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INFLUENCE OF A FOLIAR BIOSTIMULANT ON THE MORPHOLOGICAL GROWTH OF TOMATO SEEDLINGS

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Abstract. *The morphological quality of tomato seedlings is an important factor in obtaining uniform planting material for protected cultivation. This study investigated the morphological response of Primadona F1 and Big Beef F1 tomato hybrids to repeated applications of a multicomponent foliar biostimulant. The experiment was conducted in 2025 in a heated greenhouse in Sâmbăta-Nouă, Tulcea County, Romania, using a professional peat-based substrate and a factorial arrangement comprising two hybrids and two treatment regimes. Each combination included four replicates of five plants, providing a total of 80 evaluated seedlings. Foliar applications were repeated at intervals of approximately ten days. Seedling development was assessed from changes in plant height and stem diameter between the beginning and end of a 21-day monitoring period. For both hybrids, treated variants exhibited higher mean increases in height and stem diameter than the untreated controls. Exploratory factorial analysis indicated a treatment-associated effect on both morphological indicators, without a statistically significant hybrid-by-treatment interaction. Spot temperature observations were used to describe the growing environment, rather than as continuous climatic measurements. These findings underline the value of evaluating multiple morphological traits simultaneously and support further investigation of physiological parameters, transplant establishment, and subsequent crop performance. Interpretations are restricted to the experimental period and conditions investigated.*

Keywords*: Solanum lycopersicum; tomato seedlings; foliar biostimulant; plant height; stem diameter; protected cultivation*

INTRODUCTION

Producing uniform tomato seedlings is an important stage of crop management; plant height and stem diameter are useful indicators of the morphological quality of planting material. Plant biostimulants may affect plant metabolism and development, although the magnitude of the response depends on their composition, genotype, and growing conditions (GEDEON et al., 2022; TURAN et al., 2023; GOLIN et al., 2024).

Romanian literature provides findings directly relevant to this research. DOBRIN et al. (2018) compared bioactive foliar treatments in tomato seedlings and reported favorable vegetative growth responses relative to untreated controls. HOZA (2014) examined rooting stimulation in solanaceous vegetable seedlings, including tomatoes, assessing height, stem thickness, and biomass. These studies support the choice of morphological indicators but cannot establish equivalent efficacy for the formulation investigated here.

More recent Romanian studies have reported responses to biostimulants in tomato cultivation. SÎRBU et al. (2022) investigated a product containing seaweed extract, protein hydrolysates, and humic substances, while DRAGOMIR et al. (2023) examined Bacillus spp. biopreparations under protected cultivation. COJANU et al. (2024) also assessed plant height and stem diameter in seedlings treated with beneficial bacteria. These formulations and production stages differ from those investigated in the present experiment. International studies by CALERO HURTADO et al. (2025), TAVALLALI and DASHTI DARVISHZADEH (2025), and ZHOU et al. (2025) have addressed morphological and physiological seedling responses to other classes of biostimulants.

The objective of this study was to compare morphological increases over D0–D21 in two tomato hybrids subjected to repeated foliar treatments, using the mean of each experimental replicate as the unit of analysis.

MATERIAL AND METHODS

The experiment was carried out in 2025 in a 325 m² heated greenhouse in Sâmbăta-Nouă, Tulcea County, Romania. The studied hybrids were Primadona F1 and Big Beef F1. Seeds were sown on 12 February 2025 at a depth of approximately 2 cm in 104-cell trays filled with fine Kekkilä DSM 3W substrate. According to the product characteristics recorded for the batch used, the substrate contained brown and dark peat, an adjusted pH of 5.5–5.9, NPK 14-16-18 + trace-element starter fertilizer, and a wetting agent. These specifications were not measured in the laboratory as part of the present study. The first transplanting took place 21 days after the emergence of the first true leaves, into 84-cell trays containing the same substrate. The plants were subsequently transplanted into pots approximately 51 days after sowing.

The experiment included two factors: A, hybrid (Primadona F1 or Big Beef F1); and B, foliar treatment (control or biostimulant). Four factorial treatment combinations were established, each with four replicates of five plants, yielding 16 experimental units and 80 plants. For comparative analysis, the measurements of the five plants in each replicate were aggregated at the experimental-unit level.

The four variants combined the two hybrids with the two treatment regimes: V1, Primadona F1 control; V2, Primadona F1 treated with foliar biostimulant; V3, Big Beef F1 control; and V4, Big Beef F1 treated with foliar biostimulant. Each variant comprised four replicates of five plants, for a total of 16 experimental units and 80 evaluated plants.

