Scientific Papers. Series A. Agronomy, Vol. LVI, 2013
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

DEGRADATION OF ORDINARY CHERNOZEM IN THE SOUTH OF MOLDOVA AND PHYTOTECHNICAL MEASURES TO REMEDY OF THEIR FERTILITY

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Abstract

The existing system of agriculture in the Republic of Moldova led to humus losses, compaction of arable layer and decrease of its resistance to degradation factors. Researches established that only radical corrective factor to cardinal remediate the degraded characteristics of chernozems is that which leading to the formation of this type of soil - steppe vegetation composed by grasses and legumes herbs with fasciculate root system. The chernozems with whole profile, being grassed 15 years in a system without utilization of vegetal aerial mass, recovered 70 percent of humus content in the profile and restore the initial soil typical characteristics. Lucerne with its pivoting root system contributed poorly to remediation the structure and increasing the content of organic matter in soils. Resulting from the fact that in the Moldova is excluded the possibility to cardinal remediation the soil quality status by grassed (0.4 hectares of arable land per capita) has decided to develop and test phytotechnical methods to remedy the soil characteristics without interrupting the production process from agriculture.

Key words: *soil degradation, phytotechnical measure, structure remediation.*

INTRODUCTION

Degradation of the physical, chemical and biological properties of Moldovan chernozems contributes to the extension of the land desertification processes and decreases the volume of agricultural production in the country. The existing system of agriculture does not ensure long-term preservation of soil quality status and lead to worsening economic and environmental situations. To overcome this situation is possible only through the gradual implementation the system of conservative agriculture, based primarily on the use of natural and biological resources, renewable household sources and only the second on purchased inputs. Preserved internal resources, soil with its attributes, water, and biodiversity are important features of sustainable agriculture and therefore combating the soil degradation and land desertification (Cerbari, 2011).

In the absence of the necessary volume of organic fertilizers to remediate the degraded soil characteristics, the only way to preserve their quality status are agrophytotechnical measures-environmentally friendly farming practices. Methods of implementation of environment friendly practices as part of the mandatory sustainable agriculture to protect soil can be established by special research, extensive and lengthy. Sustainable agriculture is defined as an integrated system of agricultural practices of crop and animal production, environmental friendly, adapted to local specificities, in the long term, provides human needs of food and other agricultural products, improving the environment and soil fertility, efficient use of renovated resources, improving quality of life (Doran, Parkin, 1996; Leah, 2012).

Purpose of the research is intended to develop and test environmentally friendly agrophyto-technical methods that will ensure to remedy the physical and chemical properties of chernozems in the agricultural production process, contribute to long-term preservation of their quality that will lead to increased volume of agricultural production.

MATERIALS AND METHODS

To assess the changes in status of physical and chemical properties of the arable ordinary chernozems under the influence of different

agrophytotechnical environmentally friendly practices and measures were founded four experimental parcels in which were tested the variants:

1. Lucerne + Ryegrass;
2. Sainfoin + Ryegrass;
3. Winter vetch (as successive crop);
4. Manure 50 t/ha (once in 5 years).

The experimental parcels were located on the field presented by a broad ridge quasi horizontal and homogeneous surface covering by arable ordinary chernozems.

The geographical locations of the experimental parcels were established in the form of strips with 7-10 m in the width and 500-700 m in the length (Figure 1).

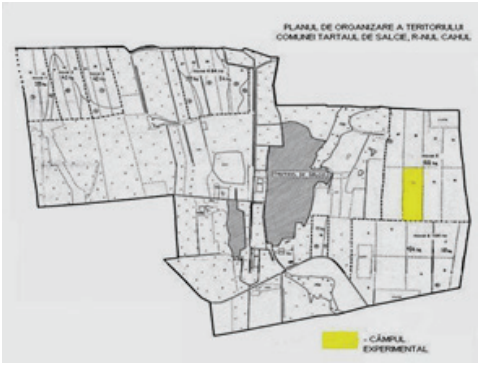

Figure 1. Experimental field lots location

In the center of experimental plots (strips) until the beginning of the experience were located one profile (Figure 2) and four semi profile of soil to assess the initial state of physical and chemical characteristics of experimental soil on the parcels.

The researches concerning morphological, physical and chemical properties of soils were performed according to conventional classical methods. Determination of roots in the studied soils was performed by washing soil samples as small monoliths by weight 4-5 kg. Annual crop size was performed on parcels of 1 m² surface for grass and cereals and 10-15 m² for maize and sunflower.

