

## OPTIMIZING MINERAL NUTRITION FOR BEAN QUALITY AND SUSTAINABLE AGRICULTURAL PRODUCTION

Mammadova Sh.A.<sup>1\*</sup>, Nasirova T.A.<sup>1</sup>, Valiyeva Z.M.<sup>1</sup>, Babayeva T.M.<sup>2</sup>

<sup>1</sup>*Institute of Geography, Ministry of Science and Education of the Republic of Azerbaijan*

117, H. Javid Ave., Baku, AZ1073

<sup>2</sup>*Mingachevir State University, Azerbaijan*

21, D. Aliyeva Street, Mingachevir, AZ4500

\*Corresponding author: [shabnam.mammadova@geo.edu.az](mailto:shabnam.mammadova@geo.edu.az)

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**Summary.** The development of domestic agricultural production is an important component of national food security. In this context, optimizing plant mineral nutrition is essential for maintaining soil fertility, improving nutrient-use efficiency, and ensuring sustainable agricultural production. This study investigated the effects of different fertilizer rates on nutrient uptake by the pods and phytomass of vegetable bean (*Phaseolus L.*) during the growing season. The experiment included an unfertilized control, 10 t ha<sup>-1</sup> manure, N30P30K30, N60P60K30, and N90P60K60 treatments. The results demonstrated that fertilizer application substantially affected nitrogen, phosphorus, and potassium removal by both pods and phytomass. Nutrient removal by bean pods was generally greater for nitrogen than for phosphorus. The highest nutrient removal by pods was recorded under the N60P60K30 treatment, reaching 51.5 kg ha<sup>-1</sup> N, 27.2 kg ha<sup>-1</sup> P, and 29.0 kg ha<sup>-1</sup> K. The same treatment also resulted in the highest nutrient accumulation in phytomass, with 17.9 kg ha<sup>-1</sup> N, 5.5 kg ha<sup>-1</sup> P, and 7.5 kg ha<sup>-1</sup> K. The lowest values were generally observed in the unfertilized control. Overall, the findings indicate that appropriate optimization of mineral fertilizer rates can improve nutrient uptake and productivity while supporting more efficient nutrient management in vegetable bean production.

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### Introduction

Efficient fertilizer management requires the appropriate determination of nutrient application rates to achieve targeted crop yields. Plant nutrition is strongly influenced by soil nutrient reserves, moisture availability, soil reaction, and organic matter content, while the effectiveness of fertilizers and other agricultural practices is closely related to soil properties (Shafran, 2022a). Fertilization is one of the major factors contributing to agricultural productivity and may account for approximately 30–50% of additional crop yield (Korchenkina et al., 2017; Liu et al., 2020). Therefore, optimizing fertilizer application according to the physicochemical and agrochemical characteristics of soils is essential for efficient crop production (Kudeyarov, 2019; Shafran, 2022b).

Sustainable agricultural production also requires the maintenance and restoration of soil fertility (Utkin, 2022). Increasing the return of plant residues to soil and improving nutrient-use efficiency can contribute to more sustainable nutrient management (Sharkov et al., 2022). At the same time, fertilizer-induced changes in soil properties depend on fertilizer type, application rate, duration of use, and inherent soil characteristics (Yaroshenko et al., 2018). Consequently, improved agricultural technologies are needed to enhance the efficient use of soil resources and plant nutrients (Roeva et al., 2023). Although mineral fertilizers can substantially increase crop productivity, their application may also affect soil humus status, nutrient regimes, biological activity, and physicochemical properties (Borontov et al., 2019; Kosyakin, 2019). Both mineral and organic fertilizers therefore play an important role in managing crop productivity and maintaining soil fertility under intensive agricultural systems (Vasyuchkov et al., 2023).

For leguminous crops, biological nitrogen fixation and effective plant–rhizobia symbiosis are particularly important for vegetative growth and stable yield formation (Alyoshin & Zavalin, 2023). A well-functioning symbiotic system can substantially reduce the requirement for external nitrogen inputs; however, when nitrogen

fixation is insufficient, legumes increasingly depend on nitrogen supplied by the soil and fertilizers (Otieno et al., 2009).

