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CONTENT

Section: Agricultural Sciences

ADAPTIVE SUNFLOWER CULTIVATION UNDER CLIMATE CHANGE CONDITIONS

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Abstract. Sunflower is one of the leading oilseed crops in Ukraine, but its productivity is increasingly constrained by climate change, particularly drought, high temperatures, and uneven rainfall distribution. The aim of the study was to evaluate the role of resource-saving nutrition and hybrid selection in stabilizing sunflower productivity under contrasting agroecological conditions of Ukraine. Field studies were conducted in 2025 in the Southern Steppe and Northern Forest-Steppe zones. In the Southern Steppe, the response of Bastion and Forsazh hybrids to seed treatment with Mykofrend, moderate $N_{30}P_{15}K_{15}$ mineral fertilization, and foliar applications of Organic Balance, Azotohelp, and boron was studied. In the Northern Forest-Steppe, eight sunflower hybrids were evaluated for seed yield, oil content, oil yield, thousand seed weight, and seed bulk density under drought and heat stress.

The results showed that, despite severe moisture deficit in 2025, resource-saving nutrition improved sunflower yield formation. The highest yield in the Southern Steppe was obtained when seed treatment, $N_{30}P_{15}K_{15}$, Organic Balance, Azotohelp, and boron were combined: 1.26 t/ha for Bastion and 1.30 t/ha for Forsazh. Forsazh showed a slightly better response to the studied nutrition system. In the Northern Forest-Steppe, the highest productivity was recorded for LG50635, with a seed yield of 1.70 t/ha, oil content of 44.0%, oil yield of 0.75 t/ha, thousand seed weight of 48 g, and seed bulk density of 360 g/L. ES Belfis and P64LE25 also demonstrated high adaptive capacity.

The study confirms that combining resource-saving nutrition with adapted hybrid selection can reduce yield losses, improve seed quality, and increase the stability of sunflower production under climate change conditions.

Keywords: sunflower; resource-saving nutrition; hybrid selection; drought stress; seed yield.

Introduction. Sunflower is one of the leading oilseed crops in Ukraine, and its cultivation has important production, economic, and agroecological significance [1]. At the same time, the cultivation conditions are becoming increasingly complex due to climate instability, rising temperature stress, uneven precipitation distribution, and frequent droughts during the growing season. These processes are especially pronounced in the Southern Steppe of Ukraine, where soil moisture deficit is often the main limiting factor in yield formation. Under such conditions, the traditional increase in fertilizer rates does not always yield the expected increase in productivity, since nutrient uptake largely depends on moisture availability, temperature regime, and the ability of plants to maintain physiological activity under stress.

In modern sunflower cultivation technologies, resource-saving nutrition is becoming increasingly important. It involves the rational use of mineral fertilizers, biological preparations, micronutrients, and foliar fertilization. This approach is aimed not at maximizing the amount of fertilizer applied, but at increasing the efficiency with which plants use it. The study by W. Jarecki found that sunflower yield depends not only on nitrogen and micronutrient nutrition but also on the weather conditions of the year. The combination of nitrogen fertilization with foliar application of micronutrients had a positive effect on yield-forming traits and achene quality; however, the effectiveness of such nutrition varied depending on growing conditions. This confirms the need for flexible fertilization systems tailored to specific years, soil conditions, and the biological characteristics of the hybrid [2].

An important direction for improving the efficiency of sunflower nutrition is to select forms that better utilize available nutrients. In the study by Coêlho et al., it was emphasized that sunflower response to nitrogen fertilization varies considerably across genotypes. Therefore, for production purposes, it is important to determine not only the optimal nitrogen dose but also the varieties and hybrids that ensure higher nitrogen use efficiency. This is especially important for drought-prone regions, where excessive fertilization may be economically unjustified, whereas moderate nutrient levels combined with an adapted hybrid can achieve a more stable result [3].

The use of micronutrients is also of considerable importance, as they play a role in regulating plant physiological and biochemical processes. For sunflowers, boron is particularly important, as it affects the formation of generative organs, flowering, pollination, and seed filling. The application of complex foliar fertilization can improve plant condition during critical growth stages, especially when nutrient uptake from the soil is limited by moisture deficits. In the study by Crista et al., it was noted that complex foliar fertilization improved the yield and quality of sunflower seeds, confirming the feasibility of incorporating micronutrients into the crop's nutrient management system [4].

Along with nutrition, hybrid selection plays a significant role in establishing stable productivity. Modern sunflower hybrids differ in the duration of the growing season, intensity of early growth, root system development, drought and heat tolerance, disease resistance, ability to maintain photosynthetic activity, and capacity to accumulate oil in seeds. Under semi-arid conditions, the response of hybrids to sowing dates and water deficit may differ substantially; therefore, preference should be given to those forms that ensure not only high but also stable yield under variable environmental conditions. This was confirmed by the study by Gul et al., which evaluated drought-tolerant sunflower hybrids under semi-arid farming conditions [5].

