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THE INFLUENCE OF ORGANIC FERTILIZERS ON THE QUALITY OF ERODED COMMON CHERNOZEM

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Abstract

During the last 40-50 years, the surface of the eroded soils of the Republic of Moldova increased by approximate 284 thousand ha, or annually by 7 thousand ha. The annual damage caused by erosion is estimated at 200 million US dollars. The problem of restoring the fertility of soils degraded by erosion under current farming conditions can be solved by using local organic fertilizers, which can serve to maintain and increase soil fertility, and not as environmental pollutants, which occurs in most cases. Being used as organic fertilizers, they increase the productivity of agricultural crops by 30-40%, reduce the humus deficit by an increase of 150-200 kg/t. Organic fertilizers applied to eroded common chernozem improve the quality of the structure and the aero-hydric regime of the soil. The use of local organic fertilizers also has a positive impact due to the fact that they are directed to study and applied according to the recommendations for their integrated exploitation in agriculture where they have origins.

***Key words**: Organic waste, soil fertility, soil properties, environment.*

INTRODUCTION

The state of agricultural lands in the Republic of Moldova has essentially worsened in recent decades, so that they can no longer cope with climate change, and the effects of problems such as drought are much more felt (Leah, 2022; 2023; IPAPS, 2004). On the lands degraded by erosion, where the crop rotation was not respected, and the soil is not properly maintained, the impact of drought and unfortunate phenomena is much more noticeable (Leah, 2021; Eroziunea..., 2004).

Combating soil erosion is of particular importance for agriculture and the country's economy as a whole (Savu, 1992; Крупеников, 2008). One of the methods regarding the regeneration of soils affected by erosion is the rational utilization of organic fertilizers on a well-designed anti-erosion background (Lixandru, 2006; Добровольский, 2003). Their action is multilateral and complex due to the content of organic matter, which serves to restore humus and all the elements necessary for plant nutrition (Siuris, 2013; 2014; Цуркан, 1985). In the conditions of the Republic Moldova, the largest part of organic fertilizers belongs to the zootechnical sector (manure, composed from cattle, pigs, sheep, goats, horses and birds). The consumption of organic fertilizers has essentially decreased in the last 30 years (Leah, 2021).

In order to maintain a beneficial circuit between human economic activity and nature, organic waste must be returned to the soil. Thus these organic materials can cause environmental pollution.

The purpose of the research was to follow the dynamics of the change in the quality state of common eroded chernozems under the influence of the different doses application of organic fertilizers. To achieve the expected goal, the following objectives were established: studying the changes in humus content and biophilic elements; determining the influence of organic fertilizers on the basic physical indices of heavily eroded common chernozem, estimating organic fertilizers on the chemical indices of eroded common chernozem.

MATERIALS AND METHODS

The studies and researches were carried out at the Experimental Station of Pedology and Erosion "Nicolae Dimo", located in the Lebedenco commune, Cahul district. The territory of Lebedenco is located in the Southern agroclimatic zone of the Republic

Moldova with warm climate and insufficient humidity (Eroziunea..., 2004).

The experimental field has a slope of 5-7° with northeast exposure. The soil cover of the slope is characterized by heavily eroded ordinary chernozems. The surface rocks consist of Quaternary loessoide deposits.

The variants of the experience are rectangular plots located from hill to valley with a length of 40 m and a width of 6 m.

The scheme of the experience was as follows:

1. Control - unfertilized;
2. Manure, *50 t/ha* - once every 2 years;
3. Manure, 100 t/ha - once every 4 years.

In the center of each plot (variants) a soil profile with a depth of 120 cm was placed, and on the central line, over every 5 m from the main profile - 4 semi-profiles (observation points) at the depth of the ploughed layer (0-22/23 cm). Soil samples were collected from all profiles and semi-profiles for laboratory analysis and studied.

On the experimental plot, a field rotation is placed over time with the following crop rotation: autumn barley, followed respectively by corn for grains, ryegrass (peas + oats), winter wheat, corn for grains, autumn barley, corn for grains, sunflower, winter wheat, alfalfa (3 years).

It should be mentioned that the natural factors of soil degradation are the contrasting climatic regime, the torrential rains, the steepness of the slope. Anthropogenic factors of soil degradation are strong surface erosion by water, dehumification, destructuration and secondary compaction of the arable and post-arable layer of soils as a result of irrational agricultural exploitation.

RESULTS AND DISCUSSIONS

In general, the investigated soil profiles are characterized by analogous morphological characters. The soil of the experimental field is characterized by a homogeneous dusty clay-loamy texture both in profile and in space (Table 1).

The dusty clay-loamy texture can be appreciated as very favorable, because it provides favorable conditions for the growth of crop plants from all points of view. Loamy-clay soils in the granulometric composition of which the coarse dust fraction dominates, at the humidity corresponding to physical maturity, are relatively easy to work and crumble into agrochemically valuable structural aggregates (Lixandru, 2006).

