

Influence of irrigation on the growth and quality of grapevine propagation material

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ABSTRACT

Efficient water management is essential in grapevine nurseries, where irrigation strongly influences the morphological quality and the suitability of propagation material for successful vineyard establishment. This study evaluated the impact of two irrigation regimes on grafted grapevine seedlings produced under protected nursery conditions in 2025. Four table-grape cultivars ('Argessis', 'Memory', 'Norocel', and 'Ștefănești') grafted onto SO4-4 rootstock were grown under irrigation levels corresponding to 100% and 75% of the Active Soil Moisture Interval (ASMI). Morphological characteristics, including leaf area, main shoot length and diameter, number of roots ≥ 2 mm, main root length, and maximum root diameter, were assessed to evaluate shoot vigor and root morphological characteristics. Water use efficiency (WUE) was also determined to characterize the technological performance of each irrigation regime. The reduced irrigation level (75% ASMI) improved the morphological characteristics of both shoots and roots in most cultivars, increased the proportion of first-quality vines, and resulted in substantially higher WUE. The results obtained have confirmed that a 75% ASMI regime can improve water-use efficiency while sustaining high morphological quality, highlighting its potential as an efficient and sustainable irrigation strategy for nurseries.

Keywords: greenhouse, grapevine propagation, irrigation, grapevine nursery, morphological quality, water use efficiency (WUE)

INTRODUCTION

Grapevines are an important crop worldwide and they can be grown with limited water supply, occupying dry and semidry lands well (Rustioni *et al.*, 2019; Cifre *et al.*, 2005; Chalmers *et al.*, 2004). Growing conditions significantly affect the vine phenotype, including the plant morphology (Dinu *et al.*, 2021). For sustainable water management, it is essential to consider the relationship between root-water uptake and leaf transpiration (Green *et al.*, 2016), as vines absorb water primarily through their roots.

In general, root elongation and increase soil exploration play a central role in adaptation to abiotic stresses (Sun *et al.*, 2020; Mariani *et al.*, 2017), including higher tolerance to drought (Köse *et al.*, 2014; Corso and Bonghi, 2014). It has been demonstrated that one morphological adaptation strategy to drought led to the development of deeper roots capable of reaching wetter soils layers (Bauerle *et al.*, 2008). Furthermore, roots proliferation, through increasing number and branching enhances water conductance (Alsina *et al.*, 2010).

This study aimed to assess the effect of two irrigation regimes on the morphological quality of grafted grapevine vines grown in a protected nursery system.

MATERIALS AND METHODS

The experiment was conducted at National Research and Development Institute for Biotechnology in Horticulture – Stefanesti (INCDBH Stefanesti), in the Laboratory of Ecology and Propagation of Horticultural Species, with the objective of improving techniques for producing grafted grapevine material under protected conditions.

The study included four local table-grape cultivars ('Argessis', 'Norocel', 'Memory', and 'Ștefănești'), which were grafted onto SO4-4 rootstock at the end of February. Scions were hydrated for 24 hours before grafting. A paraffin mixture containing growth stimulators was applied during grafting.

Green paraffin was used before planting for protection, red paraffin was applied immediately after grafting and before forcing, and an additional coating was added before field establishment to limit dehydration and protect young shoots. Grafted cuttings were planted in raised beds covered with polyethylene film, arranged in a double-row system (20 cm width). A total of 3,900 plants were grown in a 300 m² protected area.

After planting, the grafted vines were monitored throughout the entire experimental period under two irrigation treatments: V1 – 100% of the Active Soil Moisture Interval (ASMI) and V2 – 75% of ASMI.

In October, when the grafted vines were harvested for evaluation and commercial classification, the following morphological characteristics were recorded: main shoot length, main shoot diameter, leaf area, number of roots, maximum root length, main root diameter, and number of roots ≥ 2 mm. At the same time, the vines were classified into Quality I and Quality II categories according to nursery morphological criteria, and the percentage of plants in each quality class was determined for both irrigation treatments. Statistical analysis was performed using SPSS (IBM Corporation, Armonk, NY, USA). Pearson correlation was applied to evaluate the relationships between morphological characteristics, vine quality (Quality I and II), and water use efficiency (WUE).

