



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(6): 850-855
Received: 14-04-2026
Accepted: 18-05-2026

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Effect of boron, calcium and zinc on growth, yield and quality of Tomato (*Solanum lycopersicum* L.)

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i6k.5796>

Abstract

An experiment was carried out on tomato cv. Azad T-6 at the vegetable research farm of Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during rabi season from September 2025 to March 2026 to study the effect of boron, calcium, zinc and their combinations on the growth, yield and quality of tomato. The experiment was laid out in a Randomized Block Design (RBD) having eight treatments with three replications. There were 8 different combinations of zinc, calcium and boron treatments which were distributed randomly in 24 individual plots. All growth, yield and quality parameters varied significantly for different levels of zinc, calcium and boron. Tomato plants that were treated with boron 0.2%, calcium 0.5% and zinc 0.5% attained maximum height (105.30 cm), produced maximum number of primary and secondary branches (35.56), maximum flower clusters per plant (7.86), maximum flowers per cluster (6.63), maximum fruits per cluster (6.46), maximum fruits per plant (30.13), biggest fruit size (5.91 cm), maximum individual fruit weight (68.75 gm), highest fruit yield per plant (0.5 kg), highest fruit yield per plot (6.66 kg), highest fruit yield per hectare (154.33 q/ha), maximum T.S.S. (5.24 °Brix), maximum shelf life (7.26 days) and highest titrable acidity (0.82%). Based on the findings, farmers of the Central plain zone may be recommended to apply boron 0.2%, calcium 0.5% and zinc 0.5%, in addition to the recommended doses of fertilizers, to harvest a fruit yield which is around 30% higher than the average yield of Azad T-6 tomato (300 q/ha) and is also remunerative and economically sustainable as its B:C ratio is 4.80.

Keywords: Tomato, nutrients, boron, zinc, calcium, growth, yield, quality

1. Introduction

Tomato (*Solanum lycopersicum*) is one of the most popular and economically important and widely used vegetable crops. Tomatoes belong to the family Solanaceae and have a chromosome number of $2n=2x=24$. 'Tomato' might be originated from the Nahuatl word "tomatl" meaning "the swelling fruit" and first mentioned in writing in 1595. It was cultivated by Aztecs and Incas in the early 700 AD (Roberts, 2014) [1].

Tomatoes are ranked second after potatoes and sweet potatoes in respect to vegetable production in the world and occupy a prominent position in both fresh market consumption and processing industries. The total global area under tomato cultivation is approximately 5.1 million hectares, and the global tomato production is about 192 million MT, with a productivity of about 37-46 MT/ha. The top five major tomato-producing countries in the world are China, India, Turkey, the United States, and Egypt (FAO, 2025) [2].

In India, tomatoes are a major vegetable crop, constituting nearly 7-10% of India's total vegetable area. The area under tomato cultivation in India is about 841,000 to 865,000 ha with a total production of about 21.32 million MT annually (National Horticulture Board, 2024). [3]. The average productivity of tomatoes in the country is cited as approximately 24.96 MT/ha in major producing areas, with some high-performing states even exceeding this limit. The major tomato producing states include Andhra Pradesh, Madhya Pradesh, Karnataka, Tamil Nadu, Odisha, Gujarat, etc. In Uttar Pradesh, major tomato-producing districts include Sonbhadra, Varanasi, Kanpur, Agra, Bareilly, Lucknow, Aligarh, Kannauj, etc. The area under tomato cultivation in U.P is about 25,470 ha with a total production of about 84400 MT annually. The average

productivity of tomatoes in the state is about 20 to 25 MT/ha.

Tomatoes are considered an important protective food because of their richness in essential nutrients and bioactive compounds. In addition to its economic importance, tomato has been proven to be beneficial to human health, because of its content of phytochemicals such as lycopene, vitamin C, β -carotene, flavonoids, and many essential nutrients (Beutner, 2001) [4].

