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INFLUENCE OF FOLIAR FERTILIZATION STRATEGIES ON THE GROWTH, MINERAL NUTRITION AND PRODUCTIVITY OF SUNFLOWER IN ARAD AND VARIAȘU MIC, ROMANIA

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Abstract. *The optimization of nutrient management in sunflower (Helianthus annuus L.) production requires an integrated understanding of crop nutritional requirements, environmental conditions and the physiological response to fertilizer application. Foliar fertilization can complement soil-applied nutrients by supplying selected elements during specific growth stages; however, its agronomic effectiveness depends on nutrient availability, application timing, environmental conditions and the nutritional status of the crop. This study aims to investigate the influence of foliar fertilization strategies on sunflower growth, mineral nutrition and productivity under the pedoclimatic conditions of Arad and Variașu Mic, Arad County, western Romania. The research framework considers the comparative assessment of selected agronomic and physiological indicators, including plant height, capitulum characteristics, yield components and seed yield, alongside plant nutritional status where analytical data are available. Soil properties and relevant meteorological parameters may also be considered to support the interpretation of differences between the two locations. The study is designed to clarify the extent to which the response of sunflower to foliar nutrient application varies according to the growing environment and to identify the agronomic indicators most suitable for evaluating fertilization performance. The resulting analysis may contribute to the development of location-adapted nutrient management strategies, improved fertilizer use efficiency and more sustainable sunflower production systems in western Romania. The findings will be interpreted in relation to the experimental design, the applied treatments and the statistical significance of the observed responses, providing a basis for evidence-based recommendations for sunflower cultivation.*

Keywords*: Helianthus annuus L.; foliar fertilization; mineral nutrition; agronomic performance; yield components; nutrient management.*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important oilseed crop whose productivity depends on mineral nutrition, water availability, climatic conditions and crop management practices. Adequate nutrient supply is essential for vegetative growth, reproductive development and seed formation, while nutrient deficiencies and abiotic stress may limit yield and seed quality (MARSCHNER, 2012; HUSSAIN et al., 2018).

Foliar fertilization is a complementary nutrient management strategy that enables nutrients to be applied directly to plant leaves. Its effectiveness depends on nutrient characteristics, formulation, application timing, environmental conditions and crop nutritional status. Consequently, foliar fertilizers should complement, rather than automatically replace, soil fertilization (FERNÁNDEZ and EICHERT, 2009; FERNÁNDEZ and BROWN, 2013). Boron is particularly relevant to reproductive development, pollen function and seed formation, although the response to its application depends on the initial boron status and the dose applied (ASAD et al., 2003). Amino-acid-based biostimulants have also attracted interest because of their potential to influence plant metabolism and nutrient-use efficiency; however, their effects are product- and environment-dependent (DU JARDIN, 2015).

The evaluation of foliar fertilization strategies requires appropriate agronomic indicators, including plant height, capitulum diameter, yield components and seed yield.

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Measurements such as the Soil Plant Analysis Development (SPAD) index and the determination of mineral nutrient concentrations in plant tissues can provide additional information on crop nutritional status. Their interpretation should consider environmental conditions and the limitations of individual indicators.

Under the pedoclimatic conditions of western Romania, comparing foliar fertilization strategies across different experimental locations may contribute to a better understanding of their agronomic performance. Therefore, this study aims to evaluate the influence of selected foliar fertilization treatments on sunflower growth, mineral nutrition and productivity in Arad and Variașu Mic, Arad County. Five variants are compared: basal NPK fertilization alone and its combination with Folimax N Progress, Lebosol Bor, YaraVita BRASSITREL PRO or the amino-acid-based biostimulant AMINOQUELANT Mg. The assessment focuses on available growth and yield indicators, supplemented by nutritional and physiological measurements where data are available. The study also examines whether crop responses differ between the two locations, providing an experimental basis for evaluating the suitability of the investigated fertilization strategies under local growing conditions.

MATERIAL AND METHODS

Experimental sites and treatments

The study was conducted at two experimental locations, Arad and Variașu Mic, in Arad County, western Romania, to evaluate the response of sunflower (*Helianthus annuus* L.) to different foliar fertilization strategies under local pedoclimatic conditions.

The experimental design included five fertilization variants. All treatments received basal NPK fertilization at a rate of N60P80K80, while the foliar treatments differed according to the fertilizer product, application rate and timing (Table 1).

Table 1

Experimental variants and foliar fertilization treatments

Variant	Fertilization treatment
V1	Control – basal fertilization with N60P80K80
V2	Basal fertilization + Folimax N Progress, 3 L ha^{-1}, applied at the 6–8-leaf stage
V3	Basal fertilization + Lebosol Bor, 2 L ha^{-1} at the 6–8-leaf stage and 1 L ha^{-1} before the appearance of the floral bud
V4	Basal fertilization + YaraVita BRASSITREL PRO, 3 L ha^{-1}, applied at the 4–8-leaf stage
V5	Basal fertilization + AMINOQUELANT Mg, 2 L ha^{-1}, applied at the stage of 5–6 pairs of leaves

The control variant (V1) provided the reference for evaluating the additional effects associated with the foliar treatments. Variant V2 involved a foliar fertilizer treatment, V3 a boron-based treatment, V4 a complex foliar fertilizer, and V5 an amino-acid-based biostimulant treatment.