RESULTS AND DISCUSSIONS

The quality classification of grafted vines represents a key indicator in nursery production, as it determines both the commercial value of the planting material and its potential performance after establishment. The results showed clear differences between irrigation treatments, with the reduced irrigation level (75% ASMI) consistently improving the proportion of Quality I vines across all cultivars (Table 1). For 'Argessis', the percentage of Quality I vines increased from 42% under full irrigation (100% ASMI) to 53% under reduced irrigation (75% ASMI), while Quality II vines decreased from 43% to 27%. A similar trend was observed in 'Memory', where Quality I vines increased from 41% (V1) to 54% (V2), accompanied by a reduction in Quality II vines from 59% to 46%.

The most pronounced response was recorded for 'Norocel', which showed a substantial increase in Quality I vines from 47% (V1) to 67% (V2), while Quality II vines decreased from 53% to 33%. For 'Ștefănești', the proportion of Quality I vines increased from 49% to 55%, although the reduction in Quality II vines was less pronounced (from 32% to 36%). Overall, the 75% ASMI regime improved vine quality in all cultivars, suggesting that moderate water restriction promotes a more balanced vegetative and root development, ultimately leading to a higher proportion of commercially valuable planting material.

Leaf area is a key morphological indicator that reflects the plant's vegetative vigor and its capacity to use water resources efficiently, being strongly influenced by growth conditions (Green *et al.*, 2006; Dinu *et al.*, 2021).

Evaluating this parameter under different irrigation regimes provides essential information on cultivar-specific responses to water availability. Evaluating leaf area under different irrigation regimes offers valuable insight into the way grapevine cultivars adjust their growth in response to water availability.

Table 1. Classification of grafted vines (Quality I and II) under different irrigation regimes (ASMI%) for the four cultivars.

Cultivar	Irrigation regime-ASMI (%)	Quality I grafted wines (%)	Quality II grafted vines (%)
'Argessis'	v1-100	42	43
	v2-75	53	27
'Memory'	v1-100	41	59
	v2-75	54	46
'Norocel'	v1-100	47	53
	v2-75	67	33
'Ștefănești'	v1-100	49	32
	v2-75	55	36

The four cultivars showed distinct responses to the two irrigation treatments (Figure 1). The 'Argessis' cultivar recorded the highest leaf area values under both irrigation levels variants (with 152.48 cm² at 100% (V1) and 141.00 cm² at 75% ASMI indicating low sensitivity to reduced irrigation.

The 'Memory' cultivar displayed minimal variation between treatments (64,32 and 63,56 cm² leaf area) suggesting limited development and reduced responsiveness to water reduction. In contrast, 'Norocel' and 'Ștefănești' cultivars showed a positive reaction to moderate water restriction. Leaf area increased from 99.14 cm² (V1) to 147.39 cm² (V2) in 'Norocel', and from 85.00 cm² to 104.12 cm² in 'Ștefănești'. This response suggests a more efficient use of water and better vegetative balance under 75% ASMI regime. In conclusion, the cultivars showed distinct responses to reduced irrigation. 'Argessis' and 'Memory' displayed similar leaf area values under both treatments, indicating low sensitivity to changes in water supply. In contrast, 'Norocel' and 'Ștefănești' responded positively to the 75% ASMI regime, exhibiting increased leaf area under moderate water restriction.

