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THE EFFECTS OF ORGANOMINERAL NUTRITIONAL REGIMES ON *MALUS DOMESTICA* PRODUCTIVITY AND MICROBIOLOGICAL MARKERS IN SOUTHEAST KAZAKHSTAN

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Abstract. This study evaluates the effects of organo-mineral fertilization systems combined with biological preparations on the productivity and soil microbiological indicators of Golden Delicious apple trees in southeastern Kazakhstan. Using a randomized block design, six fertilization variants— including organic, bioorganic, and mineral treatments - were applied to irrigated light brown soils with low organic matter content. Results demonstrated that treatments with biohumus and BioSok Energy Plus significantly increased yields (39–64%), sugar content (0.5–1.9%), dry matter (0.8–1.5%), and fruit shelf life compared to controls. Additionally, these treatments enhanced the abundance of beneficial soil microorganisms, indicating improved soil biological activity and structure. The findings suggest that integrating organic and bioorganic fertilizers with mineral nutrition promotes sustainable orchard productivity by boosting soil fertility and microbiocenosis, thereby supporting long-term soil health and sustainable horticultural practices in arid regions.

Keywords: organic fertilizers, biopreparations, microorganisms, chestnut soils, Golden Delicious, yield, fruit quality.

INTRODUCTION

Modern horticultural development in arid and semi-arid areas necessitates a significant improvement in resource efficiency while simultaneously preserving or reestablishing soil fertility. By the end of the 20th century, it was evident that long-term use of chemicals in agriculture - such as high concentrations of mineral fertilizers and heavy use of plant protection products - depletes soil organic matter reserves, deteriorates soil structure, and reduces soil biological activity, especially in irrigated areas [1, 2].

According to [3, 4], the light brown soils in southeast Kazakhstan have a low humus content (about 1–1.5%), an alkaline

reaction, and a high sensitivity to structural and biological degradation when the organic balance is upset. The '4 per mille' concept [5] and other international initiatives to raise the organic carbon content of soils highlight the importance of actively incorporating soil biota into fertility management and systematically replenishing organic matter.

The quality of the soil is largely determined by soil microorganisms. They create humic compounds, break down organic residues, mineralize and immobilize nitrogen and other elements, and create a barrier that keeps phytopathogens out. According to studies, applying organic and bioorganic fertilizers improves agrochemi-

cal indicators, boosts microbial community diversity and activity, and helps agroecosystems develop sustainably [6-8].

Because of the favorable climate of the foothills and the availability of irrigation, horticulture, especially apple cultivation, is a promising and lucrative industry in southeast Kazakhstan. Apple farming contributes to the nation's economic growth and food security by diversifying the agricultural sector in the area.

Because of its high market value and extended shelf life, the Golden Delicious apple variety is widely available in the Almaty region. The rootstock selection, the mineral nutrition system employed, and the state of the soil microflora all have a significant impact on its productivity. Combining mineral fertilizers with biostimulants and organic fertilizers boosts yield and enhances fruit quality, according to several studies [9, 10].

Scientific novelty. This study provides a comprehensive evaluation of the combined effects of biopreparations and organo-mineral fertilizers on both the yield and quality of Golden Delicious apples and the soil microbial community in irrigated light brown soils of southeast Kazakhstan - a region where such integrated studies are limited.

The research hypothesis is that applying biopreparations together with organo-mineral fertilizers will significantly increase apple yield, improve fruit quality, and enhance the abundance and diversity of key soil microorganisms compared to mineral fertilization alone.

The purpose of this study is to assess the effects of biopreparations and organo-mineral fertilizers on the yield and quality of Golden Delicious apples as well as the prevalence of the main physiological groups of soil microorganisms in irrigated light brown soils in southeast Kazakhstan.

MATERIALS AND METHODS

The field experiment was conducted on an experimental orchard site located in the Talgar district of the Almaty region,

southeastern Kazakhstan (43°18'N, 77°12'E). The region is characterized by a sharply continental climate, with hot and dry summers and cold winters. The soil of the experimental site is an irrigated light chestnut loam.