Micronutrients are essential for plant growth, development, and metabolism. Among the micronutrients, boron, calcium, and zinc play important roles in improving the yield and quality of tomatoes in addition to preventing various diseases and physiological disorders. Zinc is an important micronutrient, a cofactor for numerous enzymes, and influences protein synthesis, carbohydrate metabolism, phosphorus metabolism, sulfur and nitrogen metabolism, sexual fertilization of plants, gene expression, structural and functional integrity of bio-membranes, photosynthetic metabolism, and growth regulation.

Boron plays an essential role in cell division, cell elongation, formation of cell walls, formation of vascular bundles, protein and nucleic acid synthesis, synthesis of pectin, maintaining correct water relations within the plant, re-synthesis of adenosine triphosphate (ATP), and translocation of sugar at the development of the flowering and fruiting stages (Bose and Tripathi, 1996) [5]. In tomatoes, boron deficiency affects the synthesis of amino acids and proteins.

Calcium plays a crucial role in the growth and development of tomato plants, from vegetative to flowering, fruiting, harvesting and post harvest stages. Calcium is a divalent cation (Ca^{2+}) required for structural roles in the cell wall, as a counter-cation for inorganic and organic anions in the vacuole, and as an intracellular messenger in the cytosol (Marschner, 1996) [6]. Calcium deficiency causes abnormal metabolism in tomato plants. This leads to low lycopene content, poor sugar-acid/TSS-acidity balance, and thus poor flavor and nutrition of the fruits. Therefore, it is essential to give these nutrients to tomato plants in balanced doses for higher growth, fruit yield and better fruit quality.

Considering these points, the present research work on “Effect of Boron, Calcium, and Zinc on Growth, Yield, and Quality of Tomato (*Solanum lycopersicum*)” was conducted to optimize different combinations of these nutrients on growth, yield and quality of tomato using variety Azad T-6.

2. Materials and Methods

The field experiment was conducted at the research farm of department of vegetable science at Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, U.P., during rabi season from September 2025 to March 2026. Geographically, Kanpur is located in the Gangetic plains of Central U.P. It lies at 25.28° to 28.50° N latitude range and 79.31° to 84.34° E longitude range at an elevation of 125.90 m above the sea level belonging to the Agro-ecological Zone “AEZVIII” of Central Plain Zone.

The climate of the experimental site is subtropical. The maximum temperature ranges from 24° to 46 °C, and the minimum temperature ranges from 6.0° to 24 °C, with relative humidity from 32% to 99% in different months of the year. The average annual rainfall is about 800-850 mm.

The experiment was laid out in a Randomized Block Design (RBD), with eight treatments and three replications. Treatment combinations were: T_1 = Control ($\text{B}_{0\%} + \text{Zn}_{0\%} + \text{Ca}_{0\%}$), T_2 = $\text{B}_{0.2\%}$, T_3 = $\text{Ca}_{0.5\%}$, T_4 = $\text{Zn}_{0.5\%}$, T_5 = $\text{B}_{0.2\%} + \text{Ca}_{0.5\%}$, T_6 = $\text{B}_{0.2\%} + \text{Zn}_{0.5\%}$, T_7 = $\text{Ca}_{0.5\%} + \text{Zn}_{0.5\%}$, T_8 = $\text{B}_{0.2\%} + \text{Ca}_{0.5\%} + \text{Zn}_{0.5\%}$.

The plant materials were obtained from the Department of Vegetable Science (Vegetable Research Station, Kalyanpur), Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh) and seedlings were made ready under nursery and were ready for transplanting at 4 to 6 leaf stage. The transplanting was done at a spacing of 60×45 cm². The plants were under regular monitoring with timely irrigation, weeding and recommended dose of fertilizer (NPK) application. Different treatment combinations were applied as foliar spray starting from 30 days after transplanting. A total of three sprays were given at 20, 50 and 80 days after transplanting (DAT). The observations were made regularly on growth, yield and quality characters of fruits. The observations on plant height, number of branches were recorded at 30, 60 and 90 DAT. Total number of flower clusters per plant, flowers per cluster, fruits per cluster, fruits per plant, diameter of fruit, individual fruit weight, yield per plant, yield per plot, yield per hectare, etc. were also counted. The fruit quality in terms of characters like T.S.S., shelf life and acidity% were also determined. The data was statistically analyzed following the methods as stated by Fisher's & Yates with analysis of variance at 5% level of significance.

