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Article

Influence of organic biostimulants on morphological and biochemical traits of radish

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A B S T R A C T

The aim of this study was to evaluate the effects of different organic biostimulants on the morphological traits and quality parameters of radish under controlled growing conditions. The experiment was conducted with three replications and five treatments: Levoamin, Algafert, yeast, humic acids, and a control. The results showed that the application of biostimulants significantly affected all analysed morphological traits compared to the control. The highest values for plant height, total plant mass, and root dimensions were recorded in treatments with Levoamin and yeast. The application of biostimulants increased vitamin C content, total phenolic compounds, total antioxidant capacity, and total chlorophyll content. The most pronounced effect occurred with the yeast treatment, which recorded the highest values of total phenols and antioxidant capacity. The results indicate that applying organic biostimulants, particularly yeast, can significantly improve the growth and nutritional quality of radish.

Keywords: radish, biostimulants, morphological traits, nutritional quality

И З В О Д

Циљ овог истраживања је био да се испита утицај различитих органских биостимулатора на морфолошке особине и параметре квалитета ротквице у контролисаним условима гајења. Оглед је постављен у три понављања са пет третмана: Левоамин, Алгаферт, квасац, хуминске киселине и контрола. Добијени резултати показали су да је примена биостимулатора значајно утицала на све анализиране морфолошке особине у односу на контролу. Највеће вредности за висину биљке, укупну масу биљке и димензију корена забележене су код третмана са Левоамином и квасцем. Примена биостимулатора довела је до повећања садржаја витамина Ц, укупних фенола, укупног антиоксидативног капацитета и укупног садржаја хлорофила. Најизраженији ефекат утврђен је код третмана са квасцем, где су забележене највеће вредности укупних фенола и антиоксидативног капацитета. Добијени резултати указују да примена органских биостимулатора, а посебно квасца, може значајно унапредити раст и нутритивни квалитет ротквице.

Кључне речи: ротквица, биостимулатори, морфолошке особине, нутритивни квалитет

1. Introduction

Radish is a root vegetable that is cultivated worldwide and valued in human nutrition. It belongs to the family Brassicaceae (2n = 18). It is most commonly consumed fresh, mainly as an ingredient in various salads. Radish can be successfully grown both in protected cultivation and in open field conditions. Producers value it for its short growing period and rapid readiness for consumption after sowing. Radish is a good source of vitamin C, carbohydrates, dietary fibre, and minerals such as calcium, potassium, and phosphorus. Radish seeds are rich in oils (Verma et al., 2017; Yousaf et al., 2021). The characteristic pungent taste is due to isothiocyanates.

Organic farming is a cultivation system that excludes synthetic inputs such as fertilisers, fungicides, pesticides, and plant growth regulators (Lampkin, 2002), and it is based on preserving and improving agroecosystems, biodiversity, and soil biological activity (Lori et al., 2017). In organic production, where synthetic inputs are restricted, alternative products are important for enhancing plant growth and development. Biostimulants are a significant group of compounds which, although not direct sources of nutrients, can positively influence physiological and biochemical processes in plants. Their use improves nutrient use efficiency, increases tolerance to stress conditions, and enhances overall plant metabolism. Biostimulants can also affect the accumulation of secondary metabolites, such as phenolic compounds, vitamin C, and antioxidant capacity, thereby directly improving the nutritional quality of vegetable crops. Thus, their use is an important approach in sustainable agricultural production.

As the growth and yield of radish largely depend on nutrient availability, this study aimed to evaluate the effect of various organic biostimulants on the morphological and phytochemical traits of radish (*Raphanus sativus* L. var. *radicula*).

2. Materials and methods

2.1. Plant material and experimental design

The experiment was conducted during the spring growing season in 2025, from 24 April to 4 June. The trial took place in a greenhouse at the Šetonje locality, Petrovac na Mlavi. Containers with 32 cells filled with organic vermicompost were used for the experiment. One seed of radish cv. 'Saxa', produced at the Institute for Vegetable Crops, Smederevska Palanka, was sown in each cell. The experiment followed a randomised block design with three replications, each containing 10 plants. The study included four treatments and a control. Four different organic biostimulants were applied in the treatments.

The following biostimulants were used:

Levoamin – a liquid biostimulant derived from microalgae strains rich in L-amino acids. It contains 4.18% glutamic acid and 4.40% glycine. The treatment was applied at a concentration of 5 mL L^{-1} water.

Aminohumic – a liquid biostimulant composed of humic acids, fulvic acids, and amino acids. Its chemical composition includes humus extract (16%), humic acids (9%), fulvic acids (7%), potassium (6%), and free amino acids (5%). The treatment was applied at a concentration of 5 mL L^{-1} water.

