The Effect of Foliar Spray with Boron on Vegetative and Qualitative Traits of Three Tomato Hybrids under Protected Cultivation Conditions.

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Abstract:

A field experiment was conducted during the autumn growing season 2024-2025 under protected cultivation conditions at the College of Agriculture, University of Diyala, to study the effect of foliar spray with boron at concentrations of 0, 75, and 150 mg L on some vegetative and qualitative traits of three tomato hybrids (Bobcat, Arwa, and Sandy). The spray was applied four times, once before flowering and three times after flowering. The results showed that the different treatments had a significant and positive effect on improving quality traits, especially relative chlorophyll content in leaves, with the highest value of 44.31 SPAD recorded for the 150 mg L treatment. The highest fruit firmness (3.711 kg cm^2) and total soluble solids (TSS) percentage (4.344%) were also recorded for the B3 treatment (150 mg L). The highest leaf area (15.90 dm^2 $plant^1$) and plant height (121.9 cm) were recorded for the 150 mg L treatment. The highest dry matter percentage (71.66%) was also recorded for the 150 mg L treatment. Among the hybrids, the Sandy hybrid (H3) outperformed the other hybrids in all studied traits. Based on these results, the current study recommends using foliar spray with boron at a concentration of 150 mg L as part of technical programs to improve vegetative traits and fruit quality of tomato plants grown under protected cultivation conditions.

Keywords: Boron, Tomato, Protected Cultivation.

Introduction

Tomato (Solanum lycopersicum L.) is one of the most widely grown, produced, and consumed vegetable crops globally. It is a herbaceous plant belonging to the Solanaceae family, and its origin is believed to be in South America (Peru and Mexico). It was introduced to Europe in the 16th century and from there spread to the rest of the world. The importance of this crop lies in the high nutritional value of its fruits, which are used in salads, cooking, and in the production of paste, ketchup, and juice (Perveen et al., 2015). Every 100 grams of tomato contains 42 IU of vitamin A, 14 mg of vitamin C, 0.54 mg of vitamin E, 237 mg of potassium, 3 mg of lycopene, 0.45 mg of beta-carotene, 0.12 mg of lutein, an average of 3-5 mg of flavonoids, and 1.2 g of fiber (FAO, 2023). Tomatoes are one of the most consumed vegetables and rank second in importance after potatoes in many countries (Gerszberg et al., 2015). The importance of tomato production also lies in its nutritional value and the diversity of its consumption, whether fresh, cooked, or as processed food products (Al-Shammari,

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2005). The global annual production of tomatoes is approximately 186.8 million tons. In Iraq, tomato production for the year 2023 was estimated at 535,000 tons, accounting for 46.4% of the total vegetable production (Central Statistical Organization, 2023).

Boron is an essential micronutrient for plant growth and development, playing a crucial role in several physiological and biochemical processes, including cell wall formation, cell division, sugar transport, growth regulation, and pollen formation and tube growth (U.S. Borax, 2023). Given that boron is often considered an element with limited mobility in plants (especially through the phloem), foliar spray is an effective method for delivering boron directly to active plant tissues, especially under conditions where soil boron availability is limited, such as in high pH soils, sandy soils with low boron content, or under environmental conditions that impair root uptake (Intagri, 2020). Bibi et al. (2022) found that spraying tomato plants with boron at concentrations of 0, 0.25, and 0.5% led to a significant increase in plant height (88.04 cm) and leaf area (65.52 cm). Harris and Lavanya (2016) reported that spraying tomato plants with boron at concentrations of 150, 250, and 350 ppm resulted in significant improvements in fruit quality traits, with TSS reaching 5.4% and fruit firmness increasing to 2.9 kg/cm compared to the control. This study aims to investigate the effect of foliar spray with boron at three concentrations (0, 75, and 150 ppm) on some vegetative and qualitative traits of tomato fruits.

Material and Methods

Study Location:
The experiment was conducted in the plastic house of the Department of Horticulture and Landscape Engineering, College of Agriculture, University of Diyala, during the autumn season 2024-2025. The aim was to study the effect of foliar spray with boron on some vegetative and qualitative traits of three tomato hybrids under protected cultivation conditions.

Experimental Design:
The experiment was conducted using a Randomized Complete Block Design (RCBD) with a split-plot arrangement and three replications. The main factor was the foliar spray treatments, which included:
- B1: Control treatment (water spray only)
- B2: Boron at a concentration of 75 mg L^-1
- B3: Boron at a concentration of 150 mg L^-1

The secondary factor consisted of three tomato hybrids:
H1: Bobcat
H2: Arwa
H3: Sandy

The plants were sprayed four times: once before flowering and three times after flowering.