3. Results and Discussion

The main findings of the study are summarized below:

3.1 Plant height (cm) at various growth stages

Plant height is one of the important parameter which is positively correlated with the yield of tomato. At 30 DAT, highest plant height 39.84 cm was recorded in T_8 (0.5% Zn + 0.5% Ca + 0.2% B), which was at par with T_6 (38.14 cm) and least plant height 24.85 cm was recorded in T_1 (Control). At 60 DAT, significantly higher plant height (63.38 cm) was recorded in T_8 , followed by T_6 (59.93 cm) and lowest plant height was recorded in T_1 (44.67 cm). At 90 DAT, significantly higher plant height (105.3 cm) was recorded in T_8 followed by T_6 (98.33cm) and T_5 (94.21cm), and lowest plant height (73.66 cm) was recorded in T_1 (Control). These results are in close agreement with researches of (Davis et al, 2003) [7], (Mondal and Ghosh, 2023) [8] etc.

Number of primary and secondary branches per plant

To measure the growth rate, the number of primary and secondary branches per plant was counted at 30, 60, and 90 DAT. At 30 DAT, highest number of branches (7.46) was recorded in T_8 (0.5% Zn + 0.5% Ca + 0.2% B) and least number of branches (2.46) was recorded in T_1 (Control). At 60 DAT, significantly higher number of branches (32.63) was recorded in T_8 followed by T_6 (28.53) and lowest number of branches (17.40) was recorded in T_1 (Control). At 90 DAT, significantly higher number of branches (35.56) was recorded in T_8 and lowest number of branches (17.73) was recorded in T_1 (Control). The result corroborated with the finding of (Mondal and Ghosh, 2023) [8].

Table 1: Mean performance of plant height (cm) and number of primary & secondary branches per plant of tomato as influenced by boron, calcium, zinc and its combinations

Treatment No.	Treatment Details	Plant height (cm)			No. of primary and secondary branches		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T ₁	Control (B ₀ + Ca ₀ + Zn ₀)	24.85	44.67	73.66	2.46	17.40	17.73
T ₂	B ₁ (0.2%)	31.18	50.12	81.15	4.46	21.03	22.10
T ₃	Ca ₁ (0.5%)	27.54	46.65	76.43	3.26	18.06	18.56
T ₄	Zn ₁ (0.5%)	33.94	51.68	84.27	3.53	19.23	19.96
T ₅	B ₁ (0.2%) + Ca ₁ (0.5%)	35.56	54.62	94.21	5.86	24.46	25.53
T ₆	B ₁ (0.2%) + Zn ₁ (0.5%)	38.14	59.93	98.33	6.60	28.53	31.10
T ₇	Ca ₁ (0.5%) + Zn ₁ (0.5%)	34.23	52.76	90.16	5.33	22.26	23.60
T ₈	B ₁ (0.2%) + Ca ₁ (0.5%) + Zn ₁ (0.5%)	39.84	63.38	105.3	7.46	32.63	35.56
C.D. (5%)		2.61	2.81	4.99	0.55	2.02	2.02
S.E.(m) ±		0.86	0.92	1.64	0.18	0.66	0.66
Level of significance		**	**	**	**	**	**

B₀= 0%, Ca₀= 0%, Zn₀= 0%, **= significant at 5% level, DAT= days after transplanting

3.2 Number of flower clusters per plant

At 40 DAT, highest number of flower clusters per plant (7.46) was recorded in T₈ (0.5% Zn + 0.5% Ca + 0.2% B) and least number of flower clusters per plant (2.46) was recorded in T₁. At 70 DAT, significantly higher number of flower clusters per plant (7.40) was recorded in T₈ followed by T₆ (7.06) and lowest number of flower clusters per plant was recorded in T₁ (1.60). At 100 DAT, significantly higher number of flower clusters per plant (7.86) was recorded in T₈ and lowest number of flower clusters per plant was recorded in T₁ (2.13). These results are in close agreement with researches of (Rab and Haq, 2012)^[9], (Shnain *et al.*, 2014)^[10], (Ali *et al.*, 2015)^[11], etc.