The main agrochemical properties of the soil were as follows: organic matter (humus) content-1.3%, determined by the wet combustion Tyurin method [11]; soil reaction (pH, water extract)-7.6, measured using a glass electrode; available phosphorus content-low, determined by the Kirsanov method [11]; exchangeable potassium content-medium, measured using a flame photometer [11]. These soil conditions are typical for irrigated foothill zones of southeastern Kazakhstan and are characterized by limited organic matter reserves and sensitivity to biological degradation.

The experiment was conducted during the 2020-2023 growing seasons. Each experimental plot included 10 trees, with a total of 180 trees involved in the study (6 treatments × 3 replicates × 10 trees). Soil samples were collected in triplicate for each treatment at the end of the growing season.

Study object and experimental design. *Malus domestica* Borkh of the Golden Delicious variety, which was grown on MM106 and M9 clonal rootstocks and was three to four years old when the experiment started, was the subject of the study. Planting layout: 4x2 m. The moisture content of the arable layer is maintained between 70 and 80% of field capacity through the use of drip irrigation. Three replicates and six variations were used in a randomized block design:

1. Control (no fertilizers);
2. Mineral background N₉₀P₉₀K₉₀;
3. NPK + Agroflorin;
4. NPK + Al Karal;
5. NPK + BioSok Energy Plus;
6. NPK + biohumus.

"Agroflorin" is a complex natural biopreparation containing enzymes, amino

acids, organic acids (succinic, fumaric, etc.), phytohormones (auxins, gibberellins), vitamins (B group), polysaccharides, and macro- (N, P, K) microelements (Fe, Zn, Cu, Mn, Na). Al Karal is an organic additive composed of 70% humic and 25% fulvic acids. BioSok Energy Plus is a biopreparation that includes beneficial bacteria, fungi, and other microorganisms.

Mineral fertilizers were applied both in early spring and after flowering. Biological products were used in accordance with the manufacturer's recommendations: Agrofloin - 2.5 ml per 1 liter of water; Al Karal - 300 ml per 50 liters of water; and BioSok Energy Plus - 300 ml per 5 liters of water. Some of the solutions were used to treat seedlings' root systems prior to planting, while others were used as root and foliar fertilizers throughout the growing season. Biohumus was applied to the tree trunk area in a calculated dose to create a comparable organic nitrogen background.

Recording fruit yield and quality. The following were determined on an annual basis.

- Yield (kg/ha and kg/tree).
- Biochemical indicators of fruits include mass fraction of sugars (%) and dry matter (%).
- Fruit shelf life (maximum storage period at +2 to +4 °C before loss of commercial quality)). ANOVA with the $LSD_{0.5}$ criterion was used at a significance level of $p \leq 0.05$ to assess the reliability of differences.

Soil microbiological studies. Soil samples for microbiological analysis were collected from the rhizosphere layer (0-20 cm) as per the requirements [12]. Combined samples were collected under Golden Delicious trees based on the experiment variants. The following indicators

have been determined: Total number of microorganisms (TNM) on meat-peptone agar (MPA); Number of actinomycetes and bacterial groups on starch-ammonia agar (SAA), dilution 10^{-3} – 10^{-5} , incubation temperature 29 ± 1 °C, duration 3–7 days; Number of nitrogen-fixing bacteria from the genus *Azotobacter* - on an azote-free Ashby medium; Number of bacteria from the genus *Pseudomonas* - on King B agar medium; Number of microscopic fungi on the Chapek–Dox acid agar medium [12, 13]. The results were expressed as colony-forming units (CFU) per 1 gram of completely dry soil. Colonies were counted with the Scan_500@ 8.0.14.0 colony counter. Statistical processing was carried out in accordance with the ISO 10576:2022 [14].

RESULTS AND DISCUSSION

All fertilization treatments significantly increased yield compared to the control ($LSD_{0.5} = 4.3$ t/ha). The control variant produced 18.0 t/ha. Application of mineral fertilizer ($NPK_{90}P_{90}K_{90}$) increased yield to 25.0 t/ha, which corresponds to a 39% increase relative to the control.

The addition of biological and organic components to the mineral background further enhanced productivity:

- NPK + Agrofloin–27.5 t/ha (53% increase vs control).
- NPK + Al Karal–26.5 t/ha (47% increase).
- NPK + BioSok Energy Plus–28.5 t/ha (58% increase).
- NPK + biohumus–29.5 t/ha (64% increase).