Despite the agronomic importance of vegetable bean, the effects of different fertilizer rates on its productivity and technological quality under irrigated gray-brown soils in arid climatic conditions remain insufficiently studied. In particular, limited information is available on changes in the quality characteristics of green pods and seeds at different developmental stages in response to mineral nutrition. Therefore, this study aimed to evaluate the effects of mineral nutrition on the yield and technological quality of vegetable bean and to identify an optimal mineral fertilizer application rate during the growing season.

### Materials and methods

The study was conducted on irrigated gray-brown soils at the Absheron Auxiliary Experimental Farm of the Research Institute of Vegetable Growing, Ministry of Agriculture of the Republic of Azerbaijan. The soils of the experimental area are characterized by a cultivated horizon with heavy- and light-loamy textures and a predominance of silt and clay fractions. Long-term agricultural use has altered the structure of the arable layer of these irrigated gray-brown soils, with silty fractions predominating throughout the soil profile and reaching higher proportions (43.7–55.0%) in the upper horizons. The soils are characterized by relatively low humus contents of 1.57% in the topsoil and 1.24% in the subsoil, relatively high carbonate contents (8.3–17.8%) in the middle horizons, and a slightly alkaline soil reaction.

The locally adapted Zulyal vegetable bean cultivar (*Phaseolus* L.) was used in the experiment. The experimental plots were plowed in autumn, followed by harrowing and sowing in spring. Planting furrows and irrigation channels were subsequently established. The major proportion of manure and mineral fertilizers was applied during autumn plowing, while the remaining portion was applied in spring. Vegetable beans were sown at a spacing of  $45 \times 10$  cm, with 45 cm between rows and 10 cm between plants, at a sowing depth of 4–5 cm.

The field experiment consisted of five fertilizer treatments: (1) control without fertilizer; (2)  $10 \text{ t ha}^{-1}$  manure; (3) N30P30K30; (4) N60P60K30; and (5) N90P60K60. Manure was used as the organic fertilizer. Ammonium nitrate containing 34% active ingredient was used as the nitrogen fertilizer, superphosphate containing 20% active ingredient as the phosphorus fertilizer, and potassium chloride containing 45% active ingredient as the potassium fertilizer.

Plant samples were analyzed using standard analytical procedures. Ashing was performed according to the K. E. Ginzburg method. Nitrogen was determined using the Kjeldahl micromethod, phosphorus by the photoelectrocolorimetric method, and potassium by flame photometry.

The plant samples were further analyzed for total nitrogen, phosphorus, potassium, and crude protein. Total nitrogen was determined photocolometrically, phosphorus was determined photometrically according to GOST 26657-97, potassium was determined by flame photometry following dry ashing, and crude protein content was calculated using the corresponding analytical values.

### Results and discussion

#### Effects of Organic and Mineral Fertilizers on Nutrient Removal by Vegetable Bean Pods and Phytomass

Crop growth and yield are influenced by the genetic potential of the cultivar, soil and climatic conditions, cultivation practices, fertilizer application, and biotic stresses (Khan et al., 2022). Organic and mineral fertilizers can improve nutrient availability and contribute to the replenishment of nutrients removed with harvested biomass (Kydyraliev & Bodoshov, 2014). For leguminous crops, nitrogen nutrition is particularly important because plant growth depends on the balance between biologically fixed nitrogen and nitrogen supplied by the soil and fertilizers (Alyoshin & Zavalin, 2023; Oldroyd & Dixon, 2014). Appropriate fertilizer management may also improve nutrient-use efficiency in legume-based production systems (Biswas et al., 2025).

The results demonstrated that nutrient removal by vegetable bean varied considerably among fertilizer treatments. Nitrogen removal by pods ranged from 29.5 to 51.5  $\text{kg ha}^{-1}$ , phosphorus from 11.0 to 27.2  $\text{kg ha}^{-1}$ , and potassium from 15.2 to 29.0  $\text{kg ha}^{-1}$  (Table 1). In general, nutrient removal increased with fertilizer application, with nitrogen being removed in the greatest quantity and phosphorus in the lowest.

The highest nutrient removal by pods was recorded under the N60P60K30 treatment, reaching 51.5  $\text{kg ha}^{-1}$  N, 27.2  $\text{kg ha}^{-1}$  P, and 29.0  $\text{kg ha}^{-1}$  K. Compared with the unfertilized control, these values represented increases of 22.0  $\text{kg ha}^{-1}$  N, 16.2  $\text{kg ha}^{-1}$  P, and 13.8  $\text{kg ha}^{-1}$  K, respectively. Thus, increased pod yield was accompanied by greater nutrient removal (Table 1).

