GREEN MANURE - ONLY POSSIBILITY TO SAVE MOLDOVA'S ARABLE SOILS FROM DEGRADATION

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Abstract

The soil as an organic-mineral system is functioning normally and has a high capacity of agricultural production only if there is a constant flow of organic matter in its arable layer. In Republic of Moldova in the last 25 years organic fertilizers are practically not applied in agricultural soils. The agricultural output was reduced 2 times and livestock - 6 times. In terms of the lack of a rational ratio between the crop sector and livestock, it was established by calculation, that humus balance in the soils became profoundly negative, minus 1 t/ha/year. The only possible solution to change the situation is the use of green manure. Field research revealed that under the climate conditions of Moldova a harvest of green mass and roots of autumn vetch, incorporated into the soil as intermediate culture, leads to humus accumulation of about 2-3 t/ha. Also in the 8 t/ha of vetch organic residues absolutely dry incorporated into soil, contains almost 270 kg/ha of biological nitrogen, 60% of which (160 kg/ha) has a symbiotic origin. Thus, for the next two years this ensures a positive balance of organic matter in arable layer of soil. The system use of this procedure leads to solving the problem of humus and nitrogen in the soil and helps improve his physical quality. The bulk density of 0-20 cm arable layer was reduced from 1.37 to 1.21 g/cm^3. It has improved soil structural state and reduced its resistance to penetration.

Key words: balance, green manure, humus, soil, structure

Agriculture in Moldova is the most important branch of production. The primary means of production in agriculture is soil. Country's food security and population wellness depends on soils quality. Currently the agriculture is facing a number of major problems seriously affecting rural development. The classic tillage soil system increased the production, but it also determined the soil degradation characteristics and reduction the production capacity of agricultural land. The excessive soil tillage favored degradation processes and onset of other negative phenomena.

The chernozem is an organic-mineral system that can provide high capacity of agricultural production, only if there is a constant flow of fresh organic matter. Creation the positive balance of organic matter in soil is the main condition for maintaining his long-term fertility and avoid the degradation of arable layer. This can be achieved only through continuous application of organic fertilizers - manure or green manure. As result of the agrarian reform negative impact and other reasons, the manure as organic fertilizer is practically not used. Its production was reduced 6 times after the livestock reduction, recently concentrated in households. The collection, composting, transportation and incorporation cost of manure into the soil is high, and crop harvest do not compensate expenses. In this situation the balance of humus in the soil became profoundly negative and continues to be reduced annually by 1 t/ha. Simultaneously the agricultural output in Moldova has decreased 2 times.

MATERIAL AND METHOD

The research object was cambic chernozem (leachate) of Central Moldova. The research aim was to restore soil characteristics by combining phyto- and agrotechnical methods, forming a positive balance of carbon, nitrogen and humus in the soil, stopping the degradation processes and regulation of CO_2 emissions in soil. To fulfill the predicted purpose in 2011-2016 were performed the following tasks: was founded the research polygon; initial assessment of soil quality condition on the polygon; cultivation and incorporation into the soil two crops of vetch on the experimental plot used as "occupied field"; determination of overhead and underground vetch mass incorporated into soil; plant analysis; harvests appreciation; assessing changes in characteristics of arable layer as a result of two crops incorporation of vetch green mass in one agricultural year. Investigations were carried out on the experimental fields of the Institute of Pedology, Agrochemistry and Soil Protection "N. Dimo". The winter vetch was sown in mid- September 2011.

On 25 April 2012 the green mass of vetch was incorporated into the soil by disking. The

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spring vetch was sowed over four days, as well as green mass was incorporated into the soil in early September. On the strip and on the polygon surface were carried out the works required for basic sowing culture - winter wheat. Thus the experimental polygon was introduced again in the existing crop rotation at the experimental station. After winter wheat in the next years were sowed corn, sunflower and again winter wheat.

