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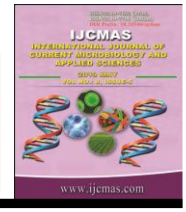

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Effect of Spray of Specific Concentration of Boron and Zinc on Growth, Yield and Quality of Tomato (*Solanum lycopersicum* Mill.)

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ABSTRACT

Keywords

Boron, Zinc, Micronutrients, Tomato, Fruit yield

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The experiment was conducted in Horticulture Garden of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during the year 2016-2017. The experiment was carried out in Factorial Randomized Block Design with sixteen treatments. The treatments were comprised of combination of four levels of both the micronutrients i.e., Boron (0 %, 0.2 %, 0.3 % and 0.4 %) and Zinc (0 %, 0.4 %, 0.5 % and 0.6 %). Overall, there were sixteen treatment combinations randomly allotted to different plots. Maximum plant height was observed with the application of treatment combination Zn3B0 (98.94 cm) at final harvesting followed by Zn3B3 (98.92 cm) and Zn3B2 (98.87 cm). The results showed that the use of Zn and B at specific concentration in the interactive treatment Zn_3B_3) considerably increased total yield up to 520.22q/ha

Introduction

Tomato (*Solanum lycopersicon* Mill.) is one of the most important vegetables belonging to the family Solanaceae and is one of the most widely grown vegetable across the world. South America is considered as the centre of origin of tomato. It was introduced in Indian subcontinent by the Europeans. India is a prime country in vegetable production by occupying the second position next to China and the production level of tomato in the country is next to potato. The production of tomato in India is about 18 million tones from an area of 0.8 million hectares (NHB). The well ripe tomato (per 100 g of edible portion) contains water (94.1%), energy (23 calories), calcium (1.0 g), magnesium (7.0 mg), vitamin A (1000 IU), ascorbic acid (22 mg), thiamin (0.09 mg), riboflavin (0.03 mg) and niacin (0.8 mg).

Various nutrients play an important role in enhancing the yield and quality of tomato fruits. Essential macro nutrient (N, P and K) and some micro nutrient such as (B, Cu and Zn) are very important for enzymatic reactions within plant body such as synthesis of RNA and DNA, protein synthesis, formation of cell wall, occurrence of flowering and fruiting, constituents of important growth hormones, while their deficiency affects growth and quality of plants. Boron plays a crucial role in improving the growth, yield and quality of tomato. At cellular level, it supports the development of cell wall, occurrence of cell division, formation of the vascular bundle, protein synthesis, root system development, fruit and seed formation, water relations and transport of sugar. Moreover, it is also encourages the uptake of calcium by plants.

Zinc is essential for synthesis of carbohydrates, protein metabolism and sexual fertilization, synthesis of nucleic acid and protein. It helps in seed production and maturation. It also helps in the utilization of phosphorus and nitrogen in plant. It is also essential for the synthesis of tryptophan, the precursor of Indole Acetic Acid (IAA). The deficiency of zinc causes shortened internodes due to non-availability of IAA. Considering the benefits of these micronutrients, an experiment was conducted with an objective to use Zn and B as foliar spray for improving the growth and quality parameters of tomato.

Materials and Methods

The experiment was conducted in the Horticulture Garden of Chandra Shekhar Azad University of Agriculture and Technology Kanpur (U.P.) during the year 2016-2017. Geographically, Kanpur is situated in the Gangetic plains of central U.P. It lies in altitude and longitude ranges between 25.28˚ to 28.50˚ North and 79.31˚ to 84.34˚ East at elevation of 125.90 m above sea level. Kanpur is characterized by the sub-tropical climate with hot dry summer and cold winters. The annual rainfall is about 800-850 mm. The major portion of rain is received between July and September, with scattered shower in winter from the North-East monsoon. The maximum temperature ranges from 24°C to 46°C and minimum 6.0°C to 24.8 °C with relative humidity from 32 to 99% in different months of the year. The experiment was laid out in Factorial Randomized Block Design with three replications on tomato variety 'Azad T-6'. Transplanting of Seedlings was done at a spacing of 45 x 30 cm and total 25 seedlings were accommodated in each plot. Immediately after transplanting, light watering with rose can was given to avoid transplanting shock. A total of 16 treatments using different concentration of each micronutrients *viz*., the treatment comprised combination of four levels of Boron (0 %, 0.2 %, 0.3 % and 0.4 %) and Zinc (0 %, 0.4 %, 0.5 % and 0.6 %).