In the context of sunflower adaptation to climate change, increasing attention is being paid to the formation of a new concept of the desired plant type. Debaeke et al. noted that sunflowers offer advantages for ecologically oriented farming systems due to their plasticity and relatively moderate water, nitrogen, and pesticide requirements. At the same time, new growing conditions require hybrids that combine productivity, resistance to abiotic stresses, efficient resource use, and suitability for less-input-intensive technologies [6].

Therefore, resource-saving nutrition and hybrid selection should be considered not as separate practices, but as interrelated components of an adaptive sunflower cultivation technology. Moderate mineral fertilization, biological preparations, micronutrients, and foliar fertilization provide better conditions for plant growth and development, while a properly selected hybrid can use the provided nutritional background more effectively. It is the combination of technological and genetic potential that enables increased yield, stabilizes productivity across years with different weather conditions, improves seed quality, and reduces production risks.

In the conditions of the Southern Steppe of Ukraine, this approach has particular value, as it enables sunflower cultivation to adapt to moisture deficits, high temperatures, and rising material costs. The scientifically grounded combination of resource-saving nutrition with the selection of drought- and heat-tolerant, highly productive hybrids provides the basis for developing an adaptive technology that ensures economically feasible, ecologically balanced sunflower production under current climate change conditions.

Literature Review. The development and implementation of resource-saving sunflower cultivation technologies is an important direction for increasing the efficiency of agricultural production under climate instability, rising costs of material and technical resources, and increasing anthropogenic pressure on agroecosystems. Modern farming requires a transition from the intensive use of fertilizers and pesticides to more balanced technological solutions focused on the rational use of nutrients, preservation of soil fertility, increased plant resistance to abiotic stresses, and stabilization of yields across years with varying weather conditions.

For sunflowers, this is especially important because the crop is mainly grown in regions with unstable or insufficient moisture supply, where the effectiveness of fertilization largely depends on the reserves of productive soil moisture. Under such conditions, simply increasing mineral fertilizer rates does not always lead to a corresponding increase in yield. Instead, the combination of moderate mineral fertilization, biological preparations, micronutrients, and foliar fertilization is more effective, as it improves plant nutrition during critical growth stages, activates physiological and biochemical processes, and increases the crop’s ability to withstand drought and high temperatures.

Scientific studies confirm that sunflower productivity is influenced by interactions among weather conditions, the fertilization system, and plant biological characteristics. W. Jarecki found that nitrogen nutrition combined with foliar application of micronutrients affected yield, structural productivity indicators, and the quality of sunflower achenes. At the same time, fertilization effectiveness depended on the year's conditions, particularly in areas with an unstable moisture supply [2].

Micronutrients, including boron, zinc, manganese, molybdenum, copper, and iron, play an important role in resource-saving nutrition systems (Fig. 1). They participate in the regulation of enzymatic activity, photosynthesis, generative development, head formation, pollination, and seed filling. For sunflowers, boron is of particular importance, since its deficiency can negatively affect flowering, seed formation, and yield quality. The study by Crista et al. demonstrated that complex foliar fertilization improved yield and quality indicators of sunflower seeds, confirming the feasibility of incorporating micronutrients into the crop nutrition system [4].

An important addition to resource-saving nutrition is the use of crop residues from preceding crops in combination with biodestructors. Under drought-prone farming conditions, returning post-harvest residues to the soil is particularly important, as it replenishes organic matter reserves, improves soil structure, stimulates microbial activity, and enhances soil water-holding capacity. The retention and incorporation of residues from preceding crops also help reduce unproductive moisture losses and protect the soil surface from overheating and erosion, which is especially important in the Southern Steppe of Ukraine [7–9].

The application of biodestructors enables the accelerated decomposition of plant residues, the activation of the transformation of organic compounds, and the gradual release of nutrients in forms available to plants. This approach enhances soil biological activity, improves conditions for the development of the sunflower root system, and increases the efficiency of mineral and foliar nutrition. In an adaptive sunflower cultivation system, the biodegradation of predecessor residues should be considered an important component for maintaining soil fertility, optimizing the nutrient regime, and increasing the agrocenosis's resistance to drought.

