SOIL HEALTH ISSUES OF ARABLE TYPICAL CHERNOZEMS OF MOLDOVA

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Abstract

Involvement of soils in agriculture is always associated with changes in natural factors of soil formation and their combination with a complex of agricultural factors. This phenomenon leads to changes, as a rule in the negative direction, in the soil health.

The research was conducted on arable typical chernozems in the North of Moldova. It was established a decline of structure quality in the arable soil in comparison with the grass fallow variant. The content of blocky elements is within 40-60%. The decline in soil structure led to the loss of soil resistance to compaction in the arable layer. The bulk density of recently plowed layer varies between 1.20-1.35 g/cm^3, while of the former arable layer is 1.40-1.50 g/cm^3. It is clearly pronounced the process of humus loss in the arable chernozems. The average humus content in the layer 0-25 cm reduced by 2.03-2.20% or 33-35 percent in comparison with the soil under grass fallow. As a negative phenomenon was recorded a significant decrease in reserves of nutrients in the soil.

Key words: soil structure, humus content, bulk density, soil health

Involvement of soils in agriculture led to significant changes in soil properties. Arable horizon is the most affected by anthropic actions and reflects better all new factors and processes.

Under the influence of agricultural complex of factors has taken place change and combination of elementary soil formation processes: new processes occured, the existing ones were modified, and some were inherited from natural phase of development. New combination of elementary processes in arable soils has been called "contemporary process of soil formation" (Никитин Б.А., 1988). This process has specific characters that take place in all types of soils: the process of accumulation of organic matter slows down; the process of humus formation and accumulation is modified due to different chemical composition of organic residues of crops in comparison with natural vegetation; the amount of nutritive elements removed from soil is much higher than the one remained with organic residues; in arable soils used without application of organic fertilizers or in case of their application in insufficient quantities takes place decrease of humus in the arable layer (Жигэу Г.В., 2008).

At the initial stage the involvement of chernozems into agriculture is associated with the structural-functional reorganization of systems of biogeocenosis. In the result of anthropogenic actions the fallow layer is destroyed and the quantity of organic matter in soil diminishes rapidly (Щеглов Д.И., Брехова Л.И., 2003). So, the maximum quantities of humus are mineralized in the first years of use in agriculture (Albrecht W.A., 1938). The above mentioned changes are located in the upper part of soil profile but further they spread in depth, covering almost the whole profile (Щеглов Д.И., 2003).

Physical properties of chernozems are most exposed to changes under the influence of anthropogenic action. Anthropization of soil formation process has the following basic effects: increasing the bulk density of the soil and structural aggregates; loss of soil structure and crust formation; layering of the soil profile (Жигэу Г.В., 2008).

Soil compaction and losses of humus and structure are interdependent factors of soil degradation. Deterioration of structure and compaction of soils extends over the entire arable land and is conditioned by mechanical destruction of soil structure during circulation of agricultural machinery, grazing and decomposition under the action of microorganisms of humus – the main binder of aggregates (Cerbari V., 2008).

Chernozems are the most widespread and most fertile soils in Moldova, forms and intensity of soil degradation of this soil type it is necessary to study in detail first of all.

The research aim is to assess the qualitative and quantitative changes in typical chernozems under the influence of anthropogenic factor.

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MATERIAL AND METHOD

The research was conducted in the North of Moldova. The objects of study were typical chernozems used in agriculture for at least 100 years. In order to track changes in soil health induced by human factor we had to compare arable soils with a soil etalon. Taking into account that all soils from the territory of Moldova are presently exploited, most of them were ploughed and involved in agriculture and it is impossible to find an intact chernozem in natural state, we compared arable soils with relative etalons - typical chernozems under grass fallow.

In the research were studied two pairs of soils. One pair was selected on experimental fields of Institute of Practical Science Phytotechny (IPSP), Balti municipality. Here it was studied an arable loamy-clayey typical chernozem, that was compared with a former arable 60 years under grass fallow loamy-clayey typical chernozem. Another pair of soils was found in Rascani district. Here we studied an arable loamy-clayey typical chernozem from the arable lands of Grinauti village. The arable chernozem was compared with a loamy-clayey typical chernozem 60 years under grass fallow from the former field aeroport, east of Drochia city.