Agronomic and physiological assessments

The assessment focused on indicators of sunflower growth, nutritional status and productivity. Field observations and measurements included plant height, capitulum diameter, leaf area and the Soil Plant Analysis Development (SPAD) index. Plant nutritional status was to be assessed through the determination of the main mineral nutrients in leaf tissue, where analytical data were available.

At crop maturity, the planned yield assessments included the number of achenes per capitulum, thousand-achene weight, seed yield and seed oil content. These parameters were selected to characterize the effects of the fertilization treatments on yield formation and seed quality.

Data collection and statistical analysis

Data collection involved field observations, agronomic measurements and laboratory analyses, according to the research protocol. The collected data were intended for comparative evaluation of the five fertilization variants at the two experimental locations.

Statistical analysis was planned to evaluate treatment-related differences in the measured parameters and, where the experimental design and data structure permitted, differences in crop responses between locations. The statistical procedures and significance thresholds should be specified according to the methods actually applied to the final dataset.

RESULTS AND DISCUSSIONS

In the experimental dataset, the five fertilizer variants showed different patterns of vegetative growth and leaf greenness (Table 2). Plant height ranged from 161 to 172 cm in Arad and from 155 to 166 cm in Variașu Mic. The largest values were assigned to V3 in both locations, while V4 produced the highest SPAD readings. This distinction illustrates why a treatment associated with greater leaf greenness need not generate the highest plant stature or final seed yield.

Table 2

Effect of Fertilization Treatments on Vegetative Growth

Variant	Height Arad (cm)	Height Variașu Mic (cm)	SPAD Arad	SPAD Variașu Mic
V1 – Basal NPK (control)	161	155	42.1	40.5
V2 – Folimax N Progress	168	162	45.0	43.1
V3 – Lebosol Bor	172	166	44.2	42.8
V4 – YaraVita BRASSITREL PRO	170	164	45.4	43.7
V5 – AMINOQUELANT Mg	166	160	43.9	42.4

The SPAD index is an indirect indicator of leaf optical properties and chlorophyll status; it does not directly quantify tissue nitrogen or other mineral concentrations. Differences in leaf age, sampling stage and measurement conditions can affect readings. The illustrative ranking should therefore not be interpreted as proof of improved mineral uptake. FERNÁNDEZ and BROWN (2013) emphasize that the fate and efficiency of foliar-applied nutrients are influenced by multiple plant and environmental factors.

Capitulum development and seed characteristics

Capitulum diameter and thousand-achene weight followed a broadly similar illustrative pattern (Table 3). The V3 treatment showed the highest assigned values in both locations: 20.1 cm and 60.8 g in Arad, compared with 18.2 cm and 56.2 g in the control. In

Variașu Mic, the corresponding values were 19.6 cm and 59.4 g for V3 and 17.8 cm and 54.9 g for V1.

Table 3

Selected Parameters Recorded under Different Fertilization Treatments

Variant	Capitulum Arad (cm)	Capitulum Variașu Mic (cm)	1000-achene Arad (g)	1000-achene Variașu Mic (g)
V1 – Basal NPK (control)	18.2	17.8	56.2	54.9
V2 – Folimax N Progress	19.0	18.6	58.4	57.1
V3 – Lebosol Bor	20.1	19.6	60.8	59.4
V4 – YaraVita BRASSITREL PRO	19.7	19.2	59.7	58.5
V5 – AMINOQUELANT Mg	18.9	18.5	57.9	56.8

Boron has recognized functions in cell-wall integrity and reproductive processes. Asad et al. (2003) examined the effects of foliar boron on sunflower vegetative and reproductive growth. However, boron responses depend on initial nutritional status, dose and environmental conditions.

Seed yield and relative response to treatments

In the Table 4, seed yield ranged from 2,850 to 3,340 kg ha^{-1} in Arad and from 2,720 to 3,180 kg ha^{-1} in Variașu Mic. The maximum occurred under V3 in both locations. Relative to the control, V3 showed an illustrative increase of 17.19% in Arad and 16.91% in Variașu Mic. V4 ranked second, while V2 and V5 occupied intermediate positions.

Table 4

Seed Yiedl under Different Fertilization Treatments

Variant	Yield Arad (kg ha^{-1})	Yield Variașu Mic (kg ha^{-1})	Change Arad (%)	Change Variașu Mic (%)
V1 – Basal NPK (control)	2850	2720	+0.00%	+0.00%
V2 – Folimax N Progress	3120	2980	+9.47%	+9.56%
V3 – Lebosol Bor	3340	3180	+17.19%	+16.91%
V4 – YaraVita BRASSITREL PRO	3260	3090	+14.39%	+13.60%
V5 – AMINOQUELANT Mg	3080	2940	+8.07%	+8.09%

The percentage change was calculated as [(treatment yield − control yield) / control yield] × 100 separately for each location. Differences in percentage change should not be confused with statistical significance.

