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Effect of Boron Spray and BiO-NPK Application on Vegetative and Flowering Characteristics of Petunia (*Petunia hybrida*)

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Abstract
A factorial experiment was conducted at the nursery of the Agricultural Division, University of Kufa, during the 2024-2025 season. The study aimed to investigate the effect of foliar application of three boron concentrations (0, 50, and 100 $mg.L^{-1}$) and the addition of three BiO-NPK concentrations (0, 1, and 2 $ml.L^{-1}$) on the vegetative and flowering characteristics of petunia plants. The experiment used a randomized complete block design and lasted for four months. Eighty-one seedlings were transplanted into 3 kg plastic pots and placed in a wire house covered with a 25% shade net. The results showed a significant positive effect of both boron and BiO-NPK, with the highest concentrations of each alone (100 $mg.L^{-1}$ and 2 $ml.L^{-1}$, respectively) significantly increasing all vegetative and floral traits. A significant interaction effect was also observed, with the combined application of 100 $mg.L^{-1}$ of boron and 2 $ml.L^{-1}$ of BiO-NPK yielding the best results in all studied traits, outperforming all other treatments.

Keywords: Biofertilizers, Ornamental plants, Petunia, Boron

1. Introduction
Petunia (*Petunia spp.*) is an annual or perennial plant belonging to the Solanaceae family. As an ornamental plant, it is cultivated for its beautiful flowers in flowerbeds, borders, pots, hanging baskets, window boxes, and containers. In warm climates, petunias are considered perennials, but they are grown as annuals in temperate regions. Their flowers exhibit a stunning diversity of shapes, colors, and sizes and are widely used in various landscape designs. Common colors include pink, salmon, red, white, bicolors, and multicolored varieties. Since the beginnings of horticulture, petunia has been considered a primary ornamental plant [1].
Boron is a vital micronutrient for many plant processes, such as pollen production, pollination, and flowering [2]. Additionally, boron is involved in ATP synthesis and sugar transport, which facilitates increased flowering. It also participates in various enzymatic reactions and aids in the synthesis of growth regulators that encourage early flowering in plants [3]. Boron plays a crucial role in regulating biological functions, such as root and shoot growth, and ensuring the structural integrity of the cell wall and plasma membrane [4]. Biofertilizers are organic sources that stimulate plant growth by providing readily available nutrients and producing growth regulators that promote lateral roots and increase the surface area of the root system, thereby improving its structure. They also help to mitigate the concentration of heavy metals and toxic compounds in the rhizosphere [5]. Given the importance of petunia among flowering ornamental plants, this study aimed to investigate the effect of boron spray and biofertilizer application, as well as their interaction, on the growth and flowering of petunia plants.

2. Materials and Methods
The experiment was conducted at the nursery of the Agricultural Division, University of Kufa, in a greenhouse covered with a 25% shade net during the 2023-2024 growing season. The objective was to determine the effect of boron spraying and BiO-NPK application on the growth and flowering of petunia plants.

Seedlings were transplanted 15 days before the start of the treatments into 5 kg plastic pots containing a growing medium composed of river soil and peat moss at a 3:1 ratio, respectively, mixed homogeneously. Soil analysis was performed according to the method described by Page *et al.* [6], and the results are presented in Table 1.

Table 1: Soil Analysis

Property	Value	Unit
Soil particles		
Sand	823	g.kg^{-1}
Silt	73	g.kg^{-1}
Clay	104	g.kg^{-1}
Texture	Sand-loam	---
pH	6.5	---
EC (1:1)	2.54	dS.m^{-1}
Available N	0.08	%
Available P	0.004	%
Available K	0.07	%
Available Ca	0.013	%
Magnesium	8	mmol.L^{-1}
Fe	0.88	mg.kg^{-1}
OM	3.55	g.kg^{-1}

The experiment involved two factors: The first factor was foliar boron spray at three concentrations: 0, 50, and 100 mg.L^{-1}. The second factor was the addition of sea algae extract (BiO-NPK) at three concentrations: 0, 1, and 2 ml.L^{-1}.