Results and Discussion

Morphological characters

Height of plant at final harvesting (cm)

The plant height at final harvesting was influenced significantly by Zn and B concentrations. Effect of different concentrations of Zn and B on plant height has been presented in Table 2. The plant height was found maximum with Zn3 (98.76 cm) followed by Zn2 (97.74 cm), while, it was found minimum with Zn0 (93.96 cm). It was recorded maximum in B3 (98.56 cm) followed by B2 and B1 as 98.55 cm and 97.08 cm, respectively. While, minimum plant height was recorded in the treatment B0 (93.57 cm). B1, B2 and B3 concentrations were found at par when compared with each other. The treatment combination Zn3B0 showed maximum plant height (98.94 cm) at final harvesting followed by Zn3B3 (98.92 cm) and Zn3B2 (98.87 cm). The minimum plant height (86.30 cm) was recorded in Zn0B0 followed by Zn0B1 (93.00 cm) and

Zn1B0 (93.37 cm). These results are close agreement with Babu (2002), Hamsaveni *et al.,* (2003), Narayan *et al.*, (2007), Patil *et al.*, (2010), Haque *et al.*, (2011), Rab and Haq (2012) and Ali *et al.,* (2013) in tomato and Hatwar *et al.*, (2003) in chilli.

Number of primary branches per plant

Interactive effect of Zn and B was also found significant at 90 DAT. Effect of different concentrations of Zn and B on number of primary branches per plant at 90 days after transplanting has been presented in Table 1. Number of primary branches per plant at 30 days after transplanting was found maximum 8.27 with Zn3B3 treatment combination followed by Zn3B2 and Zn3B1 showed 8.21 and 8.13 primary branches, respectively. It was recorded minimum 4.85 in Zn0B0 (control) followed by Zn0B1 (7.32) and Zn0B2 (7.45) respectively (Table 1). Number of primary branches per plant at 60 days after transplanting was found maximum 12.08 with Zn0B3 followed by Zn0B2 and Zn3B1 i.e. 11.90 and 11.40 respectively. It was recorded minimum (7.80) in Zn0 B0 (control) followed by Zn1B0 (9.05) and Zn1B1 (9.52) respectively (Table 1). It was recorded maximum (13.39) with Zn2 followed by Zn3 (13.36) and Zn1 (13.04). It was recorded minimum in Zn0 i.e. 11.72. Zn1, Zn2 and Zn3 were found to be at par in this regard.

It was recorded maximum (13.44) with B3 followed by B2 (13.36) and B1 (13.06). It was recorded minimum in B0 i.e. 11.92. B1, B2 and B3 when compared with each others found to be at par. The interaction between Zn and B was also found to be significant. Interactive treatment Zn3B3 produced maximum (13.89) number of primary branches per plant at 90 days after transplanting which was followed by Zn3B2 (13.83) and Zn2B3 (13.56). It was recorded minimum 8.65 in Zn0B0 followed by 12.40 with Zn0B1.

Number of secondary branches per plant

Interactive effect of Zn and B was also found to significant at 90 DAT. At 30 and 60 stages analysis of variance were not analyzed. Only effects of each treatment regarding this object were observed (Table 1). Number of secondary branches per plant at 30 days after transplanting was found maximum (2.38) with Zn3B3 followed by Zn3B2 and Zn3B1 i.e. 2.31 and 2.22 respectively. It was recorded minimum (1.26) in Zn0B0 (control) followed by Zn0B1 (1.52) and Zn0B2 (1.87), respectively (Table 1). Number of secondary branches per plant at 60 days after transplanting was found maximum (8.33) with Zn3B3 followed by Zn3B2 and Zn3B1 i.e. 8.27 and 8.20, respectively. It was recorded minimum (5.65) in Zn0B0 (control) followed by Zn0B1 (7.45) and Zn0B3 (7.62) respectively. Number of secondary branches per plant at 90 days after transplanting was influenced significantly by Zn and B concentrations. Interaction of Zn and B concentrations was also found to be non-significant. Boron also significantly influenced the number of secondary branches per plant at 90 days after transplanting. It was recorded maximum (9.72) with B3 followed by B2 (9.67) and B1 (9.45) while minimum 9.11 in B0. B3 did not differ significantly when compared with B2 and B1. The interaction between Zn and B was found to be non-significant.

