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ANTROPIC DEGRADATION OF TYPICAL CHERNOZEMS AND THEIR RESTORATION UNDER STEPPE VEGETATION

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Abstract

The paper aimed to emphasize again the problem of degradation of soils used in agriculture. Also, it was studied remediation of deep ploughed soil under steppe vegetation after 30 years of fallow. It was established that investigated arable soil lost 2.12% of humus from 0-25 cm layer or 1.60% from 0-50 cm layer (in comparison with fallow). Besides humus loss, arable soil was depleted in nitrogen and phosphorus. Soil structure of arable soil also underwent changes and became unfavorable for plants growing. It was established that during 30 years of fallow use, the former arable soil partially restored its structure. Humus content of this soils also increased by 0.66% in arable layer 0-25 cm and by 0.57% for layer 0-50 cm (0.02% annually).

Key words*: soil degradation, humus loss, soil structure, bulk density.*

INTRODUCTION

The problem of land degradation became more acute in the last years due to increasing population of the Earth and the shrinking of arable land for different reasons.

This problem persists in Moldova, being complicated by excessive land parcelling (Cerbari et al., 2010) which prevent the application of complex agro-technical measures to protect and conserve soils.

Currently in Moldova are highlighted and described 5 types and 40 types of soil degradation (Krupenikov, 2008).

The most widespread are soil erosion, salinization and solonization, landslides, humus content decrease, structure loss and secondary compaction, nutrient deficiency (Andries et al., 2012).

Thus in the Republic of Moldova humus balance is negative minus 700 kg/ha, on lands affected by erosion minus 1100 kg/ha.

It was established that 80% of agricultural land is characterized by low humus content (less than 3%) (Andries et al., 2011).

In this context, we tried to emphasize again the current state of arable chernozem and necessity of elaboration of ecological methods for their remediation.

MATERIALS AND METHODS

The research was conducted on typical chernozems located in the northern part of Moldova, Rascani district, Grinauti village.

As the object of study were used soils from the following three sites:

1. Arable land;
2. Former arable land, 30 years ago here was made a buffer strip with steppe vegetation and walnut trees. Before planting the trees, soil was deep ploughed (at the depth of 50 cm) and fertilized with organic and mineral fertilizers. Nowadays, from time to time the place is used for animal grazing;
3. Fallow land never used in agriculture with steppe vegetation characteristic for this region of Moldova, located on a slope with an angle of inclination about 5-10^0.

During the field research, at the each site 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 profiles 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.

RESULTS AND DISCUSSIONS

Arable typical chernozem is characterized by the next soil profile: Ahp1 - Ahp2 - Ah - Bh1 - Bhk2 - BCk1 - BCk2 - Ck (Figure 1).

Figure 1. Soil profile of arable typical chernozem

Recently arable layer Ahp1 (0-25 cm) is dark grey, with blocky structure. The next layer Ahp2 (25-40 cm), that was ploughed until '90 years, now is compact, with prismatic or blocky structure.

Horizon Ah (40-50 cm), never ploughed, has glomerular structure, slight compact or compact.

The former arable typical chernozem (Figure 2) have the next soil profile: Ahpt1 - Ahpt2 - Ahp - Bh1 - Bhk2 - BCk1 - BCk2 - Ck.

Fallow horizons Ahpt1 (0-10 cm) and Ahpt2 (10-28 cm) are weak compacted because they have restored glomerular structure.

The next horizon Ahp (28-49 cm), that was also deep ploughed at the foundation of the buffer strip, is compacted. The structural aggregates are prismatic, large and medium by size, practically with no pores.

Figure 2. Soil profile of the former arable typical chernozem

The fallow chernozem (Figure 3) from the third research site have the next soil profile: Aht1 - Aht2 - Ah - Bh1 - Bh2 - BCk1 - BCk2 - Ck.

Figure 3. Soil profile of the fallow typical chernozem

Humus horizons of the fallow chernozem have excellent grainy structure, are weak compacted and very rich in organic material and plants roots.

Typical chernozems from the research sites are characterized by comparatively homogeneous texture in the whole profile. On average physical clay content is 62-66%, and the fine clay - 36-39%. The soils are classified as clay loamy.