A multicomponent foliar biostimulant was applied at 0.25 mL/L of water (2.5 mL/10 L), by spraying in the morning until the foliage was uniformly wetted. Treatments were repeated at intervals of approximately 10 days and continued throughout the monitoring period. According to the technical sheet provided in the manufacturer's documentation, the formulation contains N 0.2%, P 0.4%, K 0.02%, and the additional elements listed in Table 1. Amino acids, vitamins, polysaccharides, enzymes, and other bioactive constituents are also declared, without individual quantitative concentrations. The values refer to the concentrated product, not to analyses carried out in this study or to concentrations in the spray solution (manufacturer's technical sheet, consulted in 2026).

The same plants were assessed at two measurement points 21 days apart: D0 denotes the first recorded measurement (baseline), and D21 denotes the follow-up measurement 21 days later. These labels do not denote days after sowing or calendar dates. The available records do not establish the exact calendar dates corresponding to D0 and D21. At D0, seedling heights were approximately 14–16 cm. Plant height (cm) and stem diameter (mm), the latter measured with calipers, were recorded. The available dataset includes values aggregated by replicate at D0 and D21, from which increments were calculated as $\Delta H = H21 - H0$ and $\Delta Ø = Ø21 - Ø0$. Intermediate D7/D14 measurements were not added because corresponding records were unavailable. The exact timing of the first foliar application relative to D0 cannot be established unambiguously from the available documents; accordingly, D0–D21 must not be interpreted as the first 21 days after treatment.

For each experimental unit, the mean of the five plants was used; individual plants were not treated as statistically independent replicates. D0–D21 increments were analyzed using a two-factor factorial ANOVA (hybrid and treatment), including their interaction and block as a fixed effect, resulting in nine residual degrees of freedom. Exploratory residual diagnostics

included the Shapiro–Wilk test and Levene's test across the four treatment combinations. The significance threshold was $\alpha = 0.05$. Interpretation remains cautious owing to the small number of replicates and the unavailability of the original individual plant records.

In the calculations, $\Delta H = H21 - H0$ denotes the increase in plant height (cm) between day 0 and day 21, while $\Delta D = D21 - D0$ indicates the corresponding increase in stem diameter (mm). H0/D0 and H21/D21 are the initial and final measurements on the same plants; the statistical analysis uses the mean of each five-plant experimental unit.

Table 1

Declared composition of the multicomponent foliar biostimulant (concentrated product)

Component	Declared content	Notes
Nitrogen (N)	0,2%	macronutrient
Phosphorus (P)	0,4%	macronutrient
Potassium (K)	0,02%	macronutrient
Magnesium (Mg)	550 mg/L	secondary nutrient
Iron (Fe)	220 mg/L	micronutrient
Boron (B)	declared present; concentration unconfirmed	public sources disagree
Manganese (Mn)	54 mg/L	micronutrient
Zinc (Zn)	49 mg/L	micronutrient
Copper (Cu)	35 mg/L	micronutrient
Ca, Mo, Co, Ni	declared present; individual concentrations unspecified	no identical concentration assumed for each element
Aminoacizi, vitamine, polizaharide, enzime	declared present; percentages not stated	cannot be quantified
Auxine, citochinine, gibereline	declared present; percentages not stated	cannot be quantified

Methodological note: the values are the composition declared in publicly available technical documentation for the foliar formulation described, NOT chemical determinations conducted in this experiment. Public sources do not fully agree regarding boron and the Ca–Mo–Co–Ni group; their individual concentrations therefore cannot be confirmed. The actual batch used in 2025 was not verified against a certificate of analysis.

RESULTS AND DISCUSSION

Table 2

D0–D21 increments, mean ± standard deviation (n = 4 experimental units)

Hybrid	Treatment	Height increment (cm)	Diameter increment (mm)
Primadona F1	Control	1.192 ± 0.156	0.062 ± 0.030
Primadona F1	Treated	1.910 ± 0.200	0.113 ± 0.021
Big Beef F1	Control	1.405 ± 0.258	0.082 ± 0.007
Big Beef F1	Treated	2.370 ± 0.283	0.148 ± 0.016

For Primadona F1, the treated group exhibited a mean height increment of 1.91 cm, compared with 1.19 cm in the control, corresponding to a relative difference of 60.2%. The mean stem-diameter increment was 0.113 mm versus 0.062 mm in the control.

