RESTORATION OF LEACHED CHERNOZEMS FERTILITY UNDER THE INFLUENCE OF GREEN AND ORGANIC FERTILIZERS

RESTABILIREA FERTILITĂȚII CERNOZIOMURILOR LEVIGATE SUB INFLUENȚA ÎNGRĂȘĂMINTELOR VERZI ȘI ORGANICE

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Abstract. *The paper presents the results of implementation the economic and available agrofitoameliorative procedures to remedy and long-term preservation the quality state of arable chernozems. As a result of incorporation of vetch green mass as intermediate crop and 50 t ha^{-1} of manure was established that: have increased the organic matter in soils, changed the physical parameters increased the harvest of winter wheat and sunflower.*
Key words: *humus content, physical parameters, manure, vetch*

Rezumat. *În lucrare sunt prezentate rezultatele implementării procedeelor agrofitoameliorative, economic accesibile privind remedierea şi păstrarea pe termen lung a stării de calitate a cernoziomurilor arabile. În rezultatul încorporării masei verzi de măzăriche, ca cultură intermediară şi a 50 t ha^{-1} de gunoiul de grajd s-a stabilit că: au crescut valorile fluxului de substanţă organică în soluri; s-au modificat parametrii însuşirilor fizice; a sporit recolta culturilor de grâu de toamnă şi floarea soarelui.*
Cuvinte cheie: *conținut de humus, gunoi de grajd, măzăriche, parametri fizici*

INTRODUCTION

The existing system of agriculture does not ensure long-term preservation of soil quality status and lead to worsening economic and environmental situation in the country. The physical, chemical and biological degradation of chernozems contributes to the extension of land desertification processes and decrease the volume of agricultural production. (Cerbari, 2011).

Researches regarding the restoration of arable layer quality of leached (cambic) chernozems under the influence of vetch used as green fertilizer and manure were conditioned by the following considerations:

- food security of the country depends on the quality status of chernozems which covers about 80 percent of the land surface;
- intensive tillage of chernozems (often with heavy machinery) led to loss of humus content, structure damage, strong secondary compaction of arable layer, decreased of agricultural production;
- the productivity of fine textured soils is high, if that their structure is agronomic valuable and ensures the favorable aerates of the arable layer.

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Maintaining a equilibrated or positive balance of humus contributes to tackling the physical quality of soils and this possibility can be made by the systematic application of organic fertilizers or growing perennial grasses with dominate of grasses in its composition on the arable soils. Given decreasing of cattle numbers by 6 times, the quantities of accumulated manure are respectively by 6 times lower than in 1990 (Cerbari V., 2010). Unfortunately, these small amounts of organic fertilizer not used on the land for agricultural purposes. Therefore it was necessary to find alternative sources of local organic fertilizers. The most effective source of organic fertilizer is intermediates crops used as green fertilizers. As a result of investigations it was established that for chernozems zone the best crop as green manure is winter vetch - as intermediate crop, and spring vetch – as the crop insertion into rotation for a follow field, which is incorporated two crops of vetches in the soil as green manure (Borontov, 2004,).

Researches in the Balti steppe established that radical remedial factor of typical chernozems characteristics is those, that leading to the formation of this subtype of soil - steppe vegetation with grasses domination in its composition, the plants with highly developed fasciculate root system. Typical chernozems with whole profile being grassing 60 years restored completely humus profile and properties characteristics for typical virgin soils under the influence of natural herbaceous vegetation. Recovery rate of humus in the arable layer of typical chernozems grassing 15 years under the action of perennial herbs without discharge their air mass is 0.06% annually in the 0-30 cm layer and 0.04% annually in the 0-50 cm layer (Cerbari and Balan, 2010, Tzandur et.al., 2011).

In Moldova, due to lack of free land, this variant remediation of degraded arable layer characteristics of chernozem will not be accepted. In this connection, is assessing interest the rate to restore damaged soil characteristics under the influence of perennial herbs and organic fertilizers. The purpose of this research is test the procedures to remedy agrophytotechnical soil characteristics that will contribute to long-term preservation of their quality and lead to increase the volume of agricultural production.

MATERIAL AND METHOD

For the entire purposes of the researches at the Experimental Station "Ivancea" of Institute "N. Dimo", in Centre of Moldova) were founded four experimental plots concerning the testing of phyto-technological procedures. Parcels - strips (width – 10.5 m, length - 700 m) testing vetch and manure (50 t ha^{-1}) on the leached chernozem in autumn 2010. The vetch sowing was done in the second decade of September, and spring in the last decade of April, vetch green mass was incorporated into the soil by disking. The soil was proceeding cultivated for base crop sowing. Strip was divided into 2 sectors. The first section width of 7 m was sown again with spring vetch for hay and the second, width 3.5 m - with sunflower.