As a result of such a texture, the investigated soils are predisposed to compaction, crusting and loss of structure. All these negative effects have been established both in the field investigations and laboratory analysis. Thus, the arable typical chernozem is characterized by medium quality of soil structure with moderate content of clods in the arable horizon Ahp1 (0-25 cm), see Figure 4.

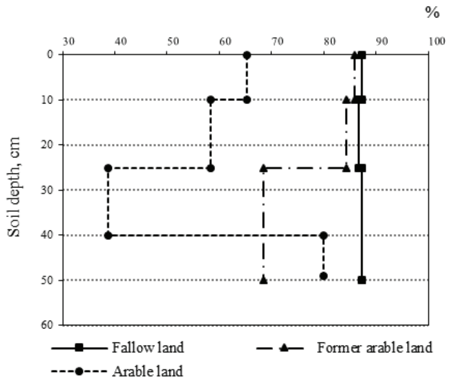

Figure 4. Content of soil aggregates 10-0.25 mm at dry-sieving analysis

The next layer Ahp2 (25-40 cm) has poor structure with high content of clods. The structural elements are prismatic. As it was mentioned above, soil layer Ahp2 was worked until '90 that have led to loss of soil structure and its resistance to compaction. As a result, for today the layer is extremely compacted.

The underlying horizon Ah was not modified by agricultural works and is characterized by excellent structure and small clods content.

We determined that soil structure of the former arable land (the second research site) was restored in the 0-25 cm layer. Soil structure of the underlying layer 25-50 cm is partially restored, but it still contains some prismatic aggregates.

Low water resistance of structural elements in arable layer indicate degradation of soil structure (Figure 5).

As a result, there is a risk of compaction and formation of soil surface crust after the fall of precipitations and drying of soil.

Water resistance of aggregates from the former arable land is very high both in the upper layer 0-25 cm and the next layer 25-50 cm.

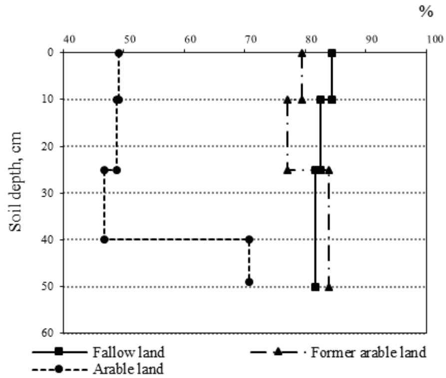

Figure 5. Content of soil aggregates 10-0.25 mm at wet-sieving analysis

The fallow land is characterized by excellent soil structure and water resistance.

The upper layer 0-10 cm of Ahp1 horizon of arable soil is worked throughout the year and is characterized by comparatively low degree of compaction, bulk density is 1.21 g/cm^3 (Figure 6).

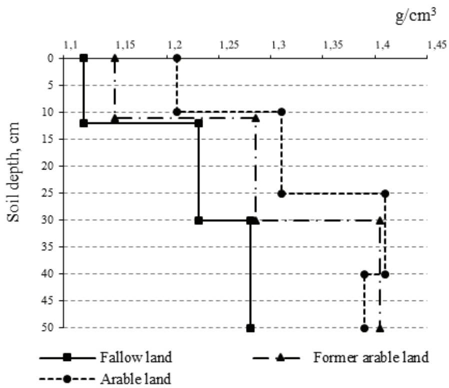

Figure 6. Bulk density of typical chernozems

The lower layer 10-25 cm of Ahp1 horizon have middle degree of compaction, its bulk density is 1.31 g/cm^3. Under the arable layer can be noticed a compact horizon Ahp2 with the bulk density of 1.41 g/cm^3 and high degree of compaction. That layer was formed due to losses of soil structure and humus, and as a result of the intensive use of soil in agriculture and heavy machinery. The next horizon Ah

(40-49 cm) was not plowed and is not compacted, the bulk density is 1.39 g/cm^3.
Fallow soil profiles are characterized by low values of bulk density 1.15-1.29 g/cm^3 in the superior layers. Horizon Aht is loose, horizon Ah is low compacted.
Total porosity values of investigated soils correlate with bulk density values (Figure 7).

