

COVER CROPS - KEY TO STORING ORGANIC MATTER AND REMEDiation OF DEGRADED PROPERTIES OF SOILS IN MOLDOVA

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Abstract

The existing system of agriculture in the Republic of Moldova has led to decreasing the humus content, destructuring of arable soil layer and loss of its resistance to compaction. Remediation of degraded chernozem characteristics can be achieved by phytoameliorative methods requiring cultivation of grasses and legumes with fasciculate root system. Given the fact that in the Republic of Moldova is excluded remediation of soil quality status by the method outlined (0.4 ha of arable land per capita) were developed and tested methods for remediation of soil characteristics without interrupting the agricultural production process. As a result of cultivation the mixture of perennial legumes and grasses herbs, the crop which was used as fodder production, it was established that this mixture of herbs over a period of 4-6 years had a positive influence on the quality state of degraded arable layer of chernozems: increased organic matter content, improved structural condition, began forming a fallow layer of 4-5 cm. Restoring characteristics of arable layer of chernozems by tested technology can be achieved in a period of 15 - 20 years. Implementation of this method to remedy the quality state of chernozems is only possible when restoring the livestock sector and allocation under perennial grasses at least 15 percent of agricultural land.

Key words: cover crops, organic matter, remediation, soil degradation, Moldova.

INTRODUCTION

Previous researches regarding to intensive agriculture in Moldova were focused on the cultivation of alfalfa in crop rotations, which were developed intensive technologies effective in favorable conditions of moisture.

The intensification of droughts and land degradation processes in recent decades requires searching for new technologies to combat soil degradation and plant varieties resistant to drought conditions. Degradation processes manifested by loss of organic matter, secondary compaction and damage structure of arable layer (0-35 cm) of soils adversely affecting the quality and capacity of their production (Cerbari et al., 2013a).

Investigations on soil quality monitoring showed that alfalfa in a vegetation period of five years contribute to the stabilization of a equilibrated balance of humus in the soil, but does not lead to improving the structure and reducing the compaction of arable layer. Chernozems, being 15 years in a fallow system of non-used the aerial herb mass, have achieved about 70 percent of humus content and the

features of the natural non-degraded soils. (Cerbari and Balan, 2010).

The mixture of perennial grasses and legumes, having as main ecotypes of spontaneous genetic resources, have been shown to be resistant to frost, drought, disease and pests, with a high production of grasses for grazing and mowing (Cerbari and Ciolacu, 2013; Dragan et al., 2009; Moga, 1993). In recent years has been undertaken research aimed at establishing the phytotechnological measures to limit the negative effects of the phenomenon of arable soil compaction by using mixtures of forage grasses (Cerbari et al., 2012; Leah and Cerbari, 2013, 2013a).

Currently in Moldova are difficulties with the production of fodder plant seed, a problem that needs to be solved in the future, with the expansion of sown pastures and establishment of specialized farms in seed production of perennial grasses and legumes. Solving this problem would contribute to the improvement of soil fertility by increasing organic matter and restore degraded structure by compaction.

MATERIALS AND METHODS

The purpose of research was the development and testing the technological procedures and maintaining long-term remediation of quality status of arable chernozems. The object of the research was Chernozem Cambic (Leachate) of Central Moldova (Ivancea, Orhei district).

Field experiments were built up of strips (width 7-10 m, length 500-700 m) with the variants: *Control (arable)*; *Ryegrass + Lucerne* (band founded in 2007); *Ryegrass + Sainfoin* (band founded in 2010). To assess the initial state of degraded soil characteristics were placed one soil profile on each strip. Researches regarding the morphological, physical and chemical properties of soils were carried out according to conventional methods approved for pedological researches in the field and laboratory.

Chernozem Cambic. The soil horizon Ah as a result of dehumification and damage of structure was compacted and characterized by unfavorable physical properties. Profile of humus (Ah + Bh) horizons and sometimes the top of horizon (BC) was leached of carbonates. The Bh horizon was characterized by reddish-brown hue, in the result of alteration "*in situ*" of the minerals.

Chernozem Cambic was characterized by loam-clay texture poorly differentiated in the profile, middle quality of structural composition, moderate compaction of arable layer and strong compaction of Bh horizon.

The humus content of Chernozem Cambic constituted: 3.2-3.5%. Investigated soil was moderately provided with mobile forms of phosphorus and potassium. Hydrolytic acidity - from 1.7 to 2.5 *me*, the content and composition of exchangeable cations on the adsorption complex were typical for chernozems of Moldova. The amount of cation exchange capacity ranging from 31 *me* in the Ahp1 horizon to 22 *me/100 g* in Ck horizon of soil.