Number of flowers per cluster

Number of flowers per cluster is one of the important parameter which is positively correlated with the yield of tomato. At 40

DAT, highest number of flowers per cluster (6.13) was recorded in T₈ (0.5% Zn + 0.5% Ca + 0.2% B), which was at par with T₆ (5.93) (0.5% Zn + 0.2% B), and least number of flowers per cluster (1.73) was recorded in T₁. At 70 DAT, significantly higher number of flowers per cluster (6.63) was recorded in T₈, which was at par with T₆ (6.56) and lowest number of flowers per cluster was recorded in T₁ (2.40). At 100 DAT, significantly higher number of flowers per cluster (6.53) was recorded in T₈ and lowest number of flowers per cluster was recorded in T₁ (2.00). Number of flowers per cluster increased significantly with B and Zn combination, because boron regulates water absorption and carbohydrate metabolism (Haque *et al.*, 2011)^[12]. Thus it is likely that higher number of flowers per cluster could be produced due to sufficient levels of carbohydrates available for flower formation (Naz *et al.*, 2012)^[13].

Table 2: Mean performance of number of flower clusters per plant and number of flowers per cluster of tomato as influenced by boron, calcium, zinc and its combinations

Treatment No.	Treatment Details	No. of flower clusters per plant			No. of flowers per cluster		
		40 DAT	70 DAT	100 DAT	40 DAT	70 DAT	100 DAT
T ₁	Control (B ₀ + Ca ₀ + Zn ₀)	0.53	1.60	2.13	1.73	2.40	2.00
T ₂	B ₁ (0.2%)	2.86	5.66	5.66	4.80	5.80	5.13
T ₃	Ca ₁ (0.5%)	0.93	2.46	3.06	2.13	3.00	2.40
T ₄	Zn ₁ (0.5%)	1.46	3.86	3.86	3.06	3.96	3.26
T ₅	B ₁ (0.2%) + Ca ₁ (0.5%)	3.53	6.33	6.40	5.46	6.13	5.86
T ₆	B ₁ (0.2%) + Zn ₁ (0.5%)	4.33	7.06	7.33	5.93	6.56	6.46
T ₇	Ca ₁ (0.5%) + Zn ₁ (0.5%)	1.86	4.80	4.80	3.66	4.80	4.13
T ₈	B ₁ (0.2%) + Ca ₁ (0.5%) + Zn ₁ (0.5%)	4.80	7.40	7.86	6.13	6.63	6.53
C.D. (5%)		0.14	0.53	0.39	0.48	0.33	0.50
S.E.(m) ±		0.04	0.17	0.13	0.15	0.11	0.16
Level of significance		**	**	**	**	NS	NS

B₀= 0%, Ca₀= 0%, Zn₀= 0%, **= significant at 5% level, DAT= days after transplanting, NS= non-significant

3.3 Number of fruits per cluster

As shown in Table 3, there was a significant difference in number of fruits per cluster of tomato due to application of different combinations of treatments. At 60 DAT, highest number of fruits per cluster (5.50) was recorded in plants treated with T₈ (0.5% Zn + 0.5% Ca + 0.2% B), which was at par with T₆ (5.06), and least number of fruits per cluster (0.73) was recorded in T₁ (Control). At 90 DAT, significantly higher number of fruits per cluster (6.46) was recorded in T₈, which was at par with T₆ (6.20) and lowest number of fruits per cluster was recorded in T₁ (1.73). At 120 DAT, significantly higher number of fruits per cluster (6.20) was recorded in T₈, which was at par with T₆ (6.10) and lowest number of fruits per cluster was recorded in T₁ (1.70). Similar results were also reported by the researches of (Harris and Mathuma, 2015)^[14].