For the vetch sowing in the soil were introduced 100 kg/ha of nitrogen-phosphorus (ammophous). Every year under basic crop, early spring, was applied a starting dose of about 50-100 kg/ha of ammonium nitrate. On the experimental polygon and the adjacent field, unfertilized with green manure, was settled by 3 pair – micropolygons, located on the opposite with 10 m^2 area for soil research and appreciation the harvests of sown crops. The distance between micro-polygons is 50 m. Vetch was sown mixed with wheat - 80 kg/ha of vetch and 50 kg/ha of wheat. The research of field phase and laboratory were conducted according to classical methods and standards (Вадюнина А.Ф., Корчагина З.А, 1986). Assessment of the results was performed according to the methodology for developing soil studies (Florea N., 1975; Canarache A., 1990).

RESULTS AND DISCUSSIONS

Intensive agriculture, soil tillage with heavy aggregate, resulted in the dehumification of arable layer, damaging the natural structure of agricultural soil and strong compacting of arable layer (*figure 1, 2*). Humification, dismantle and secondary compaction of arable layer is a crucial issue for chernozems in Moldova which 80 percent is characterized with fine or medium-fine texture (Cerbari V., 2015; Cerbari V., 2015a). Finely textured soils and favorable agronomic structure, unlike the unstructured or damaged structure ensures optimal plant growth and development (Berca M., 2011).

The balance of organic matter (humus) in arable soils must be equilibrated or positive. To assess the situation created recently was calculated balance of humus in arable soils of Moldova within the years 1990-2013 (*table 1*).

The data confirms that in 1990-1992 yrs, as a result of compliance with crop rotation with seven fields, of which one field with perennial grasses (alfalfa or sainfoin) and one field with annual grasses, simultaneous introduction about 6.7 t/ha of manure, in the arable soils of Moldova established a positive balance of humus.

Figure 1 **Chernozem cambic with glomerular-grainy structure, fallow**

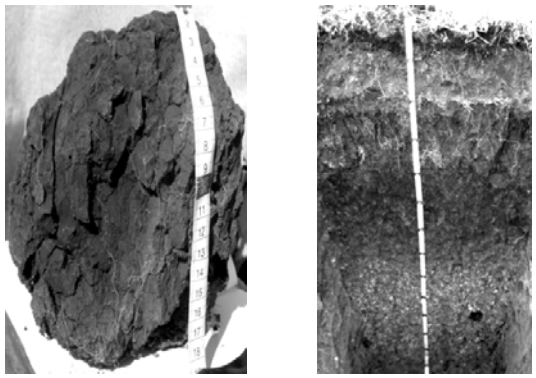

Figure 2 **Chernozem cambic with strongly compacted destructuring post arable layer, arable**

The land reform has led to the disappearance of fields sown with leguminous grasses from crop rotation; livestock was reduced by 6 times. In agricultural soils used in field crops the manure is basically not applied, the quantity of fertilizer was reduced catastrophically (40-50 kg/ha). In the described situation in arable soils was created a profoundly negative balance of organic matter and nutrients. The total agricultural production was reduced about 2 times (*table 1*).

The lack of equilibrated organic matter balance in the soils does not lead to increase the crop harvest even when increased applications of mineral fertilizers are used. The research showed that the rise in the last years of chemical fertilizers, incorporated therein, without a co-report balanced with organic and phosphorus fertilizers do not lead to the expected increase of crops.

Negative balance of organic matter in soils led to the decrease of humus content accumulated for millennia, deterioration in the structure and secondary strong compaction of soil arable layer. At the moment, due to destructuring, arable layer of chernozems practically lost the compaction to resistance.

