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Effect of fertilizer norms on potato plant productivity and nutrient elements removal from the soil in mountainous-black soils of Gadabay district

Elnara Mahmudova

Institute of Soil Science and Agrochemistry, Ministry of Science and Education of the Republic of Azerbaijan, 5 M.Rahim Str., AZ1073, Baku, Azerbaijan

For correspondence: *elnare.84@list.ru*

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The main purpose of the research is to study the effect of optimal fertilizer norms on potato productivity under the black soil of the Chaldash village of the Gadabay district in the mountainous-black soil in non-irrigated conditions, and to determine the absorption of nutrients. As a result of the research, the application of organic and mineral fertilizers on a scientific basis under the potato plant created conditions for preserving the fertility of the black soil in non-irrigated conditions and increasing productivity. The farms were offered to use optimal fertilizer rates in the cultivation of potatoes on the black soil. The proposed fertilizer rate allows optimizing the soil nutrient regime, obtaining high and quality crops from cultivated plants, maintaining soil fertility and making the cost of the product profitable.

Keywords*: Mountainous-black soil, potato plant, productivity, nutrient elements, nitrogen, phosphorus, potassium*

INTRODUCTION

Intensive development of agricultural production, efficient use of land, application of new technologies, and provision of the population with food products are among the main issues of our time. Our republic has favorable soil-climatic conditions and relief. This, in turn, allows us to produce various types of vegetables, melons and potatoes.

Efficient use of organic and mineral fertilizers, as well as increasing the productivity of crops and meeting the population's demand for high-quality products, is a topical issue of our time. Gadabay district has unique soil-climatic conditions. It is possible to apply organic and mineral fertilizers (NPK) to each hectare of land in Gadabay district in the amount required, making it suitable for sowing.

The Chaldash village of Gadabay district was formed in a mild climate with dry winters. The soil moisture coefficient of the research area is 0.6-0.7; drought index is 1.6-1.8; annual heat above 10°C is 3500-4400°C 122-132 kcal/cm^2, the number of days with air temperature above 10°C is 180-240 days, and the number of days with soil temperature above 10°C is 210-240 days. The soil-forming rocks of the area are delluvial gravelly, loess-like, carbonate clayey clays, weathering products of limestones and limestone sandstones, clayey schists, basalt eluvium, etc., bedrocks.

Raw gypsum ($CaSO_4 \cdot 2H_2O$,) with a content of 71-73% $CaSO_4$, ground, was applied as a fertilizer in the experiments. Gypsum is a unique method used to ensure the neutrality of the soil solution. In general, it is possible to improve the soil and increase its fertility by applying manure, compost, and gypsum.

Gypsum is used not only for the chemical reclamation of saline soils, but also to improve the nutrition of plants with calcium and sulfur in other soils. Gypsum, which contains calcium and sulfur, is primarily used as a fertilizer for legumes. Clover and three-leaf clover use these elements more than other plants.

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Gypsum is applied to grasses as a surface fertilizer, and to other plants as a soil fertilizer, at a dose of 3-4 centners per hectare. The positive effect of gypsum on the development and productivity of plants on acidic soils is associated not only with the improvement of calcium and sulfur nutrition, but also with the increase in the resistance of plants to an acidic environment due to the increase in calcium in the soil solution and the conversion of potassium into an easily assimilated form. As a result of the application of gypsum, the yield of clover increased by 7-10 centners per hectare on podzolic soils, and by 6-7 centners per hectare on gray forest soils and washed chernozems. Thus, gypsum plays an important role in improving soil fertility and creating optimal conditions for plant nutrition (Guliyev, 2004).

Gypsum is a convenient method for ensuring the neutrality of the soil solution. When a mixture of ammonium nitrate and gypsum is applied to the soil, a neutral salt is formed, which does not harm the plants. As a result, the soil solution becomes neutral and the physical, chemical, and biological properties of the soil improve, plant cultivation becomes easier, and the aeration process normalizes (Alizadeh, 2013). Since the mixture of salts is neutral (pH-7), plants absorb this complex fertilizer and develop intensively.

MATERIALS AND METHODS

The researches were conducted on the mountainous-black soils of the northeastern part of the Lesser Caucasus. Field soil researches were conducted to study the agrochemical and agrophysical properties of the soils of the research area.

Field experiments were conducted in 2015-2017 on the mountainous-black soils allocated for sowing in the Chaldash village of Gadabay district under the “Sevinj” potato variety.

