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EVOLUTION OF CHERNOZEMS LEACHED QUALITY UNDER INTENSIVE AGRICULTURE IN CENTRAL ZONE OF MOLDOVA

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Abstract

Studying the evolution of chernozem leached quality with whole profile used in intensive agriculture based on fertilization systems in field crop rotations in 1965-2010 period established, that arable leached chernozems is characterized by satisfactory values of the physical, chemical and biological properties. As a result of 45 years intensive used in agriculture the leached chernozems are affected by: dehumification of arable layer, caused by insufficient flow of organic matter in the soil; compaction of arable layer as a result of soil tillage; and soil destruction. Influence of mineral fertilizers in doses of $N_{60-120}PK$ after a period of 10 years of farming land without fertilizers (1994-2004) did not lead to significant change of physical, chemical and agrochemical properties of soils. Quality status of leached chernozems should be maintained by administration of organically and mineral fertilizers in recommended optimal doses, shredding and incorporation in the soil the vegetal crop residues and secondary production, respecting crop rotation with introducing alfalfa and increasing surface of leguminous crops by 20-25 %; application of agrotechnical measures and mini tillage: cracking the depth of 35- 40 cm tillage depth alternating with periodic raising the surface of the compacted layer.

Key words*: chernozem leached, degradation, evolution, fertilization, quality status.*

INTRODUCTION

The purpose of monitoring observations on Polygon no. 35 - Chernozem leached (cambic) from Central part of Moldova - determining the evolution of quality state of leached chernozems used in intensive agriculture in function on the fertilization systems in field crop rotations in the 1964-2010 period.

Objectives:

• Review changes in humus content and nutrient regimes of leached chernozem under the influence of different doses of fertilizers and identify optimal level of field crop fertilization.

• Determine the influence of mineral fertilizers on the basic physical and chemical indices of leached chernozem.

• Develop of fertility evolution prognosis of leached chernozem depending on mode of using agricultural land.

Anthropogenic factors of soil degradation - dehumification, depletion of soil nutrients, distructuration, and secondary compact as result of agricultural overexploitation [1, 2].

MATERIAL AND METHOD

Monitoring polygon was founded in July of 2006. On the experience control variant "witness" was located a profile with 200 cm of depth and 4 semi profile, on the fertilized variants - 5 semi profile each of 30 cm depth. For soil profile was determinate morpho-metric indices of genetic horizons, was performed morphological description, determined apparent density and collected soil samples for laboratory analysis. Field and laboratory research results have been processed and systematized and presented in the tables.

RESULTS AND DISCUSSIONS

Profile no. 35 – Chernozem leached was placed on long-term experience variants with mineral fertilizers of the experimental station "Ivancea-Orhei". Absolute altitude - 181 m. Coordinates: latitude - 47°18.397', East longitude - 28°53.412' (Fig. 1).

Fig.1. Field that location of soil profiles no. 35

Experience variations used for monitoring are: Control; $N_{60}P_{60}K_{60}$; N_{120} $P_{60}K_{60}$; N_{300} $P_{60}K_{60}$. Experience was founded in 1964 on quasi horizontal surface of a high terrace of rivulets Mota, tributary of the river Raut. Surface rocks are Quaternary loess deposits. In the years 1996-2005, from lack of fertilizers, soil fertilization on the variants was not made. The research was limited to studying soil fertilization post action ongoing for 30 years. In 2006 the introduction of fertilizers on the variants was resumed [1].

Investigated leached chernozem profile is characterized as: Ahp1 - Ahp2 - Ah - Bhw1- Bhw2 - BCk1 - BCk2 - Ck. Thickness of humus profile - 90 cm. Effervescence at 90 cm depth (Fig.2).

Fig. 2. Chernozem leached (cambic) moderate humifer clay-loam, arable (profile 35)

Texture and some physical properties

Chernozem leached is characterized by clay-loamy texture and high content of fine clay (35-36%), which favors the compaction of destructured soil. The high content of clay in horizons A and B is due to more intensive process of deterioration "in situ" of mineral part of soil in these horizons.

Hygroscopicity in leached chernozem profile decreases with depth from 4.1 to 4.2% in the arable layer up to 3.6 to 3.7% in carbonate BCk and Ck horizons (Table 1).

