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Short Research Article

Improvement of Growth, Yield and Quality of Tomato (*Solanum lycopersicum* L.) cv. Azad T-6 with Foliar Application of Zinc and Boron

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Abstract

The present investigation was conducted to find out the response of zinc and boron on improvement of growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Azad T-6. The experiment was layout in Randomized Block Design with three replication and 12 treatments. Treatment combinations are T_0-Control (water spray), T_1-Zinc (50 ppm), T_2-Zinc (100 ppm), T_3-Zinc (150 ppm), T_4-Boron (50 ppm), T_5-Boron (100 ppm), T_6-Boron (150 ppm), T_7-Zinc (50 ppm)+Boron (50 ppm), T_8-Zinc (100 ppm)+Boron (100 ppm), T_9-Zinc (150 ppm)+Boron (150 ppm), T_{10}-Zinc (100ppm)+Boron (50 ppm), T_{11}-Zinc (150 ppm)+Boron (50 ppm). It was found that the vegetative growth in terms of plant height and number of branches at various stages (30, 60 and 90 Days after transplanting) was greatly influenced by the application of micronutrients Zn and B. Among them treatment T_5-Boron (100 ppm) significantly increased the plant height (61.23 cm at 90 DAT) and number of branches (16.17 plant^{-1} at 90 DAT) compared to others. Whereas, application of zinc and boron each at 100 ppm (T_8) caused early flowering (31.95 DAT) as well as showed maximum number of flowers (75.21) and fruit yield (93.10 t ha^{-1}). It was also revealed that the treatment T_8 improved the physico-chemical qualities of tomato fruits specially improved the TSS:acid ratio (10.98). Thus, the study indicated that application of boron and zinc either solely or in combination is quite beneficial for vegetative growth, flowering and fruiting as well as quality improvement of tomato fruits (Azad T-6) grown under high pH soil (pH 8.2) of Lucknow.

1. Introduction

Tomato (*Solanum lycopersicum* Syn. *Lycopersicon esculentum* Mill.) might be originated from the Nahautl word "tomatl" meaning "the swelling fruit" and first mentioned in writing in 1595 and cultivated by Aztices and Incas in the early 700 AD (Roberts, 2014). Tomatoes are being used as vegetables, in sandwiches, salads and processed products like soup, sauce, juice, ketchup and drinks etc. It is a good source of potassium, vitamin A (β-Carotene) and vitamin C which helps in developing resistance against infectious agents and scavenga harmful free radicals. Tomato is one of the low calorie vegetables containing just 18 calories 100 g^{-1}. Tomatoes have been linked with reduced risk of some neurological diseases and have anti-cancer benefit. Tomatoes are also the excellent source of antioxidants, diet oxidants, dietary fiber, minerals and vitamins which are helpful for protecting cancers including colon, prostate, breast, endometrial lung and pancreatic tumors. It also contains very good levels of vitamin A and flavonoid anti-oxidants such as α and β carotenes, xanthenes which take part in vision maintain healthy mucus membranes, skin and bone health. Consumption of natural vegetables and fruit rich in flavonoids is known to help protect from lung and oral cavity cancers. Thus, tomato is an excellent crop for human consumption. The crop tomato requires good amount of nutrients for its growth and development. It is well responsive to micronutrients also. Micronutrients are required by plants in very small quantities, yet they are very effective regulating plant growth due to enzymatic action (Sathya et al., 2010). The micronutrients improve the chemical composition of fruits and general condition of plants and are known to acts as catalyst in promoting organic reaction taking place in plants (Sivaiah et al., 2013). Some micronutrients like Zinc, Iron, Manganese, Copper, Boron and Magnesium have an important role in the physiology of tomato crop and are required for plant activities such as aspiration, meristamatic development, chlorophyll formation, photosynthesis, gossypol, tannin and phenolic compounds development. For harnessing the higher

yield potential, supplementation of micronutrients is essential. Applications of micronutrients using zinc and boron have been reported in increasing seed yield in tomato (Sivaiah et al., 2013).