The experiments were carried out with the Sevinj potato variety in 6 variants and 3 replicates. The total area of the experiment is 1100 m^2, and the area of each plot is 50 m^2. The planting was carried out according to the 75x30 cm scheme. The experiments were set up according to the following scheme. The placement of variants and replicates within the space was carried out based on the methodology for field experiments (Dospekhov, 1985).

1. Control (free fertilizer)
2. Organic fertilizer manure 10 tons
3. Organic fertilizer manure 15 tons
4. N60P60K60
5. N90P90K90
6. N93P98K126 +Gypsum163 +20 tons of manure.

In the experiments, ammonium chloride (active ingredient 34%) was used as a nitrogen fertilizer, double superphosphate (P_2O_5-- 48 %-) as a phosphorus fertilizer, and potassium sulfate (K_2O-46%) as a potassium fertilizer.

As an organic fertilizer, semi-rotted cattle manure with a content of 0.5% nitrogen, 0.25% phosphorus and 0.6% potassium, and a moisture content of 65% was used.

In addition, raw gypsum ($CaSO_4 \cdot 2H_2O$,) with a ground content of 71-73% $CaSO_4$ was applied as a fertilizer in the experiments.

During the research, soil samples were taken at different depths (0-20, 20-40 and 40-60 cm) in the area. The soil pH, $CaCO_3$, humus, total nitrogen, total phosphorus, easily hydrolyzed nitrogen, mobile phosphorus, exchangeable potassium, etc. indicators were determined in the samples taken.

In order to know the dynamics of the dependence of the main nutrients in the soil on the fertilizer rates, soil samples were taken from the depths of 0-20, 20-40 cm in all variants of the replications in different phases of plant development (budding, flowering, ripening phases). In order to determine the quality indicators of the product formed in the final phase (ripening), different samples were taken from each of the variants of the replications. Soil analyses: total nitrogen (N) - by the Keldahl method, mobile phosphorus (P_2O_5) - dissolved in 1% ammonium carbonate solution - by the Machigin method, exchangeable potassium (K_2O) - dissolved in 1% ammonium carbonate solution - were carried out in a flame photometer. Mathematical statistical analysis of the research results was carried out in the SPSS26 computer program and based on the analysis of variance-statistics.

RESULTS AND DISCUSSION

It has been known from the literature that one of the main factors for obtaining high yields from agricultural crops is providing the plant with the necessary nutrients. The application of fertilizers is one of the most important agrotechnical measures in increasing the productivity of potato plants. Thus, organic fertilizers are both a source of energy and food for microorganisms in the soil. Therefore, fertilizers should be applied in specified doses. At the same time, the biological, physical-chemical properties of the soil, and the water-air regime improve. We know that the main part (40%) of the nutrients supplied to the soil every year is paid for by fertilizers (Abbasov I., 2010).

It should be noted that in order to increase productivity, it is necessary to provide the plant with nutrients during its growth phases. Studies have shown that there is a positive correlation between productivity and mineral fertilizers. Productivity can be increased by 40-50% due to fertilizer norms. That is why it is necessary to provide plants with mineral fertilizers in the correct norms. If mineral fertilizers are not given in the correct norms and proportions, their productivity and soil fertility decrease. While mineral fertilizers are characterized by a rapid effect of nutrients on plant productivity, organic fertilizers enrich the soil with all the nutrients necessary for plant nutrition. They normalize the physical and agrochemical properties of the soil and at the same time increase the amount of microorganisms important for the soil and intensify the absorption of nutrients by plants.

During the research years, when studying the effect of fertilizer rates on potato yield in mountainous black soils allocated for sowing in the Chaldash village of Gadabay district, northeastern part of the Lesser Caucasus, it was found that the yield of the "Sevinj" potato variety varied depending on the fertilizer rates and the preparation of potato seeds for sowing.

According to the results of our three-year study, the application of fertilizers in different doses affected the productivity of potato plants compared to the control (free fertilizer) variant. In the variant where 10 tons of manure were applied, the average productivity increased by 175 s/ha or 16.66% compared to the control (free fertilizer) variant, in the variant where 15 tons of manure were applied, the productivity increased by 195 s/ha, by 45 s/ha or 30.00% compared to the control variant. Depending on the norms and ratios of mineral fertilizers, the productivity changes. Thus, in the variant where N60P60K60 was applied, the productivity was 217 s/ha, an increase of 67 s/ha or 44.66% compared to the control variant. In the variant where N90P90K90 was applied, the total yield was 245 s/ha, an increase of 95 s/ha or 63.33%. The highest productivity was achieved in the potato plant in the variant with N93P98K126+ Gips163 +20 tons of manure. In this variant, the average productivity increased by 266 s/ha, compared to the control variant by 116 s/ha (Mahmudova, 2024).