Algafert is a liquid biostimulant based on seaweed extracts and amino acids. Its chemical composition includes total N (1.5%), organic N (1.4%), free amino acids (6%), and water-soluble potassium (K_2O) (3.4%). The treatment was applied at a concentration of 5 mL L^{-1} of water.

Yeast (*Saccharomyces cerevisiae*) is the most commonly used yeast species (brewer's yeast). It contains essential amino acids, B-complex vitamins, calcium, and magnesium. The yeast treatment was prepared by mixing 4 g of yeast with 4 g of sugar in 1 L of water, 24 hours prior to application at room temperature. A fresh yeast solution was prepared before each treatment.

Control, no biostimulants were applied.

Radish plants were cultivated according to organic production principles under protected conditions in a greenhouse. The first treatment was applied seven days after emergence. Four treatments and a control were performed during the growing period at seven-day intervals. All treatments were applied as foliar sprays.

2.2. Morphological analyses

At technological maturity, radishes were harvested and the following parameters were measured: total plant height, total plant biomass, number of leaves per plant, leaf length, leaf width, leaf area, root length, root diameter, and root mass without leaves.

2.3. Biochemical analyses

In the laboratory of the Faculty of Agronomy, the content of vitamin C, total phenolic compounds, and total antioxidant capacity was determined.

The total vitamin C content in the edible radish root was determined using Tillman's titration method. The total phenolic content in radish roots was measured using the Folin–Ciocalteu method (Singleton et al., 1999). Total antioxidant capacity was evaluated using the DPPH method and determined spectrophotometrically (Xu et al., 2010). Total chlorophyll content in radish leaves was determined spectrophotometrically after extraction with 80% acetone according to the modified Holm (1954) method.

2.4. Statistical analysis

The data were processed using Microsoft Excel spreadsheet software, applying the least significant difference (LSD) test to compare the mean values of the samples. The results are presented in tabular form.

3. Results and discussion

In this experiment, it was found that the application of biostimulants, compared to the control, had a statistically significant effect on all analysed morphological traits of radish (Table 1).

Table 1.
Influence of different biostimulants on morphological traits of radish

Treatments/Traits	Plant height (cm)	Total plant mass (g)	Number of leaves /per plant	Leaf area (cm^2)	Root length (cm)	Root diameter (cm)	Root mass (g)
Levoamin	10.1a	7.65a	6.70bc	34.3a	2.29a	2.09a	4.90a
Algafert	10.2a	6.40b	6.90ab	30.4a	2.16ab	1.81bc	3.45bc
Yeast	9.9ab	7.40a	7.25a	35.6a	2.18ab	2.05ab	4.50ab
Aminohumic	9.1b	5.55c	6.90ab	31.1a	1.98bc	1.71cd	3.10cd
Control	7.3c	4.85d	6.40c	23.7b	1.76c	1.54d	2.20d

Values are presented as means. Different lowercase letters within a column indicate statistically significant differences according to the LSD test ($p \leq 0.01$).

The highest plant heights were recorded in treatments with Levoamin (10.1 cm) and Algafert (10.2 cm), and these values were significantly higher than those of the control. For total plant mass, the highest values were observed in treatments with Levoamin (7.65 g) and yeast (7.40 g), with no statistically significant differences between these two treatments, but both were significantly higher than the control. The yeast treatment resulted in the highest number of leaves per plant (7.25), while the other treatments also increased this parameter compared to the control. For leaf area, all applied biostimulants increased this parameter, with less pronounced differences among treatments, although all treatments showed significantly higher values than the control (Table 1).

The analysis of root parameters indicated that the greatest effect was achieved with Levoamin, which produced the highest values for root length (2.29 cm), root diameter (2.09 cm), and root mass (4.90 g). The yeast treatment also showed high effectiveness for these parameters, with no significant differences compared to Levoamin for certain traits (Table 1).

Previous studies indicate that the use of biostimulants, particularly seaweed extracts, enhances vegetative growth and improves morphological traits in vegetable crops (Dalia et al., 2014). Lucena et al. (2023) found that amino acid-based biostimulants and yeast significantly increase radish plant height compared to the control, which aligns with the results of the present study. Pavlović et al. (2025) reported similar findings, observing the greatest plant height in onion with yeast application. This effect is attributed to the presence of cytokinins, amino acids, and B-complex vitamins in yeast, which stimulate cell division and elongation.

The significant impact of biostimulants on total plant mass has also been confirmed by other authors (El-Abagy et al., 2014; Waniese et al., 2023; Lucena et al., 2023). The increase in biomass can be attributed to improved nutrient uptake and more intensive physiological processes in plants. The positive effect of biostimulants on leaf area has also been reported by Dalia et al. (2014), Lucena et al. (2023), and Peña-Calzada et al. (2025), which is consistent with the results of this study.

