THE EFFECT OF FOLIAR FERTILIZATION WITH BIOSTIMULANTS ON THE GROWTH PARAMETERS OF EGGPLANT SEEDLINGS

EFECTUL FERTILIZĂRII FOLIARE CU BIOSTIMULATORI ASUPRA PARAMETRILOR DE CREȘTERE LA RĂSADURILE DE PĂTLĂGELE VINETE

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Abstract.
The quality of the seedlings used to establish crops directly influences the quality of vegetable production. The experience aimed to study the influence of foliar treatments with different biostimulants and fertilizers on some growth parameters of eggplant seedlings, Belona cultivar. The experiment was monofactorial, in randomized blocks with five repetitions. Four foliar treatments with Razormin, Atonik, Sprintene and Microcat Magnesium were administered at 10-day intervals, starting on the 20th day after emergence. After 60 days from emergence, five plants from each replicate were selected randomly for analysis. The measurements made concerned the height of the plants, the length of the roots and the aerial part, the stem diameter, the fresh and dry weight of whole plants, of the roots, of the aerial parts and of the leaves. There was also count the number of true leaves. The treatments with the Sprintene product proved a significantly positive influence on the eggplant seedlings.
Key words: biostimulant, eggplant, seedling vigor

Rezumat.
Calitatea răsadurilor utilizate pentru înfiinţarea culturilor influenţează direct calitatea producţiei vegetale. Prezenta experienţă a vizat studierea influenței unor tratamente foliare cu diferiți biostimulatori și fertilizanți asupra unor parametri de creştere la răsadurile de pătlăgele vinete, soiul Belona. Experiența a fost monofactorială, așezată în blocuri randomizate, în cinci repetiții. Patru tratamente foliare cu Razormin, Atonik, Sprintene și Microcat Magneziu s-au administrat la interval de 10 zile, începând cu a 20-a zi de la răsărire. După 60 de zile de la răsărire, au fost selectate aleator câte cinci plante din fiecare repetiție pentru a fi analizate. Măsurătorile efectuate au vizat înălțimea plantelor, lungimea rădăcinilor și a părții aeriene, grosimea tulpinii la colet, masa proaspătă și masa uscată a plantelor întregi, a rădăcinilor, părților aeriene și a frunzelor. Tratamentele cu produsul Sprintene au dovedit o influență semnificativ pozitivă asupra răsadurilor de pătlăgele vinete.
Cuvinte cheie: biostimulator, pătlăgele vinete, vigoarea răsadului

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INTRODUCTION

In the stages of vegetable production, the seedling production phase is an extremely important activity because the performance of the future crop depends on the quality and health of the seedlings [Costa *et al*., 2013]. A defective seedling can compromise the entire crop development process, prolonging the time required for growth and leading to yield losses [de Moraes Echer *et al*., 2007].

Eggplant (*Solanum melongena* L.) is one of the nontuberous species of the Solanaceae family and is also known as brinjal or aubergine [Kantharajah and Golegaonkar, 2004]. The fruits of *S. melongena* L. present a wide variety of shapes and colors, being ovate, pyriform, spherical or elongated, of black, purple, white, green or striped colors [Munteanu, 2003; Azarpour *et al*., 2012]. They have a low calorie and fat content, but are rich in potassium, magnesium, calcium, iron [Michalojc and Buczkowska, 2008], zinc, manganese, copper and iodine [Temelie, 2020]. Eggplant seedlings are produced in alveolar seed trays, at an optimal temperature of 20-25°C. The plants require sufficient light to avoid etiolation and regular watering to keep the soil moist. Seedlings are ready for transplanting when they have 5-6 true leaves and are well developed, usually 6-8 weeks after sowing [Munteanu, 2003]. Quality seedlings are more likely to withstand the stress associated with transplanting and, through proper crop management, contribute to the production of high quality fruit [Munteanu, 2003; Stan and Stan, 2010].