Number of fruits per plant

At 60 DAT, highest number of fruits per plant (30.13) was recorded in T₈ (0.5% Zn + 0.5% Ca + 0.2% B), followed by T₆ (25.03), and least number of fruits per plant (3.96) was recorded in T₁ (Control). At 90 DAT, significantly higher number of fruits per plant (19.73) was recorded in T₈, followed by T₆ (16.03), and lowest number of fruits per plant was recorded in T₁ (1.73) treatment. At 120 DAT, significantly higher number of fruits per plant (6.20) was recorded in T₈, followed by T₆ (15.63) and lowest number of fruits per plant was recorded in T₁ (3.73). Similar results were also reported by the researches of (Rab and Haq, 2012)^[9], (Harris and Mathuma, 2015)^[14] and (Tawab *et al.*, 2015)^[15].

Table 3: Mean performance of number of fruits per cluster and number of fruits per plant of tomato as influenced by boron, calcium, zinc and its combinations

Treatment No.	Treatment Details	No. of fruits per cluster			No. of fruits per plant		
		60 DAT	90 DAT	120 DAT	60 DAT	90 DAT	120 DAT
T ₁	Control (B ₀ + Ca ₀ + Zn ₀)	0.73	1.73	1.70	1.73	3.96	3.73
T ₂	B ₁ (0.2%)	3.83	4.86	4.83	9.66	12.26	10.00
T ₃	Ca ₁ (0.5%)	1.40	2.20	2.13	3.53	7.20	4.73
T ₄	Zn ₁ (0.5%)	2.26	2.93	3.13	5.53	10.30	6.00
T ₅	B ₁ (0.2%) + Ca ₁ (0.5%)	4.56	5.60	5.53	12.46	20.06	13.03
T ₆	B ₁ (0.2%) + Zn ₁ (0.5%)	5.13	6.20	6.10	14.73	25.03	15.63
T ₇	Ca ₁ (0.5%) + Zn ₁ (0.5%)	3.00	3.73	3.70	7.53	16.33	7.93
T ₈	B ₁ (0.2%) + Ca ₁ (0.5%) + Zn ₁ (0.5%)	5.50	6.46	6.20	17.33	30.13	19.13
C.D. (5%)		0.30	0.55	0.56	1.22	1.39	1.13
S.E.(m) ±		0.10	0.18	0.18	0.39	0.45	0.37
Level of significance		**	NS	NS	**	**	**

B₀= 0%, Ca₀= 0%, Zn₀= 0%, **= significant at 5% level, DAT= days after transplanting, NS= non-significant

3.4 Diameter of fruits (cm)

On first picking, maximum diameter of fruit (5.66 cm) was recorded in T₈ treatment and minimum diameter of fruit 2.42 cm was recorded in T₁. On second picking, significantly higher diameter of fruits (5.90 cm) was recorded in T₈ followed by T₆ (5.50 cm) and minimum diameter of fruit was recorded in T₁ (2.70 cm). At 90 DAT, significantly higher diameter of fruit (5.91 cm) was recorded in T₈ and minimum diameter of fruit was recorded in T₁ (2.57 cm). Similar results were also reported by the researches of (Saravaiya *et al.*, 2014) [16].

Individual weight of fruits (g)

Individual weight of fruits is an important character which directly influences the fruit yield. On first picking, maximum weight of fruit (62.69 g) was recorded in T₈ (0.5% Zn + 0.5% Ca + 0.2% B) and minimum weight of fruit (32.81 g) was recorded in T₁ (Control). On second picking, significantly higher weight of fruits (68.75 g) was recorded in T₈ followed by T₆ (61.37 g) and minimum weight of fruit was recorded in T₁ (39.71 g). At 90 DAT, significantly higher weight of fruit (62.19 g) was recorded in T₈ and minimum weight of fruit was recorded in T₁ (36.63 g). Similar results were also reported by the researches of (Tawab *et al.*, 2015) [15] etc.