Measurements:
The following traits were measured from five randomly selected plants from each experimental unit:

1. Fruit firmness (kg cm^2): Measured using a Pentrometer device on the shoulder of the fruit at the red ripening stage, and the average was calculated.
2. Total soluble solids (TSS) percentage: Measured using a Pocket Refractometer device by taking a drop of juice from five fully ripe fruits from each experimental unit.
3. Relative chlorophyll content (SPAD): Estimated using a SPAD-502 device.
4. Total leaf area (dm^2 plant^-1): Measured by selecting five fully grown leaves from each experimental unit,

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weighing them, and calculating the leaf area based on the fresh weight (Al-Rawi and Al-Dujaili, 2006).
5. Plant height: Measured from the soil surface to the top of the plant using a measuring tape.
6. Dry matter: Measured after the end of the experiment.
7. Statistical analysis: The results were analyzed using SAS software, and the means were compared using Duncan's multiple range test at a probability level of 0.05 (Al-Rawi and Khalaf Allah, 2000).
Results and Discussion:

Fruit Firmness (kg cm^-2):
The results in Table 2 show that there are significant differences between the foliar spray treatments in fruit firmness (kg cm^-2). The B3 treatment (boron at 150 mg L^-1) gave the highest result, with a value of 3.711 kg cm^-2, while the lowest value was recorded for the control treatment (without spray), with a value of 3.300 kg cm^-2. As for the hybrids, the H3 hybrid gave the highest value, with a value of 3.877 kg cm^-2, and the lowest value was recorded for the H1 hybrid, with a value of 3.144 kg cm^-2. Regarding the interaction, the interaction between the B3 treatment and the H3 hybrid gave the highest value, with a value of 3.877 kg cm^-2, and the lowest value was recorded for the interaction between the B1 treatment and the H1 hybrid, with a value of 2.966 kg cm^-2.

Table 1. Effect of Boron on Fruit Firmness (kg cm^-2) in Three Tomato Hybrids.

Average effect of the factor B	Hybrids			Levels of the factor A
	H3	H2	H1	
3.300 B	3.800 ab	3.133 d	2.966 d	B1
3.322 B	3.866 ab	3.100 b	3.000 d	B2
3.711 A	3.966 a	3.700 b	3.466 c	B3
	3.877 A	3.311 B	3.144 C	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%

Total Soluble Solids (TSS) Percentage:
The results in Table 3 indicate significant differences between the foliar spray treatments in TSS percentage, with the B2 treatment (boron at 75 mg L^-1) achieving the highest value of 4.433%, compared to the control treatment which had the lowest value of 4.255%. Among the hybrids, H3 recorded the highest value of 4.766%, while H1 had the lowest value of 3.988%. The interaction between treatments and hybrids showed no significant differences between B3, B2, and B1 with H3, with the lowest value observed in the interaction between B1 and H1 at 4.133%.

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Table 2. Effect of Boron on Total Soluble Solids (TSS) Percentage in Three Tomato Hybrids.

Average effect of the factor B	Hybrids			Levels of the factor B
	H3	H2	H1	
4.255 B	4.700 a	4.366 b	4.133 bc	B1
4.433 A	4.800 a	4.166 bc	3.800 d	B2
4.344 AB	4.800 a	4.300 bc	4.033 cd	B3
	4.766 A	4.277 B	3.988 C	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Relative Chlorophyll Content in Leaves (SPAD):

The results in Table 1 show that there are significant differences between the foliar spray treatments in relative chlorophyll content in leaves. The B3 treatment (boron at 150 mg L^-1) gave the highest result, with a value of 44.31 SPAD, while the lowest value was recorded for the control treatment (without spray), with a value of 39.98 SPAD. As for **the hybrids, the** H3 hybrid gave the highest value, with a value of 44.97 SPAD, and the lowest value was recorded for the H1 hybrid, with a value of 39.15 SPAD. Regarding the interaction, the interaction between the B3 treatment and the H3 hybrid gave the highest value, with a value of 46.20 SPAD, and the lowest value was recorded for the interaction between the B1 treatment and the H1 hybrid, with a value of 35.50 SPAD.

Table 3. Effect of Boron on Relative Chlorophyll Content (SPAD) in Three Tomato Hybrids.

Average effect of the factor B	Hybrids			Levels of the factor B
	H3	H2	H1	
39.98 C	44.03 b	40.43 d	35.50 e	B1
42.64 B	44.70 b	43.50 b	39.73 d	B2
44.31 A	46.20 a	44.50 b	42.23 c	B3
	44.97 A	42.81 B	39.15 C	Average effect of the factor H

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Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Total Leaf Area (dm^2 plant^-1):

The results in Table 4 show that there are significant differences between the foliar spray treatments in total leaf area (dm^2 plant^-1). The B3 treatment (boron at 150 mg L) gave the highest result, with a value of 15.90 dm^2 plant^-1, while the lowest value was recorded for the control treatment (without spray), with a value of 14.11 dm2 plant[1]. As for the hybrids, the H3 hybrid gave the highest value, with a value of 16.24 dm^2 plant, and the lowest value was recorded for the H1 hybrid, with a value of 13.28 dm^2 plant^-1. Regarding the interaction, there were no significant differences between the B3, B2, and B1 treatments with the H3 hybrid, while the lowest value was recorded for the interaction between the B1 treatment and the H1 hybrid, with a value of 12.51 dm^2 plant^-1.

