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SUSTAINABILITY MODELS OF FORMATION PROCESS AND ACCUMULATION OF HUMUS IN CONDITIONS OF ADAPTIVE - LANDSCAPE - AMELIORATIVE AGRICULTURAL BIOTECHNOLOGY

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Abstract

Arable chernozems in the Carpatho-Danubian-Pontic space have entered in a new natural-anthropogenic evolutionary phase caused by the reduction to the minimum of formation process and humus accumulation in their evolution, reflected in the degradation of function and physical regimes. Reducing its role is caused by unidirectional modification, the biotic and abiotic factors responsible for the formation process and accumulation of humus, hydrothermal and aerodynamic regimes, reduction of bioenergetic resources, quantitative reduction and qualitative degradation of soil biota, reduction of biological nitrogen reserves in the soil. Restoring its priority role in the evolution of chernozems requires unidirectional optimization of specified factors. Our research during the period 2010-2018 showed that to achieve this objective more indicative are adaptive - landscape - ameliorative agrobiotechnologies and the main component are: use of tillage systems selected according to physical state of soils, restoration of soil biota through the systematic administration of biohumic products in soils.

***Key words**: arable chernozems, formation process, humus accumulation.*

INTRODUCTION

In the chernozems pedogenesis the place and role of formation process and humus accumulation are determined by its functions in genesis, evolution and reproduction of chernozems and natural fertilizers:

- **ensuring** and reproduction of trophic chains of all soil microorganisms responsible for the realization of the whole chains of hierarchical process of decomposition - transformation and organic substances synthesis;
- **quantitative interaction** - balanced of the carbon circuits and nitrogen and their sequestration in humic substances;
- **ensuring the carbon** and nitrogen circuit content within the soil system - biotic components of landscape;
- **ensuring biogeochemical** circuits of biophile elements;
- **ensuring structural** - functional organization processes of soil ecosystem;
- **current evolution** stage of natural - anthropic pedogenesis in the Carpathian-Danubian-Pontic space is characterized by unidirectional reduction of soil biogenesis as result of humus formation process in the evolution of soils and their natural fertility.

The main causes of reducing the priority role of formation process of humus are:

- **disturbance**, anthropic degradation of pedofuctional framework (pedofunctional regimes) in continuation of humus formation process;
- **low energy** quality and a small variety of humus sources;
- **deficiency** of necessary biological nitrogen to carry out the process of humus formation;
- **accelerated** intensity of organic decomposition processes (in the absence of detrital humiferous) with the "antropised" humus formation less polymerized and condensed;
- **stressing** state of soil biota as result of "chaotic" dynamics of the component quantities and in terms of organic residues storage;
- **considerable reduction** of microbial biomass in soil from 28-30 kg to 1-2 t/ha as renewable active humus source;
- **spatial incoherence** of deposition area of organic residues and the one with optimal

conditions for carrying out humus forming processes due to the intensive degradation of arable layer;
- enhancement of mineralization processes of humic substances as a result of soil work and increase of aeration degree;
- decomposition and humus biodegradation as result of intensification of toxigenic microflora activity.
Under these conditions the trend of humus state of arable chernozems in the region implies two parameters: a) critical content, b) minimum permissible content. Critical content - content under which functional features (including agronomic) deteriorate and soil resistance at agrogen pressures and makes up 4%.
Minimum permissible content - content (2.5-3%) under which the positioning parameters and structural - aggregate, the volume and structure of porous space are valuable which are insignificantly different from those characterized by the parental rocks.
In condition where the humus content is reduced below the critical content in soils, the process of over - cultivation is established, and it presents values below the minimum allowable values in soils is established aridization - functional desertification.
According to the latest calculation 7.4-8.6% of arable chernozems in the Republic of Moldova is characterized by humus content 4-5% and is 17.7-18.2%. Prevailing soils with moderate humus content (3-4%) which makes up 42%. Only 1.4 of arable chernozems contains more than 5% humus.
Thus, more than 80% of the arable soils in Moldova are subjected to over - cultivation and about 38% carry the features of aridization - functional desertification and requires adaptive - landscape - ameliorative systematic action in order to restore the priority role of formation process and humus accumulation. This paper is dedicated to assessing the trend evolution of soils humus state within agrobiotechnology models adapted to the specific condition of agrolandscape.

MATERIALS AND METHODS

The research was conducted during 2010 - 2018 in the southern part of Moldova in SA "AXEDUM" SRL. Soils within the agricultural holding SA "AXEDUM" SRL are represented by typical low humus chernozems with Aar - AB - Bca - Cca formed on clay loamy with loessidal features. Effervescence is attested in the AB horizon and the illuvial carbonated horizon in the depth at range 97-113 cm. Based on soil prospecting 4 lands were selected with an area between 47-62 hectares.
Field activities included annual harvesting on soil samples of 30 individual samples from elementary plots with area 10-12 ha (depending on the geomorphological conditions). From the samples collected an average sample with a mass of 3.0-3.5 kg was formed.
The humus content was determined by TINAO methods in 5 repetitions. Depending on the state of soil and landscape conditions there were developed and implemented 4 models of adaptive - landscape - ameliorative agrobiotechnologies:

