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Sudheer Kumar
P.G. Scholar, Department of
Vegetable Science, C.S. Azad
University of Agriculture and
Technology, Kanpur, Uttar
Pradesh, India

Rajiv
Assistant Professor, Department of
Vegetable Science, C.S. Azad
University of Agriculture and
Technology, Kanpur, Uttar
Pradesh, India

Ritik Yadav
P.G. Scholar, Department of
Vegetable Science, C.S. Azad
University of Agriculture and
Technology, Kanpur, Uttar
Pradesh, India

Shruti Jha
P.G. Scholar, Department of
Vegetable Science, C.S. Azad
University of Agriculture and
Technology, Kanpur, Uttar
Pradesh, India

Ragini Singh
P.G. Scholar, Department of
Vegetable Science, C.S. Azad
University of Agriculture and
Technology, Kanpur, Uttar
Pradesh, India

Kamla Pati
P.G. Scholar, Department of
Vegetable Science, C.S. Azad
University of Agriculture and
Technology, Kanpur, Uttar
Pradesh, India

Corresponding Author:

Sudheer Kumar
P.G. Scholar, Department of
Vegetable Science, C.S. Azad
University of Agriculture and
Technology, Kanpur, Uttar
Pradesh, India

Study on the effect of foliar application of zinc and boron on growth and yield of Tomato (*Solanum lycopersicon* L.) NS 4266 under insect proof net house

Sudheer Kumar, Rajiv, Ritik Yadav, Shruti Jha, Ragini Singh and Kamla Pati

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Abstract

An experiment was conducted under insect proof net house on Tomato crop during the winter season 2024-25 at Vegetable Research Farm, Department of Vegetable Science of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, (U.P.). The experiment was conducted in Randomized Block Design (RBD) with nine different treatments replicated thrice. Hybrid NS-4266 was used in the experiment. The results of experiment showed the highest plant height at 45, 90, and 120 DAT (142.26, 243.04 and 345.04 cm respectively), stem girth at 45, 90 and 120 DAT (12.33, 22.42 and 33.24 mm), earlier first flowering initiation and 50% flowering (31.78 and 43.10 days) were recorded with the treatment of zinc @ 0.2% + boron @ 0.2% (T₉). Yield parameter indicates the highest number of clusters per plant (10.35), average fruit weight (108.06 gm), fruit per plant (102.06), equatorial diameter (6.22 cm), polar diameter (4.38 cm), first and last picking (115.30 days and 168.0 days) and fruit yield per plant (9.70 Kg), plot yield (116.40 Kg) and fruit yield per 1000 m² (269.36 q.) with the same treatment (T₉). The Benefit: cost ratio was worked out higher (3.45) with same treatment. Hence may be recommended for the commercial cultivation of tomato under Kanpur conditions to maximize the production and profitability.

Keywords: Tomato, Protected cultivation, zinc, boron, growth, yield and quality.

1. Introduction

Tomato (*Solanum lycopersicon* L.) belongs to the Solanaceae family, and the world's second most important vegetable crop, following potatoes. It is a dicotyledonous annual herb from the Solanaceae family, with diploid chromosomes $2n = 2x = 24$. Tomatoes are also referred to as "poor man's orange" and "wolf apple" (Dhall and Singh, 2013) [4]. Tomato originated in Peru, Bolivia, and Ecuador, was later domesticated in Mexico, and spread to Europe in 1554 and other parts of the world during the 16th century. It gained popularity in India over the last five decades (Vavilov, 1951) [18].

Tomato is grown widely throughout the world and is considered one of the most important vegetable crops. In 2023, global tomato production reached around 192 million tonnes, with China, India, Turkey, the United States, and Italy emerging as the leading producers. In India, tomato production increased from 20.43 million tonnes in 2022–23 to 21.32 million tonnes in 2023–24, and 20.60 million tonnes in 2024–25 as reported by the Press Information Bureau (PIB, 2025) [13].