A similar response was observed for nutrient accumulation in the dry phytomass. Nitrogen accumulation was 8.7  $\text{kg ha}^{-1}$  in the control, 12.2  $\text{kg ha}^{-1}$  with  $10 \text{ t ha}^{-1}$  manure, 14.3  $\text{kg ha}^{-1}$  under N30P30K30, 17.9  $\text{kg ha}^{-1}$

under N60P60K30, and 16.3 kg ha<sup>-1</sup> under N90P60K60. The corresponding phosphorus values were 1.8, 2.5, 4.5, 5.5, and 5.9 kg ha<sup>-1</sup>, while potassium accumulation was 3.7, 5.0, 6.4, 7.5, and 6.1 kg ha<sup>-1</sup>, respectively. Overall, the N60P60K30 treatment produced the highest combined nutrient accumulation in phytomass, with 17.9 kg ha<sup>-1</sup> N, 5.5 kg ha<sup>-1</sup> P, and 7.5 kg ha<sup>-1</sup> K (Table 1).

Nutrient removal by pods was substantially greater than nutrient accumulation in phytomass across all treatments. In the control, pod-to-phytomass ratios were 3.4 for N, 6.0 for P, and 4.1 for K. The corresponding ratios were 3.2, 7.8, and 4.3 with 10 t ha<sup>-1</sup> manure; 3.4, 6.6, and 4.3 under N30P30K30; 2.9, 4.9, and 3.9 under N60P60K30; and 3.1, 5.2, and 4.7 under N90P60K60. These results confirm that a substantially greater proportion of absorbed nutrients was removed with harvested pods than retained in the remaining phytomass (Table 1 and 2).

Overall, the response did not increase continuously with fertilizer rate. Although nutrient removal generally increased relative to the control, increasing fertilizer application from N60P60K30 to N90P60K60 did not result in a further improvement in most measured parameters. This indicates that the N60P60K30 treatment provided a more favorable nutrient response under the experimental conditions and that increasing fertilizer rates beyond this level did not produce proportional benefits.

**Table 1**

Nutrient removal by vegetable bean pods and biomass (three-year average)

| Treatments                                      | Pod yield                 |            |                                       |      |      | Biomass                   |            |                                       |     |     |
|-------------------------------------------------|---------------------------|------------|---------------------------------------|------|------|---------------------------|------------|---------------------------------------|-----|-----|
|                                                 | Yield, c ha <sup>-1</sup> |            | Nutrient removal, kg ha <sup>-1</sup> |      |      | Yield, c ha <sup>-1</sup> |            | Nutrient removal, kg ha <sup>-1</sup> |     |     |
|                                                 | Pods                      | dry matter | N                                     | P    | K    | Biomass                   | dry matter | N                                     | P   | K   |
| Control                                         | 155.6                     | 13.0       | 29.5                                  | 11.0 | 15.2 | 128.8                     | 12.0       | 8.7                                   | 1.8 | 3.7 |
| 10 t ha <sup>-1</sup> manure                    | 180.2                     | 15.0       | 38.7                                  | 19.5 | 21.5 | 150.4                     | 13.3       | 12.2                                  | 2.5 | 5.0 |
| N <sub>30</sub> P <sub>30</sub> K <sub>30</sub> | 213.7                     | 17.4       | 48.6                                  | 25.3 | 27.0 | 179.7                     | 14.2       | 14.3                                  | 4.5 | 6.4 |
| N <sub>60</sub> P <sub>60</sub> K <sub>30</sub> | 223.4                     | 17.6       | 51.5                                  | 27.2 | 29.0 | 220.9                     | 15.8       | 17.9                                  | 5.5 | 7.5 |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> | 219.2                     | 17.5       | 50.3                                  | 25.5 | 28.8 | 208.5                     | 15.6       | 16.3                                  | 4.9 | 6.1 |

### Correlation between yield and nutrient removal

Fertilizer application increased not only vegetable bean yield but also nutrient removal. Pod yield was strongly correlated with the removal of nitrogen ( $r = 0.999$ ), phosphorus ( $r = 0.985$ ), and potassium ( $r = 0.996$ ). Similarly, biomass yield showed strong positive correlations with nitrogen ( $r = 0.988$ ), phosphorus ( $r = 0.998$ ), and potassium ( $r = 0.937$ ) removal (Tables 1 and 2). These relationships indicate that fertilizer-induced increases in yield were accompanied by greater nutrient removal.