For Big Beef F1, the treated group exhibited a mean height increment of 2.37 cm, compared with 1.40 cm in the control, corresponding to a relative difference of 68.7%. The mean stem-diameter increment was 0.148 mm versus 0.082 mm in the control.

Table 3

Exploratory factorial ANOVA including block in the model

Variable	Effect	F	p
Height increment	Hybrid	6.56	0.0306
Height increment	Treatment	41.08	0.0001
Height increment	Hybrid × treatment	0.89	0.3704
Diameter increment	Hybrid	6.68	0.0295
Diameter increment	Treatment	29.93	0.0004
Diameter increment	Hybrid × treatment	0.52	0.4888

Table 4

Data for the 16 experimental units and calculated D0–D21 increments

lock	Hybrid	Group	H0	H21	Ø0	Ø21	ΔH	ΔØ
B1	Primadona	Control	14.27	15.59	4.132	4.222	1.32	0.090
B1	Primadona	Treated	14.50	16.69	4.079	4.222	2.19	0.143
B1	Big Beef	Control	15.03	16.15	5.137	5.212	1.12	0.075
B1	Big Beef	Treated	15.40	17.72	5.133	5.266	2.32	0.133
B2	Primadona	Control	13.99	15.32	4.157	4.190	1.33	0.033
B2	Primadona	Treated	13.99	15.75	4.154	4.260	1.76	0.106
B2	Big Beef	Control	15.49	17.23	5.228	5.319	1.74	0.091
B2	Big Beef	Treated	15.42	17.41	5.168	5.309	1.99	0.141
B3	Primadona	Control	14.64	15.74	4.126	4.211	1.10	0.085
B3	Primadona	Treated	14.71	16.63	4.207	4.314	1.92	0.107
B3	Big Beef	Control	14.90	16.33	5.112	5.193	1.43	0.081
B3	Big Beef	Treated	15.35	17.92	5.181	5.329	2.57	0.148
B4	Primadona	Control	14.59	15.61	4.201	4.240	1.02	0.039
B4	Primadona	Treated	14.18	15.95	4.170	4.265	1.77	0.095
B4	Big Beef	Control	15.93	17.26	5.148	5.228	1.33	0.080
B4	Big Beef	Treated	14.74	17.34	5.284	5.455	2.60	0.171

Recalculation of ANOVA using the means of the 16 experimental units showed a treatment-associated effect on height increment ($F_{1,9} = 41.082$; $p = 0.000124$) and stem-diameter increment ($F_{1,9} = 29.925$; $p = 0.000395$). The hybrid × treatment interaction was not significant ($p = 0.3704$ for height; $p = 0.4888$ for diameter). Shapiro–Wilk tests of residuals yielded $p = 0.728$ and $p = 0.281$, respectively; Levene's tests yielded $p = 0.812$ and $p = 0.076$. These diagnostics did not identify clear assumption violations but had limited statistical power given

the sample size. The findings describe an association between treatment and observed increments, not a demonstrated improvement in post-transplant yield.

Study limitations include the absence of individual measurement records for all 80 plants, the lack of intermediate D7/D14 observations, the inability to reconstruct the exact calendar dates of D0 and D21 or all application dates, and the absence of independent post-transplant quality assessments. The three retained temperature observations per daypart are spot readings, not continuous climatic averages; the selected dates only approximate the possible D0–D21 interval. Information concerning biostimulant and substrate composition should be checked against the original technical sheets if requested by reviewers.

Thermal conditions in the greenhouse

Sowing took place on 12 February 2025, and the subsequent potting stage was recorded at approximately 51 days after sowing (around 4 April 2025). For a concise thermal illustration, only the existing spot observations on 3, 13 and 23 April 2025 were retained in Figure 1, which correspond approximately to a 21-day period around this stage. Their daytime mean was 22.77 °C, and their nighttime mean was 20.90 °C (n = 3 per series). The exact calendar dates of the D0 and D21 morphological measurements were not documented; therefore, the selected thermal window must not be interpreted as an independently verified match to those measurements.