Interactive treatment Zn3B3 produced maximum (10.28) number of secondary branches per plant at 90 days after transplanting followed by Zn3B2 (10.18) and Zn3B1 (9.97). It was recorded minimum 8.15 in Zn0B0 followed by 8.98 with Zn0B1. Similar result was also reported by Patil *et al.*, (2008), Agrawal *et al.*, (2008), Ullah *et al.*, (2015), Yadav *et al.*, (2001) in tomato and Hatwar *et al.*, (2003) and Natesh *et al.*, (2005) in chilli.

Days to first flower initiation

Days to first flower initiation was influenced significantly by Zn and B concentrations. Interaction of Zn and B concentrations was also found to be significant. It is clear from the data given in Table 2 that the days to first flower initiation was significantly influenced by the Zn and B. Number of days taken to first flower initiation was highest (65.82 days) with Zn3 followed by Zn2 (65.31 days), whereas, it was minimum with Zn0 (63.01 days). Zn3 when compared with Zn2 and Zn1 it was found to be non-significant. Boron also significantly influenced the days to first flower initiation. It was recorded maximum (65.31 days) with B3 followed by B2 (65.24 days) and B1 (65.02 days). It was recorded minimum in B0 i.e. 63.47 days. The interaction of Zn and B was found to be significant. Interactive treatment Zn3B3 showed maximum 65.99 days to first flower initiation followed by Zn3B2 (65.95) and Zn3B1 (65.80 days). It was recorded minimum 58.73 days in Zn0B0 followed by Zn0B1 (64.01 days). It may be due to the application of zinc and boron, the plant growth was recorded significant and delayed the flowering in treated plots while the control has taken minimum days to flowering. Workers like Ali *et al.,* (2013) in tomato and Devi *et al.,* (2013) in chilli reported similar results.

Yield and quality characters

Fruit yield per plant (g)

The fruit yield per plant was influenced significantly by Zn and B concentrations. Interaction of Zn and B concentrations was found to be non- significant. It is evident from Table 2 that Zn and B significantly influenced the fruit yield per plant when compared with control Zn0. Maximum fruit yield was recorded in Zn3 (1145.11 g) followed by Zn2 (1118.73 g) and Zn1 (1104.44 g). Minimum fruit yield was observed in Zn0 (995.59 g). Fruit yield obtained with Zn3 did not differ significantly when compared among Zn1 and Zn2 respectively. Boron also influenced fruit yield and maximum yield per plant was recorded with B3 (1124.50 g) followed by B2 (1116.02 g) and B1 (1082.28 g), respectively. The minimum fruit yield per plant was recorded with B0 (1041.10 g). B1 was found significant over B0. Similarly, values of B2 over B1 and B3 over B2 did not differ significantly, whereas, B2 and B3 recorded significant variation when compared with control (B0) with this regard. The interaction of Zn and B was found to be non-significant. Interactive treatment Zn3B3 obtained maximum (1170.50 g) fruit yield per plant followed by Zn3B2 (1163.80 g) and Zn3B1 (1127.37 g). It was recorded minimum 849.27 g in Zn0B0 followed by Zn0B1 (984.99 g) respectively. Workers like Reddy and Reddy (1986), Yadav *et al.,* (2006), Patil *et al.,* (2008), Patil *et al.,* (2010), Haque *et al.,* (2011), Ali *et al.,* (2013) and Kesani *et al.,* (2013) also reported similar yield in tomato and Hatwar *et al.,* (2003) in chilli.