In the laboratory were made the next soil analysis: particle-size analysis by pipette method with preparation of soil by Kacinschi method (Вадюнина А.Ф., Корчагина З.А., 1986); hygroscopic coefficient by Nicolaev method (Васильев А.М., 1952); particle density by pycnometer method (Астапов С.В., 1958); soil bulk density by the core method; total porosity by calculation (Вадюнина А.Ф., Корчагина З.А., 1986); compaction degree by calculation (Canarache A., 1990); soil reaction by the potentiometric method; hydrolytic acidity by Kappen method; carbonates by the gasometrical method; total phosphorus by Ginzburg method; humus by Tiurin method (Соколов А.В., 1975); total nitrogen by Kielidali method; mobile phosphorus by Macighin method (Аринушкина Е.В., 1970); mobile potassium by the flame photometric method by Macighin (Соколов А.В., 1975).

RESULTS AND DISCUSSIONS

It is known that clayey or loamy soils have an optimal structural state at the presence of 70-80% of agronomic valuable aggregates (10-0.25 mm) in soil structure.

The results of dry sieving analysis revealed that soil structure of chernozems under grass fallow is excellent, with predominance of aggregates with size 1-5 mm. Sum of agronomic valuable aggregates is high – 94-87% *(figure 1)*.

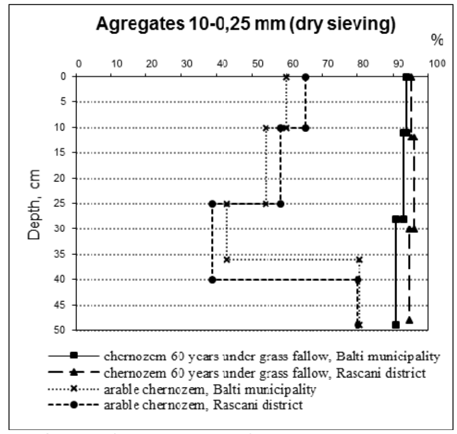

Figure 1 **Sum of agronomic favorable aggregates 10-0.25 mm, dry sieving**

Such structural elements unfavorable for plant growing as clods (>10 mm) and dust (<0.25 mm) makes only 3-10% and 1-4% respectively.

Contrary results were obtained in the case of arable chernozems. Because of intensive use these soils lost natural granular structure. Now the arable layer is highly pulverized that contributed to formation of numerous clods. Structural elements are prismatic or nutty, extremely compacted. In the arable layer (0-25 cm) of chernozems prevail clods – 40-60% *(figure 2)*.

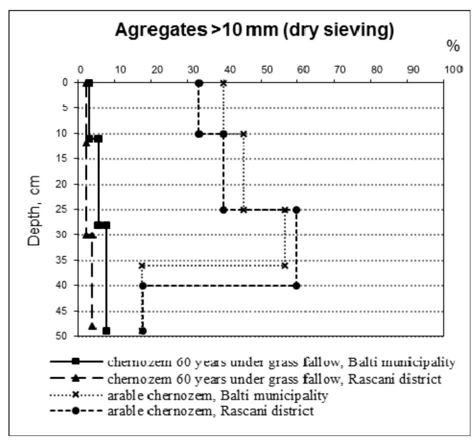

Figure 2 **Aggregates >10 mm, dry sieving**

The next layer (25-35 cm) is characterized by almost monolithic structure. This layer hadn't been worked since '90 years, but it is very compacted because of degraded soil structure as a result of humus loss.

Aggregates hidrostability of chernozems under grass fallow is very high in all studied soil layers. Sum of agronomical favorable aggregates is between 82-94% *(figure 3)*.

