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ANTHROPIC TRANSFORMATION OF CHERNOZEMS FROM BALTI STEPPE OF THE REPUBLIC OF MOLDOVA

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Abstract

Soil degradation represents a global problem because of its influence on quality of human life, environment and biodiversity. Anthropic activity had a great influence on soil quality by onset of degradation processes through agriculture development. Use of soils in agriculture led to the loss of grain structure with high agronomic value. In the arable layer of these soils, predominate fraction of blocks - 40-60%. The former arable layer (25-35 cm) is characterized by nearly monolithic structure. As a consequence the recent arable layer is characterized by medium values of bulk density and the underlying layer is heavily compacted. The total porosity of arable layer is medium and of the former arable layer - small. There is a growth trend of hydrolytic acidity in the superior layers of arable land. Humus content in arable soils decreased by 2.24% in the layer 0-25 cm and by 1.65% in the 0-50 cm layer. Humus losses were respectively 36 and 31 percent of its original amount.

Key words: *compaction, humus loss, soil degradation, total porosity.*

INTRODUCTION

Soil degradation represents a global problem because of its influence on quality of human life, environment and biodiversity. Anthropic activity had a great influence on soil quality by onset of degradation processes through agriculture development. Researches made by Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" showed that the balance of organic matter in Moldovan soils is negative and makes 0.01% per year (Andries, 2007). All agricultural soils of Moldova are subject to humus loss: initial humus reserves decreased by 40% and annually are lost about 2.4 million tons of humus (Andrie et al., 2012). As consequence soils lost their natural structure and became compacted (Tărâ ă et al., 2010; Ciolacu, 2012.). Given the fact that the soil is not a closed system, but is in close interaction with living organisms that populate it, biodiversity also suffer from soil degradation (Senicovscaia et al., 2010). At the same time, soils of Moldova represent one of the most precious estates indispensable to our country's population. The aim of the present paper is to reveal negative influence of human activity on soils quality state. This can be scientific proved by comparison of arable soils with non-arable fallow soils.

MATERIALS AND METHODS

Investigations were carried out at the experimental fields of Research Institute of Field Crops "Selectia" from Balti, Republic of Moldova. The object of the study was typical clay-loamy arable chernozem from Balti steppe, that was used in agriculture for a very long period of time (Figure 1).

Figure 1. Typical clay-loamy arable chernozem

In order to determine the level of degradation we studied typical chernozems under fallow located in the surrounding forest strip of protection founded 60 years ago (Figure 2), on an area covered with reestablished steppe vegetation (predominantly matgrass).

In both variants, we founded a key set of polygons in the form of a square with sides of 50 m with a main profile in the center and four secondary at the peaks of the square.

Laboratory tests were performed according to the standard methods approved in the Republic of Moldova: soil bulk density was determined by core method, total porosity by calculation. The organic matter content was determined by Tiurin method, total nitrogen content by Kjeldahl method, mobile phosphorus and potassium by Machighin method, soil pH by electrometric method.

Figure 2. Typical chernozem under fallow located in the forest strip founded 60 years ago

RESULTS AND DISCUSSIONS

The next type of soil profile characterizes the investigated typical arable chernozems: Ahp1 – Ahp2 – Ah – Bh1 – Bhk2 – BCk1 – BCk2 – Ck (Figure 3).

Arable layer Ahp1 (0-25 cm) is dark grey almost black. Recent ploughing was performed poorly, that in combination with rough texture and humus loss formed unfavourable for plant growth blocky structure (Figure 1). The former arable layer Ahp2 (25-36 cm) differs from recent arable layer by strong compaction and monolithic or prismatic structure. Structure of Ah horizon (36-49 cm), that never had been ploughed, is glomerular-grained, soil is compact. The lower part of soil profile (100-120 cm) is considerably modified by moles (Figure 3).

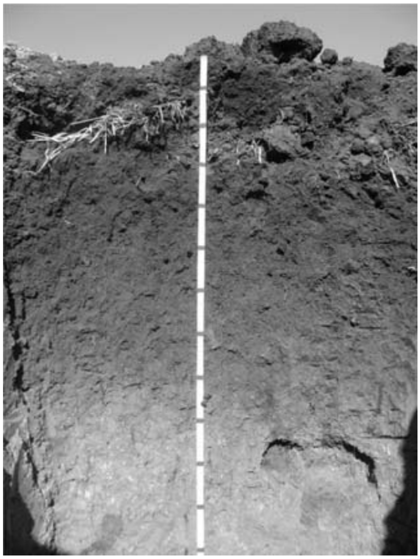

Figure 3. Soil profile of typical clay-loamy arable chernozem

Typical chernozems under fallow have well developed deep soil profile of a type: Ahț1 - Ahț2 - Ah - BH1 - Bhk2 - BCk1 - BCk2 - Ck (Figure 4). Soil colour is dark almost black, which becomes lighter with depth. Soil has a well developed grainy structure almost in the whole humus profile and a slight compaction that increases slowly at lower horizons.