The application of organic fertilizers and mineral fertilizers under potato plants, in addition to increasing productivity, significantly affects the mass, chemical composition and amount of nutrients of root and stem residues, significantly increasing soil fertility (Zamanov, Aliyeva, 2007).

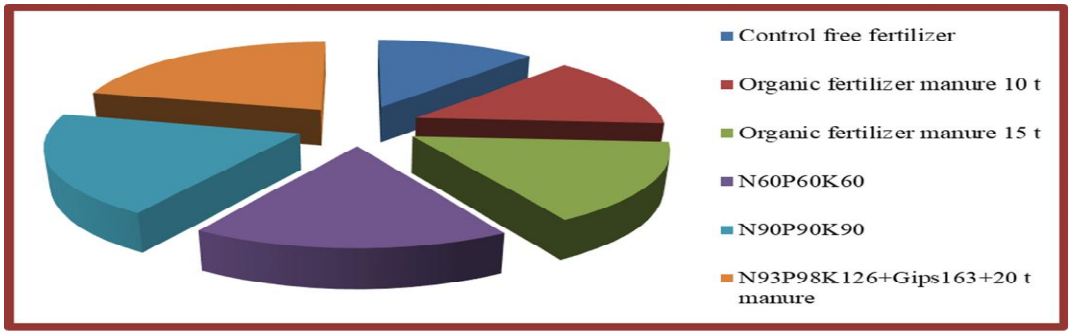

Fig. 1. Effect of different norms and ratios of mineral and organic fertilizers on the productivity of potato plants in mountainous-black soils. V=1,24-3,01%%; P=0,72-1,9%%; $HCP_{0,95}$=3,51-16,46 s/ha.

Nitrogen, phosphorus and potassium, as basic nutrients, are of great importance in the life of plants. Nitrogen has a good effect on the growth of the plant's mass and elongation by increasing its green mass. At the same time, nitrogen is included in the composition of protein, amino acids and many biologically active substances, which are considered basic nutrients (Agricultural Insurance Fund, 2022).

During the conducted research, the effect of the norms and proportions of organic, mineral and complex fertilizers on the accumulation of starch in potato plants was investigated. It was determined that in the variants where organic fertilizers were applied, starch fluctuated between 17.2–17.9%, while in the variants where mineral fertilizers were applied, starch was 18.6%. In the variant where N93P98K126+Gips163+20 tons of manure complex fertilizer was applied, the highest indicator was determined as 18.9% (Table 1).

The experiment also studied the effect of organic, mineral and gypsum fertilizers on the accumulation of crude protein in potato plants. It was determined that the application of different norms and ratios of organic and mineral fertilizers caused an increase in the amount of crude protein to one degree or another compared to the control (without fertilizer) variant. Thus, if the amount of crude protein in the control variant was 2.03 /%, then in the variants where organic and mineral fertilizers were applied, the crude protein fluctuated between 2.18–3.32 /%. The best result was determined in the variant where N93P98K126 + Gypsum163 +20 tons of manure complex fertilizer was applied, which was 4.21 /%.

During the study, the effect of different norms and ratios of organic, mineral and gypsum fertilizers on the accumulation of nitrates in potato plants was also investigated. The experiments conducted showed that the application of mineral and organic fertilizers in different norms and ratios increased the amount of nitrates by 1.3 times compared to the control (without fertilizer) variant. Thus, while the amount of nitrates in the control (without fertilizer) variant was 59 mg/kg, the amount of nitrates increased in the variants where organic fertilizers were applied: 60.6 mg/kg in the variant where 10 t of manure was applied, and 63.6 mg/kg in the variant where 15 t of manure was applied. In the variant where N93P98K126+Gypsum163 +20 tons of manure complex fertilizer was applied, the amount of nitrates was determined to be 77 mg/kg.

Table 1. The effect of applying organic and mineral fertilizers in different rates and proportions on the quality indicators of potato plants

№	Variants	Dry matter %	Dry matter yield s/ha	Starch %	Starch yield per s/ha	Crude Protein %	Nitrates mg/kg
1.	**Control free fertilizer**	19,65	12,58	17,23	10,2	2,03	59
2.	**Organic fertilizer manure 10 t**	19,78	14,84	17,43	14	2,18	60,6
3.	**Organic fertilizer manure 15 t**	20,08	16,03	17,7	15	2,53	63,6
4.	**$N_{60}P_{60}K_{60}$**	20,53	17,13	18,13	16,33	2,85	67
5.	**$N_{90}P_{90}K_{90}$**	21,05	18,61	18,33	17,23	3,32	71
6.	**$N_{93}P_{98}K_{126}$+Gips163+20 t manure**	22,36	21,40	18,73	19,33	4,21	77