1. Traditional - plowing with alternation of depth performing works for incorporation of organic residues in the rotation of 4 crops (peas - wheat - sunflower - corn).
2. Agrophytotechnical - based on ensuring the presence of fresh organic matter in soils and an optimal hydrothermal and biochemical medium for the humification process. Perspective are the models that include practicing the occupied field that involves cultivation of vetch, facelia, yellow mustard with their incorporation into the soil in the flowering phase.
3. Resource conservative - restoration and bioenergetics support of soil microbiocenosis and intensification of carbon sequestration processes by structural - aggregation of soil substance. According to more recent research in this respect are based agrobiotechnologies on the practice of green field and application of soil algae processes with the nitrogen sequestrated algae species, gen. Nostoc, Anabaena, Cylindrospermum (Jigau et al., 2018a; 2018b).
4. Resource productive - based on bioenergetics restoration and support of soil microbiota responsible for ensuring the whole decomposition chain - transformation - humification of organic matter by administration of biohumic preparations.

RESULTS AND DISCUSSIONS

Starting from results of previous research (Jigau et al., 2017; Jigau et al., 2018) present paper follow a line of investigation that includes two distinct components:

a) Evaluation of biohumic substances in the perspective of promoting resource productive models and resource productive adaptive - landscape - ameliorative biotechnologies;

b) Evaluation of development trend of humus state of arable chernozems within adaptive - landscape - ameliorative agrobiotechnology models.

In the last 15-20 years biohumic preparations have gains a wide spread on the agricultural market in Moldova. Most of these are of native origin and are obtained in well - known biotechnology worms composting.

In contrast to these of biohumus production technology in SA "AXEDUM" SRL the natural model of humification process, including insurance, is taken and supporting processes of decomposition - transformation - humification of organic substances and provides for the production of two solid, liquid and biohumic substances. According to our calculations on 1 t of organic waste from the poultry factory within this biotechnology of 600 kg humic organic matter is obtained, which contains on average 53.4% organic substances and 46.6 mineral substances (Table 1).

Table 1. Content of macro- and microelements in biohumus (solid fraction) (data belongs to SA "AXEDUM" SRL)

Parameters	Units of Measure	Organic substances content
pH		7.8
Mineral substances content	%	46.6
Organic substances content		53.4
Total nitrogen content		1.55
Total phosphorus content		1.70
Total potassium content		1.85
N - NO_3 content	mg/kg	1071
Total calcium content		380
Total magnesium content		264
Mobile copper content		2.05
Mobile zinc content		7.6
Mobile manganese content		9.30
Mobile iron content		5.30

Organic content in biohumus is 6-8 times higher in compost. At the same time, the biohumus, is richer in nitrogen, phosphorus and total potassium. Biohumus is a good source of microelements (Zn, Cu, Mn), but also calcium. The content of the last one is sufficient to compensate the amount of calcium alienated with crops. We also draw attention to the increased magnesium and iron content which are responsible for the production of chlorophyll and photosynthesis. In contrast to compost biohumus is a biologically active substance, one gram of biohumus contains up to 20 meridic colonies of microogranisms responsible for the humification of organic substances. This allows us to consider that under the presence of fresh organic matter the biohumus in the soil contributes to the restoration of soil microbiota that provides the humification process and the priority role of the formation process of humus in the development of agrogen chernozems. Liquid biohumic substances represent a specific group substances bioroutinist organic - mineral (Tables 2, 3).

Table 2. Microbiological composition of liquids biohumic substances (data belongs to SA "AXEDUM" SRL)

Parameters	Native solution	Extract with solution 0.1 N KOH
Total number of microorganisms, thousands	5969	6660
Bacteria that decompose organic substances easily accessible, thousands	2227	2459
Bacteria that decompose organic substances hardly accessible, thousands	970	702
Total number of microorganisms that assimilate mineral substances, thousands	2390	2426
Actinomycetes, thousands	654	504
Micromycetes, thousands	146	151

Table 3. Content of macro- and microelements in the composition liquid of biomus substances (data belongs to SA "AXEDUM"SRL)

Native fraction		Extract in solution 0.1 N KOH	
Parameters	Content	Parameters	Content
Organic substances content, %	23.98	Organic substances content, %	17.77
Total nitrogen content, mg/kg	49600	Total nitrogen content, mg/kg	7892
Nitric nitrogen content (N - NO_3), mg/kg	318.0	Nitric nitrogen content (N - NO_3), mg/kg	43
Total phosphorus content (P_2O_5), mg/kg	24355	Total phosphorus content (P_2O_5), mg/kg	2100
Mobile phosphorus content (P_2O_5), mg/l	137.2	Mobile phosphorus content (P_2O_5), mg/l	51.8
Total copper content, mg/l	0.69	Total copper content, mg/l	0.22
Total zinc content, mg/kg	0.93	Total zinc content, mg/kg	0.18
Total manganese content, mg/kg	0.59	Total manganese content, mg/kg	0.26
Calcium content, mg/l	345	Calcium content, mg/l	115
Magnesium content, mg/l	153	Magnesium content, mg/l	51
Mobile potassium content, mg/l	1758	Mobile potassium content, mg/l	5394

In the native fraction the content of organic substances is about 24%, which is rich in nitrogen (50 mg/kg). Due to the increased nitrification capacity the nitric nitrogen content (N-NO_3) is 318 mg/l. Total phosphorus content is 24 g/kg and the mobile one more than 130 mg/l. The content of mobile potassium (K_2O) is more than 1.7 mg/l.

