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SOIL NITROGEN CONTENT AND EFFECTIVENESS OF NITROGEN FERTILIZERS FOR WINTER WHEAT IN MOLDOVA

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Abstract

The paper presents the experimental data on the state of nitrogen fund in soil of Moldova, modification of nitrification capacity and mineral nitrogen reserves in agricultural land in use and efficiency nitrogen fertilizers in the cultivation of winter wheat. It was established that soil mineral nitrogen reserves are insufficient for plant nutrition and obtaining high yields of winter wheat. Nitrogen fertilizer application on the optimal fund of mobile phosphorus in soil provides a significant increase in harvest. Each kilogram of nitrogen applied on the cultivation of winter wheat recovers with 10-15 kg of grain.

Key words: *effectiveness, fertilizers, harvest, soil nitrogen, winter wheat.*

INTRODUCTION

Nitrogen has the leading role in plant life. It is part of the protoplasmic structural proteins, cell nuclei, nucleic acids, pigments, vitamins and enzymes. For winter wheat crop formation of 4.0 to 5.0 t/ha the plants extract from the soil 120-150 kg/ha of nitrogen. Soils of Moldova annually produce about 75 kg/ha of nitrogen available to plants from organic matter mineralization account. Insufficient nitrogen nutrition of winter wheat leads to yellowing plants, forming small low-quality crops. The experimental data on soil nitrification capacity reserves of mineral nitrogen accumulated in the soil at the current stage of development of agriculture and weather efficiency nitrogen fertilizers in the cultivation of winter wheat has been presented.

MATERIALS AND METHODS

The research was conducted in the period 1985-2013 in field long-time experiences and in production conditions. In field experiments was determined the composition of fund nitrogen and nitrification capacity depending on the soil type and subtype, and the level of fertilizer. For this purpose soil samples were taken from 0-20 and 20-40 cm layers.

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In the production conditions were determined stocks of mineral nitrogen in the soil. Investigations were carried out in all pedoclimatical zones of the country. Soil samples were collected in early spring. In each zone the land parcels was divided in dependence of soil type and subtype, degree of soil erosion, precursory culture, development phase of plants. On the each field was drilled three wells. Soil samples were collected every 20 cm on the layer to 1.6 m, the were determined to moisture and nitrate nitrogen stocks. The research was conducted every agricultural year on the 17-80 soles with an area of 1200-4500 ha.

RESULTS AND DISCUSSIONS

Diagnosis of winter wheat nitrogen nutrition was performed on the basis of the stock of N - NO_3 in the 0-100 cm layer of soil (Andries et al., 1993). The experimental data were processed by different statistical methods.

The soils of Moldova are relatively rich in nitrogen. Total nitrogen content in gray soils is 0.12-0.14% and 0.21-0.24% in chernozems

(Andries, 2011). Researches (Andries, 2007) have shown that the background of nitrogen consists from organic compounds (95-96%), unchangeable ammonium fixed in the space formed by clay minerals (3-4%), and mineral forms available to plants (less than 1% of total). The main amount of the organic nitrogen (80% of total) is shown by the non-hydrolysable organic compounds in the acid concentrates, such as humines, melanines, bitumens, closely connected with the humus.

This form plays an important role in the formation and maintenance of nitrogen fund structure in the soil. It is a distant reserve to ensure plants to this nutrient.

Hydrolysable heavy fraction (10% of total) also presents a reserve supply the plants with nitrogen. Easily hydrolysable nitrogen makes up 8-10% of the total. It is made of organic forms and mineral compounds that participate in providing plants with nitrogen. About 20-30% of the nitrogen fraction is composed of the amino acids (Donos, 2008).

Nitrification capacity of the soil (NCS) characterized the mineralization speed of organic nitrogen and is a function of humus content and quantity and quality of crop residues. Established a close link between nitrification capacity (y, mg NO_3/100 g of soil) and soil organic matter content (x, %), which is described by the following equation:

$$y = 6.71 + 7.99x - 0.67x^2, \quad r = 0.90$$

Experimentally was determined that increasing the organic matter content by 1% ensures the formation and accumulation in soil of 24 kg/ha of mineral nitrogen (Donos, 2008). Currently the soils of Moldova contain on average 3.1% of humus and annually produce 74 kg/ha of mineral nitrogen. This quantity of nitrogen available to plants is sufficient to form 2.4 t/ha of winter wheat.

In the years 1989-2013 was evaluated the reserves of moisture and mineral nitrogen in the soil, the state of wheat plants after winter period, phenological phase of plant development. Based on the results was developed winter wheat crop forecast and determine the effectiveness of nitrogen fertilizers. It was found that the reserves of N-NO_3 of 1 m layer in early spring ranged from few hundred kilograms up to 10-20 kg/ha. The largest amount of mineral nitrogen is contained in typical, leached and ordinary chernozems, with a relatively high content of humus from 3.6 to 4.3%, after the precursory cultures, as alfalfa, peas, and also in the fertilized plots, and the small (12-20 kg/ha) - in the gray and eroded soils, after later precursors (corn grain, sunflower).