Aspects such as the types of substrates, the containers used, the growing environment, as well as the irrigation and nutrition methods are techniques of particular importance in maximizing the production potential and the vitality of the plants intended for transplanting in the field [Voican and Lăcătuș, 1998]. Seedlings should be exposed to balanced fertilization to provide them with the necessary nutrients. Practices such as foliar fertilization with various nutrients have proven to be effective methods contributing to healthy seedling growth [Florescu, 1992; Voican and Lăcătuș, 1998]. Foliar fertilizers are administered in the early hours of the morning or at dusk, when temperatures are lower and plants have a better capacity to absorb nutrients. Sprays should be applied evenly to the leaves [Fageria *et al*., 2009].

These substances have shown favorable results in various fields of agriculture, including stimulating plant growth, improving stress tolerance [Wang *et al*., 2019], nutrient content in plant tissue [Ciucu Paraschiv and Hoza, 2022a], increasing crop yield [Grabowska *et al*., 2015; Kopta *et al*., 2018; Ciucu Paraschiv *et al*., 2023] and production quality [Wahba *et al*., 2015; Ciucu Paraschiv and Hoza, 2022b]. These substances also contribute to improving the activity of rhizobacteria [Liu *et al*., 2016], which play an essential role in plant development through mechanisms such as phytohormone production, phosphate solubilization, strengthening systemic plant resistance and suppressing pathogens [Bhattacharyya and Jha, 2012]. As foliar applied biostimulants, amino acids, free peptides [Wang *et al*., 2019; Du Jardin, 2015; Shchetyna *et al*., 2024], humic and fulvic acids, biological phosphorus, seaweed extracts, plant extracts, etc. The process of nitrogen absorption from amino acids occurs within 3-7 days after spray application and is influenced by their molecular weight, increasing as it decreases [Umemiya and Furuya, 2002].

MATERIAL AND METHOD

The experience was carried out in the experimental greenhouses of the Research and Development Institute for Vegetable and Flower Growing Vidra, between February and May 2024. The experiment carried out is monofactorial, laid out in randomized blocks, in five replications.

The biological material consisted in seedlings of eggplant, *Belona* cultivar. Seeds obtained in 2023 belonging to the cultivar were sown in alveolar seed tray, with 70 cells, each cell having a volume of 50 ml. The seeds were sown on the 26th of February 2024. The air temperature in glasshouses was 22-24 ℃ during the day and 15-18 ℃ during the night. Waterings were carried out at intervals of 2-4 days depending on the moisture level of the substrate. The lighting was done naturally, without additional artificial light. Four foliar treatments were applied with 4 commercial products, with chemical composition shown in table 1. Table 1 also shows the experimental variants and the concentrations of the treatment solutions used.

Table 1

Experimental variants and commercial products used

Experimental variant	Commercial product used	Chemical composition of the product	Concentration
V1	untreated	-	-
V2	Razormin	4% N, 4% P_2O_5, 3% K_2O, 7% free amino acids, 3% polysaccharides, 0.4% Fe, 0.1% Mn, 0.1% B, 0.085% Zn, 0.02% Cu, 0.01% Mo	2 mL/L
V3	Atonik	Sodium Ortho-Nitrophenolate 0.2%, Sodium 4-nitrophenolate 0.3%, Sodium 5-nitroguaiacolate 0.1%	1 mL/L
V4	Sprintene	1% Mn, 1% Zn, 80% organic matter	2 mL/L
V5	Microcat Magnesium	10% MgO; 8% N; 2.6% free amino acids; 7% organic acids	2.5 mL/L

The treatments were applied at 10-day intervals between treatments, starting with the first true leaves (at 20, 30, 40 and 50 days after emergence). After 60 days from emergence, the recommended age for planting eggplants in the field, five plants from each replicate were kept for analysis in the laboratory.

Measurements were made regarding plant height, root and aerial part length, stem diameter, fresh and dry mass of whole plants, roots, aerial parts and leaves, ash content in the roots and aerial organs of seedlings.