RESULTS AND DISCUSSIONS

To highlight the initial parameters of soil characteristics in the autumn of 2010 until the founding of experience on the experimental field was located the soil profile in 200 cm of deep and 4 semi deep soil profiles by 50 cm. Investigated profile of arable cambic chernozem is characterized by the type Ahp1-Ahp2-Ah-Bhw1-Bhw2-BCk1-BCk2-Ck. Effervescence - from 96 cm. Carbonates as pseudomycelia from 100 cm to 200 cm, from 150 cm deeper - rare accumulations of bieloglasca. Ahp2 horizon of soils as a result of structural damage and humus loss under the influence of agricultural heavy machinery and aggregate is compacted and is characterized by unfavorable physical properties. Humus profile (Ah + Bhw) and sometimes upper horizon BC is leached of carbonates. Bhw1 and Bhw2 horizons are characterized by reddish-brown hue due process of iron siallitization "in situ" of mineral part of these soils.

Investigated leached chernozems are characterized by clayey – loamy texture, poorly differentiated in profile, moderate quality of structural composition, moderate compaction of newly arable layer, high compaction of Bhw2 and Bhw1 horizons (relict feature of former eluvial horizon of forest soils). The humus profile is decarbonated. Humus content in soil profile is: 3.2 - 3.5% in the arable layer, 2.2 - 2.5% in the Bhw1, 1.0 - 2.0% - in the Bhw2, 0.7 – 1.0% in BCk1 horizon. Value ratio C: N is medium - from 8.9 to 9.4, confirming that the intensity of the annual flow of organic matter in soil is low. Investigated soils are moderately supplied with mobile forms P_2O_5 and K_20. Hydrolytic acidity of these soils is relatively low - 1.7 to 2.5 *me (mg.equiv.)*. Content and composition of exchangeable cations in the soil adsorption complex is typical for chernozems of Moldova. The cation exchange capacity: from 31 *me* in Ahp1 to 22 *me* in the Ck.

According to results on the strip sown with winter vetch used as green manure, in the soil was incorporated 7 t ha^{-1} of organic matter absolutely dry with nitrogen content of about 3.3%. On the sector strip width 3.5 m, in the spring, after incorporation the vetch into the soil was sown sunflower. On the 7 m width strip was again sown the spring vetch for hay. As a result, after the mowing of hay in the soil were still returned the 6.7 t ha^{-1} of dry plant debris with an average nitrogen content of about 2.9%. In total, on the sector of the strip with vetch (7 m width) in the agricultural year were applied in the soil 13.7 t ha^{-1} of organic waste of vetch with nitrogen average content 3.1% (table 1).

Table 1

Vetch harvest on the experimental strip, 2011

Harvest, date	Green mass, t/ha	Humidity, % of wet green mass	Dry mass, t/ha	Cereal units, t/ha	Ash	N	P_2O_5	K_2O	C
					% of dry mass				
Vetch harvest, green mass incorporated into the soil as fertilizer (K=0.2)*									
The I harvest: 22.04.2011	**19**	**79.5**	**3.9**	**3.4**	13.4	4.25	0.71	2.36	37.1
Plant roots fixing in 0-30 cm of layer			**3.1**	-	16.8	2.19	0.32	0.40	26.6
The total amount of plant debris			**7.0**	-	**14.9**	**3.30**	**0.54**	**1.49**	**32.5**

Continuing tab.1

Vetch harvest, green mass used as hay (K=0.2)*. In the soil were incorporated only main crop organic waste and roots of vetch.									
The II harvest: 12.07.2011	**24**	70.5	**7.1**	**4.8**	9.3	4.0	0.6	2.10	37.1
Vegetal waste, t/ha (25% from harvest)	**6.0**		**2.8**	-					
Plant roots fixing in 0-30 cm of layer			**3.9**	**-**	25.2	2.10	0.32	0.45	26.6
Total harvest per year	**43**	**76.0**	**11.0**	**8.2**	10.8	4.09	0.68	2.28	37.1
Vegetal waste applied into the soil, t/ha		total	6.7	-					
Roots, total mass in the layer 0-30 cm			*7.0*	-	21.5	2.11	0.32	0.43	26.6
Total mass (two crops, one for hay) of organic residues remaining in the soil			13.7	-	16.3	3.12	0.50	1.34	34.7

*Note: **K=0.2** - transformation coefficient of vetch green mass in units of conventional cereals. Humification coefficient - 0.25. Amount of 13.7 t ha^{-1} of organic waste of vetch can synthesize about 3.2 t ha^{-1} of humus.*

Harvest of principal crop on the strip width of 3.5 m, sown in spring of 2011 with sunflower (after incorporation the vetch green mass into the soil) is presented in table 2.

Table 2

Sunflower harvest (absolutely dry mass) after vetch as green fertilizer (numerator) and harvest on the control unfertilized strip (denominator)

No. of plot, surface -15 m²	Harvest on the plot (kg)	Harvest (t/ha)	Average harvest on the strips (t ha^{-1})	Growth rate of harvest (t ha^{-1})
1	3.8 / 3.0	2.5 / 2.0	2.4 / 1.9	+0.5 (0.7 t ha^{-1} of cereal units)
2	3.4 / 2.8	2.3 / 1.9		
3	3.6 / 2.9	2.4 / 1.9		
4	3.7 / 2.8	2.5 / 1.9		
5	3.4 / 2.9	2.3 / 1.9		

The data show that in 2011 the growth rate of sunflower harvest in result of use the vetch as green fertilizer was 0.5 t ha^{-1} or 0.7 t ha^{-1} of cereal units, confirming the high efficiency of this method. After harvest of vetch hay (sector of width 7 m) and sunflower culture from across the field (where is located the parcel with 50 t ha^{-1} of manure into the soil), the land was prepared for sowing, but due to severe drought in autumn, the winter wheat was sown in the third decade of October. Repeated spring drought, affected adversely the crop development. However, it was found a positive influence of vetch green fertilizer and manure on winter wheat harvest even in this dry year (table 3).

