Acta Agronomica Óváriensis

P., Makleit et al./ActAgrOvar, Vol.67.1. (2026)

The Effect of Plant Conditioner Candidates on the Morphological and Physiological Parameters of the *'Rajnai fürtös'* Cucumber Cultivar

PÉTER MAKLEIT*, OQBA BASAL, ÁDÁM HOSSZÚ, LÁSZLÓ KASZÁS, SZILVIA VERES

University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management
Institute of Applied Plant Biology, Debrecen, Hungary
ORCID iD: https://orcid.org/0000-0002-2401-6504
Email: pmakleit@agr.unideb.hu
ORCID iD: https://orcid.org/0000-0002-2396-6591
ORCID iD: https://orcid.org/0009-0008-8237-698X
ORCID iD: https://orcid.org/0000-0002-3937-6860
ORCID iD: https://orcid.org/0000-0003-4509-789X

*Corresponding author/Levelező szerző

Received/Érkezett: 28.11.2025 Revised/Átdolgozva: 14.01.2026
Accepted/Elfogadva: 30.03.2026 Published/Megjelent: 29.06.2026

ABSTRACT

Improving crop tolerance to abiotic stress is increasingly important under changing climatic conditions. This study evaluated three plant conditioner candidates (No. 2, 9 and 10) in the cucumber cultivar '*Rajnai fürtös*' grown under controlled hydroponic conditions. Plants were cultivated either in a complete nutrient solution or in a half-strength solution. Conditioner products were applied as weekly foliar sprays from weeks 4 to 10, and sampling was performed at weeks 6, 8 and 10. Water deprivation stress was imposed by polyethylene glycol (PEG) only prior to the final harvest. Stomatal conductance, net photosynthesis, relative chlorophyll content (SPAD), absolute chlorophyll content and specific leaf area were determined on the fully developed leaf, and shoot/root length, fresh biomass and root volume were also measured. Overall, the tested candidates showed limited efficacy; most traits did not differ significantly from the control under non-stress conditions. For underwater deprivation stress, candidate No. 2 partially mitigated the decline in gas-exchange parameters, whereas candidate No. 9 increased the number of flowers.
Keywords: cucumber, biostimulant, stress, PEG, hydroponics

1. INTRODUCTION

Climate-driven increases in the frequency and intensity of abiotic stress events pose a major constraint to cucumber production, where water deficit can rapidly impair stomatal functioning, photosynthesis and ultimately yield formation. In parallel, the need to improve input efficiency has stimulated interest in plant conditioners/biostimulants as complementary tools to conventional

fertilisation, aiming to enhance plant performance primarily through physiological modulation rather than direct nutrient supply. However, responses to such products are often context-dependent and require cultivar- and condition-specific evaluation.
Therefore, the objective of this study was to assess the effects of three plant conditioner candidates (No. 2, 9 and 10) on the morphological and physiological responses of the cucumber cultivar '*Rajnai fürtös*' under hydroponic cultivation. Emphasis was placed on gas-exchange parameters and leaf traits during vegetative development, and on plant responses following polyethylene glycol (PEG) induced water deprivation as osmotic stress, which was applied before the final sampling. We hypothesised that conditioner treatments would improve baseline growth and/or partially mitigate stress-related declines in photosynthetic performance.

