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Diagnosis of Potatoes's Requirements for Nitrogen Fertilizers on Chestnut Soils of Northern Kazakhstan

Serik Abeuov
Department of Agrotechnology
Pavlodar State University
named after S. Toraighyrov
Pavlodar, Kazakhstan
abeuov.s@mail.ru

Yuri Ermokhin
Department of Agrochemistry
and Soil Science
Omsk State Agrarian University
named after P. A. Stolypin
Omsk, Russia
yui.ermokhin@omgau.org

Olzhas Shoykin
Department of Agrochemistry
and Soil Science
Omsk State Agrarian University
named after P. A. Stolypin
Omsk, Russia
od.shoykin@omgau.org

Victor Kamkin
Department of Agrotechnology
Pavlodar State University
named after S. Toraighyrov
Pavlodar, Kazakhstan
vikkamkin@gmail.com

***Abstract*— A key way of assessing plants' requirements for fertilizers is field experience. It allows you to establish the effectiveness of the fertilizers used in a particular crop, to identify the relationships between the chemical compositions of the soil, plants, crops and to develop a comprehensive method for optimizing the mineral nutrition of plants. On chestnut soils, the effect of doses of nitrogen fertilizers for potatoes in the ratios 1-3:1:1 ($N_{45-135}P_{45}K_{45}$) was studied. Reliably obtained high increases from nitrogen at a dose of 90 kg A.I./ha concerning the control - 4.5 t/ha (14.9%) and to the background 3.1 t / ha (9.8%). In all cases, the payback ranged from 0.156 to 0.25 c in the control and 0.2-0.4 c in the background (P_1K_1). The studies were carried out to diagnose the need for batteries on typical chestnut soils in the conditions of the Pavlodar region of Northern Kazakhstan. Below is a summary of the assessment of various dosages of nitrogen fertilizers for potatoes on the background of phosphorus-potassium nutrition.**

Keywords—yield, nitrogen fertilizers, chestnut soil, equations, potatoes.

I. Introduction

Nitrogen fertilizers are considered to be highly effective on all types of soil in the world when applied to crops. Nitrogen is the main companion for high yields. According to the importance of nitrogen in the farming system, each person cultivating land for a planned crop is required to monitor the level of nitrogen in the soil [1].

Potato is one of the main vegetable crops in North and North-East Kazakhstan. Numerous studies show that of all the elements of mineral nutrition, it is precisely the balanced and timely application of nitrogen fertilizers that is the key condition for high and stable yields [1, 2, 3, 4].

When covering issues related to increasing yields and studying potato varieties, the data cite the effects of fertilizers and breeding varieties on yield under various conditions [5, 6]. One of the factors for increasing the yield of potato tubers is the use of fertilizers in various doses and ratios by mathematical modeling in agronomy [7]. Linking the applied doses of fertilizers with pyield and, as a result, obtaining reliable increases by closely correlating these factors.

Significant differences in the soil and climatic conditions of large regions of potato growing require a differentiated approach to the study of nitrogen nutrition of potatoes depending on the region of cultivation [8-16].

In recent decades, with a lack of fertilizer in the soil, an increase in the price of agrochemicals, there is a need to optimize nitrogen fertilizers and study their effectiveness on various types of soils [1].

In a field experiment, a diagnosis of potato needs for nitrogen fertilizers was developed and the best doses were identified. Below are experimental data on potato yields on chestnut soils identified by years of research on the Dutch (ridge) technology for cultivating potatoes with integrated protection from pests, diseases and weeds.

II. Methods

Experimental studies with fertilizers were conducted at Ushterek & K LLP in 2015-2017. Field experiments were performed on chestnut soils typical of the study area. The area of the experimental plot was 48 m^2, 4-fold repetition. The location of the plots in 4 tiers is randomized.

The objects of research were potatoes - variety "Gala", chestnut soil, mineral fertilizers associated with a single set of agrotechnical and weather conditions. Soil parameters: humus content according to Tyurin 1.7%, pH-7.1; base saturation - 23.5 mg·eq / 100 g; the cation exchange capacity is 26.5 mg·eq / 100 g. C is 4.35%. Nitrogen - ammonium nitrate, phosphoric - ammophos and potash in the form of potassium chloride were used as fertilizers. Fertilizers were applied to the soil and cultivated by a cultivator.