Table 1. Particle size composition of common chernozem strongly eroded by the application of organic fertilizers

The horizon and the depth, cm	Particle size (mm) and content (%)						
	1.0-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01
Control - unfertilized							
$Bhkp_1$ 0-22	-	11.3	43.1	6.2	13.5	25.9	45.6
$Bhkp_2$ 22-30	-	12.2	40.9	6.3	14.5	26.1	46.9
BCk_1 30-48	-	10.4	42.6	7.0	14.9	25.1	47.0
BCk_2 48-80	-	11.6	43.3	5.5	13.6	26.2	45.3
Ck 80-100	-	12.0	43.0	6.6	13.2	25.2	45.0
Ck 100-120	-	11.6	43.3	6.7	13.0	25.4	45.1
Manure, 50 t/ha - once every 2 years							
$Bhkp_1$ 0-22	-	11.4	43.3	6.9	11.8	26.6	45.3
$Bhkp_2$ 22-30	-	12.7	40.3	6.8	13.5	26.7	47.0
BCk_1 30-48	-	10.4	42.7	5.3	16.5	25.1	46.9
BCk_2 48-80	-	10.4	43.2	6.5	15.0	26.5	46.5
Ck 80-100	-	10.8	43.3	6.9	12.8	26.2	45.9
Ck 100-120	-	10.4	43.2	7.0	13.4	26.0	46.4
Manure, 100 t/ha - once every 4 years							
$Bhkp_1$ 0-22	-	13.1	41.1	7.2	12.8	25.8	45.8
$Bhkp_2$ 22-30	-	15.2	38.1	7.1	14.0	25.6	46.7
BCk_1 30-48	-	13.7	39.0	7.0	14.1	26.2	47.3
BCk_2 48-80	-	12.8	40.5	7.3	14.1	25.4	46.7
Ck 80-100	-	12.3	40.9	6.7	15.0	25.1	46.8
Ck 100-120	-	11.4	43.3	6.7	13.9	24.7	45.3

As a negative factor of this texture, the low hydrostability of the structural aggregates formed by tillage, the poor resistance to secondary compaction and the high erosion hazard can be considered.

According to the dry sieving data the soils of the experimental variants are characterized by a good quality artificial structure for the depth of 0-10 cm periodically loosened by harrowing and medium for the lower part of the arable layer (Table 2). The Hydrostability of the artificial structure of the arable layer is low for all investigated cases - result of the dusty texture and low content of humus in the soil.

Table 2. Structural composition of the common chernozem strongly eroded by the application of organic fertilizers (numerator - dry sieving, denominator - wet sieving)

The horizon and the depth, cm	Diameter of structural elements (mm) and content (% g/g)				Structure quality (dry sieving)	Hydrostability of the structure
	>10	< 0.25	Sum 10-0.25	Sum >10+ <0.25		
Control - unfertilized						
Ahp$_1$ 0-10	28.8 / –	10.7 / 66.9	60.4 / 33.1	39.6 / 66.9	good	small
Ahp$_1$ 10-22	49.5 / –	3.6 / 72.5	47.0 / 27.5	53.0 / 72.5	medium	small
Manure, 50 t/ha - once every 2 years						
Ahp$_1$ 0-10	22.9 / –	14.8 / 71.6	62.3 / 28.4	37.7 / 71.6	good	small
Ahp$_1$ 10-22	34.5 / –	8.2 / 71.5	57.3 / 28.5	42.7 / 71.5	medium	small
Manure, 100 t/ha - once every 4 years						
Ahp$_1$ 0-10	25.5 / –	9.6 / 71.0	62.9 / 29.0	37.1 / 71.0	good	small
Ahp$_1$ 10-22	37.9 / –	7.1 / 70.4	55.6 / 29.6	29.0 / 70.4	medium	small

We note that the impact of introduced organic fertilizers on the quality of the structure of the ploughed layer of the studied soils is small. On the fertilized variants, only a tendency to improve the soil structure is observed.

The hygroscopic water content reaches 3-4% in the ploughed layer of the investigated soil and decreases in depth (Ck horizon) to 2.0-2.3%. Analogous hygroscopicity coefficient values decrease with depth from 5-6% in the ploughed layer to 4-5% in the underlying horizons. (Table 3). The not too high values of the hygroscopicity coefficient confirm that the water reserves inaccessible to plants in the investigated soils are comparatively small, which can be appreciated as a positive factor. The density of the solid part of the soils varies between 2.58-2.61 in the ploughed layer and 2.70-2.71 in the BCk and Ck horizons.