Table 4. Effect of Boron on Total Leaf Area (dm^2 plant^-1) in Three Tomato Hybrids.

Average effect of the factor B	Hybrids			Levels of the factor B
	H3	H2	H1	
14.11 B	15.82 a	13.23 de	12.51 e	B1
14.75 B	16.32 ab	15.13 abc	13.31 de	B2
15.90 A	16.58 a	14.37 bcd	14.01 cde	B3
	16.24 A	14.24 B	13.28 C	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Plant Height (cm):

The results in Table 5 show that there are significant differences between the foliar spray treatments in plant height. The B3 treatment gave the highest result, with a value of 121.9 cm, and the lowest value was recorded for the control treatment (without spray), with a value of 117.8 cm. As for the hybrids, the H3 hybrid gave the highest value, with a value of 126.7 cm, and the lowest value was recorded for the H1 hybrid, with a value of 114.6 cm. Regarding the interaction, the interaction between the B3 treatment and the H3 hybrid gave the highest value, with a value of 129.8 cm, while the lowest value was recorded for the interaction between the B1 treatment and the H1 hybrid, with a value of 112.9 cm.

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Table 5. Effect of Boron on Total Leaf Area (dm^2 plant^-1) in Three Tomato Hybrids.

Average effect of the factor B	Hybrids			Levels of the factor B
	H3	H2	H1	
117.8 B	123.9 b	116.7 d	112.9 e	B1
120.3 A	126.4 b	118.8 c	115.6 de	B2
121.9 A	129.8 a	120.5 c	115.4 de	B3
	126.7 A	118.6 B	114.6 C	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Dry Matter (%):

The results in Table 6 show that there are significant differences between the foliar spray treatments in dry matter percentage. The B3 treatment gave the highest result, with a value of 71.66%, and the lowest value was recorded for the B2 treatment, with a value of 67%. As for the hybrids, the H3 hybrid gave the highest value, with a value of 82.22%, and the lowest value was recorded for the H1 hybrid, with a value of 60.44%. Regarding the interaction, the interaction between the B3 treatment and the H3 hybrid gave the highest value, with a value of 84.33%, while the lowest value was recorded for the interaction between the B2 treatment and the H1 hybrid, with a value of 56.33%.

Table 6. Effect of Boron on Dry Matter Percentage (%) in Three Tomato Hybrids.

Average effect of the factor B	Hybrids			Levels of the factor B
	H3	H2	H1	
72.66 B	81.33 ab	73.33 c	63.33 e	B1
67 B	81 b	63.66 e	56.33 f	B2
71.66 A	84.33 a	69.00 d	61.66 e	B3
	82.22 A	68.66 B	60.44 C	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

The results of the study showed that spraying with boron at a concentration of 150 mg L^-1 was the most effective in improving the vegetative and qualitative traits of tomato fruits. This treatment contributed to an increase in all the studied traits compared to the control treatment. This improvement can be attributed to several interrelated factors, including an increase in the content of major nutrients

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(nitrogen, phosphorus, and potassium) in the fruits, which play a crucial role in determining the quality and suitability of the fruit (Fathy et al., 2000; Zaghloul et al., 2001). The increase in vegetative growth traits can be attributed to the role of boron in transferring sugars from their synthesis sites to growth areas, its involvement in cell wall structure, enzymatic reactions, and cell divisions in meristematic tissues, as well as its role in carbohydrate and protein synthesis (Andriano, 1985; Wojcik, 2006).

As for the hybrids, the results extracted from the tables above show a variation in growth traits among the plants in all varieties. This variation can be attributed to genetic factors that play a fundamental role in determining the efficiency of growth and physiological development of the organism, in addition to the interaction of these factors with the surrounding environmental conditions in which the crop grows. The reason for this difference in growth indicators is likely due to genetic heterozygosity among the hybrids and the difference in their response to the prevailing environmental conditions (Gaafar and Saker, 2006).

Conclusions:

1. The results showed that spraying boron at a concentration of 150 mg/L was the most effective in improving vegetative and qualitative traits.

2. The hybrid H3 outperformed the other hybrids in all the studied traits.

3. Boron can be used as an alternative to chemical fertilizers to improve the quality of tomato fruits.

4. We recommend cultivating the hybrid H3 and using boron spray at a concentration of 150 mg/L.

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