The highest yield was recorded in the NPK + biohumus treatment, followed closely by NPK + BioSok Energy Plus. According to the statistical grouping (Figure 1), these variants formed a separate homogeneous group with significantly higher productivity compared to the control.

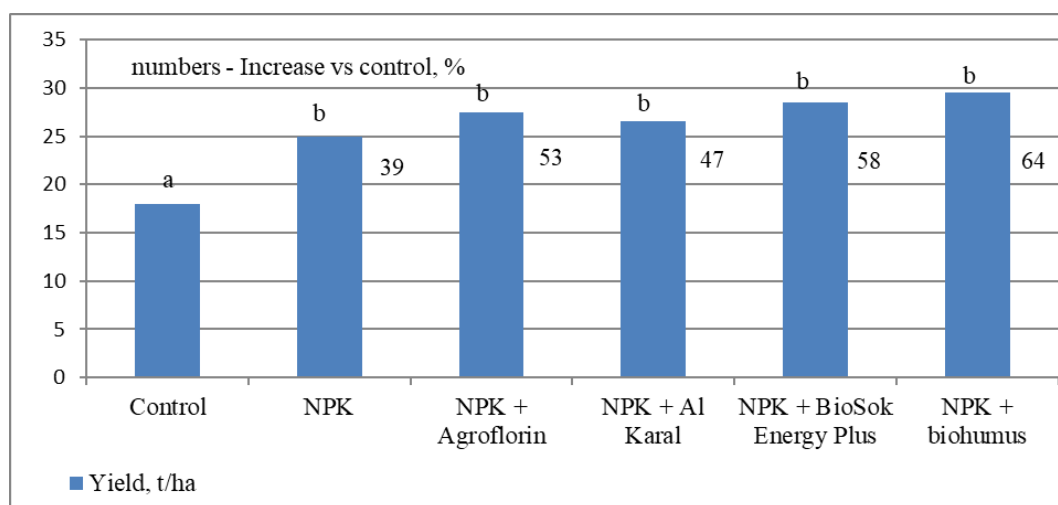


Figure 1- The yield of Golden Delicious apple tree depending on fertilization systems. Numbers represents yield increase vs control, %; the same letters above the columns indicate a statistically insignificant difference

Fruit quality and sugar content content, and shelf life are presented in Table 1. Data on yield, sugar content, dry matter

Table 1 - Yield and fruit quality of Golden Delicious apple trees depending on fertilization systems

| Treatment | Yield, t/ha | Sugars, % | Dry matter, % | Shelf life, months |
|--------------------------|-------------|------------|---------------|--------------------|
| Control | 18.0 ± 8 | 10,2 ± 0,2 | 13,8 ± 0,3 | 4,0 |
| NPK | 25.0 ± 10 | 11,0 ± 0,2 | 14,3 ± 0,2 | 5,0 |
| NPK + Agroflorin | 27.5 ± 12 | 11,6 ± 0,3 | 14,8 ± 0,3 | 5,5 |
| NPK + Al Karal | 26.5 ± 11 | 11,4 ± 0,3 | 14,6 ± 0,3 | 5,3 |
| NPK + BioSok Energy Plus | 28.5 ± 13 | 11,9 ± 0,3 | 15,0 ± 0,3 | 5,8 |
| NPK + biohumus | 29.5 ± 14 | 12,1 ± 0,4 | 15,3 ± 0,3 | 6,0 |
| LSD _{0.5} | 4.3 | 1,1 % | 1,1 % | 1,0 |

Fertilization systems also significantly affected biochemical parameters of fruits. Sugar content increased from 10.2% in the control to:

- 11.0% (NPK)
- 11.6% (NPK + Agroflorin)
- 11.4% (NPK + Al Karal)
- 11.9% (NPK + BioSok Energy Plus)
- 12.1% (NPK + biohumus)

The maximum increase in sugars (1.9%) was observed in the NPK + biohumus treatment. Dry matter content showed a similar trend, increasing from 13.8%

(control) to 15.3% under NPK + biohumus. Fruit shelf life extended from 4.0 months in the control to:

- 5.0 months (NPK)
- 5.5 months (NPK + Agroflorin)
- 5.3 months (NPK + Al Karal)
- 5.8 months (NPK + BioSok Energy Plus)
- 6.0 months (NPK + biohumus)

The differences between the control and organo-mineral treatments exceeded the LSD_{0.5} value (1.0 month), indicating statistical significance.