The fruit yield per hectare (q)

The fruit yield per hectare was influenced significantly by Zn and B concentrations whereas, interaction of Zn and B concentrations was found to be non-significant. Effect of different concentrations of Zn and B on fruit yield per hectare has been presented in Table 2. It is evident from Table 2 that Zn and B significantly influenced the fruit yield per hectare when compared with their controls. Maximum fruit yield was recorded in Zn3 (508.95q per hectare) followed by Zn2 (497.22q) and Zn1 (490.32q). Minimum fruit yield was observed in Zn0 (441.83q). Zn3 showed significant variation over Zn2 and Zn1 respectively but significant variation were recorded in all Zn treatments when compared with control (Zn0).

Table.1 Effect of spray of specific concentration of Boran and Zinc on Number of primary and secondary branches per plant at different stages

Treatments	Number of primary branches per plants at different stages			Number of primary branches per plants	Number of secondary branches per plants at different stages			Number of secondary branches per plants
	30 DAT	60 DAT	90 DAT		30 DAT	60 DAT	90 DAT	
Zn_0	4.85	7.8	8.65	11.70				8.90
Zn_1	7.81	9.05	12.58	13.04	1.89	7.78	9.16	9.35
Zn_2	7.88	10.46	13.11	7.88	1.99	7.88	9.33	9.65
Zn_3	7.98	10.71	12.32	13.36	2.06	8.01	9.81	10.06
S.E.(Diff) C.D. at 5%	0.383 0.78			0.383 0.78				0.161 0.33
B_0	4.85	7.8	8.65	11.92				9.11
B_1	7.32	11.4	12.4	13.06	1.52	7.45	8.98	9.45
B_2	7.45	11.9	12.83	13.36	1.87	7.68	9.23	9.67
B_3	7.58	12.08	12.98	13.44	1.94	7.62	9.25	9.72
S.E.(Diff) C.D. at 5%	0.383 0.78			0.383 0.78				0.161 0.33
Zn_1B_1	7.89	9.52	12.99	12.99	1.97	7.85	9.28	9.28
Zn_1B_2	7.93	9.96	13.27	13.27	2.05	7.98	9.47	9.47
Zn_1B_3	7.98	10.4	13.32	13.32	2.08	8.03	9.5	9.5
Zn_2B_1	7.97	10.68	13.35	13.35	2.11	7.97	9.59	9.59
Zn_2B_2	8.07	10.9	13.52	13.52	2.17	8.09	9.81	9.81
Zn_2B_3	8.1	10.98	13.56	13.56	2.23	8.17	9.85	9.85
Zn_3B_1	8.13	10.86	13.49	13.49	2.22	8.2	9.97	9.97
Zn_3B_2	8.21	10.98	13.83	13.83	2.31	8.27	10.18	10.18
Zn_3B_3	8.27	11.04	13.89	13.89	2.38	8.33	10.28	10.28
S.E.(Diff) C.D. at 5%				0.766 1.56				0.766 1.56

Table.2 Effect of spray of specific concentration of Boran and Zinc on Height of plant (cm), days to first flowering initiation, fruit yield per plant (g), and per hec (q) and TSS (brix)

Treatments	Height of plant at final harvesting (cm)	Days to first flower initiation	Fruit yield per plant (g)	Fruit yield per hectare (q)	Total soluble solid (Brix)
Zn_0	93.96	63.01	995.59	441.83	4.63
Zn_1	97.30	64.88	1104.44	490.32	4.96
Zn_2	97.74	65.31	1118.73	497.22	5.05
Zn_3	98.76	65.82	1145.15	508.95	5.12
S.E.(Diff) **C.D. at 5%**	1.097 2.240	0.617 1.26	27.318 55.81	10.707 21.87	0.104 0.21
B_0	93.57	63.47	1041.10	462.72	4.66
B_1	97.08	65.02	1082.28	480.36	4.93
B_2	98.55	65.25	1116.02	495.45	5.07
B_3	98.56	65.31	1124.50	499.78	5.09
S.E.(Diff) **C.D. at 5%**	1.097 2.240	0.617 1.26	27.318 55.81	10.707 21.87	0.104 0.21
Zn_1B_1	98.54	64.89	1100.39	489.06	4.96
Zn_1B_2	98.62	64.97	1112.42	492.19	5.03
Zn_1B_3	98.65	65.06	1116.70	496.31	5.06
Zn_2B_1	98.03	65.30	1116.39	496.17	4.99
Zn_2B_2	98.39	65.41	1123.93	499.52	5.13
Zn_2B_3	98.43	65.50	1126.62	500.72	5.15
Zn_3B_1	98.75	65.80	1127.37	501.05	5.10
Zn_3B_2	98.87	65.95	1163.80	517.24	5.19
Zn_3B_3	98.92	65.99	1170.50	520.22	5.22
S.E.(Diff) **C.D. at 5%**	2.193 4.480	1.234 2.25	54.636 N.S.	21.414 N.S.	0.209 N.S.
Zn_0					