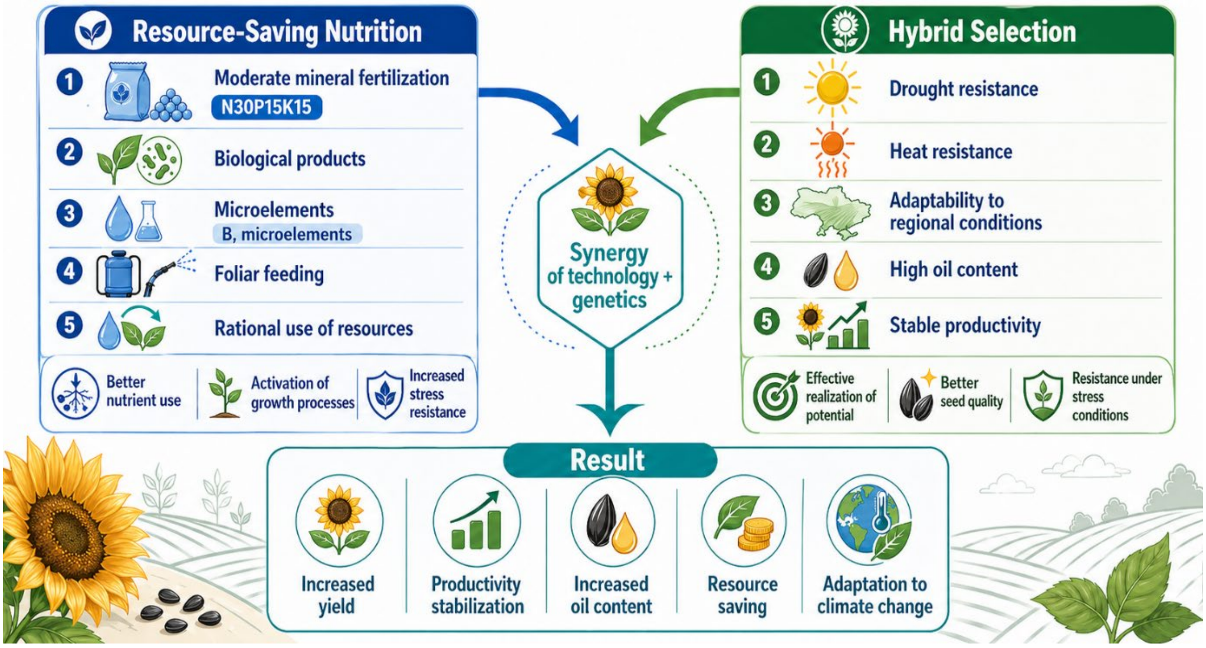

Figure 1. A combination of resource-saving nutrition and hybrid selection

Along with nutrition, hybrid selection is of considerable importance, particularly the choice of hybrids capable of realizing their production potential under limited water availability. Modern sunflower hybrids differ significantly in the duration of the growing season, early growth rate, root system development, drought and heat tolerance, resistance to diseases and sunflower broomrape (Orobanche cumana Wallr.), and their response to mineral and foliar nutrition levels. Therefore, hybrid selection should be based not only on potential yield but also on a hybrid's ability to maintain stable yield under specific soil and climatic conditions.

The expansion of sunflower cultivation areas in the Southern Steppe of Ukraine is largely associated with the development and introduction of new hybrids that combine high productivity with increased tolerance to drought and high temperatures, resistance to the main races of broomrape, and the ability to withstand herbicide pressure in modern production systems. The study by Khablak et al. showed that resistance of new sunflower hybrids to sunflower broomrape is an important factor in protecting the crop against this parasite, especially in regions where aggressive races of Orobanche cumana are widespread [10].

The issue of hybrid selection becomes even more important under climate change conditions. Debaeke et al. noted that sunflowers have considerable potential for ecologically oriented farming systems due to their plasticity and relatively moderate water, nitrogen, and plant protection product requirements. At the same time, modern production requires new-type hybrids capable of combining stable productivity, resistance to abiotic stresses, efficient resource use, and suitability for less input-intensive technologies [6].

The combination of resource-saving nutrition and hybrid selection is particularly relevant for the Southern Steppe of Ukraine. This zone is characterized by a high level of farming risk due to extremely high temperatures, insufficient precipitation, its uneven distribution, and long periods of atmospheric and soil drought. Under such conditions, sunflower yield is largely determined by the ability of plants to efficiently use limited moisture reserves, maintain root system activity, absorb nutrients under a stressful water regime, and complete generative development before the onset of the most severe drought periods.

In 2025, a prolonged absence of productive rainfall was observed in the Southern Steppe during the growing season, which caused a critical deficit of soil moisture (Fig. 2). Even the use of adapted drought-tolerant hybrids and biological preparations did not fully compensate for water shortage, since the level of moisture supply remained below the biological requirements of the crop. As a result, sunflower yield decreased by 25–40% compared with long-term average values. This situation confirms that the adaptation of cultivation technology should not rely on a single agronomic practice but should include a coordinated system of measures: pre-sowing seed treatment, moderate mineral fertilization, biological preparations, micronutrients, foliar fertilization, hybrid selection, and practices aimed at conserving soil moisture [11].