Compared to the control, organomineral variants, particularly NPK+biohumus and NPK+BioSok Energy Plus, provided: an increase in sugar content by 1.5–1.9%;

an increase in dry matter content by 1.2–1.5%;
an increase in fruit shelf life from 4 to 6 months.

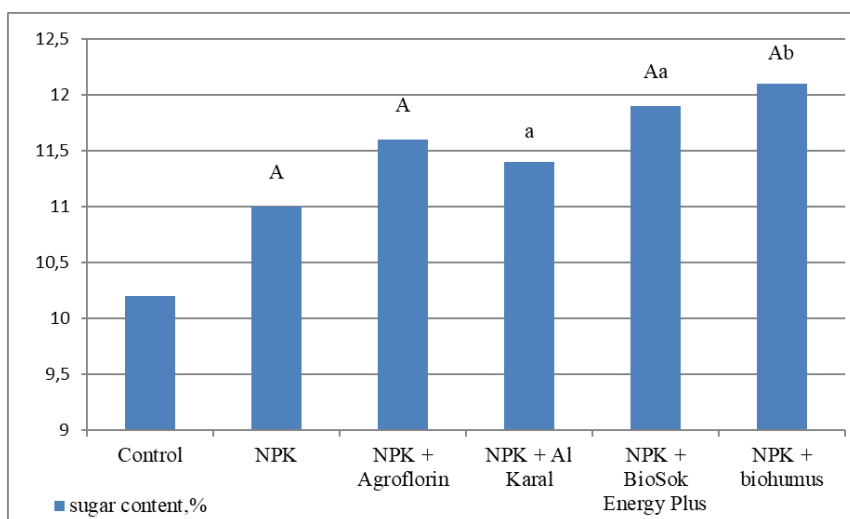


Figure 2 - Sugar content in Golden Delicious apples depending on fertilization systems; the same letters above the columns indicate a statistically insignificant difference

The effect of organic-mineral fertilizers on the microbiological properties of soil. Microbiological analysis of the rhizosphere layer under Golden Delicious trees revealed that the use of biological

products on a mineral background resulted in a significant increase in the number of different physiological groups of microorganisms (Table 2).

Table 2 - Effect of organo-mineral fertilization on soil microbiological indicators in the rhizosphere of Golden Delicious apple trees

| Treatment | Total bacteria (MPA), CFU $\times 10^6$ g ⁻¹ soil | Pseudomonas (King B), CFU $\times 10^6$ g ⁻¹ soil | Amylolytic bacteria, CFU $\times 10^5$ g ⁻¹ soil | Azotobacter abundance |
|---|--|--|---|-----------------------|
| Control (no fertilizers) | 1.03 ± 0.10 | 1.20 ± 0.01 | 1.10 | Low |
| NPK ₉₀ P ₉₀ K ₉₀ | 1.85 ± 0.10 | 2.10 ± 0.02 | 1.40 | Moderate |
| NPK + Agroflorin | 2.20 ± 0.10 | 2.80 ± 0.02 | 1.70 | Increased |
| NPK + Al Karal | 2.10 ± 0.09 | 2.60 ± 0.02 | 1.60 | Increased |
| NPK + BioSok Energy Plus | 2.40 ± 0.10 | 4.00 ± 0.01 | 2.00 | High |
| NPK + Biohumus | 2.35 ± 0.10 | 3.50 ± 0.02 | 1.90 | High |

Compared to the control:

The variants with Agrofloirin (G-2) and BioSok Energy Plus (G-4) increased the total number of bacteria on MPA by 2-2.5 times, reaching $2.4 \pm 0.1 \cdot 10^6$ CFU/g compared to $1.03 \pm 0.1 \cdot 10^6$ CFU/g in the control.