Table 1

The balance of humus in Moldova's soils on fields used in agricultural crops

Year	Surface, thousand ha	Basic harvest thousand tons / year	Basic harvest, absolute dry mass, th. t / year cereal units	Humus				
				Humus formed as result of organic waste humification, remaining in the soil, th. t/year	Humus formed from application of organic fertilizers, th. t/year	Humus lost as a result of minera-lization, th. t / year	Humus balance	
							th. t/year	t/ha /year
1990	1698.8	17190.9	5924.2	628.5	800.0	-727.8	700.7	0.41
1991	1696.4	19530.0	6811.0	705.8	692.8	-720.3	678.3	0.40
1992	1688.0	12908.0	4556.8	484.9	468.8	-610.1	343.6	0.20
1993	1863.4	15346.6	5923.6	626.1	370.5	-1833.6	-837.1	-0.45
1994	1804.8	9548.6	3466.4	277.2	147.5	-1093.7	-669.0	-0.37
1995	1714.4	9766.9	4037.1	314.4	167.3	-1665.9	-1184.2	-0.69
1996	1707.6	7338.1	3129.6	263.5	84.8	-1467.9	-1119.6	-0.66
1997	1718.7	8454.1	4308.6	383.2	33.5	-2300.6	-1884.0	-1.10
1998	1709.3	7016.8	3522.7	336.4	22.7	-1901.6	-1542.4	-0.90
1999	1654.3	5757.5	3110.7	338.7	12.2	-1773.3	-1422.4	-0.86
2000	1693.1	4980.6	2715.7	272.4	8.3	-1610.1	-1329.4	-0.79
2001	1702.7	5666.5	3290.4	302.1	9.8	-1978.9	-1666.9	-0.98
2002	1726.9	5552.2	3256.7	286.1	5.4	-1971.7	-1680.1	-0.97
2003	1588.5	4087.0	2316.7	221.6	4.7	-1486.9	-1260.6	-0.79
2004	1676.1	5579.8	3530.4	285.0	4.2	-2222.0	-1932.7	-1.15
2005	1617.0	5551.1	3411.2	285.7	4.4	-2115.9	-1825.9	-1.13
2006	1538.9	5345.6	3043.8	271.3	1.0	-1894.7	-1622.4	-1.05
2007	1542.9	2534.6	1331.7	119.7	0.8	-644.1	-523.6	-0.34
2008	1544.0	5948.6	3802.2	317.5	0.8	-2263.8	-1945.5	-1.26
2009	1580.4	4054.3	2676.9	232.6	0.7	-1611.5	-1378.2	-0.87
2010	1585.1	5194.3	3209.4	299.4	1.8	-1927.1	-1626.0	-1.03
2011	1581.1	5058.4	3265.8	299.3	3.2	-1994.1	-1691.6	-1.07
2013	1652.3	5556.1	3576.6	322.9	4.3	-2080.4	-1753.2	-1.07

The unfavorable situation on the chernozems quality state can be improved only by increasing the organic matter flow and implementation of conservative soil tillage. Unfortunately, organic fertilizers in the form of manure practically there are no exist recently. Now, the task is to replace manure as organic fertilizer with another alternative source - green manure. Certain it serves as motivation to recommend a crop rotation with five fields to include an "occupied field" with leguminous crops, autumn and spring vetch (2-3 vetch crops incorporated into the soil as green manure in the agricultural year on the every field of crop rotation once in 5 years). Crop rotation structure may be: vetch occupied field →corn →winter wheat → winter/barley → sun flowers. This procedure, used in frame of any tillage system of agricultural land will lead to forming an equilibrated balance of organic matter in the soil, to remediation quality state and increasing production capacity. The testing procedure was conducted in the 2013-2014 yrs on the territory of commune Ivancea, district Orhei.

Initial physical and chemical parameters of soil were studied in autumn 2012 until the founding of experience. Cambic chernozems is characterized by clayey-loamy texture, weakly differentiated in profile, middle-quality structural composition, moderate compaction of recently arable layer, strong compaction of horizons Bhw2 and Bhw1. Humiferous profile is decarbonated, humus content in arable layer is comparatively low and ranges between 3.2-3.5%. Data on green aerial and roots masses of two crops of vetch incorporated into soil are shown in *table 2*

Table 2

Total mass of organic debris and aerial roots of two crops of Vetch, incorporated into soil