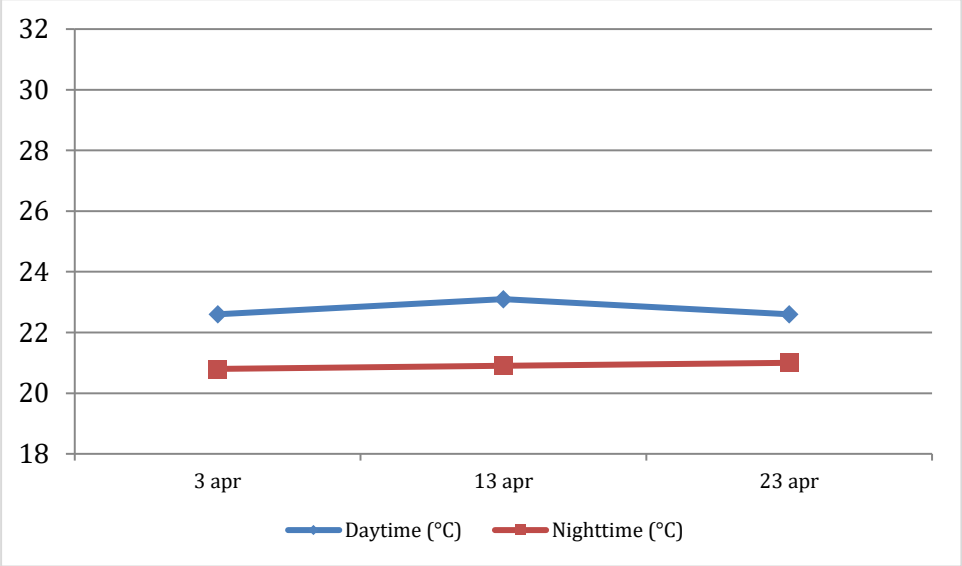


Figure 1. Selected spot temperatures in the greenhouse (3–23 April 2025; approximate monitoring window)

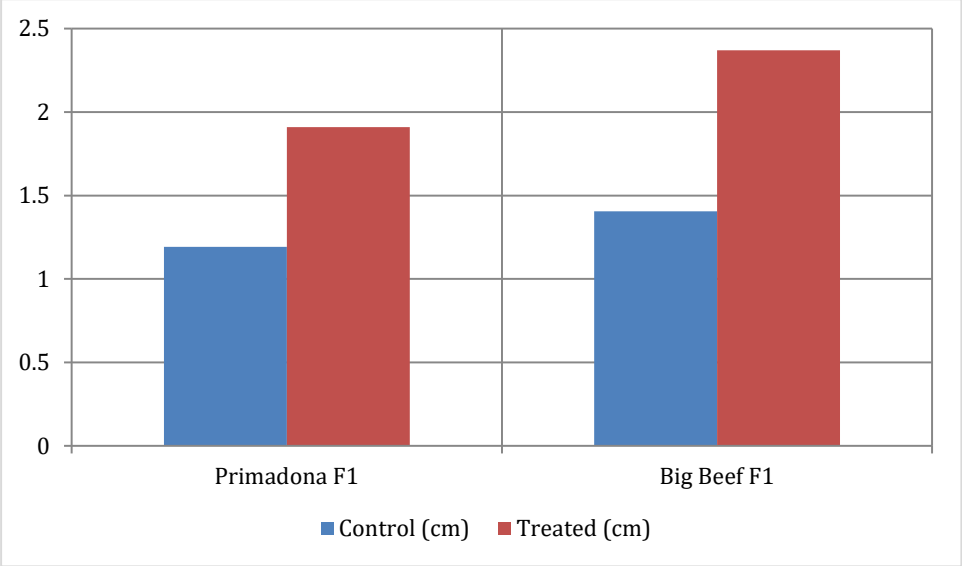


Figure 2. Mean seedling height increment by treatment combination, D0–D21.

Comparison with the literature

Comparison of our findings with Romanian studies is particularly relevant because of similarities in seedling production technologies. DOBRIN et al. (2018) observed that bioactive foliar treatments can positively affect tomato seedling growth, while HOZA (2014) reported changes in quality indicators of solanaceous vegetable seedlings. In the present study, D0–D21 increments were greater in the treated variants for both hybrids. Nevertheless, differences in tested products, application protocols, and growing conditions preclude direct numerical comparisons across experiments.