An increase in leaf area contributes to enhanced photosynthetic activity, which positively affects overall plant growth and development. Regarding the parameters of the edible root, numerous studies have reported a positive effect of biostimulants on root length, diameter, and mass (Raza et al., 2022; Lucena et al., 2023; Peña-Calzada et al., 2025). These effects can be explained by improved nutrient absorption, increased photosynthetic activity, and stimulated synthesis of plant hormones, leading to enhanced cell division and accumulation of reserve compounds in the swollen radish root.

The application of biostimulants significantly affected the quality parameters of radish, including vitamin C content, total phenolic compounds, and antioxidant capacity (Table 2). Vitamin C content increased in all treatments compared to the control, with the highest value observed in the yeast treatment (17.1 mg/100 g). However, no statistically significant differences were observed among the applied treatments. The other treatments also showed slightly higher values than the control, although the differences were less marked. The highest total phenolic compound values were found in the yeast treatment (695 mg GAE/100 g), significantly exceeding all other treatments and the control. Elevated levels of phenolic compounds were also noted in the humic treatment (581 mg GAE/100 g) and Levoamin (545 mg GAE/100 g), while the lowest values were recorded in the control (415 mg GAE/100 g).

Table 1.
Influence of different biostimulants on morphological traits of radish

Treatments/Traits	Total vitamin C content (mg/100 g FW)	Total phenols content (mg GAE/100 g FW)	Total antioxidant capacity (µg AA/ g FW)	Total chlorophyll content (µg AA/ g FW)
Levoamin	10.1a	7.65a	6.70bc	34.3a
Algafert	10.2a	6.40b	6.90ab	30.4a
Yeast	9.9ab	7.40a	7.25a	35.6a
Aminohumic	9.1b	5.55c	6.90ab	31.1a
Control	7.3c	4.85d	6.40c	23.7b

Values are presented as means. Different lowercase letters within a column indicate statistically significant differences according to the LSD test ($p \leq 0.01$).

A similar trend was observed for antioxidant capacity, with the highest value recorded in the yeast treatment (153 µg AA/g FW), while the other treatments showed a moderate increase compared to the control. The results of this experiment indicate that the application of biostimulants, particularly yeast, increases the content of bioactive compounds and antioxidant capacity in radish. These results are consistent with numerous studies in this field, which report that biostimulants can significantly increase the content of phenolic compounds in both aboveground and belowground plant organs, as well as the content of ascorbic acid (Raza et al., 2024). Similarly, Toscano et al. (2023) reported that the application of biostimulants increases total phenols and antioxidant activity (DPPH) in radish, which agrees with the results of the present study. A positive correlation between total phenolic content and antioxidant capacity has also been reported (Borș et al., 2015). Furthermore, it has been shown that biostimulants can increase ascorbic acid content by enhancing metabolic processes and antioxidant mechanisms in plants (Raza et al., 2024). However, some studies indicate that the effect of biostimulants on vitamin C content is less pronounced compared to phenolic compounds, which is also consistent with the findings of this study (Toscano et al., 2023).

The increase in total antioxidant capacity observed in biostimulant treatments is due to enhanced synthesis of phenolic compounds and other antioxidants. Biostimulants positively affect physiological and biochemical processes in plants, including the synthesis of secondary metabolites and activation of the antioxidant system, which leads to an overall improvement in the nutritional quality of the product (Toscano et al., 2023).

Based on the results obtained, it can be concluded that biostimulants, particularly yeast, have significant potential to improve the nutritional quality of radish, mainly by increasing the content of phenolic compounds and antioxidant capacity.

The application of biostimulants had a statistically significant effect on total chlorophyll content in radish leaves (Table 2). The highest total chlorophyll content was recorded in the Levoamin treatment (20.9), followed by the yeast treatment (16.8), while the lowest value was observed in the control (10.8). All biostimulant treatments significantly increased total chlorophyll content compared to the control. The higher total chlorophyll content in biostimulant treatments may be linked to enhanced photosynthetic activity and improved nutrient uptake by plants, which directly contributes to better morphological parameter values. The positive effect of biostimulants on chlorophyll content has also been confirmed by other researchers. Raza et al. (2022) and Lucena et al. (2023) reported that the application of biostimulants in radish increases chlorophyll content and enhances photosynthetic activity, which is consistent with the results obtained in the present study.

Conclusion

Based on the obtained results, it can be concluded that the application of organic biostimulants has a significant effect on the morphological traits and quality parameters of radish. All tested treatments improved plant growth and development compared to the control, with the most pronounced effects observed in the treatments with Levoamin and yeast. Levoamin treatment had the greatest effect on morphological parameters and total chlorophyll content, especially root mass and dimensions, while yeast application led to the highest increase in total phenolic content and antioxidant capacity. The increase in vitamin C content was less pronounced; however, all treated variants showed higher values than the control.

The results indicate that applying organic biostimulants, particularly yeast, is an effective method for improving the nutritional quality of radish, which is especially important in sustainable and organic production systems.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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