

Diagnosis of potato mineral nutrition based on statistical analysis of two variables

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Abstract. The purpose of the research is to diagnose the mineral nutrition of potatoes based on the characteristics of the relationship between two variables. Potato yield in terms of yield increases to the control and background of mineral nutrition shows how effective doses of mineral fertilizers in double and triple combination are. The most effective option was nitrogen in a 2:1:1 combination at doses of N₉₀P₄₅K₄₅ with an addition to the control of 1.47 t/ha (27.1%), and to the background of 1.28 t/ha (22.8%). In second place in terms of efficiency was the potassium variant in a 1:1:2 combination, where the increase was equal to the fertilizer-free variant of 1.45 t/ha (26.7%) and to the background of 0.98 t/ha (16.6%). Phosphorus fertilizers against the background of N₄₅K₄₅ gave an increase of 0.83 t/ha (14.1%), and in relation to the control – 1.29 t/ha or 23.8%. Based on the statistical analysis of two variables "x" (fertilizer dose, kg/ha) and "Y" (yield, t/ha or c/ha), it is possible to show how much one indicator changes in relation to the other. Based on correlation and regression analysis, close relationships of two variables were obtained, which corresponded to high correlation coefficients $r = 0.91$ (nitrogen), $r = 0.83$ (phosphorus) and $r = 0.93$ (potassium).

1 Introduction

In field experiments with potatoes, a program was developed on the effectiveness of nitrogen, phosphorus and potassium doses of applied fertilizers and recommendations were issued to production [1-2]. A qualitative indicator of potatoes is the content or yield of dry matter (c/ha or t/ha). The composition of the dry substance includes approximately 80% starch [1-4]. Therefore, the yield of dry matter is an important criterion of starchiness. The establishment of dependencies between the chemical composition of soil, leaves, fertilizer doses and yield clearly indicates the possibility of practical use of these patterns for the diagnosis of mineral nutrition of plants [1-2, 5-8].

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2 Materials and methods

The research was carried out in 2016-2017 on the territory of Ushterek & Co LLP in the conditions of Northern Kazakhstan. The object of the study was mineral fertilizers in various doses and combinations, and the foreign-bred potato variety "Gala". Increasing fertilizer doses was considered in increments of 45 kg a.m./ha to 135 kg for nitrogen, and up to 90 kg for phosphorus and potassium. The soil was chestnut, typical for this region with a light granulometric composition. The experiment was performed in 4-fold repetition. The placement of options was randomized. The plot area was 48 m². Mathematical patterns were established using statistical programs on a personal computer.

3 Results

The best doses of fertilizers identified by field experiments are shown in Table 1.

Table 1. Yield of potato dry matter with additions to the control and background, t/ha.

Option	Yield of dry matter, t/ha	Increase to the control		Increase to the background, t/ha			"b" payback rate of 1 kg a.m. fertilizers by yield, c/ha		
		t/ha	"b", c/ha	P ₄₅ K ₄₅	N ₄₅ K ₄₅	N ₄₅ P ₄₅	N	P	K
				N	P	K			
Control	5.42	-	-						
P ₄₅ K ₄₅	5.61	0.19	0.021						
N ₄₅ K ₄₅	5.88	0.46	0.051						
N ₄₅ P ₄₅	5.89	0.47	0.052						
N ₄₅ P ₄₅ K ₄₅	6.61	1.19	0.088	1.0	0.73	0.72	0.222	0.162	0.160
N ₉₀ P ₄₅ K ₄₅	6.89	1.47	0.082	1.28			0.142		
N ₁₃₅ P ₄₅ K ₄₅	6.51	1.09	0.048	0.9			0.067		
N ₄₅ P ₉₀ K ₄₅	6.71	1.29	0.072		0.83			0.092	
N ₄₅ P ₄₅ K ₉₀	6.87	1.45	0.081			0.98			0.109

From the data in Table 1, it can be concluded that the highest yield from the use of nitrogen-phosphorus-potassium fertilizers in comparison with the control was with a combination of 2:1:1 at doses of N₉₀P₄₅K₄₅, the increase was 1.47 t/ha (27.1%). The second place in efficiency for the yield of tubers dry matter was found in the NPK variant in a 1:1:2 combination, the increase was 1.45 t/ha or 26.8%. Phosphorus fertilizers against the background of N₄₅P₄₅ gave an increase of 0.83 t/ha, which amounted to 13.9%, and in relation to the control – 1.29 t/ha or equal to 23.8%.

They correspond to soils with low levels of nitrate nitrogen, phosphorus and potassium. The results of field experiments allow us to establish an indicator of the relationship between the yield and the dose of fertilizer ("b") [1, 2, 4].

Comparing the intensity of the action of each introduced nitrogen, phosphorus and potassium in doses from 45 to 90 kg/ha (against the PK, NK and NP backgrounds) on the dry matter tuber yield, it shows the highest coefficient ("b") of payback ratio per kilogram by yield and fertilizer dose.