The main factors of soil degradation in the Central zone of Moldova are dehumification, destructuration, secondary compaction of arable layer, decreasing reserves of nutrients, strong compaction of postarable layer of soil.

RESULTS AND DISCUSSIONS

Herb mixture (Ryegrass+Lucerne) cultivated 6 years. More than six years after the establishment of the herbal strip was made a general assessment of soil characteristics changes under the influence of root system and organic debris remaining on the soil surface after mowing of perennial grasses (about 25% of the crop harvest). Total harvest of green mass of herbs on the strip (*ryegrass+lucerne*) was 187 t/ha (or 31 t/ha per year). The total mass of organic residues accumulated in the soil during 6 years (2008-2013) on the experimental strip was 33.6 t/ha of absolutely dry mass (Table 1).

Table 1. Total harvest of perennial grasses (*ryegrass+alfalfa*) over a period of 6 years

Harvest	Green mass, t/ha, humidity 75%	Dry mass, t/ha	Grain units, t/ha	N, %	P ₂ O ₅ , %	K ₂ O, %
Total	187	46.7	29.9	2.48	0.57	1.90
Annual	31	7.8	5.0			
Mass of plant debris and roots left in the soil						
Total	-	28.8	-	1.91	0.35	0.91
Annual	-	4.8	-			

As a result of research, it was shown that in the soil layer (0-35 cm) of the strip with perennial grasses (*ryegrass+alfalfa*) in a period of 6 years in soil returned about 30 t/ha of organic debris and roots, in absolute mass dry (or 5 t/ha per year), the average nitrogen content 1.9%. In the period of 6 years, under the influence of the mixture of perennial herbs, grasses and legumes, organic matter reserves in the 0-12 cm layer of leached chernozem increased by 6.3 t/ha. Organic matter content in the 0-12 cm disking soil layer increased by 0.43%, in the 12-20 cm layer - 0.11%, in the 20-35 cm - 0.06% (Figure 1).

Intensification of the organic matter flow in the soil layer (0-12 cm) led to a partial remediation of soil structure, increase the hydrostability of favorable agronomic aggregates, decrease the bulk density (Table 2). As a result of utilization of alfalfa and ryegrass mixture for six years the quality state of 0-12 cm soil layer formed by disking has been positively modified: enriched with organic debris; improved structural status; began forming the follow layer about 4 cm thickness. But the problem that needs solving is the full restoration of quality status of compacted 0-35 cm arable layer.

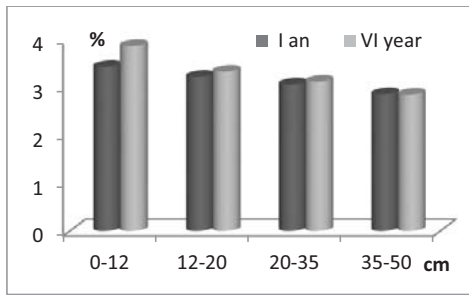


Figure 1. The content of humus in the soil of strip (ryegrass + alfalfa)

Table 2. Modification of Cambic Chernozem properties under the influence of *Ryegrass*+*Alfalfa* in a period of 6 years (*- initial parameters, ** - modified parameters)

Horizon, depth, cm	Bulk density, g/m ³	Total porosity, %	Favorable aggregates sum (10-0,25 mm), %	Hydro-stability of favorable aggregates, %
Ahp1 0-12	1.29*	50.8	66.5	65.3
	1.22**	53.4	69.0	73.0
Ahp1 12-20	1.41	46.4	51.5	68.7
	1.38	47.5	54.7	75.4
Ahp2 20-35	1.48	44.5	50.8	73.3
	1.44	45.9	52.7	78.2
Ah 35-40	1.43	46.5	79.3	75.7
	1.41	47.4	77.6	75.4

Herb mixture (*Ryegrass* + *Sainfoin*) - 4 years.

Research conducted on the strip of grasses (*ryegrass*+*sainfoin*) demonstrated that in a period of 4 years have seen positive changes in the soil layer 0-12 cm: improved structural status, began the process of fallow layer, reaching a thickness 3 cm.

According to the results, in the soil of strip (*ryegrass* + *sainfoin*) in four years was return about 17.8 t/ha of organic debris (annual 4.5 t/ha) with average nitrogen content 2.1%. Organic matter content in the 0-12 cm disking soil layer increased by 0.37%, in the 12-20 cm layer - 0.11%, in the 20-35 cm layer - not increased, 0.02% (Figure 2).

