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MODIFICATION OF CARBONATED CHERNOZEM AGROCHEMICAL INDICES UNDER INFLUENCE OF SYSTEMATIC APPLICATION OF MINERAL FERTILIZERS IN MOLDOVA

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Abstract

The paper presents the main agrochemical indexes changes: humus content, nitrate nitrogen reserves, mobile phosphorus and exchangeable potassium content in chernozem carbonated (calcareous) from south of Moldova in the period 1965 - 2015. Statistically processed data allowed to determine the dynamics of nitrogen indices with different norms: 0 - 60 - 90 - 120 - 180 kg/ha on various phosphorus funds: 1.0 - 1.5 - 2.5 - 3.5 mg/100 g of the soil. On the control variant was established that humus content decreased from 3.8% to 3.4%, nitric nitrogen reserves in soil layer of 1 m under winter wheat and maize were 67 - 102 kg/ha and decreased at the harvest to 42 - 84 kg/ha. Mobile phosphorus content decreased from 1.5 to 1.2 mg/100 g soil. Potassium exchangeable content remained at a high level of 27 - 32 mg/100 g soil. The systematic application of mineral fertilizers showed the following changes of agrochemical indices: the initial humus content was 3.8% and decreased to 3.3%, nitrate nitrogen reserves were 112 - 161 kg/ha in the spring and decreased insignificantly at harvest with 7 - 19 kg/ha. The mobile phosphorus content varied in dependence of applicable fertilizes norms. The exchange able potassium content slightly increased - on average by 2 mg/100 g soil.

Key words*: soil, fertilizers, field crops, nutritive regime, agrochemical indices.*

INTRODUCTION

In conditions of Moldova the main natural factors limiting harvests of the crop plants are humidity (atmospheric precipitation) and effective fertility of soils. Depending on the amount of annual rainfall and cultivation area in Moldova can be obtained 3.0 - 7.0 t/ha of winter wheat and 3.5 to 9.0 t/ha of maize grain.
From the account of soils natural fertility can be obtain 2.6 t/ha of winter wheat, 3.3 t/ha of maize grain. Potential harvest of precipitation achieved only 35 - 40%. An increase the crop with 25 - 35% can be obtain from account of mineral fertilizers effective application.
According to the last agrochemical soil mapping conducted in 1990 by State Agrochemical Service, about 41% of farmland in the country was characterized by a low humus content and only 20% was optimal level. Nitrification capacity of soils was low on the 80% of agricultural surface. The content of mobile phosphorus was low and very low on the 25%, moderate - 34% and optimal, high and very high level only on the 40% of the area. The potassium content was optimal, high and very high degree on the about 90% of surveyed agricultural land.
Currently, the soil effective fertility state is considerably worsened, because in the last 25 years the organic fertilizers practically were not applied and the application of the mineral fertilizers do not exceed 30 kg per ha, the share of leguminous crops that capturing the biological nitrogen from atmosphere decreased by 4 - 5 times. As a result the balance of humus and nutrients content is deeply negative in all agricultural soils. Harvests of the majority crops are small, although in some years with abundant precipitations during the summer, the productivity on the hectare rises from account of intensive mineralization of organic matter.
At present the average dose of NPK fertilizers applied in Moldovan agriculture is about 50 kg per ha, or 60 thousand tons of fertilizers per whole agricultural area.
For increasing the soil fertility and raising crop yields to European standard is required to apply annually about 230 - 300 thousand tons of

mineral fertilizers in active substance, but not 60 thousand tons as at present.

MATERIALS AND METHODS

The research was conducted at the long term experience of Pedological Experimental Station from Grigorievca village, Căușeni district, founded in 1961 on the chernozem carbonated (calcareous) from the south of Moldova. Experience consists of four fields, each field consists of 16 variants in four repetitions. In the experience is grown winter wheat in crop rotation with the following crops: peas, winter wheat, grain maize, winter barley and sunflower. According to the general scheme of experience the mineral nitrogen nutrition have following levels: 0 - 60 - 90 - 120 - 180 kg/ha on the phosphorus fund (determinate after Macighin method): 1.0 - 1.5 - 2.5 - 3.5 mg per 100 g of soil (Andries, 2011).

It was carried out the systematization and generalization of data on nutrient dynamics in carbonated chernozem of long term experience with application of mineral fertilizers in the years 1986 - 2015. For this purpose were collected the soil samples from each experimental plot in 16 variants and 4 repetitions on 4 crop fields.

In the collected soil samples were determined the major agrochemical indices: humus content - Tiurin method, nitrate nitrogen content – Gradval - Leaju method, mobile phosphorus in ammonium carbonate extract - Macighin method, exchangeable potassium by flame photometry - Maslov method.