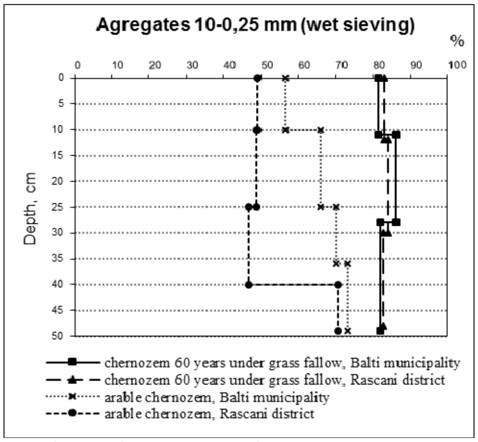

Figure 3 **Sum of agronomic favorable aggregates 10-0.25 mm, wet sieving**

Arable soils near Balti municipality showed an apparently good hydrostability due to strong compaction of aggregates. However the share of fraction <0.25 mm is big enough and makes up 27-53% *(figure 4)*.

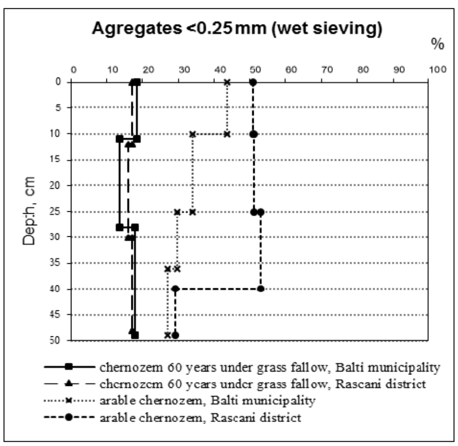

Figure 4 **Aggregates <0.25 mm, wet sieving**

Arable soils from Rascani district have medium hidrostability, which indicates degradation of soil structure. As a result, there is danger of soil compaction and crust formation after rainfall.

As it can be noticed from the *table 1*, bulk density values of arable chernozems are between 1.19-1.34 g/cm^3 in ploughed layers 0-10 cm and 10-25 cm. The next layer is strong compacted. Its bulk density values of 1.41-1.46 g/cm^3 indicates soil degradation. Bulk density values of Ahț and Ah horizons of fallow soils are optimal - 1.16-1.35 g/cm^3.

The upper 0-10 cm layer of arable soil is loose because it is worked during the growing season, total porosity has medium values. The layer 10-25 cm is more compacted, total porosity is low. The layer 25-35 cm is very compacted with a very low total porosity. Fallow soils are loose and have optimal values of total porosity *(table 1)*.

Because of the use in agriculture essential changes occurred in chemical characteristics of typical chernozems (*table 2*).

There is an increase in the acidity of arable soils – phenomena characteristic for chernozems typical used in agriculture.

The average humus content in arable layers of soils used in agriculture is moderate (4.05-3.81%). Typical chernozems under grass fallow are characterized with high humus content in Ahț1 horizon, high in Ahț2 horizon and optimal in Ah horizon. The average humus content in arable soils decreased by 2.24-2.38% of humus in the layer 0-25 cm and 1.65-1.76% of humus in the layer 0-50 cm. Humus losses were respectively 36-37 and 31-32 percent of its initial amount.