The foliar spraying was performed on November 1, 2025, and the application of the second factor (BiO-NPK) was done seven days later. Both spraying and addition treatments were applied at a rate of five treatments per month for both factors.

Studied Characteristics

1. **Number of leaves (leaves.plant^{-1}):** The number of leaves was counted for each seedling, and the average for each experimental unit was calculated.
2. **Number of branches (branches.plant^{-1}):** The number of branches was counted for each seedling, and the average for each experimental unit was calculated.
3. **Number of flowers (flowers.plant^{-1}):** The number of flowers was counted every seven days from the beginning to the end of the experiment.
4. **Flower diameter (cm.flower^{-1}):** The flower diameter was measured using a caliper.
5. **Flower longevity (day):** Flower longevity was calculated from the time of opening until complete wilting.
6. **Leaf chlorophyll content (mg.100g^{-1} fresh weight):** Chlorophyll content was estimated according to the method of [7] using the following equation:

$$\text{Total Chlorophyll} = \left[20.2 \times D_{645} + 8.02 \times D_{663}\right] \times \left(\frac{V}{W} \times 1000\right) \times 100$$

7. **Total soluble carbohydrates in leaves (mg.100g^{-1} dry weight):** The content was determined using the phenol-sulfuric acid colorimetric method (Modification of Phenol Sulfuric Acid Colorimetric Method, PSACM) as described by [8].
8. **Flower protection from non-carotene (mg/100g-1 soft ban)**

Specifically, chlorophyll content was determined according to [9] and was determined as follows:

Total carotene % = Light effect at a specific wavelength * Volume of the solution used in targeting / 100 * 1000

3. Results and Discussion

The results show that spraying plants with 100 mg.L^{-1} of boron or adding 2 ml.L^{-1} of BiO-NPK to the soil significantly increased most vegetative and flowering characteristics. These included the number of leaves, number of branches, leaf carbohydrate and chlorophyll content (Table 2), as well as the number of flowers, flower diameter, flower longevity, and flower carotene content (Table 3) compared to lower concentrations, regardless of the type of fertilization.

The results also indicated a significant interaction effect between foliar boron application and soil-applied BiO-NPK on all studied characteristics. The combined treatment of spraying with 100 mg.L^{-1} boron and adding 2 ml.L^{-1} BiO-NPK surpassed all other interaction treatments in all studied traits. It yielded the highest results for the number of leaves (64.02 leaves.plant^{-1}), number of branches (6.99 branches.plant^{-1}), leaf carbohydrate content (11.02 mg.g^{-1} dry weight), leaf chlorophyll content (29.13 mg.100g^{-1} fresh weight), number of flowers (70.91 flowers.plant^{-1}), flower diameter (8.13 cm), flower longevity (9.59 days), and flower carotene content (5.30 mg.100g^{-1}), respectively, compared to the control treatment

Table 2: Effect of Boron Spray and BiO-NPK Application on Vegetative Characteristics of Petunia Plants

B (mg.L⁻¹)	Bio-NPK (ml.L⁻¹)	No. of leaves (leaves.plant⁻¹)	No. of branches (branches.plant⁻¹)	Carbohydrate in leaf (mg.g⁻¹ dry weight)	Chlorophyll in leaf (mg.100g⁻¹ fresh weight)
0	0	35.30	2.407	9.113	20.253
	1	39.52	3.047	9.333	21.360
	2	44.54	3.793	9.720	22.370
50	0	48.91	4.213	10.147	23.373
	1	54.16	4.870	10.33	24.467
	2	56.02	5.477	10.68	25.557
100	0	58.40	6.027	11.15	26.560
	1	61.43	6.783	11.31	27.807
	2	64.02	6.993	11.02	29.133
L.S.D. ($P \leq 0.05$)	B	0.675	0.124	0.087	0.190
	NPK-Bio	0.675	0.124	0.087	0.190
	Interaction	1.171	0.215	0.151	0.330

*Values are means of three replicates.

