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SOIL BIOTA AS A NATURAL RESOURCE FOR THE RESTORATION OF DEGRADED CHERNOZEMS

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Abstract: *The role of biota as a natural resource for the restoration of degraded chernozems of the Republic of Moldova is under discussion till nowadays. The status of biota of old-arable chernozems in conditions of the green manure applications has been evaluated statistically. Two experimental sites located in the central and southern zone of the Republic of Moldova have been tested by soil biological indicators during 2010-2012. The application of vetch as a green manure had created conditions for the improvement of the biota's vital activity in chernozems which had been degraded as a result of a long-term arable use. The number of invertebrates increased from 48.1-55.0 to 71.6 - 78.0 ex m^{-2}, the number of Lumbricidae family – from 25.6-38.0 to 43.3-68.0 ex m^{-2}. The effect of green manure was manifested in the increase of share of Lumbricidae family in the total number of invertebrates by 12.1-20.8 %. The microbial biomass content in the arable layer of soils rose up in average by 1.4-1.5 times. The humification processes intensified as a result of the interaction between the fresh organic matter and the soil biota. Biological parameters did not reach the level of soils under natural vegetation. Management with the green manuring for the biota's restoration of degraded soils and for the improvement of soil quality and environment has been recommended.*

Key-words: *soil biota, green manure, degraded chernozem*

INTRODUCTION

Biota, as an essential component of soils, participates in the processes of pedogenesis, water-stable structure formation, self-purification from contaminants, nutrient cycling, energy cycle, maintains the homeostasis [1, 2 and 15]. The main role of soil biota relates to organic matter mineralization and formation of humus. Indices of soil invertebrates and microorganisms are the global indicators of soil quality [4, 5 and 9].

Soil biota should be considered as a component of the integrated management of natural resources and a natural source for the restoration of degraded chernozems. The traditional sources of organic matter for the degraded soils are organic fertilizers (different types of animal manure) and plant residues, which serve as raw material for the formation of the humic substances [11]. These methods are oriented towards the creation of conditions for the activation of the natural biota of degraded soil [12]. The way to support the functioning of soil biota, to increase the level of biodiversity and resistance of soils used for a long time as arable is the cultivation of leguminous cultures as a green manure [13]. The specific properties of green manure organic matter are the high humidity of green plants (70-90%) and the high content of cellular proteins enriched by carbon and nitrogen with a ratio of C: N = 17, readily available to the microbial decomposition. Domsch [8] compares the rapid multiplication and increased activity of soil microorganisms after incorporation of green manure with glucose effects, which are metabolized easiest among all substances in the soil.

This method can be used for the improvement of soil quality of chernozems degraded as the result of the long-term agricultural utilization.

The purpose of the research was to determine the influence of the green manure application on the biota for the improvement of soil quality and environmental certifications of degraded chernozems.

MATERIAL AND METHODS

Experimental sites and soils. Our comparative study has been performed in two zones of the Republic of Moldova. Land management practices with the application of green manuring

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(vetch) in the condition of long-term field experiments have been analyzed. Researches were carried out during the period between 2009 and 2012 years.

The first site was located in the center of the country, in the Ivancha village, Orhei region. The long-term arable soil with crop rotation without fertilizers (control) and green manure treatments was tested. Vetch was planted twice in 2009 and in 2010 and its green mass in the amount of 19 t ha^{-1} was plowed under disc in 2010. The soils were the leached chernozem with humus content of 3.43 % and pH = 6.6 in the 0-25 cm layer.

The second site was located in the southern zone, in the Tartaul de Salchie village, Cahul region. There were the plots with long-term arable soil (control) and with green manure treatments. Vetch was used once as a green manure. Vetch was planted in the autumn of 2009 and its green mass in the amount of 28 t ha^{-1} was plowed under disc in July 2010. The soil was the ordinary chernozem with humus content of 3.16 % and pH = 7.1 in the 0-25 cm layer [7].

Soil samples for the determination of microbiological and enzymatic properties were collected from the 0-25 cm layer of the experimental plots during 2010-2012.

Status of invertebrates. The state of invertebrates was identified from test cuts by manually sampling the soil layers to the depth of soil fauna occurrence applying Gilyarov and Striganova's method [10].

Microbiological properties. The microbial biomass carbon was measured by the rehydratation method based on the difference between carbon extracted with 0.5 M K_2SO_4 from fresh soil samples and from soil dried at 65-70^oC for 24h, with K_c coefficient of 0.25 [3]. K_2SO_4 - extractable carbon concentrations in the dried and fresh soil samples were measured simultaneously by dichromate oxidation; K_2SO_4-extractable carbon was determined at 590 nm using a СФ 46 spectrophotometer. Counts of microorganisms (heterotrophic bacteria, actinomycetes, fungi and polysaccharides-forming microorganisms) were obtained on agar plates [14].

Biological indices were evaluated statistically using the variation analysis. Statistical parameters of the state of soil invertebrates were calculated taking into account the depth of soil fauna occurrence, microorganisms – for the layer of 0-25 cm.

RESULTS AND DISCUSSIONS

A favorable effect of the green manure management on invertebrates in the leached and ordinary chernozem has been noted both as the average values of indicators and as the confidence intervals. The number of invertebrates in the leached chernozem increased from 55.0 to 78.0 ex m^{-2}, the number of earthworms – from 38.0 to 68.0 ex m^{-2} in comparison with the control plot (Table 1).