2. LITERATURE REVIEW

With the increasing frequency of extreme weather events and soil depletion, biostimulants are assuming an increasingly important role in sustainable crop production. Neither in Hungary nor at the international level is there a uniformly accepted legal definition of biostimulant products. Numerous studies (Vessey 2003; Calvo et al., 2014; Yakhin et al. 2017; Rouphael & Colla 2020) report on their application and mechanisms of action, based on which the concept can be summarized as follows: biostimulant is a natural or synthetic preparation applied to the seed or foliage of plants, or to the soil, which modifies plant metabolic processes as well as structural and physiological development. As a result, the plant's abiotic stress tolerance may be enhanced, and its growth and development, and, consequently, yield will improve. A further advantage is that its application may allow a reduction in the amount of chemical fertiliser applied.
Since the concept of biostimulants has not yet been precisely delimited in legal and regulatory terms, their classification is based primarily on the practice of researchers, regulators and practitioners. The scientific literature distinguishes several broadly accepted main groups that encompass both substances and microorganisms; these are briefly reviewed in the following sections.
Heterogeneous humic substances (humic acid, fulvic acid) derived from soil organic matter improve nutrient uptake through their effects on the physical, chemical and biological properties of the soil. They increase cation exchange capacity, enhance phosphorus availability, and stimulate plasma membrane H^+-ATPases, thereby promoting nutrient uptake, cell elongation and organ growth. Modulatory effects on stress responses and hormone-like activities are also presumed. The magnitude of their effects strongly depends on their source, environmental conditions and mode of application (Zandonadi et al., 2007; Jindo et al., 2020).
Mixtures of amino acids and peptides obtained by the degradation of plant- and animal-derived proteins, as well as other nitrogen-containing compounds (e.g., betaines, polyamines), directly influence nitrogen (N) uptake and assimilation, the integration of carbon–nitrogen metabolism, and hormonal homeostasis, and–through their chelating capacity–the mobility of micronutrients. Owing to their antioxidant properties, they contribute to stress tolerance. Indirectly, they also enhance soil microbial activity and soil fertility. They frequently exert beneficial effects on yield quantity and quality; however, protein hydrolysates of animal origin raise food chain safety concerns (Jindo et al., 2020; Raidasari et al., 2025).
Extracts of brown and red seaweed contain polysaccharides, nutrients, hormones and characteristic secondary metabolites. In soil, they improve water retention and cation binding and support beneficial microflora; in plants, via their hormonal and nutritional effects, they stimulate

 DOI: 10.17108/ActAgrOvar.2026.67.1.51

germination, establishment, growth and stress tolerance. A large part of their hormonal effects is exerted through the regulation of genes involved in plant hormone biosynthesis. Considerably fewer data are available on extracts from other plant sources, but their potential biostimulant role may be based on allelochemical interactions (Stirk et al. 2020; Nanda et al., 2022).
Chitosan ($C_{56}H_{103}N_9O_{39}$), the deacetylated form of chitin, in its various polymer sizes binds to the cell wall, cell membrane, DNA and specific receptors, triggering signal transduction processes similar to those elicited by plant defence elicitors. It induces hydrogen peroxide accumulation, Ca^{2+} signalling and extensive changes in gene expression, which may result in enhanced resistance to pathogens and abiotic stress, as well as improvements in quality parameters (Stasińska-Jakubas and Hawrylak-Nowak, 2022; Molnár et al., 2023).
Certain elements (Al, Co, Na, Se, Si) are not essential for all species but are classified as beneficial elements because, under specific conditions, they can enhance growth and stress tolerance. Their effects range from strengthening the cell wall and supporting osmoregulation to modifying nutrient uptake, antioxidant defence and hormonal regulation (Franzoni et al., 2022). Some inorganic salts (e.g., phosphites) exhibit both fungicidal and biostimulant effects, and their biostimulant role has already been recognised (Gómez-Merino and Trejo-Téllez 2015).
Mycorrhizal fungi (particularly arbuscular mycorrhizal fungi, AMF) live in symbiosis with most plants and improve macro- and micronutrient supply, water relations, and tolerance to both biotic and abiotic stresses (Israel et al. 2022). Hyphal networks linking roots and the soil space may even mediate signalling between plants. Other endophytic fungi (e.g., *Trichoderma spp*., *Piriformospora indica*) can be propagated at least partly independently of the host plant, are able to transfer nutrients to the host, and have significant biocontrol and biostimulant effects (enhanced stress tolerance, growth, and nutrient use efficiency) (Du Jardin 2015; Castiglione et al. 2021).
Bacteria–plant interactions span a broad spectrum from mutualism to parasitism. From a biostimulant perspective, a key group is the *Rhizobium*-type N-fixing endosymbionts and plant growth-promoting rhizobacteria (PGPR) inhabiting the rhizosphere. These bacteria can influence nutrient supply, growth, morphogenesis, stress responses and plant–microbe interactions alike. The success of their practical application depends on strain-specific properties, synergies within bacterial consortia, plant genotype, environmental conditions and product formulation. Despite these challenges, the market for bacterial biostimulants is expanding rapidly, and PGPR are increasingly regarded as “probiotics” for plants (Du Jardin 2015; Choi et al., 2016; Lastochkina et al., 2020).