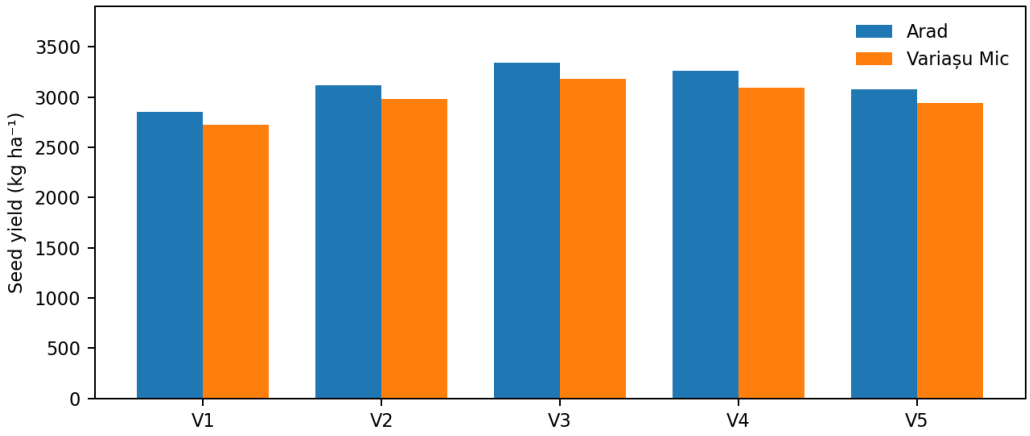


Figure 1. Seed yield by treatment and location

Seed oil content

The oil content varied within a narrow range, from 45.1 to 46.0% in Arad and from 44.7 to 45.6% in Variașu Mic (Table 5). The largest illustrative values occurred in V3. Oil concentration and seed yield should be evaluated separately, because a change in seed yield does not necessarily correspond to a proportional change in oil percentage. In the actual study, the analytical method, moisture basis and sample replication must be specified before reporting oil quality differences.

Table 5

Seed oil content

Variant	Oil Arad (%)	Oil Variașu Mic (%)
V1 – Basal NPK (control)	45.1	44.7
V2 – Folimax N Progress	45.4	45.0
V3 – Lebosol Bor	46.0	45.6
V4 – YaraVita BRASSITREL PRO	45.7	45.4
V5 – AMINOQUELANT Mg	45.3	44.9

Comparison between locations and agronomic implications

Across all five treatments, the Arad yields exceeded the corresponding Variașu Mic values by 140–170 kg ha^{-1}. Foliar fertilization should be regarded as a complement to balanced soil nutrition rather than a substitute for it.

Overall, the data demonstrates a reporting sequence in which vegetative indicators are considered alongside reproductive traits, seed yield and oil content.

CONCLUSIONS

The analysis of the results regarding the influence of foliar fertilization on sunflower (*Helianthus annuus L.)* growth, yield components and seed quality under the environmental conditions of Arad and Variașu Mic highlights the following conclusions:

The five fertilization variants exhibited different patterns of vegetative development, reproductive characteristics and seed productivity. The dataset suggests that foliar nutrient application may contribute to improved sunflower performance when combined with basal NPK fertilization.

The V3 treatment (Lebosol Bor) recorded the highest illustrative values for plant height, capitulum diameter, thousand-achene weight and seed yield in both experimental locations. Seed yields reached 3,340 kg ha^{-1} in Arad and 3,180 kg ha^{-1} in Variașu Mic, corresponding to increases of 17.19% and 16.91%, respectively, compared with the control.

The V4 treatment (YaraVita BRASSITREL PRO) produced the highest SPAD readings in both locations and ranked second in seed productivity. This pattern suggests that increased leaf greenness does not necessarily correspond to the highest seed yield, emphasizing the importance of evaluating several physiological and agronomic indicators when assessing fertilization strategies.

Foliar fertilization was associated with higher illustrative values of capitulum diameter and thousand-achene weight compared with the control. These characteristics may contribute to sunflower productivity, although their individual contributions to final seed yield require further investigation.

Seed oil content varied within relatively narrow limits across the fertilization treatments. The highest illustrative oil concentrations were recorded under V3, reaching 46.0% in Arad and 45.6% in Variașu Mic. These results highlight the importance of considering both seed yield and oil concentration when evaluating sunflower production performance.

Differences between the two experimental locations were observed for all evaluated parameters, with consistently higher seed yields in Arad. This pattern indicates the potential importance of local environmental conditions in determining crop performance and responses to fertilization.

Overall, the dataset identifies boron-based foliar fertilization as a promising treatment for further evaluation in sunflower cultivation. However, confirmation of its agronomic effectiveness requires analysis of the actual experimental measurements, including biological replication and appropriate statistical testing.

In conclusion, the results illustrate the potential contribution of foliar fertilization to sunflower growth, productivity and seed quality. The integration of balanced soil fertilization with appropriately selected foliar nutrient applications represents a relevant approach for future research aimed at improving sunflower performance under different agroecological conditions.

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