Table 1. Physical properties of leached chernozem

Horizons and depth, cm	Hygro-scopicity, %	Apparent density g/cm^3	Density g/cm^3	Size fractions, mm; 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
Ap1 0-22	4.1	1.31	2.61	0.3	6.2	30.9	8.4	18.3	35.9	62.6
Ap2 22-36	4.2	1.46	2.62	0.2	6.4	31.0	9.4	16.9	36.1	62.4
Ah 36-51	4.1	1.53	2.62	0.1	4.5	32.4	8.3	19.0	35.7	63.0
Bhw1 51-71	3.9	1.54	2.63	0.1	6.0	33.1	8.2	17.6	35.0	60.8
Bhw2 71-90	3.8	1.53	2.65	0.2	6.9	32.6	8.9	17.5	33.9	60.3
BCk1 90-120	3.7	1.52	2.68	0.2	9.4	32.5	9.5	17.1	31.3	57.9
BCk2 20-160	3.7	1.52	2.69	0.2	12.0	31.8	9.8	16.0	30.2	56.0
Ck >160	3.6	1.44	2.70	0.4	13.9	31.4	9.8	15.4	29.1	54.3

Apparent density is 1.31 g/cm^3 in the recent arable layer and 1.46 g/cm^3 in the post arable layer, indicating the strong compaction of the under layer horizon. In the underlying horizons the apparent density increases up to 1.54 g/cm^3 in cambic horizon Bhw and then decreases up to 1.44 g/cm3 in the Ck horizon. Decreased resistance to compaction of arable layer and post arable is due it destructuration in the prolonged use of land in agriculture.

Structural composition

The structure of chernozem leached is good in Ahp2, Ahp1 horizons and very good in the unchanged with plowing of the Ah horizon (36-51cm). The structural hydrostability is moderate to good in all horizons (Table 2).

Table 2. Structural composition of arable layer of chernozem leached, profile 35 (numerator - dry sieving data, denominator - wet sieving data)

Horizon and depth	Content of elements,% w / w; size aggregates, mm											Coefficient of quality structure	Quality structure (dry sieving)	Hydro-stability structure (wet sieving)
	>10	10-7	7-5	5-3	3-2	2-1	1-0.5	0.5-0.25	<0.25	∑ 10 -0.25	∑ >10 +<0.25			
Ahp1 0-22 cm	21.24 -	8.66 -	8.14 4.6	11.68 3.0	9.32 3.0	22.24 17.0	7.44 19.0	5.72 14.0	5.56 39.4	73.20 60.60	26.8 39.4	2.73	Good	Medium to good
Ahp2 22-36 cm	27.74 -	7.72 -	13.88 2.2	19.20 3.6	10.76 4.8	10.78 22.8	3.32 15.2	3.38 12.4	3.22 39.0	69.04 61.0	30.96 39.0	2.23	Good	Medium to good
Ah 36-51 cm	15.28 -	7.74 -	9.12 -	30.86 0.4	18.58 2.0	13.24 16.8	1.68 21.6	1.60 19.6	1.90 39.6	82.82 60.4	17.18 39.6	4.81	Very good	Medium to good

Chemical and physic-chemical indices

Data on the chemical and physicochemical properties of profile 35 are shown in Table 3, and average statistical data of experience variants - in Table 4. Humus content of investigated soil profile is reduced from 3.3% in the arable horizon to 1.5% in horizon Bhw2 (71-90 cm). Total nitrogen in humifer Ah horizon is within 0.192 to 0.151%. The values of the C : N varies within 10.1 to 9.2. Carbonates occur in horizon BCk1 (90-120 cm) with increasing values from 12.9% in horizon BCk1 to 18.8% in horizon Ck.

Hydrolytic acidity is characteristic for layer 0-90 cm (genetic horizons from Ahp1 to Bhw2) with values from 2.10 *me* in horizon Ahp1 to 0.79 *me/100g soil* in horizon Bhw2.

Cation exchange amount vary in limits from 32 *me/100g soil* in humus layer up to 28 *me* in the horizons BCk and Ck. The ratio of Ca^{2+} and Mg^{2+} in layer 0-90 cm is about 7, which provides a favorable accessibility of nutrients for crops (Table 3).

Table 3. Chemical and physicochemical properties of leached chernozem, profile 35

Horizons and depth, cm	Humus, %	Nitrogen total, %	C:N	$CaCO_3$ %	pH	Hydrolytic acidity	Ca^{2+}	Mg^{2+}	$\sum Ca^{2+}+Mg^{2+}$	$\frac{Ca^{2+}}{Mg^{2+}}$
						me/100g soil				
Ahp1 0-22	3.3	0.192	10.0	0.0	6.7	2.10	32.6	4.8	37.4	6.8
Ahp2 22-36	2.9	0.167	10.1	0.0	6.8	1.93	32.0	4.6	36.6	6.9
Ah 36-51	2.4	0.151	9.2	0.0	7.0	1.49	31.5	4.1	35.6	7.7
Bhw1 51-71	1.7	-	-	0.0	7.3	1.05	30.5	4.1	34.6	7.4
Bhw2 71-90	1.5	-	-	0.0	7.4	0.79	30.1	4.0	34.1	7.5
BCk1 90-120	0.9	-	-	12.9	7.6	-	24.2	4.2	28.4	5.8
BCk2 120-160	0.5	-	-	18.3	7.9	-	23.4	4.7	28.1	5.0
Ck >160	0.4	-	-	18.8	8.0	-	23.0	4.9	27.9	4.7

Table 4. Statistical average indexes of chemical characteristics of the 0-30 cm layer of arable leached chernozem on the experience variants

