soil degradation. The area of arable soils reaches 854 900 hectares (Andries, S., et al., 2004). The decrease of productivity of arable soils as a result of mineralization processes amounts to 10%, their compaction – to 10%. The main cause of the reduction of the organic matter content is its mineralization as a result of intensive soil tillage. A considerable deterioration of the physical and chemical properties of arable soils has been observed.

The habitat of soil biota has worsened significantly. In these conditions, the role of natural soil-standards, which are located in the balanced undisturbed ecosystems during long periods of time, is increasing. A good example of the soil-standard for chernozems located in the south of the country can be the xerophyte-forest chernozem. Many years ago, the famous Moldavian soil scientist Krupenikov I.A. proposed to allocate forests with xerophyte-forest chernozems and complexes of terrestrial and soil fauna for nature reservations because of their great scientific importance (Krupenikov, I.A., 1967).

The purpose of the present research was to determine the effect of the long-term agricultural land utilization on biota's state in the xerophyte-forest chernozem in the connection of the soil carbon sequestration problems, development of the national soil biota quality standards and the protection of biodiversity.

MATERIAL AND METHOD

Experimental site is located in the southern zone of the Republic of Moldova, on the Danubian steppe province, in the district no. 12 of leached and xerophyte-forest chernozems of the Tigechskaya Upland forest steppe, in the *Baurchi-Moldoveni* village, Cahul region (*figure 1*).

The long-term arable chernozem was compared to the virgin soil under forest. Sampling was carried out in 2 profiles per soil horizons to a depth of 170 - 200 cm (*figure 2*).

Status of invertebrates. The state of invertebrates was identified from test cuts by manual sampling of soil layers to the depth of soil fauna occurrence with application of Gilyarov and Striganova's method (Gilyarov, M.S. and Striganova,

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B.R., 1987). The identification of invertebrate's diversity at the rate of families and their classification according to nutrition were carried out by Gilyarov and Striganova's method (Gilyarov, M.S. and Striganova, B.R., 1987).

Figure 1 **Fragments of natural landscapes - primary forest with oaks ("Garnets") located in the southern zone of the Republic of Moldova (Baurchi-Moldoven village, Cahul region)**

1 2

Figure 2 **Soil profiles of virgin (1) and arable (2) xerophyte-forest chernozem**

Microbiological properties. The microbial biomass C was measured by the rehydratation method based on the difference between C extracted with 0.5 M K_2SO_4 from dried soil at 65-70^{0}C within 24 h and fresh soil samples with K_c coefficient of 0.25 (Blagodatsky, S.A., et al., 1987). Reserves of microbial biomass have been calculated taking into account the carbon content of the microbial cell and the bulk density of soils (Senicovscaia I., et. al., 2012). Counts of microorganisms (bacteria, actinomycetes and fungi) were obtained on agar plates (Zvyagintsev, D.G., 1991).

Soil chemical properties. Organic C was analyzed by the dichromate oxidation method (Arinushkina E.V., 1970). The humus content was calculated using the coefficient of 1.724.

Soil physical properties. The structure-aggregate composition of the soil was determined by the method of Savinov, the bulk density was analyzed by the cylinders' method (Vadyunina, A.S. and Korchagina, Z.A., 1973).

REZULTS AND DICUSSIONS

Invertebrates. Xerophyte-forest chernozems in conditions of the natural ecosystem have the sharp differences from the arable soils according to faunal indices. Invertebrate's abundance in virgin chernozems under natural vegetation was significantly higher than in arable soils. The virgin chernozem is characterized by a higher number and biomass of soil invertebrates and *Lumbricidae* family in comparison with arable chernozems (*table 1*). The number of invertebrates reaches to 148 ex m^{-2}, *Lumbricidae* family – to 76 ex m^{-2}, and their biomass – to 15.2 and 8.0 g m^{-2} accordingly. The share of earthworms in the total abundance of invertebrates constitutes of 51.4 % and their biomass – 52.6 % in the virgin xerophyte-forest chernozem.

Table 1

The number and biomass of invertebrates in the virgin and arable xerophyte-forest chernozem

Soil	Number of invertebrates, ex m^{-2}		Biomass of invertebrates, g m^{-2}	
	total	*Lumbricide* family	total	*Lumbricidae* family
Virgin xerophyte-forest chernozem	148.0	76.0	15.2	8.0
Arable xerophyte-forest chernozem	56.0	40.0	8.0	6.2

The considerable share of invertebrates in the virgin xerophyte-forest chernozem (56.8 %) and *Lumbricidae* family (47.4 %) is concentrated in the 0-10 cm layer of soil and in the debris layer.