3. MATERIALS AND METHODS

The plant conditioner candidates were tested on cucumber (Cucumis sativus L.) plants of the ‘*Rajnai fürtös*’ cultivar. The plants were grown hydroponically in a climate room under controlled conditions (light intensity 300 µmol m^{-2} s^{-1}, day/night temperature 25/20 °C, day/night hours 16 h/8 h, and relative humidity 65-75 %).
The seeds were germinated between moistened filter paper, and after the hypocotyls had elongated, they were placed in a nutrient solution, with 4 plants in each pot. One part of the pot was filled with a complete nutrient solution, while the other part was filled with a half nutrient solution (containing half the amount of all ingredients). The nutrient solution was prepared according to Treeby et al. (1989), changed every 3 days, and continuously aerated.
For treatment as a foliar fertiliser, we selected plant conditioner candidates 2, 9, and 10 at the concentrations recommended by the manufacturer, using the same amount of each candidate per pot.

 DOI: 10.17108/ActAgrOvar.2026.67.1.51

The control plants were sprayed with distilled water in the same amount as the plant conditioner candidates tested on the test plants. There were 3 independent replicates from every treatment. The treatments were performed once a week when the plants were 4-10 weeks old.
Sampling was performed at 6, 8, and 10 weeks of age, using one plant per pot. Three days before the last sampling, the plants were placed in an 8 % polyethylene glycol (PEG) solution to induce water deprivation stress.
During sampling, fresh biomass and shoot- and root-length were measured by thermogravimetry and root volume was determined using the water-displacement method. Stomatal conductance was investigated with an AP4 porometer (Delta-T, UK), while relative chlorophyll content (SPAD) was measured using a SPAD-502Plus meter (Konica Minolta, Japan). Net photosynthesis and stomatal conductance were measured on both young (uppermost fully expanded) and old (third from the bottom) leaves. Absolute chlorophyll content was determined following Moran and Porath (1980) and Wellburn (1994), and specific leaf area (SLA) was quantified on the fully developed leaf according to Garnier et al. (2001). Statistical analyses were performed in SPSS v23.0. Treatment effects were evaluated using one-way analysis of variance (ANOVA) and Student’s t-tests, and means were separated using Duncan’s multiple range test and Tukey’s HSD test. Means annotated with different letters differed significantly at $p \leq 0.05$.

4. RESULTS AND DISCUSSION

Table 1 summarises stomatal conductance and net photosynthesis across the three sampling times for the control and the plant conditioner candidates (No. 2, 9 and 10), with the different letters indicating statistically significant differences among treatments within each sampling date ($p \leq 0.05$).

Table 1: The effect of plant conditioner candidates on the stomatal conductance (mmol H_2O m^{-2} s^{-1}) and net photosynthesis (µmol m^{-2} s^{-1}) of the cucumber variety 'Rajnai fürtös' at different sampling times (1st, 2nd, 3rd). (n = 12; ± S.E.)

	Sampling	Stomatal conductance	Net photosynthesis
Control	1st	177.67 ± 11.26a	21.70 ± 1.69a
2	1st	172.83 ± 14.66a	18.58 ± 2.41a
9	1st	193.17 ± 12.94a	21.53 ± 2.64a
10	1st	211.67 ± 17.37a	17.88 ± 1.26a
Control	2nd	272.00 ± 32.52a	29.54 ± 3.63a
2	2nd	245.50 ± 20.73a	26.18 ± 2.31a
9	2nd	262.58 ± 29.18a	27.48 ± 3.14a
10	2nd	278.17 ± 32.48a	28.02 ± 2.89a
Control	3rd	77.07 ± 11.39a	8.08 ± 1.35a
2	3rd	141.96 ± 13.99b	14.24 ± 1.34b
9	3rd	107.36 ± 20.64ab	11.12 ± 2.21ab
10	3rd	98.27 ± 21.73ab	10.03 ± 2.24ab

DOI: 10.17108/ActAgrOvar.2026.67.1.51

Stomatal conductance and net photosynthesis did not differ significantly among the control and conditioner treatments (No. 2, 9, 10) at the 1st and 2nd sampling, indicating no detectable treatment effect at these time points (*Table 1*). By the 3rd sampling, both parameters declined sharply, consistent with a dominant stress effect. Under these conditions, candidate No. 2 significantly increased stomatal conductance (77.07 ± 11.39 to 141.96 ± 13.99 mmol m^{-2} s^{-1}) and net photosynthesis (8.08 ± 1.35 to 14.24 ± 1.34 µmol m^{-2} s^{-1}) relative to the stress control. Candidates No. 9 and No. 10 showed intermediate responses and were not clearly separable from either the control or candidate No. 2 at the final sampling. Overall, the data suggest that candidate No. 2 partially mitigated the stress-related decline in gas exchange, whereas no consistent benefits were observed under non-stress conditions.