III. Results

Establishing the most optimal doses and ratios of mineral fertilizers allows us to diagnose the need for plants for fertilizers, taking into account the actual content of mobile forms of nitrogen, phosphorus and potassium in the soil [9]. Diagnostics of plant nutrition makes it possible to obtain high yields before harvesting by establishing the relationship between the size of the crop, the doses of fertilizers used, as well as the chemical composition of the soil and plants [9, 10].

Currently, the effect of fertilizers on the content of chemicals in plants that determine the quality of the crop has been largely clarified. The formation of a potato crop depends on the availability of plants with nutrients in an accessible form in the soil. Long-term studies with potatoes were carried out on chestnut soils of the Pavlodar region, where a positive effect was established, they show nitrogen fertilizers against the background of $P_{45}K_{45}$. [8, 9, 11].

The effect of nitrogen fertilizers with doses of 45-135 kg was studied. A.I./ha against the background of $R_{45}K_{45}$ (class step 45 kg A.I./ha). The main results of the effect of nitrogen fertilizers on potatoes are shown in table 1.

The best nitrogen dose of 90 kg A.I./ha corresponds to soils with a low content of mobile forms P, K. The experimental data obtained in the field experiment allow us to reveal the effect of doses of nitrogen fertilizers on the yield of potato tubers [8, 11].

In the first year of fertilizer action, the yield was the highest on option $N_{135}P_{45}K_{45}$ and amounted to 37.1 t / ha. In 2016 and 2017, a nitrogen dose of 135 kg reduced yield, the best yields were obtained at N_{90} against the background of phosphorus-potassium nutrition. According to the years of research (2015-2017), depending on meteorological conditions, crop yields were in varying degrees, however, the general regularity of the action of nitrogen fertilizers of 90 kg A.I./ha remained.

TABLE I. THE YIELD OF POTATO TUBERS (AVERAGE 2015-2017) AND THE PAYBACK OF APPLIED FERTILIZERS

Variation	**Tuber yield, t/ha**	**Increase**				**Fertilizer payback with a crop of 1 kg A.I., centner**	
		To control		***To background***		***To control***	***To background***
		t/ha	***%***	***t/ha***	***%***		
Control	30.3	-	-	-	-	-	-
P_1K_1	31.7	1.4	4.6	-	-	0.156	-
$N_1P_1K_1$	33.5	3.2	10.6	1.8	5.7	0.237	0.400
$N_2P_1K_1$	34.8	4.5	14.9	3.1	9.8	0.250	0.344
$N_3P_1K_1$	34.4	4.1	13.5	2.7	8.5	0.182	0.200

Based on 3-year experimental data with fertilizers on chestnut soil in the conditions of the steppe zone of Pavlodar region, the maximum yield was obtained on the $N_{90}P_{45}K_{45}$ variant - 34.8 t/ha, the minimum on the control - 30.3 t/ha. The best dose of nitrogen (N_{90}) increased the yield compared to the control by 4.5 t/ha (by 14.9%), and compared with the background ($P_{45}K_{45}$) by 3.1 t/ha or by 9.8%.

Experience shows that on chestnut soils, the Gala potato yields maximum tuber yield increases when using NPK fertilizers in the ratio of fertilizers 2:1:1 (Fig. 1).

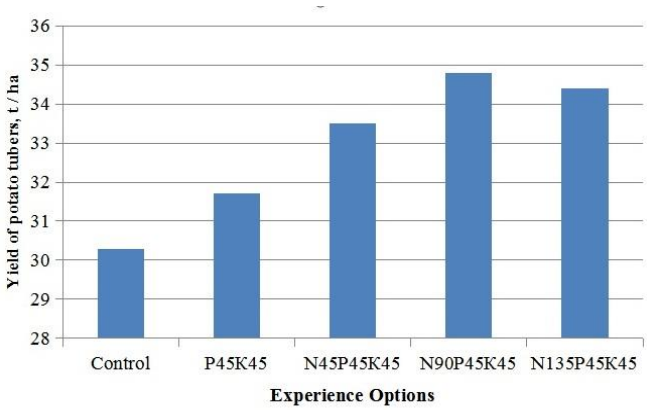

Fig. 1. Example of a figure caption. (*figure caption*)

Having the intensity factors of 1 kg of fertilizers on the size of the potato crop (kg / ha or t / ha) and the need for fertilizers (NPK) to create a crop unit (1 kg / ha or 1 t / ha), you can determine the amount of fertilizer needed to ensure the planned crop increases [8, 11].