For the evaluation of the degree of plant mineral nitrogen and the forecast efficiency of nitrogen fertilizers N-NO_3 reserves were grouped according gradation effect. The amount of N-NO_3 below 60 kg/ha is considered very low and low, 61-100 kg - moderate, 100-140 kg - optimal, more than 141 kg/ha - high (Andries and et al., 1993).

There highlighted two periods of accumulation of mineral nitrogen in soil depending on how land use. First period - 1981-1990.

During this period in the crop field rotation was applied by 3.0 to 5.6 t/ha of organic fertilizer and by 90-170 kg/ha of NPK, including 52-101 kg/ha of nitrogen fertilizers. Share of biological nitrogen fixing leguminous crops was about 300 thousand ha, including perennial grasses 180-210 thousand hectares.

Humus balance became slightly deficient, the nitrogen and phosphorus balance - positive. Systematic application of fertilizers in crop rotation field led to increase the soil fertility. Mobile phosphorus content increased 2 times, potassium content by 2-3 mg/100 g of soil.

The use of chemical substances in agriculture allowed weeds, diseases and pests plant protection (Вронских, 2005, 2011). Number of the tractors in the agriculture increased to 53.3 thousand, the drives combine up to 4.5 thousand units.

During this period, the intensive technologies (industry) implemented everywhere. Against this background of the agriculture development the reserves of mineral nitrogen at the winter wheat were under graduation in use, moderate and optimal.

For example, in 1989 the average reserves of N-NO_3 in soil were 115 kg/ha and correspond to optimal gradation of ensure plants to mineral nitrogen. But, on the land cultivated with winter wheat was a pronounced difference in providing plants with mineral nitrogen. Only 23% of the total surface of wheat was supplied optimal with nitrogen, allowed weed plant protection (Table 1).

Table 1. Nitrate nitrogen reserves in the 1 m of soil layer, in the spring at the cultivation of winter wheat, % of total

Content of $N-NO_3$	Average for 2007-2013
Low	64
Moderate	26
Optimum	10
High	0
Average, kg/ha	**55**

About 10% of the land occupied by winter wheat is characterized by a low content of nitrate nitrogen. On these fields the effectiveness of nitrogen fertilizers was high. Note that the fertilizers application without the recommendations developed by agricultural science has led to the accumulation of mineral nitrogen in the soil in amounts greater than the optimal, over 141 kg/ha.

On such soles the mineral fertilizer efficiency was low, and in some fields occur fall plants. Systematic application of fertilizers in optimal doses, compliance of winter wheat growing technologies led to yielded 3.6 t/ha of grain.

A second formative period reserves of mineral nitrogen in the soil are the years 1994-2013. During this period the volume of applied fertilizer suddenly decreased in agriculture. Each hectare upon her only by 0.01 to 1.1 t/ha of manure and 4-17 kg/ha of nitrogen fertilizers. Surface of vegetable crops in field crop rotation decreased 5-6 times, constituting 30-40 thousand ha of perennial grasses and 15-20 thousand ha of peas.

Balance of humus, nitrogen, phosphorus and potassium in soils of Moldovan agriculture became negative (Table 2).

Productivity of winter wheat in the 2006-2010 period decreased on average by 2.2 t/ha of grain. In the 2008-2011 years the weighted average reserves of $N-NO_3$ in soil cultivation of winter wheat were low, constituting 55 kg/ha. Quota of soils with low content of mineral nitrogen was 64% of the total.

The fields with high soil $N-NO_3$ have disappeared. Share of fields with optimal mineral nitrogen content in soil was low and did not exceed the 10% level.

Under these conditions essentially increased efficiency of nitrogen fertilizers applied to optimal background of phosphorus in the soil. Each kg of nitrogen recover 10-15 kg of winter wheat grain.

Table 2. Balance of nitrogen, phosphorus and potassium in the Moldovan soils, kg/ha

Years	N	$P_2 0_5$	$K_2 0$	Sum of NPK
1913	-22	-13	-52	-92
1940	-26	-15	-62	-99
1945	-15	-15	-52	-82
1950	-27	-13	-68	-108
1951-1955	-27	-12	-62	-102
1956-1960	-40	-14	-82	-136
1961-1965	-59	-14	-80	-132
1966-1970	-36	-9	-84	-130
1971-1975	-22	-1	-79	-103
1976-1980	-15	+11	-66	-69
1981-1985	+9	+22	-33	-4
1986-1990	-15	+25	-49	-8
1991-1995	-18	-11	-80	-113
1996-2000	-30	-21	-83	-134
2001-2005	-24	-23	-81	-128
2005-2010	-26	-22	-84	-132

Agriculture requirement of mineral fertilizers in the Republic of Moldova

In the conditions of Moldova the natural factors which limit the production of high harvests are the insufficiency of nutrients in the soils as well the moisture deficit.