Liquid biohumic substances are an important source of physiological microelements: the total copper content is 0.69 mg/l; zinc is 0.93 mg/l and manganese 0.59 mg/l. The calcium content is 345 mg/l and magnesium is 153 mg/l. The fraction of humic substances extracted in 0.1 n KOH solution has the same properties but with other quantitative expression (Table 3).

The content of organic substances is 16%, total nitrogen - 8 g/kg, N-NO_3 - 51.3 mg/l. The concentration of physiologically active microelements and alkaline - earth metals are 2-3 times lower than the native solution. Due to the particularities mentioned, the fraction of liquid humic substance is the fraction of liquid humic substances from the natural fertilizer which ensures visible multilateral effects: vigorous growth of plants, intensifying the photosynthesis process, increasing the resistance of crops to pathogens and pest, increasing harvest and quality.

Despite the fact that liquid biohumus substances contain large amounts of carbon, nitrogen, phosphorus, potassium and their administration in a quantity of 5-7 l in the soil does not directly affect their content in the soil. Therefore, the positive effects induced by them are based on other mechanisms. In this regard, we believe that liquid biohumus preparation (BIOVIT.md) lead to the restoration of soil biota and the intensification of biochemical processes in particular of humification process is perceived as a biophysical - chemical transformation process of organic residues with formation of stable humic substances which is achieved with the participation of saprophytic biota (Popov, 2004).

The process is carried out in several stages each link of this chain finalizing with the formation of stable groups of biohumic substances. According to Grishina (1986) these substances are represented by humic acids and humin. Agreeing with Orlov’s specified mechanisms determine the unidirectional character of the humification process in the sense of accumulation of humic substances in the soil (Orlov, 1986).

Monitoring this process in various models of agricultural biotechnology has shown that the systematic administration of biochemical products leads to the intensification of humification process (Table 4).

The maximum effects are attested in the case of resource reporductive model which is based on the combined use of liquid biohumus and solids in two rates.

In our opinion administration in rate prevent development which mineralizes newly formed humic substances. Due to this fact, in the case of resource productive model, there is a significant increase of organic matter content in a short period of 9 years (Table 4).

Table 4. Content and organic matter resources of typical low humus chernozems under various models of agricultural biotechnology (SA "AXEDUM"SRL, Cimişlia) (agrogen layer, mean values)

Model of agrobiotechnology, agrobiotechnological elements (9 years)	Soil layer, cm	Organic matter content, %	Addition based on the traditional model, %	Reserves of organic matter, t/ha
Traditional, plowing with incorporation of vegetal debris at various depths (9 years)	0-10	3.81 ± 0,06	-	40.0
	10-20	3.74 ± 0,04	-	38.3
	20-30	3.71 ± 0,03	-	36.4
	30-40	3.63 ± 0,02	-	35.4
	40-50	3.31 ± 0,02	-	34.0
	Layer 0-50	-	-	184.1
Agrophytotechnical combined system with incorporation of vegetal remains (9 years)	0-10	3.93 ± 0.06	+ 0.12	42.7
	10-20	3.87 ± 0.04	+ 0.13	41.3
	20-30	3.81 ± 0.04	+ 0.10	40.0
	30-40	3.65 ± 0.03	+ 0.02	35.8
	40-50	3.31 ± 0.02	-	34.0
	Layer 0-50	-	-	193.0
Resurce conservative Mini-Till system of work. Green field. Administration of biomumic products (BIOVIT.md) (9 years)	0-10	4.11 ± 0.13	+ 0.30	46.4
	10-20	4.07 ± 0.10	+ 0.33	44.8
	20-30	3.95 ± 0.06	+ 0.24	43.3
	30-40	3.62 ± 0.02	-0.01	41.4
	40-50	3.31 ± 0.02	-	34.0
	Layer 0-50	-	-	209.9
Resource productive Mini-Till system of work. Green field, biohumus administration, administration BIOVIT.md (9 years)	0-10	4.67 ± 0,11	+ 0.86	53.0
	10-20	4.60 ± 0,09	+ 0.79	50.9
	20-30	4.28 ± 0,06	+ 0.54	50.6
	30-40	3.98 ± 0,06	+ 0.30	48.2
	40-50	3.68 ± 0,07	+ 0.37	44.2
	Layer 0-50	-	-	247.3

CONCLUSIONS

Biohumic products obtained on the basis of natural humification process model have increased potential to restore soil biota responsible for the humification process. Systematically managing them in two rates ensures unidirectional realization the humification process and the increase in the content and reserves of organic matter.

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