Leaf developmental stage significantly affected gas exchange at the first and second sampling. The fully developed (young) leaves exhibited higher net photosynthesis and stomatal conductance than older leaves ($p \leq 0.05$) (*Table 2*).

Table 2: Net photosynthesis (µmol m^{-2} s^{-1}) and stomatal conductance (mmol m^{-2} s^{-1}) of the cucumber cultivar 'Rajnai fürtös' at different sampling times (1st, 2nd, 3rd), plotted against leaf age (old and young) growing on complete and half nutrient solution (n = 24; ± SE).

1st sampling	**Net photosynthesis**	**Stomatal conductance**	**Nutrient solution**	**Net photosynthesis**	**Stomatal conductance**
Old	17.23 ± 0.70a	167.46 ± 6.58a	Complete	23.48 ± 1.69b	201.13 ± 9.40b
Young	22.61 ± 1.80b	210.21 ± 11.44b	Half	16.36 ± 0.65a	176.54 ± 10.60a
2nd sampling	**Net photosynthesis**	**Stomatal conductance**	**Nutrient solution**	**Net photosynthesis**	**Stomatal conductance**
Old	17.23 ± 0.70a	233.17 ± 14.73a	Complete	33.07 ± 1.98b	316.83 ± 19.94b
Young	22.61 ± 1.80b	295.96 ± 22.85b	Half	22.54 ± 1.60a	212.29 ± 13.77a
3rd sampling	**Net photosynthesis**	**Stomatal conductance**	**Nutrient solution**	**Net photosynthesis**	**Stomatal conductance**
Old	10.62 ± 1.15a	103.65 ± 11.26a	Complete	11.16 ± 1.49a	106.99 ± 14.13a
Young	11.11 ± 1.53a	108.68 ± 14.59a	Half	10.57 ± 1.20a	105.33 ± 11.85a

Nutrient supply also influenced these parameters, as plants grown in the complete nutrient solution showed higher photosynthesis and stomatal conductance than those supplied with the half-strength solution at the first and second sampling. By the third sampling, differences related to leaf age and nutrient solution strength were no longer detectable, suggesting that stress effects at the final harvest overrode these influences.

 DOI: 10.17108/ActAgrOvar.2026.67.1.51

Table 3: Effect of plant conditioner candidates (Number 2, 9 and 10) on chlorophyll-a (Chl-a), chlorophyll-b (Chl-b) and carotenoid (Car) content (mg kg-1), specific leaf area (SLA: cm2 g) and relative chlorophyll content (SPAD -index) of the cucumber variety 'Rajnai fürtös' compared to the control (Cont.)

	Chl-a	**Chl-b**	**Car**	**SPAD**	**SLA**
	1st sampling				
Control	14.11 ± 0.43a	5.78 ± 0.43a	1.35 ± 0.06a	43.34 ± 0.99a	165.87 ± 11.21a
2	14.23 ± 0.36a	6.02 ± 0.33a	1.39 ± 0.05a	43.33 ± 1.04a	157.89 ± 10.45a
9	14.29 ± 0.32a	6.02 ± 0.26a	1.37 ± 0.04a	44.05 ± 0.75a	159.81 ± 9.32a
10	14.85 ± 0.39a	6.56 ± 0.36a	1.48 ± 0.05a	44.39 ± 0.91a	167.94 ± 10.66a
	Chl-a	**Chl-b**	**Car**	**SPAD**	**SLA**
	2nd sampling				
Control	14.32 ± 0.44a	6.11 ± 0.36a	1.44 ± 0.06a	43.99 ± 0.89a	146.11 ± 11.10a
2	13.49 ± 0.46a	5.54 ± 0.29a	1.35 ± 0.05a	41.90 ± 1.18a	136.34 ± 9.37a
9	14.19 ± 0.37a	5.86 ± 0.29a	1.39 ± 0.05a	44.46 ± 0.91a	140.06 ± 10.91a
10	13.68 ± 0.55a	5.58 ± 0.36a	1.35 ± 0.07a	42.29 ± 1.55a	147.99 ± 15.29a

Across both sampling dates, none of the measured traits differed significantly between the control and conditioner treatments, as all means share the same letter. Under the applied treatments, candidates No. 2, 9 and 10 did not measurably affect chlorophyll a, chlorophyll b, carotenoid concentration, SPAD index or SLA at either the first or second sampling (*Table 3*). Numerically, pigment contents and SPAD values were broadly similar among treatments at both time points, while SLA tended to be lower at the second sampling relative to the first across all treatments, suggesting a general shift in leaf structure over time rather than a treatment-specific response.
Across traits related to vegetative growth and root development (shoot and root fresh weight, root volume, shoot and root length, number of leaves and lateral shoots), no significant differences were detected between the control and conditioner-treated plants (*Figure 1*).