The BioSok Energy Plus variant had $4.0 \pm 0.01 \cdot 10^6$ CFU/g of *Pseudomonas* bacteria on King B medium, while the control had only $1.2 \pm 0.01 \cdot 10^6$ CFU/g.

Amylolytic bacteria on KAA increased significantly in the BioSok Energy Plus variant, exceeding the control level by $0.9 \cdot 10^5$ CFU/g.

The number of nitrogen-fixing bacteria from the genus *Azotobacter* in the soil under Golden Delicious trees was greater in the Al Karal (G-3), BioSok Energy Plus (G-4), and Agrofloirin (G-2) variants than in the control (G-1).



Figure 3 - View of an organic apple orchard

The most pronounced microbiological activation was observed in treatments combining mineral nutrition with biohumus or BioSok Energy Plus.

The obtained results demonstrate that the integration of mineral fertilization with organic and bioorganic components leads not only to higher yields but also to qualitative and biological improvements in the soil-plant system.

The 39% yield increase under pure NPK confirms that light chestnut soils with low humus content are primarily limited by mineral nutrition. However, the additional 11–25% yield increase in organo-mineral variants indicates that mineral nutrition alone does not fully realize the productive potential of Golden Delicious.

The superior performance of NPK + biohumus (64% increase) can be explained by several interacting mechanisms:

1. Improved soil structure and aggregation due to organic matter input.
2. Increased cation exchange capacity and nutrient retention.

3. Enhanced microbial-mediated nutrient mineralization.

4. Better synchronization between nutrient release and plant demand.

Biohumus likely created a buffering environment that reduced nutrient leaching and improved root zone conditions, which is especially important in irrigated arid soils.

The high efficiency of BioSok Energy Plus suggests that microbial consortia (*Bacillus*, *Pseudomonas*, *Azotobacter*, fungi) enhanced nutrient solubilization and phytohormone production, thereby stimulating root development and nutrient uptake efficiency.

The increase in sugar and dry matter content indicates improved carbohydrate metabolism and assimilate accumulation. Enhanced nitrogen availability combined with improved microbial activity likely stimulated photosynthetic capacity and translocation of assimilates to fruits.

Higher dry matter content directly correlates with improved storage stability.

The extension of shelf life from 4 to 6 months suggests better tissue density, improved cell wall integrity, and possibly enhanced calcium and carbohydrate balance.

The parallel increase in yield and sugar content is particularly important. Often, higher yields dilute sugar concentration, but in this study both parameters increased simultaneously, indicating improved physiological efficiency rather than simple biomass expansion.

The 2–2.5-fold increase in total microbial abundance confirms that organomineral systems activate soil biological processes.

Increased *Azotobacter* abundance suggests enhanced biological nitrogen fixation, partially compensating for mineral nitrogen dependence.

The fourfold increase in *Pseudomonas* spp. under BioSok Energy Plus is especially significant, as these bacteria are known for:

- Phosphate solubilization.
- Production of growth-promoting substances.
- Suppression of phytopathogens.

The stimulation of amyolytic and fungal communities indicates accelerated decomposition of organic residues and improved carbon cycling.

These microbiological shifts support the concept that soil in intensive orchards should be managed as a living biogeochemical system rather than a passive substrate. Enhanced microbial diversity likely improved nutrient cycling stability and increased resilience to abiotic stress.

The most effective variants included biohumus and BioSok Energy Plus, which resulted in yields of 28.5–29.5 t/ha, sugar content of 11.9–12.1%, dry matter content of 15.0–15.3%, and fruit shelf life of up to 6 months. The yield values correspond to the productivity level of intensive orchards in their third or fourth year of fruiting, as reported by [9], [10] found that combining mineral nutrition with organic and bioorganic fertilizers improves the quality and

shelf life of apple fruit. Our results on sugar content and shelf life are consistent with this.

The experiments showed that the tested organomineral fertilizers stimulated the growth of ammonifying, nitrogen-fixing bacteria from the genus *Azotobacter*, bacteria from the genus *Pseudomonas*, amyolytic forms, and a variety of microscopic fungi, indicating an increase in the biological activity of the rhizosphere zone. This indicates an increase in natural soil processes that ensure the availability of nitrogen, phosphorus, and other elements to plants. The increase in the number of *Pseudomonas* and microscopic fungi (within environmentally safe limits) corresponds to increased plant residue decomposition and improved soil structure.