The virgin xerophyte-forest chernozem contains 6 families and 7 species of invertebrates. The families of *Lumbricidae*, *Glomeridae*, *Cerambycidae, Formicidae, Pentatomidae* and *Pieridae* are usually presented in this soil. Species of *Lumbricus terrestris, Glomeris marginata, Diplopoda De Blainville, Graphosoma lineatum, Prionus coriarius, Pieris brassicae, Formica rufa* are dominated in the virgin xerophyte-forest chernozem.

The main part in the total amount of invertebrates is represented by saprophages. They comprised 90.8% in the virgin xerophyte-forest chernozem.

Indices of invertebrates' number and biomass decreased in arable chernozems by 2.6 and 1.9 times, earthworms – by 1.9 and 1.3 times respectively. The diversity of invertebrates in the arable chernozems decreases sharply. The arable soil contains 1-3 families of invertebrates. Saprophages make up 71.4%.

Microorganisms. The abundance and reserves of biota and the humus content in soil profiles decreased with their depth.The highest level of the microbial biomass and organic carbon content has been determined in the Ah1 horizon of the virgin xerophyte-forest chernozems and whereas the lowest – in the BC and C horizons of both profiles. The organic carbon content constitutes 6.27%. The quantity of the microbial biomass reaches to 521.1 μg C g^{-1} soil, the number of heterotrophic bacteria - $7.4*10^{6}$ CFU g^{-1} soil, fungi - $106.7*10^{3}$ CFU g^{-1} soil *(tab. 2)*. Microorganisms in the virgin xerophyte-forest chernozem have been encountered in sufficiently high amounts to the depth of 138 cm, and some species at the depth of 200 cm.

In the arable chernozem the base mass of microbes is concentrated in the 0-37 cm layer. This soil is characterized by the gradual decrease in the biomass with the depth as compared to virgin chernozem. Microorganisms in the arable soil have been found up to 112 cm. Topsoil was exposed to the largest impact.

The reserves of the microbial biomass in 0-200 cm layer of the virgin chernozem constitute 6.6 t dry matter ha^{-1}. The long-term use of plowing leads to decrease of content and reserves of microbial biomass in arable chernozems in upper horizons and soil profile in whole. Profiles of the arable soil are covered by the degradation process in whole. The reserves of the microbial biomass in the 0-200 cm layer of the arable xerophyte-forest chernozem are declined to the level of 5.2 t dry matter ha^{-1}.

Table 2

Abundance of microorganisms and the humus content in the virgin and arable xerophyte-forest chernozem

Genetic horizon and depth, cm	Humus, %	Organic C, %	Microbial biomass (MB)		C_{MB}/C_{org}, %	Reserves of MB (0-200 cm), kg ha^{-1}	Heterotrophic bacteria	Actinomycetes	Fungi, CFU g^{-1}soil*10^{3}
			μ g C g^{-1} soil	kg ha^{-1}			CFU g^{-1}soil*10^{6}		
Virgin xerophyte-forest chernozem									
Ah1 0-10	10.80	6.27	521.1	1042.2	0.83	6633.2	7.4	6.2	106.7
Ah 10-61	4.45	2.59	341.9	4219.7	1.32		1.5	2.0	5.0
ABh 61-80	2.81	1.63	167.9	765.6	1.03		0.8	1.4	1.1
Bh1 80-112	1.80	1.04	49.0	423.4	0.47		0.5	0.5	0
Bh2 112-138	1.09	0.63	25.4	182.3	0.40		0.7	0.4	0
BCk 138-165	0.71	0.41	0	0	0		0.7	0.3	0
DC 165-200	0.64	0.37	0	0	0		0.5	0.1	0
Arable xerophyte-forest chernozem									
Ap1 0-16	3.00	1.74	215.4	792.7	1.24	5175.9	4.8	8.7	45.7
Ap2 16-37	2.97	1.72	343.1	2089.5	2.00		4.1	13.4	35.9
B1 37-74	1.82	1.06	170.0	1736.0	1.60		1.9	4.8	3.6
B2 74-112	0.93	0.54	48.6	557.7	0.90		2.0	1.8	0
BCk 112-140	0.50	0.29	0	0	0		0.3	1.0	0
BC 140-170	0.42	0.24	0	0	0		0.3	0.6	0
C >170	0.34	0.20	0	0	0		0.1	0.5	0

A similar trend in decrease has been noticed in the number of the heterotrophic bacteria and fungi. But there was determined the increase in the number of actinomycetes, as it is known, participating in the decomposition of difficult degradable organic substances. This testifies about the intensification of the humus mineralization in the arable soil.