Length measurements were made using a digital caliper (Unior 270A). Mass measurements were made using an analytical 4-place balance (Kern ADJ 200-4).

The total dry matter content was determined by the gravimetric method (drying 10 g of plant tissue at 105°C to constant weight) [Krełowska-Kułas, 1993].

RESULTS AND DISCUSSIONS

Table 2 shows the results regarding the influence of foliar treatments on the length measurements of eggplant seedlings.

Table 2

The influence of foliar treatments on the length measurements of eggplant seedlings

Variant	Commercial product used	Stem diameter	Root length	Aerial part length	Total length
		cm	cm	cm	cm
V1	untreated	0.35±0.03^{b}	10.62±2.49^{a}	10.50±1.19^{b}	21.12±3.07^{ab}
V2	Razormin	0.41±0.03^{a}	8.97±2.53^{bc}	10.65±1.28^{b}	19.62±2.37^{bc}
V3	Atonik	0.39±0.04^{a}	8.58±3.08^{c}	10.50±1.32^{b}	19.08±3.78^{c}
V4	Sprintene	0.40±0.03^{a}	10.26±2.66^{ab}	11.70±0.92^{a}	21.96±2.86^{a}
V5	Microcat Magnesium	0.39±0.04^{a}	9.96±2.35^{abc}	10.69±1.21^{b}	20.65±3.12^{abc}

Values followed by different letters within each column are significantly different based on Duncan multiple range test (P≤0.05).

Stem diameter was significantly influenced by all foliar treatments applied to eggplant seedlings. The increases ranged between 11.43 and 17.14%. The most significant increases were observed in the case of treatment with the Razormin rooting stimulator.

An interesting aspect is that the treatments used led to a more or less significant decrease in root length. The longest roots were observed in the untreated variant, and the shortest in the variant treated with the Atonik product. Significant decreases in root length were also observed in the case of foliar treatments with the Razormin product. In the case of treated variants, decreases in length ranged between 3.39% (Sprintene product) and 19.2% (Atonik).

The aerial part of the plants increased significantly only in the case of treatments with the Sprintene product. However, this growth parameter is not desired to be stimulated, because excessive elongation of the seedlings is not desired, which would represent a decrease in its quality [Munteanu, 2023].

The length of the plants varied significantly between an average of 19.08 cm, in the case of the variant treated with Atonik, and an average of 21.96 cm in the case of the variant treated with Sprintene. Compared to the untreated variant, the plants treated with Atonik were significantly shorter than the untreated ones, which is due to the decrease in root length.

Table 3 shows the influence of foliar treatments applied to eggplant seedlings on fresh weight measurements.

Table 3

The influence of foliar treatments on the weight measurements of eggplant seedlings

Variant	Commercial product used	Root weight	Leaf weight	Aerial part weight	Plant weight
		g	g	g	g
V1	untreated	1.06±0.14^{c}	1.79±0.15^{bc}	3.10±0.27^{b}	4.16±0.37^{c}
V2	Razormin	1.17±0.19^{bc}	1.62±0.16^{b}	3.17±0.31^{b}	4.34±0.28^{c}
V3	Atonik	1.47±0.25^{ab}	1.52±0.11^{b}	3.11±0.26^{b}	4.58±0.43^{bc}

V4	Sprintene	1.56±0.31[a]	2.03±0.25[ab]	3.85±0.32[a]	5.40±0.51[a]
V5	Microcat Magnesium	1.40±0.21[ab]	2.11±0.32[a]	3.61±0.45[a]	5.01±0.44[ab]

Values followed by different letters within each column are significantly different based on Duncan multiple range test (P≤0.05).

Root weight was positively influenced by some of the foliar treatments used. Even though the roots decreased in length, their weight increased significantly in the case of treatments with Microcat Magnesium, Atonik and Sprintene. The increases determined by these products ranged between 32.08 (Microcat Magnesium) and 47.17% (Sprintene).