The obtained data were processed by different statistical methods using MS Excel program.

Figure 2. Profile of the ordinary chernozem

RESULTS AND DISCUSSIONS

Researches conducted on these problems showed the massive damage of natural structure of arable soils, initially excellent (Cerbari, Balan, 2010).

Maintaining a positive balance of humus contributes to remedy of soil quality status that is possible through the systematic introduction of organic fertilizers into arable land and the perennial herbs in the composition of which dominate grasses as a green manure. Given decreasing cattle numbers in 6 times, the accumulated quantities of manure are respectively in 6 times smaller than 20 years ago. Unfortunately these small quantities of organic fertilizers not used on the land for agricultural purposes. There was need to find other alternative sources of organic fertilizers to restore the soil fertility of degraded characteristics (Cerbari, et al., 2012; Shein, Milanovsky, 2002; Боронтов, 2004). The best conditions suited and effective sources of organic fertilizers for Moldova are green fertilizer used as intermediate crops. As a result of preliminary investigations carried out that winter and spring vetch are the best green manure for the chernozems as an intermediate crop used in agricultural rotation (Возняковкая, et al., 1988; Цандур, et al., 2011).

1. The initial parameters of ordinary chernozems characteristics.

The purpose of founding experimental strips is to develop and test the agrophytotechnical measures for remediation the state of degraded arable layer of ordinary chernozems while increasing their agricultural production capacity. Strips – variants with: Sainfoin + Ryegrass, Lucerne + Ryegrass and Manure, were founded in the spring of 2010. The variant with winter vetch was established (sown) in autumn 2009 and harvested 28 t/ha of green mass was incorporated into the soil as green manure in august of 2010. In September this parcel was prepared and sowing with winter wheat.

Initial parameters of investigation soil were carried out in autumn until to founding the experience. Data concerning the initial parameters of the investigated chernozems characteristics are presented in table 1-4.

Due the coarser texture, silt clay loam, with fine clay contain lower than chernozems from central Moldova, the ordinary chernozems are characterized by a more favorable state of physical quality. On the other hand, ordinary chernozem in the South of Moldova are less content of humus and poorer in the nutrients than central chernozems.

2. Modification of quality status of arable layer of ordinary chernozems under the influence of vetch as green manure.

In the experience was tested incorporation into the soil a crop of vetch green mass in size of the 28 t/ha that are equivalent to 6.1 t/ha of absolutely dry mass containing 4.2% nitrogen (Figure 3).

In result of this measure the content of organic matter in arable layer 0-25 cm of soil, increased by 0.19%, the soil structural status was improvement and the mobile phosphorus content increased.

The action of incorporation into the soil a mass of vetch as green manure increase the harvest of winter wheat with 1.3 t/ha of cereal units (Figure 4, Tables 5-7).

Table 1. The texture of the arable ordinary chernozem

Horizon and depth (cm)	Dimension of fractions (mm), content (%)						
	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	< 0.001	< 0.01
Ahp1, 0-25	0.8	16.6	33.5	8.1	10.0	31.0	49.1
Ahp1, 25-34	0.8	16.6	33.5	7.3	11.1	30.7	49.1
Ahk, 34-49	0.6	15.5	33.9	8.2	11.0	30.8	50.0
Bhk1, 49-71	0.5	9.9	38.2	8.9	11.5	31.0	51.4
Bhk2, 71-96	0.5	8.1	40.0	8.2	11.8	31.4	51.4
BCk, 96-120	0.4	7.0	41.3	8.1	12.2	31.0	51.3
Ck, 120- 150	1.1	7.1	40.2	9.2	12.6	29.8	51.6

Table 2. Structural composition of the ordinary chernozems (numerator - dry sifting, denominator - wet sifting data)

Horizon and depth (cm)	Diameter of structural elements (mm) and content (%)				Quality of structure (dry sieve)	Hydro-stability of structure
	> 10	< 0.25	Sum 10-0.25	Sum >10+ < 0.25		
Ahp1 0-25	35.5 / -	14.0 / 70.2	50.5 / 29.8	49.5 / 70.2	medium	small
Ahp2 25-34	57.0 / -	2.9 / 75.2	40.1 / 24.8	59.9 / 75.2	medium	small

