Effect of Vermicompost and Boron spraying on the Vegetative growth of *Borago officinalis* L.

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Abstract

The study was conducted in the fields of the Department of Horticulture and Landscape Engineering / College of Agriculture / University of Kerbala, Al-Hussainiya District for the winter agricultural season 2024. The study was implemented as Factorial experience according to the Randomized Complete Block Design (R.C.B.D) with three replicates. Two factors were added: vermicompost, a ground addition, at four concentrations (0, 2, 4, and 6 ml L^{-1}), and boron, using a flower spray at four concentrations (0, 25, 50, and 75 mg L^{-1}). The results showed that adding vermicompost at a concentration of (6 ml L^{-1}) and spraying with boron at a concentration of (50 mg L^{-1}) had a significant effect on all vegetative characteristics (plant height, diameter, number of leaves, leaf area, and number of shoot branches). The bilateral interactions between the two study factors had a significant effect on all vegetative characteristics, especially at the fertilizer level. 6 (ml L^{-1})- and spraying with boron at a concentration of (50 mg L^{-1}) - which gave the highest rates of plant height of (72.20 cm) compared to the control treatment, which recorded (28.02 cm), and the stem diameter was (28.496 mm) compared to the control treatment, which recorded (22.82 mm), and the number of leaves was (210.40 leaves per plant^{-1})compared to the control treatment, which recorded (98.30 leaves per plant^{-1}), and the leaf area was (79.37 cm^2) compared to the control treatment, which recorded (48.84 cm^2), and the number of branches was (9.267 branches per plant^{-1}) compared to the control treatment, which recorded (3.60 branches per plant^{-1}).

Keyword : Borago, Vermicompost, Boron , Vegetative growth.

Introduction

Borage (*Borago officinalis* L.), a member of the Boraginaceae family, also known as "star flower," is an annual herb that originated in Syria but has spread throughout the Mediterranean region, as well as Asia Minor, Europe, North Africa, and South America. [1] Medicinal plants have been used throughout the ages as a primary source of treatment, and their knowledge has been passed down through generations and communities. These plants possess active compounds responsible for their therapeutic properties, particularly against infectious diseases. Its therapeutic uses have proven effective in treating a wide range of conditions, from multiple sclerosis and diabetes to heart disease, arthritis, and eczema, and it remains a promising element in the health and therapeutic fields. [2, 3] In addition to its therapeutic properties, this natural resource has powerful effects, including pain relief, antioxidant protection, radiation protection, memory enhancement, liver protection, and anti-inflammatory properties. [3] It also has biological properties, including its ability to combat microbes, bacteria, and fungi, in addition to its pain-relieving effects. It contributes to accelerating wound healing, relieving chest congestion, and treating burns, whooping cough, sinusitis, asthma, and rheumatoid arthritis, while promoting and protecting skin health, urinary tract stones, thrombosis, and biofilms. [4] It is used for culinary and medicinal purposes, but its commercial cultivation is limited. It is also used to relieve colds, bronchitis, and respiratory infections, thanks to its anti-inflammatory and soothing properties. Its flowers can be prepared as a medicinal infusion. In Unani medicine, it is known as Gaozaban and is used in herbal recipes to support heart health. [5] Plants are a primary source of bioactive compounds that are used in a variety of fields. Borage is rich in these compounds, making it a key ingredient in folk medicine and the food industry. Recently, its use in the production of Bio stimulants has become prominent, contributing to increased plant yields, stimulating secondary metabolism, and supporting photosynthesis [6].

Vermicomposting is a process of decomposing organic waste with the help of earthworms, which feed on various organic wastes such as scrap paper, livestock manure, crop residues, and food and garden scraps, converting them into valuable products [7]. These wastes are decomposed by the worms, which digest them and secrete special enzymes, along with the contribution of bacteria and fungi native to their environment. This compost is characterized by its purity from plant pathogens and its richness in nutrients, facilitating direct absorption by plants, making it a natural and effective option for promoting plant growth. [8] It works to improve soil fertility at the physical, chemical, and biological levels. It enhances soil aeration, porosity, and water-holding capacity, contributing to increased productivity. However, its effect is not limited to improving nutrients alone; it contains additional elements that support plant growth. However, using it in high concentrations may harm plants due to its high content of soluble salts [9]. Vermicompost tea is a liquid organic biofertilizer that is gaining increasing importance in organic farming, given its effective role in improving soil fertility and promoting plant growth in a sustainable and environmentally friendly manner. This tea consists of a mixture of microorganisms such as beneficial bacteria and fungi, plant nutrients, and natural hormones. These organisms help suppress many plant diseases and enhance microbial activity in the root zone, leading to improved nutrient uptake and increased plant physiological efficiency [9].