Figure 4. Soil profile of typical chernozem under fallow

Investigated typical chernozems are characterized by comparatively homogeneous texture in the whole profile. On average physical clay content is 62-63%, and the fine clay - 36-38%. The soils are classified as clay loamy. Under the influence of anthropogenic factor (intensive arable work with heavy machinery), these chernozems are predisposed to loss of structure, compaction and crusting.

For soils with clayey or loamy texture, the optimum structural condition is achieved in the presence of 70-80% of agronomical valuable hydro-stable aggregates (of size 0.25-10 mm) (Bondarev, 1994), which is observed in typical chernozems under fallow (Figure 5 and 6). Because of intensive exploitation of arable typical chernozems, they lost their valuable agronomic grainy structure. According to dry sieve analysis, in the arable layer of these soils, predominate fraction of clods - 40-60% (Figure 5).

At the same time, these soils are characterized by practically monolithic structure in the former arable layer 25-35 cm. This layer in the last 15 years was not ploughed and, having a poor structure as a result of intensive work until 1990 year, lost resistance to compaction and become compacted.

Apparently good hydrostability of aggregates is due to strong compaction of structural aggregates formed as a result of soil tillage (Figure 6). However the content of agronomical unfavorable fraction is quite high and constitutes 27-44%.

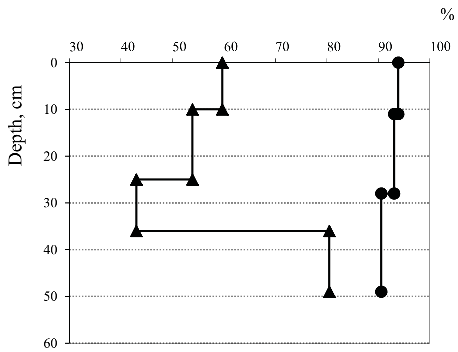

Figure 5. Content of aggregates 10-0.25 mm at sieve dry: ▲ – arable typical chernozem; ● – typical chernozem under fallow

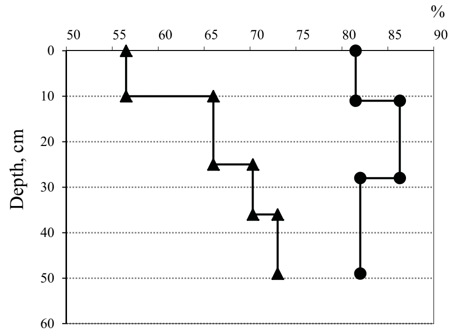

Figure 6. Content of hydrostable aggregates 10-0.25 mm at wet dry: ▲ – arable typical chernozem; ● – typical chernozem under fallow

Investigations of Moldovan soils carried out by Atamaniuk A.K. (Atamaniuk A.K., 1964) established that the optimal values of soil bulk density to retain the maximum amount of moisture are from 1.25 to 1.30 g/cm^3. According to our data, arable layer of investigated soils is characterized by medium values of bulk density (1.34 g/cm^3) while the underlying layer is heavily compacted – 1.46 g/cm^3 (Figure 7).

Bulk density values of Ahț and Ah horizons of fallow soils are optimal for plants growth (1.16-1.29 g/cm^3).

The upper part of the Ahp1 layer (0-10 cm) of arable soil is loose because it is worked during the vegetation period, total porosity is medium – 54.7% (Figure 8).

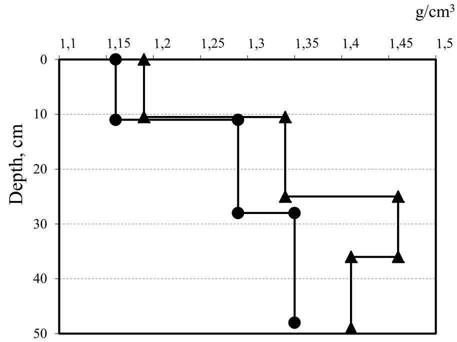

Figure 7. Bulk density of typical chernozems: ▲ – arable typical chernozem; ● – typical chernozem under fallow

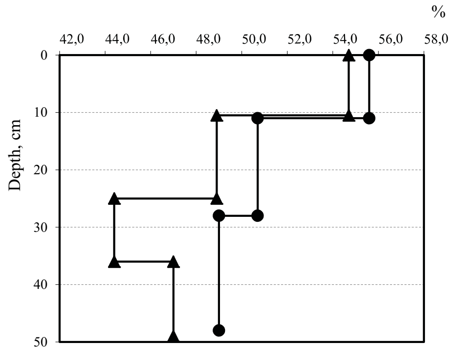

Figure 8. Total porosity of typical chernozems: ▲ – arable typical chernozem; ● – typical chernozem under fallow

The lower part (10-25 cm) is compacted, the total porosity is low – 48.9%. The former arable layer Ahp2 (25-35 cm) is very compacted and as a result its porosity is very small – 44.4%. The optimal values of total porosity vary between 50-60% (Bondarev A.G., 1994), which was found in the case of fallow soil, where total porosity of horizons Ah 1 and Ah 2 is between 55.6 and 50.7%. With depth soil became naturally slightly compacted with total porosity on average 49.0%.