Table 3. Physical properties of the arable ordinary chernozems

Horizon and thickness (cm)		Hydro-scopicity coefficient	Den-sity	Total poro-sity	Degree of com-paction
		%	g/cm^3	%	
Ahp1	25	6.8	2.59	49.4	3
Ahp1	9	6.0	2.60	44.2	13
Ahk	18	5.8	2.63	49.0	4
Bhk1	23	5.8	2.65	47.9	7
Bhk2	25	5.4	2.67	47.6	7
BCk	19	4.7	2.68	-	-
Ck	30	4.3	2.70	-	-

Table 4. Chemical characteristics of genetic horizons of the arable ordinary chernozem

Horizon and thickness, cm	pH (H_2O)	$CaCO_3$	P_2O_5 total	Humus	N total	C : N	Mobile forms (mg/100 g soil)	
	%					P_2O_5	K_2O	
Ahp1 0-25	7.1	0	0.139	3.16	0.208	8.8	1.6	21
Ahp1 25-34	7.2	0	0.111	3.11	0.202	8.9	1.0	18
Ahk 34-49	7.3	0	0.080	2.85	0.190	8.7	0.8	14
Bhk1 49-71	7.6	1.4	-	2.60	-	-	-	-
Bhk2 71-96	7.8	4.0	-	1.84	-	-	-	-
BCk 1 96-120	7.9	6.6	-	1.00	-	-	-	-
BCk 2 120- 150	8.0	8.0	-	0.61	-	-	-	-

Figure 3. The strip with vetch, 2010

Figure 4. The strip with winter wheat sown in soil after incorporation of vetch green mass

Table 5. Winter wheat yield on the parcel fertilized with green mass of vetch (numerator) and on the adjacent unfertilized variant (denominator)

No. of plots 15 m²	Harvest (t/ha)	Average harvest (t/ha)	Growth rate of the harvest (t/ha)
1	4.2/2.8	4.2/2.9	+1.3
2	4.2/2.9		
3	4.1/3.0		
4	4.3/2.8		
5	4.4/2.9		

Table 6. Modification of the characteristics of arable layer of ordinary chernozem in result of incorporation into the soil the vetch as a green manure (numerator-the initial parameters, denominator – the modification characteristics)

Horizon and depth, cm	Balanced apparent density (g/cm^3)	Total porosity (%)	Sum of aggregates 10-0.25 mm (%)	Hydro-stability (%)	Humus (%)	Mobile forms (mg/100g soil)	
						P_2O_5	K_2O
Ahp1 0-10	1.25 1.21	51.7 53.3	50.5 68.8	29.8 43.4	3.16 3.36	1.6 1.9	21 21
Ahp1 10-25	1.35 1.30	47.9 49.8			3.16 3.34	1.6 1.8	21 21
Ahp2 25-34	1.45 1.43	44.2 45.0	40.1 41.5	24.8 38.6	3.11 3.06	1.5 1.4	18 18
Ahk 34-49	1.34 1.35	49.0 48.7	-	-	2.85 2.90	0.8 0.9	14 14

Table 7. Vetch harvest on the arable ordinary chernozem

Green mass yield (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				
28	78.2	6.1	5.6	11.4	4.12	1.00	2.38	35.1
Roots of 0-30 cm layer		5.6	-	19.7	1.51	0.27	0.85	28.7

3. Modification of the quality status of arable layer of ordinary chernozems under the influence of manure.

As a result of soil incorporation of 50 t/ha of fermented sheep manure in the arable layer 0-25 cm of soil the organic matter content increased by 0.20%. Simultaneously there is a tendency to improve the structural status of the soil and increase mobile phosphorus content (Table 8). Incorporation in the soil of 50 t/ha manure of sheep led to the increase of sunflower harvest by 0.4 t / ha (Table 9).

Table 8. Modification of the features of arable layer of ordinary chernozem as a result of incorporation of 50 t/ha of sheep manure into the soil (numerator-the initial parameters, denominator-modified parameters of soil)

Horizon and depth (cm)	Balanced apparent density (g/cm^3)	Total porosity (%)	Sum of favorable aggregates, 10-0.25 mm (%)	Hydrostability of favorable aggregate (%)	Humus (organic matter) (%)	Mobile forms (mg/100g soil)	
						P_2O_5	K_2O
Ahp1 0-10	1.25 1.23	51.7 52.5	50.5 57.5	29.8 31.8	3.16 3.37	1.6 1.9	21 22
Ahp1 10-25	1.35 1.33	47.9 48.6			3.16 3.35	1.6 1.8	21 21
Ahp2 25-34	1.45 1.43	44.2 45.0	40.1 42.1	24.8 25.8	3.11 3.16	1.5 1.5	18 19
Ahk 34-49	1.34 1.35	49.0 48.7	-	-	2.85 2.87	0.8 1.0	14 16