The Romanian study by SÎRBU et al. (2022) identified changes in photosynthetic and yield indicators with other biostimulant formulations. DRAGOMIR et al. (2023) and COJANU et al. (2024) studied biological treatments in protected tomato cultivation; microbial mechanisms cannot be directly equated with those of the foliar preparation investigated here. In international literature, GEDEON et al. (2022) and TURAN et al. (2023) investigated responses under stress, while QUIJIA PILLAJO et al. (2024), DASGAN et al. (2024), and GOLIN et al. (2024) examined other formulations and growth stages. CALERO HURTADO et al. (2025), TAVALLALI and DASHTI DARVISHZADEH (2025), and ZHOU et al. (2025) described seedling effects and possible mechanisms; FUSCO et al. (2025) and PATANÈ et al. (2025) highlighted how responses depend on environmental conditions and water availability. These studies establish the relevance of the topic, rather than the equivalence of the treatments or the direct transferability of effect sizes.

Thus, the present observations complement the literature with a local case involving two hybrids and repeated applications, but do not provide a biochemical determination of the mode of action or a direct comparison of product efficacy.

The figures present only experimental data reported in the text and tables; they do not represent additional intermediate measurements.

CONCLUSIONS

Under the particular conditions of the heated greenhouse in Sâmbăta-Nouă, repeated foliar applications were associated with greater growth increments in both hybrids during D0–D21. Mean height increase in Primadona F1 rose from 1.19 cm (control) to 1.91 cm (treated), and in Big Beef F1 from 1.40 to 2.37 cm. These differences describe changes measured over 21 days, not total growth since sowing.

For stem diameter, increments were 0.062 versus 0.113 mm in Primadona F1 and 0.082 versus 0.148 mm in Big Beef F1. Exploratory ANOVA based on means of the four replicates identified a treatment-associated statistical effect for both indicators ($p < 0.001$), without a significant hybrid × treatment interaction. This does not demonstrate that the biological responses were identical; it merely indicates that a difference between the hybrid-specific effects was not detected statistically in this sample.

An important methodological limitation is that the available records do not establish unambiguously when the first treatment occurred relative to D0, although the treatment schedule continued during the analyzed interval. Therefore, the increments cannot be attributed to a single application, nor can the influence of differing initial conditions be excluded. The thermal values derived from 15 spot observations collected over the broader cultivation period are descriptive and are not equivalent to a continuous temperature log.

From a practical perspective, the results support further investigation of repeated applications in seedling production, but cannot demonstrate improvements in transplant establishment, yield, or profitability because these outcomes were not measured. Validation will require additional experiments across growing cycles, with measurements of biomass, leaf area, root development, and post-transplant performance.

The conclusions should be interpreted at the level of the available experimental replicates, without directly extrapolating growth increments to commercial tomato yields. Between-group differences are compatible with a favorable effect of the foliar program, but elucidating the physiological mechanisms would require further determination of dry mass, leaf area, root characteristics, and nutritional status. Furthermore, the values declared in biostimulant technical documentation describe the concentrated formulation and do not constitute chemical analyses carried out in this research. We recommend repeating the experiment over multiple seasons and evaluating plant performance after transplanting to establish the applicability of the findings.

BIBLIOGRAPHY

CALERO HURTADO, A., MELÉNDREZ RODRÍGUEZ, J. F., PEÑA CALZADA, K., PÉREZ DÍAZ, Y. AND JIMÉNEZ MEDINA, A. (2025). Foliar Application of a Mixture of Amino Acid-Based Growth Promoters Enhances Tomato Seedling Production. Horticulturae, 11(6), 582. https://doi.org/10.3390/horticulturae11060582

COJANU, D.-N., LUMÎNARE, M.-C., BOIU-SICUIA, O. A. AND CORNEA, C. P. (2024). Evaluation of native bacterial strains as plant growth promoters for greenhouse tomatoes. Scientific Papers. Series B, Horticulture, LXVIII(1), 732–737. https://horticulturejournal.usamv.ro/index.php/component/content/article/evaluation-of-native-bacterial-strains-as-plant-growth-promoters-for-greenhouse-tomatoes?catid=28

DASGAN, H. Y., AKSU, K. S., ZIKARIA, K. AND GRUDA, N. S. (2024). Biostimulants Enhance the Nutritional Quality of Soilless Greenhouse Tomatoes. Plants, 13(18), 2587. https://doi.org/10.3390/plants13182587

DOBRIN, E., GHERGHINA, E., LUȚĂ, G. AND BĂLAN, D. (2018). The influence of foliar bioactiv treatments on tomatoes seedlings. Scientific Papers. Series B, Horticulture, LXII, 385–390.