Harvest	Dry mass, t/ha	Ash	N	P_2O_5	K_2O	C
		% of absolutely dry mass				
Total mass of organic debris	12.0	5.9	3.6	0.7	1.9	42.0

Influence of green fertilizers on soil characteristics plowing on 20 cm depth for incorporation of the first crop of spring vetch under furrow, and worked in spring with discs at 12 cm depth for incorporation into the soil the next crop of vetch is shown in *table 3*. The harvest of basic crop after incorporation into the soil two crops of vetch green mass is presented in *table 4.*

Table 3

Modification of the main features of arable layer of cambic chernozems
(Numerator - the initial parameters; Denominator - the changed parameters)

Horizon and depth (cm)	The balanced bulk density, g/cm^3	Total porosity, %v/v	Sum of favorable aggregate 10-0,25 mm, %	Hydro-stability of favorable aggregates, %	Humus (organic matter), % g/g	Mobile forms, mg / 100g soil	
						P_2O_5	K_2O
Ahp1 0-12	1.29 1.11	50.8 57.6	66.5 71.0	65.3 71.4	3.43±0.15 3.72±0.06	2.3±0.4 2.7	23±1 26
Ahp1 12-20	1.41 1.35	46.4 47.9	51.5 54.4	68.7 72.4	3.22±0.08 3.40±0.05	1.7±0.2 1.9	21±2 22
Ahp2 20-35	1.48 1.49	44.5 45.9	50.8 51.3	73.3 74.2	3.06±0.10 3.08±0.04	1.4±0.2 1,5	14±1 15
Ah 35-50	1.43 1.41	46.5 47.4	79.3 78.5	75.7 74.8	2.86±0.09 2.85±0.07	1.2±0.2 1,2	13±1 14

Table 4

Harvest of basic crops in 2013-2016 on the experimental variants after incorporation into the soil two crops of vetch aerial and roots green

Variant	Harvest on the evidence parcels (at 12% moisture)						Harvest growth rate compared to control	
	1	2	3	4	5	average	t/ha %	Probability essential difference , %
Year 2013, Corn, t / ha								
Control - Corn	6.2	7.1	5.9	6.3	6.5	6.4	-	-
I Year - Corn after Vetch	6.8	8.0	7.5	7.1	7.5	7.4	1.0 15.6	99.0
Year 2014, Winter wheat, t/ha								
Control - Winter wheat	4.2	3.8	3.9	4.1	3.9	4.0	-	-
II Year - Winter wheat after Vetch and Corn	5.9	5.9	6.1	5.9	5.8	5.8	1.8 45.0	99.0
Year 2015, Sun flower								
Control - Sun flower	1.5	1.2	1.4	1.5	1.4	1.4	-	-
III Year - Sun flower after Vetch	2.0	1.7	2.0	1.9	1.7	1.9	0.5 26.0	99.0
Year 2016, Winter wheat, t/ha								
Control - Winter wheat	4.8	4.5	4.9	-	-	4.7	-	-
IV Year - Winter wheat after Vetch and Corn	5.8	5.6	6.0	-	-	5.8	1.0 20.8	95.0

CONCLUSIONS

As result of incorporating in the arable layer of chernozem cambic in agricultural year 2012 two crops of vetch green mass about 12 t/ha of residues on a occupied field provided: accumulation in the soil of 430 kg of nitrogen, of which 260 kg fixed from the atmosphere; synthesis around 3 t/ha of humus or 1.7 t/ha of carbon; sequestration of about 6.3 t/ha of CO_2; a weakly positive balance of organic matter and nitrogen in the soil over a period of four years; an increase of maize crop of about 1 t/ha in the I year, 1.8 t/ha of winter wheat in the II year, 0.5 t/ha of sunflower in the III year and 1 t/ha of winter wheat in the IV year after incorporation into the soil of green mass of vetch.

Systemic use of green manure couple with phosphorus and potassium fertilities may partially restored gradually the quality of physical, chemical and biological status of soil and increase sufficiently the capacity of their agricultural production. The problem consists in development and implementation of a system that will use this procedure.

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