### Effects of organic and mineral fertilizers on nutrient uptake

Plants do not fully utilize nutrients supplied through organic and mineral fertilizers; therefore, fertilizer application rates should be adjusted according to crop nutrient requirements and soil nutrient availability. Nitrogen, phosphorus, and potassium uptake depends on their availability in the soil, fertilizer application, and plant developmental stage. Previous studies have also emphasized the importance of maintaining an appropriate nutrient balance in agricultural soils (Sychev & Shafran, 2017). The efficiency of fertilizer-derived nutrient uptake is strongly influenced by the availability of readily accessible nutrient reserves in the soil (Gadjimammadov et al., 2019).

In the unfertilized control, vegetable bean production depended entirely on soil nutrient reserves. With fertilizer application, both native soil nutrients and fertilizer-derived nutrients contributed to crop nutrient uptake. Nitrogen removal by pods increased from 29.5 kg ha<sup>-1</sup> in the control to 38.7–51.5 kg ha<sup>-1</sup> in the fertilized treatments. Phosphorus removal increased from 11.0 to 19.5–27.2 kg ha<sup>-1</sup>, while potassium removal increased from 15.2 to 21.5–29.0 kg ha<sup>-1</sup>. The highest values were consistently recorded under N60P60K30.

Compared with the control, nitrogen removal by pods increased by 9.2 kg ha<sup>-1</sup> under 10 t ha<sup>-1</sup> manure, 19.1 kg ha<sup>-1</sup> under N30P30K30, 22.0 kg ha<sup>-1</sup> under N60P60K30, and 20.8 kg ha<sup>-1</sup> under N90P60K60. The corresponding increases in phosphorus removal were approximately 8.5, 14.3, 16.2, and 14.5 kg ha<sup>-1</sup>, while potassium removal increased by approximately 6.3, 11.8, 13.8, and 13.6 kg ha<sup>-1</sup>, respectively. These results demonstrate that phosphorus was removed in smaller quantities than nitrogen and potassium and that increasing fertilizer rates beyond N60P60K30 did not result in further nutrient removal.

Nutrient accumulation in phytomass showed a similar response. Across the treatments, nitrogen accumulation ranged from 8.7 to 17.9 kg ha<sup>-1</sup>, phosphorus from 1.8 to 5.5 kg ha<sup>-1</sup>, and potassium from 3.7 to 7.5 kg

ha<sup>-1</sup>, with the lowest values in the control and the highest values under N60P60K30. Overall, the results demonstrate that nutrient removal with harvested pods was substantially greater than nutrient accumulation in the remaining phytomass.

Table 2

Nutrient uptake by vegetable bean phytomass from soil and fertilizers (three-year average)

| Treatment                                       | Nitrogen,<br>kg ha <sup>-1</sup> | Of total, % |                  | Phosphorus,<br>kg ha <sup>-1</sup> | Of total, % |                  | Potassium,<br>kg ha <sup>-1</sup> | От общего, % |                  |
|-------------------------------------------------|----------------------------------|-------------|------------------|------------------------------------|-------------|------------------|-----------------------------------|--------------|------------------|
|                                                 |                                  | From soil   | From fertilizers |                                    | From soil   | From fertilizers |                                   | From soil    | From fertilizers |
| Control                                         | 8,8                              | 100         |                  | 1,8                                | 100,0       |                  | 3,7                               | 100          |                  |
| 10 t ha <sup>-1</sup> manure                    | 12,2                             | 72,1        | 27,9             | 2,5                                | 72,0        | 28,0             | 5,0                               | 74,0         | 26,0             |
| N <sub>30</sub> P <sub>30</sub> K <sub>30</sub> | 14,3                             | 61,5        | 38,5             | 3,8                                | 47,4        | 52,6             | 6,3                               | 58,7         | 41,3             |
| N <sub>60</sub> P <sub>60</sub> K <sub>30</sub> | 17,9                             | 49,2        | 50,8             | 5,5                                | 32,7        | 67,3             | 7,5                               | 49,3         | 50,7             |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> | 16,3                             | 54,0        | 46,0             | 4,9                                | 36,7        | 63,4             | 6,1                               | 60,7         | 39,3             |

### Nutrient uptake from applied fertilizers

Based on the experimental results, nutrient uptake coefficients for vegetable bean were calculated considering nutrient removal by the main and secondary yield components, including roots, leaves, and stems, according to the established methodology (Narusheva, 2014).

