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PROCESSES AND TYPES OF AGGREGATE ORGANIZATION OF A TYPICAL MODERATED HUMIFEROUS CHERNOZEM IN CONDITIONS OF VARIOUS NO-TILL MODELS

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Abstract

Efficiency of no-till technology is appreciated both based on obtained crops and the cost of the unit production or on the basis of agrochemical indices (humus content, grade of mineral nitrogen (NO_3, NH_4), mobile phosphorus, exchangeable potassium, etc. With regrets about the meaning and evolution of the physical characteristics, the conclusions are drawn based on field observations aimed at incorporating soil water by measuring the wetted layer thickness, resistance of penetration that is determined using a simple method of metal rings in soil etc.

Key words: *no till, genetic profile, soil ecosystem, chernozem.*

INTRODUCTION

No-till farming technologies in the literature are known as procedures that ensure enlarged reproduction of soil ecosystem and this because from exterior in their impact on the soil is reduced only the pressures exerted of the tillage process during planting, crop protection and harvesting. Under these conditions the impact is reduced primarily through mechanical pressure exercised by the farm equipment these being, in greater or lesser attenuated by organic mulch layer covering the soil surface. Therefore, the loosening-compaction dynamic is determined preponderantly by natural forces resulting from wetting-drying, freezing-thawing, expansion-contraction [1]. Under this the self-reproduction processes require self-loosening and self-structuring. On the other hand maintaining annually the organic debris in the arable layer, preponderantly in the first 10-20 cm, that system ensures the reproduction of organic matter in soil:

Organic debris → humiferous detrit ↗ Humic substances → accumulation→ progressive accumulative evolution profile humus formation ↘ →
Organic debris → humiferous detrit ↘ Labile organic matter → migration → expansion process → pedogenesis on the profile ↗ →
→ evolution of genetic profile → development of soil ecosystem → ecosystem function → extended reproduction of the soil ecosystem (Jigău et al., 2012).

A challenging element of this technology compared with other technologies is the increasing (by approx. 1.5 times) the quantities of plant protection products, primarily herbicides used to protect crops. This implies the risk of a negative impact on soil biota.

Regretfully particular investigations in this area have not been conducted. However in the field our applied research showed that the number of earthworms in the top 0-30 cm in dry periods of 2010-2012 is 3-4 times higher compared with cultivated land under conventional technologies, and about two times higher than within the treatment with paraplow technologies and loosening deep without furrow turning, that fact is determined, in our opinion by more attenuated dynamics of hydrothermal regime of soil under no-till condition but also by increasing soil organic matter reserves. Even under these conditions we consider that the issue in question requires special investigation. This issue is important because the practice of no-till technologies in Republic of Moldova is increasing year by year. In addition, to this fact that follows from several factors, during the dry period 2007-2012, the cumulative effect of the pedological and hydrological drought, no-till technologies have ensured a stable harvest crops (wheat, barley, maize, sunflower, soybean, rapeseed, peas, etc.). This implies the need for further studies related to the functioning mechanisms of the soils in these technologies.

MATERIAL AND METHOD

The research was carried out in agricultural unit "Civea-Agro" Edinet district where on the total area of 2640 ha from 2002 to 2006 inclusive was practiced agricultural system Mini-Till reduced version and since 2007 are practiced No-Till farming system. In the investigated area the soils are represented by typical moderated humiferous chernozems clay loam formed on the loamy clays. The physical clay content varies in a large range of values (45-60%). In the composition of particle size fraction is dominated very fine sand (0.05-0.01mm) and fine clay (<0.001 mm). On the profile the particle size is relatively homogeneous. In the arable layer there was a slight clay disruption by the wind blowing on surface soil. The analyzed soils have a high potential for aggregate organization. The structuring granulometric index constitutes about 100%. This potential is supported by the humus content comprised predominantly between 4 and 5%, calcium content in adsobtiv complex more than 80% and the degree of base saturation is 100%.

Frequently in the literature the efficiency of no-till technology is appreciated both based on obtained crops and the cost of the unit production or on the basis of agrochemical indices (humus content, grade of mineral nitrogen (NO_3, NH_4), mobile phosphorus, exchangeable potassium, etc. With regrets about the meaning and evolution of the physical characteristics, the conclusions are drawn based on field observations aimed at incorporating soil water by measuring the wetted layer thickness, resistance of penetration that is determined using a simple method of metal rings in soil etc.

The present paper is a first synthesis that assessing the aggregate organization processes in different soil models by using no-till technology:

1. No-Till classic model based on maintaining organic remains on the soil surface.
2. The No-Till model with the intermediate crops.
3. No-Till model with the inclusion of lucerne in cropping patterns.