DOI: 10.17108/ActAgrOvar.2026.67.1.51

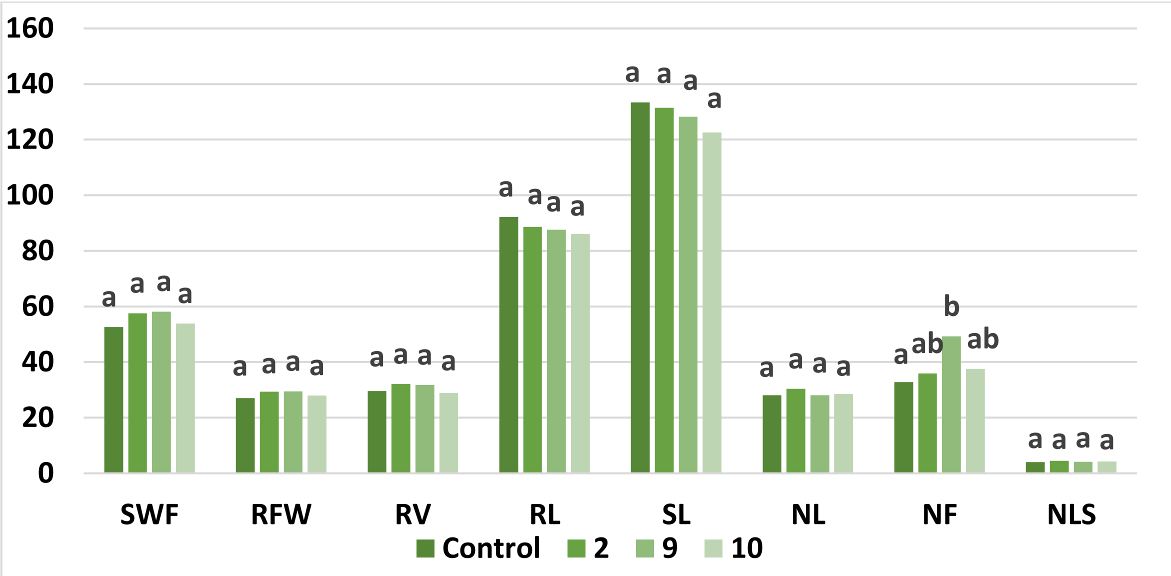

Figure 1: Effect of plant conditioner candidates (Number 2, 9 and 10) on morphological parameters of cucumber cultivar 'Rajnai fürtös' on the average of samplings. (SFW: shoot fresh weight (g); RFW: root fresh weight (g); RV: root volume (cm3); RL: root length (cm); SL: shoot length (cm); NL: number of leaves; NF: number of flowers; NLS: number of lateral shoots) (n = 18; ± SE)

In contrast, the number of flowers (NF) showed a treatment effect: candidate No. 9 resulted in significantly higher flowering compared with the control, while candidates No. 2 and No. 10 exhibited intermediate values. Overall, the conditioner candidates had negligible effects on biomass accumulation and root/shoot architecture under the applied conditions, whereas candidate No. 9 may have promoted reproductive development.

Figure 1 indicates that, when averaged across sampling dates, the plant conditioner candidates (No. 2, 9 and 10) produced no statistically supported changes in most morphological traits (SFW, RFW, RV, RL, SL, NL and NLS), as reflected by the uniform significance groupings. The *Figure 2* comparison of control plants and plants treated with candidate No. 9 supports these findings by revealing broadly similar vegetative growth and root system development, with the most apparent difference being the higher flowering intensity in the candidate No. 9 treatment. The representative phenotypes under PEG-induced water deprivation stress further demonstrate that PEG caused pronounced stress symptoms in all treatments; visually, none of the conditioner candidates fully prevented the development of stress-related damage, consistent with the overall limited treatment effects on morphology, observed in *Figure 3*.