Table 2. Effect of fertilizer norms on the amount of nutrient elements removed from mountainous-black soil by potato tubers

Variants	Potato productivity, s/ha	Amount of nutrients, %			Removing of nutrients, kg/ha		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
Control free fertilizer	150	0,16	0,06	0,56	24,0	9,0	84,0
Organic fertilizer manure 10 t	175	0,19	0,09	0,60	33,25	15,75	105,0
Organic fertilizer manure 15 t	195	0,23	0,11	0,62	44,25	21,45	120,9
$N_{60}P_{60}K_{60}$	217	0,29	0,14	0,67	62,93	30,38	145,4
$N_{90}P_{90}K_{90}$	245	0,34	0,17	0,72	83,30	41,65	176,4
$N_{93}P_{98}K_{126}$+Gips163+20 t manure	266	0,40	0,20	0,78	106,4	53,20	207,5

Phosphorus not only has a positive effect on the development of the fruit-forming organs of the plant, but also minimizes the vegetation period of the plant. Phosphorus improves productivity and product quality (Mammadov, 2007).

Potassium also affects the chemical composition of plants. Although potassium is not included in the composition of organic compounds in the plant, it has an activating effect on metabolism. When potassium fertilizer is applied, it enhances the synthesis of sucrose, fats, and starch in the plant (Agricultural Insurance Fund, 2022).

It is known from literature that, with proper adherence to agrotechnical rules, 100 centners of potato tubers and 80 centners of green mass remove 40-60 kg of nitrogen, 15-20 kg of phosphorus, and 80-100 kg of potassium from the soil (Torikov, Sorokin, 2011).

When a potato plant is just starting to grow, it removes a small amount of nutrients from the soil. During the budding and flowering phase, the potato plant takes up 60% of the total nitrogen, 60% of phosphorus, and 50% of potassium from the soil.

It has been found from the researches that 6.2 kg of nitrogen, 2 kg of phosphorus, 14.5 kg of potassium are used to produce one ton of crop. In this case, approximately 138 kg of nitrogen, 63 kg of phosphorus and 240 kg of potassium are used to produce 30 tons of potato crop (Seyidzadi, 2021).

We also studied the amount of nutrients taken from the soil by potato tubers of fertilizer norms in our researches.

At the same time, in the research, we studied the amount of nutrients taken from the soil by potato tubers of fertilizer norms with average indicators over 3 years. The results are given in Table 2. It can be seen from the table that in the control variant free fertilizer, 24.0 kg of nitrogen, 9.0 kg of phosphorus and 84.0 kg of potassium were taken per hectare by potato tubers of 150.00 s/ha. In the 10-t organic fertilizer variant, 32.25 kg of nitrogen, 15.75 kg of phosphorus, and 105.0 kg of potassium were applied per hectare with a potato yield of 175 s/ha. In the 15-t organic fertilizer variant, 44.25 kg of nitrogen, 21.45 kg of phosphorus, and 120.9 kg of potassium were applied per hectare with a yield of 195 s/ha, and in the N60P60K60 variant, 65.93 kg of nitrogen, 30.38 kg of phosphorus, and 145.4 kg of potassium were applied per hectare with a yield of 217.0 s/ha. In the N90P90K90 variant, 83.30 kg of nitrogen, 41.65 kg of phosphorus, and 176.4 kg of potassium were absorbed per hectare with a yield of 245.0 s/ha. In the N93P98K126+ Gypsum163 +20 tons of manure variant, 106.4 kg of nitrogen, 53.20 kg of phosphorus, and 207.5 kg of potassium were absorbed per hectare with a yield of 266.0 s/ha.

CONCLUSIONS

- The highest yield in the "Sevinj" potato variety was obtained at the N93P98K126+ +Gips163+20 tons of manure fertilizer norm, the yield was 266 sen/ha on average in 3 years. This is 43.60% more compared to the control variant.
- Removing nitrogen, phosphorus, and potassium by the yield of tubers of the "Sevinj" potato variety was 24.0 kg/ha, 9.0 kg/ha, 84.0 kg/ha in the control free fertilizer variant. At the N93P98K126+Gips163+20 tons of manure fertilizer norm, nitrogen increased by 76.9%, phosphorus by 82.6%, and potassium by 58.5% compared to the control variant.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to this study.

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ORCID

Elnara Mahmudova: https://orcid.org/0009-0008-8860-8622