In the studies we started from the concept that the soil structure as the soil feature is the integrated product of all the formation processes, integration and organization of the soil mass.

Through this prism of ideas is understood the mode of organization structure of elementary particles that contribute to the soil formation and the structural elements (aggregates) and the shape, size, stability, porosity and other properties of these structural elements. In this paper we will refer only to the composition of aggregate according to the size and form of aggregates. Structural separation of elements size classes and structural species was performed by dry fractionation, through sieving carried out at natural moisture content of the soil.

RESULTS AND DISCUSSIONS

1. Aggregate composition of typical moderated humiferous chernozems under conditions of No-Till classic model

No-Till classic model involves practice version which provides accumulation from year to year and the restoration system of organic mulch of organic matter in the soil. Organization aggregate in this case involves physical and mechanical processes determined by wetting-drying, freeze-thaw, expansion-contraction, chemical and physico-chemical processes caused by coagulation, agglutination and partly determined by improvement of biological processes of organic matter in the soil system (increasing activity of soil biota, primarily earthworms, development of more vigorously root system and etc.).

All this, together, lead to the formation of a structure in which valuable agronomic is predominant.

Table 1. Indices of aggregate organization of typical moderated humiferous chernozems (without crop rotation of lucerne)

Depth (cm)	Apparent density (g/cm³)	Total porosity (%)	Aggregate composition. Species structure			
			Boulder (%)	Grain (%)	Clod (%)	Powdery (%)
Profile 9. Typical moderated humiferous chernozems (wheat crop)						
0-10	1.19	53	10	70	15	5
15-20	1.26	50	10	70	15	5
30-40	1.43	44	20	60	20	-
50-60	1.45	44	20	60	20	-
60-70	1.43	43	20	45	35	-
Profile 10. Typical moderated humiferous chernozems (wheat crop)						
0-10	1.22	52	10	65	25	-
15-20	1.22	52	10	65	25	-
30-40	1.48	42	20	45	35	-
50-60	1.50	41	30	30	40	-
60-70	1.54	40	40	30	40	-
Profile 12. Typical moderated humiferous chernozems (soy culture)						
0-10	1.21	52	10	65	20	5
15-20	1.20	50	10	60	25	5
30-40	1.34	47	10	60	30	-
50-60	1.46	43	20	56	30	-
60-70	1.49	42	20	30	50	-

The data from the Table 1 shows that, despite affirmation, after 6 years of no-till practice against a background of four years of agrotechnics preparation the typical moderated humiferous chernozems comprises a problematic state of structural-aggregate organization.

From the table we see that in all cases active agricultural layer is divided into two overlapping substrates with residual layers and arable farming from previous stage.

This implies that for about 6 years is sufficient for the initiation of processes to restore the structural condition of the soil, but is insufficient for decompactation of structural aggregates, restoring aggregate porosity and pore space continuity.

2. State aggregate indices in the model with the inclusion of lucerne cropping patterns

According to the work concept lucerne in the evaluated model was grown as a crop rotation component that required for expanded reproduction of stored organic matter in the soil surface long covered with vegetation. At the same time, is recognized the lucerne root systems helps improve soil aggregate composition.

Table 2. Recovery effect of aggregate organization indices of typical moderated humiferous chernozems under No-Till by cultivating lucerne

Depth (cm)	Wheat			Lucerne			Soy		
	Apparent density (g/cm³)	Aggregate organization (%)		Apparent density (g/cm³)	Aggregate organization (%)		Density apparent (g/cm³)	Aggregate	
		Ball	Grain		Ball	Grain		I	II
0-10	1.27	-	20	1.09	40	60	1.23	40	60
30-40	1.48	10-20	20-30	1.27	20	80	1.41	40	60
50-60	1.59	20	<10	1.29	10	90	1.50	60	30

The data presented in the Table 2 shows that lucerne helps to the soil decompactation and to the formation of a homogeneous active agricultural layer in which apparent density values remain within the optimal range for chernozems with fine medium size composition.

Probably decompaction under the influence of lucerne root system involves the fragmentation grinding of soil mass.

Evidence is the fact that after three years of cultivation of lucerne the grains aggregate content in 30-60 cm layer forms 80-90%. At the same time the land with wheat grains aggregated content constitutes only 20-30%.

Even though, in the case of soya culture there is a situation relatively improved in the aggregate organization, however agro-physical profile involves layers with different values of apparent density and structural aggregate content.

We mention that research presented above belongs to a confined space and only by the one subtype of chernozems.

In this particular case it must be concluded that the involvement of lucerne in crop rotations in the

No-Till structure that creates preconditions for substantial intensification of biological processes in the case of integrated process of structuring the soil and contribute to a more accelerated recovery of aggregate mass organization in no-till soil practices.