Table 3. Physical indices of common chernozem strongly eroded by the application of organic fertilizers

The horizon and the depth, cm	Physical sand, >0.01 mm	Physical clay, <0.01mm	Hygroscopic water, % g/g	Coefficient of hygroscopicity	Density, g/cm^3	Bulk density, g/cm^3	Total porosity, % v/v
1	2	3	4	5	6	7	8
Control - unfertilized							
Bhkp$_1$ 0-10	25.8	45.0	3.7	5.9	2.58	1.21	53.1
Bhkp$_1$ 10-22	25.9	45.9	3.1	5.8	2.60	1.29	50.4
Bhkp$_2$ 22-30	26.1	46.9	2.8	5.5	2.61	1.40	46.4
BCk$_1$ 30-48	25.1	47.0	2.5	5.1	2.65	1.34	49.4
BCk$_2$ 48-60	26.4	45.4	2.4	5.0	2.68	1.35	49.6
BCk$_2$ 60-80	25.9	45.0	2.4	4.8	2.70	1.35	50.0
Ck 80-100	25.2	45.0	2.3	4.7	2.70	1.35	50.0
Ck 100-120	25.4	45.1	2.2	4.5	2.71	1.32	51.3
Manure, 50 t/ha - once every 2 years							
Bhkp$_1$ 0-10	26.3	45.4	3.1	5.9	2.59	1.27	51.0
Bhkp$_1$ 10-22	26.8	45.1	3.1	5.8	2.59	1.33	48.6

Continuation of the Table 3

1	2	3	4	5	6	7	8
$Bhkp_2$ 22-30	26.7	47.0	3.0	5.8	2.61	1.39	46.7
BCk_1 30-50	25.1	46.9	2.6	5.2	2.63	1.35	48.7
BCk_2 50-60	26.4	46.6	2.5	4.9	2.63	-	-
BCk_2 60-80	26.5	46.3	2.3	4.7	2.64	-	-
Ck 80-100	26.2	45.9	2.3	4.5	2.66	-	-
Ck 100-120	27.0	46.4	2.3	4.5	2.68	-	-
Manure, 100 t/ha - once every 4 years							
$Bhkp_1$ 0-10	25.8	45.7	2.9	5.9	2.59	1.23	52.5
$Bhkp_1$ 10-22	25.8	45.7	2.9	5.6	2.59	1.31	49.4
$Bhkp_2$ 23-30	25.6	46.7	2.8	5.4	2.62	1.39	46.9
BCk_1 30-50	26.2	47.3	2.5	5.0	2.64	1.37	48.1
BCk_2 50-60	25.7	47.0	2.3	4.6	2.68	-	-
BCk_2 60-80	25.1	46.4	2.3	4.7	2.70	-	-
Ck 80-100	25.1	46.8	2.3	4.7	2.71	-	-
Ck 100-120	22.7	45.3	2.0	4.0	2.71	-	-

The apparent density values are optimal for the recently ploughed layer (1.20-1.30 g/cm^3) and less favorable for the compacted postarable layer (1.39-1.40 g/cm^3).
In depth on the profile, the loessoide deposits on which the investigated soil was formed are relatively poorly compacted and the apparent density values do not exceed 1.35 g/cm^3.
In general, the physical quality of the investigated common chernozem is good.

The soil studied in the long-term experience is carbonated from the surface and is characterized by a slightly alkaline reaction, the pH values are equal to 7.8-8.0 units in the ploughed layer and 8.1-8.9 in the BCk and Ck horizon.
The content of carbonates varies on the profiles from 5.8-7.0% in the ploughed layer to 15-17% in the BCk and Ck horizons (Table 4).

Table 4. Chemical and physico-chemical indices of common chernozem strongly eroded upon application of organic fertilizers

The horizon and the depth, cm	pH	$CaCO_3$	Humus	N total	C:N	Mobile forms, mg/100 g soil		Exchangeable cations, me/100 g soil		
		% g/g				P_2O_5	K_2O	Ca^{++}	Mg^{++}	Sum
1	2	3	4	5	6	7	8	9	10	11
Control - unfertilized										
$Bhkp_1$ 0-10	7.8	5.8	2.40	0.134	10.4	1.57	16	25.8	3.1	28.9
$Bhkp_1$ 10-22	7.9	6.2	2.18	0.121	10.4	1.30	16	25.4	3.1	28.5
$Bhkp_2$ 22-30	8.0	7.9	1.38	0.076	10.5	0.99	14	24.8	3.3	28.1
BCk_1 30-48	8.1	10.2	0.96	0.057	9.9	0.47	13	24.0	3.4	27.4
BCk_2 48-60	8.1	16.3	0.69	-	-	-	-	23.5	3.6	27.1
$BCk_2$60-80	8.1	16.8	0.64	-	-	-	-	22.3	3.6	25.9
Ck 80-100	8.2	17.1	0.48	-	-	-	-	20.3	3.0	23.3
Ck 100-120	8.2	16.3	0.53	-	-	-	-	19.9	3.0	22.9
Manure, 50 t/ha - once every 2 years										
$Bhkp_1$ 0-10	8.0	6.2	2.81	0.154	10.6	3.39	23	29.6	3.0	32.6
$Bhkp_1$ 10-22	8.0	7.0	2.55	0.140	10.6	2.83	20	27.3	3.0	30.3
$Bhkp_2$ 23-30	8.1	8.5	1.60	0.088	10.5	1.78	20	25.8	3.1	28.9
BCk_1 30-50	8.1	8.9	1.01	0.056	10.5	0.81	15	23.4	3.1	26.5
BCk_2 50-60	8.2	14.1	0.71	-	-	-	-	24.6	3.2	27.8
$BCk_2$60-80	8.2	16.3	0.55	-	-	-	-	25.1	3.2	28.3
Ck 80-100	8.3	17.4	0.49	-	-	-	-	23.3	3.4	26.7
Ck 100-120	8.3	15.2	0.55	-	-	-	-	20.4	3.4	23.8