Boron (B) is one of the eight essential micronutrients, also called critical elements required for the normal growth of most plants. It is the only non-metallic element among plant micronutrients. Boron was first recognized as an essential element for plants in the early 20th century [10]. Boron is a trace element essential for the integrity of the plant cell wall structure and is involved in various plant processes such as cell division, calcium utilization, pollen production, and anther development during the reproductive phase. [11] Plants need to obtain sufficient amounts of boron while protecting themselves from its toxic effects [12] .Given the importance of medicinal and health plants and the lack of studies linking the effect of vermicompost tea and boron application on the growth and vegetative characteristics of borage, this study was conducted to shed light on these effects.

Materials and Methods

The study was conducted in the fields of the College of Agriculture, University of Kerbala, located in Al-Hussainiya District, Karbala Governorate, during the winter agricultural season of 2024-2025, starting from October 1, 2024, to March 1, 2025. Seeds were planted in special pots to prepare seedlings on October 1, 2024, inside a refrigerated plastic tunnel in the nurseries of the Al-Abbas's (p) Holy Shrine to control environmental conditions. The germination process began 5 to 7 days after planting. The seedlings were transferred to the permanent field on 10/15/2024 after reaching the appropriate growth stage (the appearance of 3-4 true leaves). The study was Factorial experience as a Randomized Complete Blocks Design (R.C.B.D) experiment with three replicates. The treatments were randomly distributed so that each replicate contained 16 treatments with 12 plants in each treatment. Thus, the number of plants included in the study was (16 treatments × 12 observations × 3 replicates = 576 plants). The experiment included four concentrations (0, 2, 4, 6 ml L^{-1}) of vermicompost tea. The first addition began 20 days after the seedlings were transferred to the permanent field. The treatment was applied in three consecutive batches, with a time interval of 20 days between each batch of vermicompost and boron at four concentrations (0, 25, 50, 75 mg L^{-1}), with two batches of boron between each spraying, with a time interval of 30 days between each batch. Samples were taken from the experimental units and some vegetative measurements were made such as plant height (cm), stem diameter (mm), number of leaves (leaf $plant^{-1}$), number of plant (branches plant $branch^{-1}$) and leaf area (cm2 $plant^{-1}$) using the Image program in the Windows 7 operating system. By multiplying the area of one leaf by the number of leaves per plant, the leaf area per plant was calculated.

Results and Discussion

Plant height (cm)

The results of Table (1) indicate that there are significant differences in the average height of the borage plant due to the effect of the biofertilizer (Vermicompost), as the concentration (6 ml L^{-1}) recorded the highest average of (67.20 cm) compared to the comparison treatment, which gave the lowest average of (31.41 cm). The table also showed that spraying with boron had a significant effect on plant height, as the concentration (50 mg L^{-1}) achieved the highest average of (55.40 cm), while the comparison treatment without spraying gave the lowest average of (80.47cm). The two-way interactions between vermicompost and spraying with boron showed significant differences, as the interaction treatment (6 ml L^{-1}) of vermicompost and boron was superior, as the interaction treatment (50 mg L^{-1}) was superior, giving the highest plant height of (72.20 cm), while the lowest value for plant height was in the interaction comparison treatment, which amounted to (28.02 cm).

Table (1): Effect of adding vermicompost, spraying with boron and their interaction on stem length (plant height cm $^{-1}$) of borage plant

Vermicompost (ml L^{-1})	Boron spraying (mg L^{-1})				Average effect of Vermicompost (cm)
	0	25	50	75	
0	28.02	32.02	35.40	30.20	31.41
2	42.60	43.93	49.00	43.00	44.63
4	57.40	59.20	65.00	58.80	60.10
6	63.20	67.00	72.20	66.40	67.20
Average boron spraying effect (cm)	47.80	50.54	55.40	49.60	

L.S.D. 0.05		
Vermicompost = 2.32	Boron spraying = 2.32	Interference = 4.65

Stem diameter (mm)

The results in Table(2) showed significant differences in the stem diameter of borage plants due to the effect of vermicompost levels, boron spray levels, and the interaction between them. The results showed that the use of vermicompost at a concentration of(6 ml L^{-1}) resulted in the highest average stem diameter of (27.309 mm), while the lowest average was recorded for the treatment (0 ml L^{-1}), at(23.199 mm). Regarding the effect of spraying with boron alone, it was observed that a concentration of (50 mg L^{-1})of boron achieved the highest average stem diameter of (26.615 mm), while the lowest average was recorded at a concentration of (0 mg $L^{-1)}$, at (24.681 mm). These results indicate that spraying with boron at a concentration of (50 mg L^{-1}) has a positive role in promoting stem growth and increasing its diameter. As for the interaction effect between the two study factors, the results showed that the interaction between vermicompost at a concentration of(6 ml L^{-1}) and boron spraying at a concentration of (50 mg L^{-1}) resulted in achieving the highest average stem diameter of (28.496 mm), while the lowest value was recorded in the treatment of (0 ml L^{-1}) of vermicompost with (75 mg L^{-1})boron, reaching (22.494 mm). The value of the least significant difference (L.S.D) at the probability level of (0.05)for each of the effects of vermicompost, boron spraying, and the interaction between them was(0.390 mm), which confirms the significance of the differences recorded between the different treatments.