The research has established that the ameliorative effect derived from lucerne cultivation period is therefore lucerne cultivation of three years that provide favorable aggregate state a longer period than is provided by agronomic measures (Table 3).

Table 3. Aggregate structural indices of typical moderated humiferous chernozems under post-cultivation lucerne

Depth (cm)	Apparent density (g/cm³)	Total porosity (%)	Aggregation organization (%)			
			Ball	Grain	Bulk	Powder
Profile 11. Wheat 3 years after rape						
0-10	1.21	52	30	20	45	5
15-20	1.50	41	55	-	45	-
20-25	1.35	47	15	40	45	-
25-30	1.36	47	15	35	50	-
30-40	1.46	43	20	10	70	-
40-50	1.52	41	10	10	80	-
50-60	1.47	43	-	15	85	-
60-70	1.48	43	-	10	80	-
Profile 12. Wheat 3 years after lucerne						
0-10	1.14	55	10	60	10	10
15-20	1.16	54	10	70	20	-
20-25	1.19	53	-	85	15	-
25-30	1.20	53	-	80	20	-
30-40	1.38	46	-	70	30	-
40-50	1.29	43	-	70	30	-
50-60	1.37	47	-	40	60	-
60-70	1.45	43	-	35	65	-
Profile 12a. Sunflower 3 years after lucerne						
0-10	1.05	57	10	40	20	30
15-20	1.27	50	-	80	20	-
20-25	1.23	51	-	80	20	-
25-30	1.30	49	-	70	30	-
40-50	1.37	46	-	60	40	-
50-60	1.35	48	-	55	45	-
60-70	1.40	46	-	40	60	-

Specified in the table we find that three years after lucerne culture the agro-physical profile of soil, bearing common features with profiles that are not subject works. In addition soil structure with few exceptions, represented by the aggregate grains are part of the valuable agronomic structure.

Fact that the structures remains practically untouched three years after lucerne culture which requires the idea that the process of hydrostatic structural organization aggregate are formed.

3. Aggregate composition of typical moderated humiferous chernozems under intermediary crop practice

Another No-Till model practiced in Republic of Moldova is the model that includes intermediary cultures. Intermediary crops for cultivation involve covering the soil surface with permanent vegetation that ensures a relatively constant hydrothermal system by reducing physical evaporation and erosion risk mitigation. At the same time they are cultivated as fresh organic matter in the soil. Frequently used for such purposes yellow mustard.

The data from the Table 4 indicates that even a short period of growing mustard was sufficient to ensure the regime which favors hydrothermal processes that forming aggregates grains.

Table 4. Recovery effect of (rape culture predecessor) indices of aggregation of typical moderated humiferous chernozems under No-Till the intermediary culture of mustard

Without intermediate culture					**With intermediate culture**			
Depth (cm)	Apparent density (g/cm³)	Aggregation organization (%)			Apparent density (g/cm³)	Aggregation organization (%)		
		Boulder	Grain	Ball		Boulder	Grain	Ball
0-10	1.27	10	60	30	1.23	10	70	20
20-35	1.49	-	55	45	1.41	-	70-80	10-20
35-60	1.64	5	45	50	1.47	-	60	40
75-90	1.52	20	40	40	1.46	10	60	30

Approximately the same ensure the intermediate facile culture (Table 5). We mention that investigations were conducted under conditions of drought when water reserves under conventional technologies were at an appropriate level hygroscopicity of the soil.

Table 5. Recovery effect of the state of typical moderated humiferous chernozems under No-Till the intermediary culture of facile

Without intermediate culture					**With intermediate culture**			
Depth (cm)	Apparent density (g/cm³)	Aggregate organization (%)			Apparent density (g/cm³)	Aggregate organization (%)		
		Boulder	Grain	Ball		Boulder	Grain	Ball
0-10	1.14	10-15	20-25	65-70	1.28	-	< 20	>80
20-35	1.64	80-90	10-20	-	1.48	-	10-20	80-90
45-55	1.50	70-55	20-30	10-15	1.48	5	15-20	80
65-75	1.60	60-85	30	10-15	1.53	20-15	20-25	60

CONCLUSIONS

Transfer from the classic to no-till tillage of soils requires not only practice-oriented technologies that reduce pressures on soil (variant Mini Till reduced works), but also the obligatory measures for management of agroecosystems by soil organic matter reserves.

No-Till classic is insufficient to recover the state of the aggregate organizationa chernozems with high degree of modification of agro-physical profile. In this context systemic measures are required based on practice culture structures capable of providing agroecosystems similar to natural ecosystems.

REFERENCES

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