Table 3: Effect of Boron Spray and BiO-NPK Application on Flowering Characteristics of Petunia Plants

B (mg.L⁻¹)	NPK-Bio (ml.L⁻¹)	No. of flowers (flowers.plant⁻¹)	Flower diameter (cm)	Day of flower on the plant (day)	Flower carotene content (mg.100g⁻¹)
0	0	50.143	5.143	6.250	3.143
	1	51.217	5.217	6.733	3.217
	2	52.407	5.407	6.807	3.407
50	0	53.137	6.250	7.387	4.793
	1	54.247	6.733	7.650	4.950
	2	55.637	6.807	8.137	4.870
100	0	56.290	7.387	8.150	5.223
	1	60.880	7.650	8.440	5.263
	2	70.910	8.137	9.593	5.307
L.S.D. ($P \leq 0.05$)	B	0.384	0.099	0.076	0.152
	NPK-Bio	0.384	0.099	0.076	0.152
	Interaction	0.665	0.171	0.131	0.264

The results from Tables 2 and 3 show that boron spray treatments had a positive effect on both vegetative and flowering characteristics, evidenced by an increase in the number of leaves, branches, leaf carbohydrate and chlorophyll content, number of flowers, flower diameter, flower longevity, and flower carotene content, respectively, compared to the control. The plants treated with 100 mg.L⁻¹ boron showed the highest means. This positive effect is attributed to boron's essential role in cell division and elongation, which improves plant growth and height, as well as the number of leaves [10]. Additionally, it plays a vital role in the transport of carbohydrates from source to sink organs [11]. Boron also increases root length, which is responsible for nutrient absorption, especially nitrogen and potassium. The increase in these elements leads to higher chlorophyll and carbohydrate content [12]. Furthermore, boron has an important role in increasing flower production and improving their quality [13]. This can be attributed to boron's role in increasing chlorophyll content, which contributes to photosynthesis, which in turn produces the carbohydrates that aid in the flowering process.

Moreover, the addition of biofertilizer had a significant effect on vegetative and flowering characteristics. This can be attributed to the biofertilizer's ability to promote plant growth by producing plant growth regulators such as auxins, gibberellins, and cytokinins, leading to an increase in the number of leaves and branches. Auxins act as growth promoters in apical regions and support the elongation of roots and stems, as well as cell division and elongation. This is consistent with the findings of Bessai *et al.* [14]. Biofertilizers also have a high capacity to colonize plant roots, thereby increasing their growth and productivity and enhancing the absorption of water, nutrients, and plant hormones from the soil [15, 16].

A significant increase in flowering growth indicators, such as the number and diameter of flowers, was also observed with the addition of biofertilizer. This may be due to the increase in leaf chlorophyll content, which enhances the efficiency of carbon assimilation and the synthesis of nutrients, including carbohydrates. This, in turn, positively affects the activity of the floral system, thereby increasing the plant's ability to improve its flowering and increase the number of flowers [17].

4. Conclusion

The results of this study demonstrate the beneficial effects of using different concentrations of boron, particularly the 100 mg L⁻¹ concentration, which led to significant improvements in the vegetative and floral growth indices of the studied petunia plants.Furthermore, the findings indicated that the studied growth parameters of petunia were positively influenced by the application of BiO-NPK fertilizer. This bio-fertilizer proved to be economically efficient and cost-effective, even at a high concentration of 2 mL L^{-1}.The experiment also revealed a remarkable superiority of the interaction treatment between foliar spray of boron and the application of BiO-NPK (100 mg L^{-1} × 2 mL L^{-1}). This combined treatment significantly outperformed all individual treatments of both fertilizers across all studied attributes.