In the unfertilized control, total nitrogen removal by above- and below-ground plant organs was 38.3 kg ha<sup>-1</sup>. Fertilizer application increased total nitrogen removal to 50.9–69.4 kg ha<sup>-1</sup>, depending on the treatment. The calculated nitrogen uptake coefficients were 25.2% for 10 t ha<sup>-1</sup> manure, 82.0% for N30P30K30, 51.8% for N60P60K30, and 31.4% for N90P60K60 (Table 3).

Total phosphorus removal was 12.8 kg ha<sup>-1</sup> in the control and increased to 22.0–32.7 kg ha<sup>-1</sup> following fertilizer application. The corresponding phosphorus uptake coefficients were 36.6, 54.4, 33.2, and 29.4% for the manure, N30P30K30, N60P60K30, and N90P60K60 treatments, respectively. Total potassium removal increased from 18.9 kg ha<sup>-1</sup> in the control to 26.5–36.5 kg ha<sup>-1</sup> in the fertilized treatments. Potassium uptake coefficients were 12.6% with manure, 48.0% under N30P30K30, 58.6% under N60P60K30, and 26.6% under N90P60K60 (Table 3).

Overall, nutrient uptake efficiency varied substantially with fertilizer rate. The highest nitrogen and phosphorus uptake coefficients were recorded under N30P30K30 (82.0 and 54.4%, respectively), whereas the highest potassium uptake coefficient occurred under N60P60K30 (58.6%). These results indicate that the N30P30K30 and N60P60K30 treatments provided the most favorable nutrient-use responses, while further increasing fertilizer application to N90P60K60 reduced the uptake efficiency of all three nutrients.

Table 3

Nutrient Uptake Coefficients of Vegetable Bean from Fertilizers  
by Above- and Below-Ground Plant Organs (Three-Year Average)

| Treatment                                       | Nitrogen,<br>kg ha <sup>-1</sup> | Difference | Uptake coefficient,<br>% | Phosphorus, kg<br>ha <sup>-1</sup> | Difference | Uptake coefficient,<br>% | Potassium, kg<br>ha <sup>-1</sup> | Difference | Uptake coefficient,<br>% |
|-------------------------------------------------|----------------------------------|------------|--------------------------|------------------------------------|------------|--------------------------|-----------------------------------|------------|--------------------------|
| Control                                         | 38,3                             |            |                          | 12,8                               |            |                          | 18,9                              |            |                          |
| 10 t ha <sup>-1</sup> manure                    | 50,9                             | 12,6       | 25,2                     | 22,0                               | 9,1        | 36,6                     | 26,5                              | 7,5        | 12,6                     |
| N <sub>30</sub> P <sub>30</sub> K <sub>30</sub> | 62,9                             | 24,6       | 82,0                     | 29,1                               | 16,3       | 54,4                     | 33,3                              | 14,4       | 48,0                     |
| N <sub>60</sub> P <sub>60</sub> K <sub>30</sub> | 69,4                             | 31,1       | 51,8                     | 32,7                               | 19,9       | 33,2                     | 36,5                              | 17,6       | 58,6                     |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> | 66,6                             | 28,3       | 31,4                     | 30,4                               | 17,6       | 29,4                     | 34,9                              | 15,9       | 26,6                     |

### Conclusion

The results demonstrated that mineral nutrition significantly influenced nutrient removal and uptake by vegetable bean. Fertilizer application increased the removal of nitrogen, phosphorus, and potassium by both pods and phytomass compared with the unfertilized control. The N60P60K30 treatment produced the highest

pod yield and the greatest nutrient removal, reaching 51.5 kg ha<sup>-1</sup> N, 27.2 kg ha<sup>-1</sup> P, and 29.0 kg ha<sup>-1</sup> K in pods and 17.9 kg ha<sup>-1</sup> N, 5.5 kg ha<sup>-1</sup> P, and 7.5 kg ha<sup>-1</sup> K in phytomass. Increasing the fertilizer rate to N90P60K60 did not provide a further improvement in these parameters.