Leaf weight increased significantly only after treatments with Microcat Magnesium. It increased by 17.88%, from 1.79 g to 2.11 g. The differences determined by the Sprintene product in leaf mass were not sufficient to be significant. In the case of the Razormin and Atonik products, a decrease in leaf weight was even observed, but without being significant compared to the untreated variant.

The Sprintene and Microcat Magnesium treatments also had conducted to significant increases in both aerial and whole plant weight. Sprintene led to a 29.81% increase in plant weight, and Microcat Magnesium led to a 20.43% increase.

The increase in the weight of different parts of eggplant seedlings has previously been obtained following treatments with different organic or mineral fertilizers [Dascălu Constantin *et al*., 2022].

In Table 4 is presented which was the influence of foliar treatments used on dry weight of roots and aerial organs of seedlings.

Table 4

The influence of foliar treatments on the dry weight of different parts of the plant

Variant	**Comercial product used**	**Root dry weight**	**Leaf dry weight**	**Aerial part dry weight**	**Plant dry weight**
		%	**%**	**%**	**%**
V1	untreated	10.71±0.74[b]	13.39±0.76[b]	13.21±0.75[b]	12.48±1.19[b]
V2	Razormin	14.26±2.93[a]	14.03±1.72[ab]	14.28±1.91[ab]	14.09±1.83[a]
V3	Atonik	13.08±2.97[ab]	14.01±1.03[ab]	14.36±0.93[ab]	13.63±.74[ab]
V4	Sprintene	11.57±3.50[ab]	14.72±1.28[a]	14.54±1.22[a]	13.96±1.09[a]
V5	Microcat Magnesium	11.56±1.93[ab]	14.63±0.37[a]	14.61±0.35[a]	13.49±0.85[ab]

Values followed by different letters within each column are significantly different based on Duncan multiple range test (P≤0.05).

Root dry weight was significantly influenced by the treatments used with the Razormin product, which determined significant differences of 33.15%.

Leaf and aerial part dry weight increased significantly with Sprintene and Microcat Magnesium treatments. Sprintene had produced an increase of 9.93% of leaf dry weight and Microcat Magnesium, of 9.26%. The same products led to a 10.07-10.60% increase in the dry weight of the aerial part of the plants. Positive results were previously obtained in increasing leaf dry weight by using organic fertilizers on seedlings such as cucumber, melon and zucchini [Sovarel, 2023].

In the whole plant, dry weight varied significantly in the case of treatments with Razormin (an increase of 12.90%) and Sprintene (an increase of 11.96%).

Among the treatments used on eggplant seedlings, it is observed that the best results were obtained in the case of foliar treatments with the products Sprintene (V4) and Microcat Magnesium (V5). Therefore, correlations were made between the parameters measured in the case of these treatment options with those in the untreated variant, and the results are presented in Table 5.

	Variant	Stem diameter	Root length	Aerial part length	Total length	Root weight	Leaf weight	Aerial part weight	Plant weight	Root DW	Leaf Dw	Aerial part DW	Plant DW
Variant	1	0.514*	-0.207	0.101	-0.110	0.472	0.489	0.461	0.527*	0.284	0.652**	0.681**	0.433
Stem diameter		1	0.356	0.554*	0.527*	0.775**	0.652**	0.811**	0.901**	0.162	0.545*	0.731**	0.466
Root length			1	0.267	0.902**	0.224	0.153	0.250	0.271	-0.076	-0.372	-0.006	-0.279
Aerial part length				1	0.622*	0.473	0.516*	0.727**	0.707**	0.239	0.306	0.428	0.583*
Total length					1	0.391	0.367	0.536*	0.541*	0.136	-0.143	0.174	0.085
Root weight						1	0.308	0.546*	0.819**	-0.190	0.587*	0.724**	0.294
Leaf weight							1	0.865**	0.730**	0.553*	0.476	0.710**	0.759**
Aerial part weight								1	0.928**	0.456	0.553*	0.725**	0.747**
Plant weight									1	0.229	0.640*	0.819**	0.642**
Root DW										1	0.258	0.184	0.677**
Leaf DW											1	0.816**	0.683**
Aerial part DW												1	0.658**
Plant DW													1