Boron also increased fruit yield and maximum yield per hectare was recorded with B3 (499.78 q per hectare) followed by B2 (495.45q) and B1 (480.36q), respectively. The minimum fruit yield was recorded with B0 (462.72q). Per hectare yield of treatment B3 and B2 recorded significant variation over control barring B1 treatment. The interaction of Zn and B was found to be non-significant. Interactive treatment Zn3B3 obtained maximum fruit yield per hectare 520.22q followed by Zn3B2 (517.24q) and Zn3B1 (501.05q). It was minimum 377.45q in Zn0B0 followed by Zn0B1 (435.17q) respectively. Findings are in with the reports of Babu (2002), Das and Patro (1989), Singh and Verma (1991), Bhat and Prasad (2004), Bokade *et al.,* (2006), Yadav *et al.,* (2006), Meena (2008), Patil *et al.,* (2008), Mishra *et al.,* (2012), Sarangthem *et al.,* (2015) in tomato and Karuppaiah (2005) in brinjal.

Total soluble solid (Brix)

The total soluble solid was influenced significantly by Zn and B concentrations. Interaction of Zn and B concentrations was found to be non- significant. It is clear from Table 2 that Zn and B concentrations significantly influenced the total soluble solid over their controls. Maximum total soluble solid was recorded in Zn3 (5.12°Brix) followed by Zn2 (5.05°Brix) and Zn1 (4.96°Brix). The minimum total soluble solid was observed in Zn0 (4.63°Brix). Zn3 did not show significant variation when compared among Zn2 and Zn1, respectively. Whereas, significant variations were observed in all Zn treatments i.e. Zn1, Zn2 and Zn3 over control (Zn0). Boron also increased total soluble solid and maximum total soluble solid was recorded with B3 (5.09°Brix) followed by B2 (5.07°Brix) and B1 (4.93°Brix), respectively. The minimum total soluble solid was recorded with B0 (4.66°Brix). B3 was noted non-significant value in this regard over B2 and B1, respectively. Whereas, all boron treatments such as B1, B2 and B3 had presented significant variations over control (B0). The interaction between Zn and B was found to be non-significant. Interactive treatment Zn3B3 obtained maximum total soluble solid 5.22°Brix followed by Zn3B2 (5.19°B) and Zn2B3 (5.15°Brix). It was recorded minimum in Zn0B0 (3.97°Brix) followed by Zn0B1 (4.68°Brix). Similar results were reported by Paithankar *et al.,* (2004), Patil *et al.,* (2010), Salam *et al.,* (2010), Ejaz *et al.,* (2011), Kumari (2012), Rab and Haq (2012) and Harris and Vellupillai (2015) in tomato.

It is concluded that plant height, number of primary branches per plant, number of secondary branches per plant, spread of tomato plant, number of fruits per plant, diameter of fruit, weight of fruit, fruit yield per plant, fruit yield per hectare, total soluble solid, ascorbic acid content were increased with the application of boron at 0.4%, zinc at 0.6%. On the other hand, days to first flower initiation was recorded minimum in control. Titrable acidity of fruits were increased with the application of zinc and decreased with the application of boron and maximum acidity was observed in B0 (control). Interactive treatment Zn3B3 also maximized every attributes of tomato except acidity. Interactive treatment Zn3B0 revealed maximum titrable acidity. From above scenario of result, B3 (0.4%) and Zn3 (0.6%) produced maximum significant values of every growth, yield and quality attributes of tomato. So, it is advised to research workers and vegetable growers of Central Uttar Pradesh that for obtaining optimum yield with better quality, spraying with 0.4% boron and 0.6% zinc is recommended.

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