Tomato fruit has the following nutrients for every 100 grams of fruit pulp: 93.1 grams of water, 1.9 g. of protein, 0.1 g of fat, 3.6 g of carbohydrates, 0.6 g of mineral matter, 20 mg of Ca, 36mg of P, 0.8 mg of Fe, 320 IU vita. A, 2.27 mg thiamine, 0.4 mg nicotinic acid, 0.01 mg riboflavin, and 31 mg vita. C Additionally, it contains vitamin K, folic acid, pantothenic acid, biotin, and vita. E (Aykroyd *et al.*, 1963) [2].

Boron is an important micronutrient needed for better growth, higher yield, and improved quality of crops (Dale and Krystyna, 1998) [3]. It helps in cell wall formation, lignification, metabolism of RNA, carbohydrates, phenolic compounds, IAA, respiration, and maintaining cell membrane stability (Parr and Loughman, 1983) [10]. Boron also improves pollen germination, pollen tube

growth, and fruit setting, while supporting calcium metabolism in plants (Yamaguchi *et al.*, 1986)^[19]. Deficiency of boron can cause wilting, leaf fall, and reduction in yield and quality of tomato crops (Zekri and Obreza, 2003; Imtiaz *et al.*, 2010)^[20]. Boron can be supplied through soil and foliar application during the reproductive stage to enhance plant growth and productivity (Sajid, 2009)^[14].

Zinc (Zn) is an important micronutrient that helps plants grow properly by supporting the production of tryptophan, which is needed for the synthesis of IAA, a growth-promoting hormone (Mallick and Muthukrishnan, 1980)^[8]. It also plays a role in the formation of carbonic anhydrase, an enzyme involved in CO₂ transport during photosynthesis (Alloway, 2008)^[11]. Zinc deficiency leads to poor plant growth, shorter internodes, chlorotic spots on older leaves, curling of leaf margins, and abnormal development (Passam *et al.*, 2007)^[11]. This deficiency may occur because of low zinc availability in soil or due to interactions with nutrients like Ca, Mn, Fe, P, and K, along with certain soil conditions (Srivastava and Singh, 2003)^[16]. Since zinc movement in soil is limited, foliar application is generally more effective than soil application for correcting zinc deficiency (Swietlik, 2002)^[17].

2. Materials and Methods

2.1 Experimental site and location: The present trial entitled “Study on the effect of foliar application of zinc and boron on growth, yield and quality of tomato (*Solanum lycopersicon* L.) NS 4266 under insect proof net house” was in the Vegetable Research Farm, Department of Vegetable Science, of Chandra Shekhar Azad University of Agricultural and Technology, Kanpur, during the Rabi season 2024-2025. Kanpur is situated in the Central Plain Zone of Uttar Pradesh, but the ICAR's agroclimatic zones place it in the Upper Gangetic Plain Zone. It is located 125.91 meters above mean sea level (MSL). It is located geographically at altitude range between 25.28° to 28.50° North and longitude range between 79.31° to 84.34° East.

2.2 Crop details and cultural practices: tomato variety-Ramdhari 4266 (NS 4266) is an indeterminate F1 hybrid tomato variety developed by 'Namdhari seeds company'. These variety is popular for commercial farming and suitable for growing in polyhouse at kharif and rabi both seasons. Seeds were sown in nursery bed on 13 November 2024, and 27 days old seedlings were transplanted in 10 December 2024, under insect proof net house. The crop seedling transplanted at spacing of 60 × 60 cm in plots size measuring 3.9 × 1.0 m², and seed rate is 150gm/ha. All recommended agronomic practices, including irrigation, training, pruning and nutrient application was applied in 30, 45 and 60 DAT, were followed throughout the crop seasons.

2.3 Experimental design and treatment details: The experiment was conducted in Randomized Block Design (RBD) with 3 replication and 9 treatments with the combination of zinc and boron various concentration (0.0%, 0.1% and 0.2%) of

treatments viz. T₁- Zn 0.0%+ B 0.0%, T₂- Zn 0.0%+ B 0.1%, T₃- Zn 0.0%+ B 0.2%, T₄- Zn 0.1%+ B 0.0%, T₅- Zn 0.1%+ B 0.1%, T₆- Zn 0.1%+ B 0.2%, T₇- Zn 0.2%+ B 0.0%, T₈- Zn 0.2%+ B 0.1% and T₉- Zn 0.2%+ B 0.2%.