DOI: 10.17108/ActAgrOvar.2026.67.1.51

Figure 2: Control plants (left) and the plants treated with candidate number 9 plant conditioner (right)

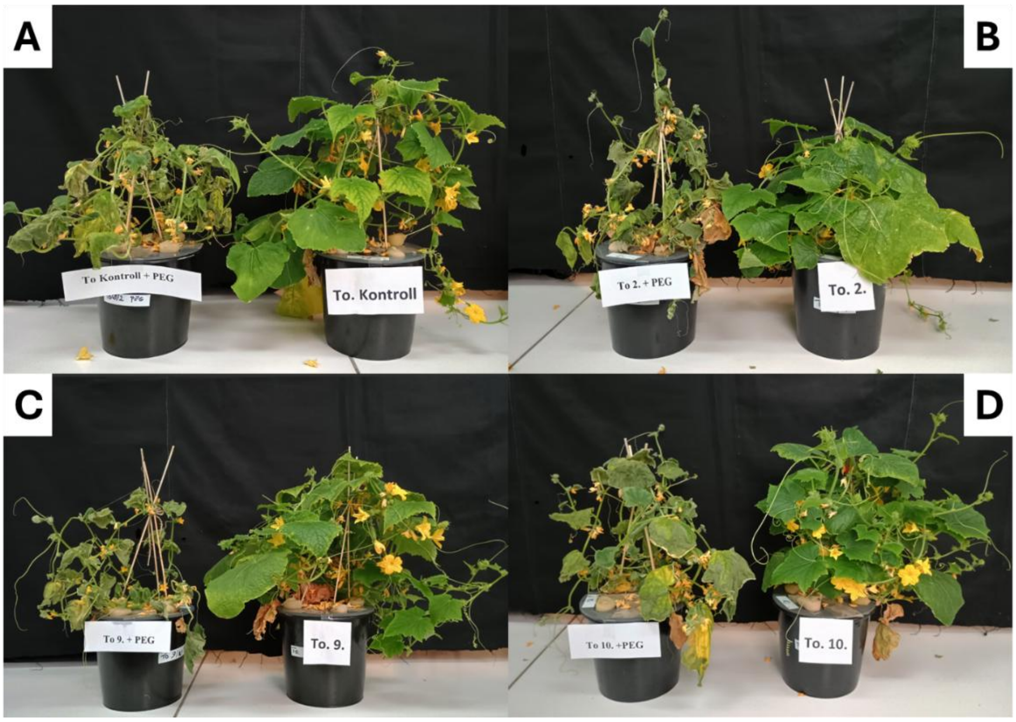

Figure 3: Representative phenotypes of plants treated with plant conditioner candidates under control and PEG-induced osmotic stress conditions. (A) Untreated control and PEG-treated plants. (B) Plants treated with conditioner candidate No. 2 in the absence or presence of PEG. (C) Plants treated with conditioner candidate No. 9 in the absence or presence of PEG. (D) Plants treated with conditioner candidate No. 10 in the absence or presence of PEG

PEG was used to impose osmotic stress. Photographs show representative plants from each treatment.

DOI: 10.17108/ActAgrOvar.2026.67.1.51

There are several possible reasons for these results: the plant conditioner agent candidates do not contain the active ingredient(s) suitable for this purpose, the conditioners are not effective at this growth stage of plants, the applied amount of potential conditioner was not correct, or the degree of water deprivation stress was too severe for the cucumber plants to survive. The plant conditioner agent candidates improved the performance of the tested plants in a few measured parameters compared to the control plants, but it is noteworthy that candidate No. 9 increased the number of flowers. More flowers have the potential to develop into more fruit, which could improve cucumber yield. Candidate No. 2 increased stomatal conductance, implying the possibility of more intense photosynthesis as more carbon dioxide could enter the plant through the open stomata. This increases the efficiency of photosynthesis, a fundamental process in the production of organic matter.

5. CONCLUSION

Under controlled hydroponic conditions, the tested plant conditioner candidates (No. 2, 9 and 10) exerted overall limited and inconsistent effects on the physiological and morphological performance of the cucumber cultivar '*Rajnai fürtös*'. Across the non-stressed sampling dates, none of the candidates produced a consistent improvement in leaf pigment traits, relative chlorophyll content (SPAD) or specific leaf area, indicating that the treatments did not measurably enhance leaf photosynthetic pigment status or leaf structural traits under the applied conditions. Likewise, averaged morphological parameters were only marginally affected, with the most notable qualitative response being an increased flowering tendency in plants treated with candidate No. 9. Following the PEG treatment used to impose water deprivation, plant performance declined markedly across all treatments, and none of the candidates prevented the development of severe stress symptoms. Nevertheless, candidate No. 2 showed a measurable mitigation of stress-related reductions in gas-exchange parameters at the third sampling: stomatal conductance increased from 77.07 to 141.96 mmol m^{-2} s^{-1} and net photosynthesis from 8.08 to 14.24 µmol m^{-2} s^{-1} relative to the PEG-treated control, suggesting a potential capacity to partially sustain stomatal function and photosynthetic activity under stress. In contrast, candidates No. 9 and No. 10 did not yield statistically robust improvements in these parameters under PEG stress.