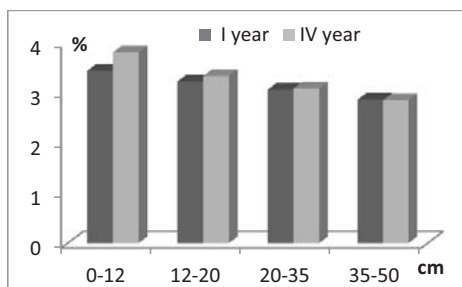


Figure 2. The content of humus in the soil of strip (*ryegrass* + *sainfoin*)

Intensification of the organic matter flow in the soil layer (0-12 cm) led to a partial remediation of structure, increase hydrostability of favorable agronomic aggregates, decrease bulk density (Table 3).

Table 3. Modification of Cambic Chernozem properties under the influence of *Ryegrass* + *Sainfoin* in a period of 4 years (* - initial parameters, ** - changed parameters)

Horizon, depth, cm	Bulk density, g/m ³	Total porosity, %	Favorable aggregates sum (10-0,25 mm), %	Hydro-stability of favorable aggregates, %
Ahp1 0-12	1.29*	50.8	66.5	65.3
	1.21**	53.8	71.6	70.9
Ahp1 12-20	1.41	46.4	51.5	68.7
	1.35	48.7	55.4	72.4
Ahp2 20-35	1.48	44.5	50.8	73.3
	1.48	44.5	51.3	74.2
Ah 35-40	1.43	46.5	79.3	75.7
	1.41	47.4	78.5	75.4

The harvest of sainfoin and ryegrass mixture on the strip was very low in the first year (the biology growth particularities of this culture in the first year), lower - in the second year (severe drought), high - in the third and fourth year.

The mixture of herbs was in good condition and provided a great harvest in the fifth year. A negative part of the process of restoring soil quality status by sowing the mixture of sainfoin and steppe ryegrass is that after the third year the sainfoin completely overshadows the ryegrass and as a result, in the fourth year this plant practically disappears, that do not happens when was growing alfalfa and steppe ryegrass mixture.

Introduction into a five fields rotation the field sown with alfalfa and ryegrass or sainfoin and ryegrass is an effective method of restoring quality state of physical, chemical and biological properties of degraded arable layer of soils, and maintaining in this layer a balanced or slightly positive balance of carbon and humus. The problem is to restore the livestock sector, to have consumers of perennial grasses if the area occupied by these crops will be increased.

The total and stable remediation of degraded properties of Cambic Chernozem in the Central part of Moldova by using herbal mixtures can be achieved in a more long period - 15 to 20 years. Technology remediation of quality status of chernozems is required to be implemented at present on about 250,000 ha (13-15% of the

territory). It is mandatory for growing perennial grasses surface fodder needed to restore the livestock sector and creation the conservation agriculture system in Moldova.

In the Central Moldova the cultivation of sainfoin and steppe ryegrass mixture as a measure to remediation the quality status of chernozems is necessary to implement simultaneously with the cultivation of alfalfa and steppe ryegrass mixture. Direct economic efficiency of perennial grasses growing is ensured to feed production at least 4 t/ha/year of unit grain. Annual net income is about 5000 LMD/ha (or 250 Euro/ha).

Expanding the culture of drought-resistant species have a positive economic impact on farmers, which can provide necessary of feed in this way with reduced inputs. In addition to obtain high yields of feed mixtures should be noted that sainfoin as a perennial legume has an important role on the soil amelioration, do not require nitrogenous fertilizer, issue nitrogen into the soil for next plant, uses nitrogen leached into the soil at greater depths. These are good reasons of perennial grasses which fits perfectly into the modern concepts of conservative and organic farming in Moldova.

The ecological effectiveness of technologies is manifested by: formation of preconditions for implementation of sustainable agriculture that protects the soil, concomitantly with achieving the high and quality fodder production; ensuring a equilibrated or slightly positive balance of organic matter in the soil; gradual restoration of physical, chemical and biological status of soil.

CONCLUSIONS

Mixtures of grasses *alfalfa* + *steppe ryegrass* and *sainfoin* + *steppe ryegrass* ensures high production of fodder - 4 ton of dry matter per hectare in Central part of Moldova.

Increasing the organic matter flow in soil cultivated with perennial grasses mixture (*alfalfa* + *ryegrass*) and (*sainfoin* + *ryegrass*) -

4-6 years, led to positive changes in organic matter content, favorable modification in physical and chemical properties.

Cultivation of fodder mixtures (the suitable concept of organic farming) is achieved with low consumption of fertilizer and without herbicides, have a positive economic impact on the farmers.

The experimental results justify the extension of alfalfa, sainfoin and steppe ryegrass mixtures as ameliorative crops of degraded properties of arable soil layer, as fodder species with superior behavior during drought conditions.

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