2.4 Observation Recorded

Growth and yield parameter: Among the growth and yield following parameter were observed viz. plant height (cm) at 45, 90 and 120 DAT, plant stem girth (mm) at 45, 90 and 120 DAT, days of first flowering initiations, average fruit weight (gm) at 2nd picking, number of fruits per plant, number of clusters per plants, fruit diameter (centimetre) polar and equatorial at 2nd picking, days of last fruit harvesting (days), fruit yield per plant (Kg), fruit yield per plot (Kg), and fruit yield/1000 m² (quintal).

3. Results and Discussion

The plant height is measured by wooden stick meter. These vegetative parameters were significantly influenced by the foliar application of zinc and boron. The plant height observed at 45, 90 and 120 DAT, T₉- zinc @ 0.2%+ boron @ 0.2 % had the highest plant height with (142.26, 243.04 and 345.04 cm), followed by T₆- zinc @ 0.1%+ borax @ 0.2 % (136.77, 234.22 and 336.5 cm), T₈- Zn @0.2%+ B @0.1% (131.25, 225.4 and 327.72 cm), T₅- Zn @ 0.1%+ B @ 0.1% (125.79, 216.58 and 319.42 cm) and T₇- zinc sulphate @ 0.2 % (120.3, 207.76 and 310.88 cm) treatments. all of the remaining treatments were found to be beneficial in raising plant height is significantly better than the control. Treatments with T₁- (control) show the minimum plant height is 98.34, 172.48 and 276.72 cm. these treatments are at par T₆ and T₈, similar research has been also reported by Haque *et al.* (2011)^[5] and Naga *et al.* (2013)^[9].

The plant stem girth was significantly influenced by zinc and boron application. The stem girth was observed at 45, 90 and 120 DAT, T₉- zinc @ 0.2%+ boron @ 0.2 % (12.33, 22.42 and 33.24 mm) maximum which was significantly superior over all treatments, followed T₆- zinc @0.1%+ borax @0.2 % (11.91, 21.67 and 32.36 mm), T₈- Zn @0.2%+ B @0.1% (11.51, 20.90 and 31.48 mm), and T₅- zinc @ 0.1% + boron @ 0.1 % (11.11, 20.13 and 30.60 mm) by while the minimum stem girth observed in T₁- zinc @0.0%+boron @0.0% (Control) with 9.10, 16.28 and 26.2 mm. Some treatments are at par T₆ and T₈ similar research has been also reported by Kumari *et al.* (2020)^[7].

After a month of transplanting when earlier flowering initiations was observed in T₉- zinc @ 0.2%+ boron @ 0.2 % (31.78 days) which was some treatments is followed by T₆- zinc @0.1%+ borax @0.2 % (32.22 days), T₈- Zinc @0.2%+ Boron @0.1% (32.66 days), T₅- Zinc @0.1%+ Boron @0.1% (33.10 days) and T₇- zinc @ 0.2 % + boron @ 0.0% (33.54 days). The late flowering was observed in treatment T₁- (control) Zinc @0.0%+ Boron @0.0% (35.33 days). The combined application of zinc and boron further enhanced floral initiation and reduced days to flowering in tomato. Similar research has been observed by Mallick and Muthukrishnan (1980)^[8].