RESULTS AND DISCUSSIONS

Humus is the main index of soil fertility on that depends largely agrochemical, agro-physical and biological soil properties. Founder of genetic pedology V.V. Dokuceaev investigated soils of Moldova in 1881, established that Moldavian chernozems contained 4 - 7% of humus. After a century period the research conducted by I.A. Krupenikov at the same objects, revealed considerable decline in soil organic matter up to 2 - 4%. Research conducted by A.Ursu on the chernozem from Soroca district over 135 years after V.V. Dokuceaev have established a decrease in organic matter content about 2.36% (Ursu, 1988, 2003).

Losses of organic matter for 100 years constituted about 41% on average. Studies by V.Cerbari demonstrated that arable ordinary chernozem from commune Băneşti, district Teleneşti have the humus content of 4.46% or 30% less than in the fallow chernozem (Cerbari, 2000).

The systematic application of mineral fertilizers in field crop rotation helps to offset the loss of organic matter in soils with applying the high quantity (30-40% compared to control) of plant debris.

Following investigations it was established that within 50 years the humus content in the control variants was significantly decreased. On the carbonated chernozem losses were: 0.52% or 0.011% annually (Figure 1).

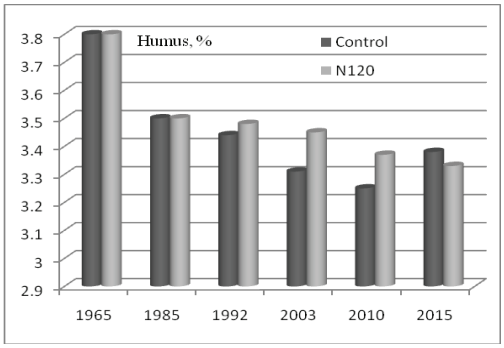

Figure 1. Dynamics of humus content in carbonated chernozem

Soil dehumification rhythm was different per periods. In the first 20 years the rhythm decline of dehumification was more intensive. The humus content in the carbonated chernozem was reduced from 3.8 to 3.4% (Table 1).

Table 1. Modification of organic matter content (%) in carbonated chernozem in the period 1965-2015

Soil	Variant	1965	1985	1992	2003	2010	2015
Cher-nozem carbo-nated	Control	3.80	3.50	3.44	3.31	3.25	3.38
	N_{120}	-	3.50	3.48	3.45	3.37	3.33

Since 1985 the humus losses were very small, but the pace of humification was stabilized at a insignificant quantity.

Nitrate nitrogen reserve was calculated on the field with winter wheat and maize. Reserve of nitrate nitrogen to control variant in the spring, under winter wheat was 67 kg/ha and at harvesting was reduced to 42 kg/ha.
Variants fertilized with nitrogen it is higher compared to control, because the preceding remaining reserves in soil. At harvest nitrate nitrogen reserves decrease, but remain high in the variants with high doses of 120 - 180 kg N/ha (Table 2).

Table 2. Modification of the nitrate nitrogen content in carbonated chernozem (kg/ha)

Soil	Variant	Spring		Harvesting	
		winter wheat	maize	winter wheat	maize
Cher-nozem carbonated	Control	67	102	42	84
	N_{60}	96	115	43	109
	N_{120}	102	138	81	138
	N_{180}	112	161	105	142

Nitrate nitrogen reserves on the witness variant under maize before sowing was 102 kg/ha in the carbonated chernozem, at the harvest its reserves insignificant decreased. Systematically fertilized variants with nitrogen before sowing, led to high content of nitrate nitrogen reserves in the 1 m of soil layer 112 - 161 kg/ha. At the maize harvesting faze the nitrogen reserves remain highly, especially on the variants with highly doses of nitrogen application.
From the obtained results, it appears that the systematic application of nitrogen fertilizers in the doses above 90 kg/ha on the carbonated chernozem in crop rotation led to the accumulation of nitrate nitrogen in the soil, that is gradually washed down in the profile, becoming a source of environment pollution.
Mobile phosphorus content is a basic characteristic of soil fertility. Chernozems of Moldova is characterized by a low content of mobile phosphorus.
During intensive agricultural chemicalization into the soil were incorporated 1143 kg/ha of phosphorus (P_2O_5) fertilizers. As a result at the end of 90s of last century, according to the last agrochemical mapping cycle the content of mobile phosphorus in soils of Moldova was increased by 2.0 times. The sharp reduction of fertilizer application after 1992 (up to 25-50 kg/ha), including phosphorus (up to 1-2 kg/ha) have led to reduced the amount of mobile phosphor in the soils (Ţîganoc, 2003). The reserve of mobile P_2O_5 was exhausted in the study years 2012 - 2014.
Therefore, the periodic determination of mobile phosphor content in the soils is a necessity for knowing the assurance level of plant in this nutrient. Changes of mobile phosphor content in soil over 50 years is shown in Table 3.