Nutrient uptake efficiency also varied among fertilizer treatments. The highest uptake coefficients for nitrogen (82.0%) and phosphorus (54.4%) were recorded under N30P30K30, whereas the highest potassium uptake coefficient (58.6%) occurred under N60P60K30. Overall, the results indicate that N30P30K30 and N60P60K30 provided the most favorable nutrient-use responses, while N60P60K30 was the most effective treatment for maximizing yield and nutrient removal under the experimental conditions.

## REFERENCES

- Alyoshin, M.A., & Zavalin, A.A. (2023). Response of pea to nitrogen fertilizer and seed inoculation with rhizotorfin on sod-podzolic soil with different degrees of cultivation. *Agrochemistry*, (6), 22–38.
- Biswas, D.R., Bhattacharyya, R., Basak, B.B., Sarkar, A., & Das, D. (2025). Soil phosphorus fractionations under different fertilization practices on soybean (*Glycine max*)-based cropping systems in a Vertisol. *Journal of Plant Nutrition*, 48(8). <https://doi.org/10.1080/01904167.2024.2441302>
- Borontov, O.K., Kosyakin, P.A., & Manaenkova, E.N. (2019). Effects of primary tillage and fertilizers on the nutrient regime and physical properties of soil under sugar beet cultivation. *Zemledelie*, (2), 33–35.
- Gadjimammadov, I.M., Veliyeva, S.R., & Jafarova, F.N. (2019). Dependence of the nitrogen uptake coefficient from fertilizers on the developmental stage of the “Gobustan” bread wheat cultivar and fertilizer rates and ratios. *Proceedings of the Azerbaijan Society of Soil Scientists*, 15, 473–477.
- Khan, M.U.A., Khan, M.A., Abbasi, U.A., Amin, M., Kalsoom, T., Basit, A., & Shahzad, B. (2022). Kiwi plant growth monitoring with soil and climatic conditions in the semi-arid region of Pakistan. *Environmental Sciences Proceedings*, 23, 36. <https://doi.org/10.3390/envirosciproc2022023036>
- Korchenkina, N.A., Dabakhova, E.V., & Titova, V.I. (2017). Phosphate status of light-gray forest soil under increasing application rates of distillery stillage. *Agricultural Science Euro-North-East*, (2[57]), 35–40.
- Kosyakin, P.A. (2019). Role of chelated micronutrient fertilizers in increasing sugar beet yield in crop rotation in the Central Black Earth Region. *AgroForum*, (5), 55–57.
- Kotsareva, N.V. (2012). Potential for vegetable bean seed production in the southwestern part of the Central Black Earth Region. *Scientific Bulletin: Natural Sciences Series*, (9[128]), 64–68.
- Kudeyarov, V.N. (2019). Agrogeochemical cycles of carbon and nitrogen in modern Russian agriculture. *Agrochemistry*, (12), 3–15.
- Kydyraliev, N.A., & Bodoshov, A.U. (2014). Determination of selected physical properties of bean grains grown in the Talas Region of the Kyrgyz Republic. *Young Scientist*, (5[64]), 70–74.
- Liu, L.-Y., Hua, W., Zhang, S.-Y., Peng, Q.-C., Dai, J., & Han, X.-R. (2020). Nitrogen uptake of soybean and soil nitrate nitrogen under long-term rotation and different fertilization in a brown soil of northeast China. *Journal of Plant Nutrition and Fertilizers*, 26(1), 10–18.
- Mammadova, Sh.A. (2020). Effect of fertilizers on the chemical composition of vegetable bean. *Bulletin of Science and Practice*, 6(11), 188–196. <https://doi.org/10.33619/2414-2948/61>
- Mehdiyeva, N., Muradova, S., Mursal, N., & Babayeva, L. (2025). Distribution, phytocenotic characteristics and antimicrobial properties of some medicinal plants of the highlands of the Greater Caucasus (within Azerbaijan). *Acta Botanica Caucasica*, 4(1), 89–105. <https://doi.org/10.30546/abc.2025.4.1.620>
- Narusheva, E.A. (Comp.). (2014). *Research methods in agrochemistry: A short course of lectures for postgraduate students*. Saratov State Agrarian University.
- Oldroyd, G.E., & Dixon, R. (2014). Biotechnological solutions to the nitrogen problem. *Current Opinion in Biotechnology*, 26, 19–24. <https://doi.org/10.1016/j.copbio.2013.08.006>
- Otieno, P.E., Muthomi, J.W., Chemining'wa, G.N., & Nderitu, J.H. (2009). Effect of rhizobia inoculation, farmyard manure and nitrogen fertilizer on nodulation and yield of food grain legumes. *Journal of Biological Sciences*, 9, 326–332. <https://doi.org/10.3923/jbs.2009.326.332>
- Roeva, T.A., Leonicheva, E.V., & Leontieva, L.I. (2023). Fertility indicators of agro-gray soil in a cherry orchard under nitrogen and potassium fertilization. *Agrochemistry*, (7), 9–18.
- Shafran, S.A. (2022a). Assessment of soil cultivation status based on a set of agrochemical indicators. *Agrochemistry*, (4), 3–10.
- Shafran, S.A. (2022b). Nitrogen fertilizer inputs for grain yield formation depending on the agrochemical cultivation status of soils. *Agrochemistry*, (5), 38–46.
- Sharkov, I.N., Kolbin, S.A., Prozorov, A.S., & Samokhvalova, L.M. (2022). Efficiency of nitrogen fertilizer with increased incorporation of plant residues into soil in the forest-steppe zone of Western Siberia. *Agrochemistry*, (3), 22–30.
- Sychev, V.G., & Shafran, S.A. (2017). Nutrient balance in Russian agriculture. *Plodородie*, (1), 1–4.
- Utkin, A.A. (2022). Fertility and ecotoxicological status of reference sites of sod-podzolic loamy soils in the Vladimir Region. *Agrochemistry*, (6), 3–13.
- Vasyuchkov, I.Yu., Borisov, V.A., & Uspenskaya, O.N. (2023). Changes in the fertility of alluvial meadow soil under different fertilization systems in vegetable crop rotation. *Agrochemistry*, (5), 13–19.
- Yaroshenko, T.M., Klimova, N.F., & Zhuravlev, D.Yu. (2018). Long-term stationary experiment in the steppe Volga region: Results from the eighth rotation of a grain-fallow crop rotation. In V. G. Sychev (Ed.), *Results of the fundamental scientific research program of state academies for 2013–2020* (pp. 420–429). VNIIA.
- Zamanov, P.B., & Aliyeva, A.A. (2015). Assessment of plant nutrient supply during the growing season using leaf diagnostics. *Soil Science and Agrochemistry*, 22(1–2), 331–334.