Table 1. Status of invertebrates in the leached chernozem in conditions of the land management with green manure

Index	**Unit**	**Mean value**	**Experimental value**		**S^2**	**V, %**	**Confidence interval (P ≤ 0.05)**	**n**
			min	max				
Control								
Number of invertebrates	ex m^{-2}	55.0	8.0	120.0	966.2	56.5	35.2-74.8	12
Number of *Lumbricidae* family		38.0	8.0	112.0	781.1	73.6	20.2-55.8	12
Biomass of invertebrates	g m^{-2}	13.3	1.6	48.8	235.4	115.4	3.5-23.1	12
Biomass of *Lumbricidae* family		8.3	0.8	48.0	197.3	169.3	0-17.2	12
Green manure (vetch)								
Number of invertebrates	ex m^{-2}	78.0	48.0	128.0	1048.0	41.5	44.0-112.0	6
Number of *Lumbricidae* family		68.0	40.0	120.0	1171.2	50.3	32.1-103.9	6
Biomass of invertebrates	g m^{-2}	9.0	4.0	14.4	30.1	60.9	3.2-14.8	6
Biomass of *Lumbricidae* family		8.3	3.2	13.6	31.2	67.3	2.4-14.2	6

The number of invertebrates in the ordinary chernozem rose from 48.1 to 71.6 ex m^{-2}, the number of *Lumbricidae* family – from 25.6 to 43.3 ex m^{-2} (Table 2).

The biomass of invertebrates and *Lumbricidae* family in the leached chernozem remained practically unchanged, while the biomass of invertebrates and earthworms in the ordinary chernozem increased by 1.3-1.4 times when the green manure was applied.

The dominant position in the complex of invertebrates occupies the *Lumbricidae* family. The share of *Lumbricidae* family in the total population increased from 69.1% to 87.2% in the leached chernozem and from 53.2% to 60.5% in the ordinary chernozem by the application of green manure.

A maximum number of invertebrates and earthworms in the soil was registered in spring, the minimum – in autumn. It is not only due to the reduction of the fresh organic matter in the soil but also to the decrease of moisture content in the root layer (0-40 cm) in autumn.

Table 2. Status of invertebrates in the ordinary chernozem in conditions of the land management with green manure

Index	**Unit**	**Mean value**	**Experimental value**		**S^2**	**V, %**	**Confidence interval (P ≤ 0.05)**	**n**
			min	max				
Control								
Number of invertebrates	ex m^{-2}	48.1	16.0	96.0	667.1	53.7	31.7-64.5	12
Number of *Lumbricidae* family		25.6	0	56.0	408.3	78.9	12.8-38.4	12
Biomass of invertebrates	g m^{-2}	7.6	0.8	22.4	52.7	95.5	3.0-12.2	12
Biomass of *Lumbricidae* family		6.2	0	20.8	56.3	121.1	1.4-11.0	12
Green manure (vetch)								
Number of invertebrates	ex m^{-2}	71.6	16.0	128.0	2518.9	70.1	35.7-107.5	10
Number of *Lumbricidae* family		43.3	0	104.0	1947.8	101.9	11.7-74.9	10
Biomass of invertebrates	g m^{-2}	10.4	1.2	31.2	98.7	95.5	3.3-17.5	10
Biomass of *Lumbricidae* family		7.8	0	26.4	87.5	119.9	1.1-14.5	10

According to the statistical data, the use of green manure method lead to the increase of microbial biomass content on average from 275.8 to 384.6 μ g C g^{-1} sol in the leached chernozem and from 216.2 to 313.5 μ g C g^{-1} sol in the ordinary chernozem (Table 3).

Table 3. Statistical parameters of the microbial biomass in chernozems in conditions of the land management with green manure

Soil	**Variant**	**Mean value**	**Experimental value**		**S^2**	**V, %**	**Confidence interval (P ≤ 0.05)**	**n**
			min	max				
Leached chernozem	Control	275.8	137.2	350.0	4793.9	25.1	213.8-319.8	12
	Green manure (vetch)	384.6	238.4	438.6	4930.1	18.3	330.5-438.7	9
Ordinary chernozem	Control	216.2	183.6	278.1	851.0	13.5	205.8-226.6	15
	Green manure (vetch)	313.5	216.3	388.5	3050.3	17.6	282.8-344.2	15

The stimulation of growth of bacteria and fungi has been observed under the application of green manure. Vetch contributed to growth of microorganisms forming polysaccharides in the chernozem leached, their number was greater than in control by 1.4 times.

The use of green fertilizers restores the biota's functioning to the zone of homeostasis and increases the resistance of soils to the degradation (stability of soils in terms of degradation). However, these methods do not lead the degraded soil to the level of natural standard [12]. The humus content level was higher on plots under green manure by 0.19 % in comparison with arable plots [6]. Thus, the farming system with the application of vetch improves the status of biota and fertility of arable soils.

CONCLUSIONS

The application of vetch as a green manure had created conditions for the improvement of the biota's vital activity in chernozems which had been degraded as a result of a long-term arable use. The green manure application on degraded chernozems helps to prevent ecological violations in the state of soil biota, to restore species and populations of invertebrates and to enhance the total microbial biomass. Indices of the number of invertebrates and *Lumbricidae* family have risen in the green manures' chernozems by 1.4-1.8 times. The effect of green manure was manifested in the increase of share of *Lumbricidae* family in the total number of invertebrates by 12.1-20.8 %. The microbial carbon content in the arable layer of the leached and ordinary chernozem has grown by 1.4-1.5 times. These methods improve the resistance of soils to degradation, but biological parameters do not reach the level of soils under the natural vegetation. Management with the green manuring for the biota's restoration of degraded soils and for the improvement of soil quality and environment has been recommended.

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