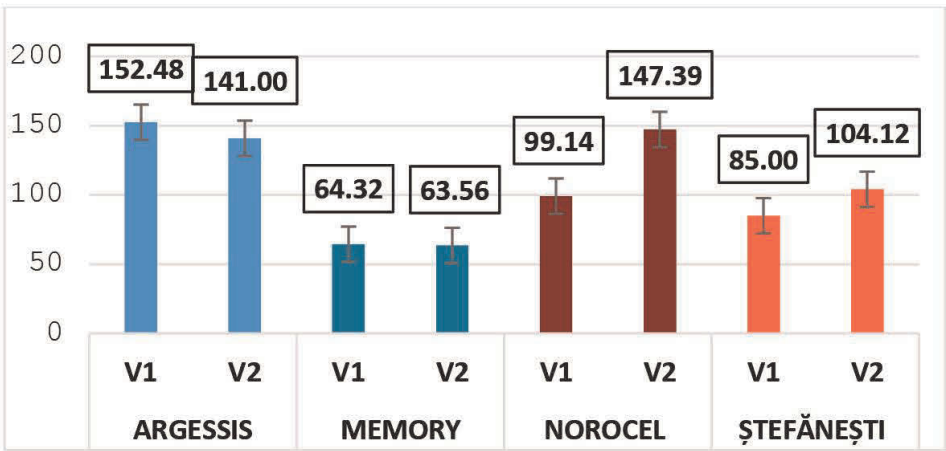


Figure 1. Influence of irrigation regimes on leaf area

Main shoot length is an essential morphological indicator, as it reflects vegetative vigour and the plant's ability to allocate resources efficiently under varying water conditions. Irrigation level can significantly influence shoot development, with cultivar-specific responses often reported in grapevine studies (Dinu *et al.*, 2021).

The 'Argessis' cultivar recorded the highest shoot length values in both experimental variants, reaching 50,08 cm under the influence of irrigation applied at in the at 100% ASMI (V1), respectively 54,46 cm when irrigation was applied at 75% ASMI (V2) indicating stable growth regardless of water reduction.

The 'Memory' cultivar recorded, lowest shoot length values among the cultivars studied with small differences between irrigation regimes: 28.44 cm under the influence of 100% ASMI irrigation (V1) and 24.14 cm at the application of irrigation calculated at 75% ASMI (V2). These results emphasize its reduced vegetative development and limited sensitivity to irrigation level-28,44 cm and 24,14 cm.

More pronounced differences were observed in the "Norocel" cultivar. Under the influence of irrigation applied at 100% ASMI (V1), the shoot length was only 15.44 cm, while the application of irrigation calculated at 75% ASMI (V2) led to a substantial increase, reaching 43.34 cm. A similar response was also recorded in the 'Ștefănești' cultivar. The application of irrigation at 100% ASMI (V1) led to a shoot length of only 14.63 cm, while the irrigation applied at 75% ASMI (V2) led to a considerable increase, reaching 43.69 cm. These results confirm that this cultivar responds more favorably to moderate irrigation than to full water availability.

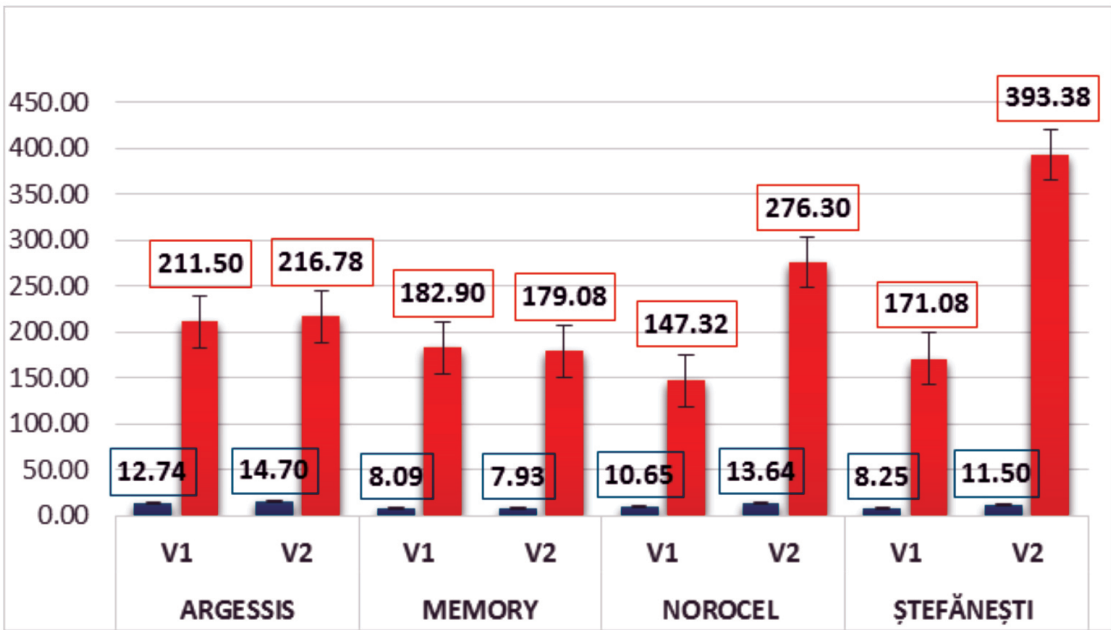


Figure 2. Influence of irrigation regimes on main shoot length and diameter in the four grapevine cultivars