Table 4: Mean performance of diameter of fruits (cm) and Individual weight of fruits (gm) of tomato as influenced by boron, calcium, zinc and its combinations

Treatment No.	Treatment Details	Diameter of fruits (cm)			Individual weight of fruits (g)		
		1st picking	2nd picking	3rd picking	1st picking	2nd picking	3rd picking
T ₁	Control (B ₀ + Ca ₀ + Zn ₀)	2.42	2.70	2.57	32.81	39.71	36.63
T ₂	B ₁ (0.2%)	3.56	4.50	4.03	44.93	51.80	47.77
T ₃	Ca ₁ (0.5%)	3.15	3.78	3.54	41.81	46.90	43.96
T ₄	Zn ₁ (0.5%)	2.75	3.30	3.02	35.91	42.81	38.92
T ₅	B ₁ (0.2%) + Ca ₁ (0.5%)	4.54	5.33	4.88	56.71	64.91	58.84
T ₆	B ₁ (0.2%) + Zn ₁ (0.5%)	5.02	5.50	5.38	51.86	61.37	55.03
T ₇	Ca ₁ (0.5%) + Zn ₁ (0.5%)	4.15	5.03	4.46	48.68	55.92	51.32
T ₈	B ₁ (0.2%) + Ca ₁ (0.5%) + Zn ₁ (0.5%)	5.66	5.90	5.91	62.69	68.75	62.19
C.D. (5%)		0.25	0.28	0.29	2.95	3.06	3.14
S.E.(m) ±		0.08	0.09	0.09	0.97	1.00	1.02
Level of significance		**	**	**	**	**	NS

B₀= 0%, Ca₀= 0%, Zn₀= 0%, **= significant at 5% level, NS= non-significant

3.5 Yield per plant (kg), Yield per plot (kg), Yield per hectare (q/ha)

As shown in Table 5, there is a significant difference in yield per plant of tomato due to application of different combinations of treatments. Highest yield per plant (1.14 kg) was recorded in T₈ (0.5% Zn + 0.5% Ca + 0.2% B), and minimum yield per plant (0.72 kg) was recorded in T₁ (Control). Highest yield per plot (16.96 kg) was recorded in T₈ (0.5% Zn + 0.5% Ca + 0.2% B) and minimum yield per plot (9.53 kg) was recorded in T₁ (Control).

Highest yield per hectare (392.77 q) was recorded in T₈ (0.5% Zn + 0.5% Ca + 0.2% B) and minimum yield per plot (220.77q) was recorded in T₁ (Control). Similar results were also reported by the researches of (Verma *et al.*, 2018) [17] etc. Yield of fruits increased significantly with B and Zn combination, because boron regulates water absorption and carbohydrate metabolism (Haque *et al.*, 2011) [12]. Thus, it is likely that higher number of fruits per plant could be due to sufficient levels of carbohydrates available for flower formation and fruit set (Kumar *et al.*, 2004) [18].

Table 5: Mean performance of Yield per plant (kg), Yield per plot (kg) and Yield per hectare (q/ha) of tomato plant as influenced by boron, calcium, zinc and its combinations

Treatment no.	Treatment details	Yield per plant (kg)	Yield per plot (kg)	Yield per hectare (q/ha)
T ₁	Control (B ₀ + Ca ₀ + Zn ₀)	0.72	9.53	220.77
T ₂	B ₁ (0.2%)	0.78	12.76	295.54
T ₃	Ca ₁ (0.5%)	0.88	14.36	332.58
T ₄	Zn ₁ (0.5%)	0.85	13.86	321.01
T ₅	B ₁ (0.2%) + Ca ₁ (0.5%)	1.03	15.26	353.42
T ₆	B ₁ (0.2%) + Zn ₁ (0.5%)	1.07	16.10	372.71
T ₇	Ca ₁ (0.5%) + Zn ₁ (0.5%)	0.94	14.73	341.07
T ₈	B ₁ (0.2%) + Ca ₁ (0.5%) + Zn ₁ (0.5%)	1.14	16.96	392.77
C.D. (5%)		0.14	0.95	22.08
S.E.(m) ±		0.04	0.31	7.26
Level of significance		NS	**	**
B ₀ = 0%, Ca ₀ = 0%, Zn ₀ = 0%, **= significant at 5% level, NS= non-significant				