2. Materials and Methods

The experiment was conducted at Horticulture Research Farm of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow (U.P), during the year 2013-2014. The experiment was laid out in Randomized Block Design with three replication and 12 treatments. Treatment combinations were, T_0-Control (water spray), T_1-Zinc (50 ppm), T_2-Zinc (100 ppm), T_3-Zinc (150 ppm), T_4-Boron (50 ppm), T_5-Boron (100 ppm), T_6-Boron (150 ppm), T_7-Zinc (50 ppm)+Boron (50 ppm), T_8-Zinc (100 ppm)+Boron (100 ppm), T_9-Zinc (150 ppm)+Boron(150 ppm), T_{10}-Zinc (100 ppm)+Boron (50 ppm), T_{11}-Zinc (150 ppm)+Boron (50 ppm).

The plant materials were collected 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 cm^2. The plants were under regular monitoring with proper irrigation, weeding and recommended fertilizers (NPK) were applied to all plants. The micronutrients were procured and applied as foliar spray as per treatment starting from 30 days after transplanting. A total of three sprays were given at an interval of 15 days i.e. at 30, 45 and 60 days after transplanting (DAT). The observations were made regularly on vegetative growth, fruiting yield and quality of fruits. The observations on plant height, number of branches were recorded at 30, 60 and 90 DAT. First flower opening after transplanting was recorded in each treatment to get the earliness in bearing. Total number fruit cluster, flower number, number of fruits etc. were also counted. The fruit quality in terms of physical characters (fruit length, diameter, weight, pericarp thickness) and chemical characters like-TSS, acidity, sugars, vitamin C etc. were determined by following the standard procedures (AOAC, 2000). The data was statistically analyzed following the methods as stated by Panse and Sukhatme (1985) with analysis of variance at 5% level of significance.

3. Results and Discussion

Table 1 showed that plant height was significantly increased with the application of various micronutrients on tomato at 60 and 90 DAT. However, at 30 DAT the increase was not statistically significant, that might be because of late response of crop to the treatment and as the micronutrient were applied at 30 DAT as first spray. At the later stage of growth, it was revealed that plant height was increased with treatment T_5 (Boron 100 ppm) and recorded maximum height 41.05 cm and 61.23 cm at 60 DAT and 90 DAT, respectively. All though, effect of micronutrient on the number of branches $plant^{-1}$ was found statistically non-significant at all the stages of crop growth, but all the treatments increased the number of branches per plant over control. However, application of Boron (T_5) was found better among the treatments and produced maximum branches $plant^{-1}$ (9.17, 12.72 and 16.17 at 30 60 and 90 DAT, respectively).

Patil et al. (2008) also reported the similar trend. They observed that among the various treatments the foliar application of micro-nutrients, boric acid @ 100 ppm resulted in maximum plant height (79.17 cm), followed by the best treatment the mixture of micro-nutrients (B, Zn, Mn and Fe @100 ppm and Mo @ 50 ppm). It was also found by Sathya et al. (2009 and 2010) who reported that among the various levels of application of boron, borax @ 20 kg ha^{-1} recorded maximum number of branches and 0.25% borax spray produced taller plants with more no. of branches. Similar result has also been reported by Kumar et al. (2009) in okra. Similar trend was also found by Meena et al. (2014); Singh et al. (2014); Kashyap et al. (2014); Parihar et al. (2014); Kumar et al. (2014) while experimenting on tomato, broccoli and brinjal, stevia and radish reported better vegetative growth with bio-fertilizers and organic manures and they explained that bio-fertilizers and organic manures improve the soil nutrient along with micro nutrient status and thus increases the vegetative growth of crops. Maji and Das (2008) also suggested that organic amendments improve soil nutrient availability to the plants and increased growth and development.