Table 3. Modification of the mobile phosphorus content in carbonated chernozem (mg/100g soil)

Soil	Variant	**1965**	**1985**	**1992**	**2010**	**2015**
Cher-nozem carbonated	Control	1.5	1.4	1.5	1.2	1.2
	Fertilized	3.3	2.9	2.0	3.2	2.3

From the obtained data it was evident that mobile phosphorus content decreased from 1.5 to 1.2 mg/100 g soil in the control variant (Figure 2).

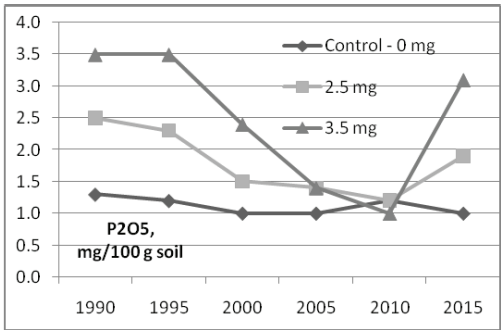

Figure 2. Dynamic of mobile phosphorus content in carbonated chernozem

Therefore, declining of phosphorus rhythms in the soils are not previously forecasted, but are much smaller. Rates of mobile phosphorus content decrease slowly at low concentrations. In support of this hypothesis the obtained harvests in the years 2013 and 2014 was very high to majority crops cultivated in the country, although the phosphorus fertilizers have not been applied in the soils from 90s.
Exchangeable potassium content in the soils is determined to optimize plant nutrition with this element by applying differentiated fertilizers. Moldovan soils are formed on the rocks with minerals rich in potassium, therefore its characterized by a relatively high content of exchangeable potassium. It has been established that potassium content in soils of Moldova depends largely on mineral and size composition.

Generally, the exchangeable potassium content in the soils of Moldova is 17 - 30 mg/100 g soil or 1.4 - 2.3% from the total content. The systematic application of fertilizers in the period 1965 - 1990 led to the formation of a positive balance of potassium in soils and increase its content by 1 - 2 mg K_2O/100 g soil (Burlacu, 2004).

For maintaining the exchangeable K_2O content at the optimal levels is recommended the application of organic and mineral fertilizers. Research has shown that over 50 years, the exchangeable potassium content at the witness variant of the investigated soil was changed slightly, although with crop harvest was exported from soil about 4.5 - 5.0 t/ha of potassium (Figure 3).

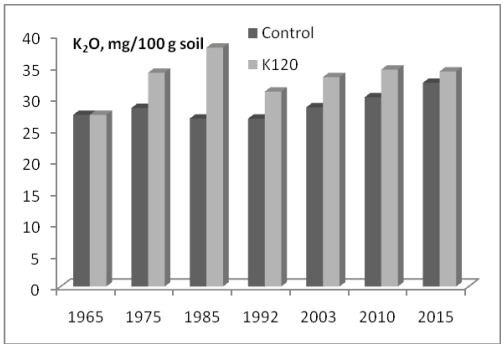

Figure 3. Dynamic content of exchangeable potassium in the carbonated chernozem

The exchangeable potassium content in carbonated chernozem is 27 - 32 mg/100 g soil. The obtained results demonstrate the high capacity of investigated calcareous chernozem in maintaining a dynamic equilibrium between different forms of potassium in the soil (Table 4).

Table 4. Modifying the content of exchangeable potassium in carbonated chernozem (mg/100 g soil)

Soil	Variant	1965	1975	1985	2003	2010	2015
Cerno-ziom carbo-nated	Control	27.3	28.4	26.7	28.5	30.1	32.4
	K_{120}	-	34.0	38.0	33.3	34.5	34.2

Systematic application of potassium fertilizers in crop rotation resulted in a slight increase of potassium in soil. During of 50 years the potassium content from fertilizers account was increased by 2 mg in chernozem carbonated. The same significant changes were recorded in soils of other experiences and in cycles of agrochemical mapping carried out in our country in 90 years.

CONCLUSIONS

The research was conducted during the years 1965 - 2015 and indicate the dynamic changes of nutritive regime parameters in chernozem carbonated as a result of systematic and lengthy application of mineral fertilizers in field crop rotation.

At the control variant was established that the humus content has decreased from 3.8% to 3.4%, nitric nitrogen reserves in 1 m of soil layer in the spring period at the winter wheat and maize were 67 - 102 kg/ha and at harvest period these indices decreased to 42 - 84 kg/ha. The content of mobile phosphor decreased from 1.5 to 1.2 mg/100 g soil, and the exchangeable potassium content remains at the same level 27 - 32 mg/100 g soil.

The systematic application of mineral fertilizers showed the following changes of agrochemical indices: humus content decreased to 3.3%, nitric nitrogen reserves under winter wheat and maize in the spring faze were 112 - 161 kg/ha. Phosphorus mobile content varied in dependence of fertilization norms and the exchangeable potassium content slightly increased on average by 2 mg/100 g soil.

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