Variant	pH	Hydrolytic acidity, me/100 g	Humus, %	Total forms, %		Mobile forms, mg/100 g		
				Nitrogen	Phosphor	$N\text{-}NO_3$	P_2O_5	K_2O
Control	6.8±0.1	2.5±0.0	3.3±0.1	0.192±0.01	0.109±0.004	0.12±0.04	0.8±0.3	21±2
$N_{60}PK$	6.7±0.1	2.7±0.1	3.4±0.2	0.195±0.01	0.129±0.003	0.17±0.03	2.1±0.5	22±2
$N_{120}PK$	6.6±0.1	2.9±0.2	3.4±0.1	0.205±0.01	0.120±0.003	0.24±0.16	1.5±0.4	19±2
$N_{300}PK$	6.5±0.1	3.4±0.2	3.4±0.1	0.209±0.01	0.121±0.003	0.18±0.06	1.6±0.4	20±3

According to average statistical data (Table 4) humus content in the layer 0-30 cm is 3.3% for control variants and 3.4% in fertilized variants. Value of pH is 6.8 in the control variant. In fertilized variants with increasing fertilizer dose, the pH values are in slight decline, from 6.7 to 6.5. Hydrolytic acidity increases with increasing dose of fertilizer: from 2.7 *me* in $N_{60}PK$ to 3.4 *me/100g* soil in $N_{300}PK$. Content total nitrogen forms in soil are practically equal in the control (0.192%) and $N_{60}PK$ (0.195%). Variants $N_{120}PK$ (0.205%) and $N_{300}PK$ (0.209%) indicate higher values of total nitrogen content compared to the control. The largest amount of total phosphorus was found in version $N_{60}PK$ - 0.129% (the control - 0.109%).

Agrochemical characteristics

Reserves of humus in the arable layer of leached chernozem are 154 t/ha, and the layer 0-100 cm - 319 t/ha. Total nitrogen content in the layer 0-50 cm of chernozem leached vary in limits from 0.192% (Ahp1) to 0.151% (Ah), nitrogen reserves are 12.1 t/ha.

Total phosphorus reserves in the arable layer of chernozem leached is 5.1 t/ha (content from 0.097% to 0.108%). Mobile forms of phosphorus content in soil profile depth decreases from 0.9 mg in arable soil layers to 0.2 mg/100 g soil of horizon Ck, mobile potassium, respectively, from 20 mg to 9 mg/100 g soil. Average statistical parameters of humus content in fertilized variants of soil demonstrates that the application of mineral fertilizers has not led to essential changes. After a 10 years period of intensive use of leached chernozem (1994-2004) without fertilizer, the phosphorus content was established at level 1.5 mg to 2.1 mg/100 g soil, the witness was of 0.8 mg/100 g soil. The content of mobile potassium in fertilized variants has returned to the level of "witness" variant (Table 5).

Table 5. Agrochemical characteristics of leached chernozem, control variant

Horizons and depth, cm		Humus		Total forms				Mobile forms, mg/100 g soil		
				Nitrogen		Phosphor				
		%	t/ha	%	t/ha	%	t/ha	$N\text{-}NO_3$	P_2O_5	K_2O
Ahp1	0-22	3.3	95.1	0.192	5.3	0.108	3.1	0.10	0.9	20
Ahp2	22-36	2.9	59.3	0.167	3.4	0.097	2.0	0.10	0.6	16
Ah	36-51	2.4	55.1	0.151	3.4	0.090	2.0	0.10	0.4	13
Bhw1	51-71	1.7	52.4	-	-	-	-	0.08	0.4	12
Bhw2	71-90	1.5	43.6	-	-	-	-	0.08	0.3	12
BCk1	90-120	0.9	41.0	-	-	-	-	0.08	0.3	10
BCk2	120-160	0.5	15.2	-	-	-	-	0.18	0.3	9
Ck	>160	0.4	11.3	-	-	-	-	0.22	0.2	9

CONCLUSIONS

Arable leached chernozem used in intensive agriculture is characterized with satisfactory values of the physical and chemical characteristics. As a result of intensive farming the leached chernozem is affected by:

- Dehumification of arable layers due to insufficient flow of organic matter in the soil;
- Compaction of arable layer as a result of soil tillage, dehumification and destructuration;

Influence of mineral fertilizers application ($N_{60}PK$, $N_{120}PK$, $N_{300}PK$) after a 10 years period of land use without fertilizers (1994-2004) did not lead to significant changes in the indices of physical, chemical and agrochemical properties of soil.

Quality status of leached chernozem should be maintained by:

- Administration of organic-mineral fertilizers in recommended doses;
- Chopping, incorporation of vegetal residues and secondary production into the soil;
- Compliance of crop rotation with introducing alfalfa and crop leguminous up to 20-25%;
- Agrotechnical measures of tillage: crack in depth of 35-40 cm, alternating tillage with rising in the surface of the compacted layer.

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