Based on mathematical modeling of the effect of nitrogen fertilizers on potato yield, a significant correlation was established in the system "dose N (x, kg A.I./ha) → crop (Y,t/ha)" according to the years of study (Figure 2-5).

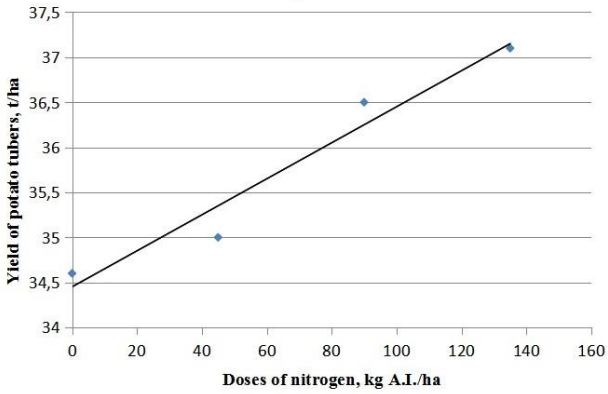

Fig. 2. The relationship of potato yields with doses of nitrogen fertilizers relative to the background (2015)

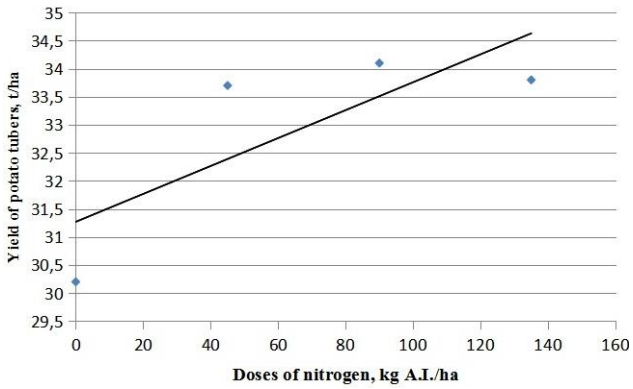

Fig. 3. The relationship of potato yield with doses of nitrogen fertilizers relative to the background (2016)

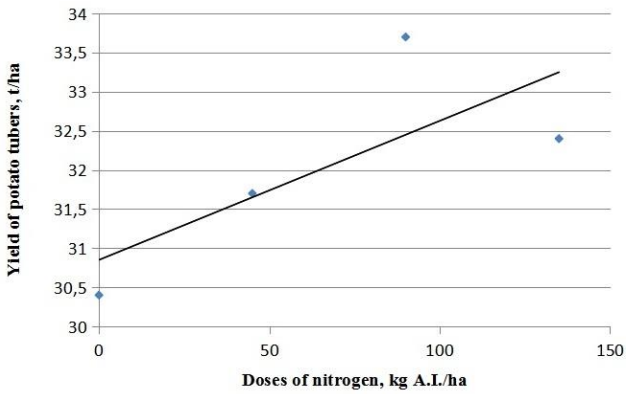

Fig. 4. The relationship of potato yield with doses of nitrogen fertilizers relative to the background (2017)

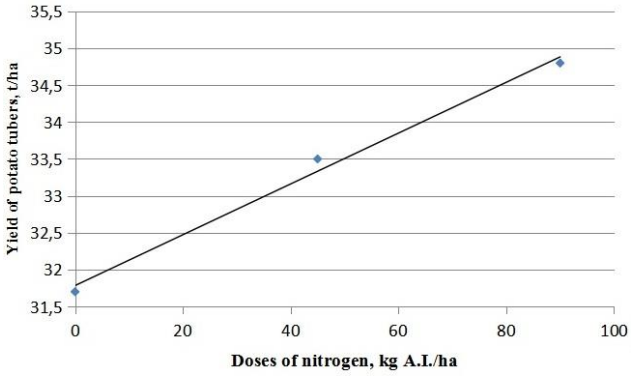

Fig. 5. The relationship of potato yield with doses of nitrogen fertilizers relative to the background (average 2015-2017)

The figures indicate that each kilogram of nitrogen introduced into the soil increases the yield of potato tubers by 0.02, 0.025, 0.018 and 0.0344 t / ha, respectively. The figures show the current relationship between yields and doses of nitrogen fertilizers characterized by significant correlation indices.