Overall, the results suggest that the evaluated products, as applied here (weekly foliar sprays and a short-term serious water deprivation), are not sufficient to provide broad-spectrum enhancement of cucumber growth or stress tolerance. Future work should therefore (i) test a graded, less severe water deprivation stress, (ii) include dose–response assessments and application timing optimisation, and (iii) characterise product composition and/or key active fractions to support mechanistic interpretation and reproducibility under practical production conditions.

Acknowledgments

The authors acknowledge the financial support of the 2024-1.1.1-KKV_FÓKUSZ-2024-00031 project.

 DOI: 10.17108/ActAgrOvar.2026.67.1.51

Acta Agronomica Óváriensis

P., Makleit et al./ActAgrOvar, Vol.67.1. (2026)

Növénykondicionáló-jelöltek hatása a „*Rajnai fürtös*” uborkafajta morfológiai és élettani paramétereire

MAKLEIT PÉTER*, OQBA BASAL, HOSSZÚ ÁDÁM, KASZÁS LÁSZLÓ, VERES SZILVIA

Debreceni Egyetem, Mezőgazdaság- és Élelmiszertudományi és Környezetgazdálkodási Kar
Alkalmazott Növénybiológiai Intézet, Debrecen
ORCID iD: https://orcid.org/0000-0002-2401-6504
Email: pmakleit@agr.unideb.hu
ORCID iD: https://orcid.org/0000-0002-2396-6591
ORCID iD: https://orcid.org/0009-0008-8237-698X
ORCID iD: https://orcid.org/0000-0002-3937-6860
ORCID iD: https://orcid.org/0000-0003-4509-789X

*Corresponding author/Levelező szerző

ÖSSZEFOGLALÁS

A változó éghajlati viszonyok mellett egyre fontosabb a növények abiotikus stresszekkel szembeni tűrőképességének fokozása. Jelen vizsgálatban három növénykondicionáló-jelölt (2., 9. és 10.) hatását értékeltük a „Rajnai fürtös” uborkafajtán kontrollált, hidroponikus körülmények között. A növényeket teljes tápoldatban, illetve fél töménységű tápoldatban neveltük. A készítményeket a 4-10. hetek között hetente egyszer lombpermetezéssel juttattuk ki, a mintavételezés a 6., 8. és 10. héten történt. A vízhiány stresszt polietilén-glikol (PEG) alkalmazásával kizárólag a végső betakarítás előtt idéztük elő (a 3. mintavételt megelőző 3 napban). A sztóma konduktanciát, a nettó fotoszintézist, a relatív klorofilltartalmat (SPAD), az abszolút klorofilltartalmat és a fajlagos levélfelületet az utolsó teljesen kifejlődött levélen határoztuk meg; emellett mértük a hajtás és a gyökér hosszát, friss tömegét, valamint a gyökértérfogatot. Összességében a vizsgált jelöltek hatékonysága korlátozott volt; stresszmentes körülmények között a legtöbb vizsgált tulajdonság szignifikánsan nem különbözött a kontrolltól. PEG-stressz hatására a 2-es jelölt részben mérsékelte a gázcsere-paraméterek csökkenését, míg a 9-es jelölt növelte a virágok számát.

Kulcsszavak: uborka, biostimulator, stress, PEG, hidropónia

 DOI: 10.17108/ActAgrOvar.2026.67.1.51

REFERENCES

Calvo, P., Nelson, L., & Kloepper, J. W. (2014). Agricultural uses of plant biostimulants. *Plant and Soil*, *383*(1-2), 341. https://doi.org/10.1007/s11104-014-2131-8

Castiglione, A. M., Mannino, G., Contartese, V., Bertea, C. M., & Ertani, A. (2021). Microbial Biostimulants as Response to Modern Agriculture Needs: Composition, Role and Application of These Innovative Products. *Plants*, *10*(8), 1533. https://doi.org/10.3390/plants10081533