Table (2): Effect of adding vermicompost, spraying with boron and their interaction on the stem diameter (mm) of borage plant

Vermicompost (ml L^{-1})	Boron spraying (mg L^{-1})				Average effect of Vermicompost (cm)
	0	25	50	75	
0	22.494	23.570	23.904	22.826	23.199
2	24.340	25.516	26.588	24.407	25.213
4	25.123	26.170	27.472	25.200	25.991
6	26.435	27.357	28.496	26.946	27.309
Average boron spraying effect (cm)	24.598	25.653	26.615	24.844	
L.S.D. 0.05					
Vermicompost = 0.390	Boron spraying =0.390		Interference = 0.390		

Number of leaves (leaf plant^{-1})

The results of Table (3) showed a significant effect of adding vermicompost and spraying with boron, as well as their interaction, on the number of leaves (leaf plant^{-1}). The (6 ml L^{-1}) fertilizer treatment achieved the highest average leaf number, reaching (201.25 leaves plant^{-1}), while the (0 ml L^{-1}) treatment gave the lowest average, reaching (112.80 leaves plant^{-1}). The number of leaves gradually increased with increasing fertilizer concentration, reaching an average of (158.10) at a concentration of (2 ml L^{-1}) and (187.58) at a concentration of (4 ml L^{-1}). The effect of spraying with boron was significant, as the (50 mg L^{-1}) concentration recorded the highest average leaf number, reaching (174.93 leaves plant^{-1}), followed by the (25 mg L^{-1}) concentration with an average of (170.53, while the 0 mg L^{-1}) concentration recorded the lowest average leaf number, reaching (151.30 leaves plant $^{-1}$). As for the interaction between fertilization and spraying, the interaction between a(6 ml L^{-1}) vermicompost concentration and spraying at a 50 mg L^{-1}) concentration achieved the highest average leaf number, reaching (210.40 leaves plant^{-1}), while the interaction between no fertilization and no spraying recorded the lowest leaf number, reaching (98.30 leaves plant^{-1}). An LSD value of (1.05) indicates the presence of truly significant differences between treatments.

Table (3): Effect of adding vermicompost, spraying with boron, interaction and variation on the number of leaves (leaf of seedling^{-1}) of borage plant

Vermicompost (ml L^{-1})	Boron spraying (mg L^{-1})				Average effect of Vermicompost (cm)
	0	25	50	75	
0	98.30	120.40	122.20	110.30	112.80
2	145.40	164.20	166.43	156.37	158.10
4	166.20	198.03	200.70	185.40	187.58

6	195.30	199.50	210.40	199.80	201.25
Average boron spraying effect (cm)	151.30	170.53	174.93	162.96	
L.S.D. 0.05					
Vermicompost = 1.05	Boron spraying = 1.05		Interference =2.11		

Leaf area (cm^2 plant^{-1})

The results of Table (4) showed a significant effect of vermicompost, boron spraying, and their interaction on leaf area (cm²). Leaf area increased with increasing vermicompost concentration, with the(6 ml L^{-1}) concentration recording the highest average of (74.87 cm²), followed by the (4 ml L^{-1}) concentration with an average of (72.08 cm²), while the(0 ml L^{-1}) concentration gave the lowest average of (50.56 cm²), indicating that vermicomposting effectively contributed to increasing vegetative growth. The effect of boron spraying was also significant, with the(50 mg L^{-1}) concentration giving the highest average leaf area of (68.57 cm²), followed by the (25 mg L^{-1}) concentration with an average of(65.27 cm²), while the lowest average was (0 mg L^{-1}) without, reaching (61.07 cm²), indicating the importance of boron in stimulating leaf growth. Regarding the interaction between vermicompost and boron spraying, the interaction between the(6 ml L^{-1})fertilizer concentration and the (50 mg L^{-1}) spraying was the highest in terms of leaf area, reaching(79.37 cm²), while the interaction between the treatment without fertilization and without spraying was the lowest, reaching(48.84 cm²). The LSD value at the (0.05)probability level for both main factors and the interaction was(0.86) indicating the presence of real significant differences between the studied treatments.