Table 1: Variability of fruit parameters in different treatments

Treatment	Treatment details	Plant Height (cm)			Stem girth(mm)			First flowering (DAT)	Number of clusters/plants	Number of fruits/plants
		45 DAT	90 DAT	120 DAT	45 DAT	90 DAT	120 DAT			
T ₁	(Control)	98.34	172.48	276.72	9.10	16.28	26.2	35.33	8.16	89.07
T ₂	Zn0 (0.0%) + B1 (0.1%)	109.32	190.12	293.8	9.91	17.82	27.96	34.42	8.94	92.21
T ₃	Zn0 (0.0%) + B2 (0.2%)	114.81	198.94	302.34	10.31	18.59	28.84	33.98	9.22	93.83
T ₄	Zn1 (0.1%) + B0 (0.0%)	103.83	181.3	285.26	9.51	17.05	27.08	34.86	8.53	92.10
T ₅	Zn1 (0.1%) + B1 (0.1%)	125.79	216.58	319.42	11.11	20.13	30.60	33.10	9.82	96.04
T ₆	Zn1 (0.1%) + B2 (0.2%)	136.77	234.22	336.5	11.91	21.67	32.36	32.22	10.14	99.67
T ₇	Zn2 (0.2%) + B0 (0.0%)	120.3	207.76	310.88	10.71	19.36	29.72	33.54	9.48	94.44
T ₈	Zn2 (0.2%) + B1 (0.1%)	131.25	225.4	327.72	11.51	20.90	31.48	32.66	10.00	98.26
T ₉	Zn2 (0.2%) + B2 (0.2%)	142.26	243.04	345.04	12.33	22.42	33.24	31.78	10.35	102.06
	CD	3.047	5.382	24.302	0.261	0.533	2.593	N/A	0.815	7.265
	SE(m)±	9.214	16.275	8.037	0.790	1.612	0.857	0.940	0.270	2.402

Table 2: Variability of fruit parameters in different treatments

Treatment	Treatment details	Fruit Diameter (cm)		Last fruit picking (DAT)	Average fruit weight (gm)	Fruit yield/plant (Kg)	Fruit yield/plot (Kg)	Fruit yield/1000 m ² (quintal)	C:B ratio
		Polar	Equatorial						
T ₁	(Control)	3.15	5.10	176.50	90.56	7.80	93.60	216.60	1: 2.73
T ₂	Zn0 (0.0%) + B1 (0.1%)	3.30	5.25	174.30	94.03	8.20	98.40	227.71	1: 2.86
T ₃	Zn0 (0.0%) + B2 (0.2%)	3.43	5.44	173.55	96.40	8.45	101.40	234.65	1: 2.92
T ₄	Zn1 (0.1%) + B0 (0.0%)	3.22	5.18	175.45	92.48	8.05	96.60	223.54	1: 2.83
T ₅	Zn1 (0.1%) + B1 (0.1%)	3.68	5.74	171.25	100.33	8.82	105.84	244.93	1: 3.19
T ₆	Zn1 (0.1%) + B2 (0.2%)	4.03	6.00	168.95	105.66	9.30	111.60	258.26	1: 3.29
T ₇	Zn2 (0.2%) + B0 (0.0%)	3.50	5.61	172.40	98.38	8.60	103.20	238.82	1: 3.06
T ₈	Zn2 (0.2%) + B1 (0.1%)	3.80	5.83	170.10	103.11	8.90	106.80	247.15	1: 3.14
T ₉	Zn2 (0.2%) + B2 (0.2%)	4.38	6.22	168.00	108.06	9.70	116.40	269.36	1: 3.45
	CD	0.089	0.151	N/A	7.906	0.790	8.796	20.252	
	SE(m)±	0.270	0.456	4.097	2.615	0.261	2.909	6.698	

Fruit diameter both polar and equatorial were observed in 115 DAT at 2nd fruit picking stage. T₉ - zinc sulphate @ 0.2% + borax @ 0.2 % (4.38 cm and 6.22cm) had the highest polar & equatorial diameter respectively, followed by T₆ - zinc sulphate @ 0.1% + Borax @ 0.2 % (4.03 cm & 6.00 cm), T₈ - zinc sulphate @ 0.2% + borax @ 0.1 % (3.80 cm & 5.83cm), T₅ - zinc sulphate @ 0.1% + borax @ 0.1 % (3.68 cm & 5.74cm), and T₇ - zinc sulphate @ 0.2 % + borax @ 0.0% (3.50 cm & 5.61cm). The smallest polar diameter was found in T₁ - Control (3.15 cm & 5.10cm) polar and equatorial diameter respectively. Kumar *et al.* (2012) [6].