The results obtained highlighted how the analyzed cultivars responded to the experimental variants (irrigation level applied). A significant difference in shoot diameter is observed between the cultivars but also between the two experimental variants (V1 and V2). The 'Argessis' cultivar recorded the highest shoot diameter value, with 12,74 mm under the influence of irrigation applied at 100% ASMI (V1), respectively 14.70 mm when irrigation was applied at 75% ASMI (V2). The resulting increase of +1.96 mm of irrigation at 75%_did

not affect growth, but stimulated shoot thickening. In the 'Memory' cultivar, shoot diameter was relatively constant between irrigation regimes (8.09 mm in V1 and 7.93 mm in V2), suggesting a indicating balanced but limited growth, regardless of water supply. The 'Norocel' cultivar responded positively to reduced irrigation level—with shoot diameter increasing from 10.65 mm (V1) to 13.64 mm (V2).

A similar trend was observed in the 'Ștefănești' cultivar where shoot diameter increasing from 8.25 mm (V1) to 11.50 mm (V2). In contrast, the 'Memory' cultivar recorded similar values between treatment, indicating stable growth but a reduced capacity to adjust to modified humidity conditions. These differences underlines the genetic variability among cultivars and their distinct ability to capitalize available resources.

Regarding the number of roots with a diameter ≥ 2 mm, the results showed clear differences between cultivars and irrigation treatments.—The 'Argessis' cultivar recorded the highest values, in both irrigation regimes, with 7.20 roots under the influence of irrigation applied at 100% ASMI (V1) and 12.80 when irrigation was applied at 75% ASMI (V2), indicating strong root development under moderate moisture conditions.

The 'Memory' cultivar in the number of roots increased markedly from 3.00 mm (V1) to 6.40 mm (V2), suggesting that reduced irrigation stimulated the formation of roots with larger diameter.

A similar trend was observed in the 'Norocel' cultivar—where the number of roots ≥ 2 mm increased from 4.80 roots under 100% ASMI (V1) to 9.00 roots under 75% ASMI (V2), confirming good adaptation to moderate soil moisture. In contrast, the 'Ștefănești' cultivar recorded similar values of roots with a diameter of ≥ 2 mm between the experimental variants (4.80 mm – V1, respectively 6.20 mm – V2).

Overall, most cultivars showed an improvement in root development, under reduced irrigation condition (V2).