In order to achieve the growth rate in harvest of 40-50% it is necessary to compensate the deficit of nutrients by the use of fertilizers and rational utilization of the soil moisture.

The optimal level of fertilization provides the increase of the fertility of soils, obtaining high crops and a maximum profit from a unit of agricultural land, the protection of the environment from the pollution by nutrients.

The optimal application of fertilizers is required for a level of the modern agriculture soil no-till with respecting zonal crop rotations, the soil no-till, the integrated protection of plants, extension of irrigation, the development of the livestock sector, the implementation of intensive technologies of plant cultivation.

This system is based on the combined application of organic and mineral fertilizers in couple with fuller use of the biologic nitrogen (Table 3).

The optimal demand for nitrogenous fertilizers for the crop rotation will be 82.3 thousand tons of the active substance or N_{55} on average per 1 ha.

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Table 3. The optimum doses of mineral fertilizers for the fertilization of the main crop plants, kg/ha of the active substance

Crop plants	*Recommended dose*			*Remark*
	N	**P_2O_5**	**K_2O**	
Winter wheat	80	60	40	annual
Winter barley	34	60	0	*
Spring barley	34	60	0	*
Maize grains	60	50	0	*
Peas for grains	30	20	0	*
Sugar beet	105	80	40	*
Sunflower	45	40	40	*
Tobacco	35	40	40	*
Potatoes	60	60	60	*
Vegetables	90	60	60	*
Maize for silage	40	40	0	*
Fruitful vineyards	60	60	60	once in 3 years
Fruitful orchards	60	60	60	once in 3 years
New vineyards (founding)	-	400	400	to foun-ding
New orchards (founding)	-	400	400	to foun-ding

For potatoes and vegetable crops will be needed 6.8 thousand tons of nitrogen with the average dose for 1 ha - N_{60}. For the fruitful orchard fertilization will be needed 2.0 thousand tons of nitrogen, for the fruitful vineyards 1.5 thousand tons. The phosphoric fertilizer requirements will constitute 69.9 thousand tons for the field crops, 9.0 thousand tons for vegetables and potatoes, 1.5 thousand tons – for fruitful vineyards, 1.2 thousand tons for the fruitful orchards. The annual requirement of potassium fertilizers will be 28.3 thousand tons for field crops, 6.8 thousand tons for vegetables and potatoes and 3.1 thousand tons supplementary for the irrigated lands.

The total annual demand of fertilizers for the agriculture of the Republic of Moldova after 2020 will constitute 236.7 thousand tons of the active substance, including 99.9 tons of nitrogen, 91.0 thousand t of phosphorus and 45.8 thousand tons of potassium. This level of fertilization was reached in the 1976-1985 years by applying annually 243.6-362.0 thousand tons.

The use of the optimal fertilization system coupled with other technological links of cultivation of the crop plants will allow to get 4.0-4.2 tons of the winter wheat, 3.6 tons of grain maize and will form an equilibrated nutrient balance in Moldova's agriculture.

CONCLUSIONS

In the result of the investigations it was established that during the years 1981-1990, when in soil was applied 3-6 t/ha of manure, 50-70 kg/ha of nitrogen fertilizers, and quota of biological nitrogen fixing leguminous crops was about 300 thousand ha, the reserves of N-NO_3 in the root layer formation were optimal for yields of 3.4-3.8 t/ha with high bakery quality. In recent years (1996-2013) the amount of applied fertilizers in agriculture fell sharply, constituting 0.01 to 1.1 t/ha of manure and 5-20 kg/ha of NPK. Balance of humus and nutrients in the soils is negative. Accumulated reserves of mineral nitrogen in the soils are low, and provide only to 2.2-2.5 t/ha of winter wheat. Application of nitrogen fertilizers on optimal background of phosphorus and potassium nutrition ensures a significant increase in harvest. Each kg of nitrogen applied to winter wheat cultivation recovers 10-15 kg of grain.

REFERENCES

Andries S., 2011. Agrochemistry of nutrients. Fertilization and soil ecology. Chisinau: Pontos, p. 171-198 (rom).

Andries S., 2007. Optimization of soil nutrients regimes and crop productivity. Chisinau: Pontos, p.374 (rom).

Andries S. et al., 1993. Methodical instructions on soil-plant system diagnosis of mineral nutrition of winter wheat. Chisinau: Pontos, p.14-35 (rom).

Donos A., 2008. Accumulation and transformation of nitrogen in the soils. Chisinau: Pontos, p. 206 (rom).

Вронских М., 2005. Technology of crops cultivation and pests and diseases development. Chisinau: Pontos, p. 5-10 (rus).

Вронских М., 2011. Climate change and agricultural production risks in Moldova. Кишинев: Grafita Libris, p. 559 (rus).