The main components of "Agroflorin" are enzymes and fungal metabolites, which destroy toxins and improve nutrient absorption [15, 16]. Amino acids are essential building blocks for plants, forming proteins that drive metabolic processes such as photosynthesis, nutrient transport, and stress response while also serving as precursors for hormones, signaling molecules, and chlorophyll [17]. Organic acids are essential for plant metabolism, serving as energy/redox carriers (such as malate in the malate valve), carbon storage, pH regulators, and biosynthesis precursors; they are essential for stress tolerance (metal chelation, signaling), nutrient acquisition, and linking photosynthesis and respiration, with key examples including malate, citrate, oxalate, and succinate [18, 19]. Phytohormones are chemical messengers that regulate almost every aspect of plant growth, development, and response to the environment, including cell division, elongation, flowering, fruiting, stress adaptation, and even programmed cell death [20]. B vitamins, particularly thiamine (B1) and pyridoxine (B6), significantly boost plant immunity and stress resistance by activating defense pathways (such as SAR), acting as critical enzyme cofactors, and aiding in metabolic stress management, with applications in

improving crop resilience to diseases and environmental challenges [21, 22]. Macronutrients (N, P, K, Ca, Mg, S, as well as C, H, O from air/water) are required in larger amounts for structure, energy, and photosynthesis, whereas micronutrients (Fe, Mn, Zn, Cu, B, Mo, Cl, Ni) are vital in tiny amounts for enzyme function, metabolism, and enzyme activation [23, 24].

The "AL KARAL" significantly benefit plants by stimulating root growth, improving soil structure for better water/nutrient access, enhancing nutrient absorption (fulvic is an excellent carrier), and increasing stress resistance (drought, salinity) by improving overall plant health and cellular function, making them powerful tools in sustainable agriculture [25, 26]. It also contains amino acids, peptides, polysaccharides, vitamins, proteins, which act as building blocks, participate in metabolic processes, and boost immunity.

"BioSok Energy Plus" promotes plant growth and health by improving nutrient uptake (e.g., nitrogen fixation, phosphate solubilization), producing plant hormones, increasing stress tolerance (drought, salinity), and suppressing pathogens, making it an environmentally friendly alternative to chemical fertilizers in sustainable agriculture [27]. *Bacillus*, *Pseudomonas*, *Trichoderma*, *Azotobacter*, and mycorrhizal fungi are key beneficial microorganisms that work directly or indirectly through mechanisms such as root colonization and metabolite production [28, 29].

Thus, soil is no longer viewed as a passive "substrate" for roots, but rather as an active living system in which microbiota play an important role in fertility regulation. This is entirely consistent with our current understanding of soil as a complex biogeochemical system [30-32].

CONCLUSIONS

The findings of this study underscore the vital role that integrating biopreparations and organo-mineral fertilizers

plays in enhancing both the productivity and quality of Golden Delicious apples cultivated in southeast Kazakhstan. The marked increases in yield, sugar content, dry matter, and shelf life observed - especially with the application of biohumus and BioSok Energy Plus - demonstrate the tangible benefits of combining mineral nutrition with organic and bioorganic inputs.

From an analytical perspective, the use of organo-mineral fertilizers stimulated the biological activity of the soil, as evidenced by increased numbers of nitrogen-fixing bacteria, *Pseudomonas*, amylolytic bacteria, and diverse microscopic fungi. These changes improve the availability of nutrients for plants and contribute to better fruit quality. Specifically, sugar content increased by 1.5–1.9%, dry matter by 1.2–1.5%, and fruit shelf life extended from 4 to 6 months. This approach not only enhances fruit quality and economic returns but also supports sustainable agricultural practices by fostering a more active and diverse soil microbiome.

Practical recommendations:

1. Biohumus and BioSok Energy Plus, in combination with mineral fertilizers, should be used as the main fertilization system to ensure stable productivity and fruit quality of Golden Delicious apple orchards.

2. Soil microbiome monitoring and assessment of biopreparation effects are recommended to optimize fertilizer application rates and maximize efficiency.