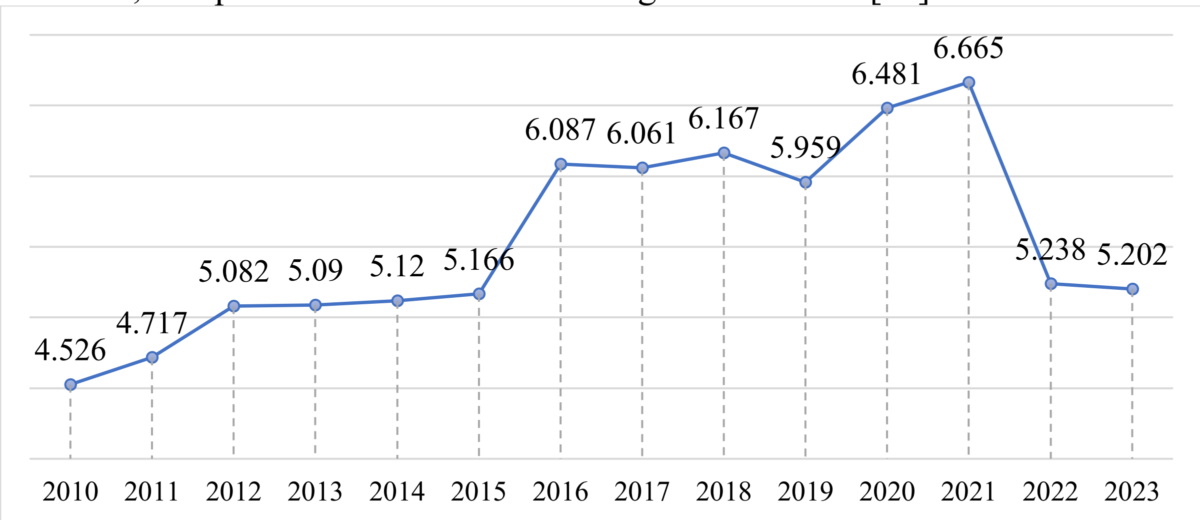

Figure 2. Dynamics of sunflower sown areas in Ukraine, million ha
Source: FAOSTAT, 2025

Despite climate risks, sunflowers remain among the most economically attractive crops in Ukraine's agricultural sector. Its importance is determined by stable demand for seeds, oil, meal, and processed products, high marketability, and well-developed processing infrastructure. The development of domestic processing, particularly the production of biofuel, meal, and compound feed, may increase product value and strengthen the sector's export potential. At the same time, any further expansion of sunflower areas should be accompanied by scientifically grounded crop rotations, maintenance of soil fertility, and the introduction of technologies that prevent the depletion of agroecosystems.

Thus, resource-saving nutrition and hybrid selection should be considered as interrelated components of adaptive sunflower cultivation technology. Moderate mineral fertilization, biological preparations, and micronutrients create conditions for better plant growth, development, and stress tolerance, while a properly selected hybrid ensures a more efficient use of the applied nutrient background. Their combination enables stabilization of yield, improvement of seed quality, reduction of production costs, decreased environmental pressure, and increased resilience of agrocenoses to climate change.

Methodology. The studies were conducted in 2025 across two soil and climatic zones of Ukraine, allowing assessment of sunflower response to different technological practices and weather conditions that year. The first part of the research aimed to study the effect of resource-saving nutrition on the productivity of the sunflower hybrids Forsazh and Bastion under conditions in the Southern Steppe of Ukraine. The field experiment was established on the farm enterprise Orbita's land in the Novosvitlivka settlement, Voznesensk district, Mykolaiv region, on southern chernozem. The preceding crop was maize for grain. The weather conditions in 2025 were characterized by a prolonged absence of effective precipitation, high air temperatures, and an acute deficit of productive moisture throughout the growing season, which placed severe stress on sunflower plants.

The experimental design compared two sunflower hybrids across different nutritional backgrounds and pre-sowing seed treatments. Seeds were treated with water or with the biological preparation Mykofrend at a rate of 7 L/t. The nutrition system included a control treatment without additional fertilization, foliar fertilization with Organic Balance at 0.5 L/ha, Azotohelp at 0.5 L/ha, and boron at 0.5 L/ha, as well as the mineral background $N_{30}P_{15}K_{15}$, applied separately and in combination with biological preparations and boron. Yield was determined for each experimental treatment, followed by calculation of the yield increase due to pre-sowing seed treatment and the nutrition system. The least significant difference (LSD_{05}) was used to assess the significance of differences among experimental factors and their interactions.

The second part of the research was conducted in the Northern Forest-Steppe of Ukraine at Dniprotransagro LLC. Its purpose was to conduct a comparative assessment of the productivity and seed quality of eight sunflower hybrids under moisture deficit and elevated temperatures during critical phases of crop development. The study included the hybrids SY Kupava, NK Neoma, P64LE25, LG50455, LG50635, MAS 83.R, Sumiko HTS, and ES Belfis. Seed yield, oil content, oil yield, thousand seed weight, and seed bulk density were evaluated.

During the analysis of the results, it was noted that 2025 was unfavorable for sunflower productivity in both research zones. In the Southern Steppe, the limiting factor was a prolonged deficit of productive moisture combined with high temperatures, whereas in the Northern Forest-Steppe, the negative effect was manifested through uneven moisture supply, dry periods in the second half of summer, and thermal stress during budding, flowering, and seed filling. This made it possible to consider the obtained data not only as a productivity assessment but also as a manifestation of hybrids' adaptive response to the year's stressful conditions.

Results. The results of the field experiment conducted in the Southern Steppe of Ukraine showed that even under an acute moisture deficit, the use of resource-saving nutrition improved sunflower yield. In the control treatments, the yield of the Bastion hybrid was 0.87 t/ha with water seed treatment and 0.93 t/ha with Mykofrend. In the Forsazh hybrid, these values were 0.91 and 0.95 t/ha, respectively. This indicates that pre-sowing seed treatment with the biological preparation, even without additional nutrition, improved plant condition to some extent; however, its effect was limited by severe drought.