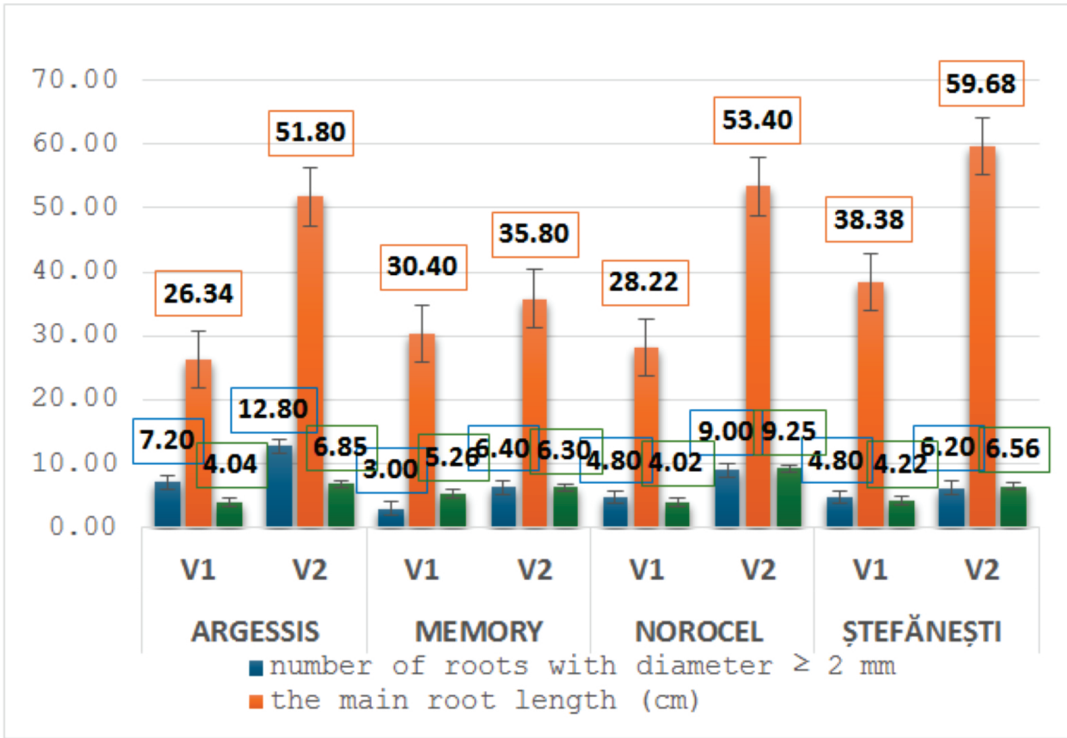


Figure 3. Influence of irrigation variants on the number of roots with diameter ≥ 2 mm, the main shoot length and maximum root diameter

Analyzing the influence of experimental variants on the main root lenght in the 4 cultivars, significant differences are found between genotypes, with a tendency to intensify root growth under the conditions of applying irrigation calculated at V2, compared to V1 (Figure 3).

The 'Argessis' cultivar recorded a significant increase in the lenght of the main root from 26.34 cm in the V1 variant to 51.80 cm in the V2 variant, which indicates a positive reaction to the moderate reduction in water intake.

The results indicate that reducing the level of irrigation favored the elongation of the main root, which suggests an effective adaptive strategy by which plants optimize the absorption of water under conditions of limited resources. In the case of experimental variants with reduced dose of water (V2) to complete the life requirement, they explore a larger volume of soil (chemotropism) and as a result, create a more extensive root system than in the case of plants receiving optimal amount of water.

Regarding the maximum root diameter, the results show consistent increases under the application of irrigation calculated at 75% ASMI (V2), with all cultivars displaying thicker roots under reduced water supply.

The 'Argessis' cultivar recorded a marked increase in maximum root diameter when irrigation was reduced to 75% ASMI (V2), rising from 4.04 mm under the influence of irrigation applied at 100% ASMI (V1) to 6.85 mm in V2, representing a +2.81 mm increase.

The 'Memory' cultivar showed a similar trend, with maximum root diameter increasing from 5.26 mm under the influence of irrigation applied at 100% ASMI (V1) to 6.30 mm when irrigation was applied at 75% ASMI (V2), suggesting a good adaptation capacity.

In the 'Norocel' cultivar, increase was even more pronounced, maximum root diameter 9.25 mm in V2, suggesting enhanced root tissue development and a strong adaptive response to reduced irrigation input.

The 'Ștefănești' cultivar recorded the same positive trend, with the maximum root diameter increasing from 4.22 mm (V1) to 6.56 mm (V2).

The results obtained showed that reducing the level of irrigation to 75% resulted in a thickening of the roots in all the cultivar analyzed, suggesting a better efficiency in the use of water resources.

Tabel 1. Correlation (r) between the morphological indicators

Morphologic indicator	Ist Quality	IInd Quality	WUE
Lenght of the main shoot (cm)	0,57	-0,62	0,71
Diameter of the shoot (mm)	0,02	-0,03	0,04
Leaf area (cm ²)	0,26	-0,21	0,24
Lenght of the main root (cm)	0,34	-0,35	0,31
Maximum root diameter (mm)	-0,13	0,09	0,03
Number of roots with diameter ≥ 2 mm	0,65	-0,67*	0,77*

The results obtained shows that balanced development of both aerial part and the root system play an essential role in the efficient use of water, especially under the 75% ASMI irrigation regime, where these relationships were more evident.

Extending the Pearson correlation analysis to include Quality II vines revealed several inverse and statistically significant relationships between morphological indicators and this quality category.

Thus, the lenght of the main shoot and the number of roots with a diameter of ≥2 mm shows significant negative correlations with the percentage of Quality II vines ($r = -0.62$ and $r = -0.67$, $p < 0.05$).

These results suggest that a vigorous shoot development vines and a well-defined root system favor the formation of Quality I vines, thereby reducing the proportion of lower quality plants.

Other indicators, such as main root length also showed negative but nonsignificant correlations ($r = -0.28$ and $r = -0.35$), confirming that vines with weaker morphologically development tend to fall into the Quality II category.