## ОПТИМИЗАЦИЯ МИНЕРАЛЬНОГО ПИТАНИЯ ФАСОЛИ ДЛЯ ПОВЫШЕНИЯ КАЧЕСТВА ПРОДУКЦИИ И ОБЕСПЕЧЕНИЯ УСТОЙЧИВОГО СЕЛЬСКОХОЗЯЙСТВЕННОГО ПРОИЗВОДСТВА

Мамедова Ш.А.<sup>1\*</sup>, Насирова Т.А.<sup>1</sup>, Велиева З.М.<sup>1</sup>, Бабаева Т.М.<sup>2</sup>

<sup>1</sup>Институт географии Министерства науки и образования Азербайджанской Республики, Азербайджан  
AZ1073, Баку, пр. Г. Джавида, 117

<sup>2</sup>Мингячевирский государственный университет, Азербайджан  
AZ4500, Мингячевир, ул. Д. Алиевой, 21

\*Автор, отвечающий за переписку: shabnam.mammadova@geo.edu.az

**Резюме.** Развитие отечественного сельскохозяйственного производства является важной составляющей национальной продовольственной безопасности. В этом контексте оптимизация минерального питания растений имеет существенное значение для сохранения плодородия почв, повышения эффективности использования питательных элементов и обеспечения устойчивого сельскохозяйственного производства. В исследовании изучалось влияние различных норм внесения удобрений на поглощение питательных элементов бобами и фитомассой овощной фасоли (*Phaseolus L.*) в течение вегетационного периода. Схема опыта включала контрольный вариант без внесения удобрений, внесение навоза в норме 10 т/га, а также варианты N30P30K30, N60P60K30 и N90P60K60. Результаты показали, что внесение удобрений существенно влияло на вынос азота, фосфора и калия как бобами, так и фитомассой растений. Вынос питательных элементов бобами фасоли в целом был выше по азоту, чем по фосфору. Наибольший вынос питательных элементов бобами отмечен в варианте N60P60K30 и составил 51,5 кг/га азота, 27,2 кг/га фосфора и 29,0 кг/га калия. В этом же варианте установлено максимальное накопление питательных элементов в фитомассе: 17,9 кг/га азота, 5,5 кг/га фосфора и 7,5 кг/га калия. Наименьшие значения преимущественно наблюдались в контрольном варианте без внесения удобрений. В целом полученные результаты свидетельствуют о том, что оптимизация норм внесения минеральных удобрений способствует улучшению поглощения питательных элементов и повышению продуктивности, одновременно обеспечивая более эффективное управление питательным режимом при выращивании овощной фасоли.