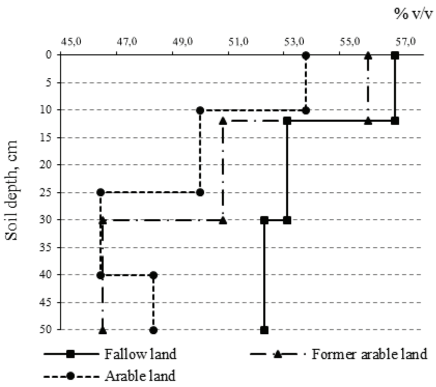

Figure 7. Bulk density of typical chernozems

Thus, in the arable soil total porosity is medium (50-54%) in the Ahp horizon (0-25 cm) and low in the Ahp2 horizon (25-40 cm) - 46%. Fallow soils have high porosity in all Aht horizons - 50-57%.
Data about chemical characteristics of investigated typical chernozems are shown in Table 1. Arable typical chernozem is characterized by average values of pH 6.3 in Ahp horizon and 8.0 in horizon Ck. Soil layer 0-50 cm of fallow soils have lower pH, because of the influence of organic matter from steppe vegetation rich in calcium. The pH values are between 6.5 and 7.0.
Hydrolytic acidity of arable is low (2.0-2.4 me/100 g soil) in Ah horizon and very low (1.0 me/100 g soil) in Bh1. Fallow soils are characterized with very low values of the index.
Humus accumulation in chernozems of Moldova has a specific character: in the upper horizon, humus content is 4-5%, its amount decreases gradually with depth and at 1 m there is only a third part of its amount in comparison with the superior layers. As a result, the reserves of humus in typical chernozems are quite large (Zaimov, 1969).

Typical chernozems from the research sites are characterized by deep humiferous soil profile: in arable soils the average thickness is 91 cm; in the former arable soil - 94 cm, soil under the fallow - 88 cm. Investigated arable chernozems have moderate humus content while the former arable soil and fallow soil have high humus content. Because of agricultural use, the arable typical chernozem lost 2.12% of humus from 0-25 cm layer or 1.60% from 0-50 cm layer. Humus content of 0-25 and 0-50 cm layer of arable soil compared to fallow land reduced respectively by 34 and 29 percent. The former arable chernozems, being under the fallow for 30 years, increased humus content in comparison with arable soil, by 0.66% in arable layer 0-25 cm and by 0.57% for layer 0-50 cm (0.02% annually).
Total nitrogen content in the investigated soils is 0.18-0.23% and correlates with humus content.
Total phosphorus content in fallow and the former arable chernozem profiles varies from 0.17 in Aht1 horizon to 0.10% in Ck horizon. Arable soils have a lower content of total phosphorus from 0.14% in Ahp1 horizon to 0.10% in Ck horizon.
Mobile phosphorus content in fallow typical chernozem is moderate in Aht1 horizon and low in Aht2 and Ah. The former arable chernozem is characterized by moderate phosphorus content throughout genetic Ah horizon. In arable soil phosphorus reserves decreased substantially in arable and former arable layers up to 1.2-1.3 mg/100 g soil.
Content of mobile forms of potassium in these soils is optimal in the arable layer and moderate in former layer.
The fallow chernozem is characterized by a very high content of mobile potassium in the horizon Aht1 - 44-48 mg/100 g soil.
The underlying horizons have an optimal contain of mobile potassium in Aht2 horizon (30-34 mg/100 g soil) and moderate in Ah horizon (15-24 mg/100 g soil). Thus, reserves of mobile phosphorus and potassium in the investigated arable typical chernozems are lower than in the fallow chernozem, due to their intensive use in agriculture.