3.6 Total Soluble Solids (⁰Brix)

The highest TSS (5.24⁰Brix) was recorded in plants treated with T₈ (0.5% Zn + 0.5% Ca + 0.2% B) followed by T₆ (0.2% B + 0.5% Zn) (5.02⁰Brix) and T₅ (0.2% B + 0.5% Ca) (4.94 ⁰Brix). The minimum TSS (4.1⁰Brix) was recorded in T₁ (control). The increase in TSS may be attributed to the growth promoting substances which could have accelerated synthesis of carbohydrates, vitamins and other quality characters (Kumari *et al.*, 2012) ^[19].

Shelf life (days)

As shown in Table 6, there is a significant difference in shelf life of tomato fruits due to application of different combinations of treatments. On first picking, longest shelf life (6.33 days) was recorded in T₈ treatment and shortest shelf life (1.46 days) was recorded in T₁. On second picking, significantly longer shelf life (7.26 days) was recorded in T₈, and shortest shelf life was

recorded in T₁ (1.8 days) treatment. On third picking, significantly higher shelf life (6.80 days) was recorded in T₈ and shortest shelf life was recorded in T₁ (1.66 days). Similar results were also reported by the researches of (Verma *et al.*, 2018) ^[17] and Salam *et al.* (2010) ^[20].

Titration acidity (%)

The highest titration acidity (0.82%) was recorded in plants treated with T₈ (0.5% Zn + 0.5% Ca + 0.2% B) followed by (0.73%) of T₆ (0.2% B + 0.5% Zn) and T₇ (0.5% Zn + 0.5% Ca) (0.64%). The minimum titration acidity (0.42%) was recorded in T₁ (control). The increase in titration acidity may be attributed to the growth promoting substances, enzymes which could have accelerated synthesis of carbohydrates, vitamins and other quality characters. Zinc and boron increases the titration acidity of fruits (Kumari *et al.*, 2012) ^[19]. Similar results were also reported by the researches of (Raj *et al.*, 2012) ^[21] etc.

Table 6: Mean performance of T.S.S. (⁰Brix), Shelf life (days) and Titration acidity (%) of tomato fruits as influenced by boron, calcium, zinc and its combinations

Treatment no.	Treatment details	T.S.S. (⁰ Brix)	Shelf life (days)			Titration acidity (%)
			1 st picking	2 nd picking	3 rd picking	
T ₁	Control (B ₀ + Ca ₀ + Zn ₀)	4.10	1.46	1.80	1.66	0.44
T ₂	B ₁ (0.2%)	4.49	2.46	3.20	2.93	0.52
T ₃	Ca ₁ (0.5%)	4.21	2.93	4.13	3.46	0.49
T ₄	Zn ₁ (0.5%)	4.37	1.80	2.53	2.26	0.58
T ₅	B ₁ (0.2%) + Ca ₁ (0.5%)	4.94	5.66	6.26	6.00	0.64
T ₆	B ₁ (0.2%) + Zn ₁ (0.5%)	5.02	5.00	5.80	5.26	0.75
T ₇	Ca ₁ (0.5%) + Zn ₁ (0.5%)	4.57	4.06	4.73	4.40	0.69
T ₈	B ₁ (0.2%) + Ca ₁ (0.5%) + Zn ₁ (0.5%)	5.24	6.33	7.26	6.80	0.86
C.D. (5%)		0.25	0.57	0.49	0.34	0.04
S.E.(m) ±		0.08	0.19	0.16	0.11	0.01
Level of significance		**	**	**	**	NS
B ₀ = 0%, Ca ₀ = 0%, Zn ₀ = 0%, **= significant at 5% level, NS= non-significant						

4. Conclusion

Foliar application of boron (0.2%), calcium (0.5%) and zinc (0.5%) was found to be the best treatment to improve growth, yield and fruit quality of tomato cv. Azad T-6 under Kanpur subtropical condition having high moderate pH.

Acknowledgement

The authors gratefully acknowledge the Department of Vegetable science, College of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P., for providing the essential support and research facilities required for the successful execution of this experiment.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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