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

Fig. 1. Correlation matrix (Pearson correlation coefficients, "r") among treatment variants, stem diameter (cm), root length (cm), aerial part length (cm), total length (cm), root weight (g), leaf weight (g), aerial part weight (g), plant weight (g), root dry weight (%), leaf dry weight (%), aerial part dry weight (%) and plant dry weight (%) between variants V1, V4 and V5

In fig. 5 is observed a close interdependence (significant, marked with an asterisk, * probability of error of 5%, and distinctly significant, marked with two asterisks, ** probability of error of 1%) between the characteristics of the analyzed seedlings. Thus, the treatment variant V4 and V5 positively and distinctly significantly influenced the dry weight of the leaves and the dry weight of the aerial part, the correlation coefficients being r=0.652 and r=0.681, respectively. Also, a significant positive relationship is observed between the treatment variant and stem diameter (r=0.514) or plant weight (r=0.527). As the nutrient content available to plants improves, the plant becomes more robust, which is reflected in the stem size and overall weight.

The interdependence between stem diameter and aerial part length, total length and dry weight of leaves is of lower intensity, but significant, the correlation coefficients being r=0.554; r=0.527 and r=0.543. The correlation between root length and total plant length is ascending, having a very high intensity (r=0.902), meaning that plants with longer roots tend to have a greater total length. A distinctly significant upward interdependence is also observed between root weight and plant weight, as well as between the dry weight content of the extra-radicular part of the seedlings (r=0.819 and r=0.724). This means that plants that develop denser roots generally have a greater total mass. This aspect can be important for the plant's stability and ability to absorb essential resources. The intensity of the correlation between this and the dry weight content of the leaves or the extra-radicular weight of the seedling is lower, but significant. As expected, the increase in leaf weight leads to a distinctly significant increase in the extra-radicular weight of the seedling, the total weight of the plant, the dry weight content of the aerial part of the seedling and, respectively, of the whole plant (the correlation coefficients being r=0.865, r=0.730, r=0.710 and r=0.759).

As expected, the increase in leaf weight leads to a distinctly significant increase in the extra-radicular weight of the seedling, the total weight of the plant, the dry weight content of the aerial part of the seedling and, respectively, of the whole plant (the correlation coefficients being r=0.865, r=0.730, r=0.710 and r=0.759). Increasing the dry weight content of the root also causes an increase in the dry weight content of the whole plant (r=0.677).

The greater the seedling weight, the higher the dry weight content in the extra-radicular area, as well as in the entire plant, the relationship between these characteristics being distinctly significant. The dry weight of a plant represents its mass without water and is an important indicator of the plant's health and development. A higher dry weight content indicates a more robust plant, able to store nutrients more efficiently and better resist external stresses, such as drought or disease.

In conclusion, the nutrient use strategy can significantly influence the development of certain parts of eggplant plants, leading to a healthy and vigorous seedling (Figure 2).

a **b**

Fig. 2. Untreated eggplant seedling (a) and treated with Microcat Magnesium

CONCLUSIONS

Variant V2 (Razormin) determined a significant increase of stem diameter, root and plant dry weight.

Variant V3 (Atonik) conducted to a significant increase of stem diameter, root weight.

Variant V4 (Sprintene) produced a significant increase of stem diameter, aerial part and plant length, root, aerial part and plant fresh weight, leaf, aerial part dry and plant dry weight.

Variant V5 determined a significant increase of stem diameter, root, leaf, aerial part and plant weight, leaf, aerial part dry weight.

The treatments with Sprintene (V4) and Microcat Magnesium (V5) proved a significantly positive influence on the eggplant seedlings.

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