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

Horizon and depth, cm		pH	Hydrolytic acidity, me/100 g sol	$CaCO_3$	P_2O_5 total	Humus	N total	C:N	Mobile forms of, mg/100 g sol	
				%					P_2O_5	K_2O
Arable land										
Ahp1	0-25	6.3±0.2	2.4±0.2	0	0.14±0.01	4.05±0.13	0.193±0.009	12.2±0.5	1.3±0.1	30.0±3.5
Ahp2	25-40	6.3±0.2	2.3±0.2	0	0.13±0.01	3.94±0.08	0.188±0.008	12.1±0.5	1.2±0.2	25.0±5.2
Ah	40-49	6.5±0.3	2.0±0.4	0	0.12±0.01	3.25±0.15	0.159±0.008	11.9±0.5	0.9±0.2	18.0±1.3
Bhk1	49-70	6.9±0.2	1.0±0.4	0	-	2.53±0.14	-	-	-	-
Bhk2	70-91	7.6±0.1	-	8.9±3.6	-	1.51±0.04	-	-	-	-
BCk1	91-110	7.7±0.1	-	22.0±4.9	-	0.91±0.07	-	-	-	-
BCk2	110-140	7.8±0.1	-	24.6±4.7	-	0.68±0.07	-	-	-	-
Ck	140-160	8.0±0.1	-	28.6±5.1	0.10	0.46±0.03	-	-	-	-
Former arable land, 30 years under the fallow										
Ahpt1	0-12	6.8±0.4	2.0±0.7	0	0.17±0.01	5.02±0.43	0.228±0.014	12.8±0.4	2.7±0.4	48.4±8.4
Ahpt2	12-30	7.0±0.4	1.5±0.7	0	0.13±0.01	4.43±0.49	0.204±0.017	12.3±0.4	2.2±0.4	30.4±1.9
Ahp3	30-50	7.0±0.3	1.1±0.4	0	0.12±0.01	4.03±0.32	0.194±0.012	12.0±0.2	1.7±0.5	15.6±0.9
Bhk1	50-71	7.5±0.4	0.7	0	-	2.88±0.21	-	-	-	-
Bhk2	71-94	8.0±0.3	-	6.3±3.5	-	1.78±0.31	-	-	-	-
BCk1	94-117	8.2±0.3	-	15.5±4.2	-	0.95±0.07	-	-	-	-
BCk2	117-170	8.2	-	22.0	-	0.91	-	-	-	-
Ck	170-200	8.2	-	24.5	0.10	0.69	-	-	-	-
Fallow land										
Aht1	0-12	6.5±0.4	1.9±0.7	0	0.17±0.01	6.86±0.57	0.296±0.027	13.5±0.4	2.4±0.6	44.4±4.7
Aht2	12-30	6.7±0.3	1.6±0.6	0	0.14±0.01	5.53±0.70	0.248±0.037	12.9±0.4	1.4±0.4	34.6±5.2
Ah	30-48	6.9±0.2	1.0±0.5	0	0.13±0.01	4.61±0.67	0.213±0.035	12.6±0.3	1.0±0.2	23.8±0.8
Bh1	48-68	7.0±0.2	0.3	0	-	3.54±0.58	-	-	-	-
Bhk2	68-88	7.2±0.4	-	8.0	-	1.83±0.11	-	-	-	-
BCk1	88-109	7.5±0.6	-	19.5	-	0.78±0.09	-	-	-	-
BCk2	109-120	8.6	-	23.0	-	0.35	-	-	-	-
Ck	120-200	9.2	-	15.7	0.10	0.12	-	-	-	-

CONCLUSIONS

It was established that the main negative changes of arable typical chernozem occurred in their arable layer. As a result of anthropic activity, there take place processes of humus loss, soil compaction and structure loss. Thus, typical arable chernozem lost about 35 percent of the initial content of humus from 0-25 cm layer. It was detected a trend of depletion of nutrients reserves in comparison with their content in fallow soils.

Chernozems under the fallow for 30 years recovered their initial characteristics by about 80-90 percent only in 0-30 cm layer. The next soil layer (30-50 cm) is characterized by mainly prismatic structure and high bulk density.

Thus, our research confirms the possibility of restoring the quality of cernozems by influence of steppe vegetation that once formed it.

We have to emphasize that the use of land under the fallow for a long time is impossible, but obviously, it is necessary to include grasses in crop rotation to improve the soil condition.

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