Table 1

Analytical data of physical features of chernozems from the North of Moldova

Soil horizon	Depth, cm	Fraction, % <0,01	Fraction, % <0,001	Hygroscopic coefficient	Particle density, g/cm^3	Bulk density, g/cm^3	Total porosity, %	Compaction degree
Arable loamy-clayey typical chernozem, experimental fields of IPSP								
Ahp1	0-10	62.1	39.0	7.1	2.62	1.19	54.7	-4
Ahp1	10-25	62.6	38.6	7.1	2.62	1.34	48.9	7
Ahp2	25-36	62.5	38.9	6.9	2.63	1.46	44.4	16
Ah	36-49	62.3	38.9	6.8	2.65	1.41	47.0	11
Loamy-clayey typical chernozem 60 years under grass fallow, experimental fields of IPSP								
Ahpț1	0-11	61.2	37.1	8.0	2.62	1.16	55.6	-6
Ahpț2	11-28	61.8	38.7	7.8	2.63	1.29	50.7	3
Ah	28-48	61.8	39.2	7.8	2.65	1.35	49.0	7
Arable loamy-clayey typical chernozem, Grinauti village, Rascani district								
Ahp1	0-10	63.3	38.3	7.8	2.62	1.21	54.0	-2
Ahp1	10-25	63.3	38.3	7.8	2.62	1.31	50.1	5
Ahp2	25-40	63.3	38.3	7.8	2.63	1.41	46.3	12
Ah	40-49	63.1	38.0	7.7	2.69	1.39	48.2	9
Loamy-clayey typical chernozem 60 years under grass fallow, near Drochia city								
Ahț1	0-10	60.7	36.5	8.7	2.61	1.22	53.1	-4
Ahț2	10-25	61.5	36.3	8.5	2.62	1.30	50.4	1
Ah	25-40	62.1	36.1	8.3	2.65	1.36	48.5	5

Table 2

Analytical data of chemical features of chernozems from the North of Moldova

Soil horizon	Depth, cm	pH	Hydrolytic acidity	$CaCO_3$, %	Total P_2O_5,%	Humus, %	Total N, %	C:N	Mobile P_2O_5, mg/100 g soil	Mobile K_2O, mg/100 g soil
Arable loamy-clayey typical chernozem, experimental fields of IPSP										
Ahp1	0-25	6.3	2.4	0	0.13	4.03	0.216	10.9	2.0	32.6
Ahp2	25-36	6.4	2.3	0	0.12	3.81	0.205	10.8	1.4	23.1
Ah	36-49	6.5	1.7	0	0.10	3.01	0.172	10.1	0.9	17.5
Loamy-clayey typical chernozem 60 years under grass fallow, experimental fields of IPSP										
Ahpţ1	0-11	6.8	1.8	0	0.16	6.70	0.320	12.2	3.0	60.0
Ahpţ2	11-28	6.7	1.9	0	0.13	5.94	0.290	11.9	2.1	35.6
Ah	28-48	6.8	1.7	0	0.11	4.23	0.220	11.4	1.0	18.8
Arable loamy-clayey typical chernozem, Grinauti village, Rascani district										
Ahp1	0-25	6.3	2.4	0	0.14	4.05	0.193	12.2	1.3	30.0
Ahp2	25-40	6.3	2.3	0	0.13	3.94	0.188	12.1	1.2	25.0
Ah	40-49	6.5	2.0	0	0.12	3.25	0.159	11.9	0.9	18.0
Loamy-clayey typical chernozem 60 years under grass fallow, near Drochia city										
Ahţ1	0-10	6.7	2.0	0	0.18	7.55	0.389	11.5	2.5	49.2
Ahţ2	10-25	6.8	1.7	0	0.16	5.68	0.293	11.3	1.6	26.4
Ah	25-50	7.0	1.0	0	0.13	4.77	0.243	11.1	0.9	17.8

Investigated typical chernozems are formed on loess deposits low in phosphorus (0.08-0.06%). There is a bioaccumulation of phosphorus in the soils under grass fallow in Ahţ1 horizons (0.16-0.18%). Total phosphorus content in arable soils is smaller and constitutes 0.13-0.14% upper layer.

Typical chernozems under grass fallow are characterized by moderate content of mobile forms of phosphorus in upper horizons. Arable chernozems have low content of this element.

Soils under grass fallow are characterized by high content of mobile forms of potassium in Ahţ1 horizon, high in Ahţ2 and moderate in Ah horizon.

Content of mobile forms of potassium in arable soils is high in the horizon Ahp1, optimal in Ahp2 horizon and moderate in Ah horizon.

CONCLUSIONS

The main soil health issues of the studied arable typical chernozems are decline of soil structure quality, negative humus balance and significant decrease in reserves of nutrients. Degradation of structure is caused by low humus content and intensive work with heavy machinery. The decrease in reserves of nutrients in the soil is the result of prolonged use of soils in farming without organic fertilizing of soils.

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