Table (4): Effect of adding vermicompost, spraying with boron, and their interaction on the leaf area (cm^2) of borage plant

Vermicompost (mg L^{-1})	**Boron spraying (mg L^{-1})**				**Average effect of Vermicompost (cm)**
	0	**25**	**50**	**75**	
0	48.84	51.42	25.74	49.24	50.56
2	58.76	61.58	64.79	60.35	61.37
4	64.23	73.53	77.37	72.16	72.08
6	72.46	74.56	79.37	74.12	74.87
Average boron spraying effect (cm)	61.07	65.27	68.57	63.96	
L.S.D. 0.05					
Vermicompost = 0.86	Boron spraying = 0.86		Interference = 1.72		

Number of plant branches (plant branch $^{-1}$)

The results in Table (5) showed significant differences in the number of branches of borage plant due to the effect of vermicompost levels, boron spray levels, and the interaction between them. The results showed that the use of vermicompost at a concentration of (6 ml L^{-1}) achieved the highest average number of branches, amounting to (428.3 branches per plant) , while the lowest average was recorded for the (0 ml L^{-1}) treatment, amounting to (4.075 branches per plant). As for the effect of spraying with boron alone, it was observed that the concentration of (50 mg L^{-1}) of boron achieved the highest average number of branches, amounting to (36.98 branches per plant), while the lowest average was recorded at a concentration of (0 mg L^{-1}), amounting to (5.733 branches per plant). These results indicate that spraying with boron at a concentration of (50 mg L^{-1}) has a positive role in stimulating branch production and increasing their number. As for the interaction effect between the two study factors, the results showed that the interaction between vermicompost at a concentration of(6 ml L^{-1})and spraying with boron at a concentration of (50 mg L^{-1})led to achieving the highest average number of branches, amounting to (9,267 plant branches), while the treatment of(0 ml L^{-1})of vermicompost with(75 mg L^{-1}) boron recorded (3,600 plant branches). The value of the least significant difference (L.S.D) at the probability level of (0.05) for each of the effect of vermicompost, spraying with boron, and the interaction between them reached (0.539 and 1.078,) respectively, which confirms the significance of the differences recorded between the different treatments.

Table (5): Effect of adding vermicompost, spraying with boron and their interaction on the number of branches (plant^{-1} branch) of borage plant

Vermicompost (mg L^{-1})	Boron spraying (mg L^{-1})				Average effect of Vermicompost (cm)
	0	25	50	75	
0	3.600	4.200	4.800	3.700	4.075
2	5.200	6.000	5.533	5.300	5.508
4	6.467	7.433	8.333	7.267	7.375
6	7.667	8.600	9.267	7.833	8.342
Average boron spraying effect (cm)	5.733	6.558	6.983	6.025	
L.S.D. 0.05					
Vermicompost =0.539	Boron spraying =0.539	Interference =1.078			

The results showed that vermicompost significantly increased the vegetative growth characteristics in Tables (1, 2, 3, 4, 5) with increasing levels of liquid vermicompost, which is a rich source of micro- and macronutrients, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), and manganese (Mn).

These nutrients are essential for various physiological processes in plants, including photosynthesis, enzyme activity, and cell wall formation [14]. Increased nitrogen uptake by roots increases vegetative growth and production, and increases the number and activity of beneficial soil microorganisms, such as mycorrhizal fungi, providing plants with the nutrients they need [15, 16]. This enhancement in nutrient uptake is attributed to the presence of plant-available minerals and humic substances in vermicompost, which facilitates the absorption and utilization of nutrients by plants [17,18]. In addition to nutrients, the results showed that vermicompost treatments increased gibberellic acid content in the roots, which stimulates stem elongation and leaf number. Calcium and potassium were also important in increasing leaf area, which is important for cell expansion, and stem diameter, which strengthens the cell wall and increases trunk thickness. Meanwhile, the increase in branch number resulted from stimulating the growth of lateral branches, which is enhanced by cytokinin-like substances present in vermicompost. These results were consistent with [19]. Boron had a significant effect on improving some vegetative growth traits, particularly at a concentration of 50 mg L-1 when added alone or in combination with vermicompost. This was due to improved growth and development of the treated plants, as boron helps activate plant metabolic processes, including photosynthesis, enzyme activity, hormone synthesis, and nitrogen fixation. This contributed to improving vegetative growth characteristics and, consequently, flowering characteristics. These results were consistent with [20], regarding boron's involvement in membrane processes. The rapid changes in membrane function induced by boron can be attributed to the boron compounds that constitute it. Boron may affect metabolic pathways by binding proteins to hydroxyl groups in cell walls and membranes, and by interfering with manganese-dependent enzymatic reactions. Agreed with [21].

Based on the results of this study, we recommend adding (6 ml L^{-1}) of liquid vermicompost to enhance vegetative growth characteristics. We also suggest conducting additional studies to explore the effect of higher levels of this fertilizer to gain more insight into various traits.

Also recommend spraying borage plants with(75 mg L^{-1})of boron to increase vegetative growth, and we suggest experimenting with higher concentrations to explore further characteristics.

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