Foliar fertilization without a mineral background resulted in a gradual increase in yield for both hybrids. The application of Organic Balance together with boron increased the yield of Bastion to 0.93–0.98 t/ha and that of Forsazh to 0.95–1.01 t/ha. The use of Azotohelp with boron was somewhat more effective: the yield of Bastion reached 0.96–1.01 t/ha, while that of Forsazh reached 0.99–1.05 t/ha. The best result among the treatments without basic mineral fertilization was obtained with the combined application of Organic Balance, Azotohelp, and boron: the yield of Bastion increased to 1.02–1.08 t/ha and that of Forsazh to 1.04–1.10 t/ha (Fig. 3).

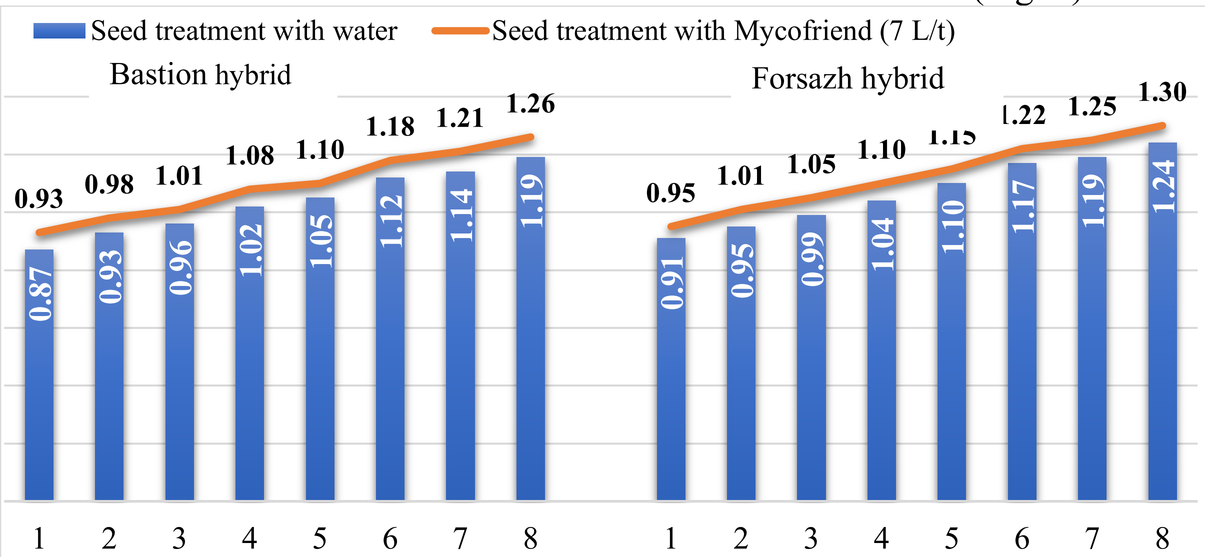

Figure 3. Yield of sunflower hybrids (2025)

Notes: Control; Organic Balance 0.5 L/ha + Boron 0.5 L/ha; Azotohelp 0.5 L/ha + Boron 0.5 L/ha; Organic Balance 0.5 L/ha + Azotohelp 0.5 L/ha + Boron 0.5 L/ha; $N_{30}P_{15}K_{15}$; $N_{30}P_{15}K_{15}$ + Organic Balance 0.5 L/ha + Boron 0.5 L/ha; $N_{30}P_{15}K_{15}$ + Azotohelp 0.5 L/ha + Boron 0.5 L/ha; $N_{30}P_{15}K_{15}$ + Organic Balance 0.5 L/ha + Azotohelp 0.5 L/ha + Boron 0.5 L/ha.

A more pronounced increase in productivity was observed with the application of the mineral background $N_{30}P_{15}K_{15}$. In this background, the yield of Bastion was 1.05 t/ha with water treatment and 1.10 t/ha with Mykofrend. In the Forsazh hybrid, these values were higher, at 1.10 and 1.15 t/ha, respectively. Thus, even in a dry year, moderate mineral fertilization supported plant growth, promoted vegetative mass development, and contributed to the formation of generative organs.

The highest yield values in the experiment were obtained with a combination of a pre-sowing seed treatment with Mykofrend, a mineral background of $N_{30}P_{15}K_{15}$, and foliar applications of Organic Balance, Azotohelp, and boron. Under this treatment, the yield of the Bastion hybrid reached 1.26 t/ha, while that of the Forsazh hybrid reached 1.30 t/ha. The yield increase resulting from seed treatment and the nutrition system reached 0.39 t/ha, which was the highest value recorded in the experiment. Similar results were also obtained with the treatments $N_{30}P_{15}K_{15}$ + Azotohelp + Boron and N30P15K15 + Organic

Balance + Boron; however, maximum productivity was observed with the more complete combination of mineral, biological, and micronutrient nutrition.

The comparison of hybrids in the Southern Steppe showed that Forsazh yielded slightly higher than Bastion across all treatments. The difference between them was small but consistent, indicating a better response of Forsazh to the proposed nutrition system under the conditions of 2025. Both hybrids responded positively to pre-sowing treatment with Mykofrend. The additional yield increases from this practice ranged from 0.05 to 0.07 t/ha in Bastion and from 0.04 to 0.06 t/ha in Forsazh, depending on the nutrition treatment.