Continuation of the Table 4

1	2	3	4	5	6	7	8	9	10	11
Manure, 100 t/ha - once every 4 years										
$Bhkp_1$ 0-10	7.8	6.2	2.81	0.155	10.5	3.22	18	28.4	3.1	31.5
$Bhkp_1$ 10-22	7.9	6.8	2.57	0.143	10.4	2.72	17	26.1	3.1	29.2
$Bhkp_2$ 23-30	8.0	8.3	1.62	0.090	10.4	1.72	17	25.9	3.2	29.1
BCk_1 30-50	8.0	10.8	1.19	0.066	10.4	0.68	15	25.9	3.2	29.1
BCk_2 50-60	8.1	15.2	0.97	-	-	-	-	24.9	3.3	28.2
$BCk_2$60-80	8.1	16.3	0.71	-	-	-	-	24.8	3.3	28.1
Ck 80-100	8.2	16.4	0.68	-	-	-	-	24.1	3.2	27.3
Ck 100-120	8.3	15.1	0.59	-	-	-	-	23.3	3.4	26.7

Carbonates being a negative factor in terms of physiological processes in plants are also a stabilizing factor of the physical properties of soils (Siuris, 2017; Siuris et al., 2023).

The investigated eroded soils are submoderately humiferous. The humus content in their ploughed layer varies between 2.2-2.4% in the control variant and 2.5-2.8% in the fertilized variants.

As a result of the application of 300 t/ha of manure during 12 years, the humus content in the soils of the fertilized variants of the experiment increased veridical by about 0.4% (Table 5).

Table 5. Average statistical agrochemical indices of common chernozem strongly eroded when applying organic fertilizers

The horizon and the depth, cm	pH	$CaCO_3$	Humus	Mobile forms, mg/100 g sol	
		% g/g		P_2O_5	K_2O
Control - unfertilized					
$Bhkp_1$ 0-10	7.8±0.1	6.3±0.4	2.36±0.19	1.6±0.1	17±2
$Bhkp_1$ 10-22	7.9±0.1	7.0±0.6	2.16±0.14	1.3±0.1	16±2
Manure, 50 t/ha - once every 2 years					
$Bhkp_1$ 0-10	7.9±0.1	6.3±0.3	2.76±0.15	3.0±0.4	22±1
$Bhkp_1$ 10-22	8.0±0.1	6.9±0.4	2.50±0.14	2.6±0.2	20±1
Manure, 100 t/ha - once every 4 years					
$Bhkp_1$ 0-10	7.7±0.2	6.3±0.4	2.79±0.20	3.2±0.1	20±3
$Bhkp_1$ 10-22	7.9±0.1	6.8±0.2	2.56±0.17	2.6±0.1	19±2

Increasing humus content is a favorable factor for increasing the fertility of eroded soils.

The application of organic fertilizers in large doses also contributed to the increase in the ploughed layer of eroded soils in the content of mobile phosphorus: from 1.3-1.6 (control variant) to 2.6-3.2 mg/100 g soil (fertilized variants).

Analogy exchangeable potassium content increased from 16-17 mg/100 g soil to 19-22 mg/100 g soil.

The amount of exchangeable cations in the ploughed layer of the studied soils varies from 28-29 me in the control variant to 29-33 me in the fertilized variants.

In all investigated soil profiles, the reduction of the amount of exchangeable cations in the BCk and Ck horizons is detected up to 24-26 me.

CONCLUSIONS

The incorporation of 300 t/ha of manure into the soil during 12 years led to the formation of a positive balance of humus in heavily eroded soils and to the increase in the content of mobile forms of phosphorus and potassium in these soils. Improving the main fertility indices of heavily eroded soils has contributed to a sufficient increase in their production capacity.

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