It was also observed that micronutrient (Zn and B) induced earliness in flowering (Table 1). The control plants showed flowering at late (39.73 DAT) as compared to others treated with micronutrients. Significantly, the plants under treatment T_8 look the minimum days (31.95 DAT) to produce flowers followed by T_9 and T_5. Similarly, T_8 also produced maximum number of flowers (75.21 $plant^{-1}$) and flower cluster $plant^{-1}$ (6.48) as compared to the other treatments. As a result, the highest number of fruits $plant^{-1}$ (45.64) was recorded under treatment T_8. Accordingly, fruit yield was obtained maximum in the plants treated with Zinc (100 ppm)+Boron (100 ppm) (T_8) (2.51 kg $plant^{-1}$, 22.62 kg $plot^{-1}$ and 93.10 t ha^{-1} respectively). The improvement of yield is also associated with better flowering as recorded in the present investigation. Yadav et al. (2001) also found the improvement in flowering with application of zinc and boron. The result corroborated with the finding of Singh and Tiwari (2013). They found increase in maximum number of flowers $plant^{-1}$, number of fruits $plant^{-1}$ and fruit yield with the application of (boric acid+zinc sulphate+copper sulphate @ 250 ppm each). Similar trend was

Table 1: Effect of zinc and boron on growth, flowering, fruiting and yield of tomato

Treatments	Plant height (cm)			Number of branches plant^{-1}			Day of first flowering	Flowers plant^{-1}	Flower cluster plant^{-1}	Fruit plant^{-1} (kg)	Fruit yield plant^{-1} (kg)	Fruit yield plot^{-1} (kg)	Fruit yield ha^{-1} (t)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT							
T_0	22.97	34.87	53.27	6.72	9.78	13.28	39.73	38.45	3.00	26.25	0.93	8.38	34.47
T_1	25.88	40.19	59.51	8.39	11.61	15.33	38.41	46.43	5.58	30.10	1.30	11.68	48.07
T_2	24.57	38.56	58.24	8.33	11.72	15.61	36.54	51.24	5.33	32.41	1.24	11.12	45.76
T_3	25.88	40.97	59.01	9.00	11.94	15.61	34.38	58.17	5.18	40.50	1.60	14.40	59.26
T_4	25.26	39.68	58.86	8.39	11.61	15.33	35.17	61.75	5.13	36.64	1.58	14.19	58.40
T_5	26.39	41.05	61.23	9.17	12.72	16.17	34.27	68.21	5.79	42.17	1.60	14.37	59.14
T_6	25.91	40.40	60.85	8.89	11.94	15.44	36.12	70.87	4.34	35.06	1.47	13.27	54.62
T_7	25.45	39.74	59.36	8.50	11.89	15.72	34.69	65.04	3.67	44.27	1.66	14.95	61.53
T_8	25.99	40.63	60.55	8.83	11.83	15.83	31.95	75.21	6.48	45.64	2.51	22.62	93.10
T_9	25.08	39.11	59.20	8.44	11.67	15.56	34.10	73.10	5.27	41.36	1.71	15.37	63.27
T_{10}	24.24	39.20	58.53	7.78	11.00	15.06	37.43	59.22	4.43	38.83	1.74	15.66	64.43
T_{11}	24.37	38.92	58.39	7.17	10.61	14.67	37.13	63.10	3.47	40.29	1.50	13.48	55.46
SEm±	3.850	1.046	1.910	1.780	1.939	1.795	0.577	3.128	0.622	4.728	0.316	2.842	11.693
CD (p=0.05)	NS	2.17	5.50	NS	NS	NS	1.58	6.49	1.29	9.80	0.65	5.89	24.25

also been reported by Kumar et al. (2009) in okra. Fruit yield plant^{-1} depends upon the number of fruits and weight of fruits. These both the characters are higher in treatment of mixture of micro-nutrients for that the yield plant^{-1} was higher in T_8. It was noticed (Table 2). that the fruit size in term of length and diameter was insignificantly affected by the application of Zn and B alone or in combination. The fruit diameter was maximum (3.89 cm) with treatment T_8 whereas, length was maximum (4.22 cm) under treatment T_5. Interestingly, fruit weight was significantly improved by the application