By having the intensity coefficients of 1 kg of fertilizers per potato crop (c/ha or t/ha) and "b" - fertilizer requirements (NPK) to create a yield unit (1 c/ha or 1 t/ha), it is possible to determine the amount of fertilizers needed to ensure the planned increase in yield.

Based on field experiments with fertilizers and statistical analysis, as well as the mathematical correlation and regression method, these indicators ("b_N", "b_P", "b_K") were obtained, characterizing the dynamics of the relationship between the variables "x" (fertilizer doses) and "Y" (potato yield). They show how much, on average, the value of

one feature changes when another changes, and are calculated according to accepted calculation methods (Figures 1-3).

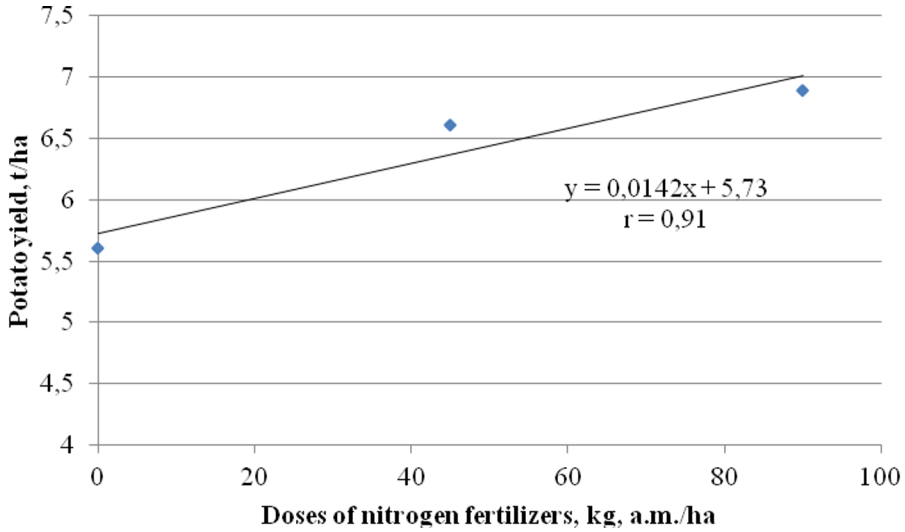


Fig. 1. The relationship between potato yield and doses of nitrogen fertilizers.

Each kilogram of nitrogen introduced into the soil increased the yield of tubers by 0.014 t/ha.

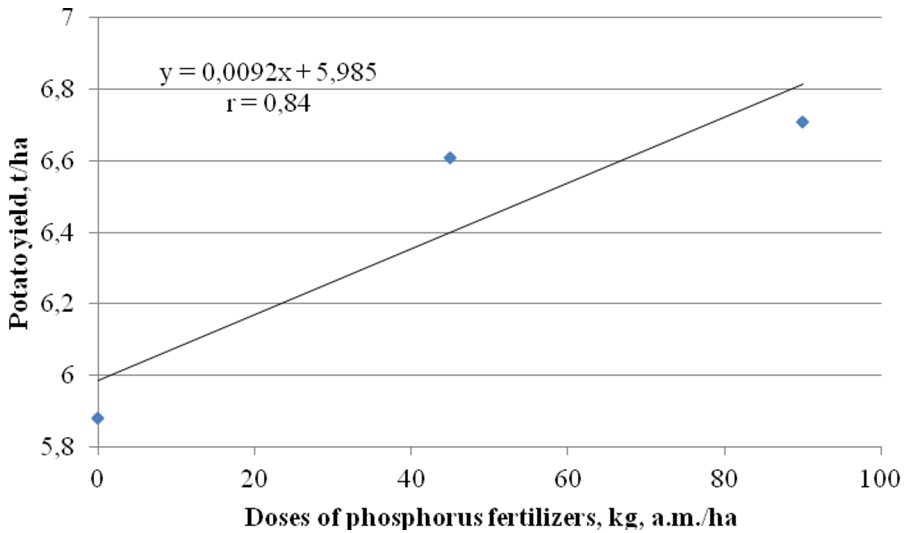


Fig. 2. The relationship between potato yield and doses of phosphorus fertilizers.

Each kilogram of phosphorus introduced into the soil increased the potato yield by 0.009 t/ha.