Table 9. Harvest of sunflower (absolutely dry mass) on the variant fertilized with 50 t/ha of sheep manure (numerator) and the adjacent unfertilized variant (denominator)

No. of parcel 15 m^2	Harvest on the parcel (kg)	Harvest (t/ha)	Average harvest (t/ha)	Growth rate of the harvest (t/ha)
1	3.5/2.8	2.3/1.9	2.4/2.0	+ 0.4
2	3.7/3.0	2.5/2.0		
3	3.7/3.0	2.5/2.0		
4	3.3/3.0	2.2/2.0		
5	3.6/2.9	2.4/1,9		

4. The influence of mixture of perennial grasses and grass hay sown on soil quality.

The influence of perennial herbs and grasses mixture sown as hay, on the soil quality status after the first and second years of vegetation is relatively small and will be assessed in the coming years. Visual and quantitative assessments are possible finding that in the condition of South Moldova the productivity of Sainfoin + Ryegrass mixture is much higher than Alfalfa + Ryegrass mixture productivity.

In the 2011 the harvest of green mass of Sainfoin + Ryegrass at about 80% humidity was equal to 35 t/ha (7 t/ha absolutely dry mass) and Alfalfa + Ryegrass at 76% humidity-17 t/ha (4 t/ha absolutely dry mass).

In the 2012 – a very drought year, the harvest of green mass of Sainfoin + Ryegrass mixture at the 72% humidity was equal to 18 t/ha (5 t/ha of absolutely dry mass) and Ryegrass + Alfalfa mixture at 69.5% humidity-10 t/ha (3 t/ha of absolutely dry mass).

Under the action of perennial Sainfoin + Ryegrass and Lucerne + Ryegrass mixtures in the second year of vegetation was shown a beginning process of remediation of degraded characteristics of arable layer of ordinary chernozems in the south of Moldova.

Drought of 2012 led to total loss of the corn grains crop on the all fields of country and experimental strips-variants, sown with this crop. Harvest of perennial grasses in the 2012 year decreased by 40-43 percent compared to 2011 year (Figure 5).

Figure 5. Strip with ryegrass + alfalfa in the third year of harvest (2012)

CONCLUSIONS

Given the fact that in the Republic of Moldova the remediation action of the soil quality status by grassing is excluded (0.4 hectares of arable land per capita) has decided to develop and test methods to remediate the soil characteristics without interrupting the agriculture production process.

Research has established that:

- the cardinal factor to radical remediate the degraded characteristics of chernozems is that which leading to the formation of this type of soil – the steppe vegetation when in its components dominate the grasses and legumes with fasciculate root system;

- the chernozems with whole profile being fallow during 15 years in the agricultural system without utilization of aerial mass, have;
- recovered 70 percent of the humus profile and initial typical soils characteristics;
- alfalfa with pivoting root system contributes slightly to remediation the structure and content of organic matter in soils.

Following use the ordinary chernozem under mixture perennial grasses and legumes (alfalfa+ryegrass), the crop production which used as fodder, it was established that this process along 5 years positive influenced the changes in the quality status of arable layer of degraded chernozem:

- in result of return in the 0-35 cm soil arable layer of about 25.5 t/ha of organic residues absolutely dry (annual 5.1 t/ha with average nitrogen content 1.9%) were created allowed the synthesis of about 5.6 t/ha of humus (1.1 t/ha annually); organic matter content in this layer increased on average by about 0.20% or 0.04% annually;
- the 0-12 cm soil layer, formed through disking, enriched with organic matter (0.43% in 5 years or 0.09% per year), became biogenic, and sufficient improved the structural layer, began the formation of follow stratum with thick of 3-5 cm.

Wide implementation of the remediation technology to restore the quality status of chernozems is possible only if the livestock sector will be restoration and allocation in perennial grasses about 13-15 percent of land or 200 thousand ha.

Direct economic effectiveness of technology:

- annual spending a whole 5 years of growing alfalfa + ryegrass mixture is 2300 MDL;
- annual net income is about 5500 lei/ha per year;
- annual net income as possible for the country on the surface of 200 000 ha-1100 million MDL.

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