Table 2: Effect of zinc and boron on fruit quality of tomato

Treatments	Fruit		Avg.fruit weight (g)	Locules-fruit^{-1}	Pericarp thick. (cm)	Titratable acidity (%)	TSS (°Brix)	Ascorbic acid (mg 100 g^{-1})	TSS: acid ratio	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)
	Dia (cm)	Length (cm)										
T_0	3.39	3.72	35.50	4.73	0.45	0.58	2.97	22.23	5.12	2.57	1.91	0.66
T_1	3.46	3.84	43.33	5.60	0.51	0.49	3.90	24.06	7.96	2.81	2.00	0.81
T_2	3.43	3.83	37.93	5.73	0.47	0.48	4.17	27.63	8.69	2.90	2.40	0.50
T_3	3.62	3.99	39.07	5.60	0.50	0.52	3.68	22.79	7.08	3.00	2.38	0.62
T_4	3.61	3.91	42.33	5.40	0.47	0.50	4.23	23.02	8.46	3.25	2.68	0.57
T_5	3.62	4.22	37.47	5.47	0.55	0.45	4.75	26.17	10.56	3.83	2.99	1.55
T_6	3.54	3.80	41.97	5.00	0.45	0.56	4.30	26.41	7.68	3.37	2.09	1.28
T_7	3.69	4.04	37.20	5.47	0.48	0.49	4.30	25.11	8.78	3.27	2.28	0.47
T_8	3.89	4.00	54.97	6.27	0.45	0.46	5.05	27.02	10.98	3.93	2.80	0.94
T_9	3.46	3.94	41.30	5.13	0.51	0.51	4.60	23.13	9.02	3.40	2.76	0.64
T_{10}	3.61	4.01	44.40	5.40	0.48	0.53	4.53	24.80	8.55	2.80	2.01	0.79
T_{11}	3.48	4.00	37.47	5.13	0.49	0.50	3.77	25.43	7.54	3.30	2.36	0.94
SEm±	0.266	0.252	2.530	0.533	0.070	0.057	0.500	2.728	0.512	.301	0.277	1.500
CD (p=0.05)	NS	NS	7.80	NS	NS	NS	1.12	NS	1.13	.610	0.58	NS

of micronutrients like Zn and B. The fruit with the highest weight were obtained from the plant treated with Zinc 100 ppm+Boron 100 ppm (T_8). This increase might be due to greater accumulation of carbohydrates owing to greater photosynthesis which caused the fruit to increase in length.

The result on average fruit weight has been presented in (Table 2). indicated that the application of mixture of all micronutrients T_8 have maximum fruit weight (54.97 g) as compared to the minimum (35.50 g) in control. This increase in fruit weight might be assigned to mixture of all, since by its characteristics virtue (cell elongation) it has promoted the growth of all vegetative parts and consequently more food material for fruit development was produced by such plants and fruits with higher weight were obtained. The increasing fruit weight as results mixture of all application has also been obtained by Kumar et al. (2009) in okra.

The treatment effect was found non-significant regarding locule number and pericarp thickness of fruits, however, maximum locule (6.27) and pericarp thickness (0.55 cm) were recorded under the treatment T_8 and T_5, respectively. Similarly titra table acidity was found the lowest (0.46%) and maximum vitamin C (27.02 mg ascorbic acid 100 g^{-1} edible part) under treatment T_8 comparison to other treatments. However, the treatment effects were found statistically at par, the application of zinc and boron improved ascorbic acid contain in fruits better than control. Singh and Tiwari (2013) also reported that maximum T.S.S. and ascorbic acid were found with the application of boric acid+zinc sulphate+copper sulphate @ 250 ppm each. It is clear from present finding that T_8 showed maximum total sugar (3.93%) content in fruits, significantly superior over control (2.57%). Salam et al. (2011) also found the similar result whereas, Sathya et al. (2010) reported that application of boron improved the quality of PKM-1 tomato fruit as well as growth and yield.

5. Conclusion

Foliar application of boron and zinc @ 100 ppm each was found to be the best treatment to improve growth, yield and fruit quality of tomato cv. Azad T-6 under Lucknow subtropical condition having high soil pH.

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