Table 3

Winter wheat harvest (t ha^{-1}) on the experimental variants, 2012

No.	Variant	Average harvest, t ha^{-1}	Growth rate compared to the control variant	
			t ha^{-1} / %	probability of difference, %
1	Control	2.3	-	-
2	Winter wheat after vetch, I year	3.2	0.9 / 39.1	99.9
3	Winter wheat after vetch, II year (I year – sunflower)	2.7	0.4 / 17.4	95.0
4	Winter wheat on the plots with manure, 50 t ha^{-1}, II year; (I year – sunflower)	3.1	0.8 / 34.8	99.9

It was established that vetch green fertilizer and manure contributed to a partial correction of degraded arable layer characteristics of chernozems. Intensifying flow of organic matter in the soil led to a partial remedy structure; increase the favorable agronomic hydrostabile aggregates, decrease the apparent density values (table 4-6).

Table 4

Changing the value of apparent density (g/cm3) of arable layer of chernozem leached influenced by vetch green fertilizer and manure

Horizon and depth (cm)	Control	Winter wheat after vetch, I year	Winter wheat after vetch, II year; (I year – sunflower)	Winter wheat on the plots with manure, 50 t ha^{-1}, II year; (I year – sunflower)
Ahp1 0-12	1.24	1.14	1.15	1,.17
Ahp1 12-20	1.46	1.33	1.45	1.32
Ahp2 20-35	1.48	1.44	1.49	1.43
Ah 35-50	-	1.42	-	-

Table 5

Changing of the structural state of chernozem cambic arable layer

Horizon and depth (cm)	The sum of agronomic favorable aggregate (numerator) and hydrostabile aggregates (denominator),%			
	Control	Winter wheat after vetch, I year	Winter wheat after vetch, II year; (I year – sunflower)	Winter wheat on the plots with manure, 50 t ha^{-1}, II year; (I year – sunflower)
Ahp1 0-12	65.3 / 50.4	76.3 / 61.2	66.3 / 58.6	74,.1 / 61.8
Ahp1 12-20	50.3 / 70.4	58.8 / 76.4	53.9 / 76.0	58.0 / 77.0
Ahp2 20-35	46.5 / 70.2	47.7 / 74.6	46.4 / 73.4	46.0 / 72.8
Ah 35-50	-	68.5 / 75.2	-	-

Organic matter content in the soil layer 0-12 cm of the variant whit winter wheat after vetch and manure (50 t ha^{-1}) increased by 0.2%. Incorporation in one year in the arable layer of soil a quantity of 13.7 t of vetch green mass with 3.1% nitrogen content created conditions for the synthesis of about 3.2 t ha^{-1} of humus.

Table 6

Changing of humus content (%) in the arable layer of chernozem leached

Horizon and depth (cm)	Control	Winter wheat after vetch, I year	Winter wheat after vetch, II year; (I year – sunflower)	Winter wheat on the plots with manure, 50 t ha^{-1}, II year; (I year – sunflower)
Ahp1 0-12	3,39	3,62	3,46	3,60
Ahp1 12-20	3,15	3,30	3,26	3,36
Ahp2 20-35	3,00	3,06	3,02	3,06
Ah 35-50	-	2,87	-	-

The advantage of the proposed technology to remedy the degraded characteristics of arable layer of chernozem is that it is accessible and expensive for farmers, contributing to increase the harvest and restoration of soil quality. To implement this technology is required to create the seeds base of vetch. Technology is recommended to be gradually implemented in central and southern areas of Moldova at least 100 000 hectares, 10 hectares annually.

CONCLUSIONS

The winter vetch as intermediate crop using as green fertilizer, it is recommended to be sown every two years, after the culture that creates this possibility. This technology leads to:

- creation the preconditions for implementation of minimum tillage system, that in combination with this technology will contribute to soil protection and remediation of degraded characteristics;
- formation of equilibrated balance of organic matter and nitrogen in the soil: annual is return in the arable layer with crop of vetch about 7 t ha^{-1} of dry plant residues, containing 3.3% of nitrogen, which provides a synthesis of 1.75 t ha^{-1} of humus or 1.0 t ha^{-1} of carbon and sequestration of 3.7 tons of CO_2;
- increasing humus content in arable layer 0-35 cm by 0.11%, improving physical quality of 0-12 cm layer formed by disking, increasing the volume of agricultural production by 20-30 per cent.
- ensuring the agricultural production increase at least 0.9 t ha^{-1} of cereal units in the I^{st} year and by 0.4 t ha^{-1} of units in the II^{nd} year after incorporation;

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