The results obtained in the Northern Forest-Steppe of Ukraine revealed substantial differences among sunflower hybrids in terms of yield and seed quality (Figs. 4, 5). In 2025, seed yield of the studied hybrids ranged from 1.10 to 1.70 t/ha, oil content from 40.0 to 44.0%, oil yield from 0.44 to 0.75 t/ha, thousand seed weight from 40 to 48 g, and seed bulk density from 320 to 360 g/L. The relatively low values of thousand-seed weight and bulk density indicate a limited realization of hybrid potential due to moisture deficit and high temperatures during the critical stages of development.

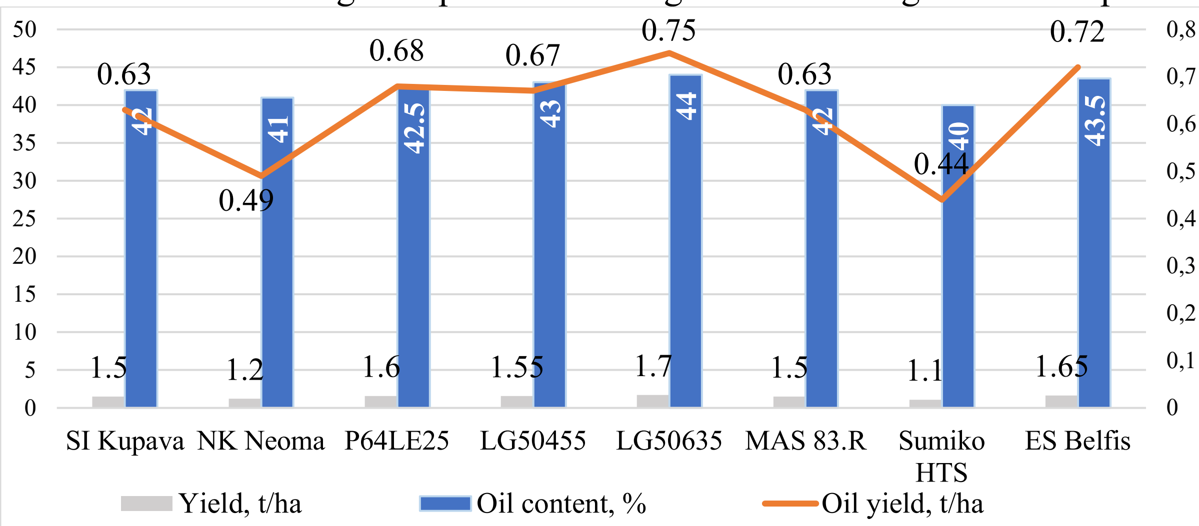

Figure 4. Seed yield, oil content, and oil yield of sunflower hybrids under the conditions of 2025

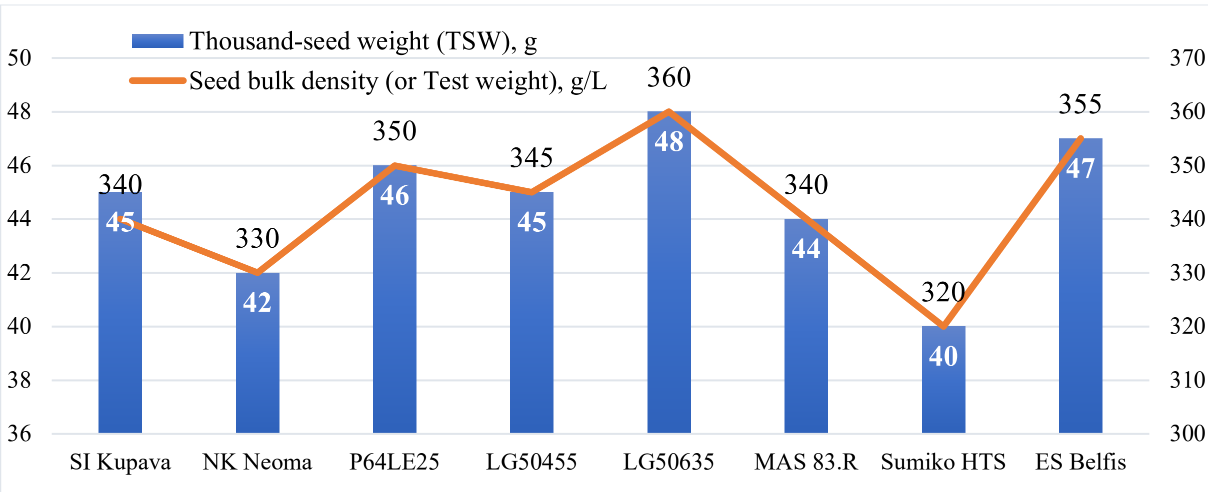

Figure 5. Seed quality indicators of sunflower hybrids under the conditions of 2025

The highest productivity was achieved with the hybrid LG50635, which produced a seed yield of 1.70 t/ha, an oil content of 44.0%, and an oil yield of 0.75 t/ha. In addition, this hybrid had the best seed-filling characteristics: thousand-seed weight was 48 g, and seed bulk density was 360 g/L. These results indicate its high adaptability to the stressful conditions of the study year.