Choi, E.-S., Sukweenadhi, J., Kim, Y.-J., Jung, K. H., Koh, S.-C., Hoang, V.-A., & Yang, D.-C. (2016). The effects of rice seed dressing with Paenibacillus yonginensis and silicon on crop development on South Korea's reclaimed tidal land. *Field Crops Research*, *188*, 121-132. https://doi.org/10.1016/j.fcr.2016.01.005

Du Jardin, P. (2015). Plant biostimulants: Definition, concept, main categories and regulation. *Scientia Horticulturae*, *196*, 3-14. https://doi.org/10.1016/j.scienta.2015.09.021

Franzoni, G., Cocetta, G., Prinsi, B., Ferrante, A., & Espen, L. (2022). Biostimulants on Crops: Their Impact under Abiotic Stress Conditions. *Horticulturae*, *8*(3), 189. https://doi.org/10.3390/horticulturae8030189

Garnier, E., Shipley, B., Roumet, C., & Laurent, G. (2001). A standardized protocol for the determination of specific leaf area and leaf dry matter content. *Functional Ecology*, *15*(5), 688-95. https://doi.org/10.1046/j.0269-8463.2001.00563.x

Gómez-Merino, F. C., & Trejo-Téllez, L. I. (2015). Biostimulant activity of phosphite in horticulture. *Scientia Horticulturae*, *196*, 82-90. https://doi.org/10.1016/j.scienta.2015.09.035

Israel, A., Langrand, J., Fontaine, J., & Lounès-Hadj Sahraoui, A. (2022). Significance of Arbuscular Mycorrhizal Fungi in Mitigating Abiotic Environmental Stress in Medicinal and Aromatic Plants: A Review. *Foods*, *11*(17), 2591. https://doi.org/10.3390/foods11172591

Jindo, K., Olivares, F. L., Malcher, D. J. D. P., Sánchez-Monedero, M. A., Kempenaar, C., & Canellas, L. P. (2020). From Lab to Field: Role of Humic Substances Under Open-Field and Greenhouse Conditions as Biostimulant and Biocontrol Agent. *Frontiers in Plant Science*, *11*, 426. https://doi.org/10.3389/fpls.2020.00426

Lastochkina, O., Garshina, D., Ivanov, S., Yuldashev, R., Khafizova, R., Allagulova, C., Fedorova, K., Avalbaev, A., Maslennikova, D., & Bosacchi, M. (2020). Seed Priming with Endophytic Bacillus subtilis Modulates Physiological Responses of Two Different Triticum aestivum L. Cultivars under Drought Stress. *Plants*, *9*(12), 1810. https://doi.org/10.3390/plants9121810

Nanda, S., Kumar, G., & Hussain, S. (2022). Utilization of seaweed-based biostimulants in improving plant and soil health: Current updates and future prospective. *International Journal of Environmental Science and Technology*, *19*(12), 12839-12852. https://doi.org/10.1007/s13762-021-03568-9

Rouphael, Y., & Colla, G. (2020). Editorial: Biostimulants in Agriculture. *Frontiers in Plant Science*, *11*, 40. https://doi.org/10.3389/fpls.2020.00040

Stasińska-Jakubas, M., & Hawrylak-Nowak, B. (2022). Protective, Biostimulating, and Eliciting Effects of Chitosan and Its Derivatives on Crop Plants. *Molecules*, *27*(9), 2801. https://doi.org/10.3390/molecules27092801

Treeby, M., Marschner, H., & Römheld, V. (1989). Mobilization of iron and other micronutrient cations from a calcareous soil by plant-borne, microbial, and synthetic metal chelators. *Plant and Soil*, *114*(2), 217-226. https://doi.org/10.1007/BF02220801

Vessey, J. K. (2003). Plant growth promoting rhizobacteria as biofertilizers. *Plant and Soil*, *255*(2), 571-586. https://doi.org/10.1023/A:1026037216893

Yakhin, O. I., Lubyanov, A. A., Yakhin, I. A., & Brown, P. H. (2017). Biostimulants in Plant Science: A Global Perspective. *Frontiers in Plant Science*, *7*. https://doi.org/10.3389/fpls.2016.02049

Zandonadi, D. B., Canellas, L. P., & Façanha, A. R. (2007). Indolacetic and humic acids induce lateral root development through a concerted plasmalemma and tonoplast H+ pumps activation. *Planta*, *225*(6), 1583-1595. https://doi.org/10.1007/s00425-006-0454-2

DOI: 10.17108/ActAgrOvar.2026.67.1.51