**Ключевые слова:** овощная фасоль, минеральное питание, норма удобрений, поглощение питательных веществ, фитомасса, эффективность использования питательных веществ, устойчивое сельское хозяйство

## MƏHSULUN KEYFIYYƏTİNİN YÜKSƏLDİLMƏSİ VƏ DAYANIQLI KƏND TƏSƏRRÜFATI İSTEHSALININ TƏMİN EDİLMƏSİ ÜÇÜN LOBYANIN MİNERAL QIDALANMASININ OPTİMALLAŞDIRILMASI

Məmmədova Ş.A.<sup>1\*</sup>, Nəsirova T.A.<sup>1</sup>, Vəliyeva Z.M.<sup>1</sup>, Babayeva T.M.<sup>2</sup>

<sup>1</sup>Azərbaycan Respublikası Elm və Təhsil Nazirliyi, Coğrafiya İnstitutu, Azərbaycan  
AZ1073, Bakı, H. Cavid pr. 117

<sup>2</sup>Mingəçevir Dövlət Universiteti, Azərbaycan  
AZ4500, Mingəçevir, D. Əliyeva küç. 21

\*Məsul müəllif: shabnam.mammadova@geo.edu.az

**Xülasə.** Yerli kənd təsərrüfatı istehsalının inkişafı milli ərzaq təhlükəsizliyinin mühüm tərkib hissəsidir. Bu baxımdan bitkilərin mineral qidalanmasının optimallaşdırılması torpaq münbitliyinin qorunması, qida elementlərindən istifadə səmərəliliyinin artırılması və dayanıqlı kənd təsərrüfatı istehsalının təmin edilməsi üçün mühüm əhəmiyyət kəsb edir. Tədqiqatda vegetasiya dövründə müxtəlif gübrə normalarının tərəvəz lobyasının (*Phaseolus L.*) paxlaları və fitokütləsi tərəfindən qida elementlərinin mənimsənilməsinə təsiri araşdırılmışdır. Təcrübəyə gübrə verilməyən nəzarət variantı, 10 t/ha peyin, N30P30K30, N60P60K30 və N90P60K60 gübrələmə variantları daxil edilmişdir. Nəticələr göstərmişdir ki, gübrələrin tətbiqi həm paxlalar, həm də fitokütlə tərəfindən azot, fosfor və kaliumun mənimsənilməsinə əhəmiyyətli dərəcədə təsir göstərmişdir. Lobyə paxlaları tərəfindən qida elementlərinin mənimsənilməsi ümumilikdə azot üzrə fosfora nisbətən daha yüksək olmuşdur. Paxlalar tərəfindən qida elementlərinin ən yüksək mənimsənilmə göstəriciləri N60P60K30 variantında qeydə alınmış və azot üzrə 51,5 kq/ha, fosfor üzrə 27,2 kq/ha, kalium üzrə isə 29,0 kq/ha təşkil etmişdir. Eyni variantda fitokütlədə qida elementlərinin ən yüksək toplanma göstəriciləri müəyyən edilmişdir: azot üzrə 17,9 kq/ha, fosfor üzrə 5,5 kq/ha və kalium üzrə 7,5 kq/ha. Ən aşağı göstəricilər əsasən gübrə tətbiq edilməyən nəzarət variantında müşahidə olunmuşdur. Ümumilikdə, tədqiqatın nəticələri mineral gübrə normalarının düzgün optimallaşdırılmasının qida elementlərinin mənimsənilməsinə və məhsuldarlığı artırma, eyni zamanda tərəvəz lobyasının becərilməsində qida elementlərinin daha səmərəli idarə olunmasına şərait yarada biləcəyini göstərir.

**Açar sözlər:** tərəvəz lobyası, mineral qidalanma, gübrə norması, qida elementlərinin mənimsənilməsi, fitokütlə, qida elementlərindən istifadə səmərəliliyi, dayanıqlı kənd təsərrüfatı