The long-term use of the soil under arable affected the structure of soil microbial communities. More intensive land-use involving soil tillage stimulates the microbial decomposition of organic matter and tends to result in decrease in the microbial carbon pool and ultimately in decrease in the humus content.

Physical properties. The xerophyte-forest chernozem has a granular structure with favorable physical properties and the low bulk density – 1.00-1.20 g cm^{-3}. This soil is characterized by the increased size of macrostructure, the content of particles >10 mm reaches to 48.2%. It has the increased share of agronomic valuable aggregates (Σ 10-0.25 mm) constituting 76.0% in the upper layer and the high structure coefficient (Ks) – 3.2. Structural aggregates show a high hydro-stability with the value more than 74% in horizons Ah1 and Ah. In fact, the top layer of this soil-standard consists of a layer of coprolites of earthworms; it has an excellent water-stable structure.

The long-term plowing leads to the destruction of water-stable soil structure. The bulk density values attest to 1.45 g cm^{-3}. The hydro-stability of agronomic valuable aggregates decreases in the arable layer by 2 times on average. The content of the aggregates < 0.25 mm increases in the dry sieving and as well as in the wet.

Table 3

Physical properties of the xerophyte-forest chernozem under different land management

Genetic horizon and depth, cm	Bulk density, g cm^{-3}	Aggregates content (%) with the diameter (mm)			Ks
		>10	Σ 10-0.25	<0.25	
Virgin xerophyte-forest chernozem					
Ah1 0 -10	1.00	18.0 / 9.8	76.0 / 76.0	6.0 / 14.2	3.2
Ah 10-61	1.21	48.2	48.2 / 73.8	3.6 / 26.2	0.9
ABh 61-80	1.20	39.4	55.5 / 56.4	5.1 / 43.6	1.2
Arable xerophyte-forest chernozem					
Ap1 0 -16	1.15	24.9	61.7 / 37.2	13.4 / 62.8	1.6
Ap2 16-37	1.45	26.4	65.4 / 39.6	8.2 / 60.4	1.9
B1 37-74	1.38	27.4	65.6 / 52.6	7.0 / 47.4	1.9

*numerator - dry sieving; denominator - wet sieving

CONCLUSIONS

The xerophyte-forest chernozem in the natural ecosystem possesses the favorable physical and chemical properties and is the standard of the edaphic biota's composition and activity. This soil has the high content of invertebrates, microorganisms and organic carbon in the top layer and the favorable physical status for the plant growth. A characteristic feature of the natural xerophyte-forest chernozem is the high concentration of invertebrates and *Lumbricidae* family in the upper layers of soils and in the litter. Saprophages prevail in the composition of the edaphic fauna in the virgin chernozem under forest, accounting for 90.8% of the total abundence. Six families and seven species of invertebrates were found in the virgin chernozem. The concentration of microorganisms in the top layer reaches 521.1 μ C g^{-1} soil. The soil biota's composition in natural ecosystems is complex and diverse. Forests and field-protective belts are medium for the conservation and restoration of the diversity and abundance of soil invertebrates and microorganisms. The conservation of soil-standards in protected zones is important not only in terms of the protection of environment, but it has also significant scientific information.

The long-term arable use of the xerophyte-forest chernozem leads to decline of biota and humus content. A major reason of the biological and physical degradation of chernozems under arable management is annual tillage, which aerates the soil and breaks up aggregates where microbes are living. Furthermore, the soil doesn't obtain the plant residues sufficiently for the supply of edaphic fauna. Prolonged use of chernozem in the agricultural production led to the destruction of soil structure, reduction of humus content and contributed to degradation and decrease of soil biota stability. The negative effects on soil biota were observed as a result of mineralization processes and long-term land management practices without organic fertilizers. A land management with the fallow areas is recommended for the regeneration of the edaphic fauna and microorganisms and the natural restoration of the quality of xerophyte-forest chernozems.

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