Arable typical chernozems are characterized by weak acid or neutral reaction in upper horizons and slightly alkaline reaction in lower horizons (Table 1).

There is an increase in the acidity of arable land. Hydrolytic acidity of soils is low and very low, but there is a growing trend of hydrolytic acidity in the superior horizons of arable soil.

Dokuceaev (1952) noted the specific feature of our chernozems - large reserves of humus due to the large thickness of the humus profile along with relatively low humus content (in comparison to other chernozems from chernozem belt).

In soils investigated by us, humus is distributed evenly on fallow soil profile and reaches 80-94 cm (that is classified as very deep humus profile). Humus content in arable soils, due to intensive use in agriculture, decreased by 2.24% in the layer 0-25 cm and by 1.65% in the 0-50 cm layer (Table 1). Humus losses were respectively 36 and 31 percent of its original amount (in comparison with typical chernozem under fallow).

Table 1. Characteristics of typical chernozems used in agriculture and under fallow

Horizon/layer	and depth, cm	pH	Hydrolytic acidity, me/100 g soil	$CaCO_3$	Total P_2O_5	Humus	Total N	C:N	Mobile forms of, mg/100 g sol	
				%					P_2O_5	K_2O
Arable typical chernozems										
Ahp1	0-25	6.3±0.3	2.4±1.1	0	0.13±0.01	4.03±0.09	0.216±0.021	10.9±1.0	2.0±0.4	32.6±6.3
Ahp2	25-36	6.4±0.4	2.3±1.1	0	0.12±0.01	3.81±0.22	0.205±0.020	10.8±0.9	1.4±0.4	23.1±4.9
Ah	36-49	6.5±0.5	1.7±0.8	0	0.10±0.01	3.01±0.21	0.172±0.023	10.1±1.1	0.9±0.1	17.5±2.2
Bhk1	49-70	7.2	0.9	0	-	2.27	-	-	-	-
Bhk2	70-94	7.5	-	3.3	-	1.31	-	-	-	-
BCk1	94-120	7.8	-	15.1	-	0.93	-	-	-	-
BCk2	120-150	7.9	-	16.7	-	0.77	-	-	-	-
Ck	150-200	8.0	-	17.6	0.08	0.41	-	-	-	-
Typical chernozems under fallow										
Ahț1	0-11	6.8±0.1	1.8±0.3	0	0.16±0.02	6.70±0.14	0.320±0.02	12.2±0.6	3.0±1.3	60.0±13.7
Ahț2	11-28	6.7±0.2	1.9±0.4	0	0.13±0.01	5.94±0.07	0.290±0.01	11.9±0.4	2.1±0.8	35.6±13.8
Ah	28-49	6.8±0.3	1.7±0.9	0	0.11±0.01	4.23±0.23	0.220±0.01	11.4±0.3	1.0±0.4	18.8±2.3
Bh1	49-64	7.2	0.3	0	-	2.99	-	-	-	-
Bhk2	64-90	7.9	-	8.4	-	1.70	-	-	-	-
BCk1	90-110	7.9	-	17.6	-	1.00	-	-	-	-
BCk2	130-150	8.0	-	18.8	-	0.72	-	-	-	-
Ck	180-200	8.2	-	22.0	0.06	0.52	-	-	-	-

Total nitrogen content correlates with humus content. The increase of the C:N ratio in fallow soil is explained by a greater flow of carbon in these soils due to rich steppe vegetation.
Investigated typical chernozems are formed on loess poor in phosphorus (0.06-0.08%). It can be noticed that there is a bioaccumulation of phosphorus in the horizon Ahț1 of soil under fallow (0.16±0.02%).
Total phosphorus content in arable soils is smaller and makes 0.13±0.01% in the Ahp1 horizon. Its quantity slightly decreases with depth.
Plant growth is influenced not only by soil physical state. Reserves of such nutritive elements as mobile phosphorus and potassium are important for plant development and yields formation. Intensive use of soils resulted in removal of these elements with yields from the arable layer. So, the reserves of mobile phosphorus and potassium in typical chernozems are lower in comparison with soil under fallow. Mobile phosphorus content is 2.0 mg/100 g soil in the Ahp1 layer and it is decreasing with depth. Mobile potassium content is 32.6 mg/100 g soil in Ahp1 layer, 23.1 mg/100 g soil in Ahp2 and 17.5 mg/100 g soil in Ah layer. It can be concluded that because of long use of land in agriculture the initial reserves of these elements significantly reduced.

CONCLUSIONS

Irrational use of soil resources in agriculture led to deterioration of chernozems natural structure favourable for plant growth, increase of bulk density and soil compaction. The former arable layer (25-35 cm) became compacted because of humus loss and heavy traffic, and formed an impediment for roots growth. Humus losses were about 35 percent of the initial content. Reserves of nutrients in the soil significantly decreased.

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