High performance was also recorded for the hybrids ES Belfis and P64LE25. The yield of ES Belfis was 1.65 t/ha, with an oil yield of 0.72 t/ha, a thousand-seed weight of 47 g, and a seed bulk density of 355 g/L. The hybrid P64LE25 provided a yield of 1.60 t/ha, oil content of 42.5%, oil yield of 0.68 t/ha, thousand seed weight of 46 g, and seed bulk density of 350 g/L. Based on the combination of productivity and seed quality traits, these hybrids can be considered among the most suitable for cultivation under increasing climate risks in the Northern Forest-Steppe zone.

The hybrids SY Kupava, LG50455, and MAS 83.R provided an intermediate level of productivity, with seed yield ranging from 1.50 to 1.55 t/ha. Although they did not reach the maximum yield values, their oil content, oil yield, thousand-seed weight, and seed bulk density remained at sufficient levels, indicating they are relatively stable under unfavorable weather conditions. The lowest productivity was recorded for Sumiko HTS and NK Neoma. In Sumiko HTS, seed yield was only 1.10 t/ha, oil content was 40.0%, and oil yield was 0.44 t/ha; in NK Neoma, these indicators were 1.20 t/ha, 41.0%, and 0.49 t/ha, respectively. At the same time, these hybrids had the lowest values of thousand-seed weight and seed bulk density, indicating a weaker realization of their production potential under water and temperature stress.

Discussion. The obtained results confirm that adaptive sunflower cultivation technology should be based on the simultaneous consideration of the nutrition system and the biological properties of hybrids. In the Southern Steppe of Ukraine, even under the extremely dry conditions of 2025, moderate mineral fertilization, biological preparations, boron, and pre-sowing seed treatment contributed to increased yields. However, the absolute yield level remained low, demonstrating the leading role of the water regime in determining sunflower productivity.

The positive effects of Mykofrend, Organic Balance, Azotohelp, and boron, especially in combination with $N_{30}P_{15}K_{15}$, may be explained by improved initial plant growth, more active root development, better use of available moisture, and maintenance of plant physiological activity during critical growth stages. Boron, as a micronutrient, is important for the generative development of sunflowers, flowering, pollination, and seed formation. Therefore, its use in foliar fertilization is appropriate, especially when soil nutrient uptake is limited by moisture deficit.

At the same time, the experimental results show that none of the applied practices can fully compensate for the impact of prolonged drought. This was particularly evident in the yield level of the control treatments, where productivity did not exceed 0.87–0.95 t/ha. Even in the best treatments, yield reached only 1.26–1.30 t/ha, which is a moderate value for sunflower. Therefore, resource-saving nutrition under acute moisture deficit should be considered not as a means to completely eliminate stress, but rather as a way to reduce yield losses and maintain plant viability.

The comparison of the Forsazh and Bastion hybrids showed that the genotypic response to nutrition has practical importance. Forsazh produced a slightly higher yield than Bastion across all treatments, suggesting a better ability of this hybrid to utilize a moderate mineral background and foliar fertilization under stress conditions. This pattern confirms that hybrid selection should not be carried out separately from the cultivation technology, but in close connection with the level of nutrition, the method of pre-sowing seed treatment, and the expected water regime.

The data obtained in the Northern Forest-Steppe of Ukraine complement the results of the experiment in the Southern Steppe and show that, under unfavorable weather conditions, the ability of hybrids to maintain the stability of the production process becomes especially important. In 2025, the most adapted hybrids were LG50635, ES Belfis, and P64LE25. They provided not only higher yield but also better seed quality, as reflected in greater thousand-seed weight, higher seed bulk density, increased oil content, and higher oil yield.

The positive relationship between yield and seed quality indicators shows that better-adapted hybrids not only produce more but also complete seed filling more effectively. Under water and temperature stress, this is particularly important, since drought during flowering and seed filling may reduce the number of well-filled achenes, decrease thousand seed weight, and impair oil content. Therefore, evaluating hybrids solely by yield is insufficient; oil yield and physical seed quality indicators should also be considered.

The hybrids Sumiko HTS and NK Neoma showed lower adaptation to the study year's conditions. Their lower yield was combined with lower oil content, lower oil yield, reduced thousand seed weight, and lower seed bulk density. This indicates that, under stress conditions, these hybrids realized their production potential less effectively and were less able to maintain seed formation and filling processes.

The generalization of the two studies allows an important conclusion to be drawn: stable sunflower production under current climate change is possible only when an adapted hybrid is combined with a rational nutrition system. In the Southern Steppe, the main limitation was critical moisture deficiency; therefore, the best results were obtained in treatments that supported plants through pre-sowing seed treatment, moderate mineral fertilization, and foliar fertilization. In the Northern Forest-Steppe, where a wider range of hybrids was compared, the most productive forms were those capable of maintaining seed filling and high oil yield during dry periods and elevated temperatures.