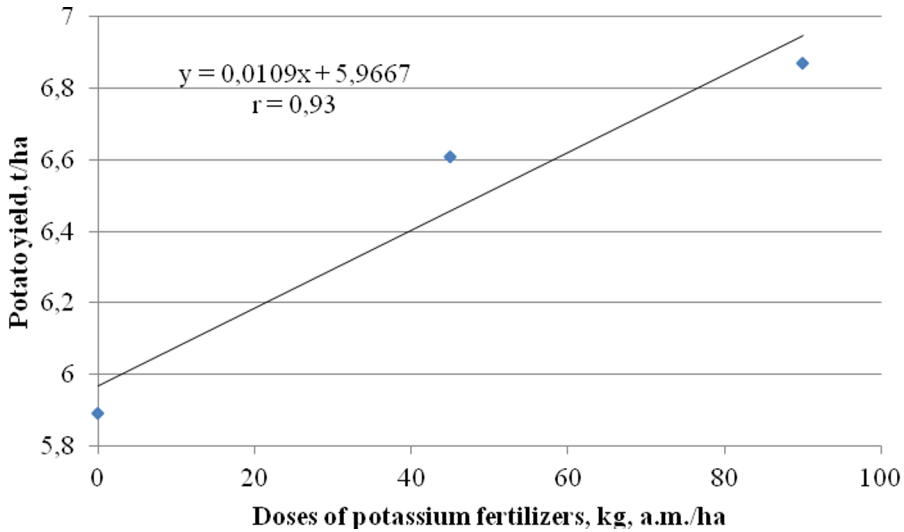


Fig. 3. The relationship between potato yield and doses of potassium fertilizers.

Figure 3 notes that 1 kg of potassium fertilizers increased the yield of potato dry matter by 0.011 t/ha. Figures 1-3 indicate the current relationship of the crop with the use of fertilizers (NPK).

To determine the amount of necessary fertilizers for potatoes on chestnut soils, the following data should be available: the amount of crop increase, the intensity coefficient of the fertilizer unit per crop (" b ") and the ratio N:P:K developed for this crop and soil type: nitrogen, phosphorus and potassium were added in a combination of 2:1:1. The payback ratio of 1 kilogram of nitrogen was 0.14 kg of potato dry matter, of phosphorus fertilizers " b_N " – was 0.09 kg/ha. Thus, the applied doses of NPK fertilizers in a combination of 2:1:1 (N₉₀P₄₅K₄₅) gave the highest yield increase of potato tubers compared to the control – 0.082.

The amount of crop increase is calculated based on knowledge of the basic yield, i.e. yield without the use of mineral fertilizers. Thus, our research shows that the average increase in potato yield (I) from nitrogen fertilizers (against the background of P₄₅K₄₅) can be obtained in the range of 12.8 c/ha (1.3 t/ha), from phosphorus (against the background of N₄₅K₄₅) – 8.3 c/ha (0.83 t/ha), from potassium fertilizers (against the background of N₄₅P₄₅) – 9.8 c/ha (0.98 t/ha). All increases were obtained from nitrogen fertilizers in a ratio of 2:1:1 (in the sum of parts – 4), from phosphorus fertilizers in a ratio of 1:2:1 (in the sum of parts – 4), from potassium fertilizers – 1:1:2 (in the sum of parts – 4). The coefficient " b_N " = 14.2, " b_P " = 9.2, " b_K " = 10.9, i.e. each kilogram of fertilizers increased yields, respectively, by 14.2, 9.2 and 10.9 kg (Table 1).

The correlation coefficient between the doses of nitrogen, phosphorus and potassium applied as fertilizers for potatoes and the dry matter tuber yield were, respectively, $r = 0.91$, $r = 0.83$, $r = 0.93$, and the equations in Figures 1, 2, 3 indicate the current relationship between the two variables.

The amount of nutrients (D) required to ensure the planned increase in yield is determined by formula 1:

$$D = \frac{U_P - U_F}{b}, \quad (1)$$

Where U_P is the planned yield, t/ha; U_F is actual yield, t/ha.

Calculation of doses $N_2 + P_1 + K_1$ for an increase of 1.5 t/ha and " b " = 0.082.

$$\sum N_2 + P_1 + K_1 = 4$$

$$D_{N_2+P_1+K_1} = \frac{15c}{0,082} \approx 180 \text{hg} / \text{ha}$$

$$D_N = \frac{180}{4} \cdot 2 = 90 \text{kg} / \text{ha}$$

$$D_{P_2O_5} = \frac{180}{4} \cdot 1 = 45 \text{kg} / \text{ha}$$

$$D_{K_2O} = \frac{180}{4} \cdot 1 = 45 \text{kg} / \text{ha}$$

4 Discussion

Thus, having the identified best doses of fertilizers for potato yields in a ratio of 2:1:1 in the sum of $N + P + K = 4$, with a coefficient of " b " = 0.082 quintal, doses of nitrogen, phosphorus, potassium fertilizers can be calculated and recommended for production.

Therefore, with a 2:1:1 fertilizer combination, the planned increase in potato yield can be obtained by adding 90 kg of nitrogen, 45 kg of phosphorus and 45 kg of potassium. Table 1 shows the optimal doses of fertilizers identified by field experiments, they are in good agreement with the calculated doses.

5 Conclusion

Thus, based on the data obtained by methods of field experience and statistical analysis, it is possible to diagnose the need of plants for mineral fertilizers to obtain planned yields on chestnut soils. The doses of fertilizers for the main application should be adjusted by the method of soil diagnostics, taking into account the action of various growth factors.

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