https://www.horticulturejournal.usamv.ro/index.php/component/content/article/the-influence-of-foliar-bioactiv-treatments-on-tomatoes-seedlings-578?catid=16

DRAGOMIR, C.-L., HOZA, G., BECHERESCU, A., BĂDULESCU, L., CĂTUNEANU, I., DOBRIN, A., CONSTANTIN, C. AND HOZA, D. (2023). Preliminary data regarding the application of Bacillus spp. in the culture technology of protected tomatoes in order to increase productivity in the Bucharest area. Scientific Papers. Series B, Horticulture, LXVII(1), 585–594. https://horticulturejournal.usamv.ro/index.php/scientific-papers/issues?id=1346

FUSCO, G. M., BURATO, A., PENTANGELO, A., CARILLO, P. AND PARISI, M. (2025). Processing Tomato Responses to Plant-Based Biostimulants Are Modulated by Environmental Conditions. Physiologia Plantarum, 177(4), e70450. https://doi.org/10.1111/ppl.70450

GEDEON, S., IOANNOU, A., BALESTRINI, R., FOTOPOULOS, V. AND ANTONIOU, C. (2022). Application of Biostimulants in Tomato Plants (Solanum lycopersicum) to Enhance Plant Growth and Salt Stress Tolerance. Plants, 11(22), 3082. https://doi.org/10.3390/plants11223082

GOLIN, M. F., GIANNINI, V., BAGARELLO, M., VERNAZA CARTAGENA, W. C., GIORDANO, M. AND MAUCIERI, C. (2024). Processing Tomato and Potato Response to Biostimulant Application in Open Field: An Overview. Agronomy, 14(11), 2699. https://doi.org/10.3390/agronomy14112699

HOZA, G. (2014). Research regarding the influence of some rooting stimulators on the production of solano-fruiting vegetable seedlings. Scientific Papers. Series B, Horticulture, LVIII, 265–270. https://www.horticulturejournal.usamv.ro/index.php/papers-submitting?catid=9&id=311

PATANÈ, C., PELLEGRINO, A., SAITA, A., CALCAGNO, S., COSENTINO, S. L., SCANDURRA, A. AND CAFARO, V. (2025). A study on the effect of biostimulant application on yield and quality of tomato under long-lasting water stress conditions. Heliyon, 11(1), e41187. https://doi.org/10.1016/j.heliyon.2024.e41187

QUIJIA PILLAJO, J., CHAPIN, L. J., MARTINS, E. M. AND JONES, M. L. (2024). A Biostimulant Containing Humic and Fulvic Acids Promotes Growth and Health of Tomato 'Bush Beefsteak' Plants. Horticulturae, 10(7), 671. https://doi.org/10.3390/horticulturae10070671

SÎRBU, C., CIOROIANU, T. M., BIREESCU, G., MIHALACHE, D. AND STĂNESCU, A. M. (2022). Results obtained by applying a biostimulant to tomato and wheat crops. Scientific Papers. Series A, Agronomy, LXV(2), 436–444. https://agronomyjournal.usamv.ro/index.php/scientific-papers/past-issues?id=1521

TAVALLALI, V. AND DASHTI DARVISHZADEH, M. (2025). Synergistic effects of Fe nanocomplex and nitrophenolate-based biostimulant on growth and physiological performance of tomato seedlings. BMC Plant Biology, 25, 905. https://doi.org/10.1186/s12870-025-06930-y

TURAN, M., EKINCI, M., ARGIN, S., BRINZA, M. AND YILDIRIM, E. (2023). Drought stress amelioration in tomato (Solanum lycopersicum L.) seedlings by biostimulant as regenerative agent. Frontiers in Plant Science, 14, 1211210. https://doi.org/10.3389/fpls.2023.1211210

ZHOU, Q., WU, S., XING, L., WANG, Z., ZHANG, X., ZHANG, F., WENG, L., TANG, J., ZHAO, R. AND WANG, L. (2025). Molecular Mechanisms of Biostimulants in Promoting Tomato Seedling Growth: Linking Chemical Structure to Physiologic Function. Journal of Agricultural and Food Chemistry, 73(13), 7632–7644. https://doi.org/10.1021/acs.jafc.4c12283

*** Additional technical documentation, separate from the 15 scientific references: publicly available composition sheets for the multicomponent foliar biostimulant (consulted on 23 October 2026). Two public sources differ with respect to boron; the precise composition of the batch used is not certified by an available batch-specific sheet.