Thus, the research results are consistent with the literature review, which substantiates the need to combine resource-saving nutrition and hybrid selection. Moderate mineral fertilization, biological preparations, micronutrients, and foliar fertilization create conditions for better plant functioning, while an adapted hybrid uses the provided nutritional background more efficiently. This approach enables reducing yield losses in dry years, increasing productivity stability, improving seed quality, and reducing production risks.

Conclusions. In 2025, under the conditions of the Southern Steppe of Ukraine, the highest sunflower yield was provided by the combination of pre-sowing seed treatment with Mykofrend, the mineral background $N_{30}P_{15}K_{15}$, and foliar fertilization with Organic Balance, Azotohelp, and boron. Under this treatment, yield reached 1.26 t/ha in the Bastion hybrid and 1.30 t/ha in the Forsazh hybrid.

The Forsazh hybrid produced a slightly higher yield than Bastion in all experimental treatments, indicating its better response to resource-saving nutrition under acute moisture deficit.

In the Northern Forest-Steppe of Ukraine, the most adapted hybrids to the stressful conditions of 2025 were LG50635, ES Belfis, and P64LE25. The highest productivity was recorded for LG50635: seed yield – 1.70 t/ha, oil content – 44.0%, oil yield – 0.75 t/ha, thousand seed weight – 48 g, and seed bulk density – 360 g/L.

The combination of resource-saving nutrition with the selection of adapted hybrids is a scientifically grounded basis for improving sunflower cultivation technology under climate instability. This approach contributes to yield stabilization, improved seed quality, and more rational use of production resources.

References

1. Sydiakina, O. V., & Hamaiunova, V. V. (2023). Current state and prospects of sunflower seed production. Tavrian Scientific Bulletin, 131, 196–204. https://doi.org/10.32782/2226-0099.2023.131.25
2. Jarecki, W. (2022). Effect of varying nitrogen and micronutrient fertilization on yield quantity and quality of sunflower (Helianthus annuus L.) achenes. Agronomy, 12(10), Article 2352. https://doi.org/10.3390/agronomy12102352
3. Coêlho, E. S., Souza, A. R. E., Lins, H. A., Santos, M. G., Souza, M. F., Tartaglia, F. L., Oliveira, A. K. S., Lopes, W. A. R., Silveira, L. M., Mendonça, V., & Barros Júnior, A. P. (2022). Efficiency of nitrogen use in sunflower. Plants, 11(18), Article 2390. https://doi.org/10.3390/plants11182390
4. Crista, F., Radulov, I., Imbrea, F., Manea, D. N., Boldea, M., Gergen, I., Ienciu, A. A., & Bănățean Dunea, I. (2023). The study of the impact of complex foliar fertilization on the yield and quality of sunflower seeds (Helianthus annuus L.) by principal component analysis. Agronomy, 13(8), Article 2074. https://doi.org/10.3390/agronomy13082074
5. Gul, R. M. S., Sajid, M., Rauf, S., Munir, H., Shahzad, M., & Haider, W. (2021). Evaluation of drought-tolerant sunflower (Helianthus annuus L.) hybrids in autumn and spring planting under semi-arid rainfed conditions. OCL, 28, Article 24. https://doi.org/10.1051/ocl/2021012
6. Debaeke, P., Casadebaig, P., Flenet, F., & Langlade, N. B. (2021). New challenges for sunflower ideotyping in changing environments and more ecological cropping systems. OCL, 28, Article 29. https://doi.org/10.1051/ocl/2021001
7. Hamaiunova, V. V., & Pavlov, V. O. (2024). From stubble to healthy soil: The role of biodestructors in agriculture. Agrarian Innovations, 28, 32–37. https://doi.org/10.32848/agrar.innov.2024.28.5

8. Hamaiunova, V. V., & Pavlov, V. O. (2025). The role of biodestructors, pre-sowing seed treatment and mineral nutrition optimization in sunflower yield formation. Agrarian Innovations, 29, 29–34. https://doi.org/10.32848/agrar.innov.2025.29.5
9. Hamaiunova, V. V., & Pavlov, V. O. (2024). Total water consumption of sunflower under the influence of the studied factors in the Southern Steppe of Ukraine. Tavrian Scientific Bulletin, 140, 88–95. https://doi.org/10.32782/2226-0099.2024.140.12
10. Khablak, S. H., Bondareva, L. M., Dolia, M. M., Blume, Y. B., Tymoshchuk, T. M., Mrynskyi, I. M., Hrytsiuk, N. V., & Spychak, V. M. (2025). Resistance of new sunflower hybrids to sunflower broomrape (Orobanche cumana) and the possibility of their use in the strategy of protection against the parasite. Regulatory Mechanisms in Biosystems, 16(2), Article e25063. https://doi.org/10.15421/0225063
11. Hamaiunova, V. V., & Kasianov, P. V. (2026). Development of resource-saving measures for sunflower cultivation under the conditions of the Southern Steppe of Ukraine. Tavrian Scientific Bulletin. Series: Agricultural Sciences, 147(1), 98–105. https://doi.org/10.32782/2226-0099.2026.147.1.13