In contrast, the maximum root diameter did not have a significant influence on quality, the correlation values being close to zero ($r = 0.09$).

Overall, these correlations emphasize that the moderate irrigation regime (V2) promotes—to a more balanced morphological development, increases the proportion of Quality I vines, and reduces the share of Quality II vines, thereby improving the overall quality of the planting material Quality II and increasing the proportion of Quality I vines.

CONCLUSIONS

The results of the study show that the irrigation regime of 75% ASMI (V2) supported a more balanced development of the grafted vines compared to full irrigation (V1). Moderate water restriction stimulated root thickening, increased the number of roots with a diameter ≥ 2 mm, and improved main shoot growth in most cultivars. ‘Norocel’ and ‘Ștefănești’ showed the strongest positive reactions to reduced irrigation, while ‘Argessis’ displayed stable development under both irrigation levels. In contrast, ‘Memory’ exhibited limited variability, indicating a lower sensitivity to changes in water supply. Quality classification confirmed these trends: the 75% ASMI regime increased the proportion of Quality I vines and reduced the number of Quality II vines across all cultivars. Correlation analysis further highlighted the importance of a well-developed root system and balanced shoot growth for achieving higher-quality grafted vines and better water-use efficiency.

Overall, the 75% ASMI irrigation regime ensured efficient resource use and contributed to obtaining high-quality grafted vines, demonstrating its suitability as an optimal technological solution for the conditions analyzed.

REFERENCES

1. Alsina, M.M., Smart, D.R., Bauerle, T., De Herralde, F., Biel, C., Stockert, C., Negron, C., Save, R. (2010). Seasonal changes of whole root system conductance by a drought-tolerant grape root system. *Journal of Experimental Botany*, 62, 99–109.
2. Bauerle, T.L., Smart, D.R., Bauerle, W.L., Stockert, C., Eissenstat, D.M. (2008). Root foraging in response to heterogeneous soil moisture in two grapevines that differ in potential growth rate. *New Phytologist* 179, 857–866.
3. Chalmers, Y., Kelly, G., Krstic, M. (2004). Partial Rootzone Drying of *Vitis Vinifera* cv. ‘Shiraz’ Winegrapes in a Semi-Arid Climate. *Acta Horticulturae*, 664, 133–138.
4. Cifre, J., Bota, J., Escalona, J., Medrano, H., Flexas, J. (2005). Physiological tools for irrigation scheduling in grapevine (*Vitis vinifera* L.): An open gate to improve water-use efficiency? *Agriculture Ecosystems & Environment*, 106, 159–170.
5. Corso, M., Bonghi, C. (2014). Grapevine rootstock effects on abiotic stress tolerance. *Plant Science. Today*, 1, 108–113.
6. Dinu, D.G., Bianchi, D., Mamasakhlisashvili, L., Quarta, C., Brancadoro, L., Maghradze, D., Cardinale, M., Rustioni, L. (2021). Effects of genotype and environmental conditions on grapevine (*Vitis vinifera* L.) shoot morphology. *Vitis*, 60, 85–91.
7. Green, S.R., Kirkham, M., Clothier, B.E. (2006). Root uptake and transpiration: From measurements and models to sustainable irrigation. *Agricultural Water Management*, 86, 165–176.
8. Köse, B., Karabulut, B., Ceylan, K. (2014). Effect of Rootstock on Grafted Grapevine Quality *European Journal of Horticultural Science*, 79, 197.
9. Mariani, L., Ferrante, A. (2017). Agronomic Management for Enhancing Plant Tolerance to Abiotic Stresses—Drought, Salinity, Hypoxia, and Lodging. *Horticulturae*, 3, 52.

10. Rustioni, L., Cola, G., Maghradze, D., Abashidze, E., Argiriou, A., Aroutiounian, R., Brazão, J., Chipashvili, R., Cocco, M., Cornea, V., et al. (2019). Description of the *Vitis vinifera* L. phenotypic variability in enocarpological traits by a Euro-Asiatic collaborative network among ampelographic collections. *Vitis*, 58, 37–46.
11. Sun, X., Chen, F., Yuan, L., Mi, G. (2020). The physiological mechanism underlying root elongation in response to nitrogen deficiency in crop plants. *Planta*, 251, 84.