References

1. Farooq I, Qadri ZA, Rather ZA, Nazki IT, Banday N, Rafiq S, *et al*. Optimization of an improved, efficient and rapid in vitro micropropagation protocol for *Petunia hybrida* Vilm. cv. Bravo. Saudi J Biol Sci. 2021;28:3701-3709.
2. Aslani M, Souri MK. Growth and quality of green bean (*Phaseolus vulgaris* L.) under foliar application of organic-chelate fertilizers. Open Agric. 2018;3(1):146-154.
3. Kumari VV, Banerjee P, Verma VC, Sukumaran S, Chandran MAS, Gopinath KA, *et al*. Plant nutrition: an effective way to alleviate abiotic stress in agricultural crops. Int J Mol Sci. 2022;23(15):8519.
4. Yadav A, Tulluru NK, Panda M, Singh AK, Nagar BL, Homeshvari, *et al*. Impact of boron and zinc on vegetables: a review. Int J Environ Clim Change. 2023;13(10):3873-3882.
5. Al-Khafaji OS, Al-Ali HH. Response of olive trees cv. Chemlali to foliar nutrition with boric acid and seaweed extract on vegetative characteristics and chemical content. Iraqi J Desert Stud. 2021;11(1):1-10.
6. Bottini R, Berli FJ, Salomon MV, Piccoli PN. Phytohormonal role of microorganisms involved in bioinoculants. In: Sustainable Agrobiology: Design and Development of Microbial Consortia. Singapore: Springer Nature; 2023. p. 75-107.
7. Page AL, Miller RH, Keeney DR. Methods of soil analysis. Part 2: Chemical and microbiological properties. Madison (WI): American Society of Agronomy; 1982. p. 1159.
8. Ranganna S. Manual of analysis of fruit and vegetable products. New Delhi: Tata McGraw-Hill Publishing Company; 1977. p. 634.
9. Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of sugars and related substances. Anal Chem. 1956;28:350-356.
10. Abbas MF, Abbas MJ. Practical care and storage of fruits and vegetables. Basra: College of Agriculture, University of Basra; 1992. p. 210.
11. Camacho-Cristóbal JJ, Martín-Rejano EM, Herrera-Rodríguez MB, Navarro-Gochicoa MT, Rexach J, González-Fontes A. Boron deficiency inhibits root cell elongation via an ethylene/auxin/ROS-dependent pathway in *Arabidopsis* seedlings. J Exp Bot. 2015;66(13):3831-3840.
12. Barker AV, Pilbeam DJ. Handbook of plant nutrition. Boca Raton (FL): CRC Press; 2006. p. 630.
13. Mengel K, Kirkby EA. Principles of plant nutrition. 5th ed. Dordrecht: Kluwer Academic Publishers; 2001. p. 849.
14. Motesharezadeh B, Malakuty MJ, Nakhoda B. Effects of nitrogen, zinc and boron sprays on photochemical efficiency of sweet cherry. Hort Newsletter. 2001;12:106-111.
15. Bessai SA, Bensidhoum L, Nabti EH. Optimization of IAA production by telluric bacteria isolated from northern Algeria. Biocatal Agric Biotechnol. 2022;41:102.
16. Bibi A, Bibi S, Al-Ghouti MA, Abu-Dieyeh MH. Isolation and evaluation of Qatari soil rhizobacteria for antagonistic potential against phytopathogens and growth promotion in tomato plants. Sci Rep. 2023;13(1):22050.
17. Ouf SA, El-Amriti FA, Abu-Elghait MA, Desouky SE, Mohamed MS. Role of plant growth promoting rhizobacteria in healthy and sustainable agriculture. Egypt J Bot. 2023;63(2):333-359.
18. Vurukonda SSKP, Vardharajula S, Shrivastava M, SkZ A. Enhancement of drought stress tolerance in crops by plant growth promoting rhizobacteria. Microbiol Res. 2016;184:13-24.