After 120 DAT number of cluster per plant was observed and it was found the maximum number of clusters per plant (10.35) was recorded from the plants sprayed with T₉ - zinc sulphate @ 0.2% + borax @ 0.2 %, followed by T₆ - zinc sulphate @ 0.1% + Borax @ 0.2 % with 10.14, T₈ - zinc sulphate @ 0.2% + borax @ 0.1 % with 10.00 and T₅ - zinc sulphate @ 0.1% + borax @ 0.1 % with 9.82. All the remaining treatments were found to be effective in increasing the number of clusters per plant and were significantly superior over control. The minimum number of clusters per plant 8.16 was found under the treatment T₁ - (control). Similar research has been in Paithankar *et al.*

After 115 DAT number fruits per plant in every was observed and found in T₉ - zinc sulphate @ 0.2% + borax @ 0.2 % produced the most fruits per plant (102.06), followed by T₆ - zinc sulphate @ 0.1% + Borax @ 0.2 % (99.67), T₈ - zinc sulphate @ 0.2% + borax @ 0.1 % (98.26), T₅ - zinc sulphate @ 0.1% + borax @ 0.1 % (96.04), T₇ - zinc sulphate @ 0.2 % + borax @ 0.0% (94.44), T₃ - borax @ 0.2 % (93.83), T₂ - borax @ 0.1% (92.21), and T₄ - zinc sulphate @ 0.1% (92.10). The T₁ - Control group produced the lowest fruits per plant (89.07) of compared to other treatments. Similar results were reported by Mallick and Muthukrishnan (1980) [8].

At the time of second fruit picking stage observed the average fruit weight. It was found highest in treatment T₉ (zinc sulphate @ 0.2% + borax @ 0.2%) with 108.06 g, followed by T₆ (105.66 g), T₈ (103.11 g), T₅ (100.33 g), and T₇ (98.38 g), while the lowest fruit weight was observed in the control T₁ (90.56 g).

Fruit yield/plant(kg), fruit yield/ plot(kg) and fruit yield/1000m² (Quintal): After 115 DAT fruit yield/plant (kg), fruit yield/ plot (kg) and fruit yield/1000m² was found highest treatment T₉ - zinc sulphate @ 0.2% + borax @ 0.2 % (9.70 kg, 116.40kg & 269.15 q.) produced the highest yield respectively, followed by T₆ - zinc sulphate @ 0.1% + Borax @ 0.2 % (9.30 kg, 111.60kg, & 258.26 q.), T₈ - zinc sulphate @ 0.2% + borax @ 0.1 % (8.90 kg, 106.40 kg & 247.15 q.), T₅ - zinc sulphate @ 0.1% + borax @ 0.1 % (8.82 kg, 105.84 kg & 244.93 q.), and T₇ - zinc sulphate @ 0.2 % + borax @ 0.0% (8.60 kg,

103.20 kg & 238.82 q.). The lowest fruit output per plant was achieved in T₁ - Control (7.80 kg, 93.60kg & 216.60 q.) respectively, which was significantly lower than all other treatments. Similar results were reported by Singh *et al.* (2022) [15].

The effect clearly indicate that micronutrient application had a positive impact on the cost- benefit ratio also rose markedly from 1:2.73 in the T₁ control to 1:3.45 in T₉, showing that the additional investment was highly economical. Among treatments, T₆ (1:3.29) performed best after T₉, followed by T₈ (1:3.14) and T₅ (1:3.19), indicating that combined micronutrient sprays consistently enhanced economic efficiency over the control.

4. Conclusion

The result show that enhanced the vegetative growth, yield and parameters were obtained with foliar applications of various dosages of zinc sulphate and borax. The most effective combination is achieving maximum growth and yield of number T₉ (zinc sulphate @ 0.2% + borax @ 0.2 %) treatment and after that followed T₆ (zinc sulphate @ 0.1% + Borax @ 0.2 %) and the lowest result observed in treatment T₁(water spray).

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