3. Other organic and bioorganic additives (Agroflorin, Al Karal) can be applied as supplementary treatments depending on regional conditions and resource availability.

Overall, the study confirms that integrating mineral and organic-bioorganic fertilization is an effective strategy for improving apple yield, quality, and storage potential, while also promoting soil health and sustainable orchard management.

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ОҢТҮСТІК-ШЫҒЫС ҚАЗАҚСТАНДАҒЫ *MALUS DOMESTICA* МАРКЕРІНІҢ
ӨНІМДІЛІГІНЕ ЖӘНЕ МИКРОБИОЛОГИЯЛЫҚ БЕЛГІЛЕРГЕ
ОРГАНИКАЛЫҚ-МИНЕРАЛДЫ ТАМАҚТАНУ РЕЖИМДЕРІНІҢ ӘСЕРІ

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Бұл зерттеу Оңтүстік-Шығыс Қазақстандағы Голден Делишес алма ағаштарының өнімділігі мен топырақ микробиологиялық көрсеткіштеріне орғано-минералды тыңайтқыш жүйелерінің биологиялық препараттармен үйлескен әсерін бағалайды. Органикалық заттардың мөлшері суармалы ашық –қара қоңыр топырақтарға органикалық, биоорганикалық және минералды тыңайтқыштарды қоса алғанда, алты тыңайтқыш нұсқасы қолданылды. Нәтижелер биогумус пен BioSok Energy Plus өңдеулері бақылау нұсқасымен салыстырғанда өнімділікті (39–64%), қант мөлшерін (0,5–1,9%), құрғақ заттарды (0,8–1,5%) және жемістердің сақтау мерзімін айтарлықтай арттырғанын көрсетті. Сонымен қатар, бұл өңдеулер пайдалы топырақ микроорганизмдерінің санын арттырды, бұл топырақтың биологиялық белсенділігі мен құрылымының жақсарғанын көрсетеді. Зерттеу нәтижелері органикалық және биоорганикалық тыңайтқыштарды минералды қоректік заттармен біріктіру топырақтың құнарлылығы мен микробиоценозды арттыру арқылы бақшаның тұрақты өнімділігін арттыратынын, осылайша құрғақ аймақтарда ұзақ мерзімді топырақ денсаулығы мен тұрақты бау-бақша тәжірибесін қолдайтынын көрсетеді.

Түйінді сөздер: органикалық тыңайтқыштар, биопрепараттар, микроорганизмдер, қара-қоңыр топырақтары, Голден Делишес, өнімділік, жеміс сапасы.

РЕЗЮМЕ

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ВЛИЯНИЕ ОРГАНОМИНЕРАЛЬНЫХ РЕЖИМОВ ПИТАНИЯ НА ПРОДУКТИВНОСТЬ И
МИКРОБИОЛОГИЧЕСКИЕ МАРКЕРЫ *MALUS DOMESTICA* В ЮГО-ВОСТОЧНОМ
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В данном исследовании оценивается влияние органоминеральных удобрений в сочетании с биологическими препаратами на продуктивность яблонь сорта «Голден Делишес» и почвенные микробиологические показатели в юго-восточном Казахстане. С использованием рандомизированного блочного дизайна было изучено шесть вариантов удобрения - органическое, биоорганическое и минеральное - на орошаемых каштановых почвах с низким содержанием органического вещества. Результаты показали, что обработка биогумусом и BioSok Energy Plus значительно увеличила урожайность (39–64%), содержание сахара (0,5–1,9%), содержание сухого вещества (0,8–1,5%) и срок хранения плодов по сравнению с контрольными образцами. Кроме того, изученные факторы повысили численность полезных почвенных микроорганизмов, что указывает на улучшение биологической активности и структуры почвы. Полученные данные свидетельствуют о том, что интеграция органических и биоорганических удобрений с минеральным питанием способствует устойчивой продуктивности садов за счет повышения плодородия почвы и микробиоценоза, тем самым поддерживая долгосрочное здоровье почвы и устойчивые методы садоводства в засушливых регионах.

Ключевые слова: органические удобрения, биопрепараты, микроорганизмы, каштановые почвы, сорт «Голден Делишес», урожайность, качество плодов.

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