The dependence of the yield of potato tubers (Y,t/ha) on the doses of nitrogen fertilizers (N kg A.I./ha) is described by the regression equations (1-4).

a) 1st year of fertilizer application

$$Y = 34{,}45 + 0{,}02N; \qquad r = 0{,}95 \qquad (1)$$

b) 2nd year of fertilizer application

$$Y = 31{,}27 + 0{,}025N; \qquad r = 0{,}62 \qquad (2)$$

c) 3rd year of fertilizer application

$$Y = 30{,}85 + 0{,}018N; \qquad r = 0{,}56 \qquad (3)$$

When nitrogen fertilizers were applied from low (N_{45}) to optimal doses (N_{90}) for potatoes on chestnut soils, a high correlation coefficient and regression equations were obtained (4).

d) Three years on average

$$Y = 31{,}78 + 0{,}0344N; \qquad r = 0{,}99 \qquad (4)$$

From equation 4 it follows that each kilogram of nitrogen fertilizers applied from low (N_{45}) to optimal doses (N_{90}) against the background of $P_{45}K_{45}$ increases the yield of potato tubers by 0.0344 t/ha or 0.344 c/ha. Consequently, the introduction of a dose of nitrogen into the soil and the formation on this soil of the potato tuber crop yield - the plant's identification response to fertilizers ("b" - 0.344) allows diagnosing not only the potato needs for fertilizers, but also calculating the doses of nitrogen fertilizers according to formula 5.

$$D_N = \frac{Ey - Ay}{b}, kg/ha \qquad (5)$$

$$\text{Or } D_N = \frac{I}{b}, kg/ha \qquad (6)$$

Where:

Ey – expected yield, c/ha (348 c/ha);

Ay – actual yield, c/ha (317 c/ha);

b – the intensity of the action of a unit of introduced nitrogen on the yield of potatoes ("b" - 0.344)

I – increase, c/ha.

The calculation of the dose of nitrogen is:

$$D_{N,kg/ha} = \frac{348-317}{0{,}344} = \frac{31}{0{,}344} = 90\,kg/ha \qquad (7)$$

Field experiments with potato fertilizers show that nitrogen-phosphorus-potassium fertilizers were applied in a combination of 2: 1: 1, in the amount of 180 kg / ha (90 + 45 + 45). Calculations show that per unit of fertilizer applied in kg / ha accounts for: 180 kg / ha: 4 = 45 kg / ha. 2 times more nitrogen fertilizers were introduced, therefore, the calculation of nitrogen fertilizers amounted to

$$D_{nitrogen} = \frac{180}{4} \cdot 2 = 90,\ kg/ha \qquad (8)$$

$$D_{phosphorus} = \frac{180}{4} \cdot 1 = 45,\ kg/ha \qquad (9)$$

$$D_{potassium} = \frac{180}{4} \cdot 1 = 45,\ kg/ha \qquad (10)$$

In fact, taking into account the use of NPK fertilizers for potatoes in the total amount of doses in specific combinations ($N_2P_1K_1$), it seems possible to calculate the doses of nitrogen-phosphorus-potassium fertilizers, using the data of field methods with fertilizers on chestnut soils of Pavlodar region.

Thus, this approach to determining the amount of fertilizer per crop increase taking into account the payback allows you to link the payback fertilizer yield on chestnut soils by the method of statistical analysis obtained on farms and monitor the effectiveness of fertilizers. In terms of fertilizer payback, it is of interest to use complex fertilizers, in which 2-3 nutrient components are present in the active substance, which provides synergies in the availability of nitrogen assimilation to the potato plant.

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