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Influence of foliar application of micronutrients on growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Bargad

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ABSTRACT

An investigation was undertaken to study the influence of foliar application of micronutrients on growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. *Bargad* during *kharif* 2016 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India. It indicated that the maximum plant height plant girth (3.20) and minimum days to first flowering (24.29), first fruiting (35.33) and days to maturity (63.33) was recorded in T_5. Equally maximum numbers of fruits per plant (72.07), fruit length (5.66 cm), fruit diameter (4.77 cm), fruit weight (80.06 g), yield per plant (4.77 kg) and fruit yield per ha (562.57 q) was recorded in T5. In quality traits also this treatment (T_5) exhibited more shelf life (16.63 days), the maximum T.S.S (5.25 %), acidity (0.42 %), reducing (1.68 %), non-reducing (2.00 %), total sugar (3.63 %) and ascorbic acid content (19.94 mg). This treatment had the maximum net return (₹ 138528 ha^{-1}) and B:C Ratio 3.08 : 1 out all other treatments than over control.

Key words: Growth, micronutrients, quality, tomato, yield

INTRODUCTION

Vegetables are considering potential crops for improving nutrition, food security and also to generate employment in the country. Globally, vegetables are recognized as "protective foods" since they supply adequate quantities of vitamins, minerals, organic acids, folic acids, essential amino acids, dietary fibers, carbohydrates, have anti-carcinogenic and antioxidant properties. India is bestowed with varied favorable agro climatic zones and soils, makes it feasible to grow the largest number of vegetable crops in the world, all the year round and is regarded as a "Horticulture Paradise" (Saravaiya and Patel, 2005). As many as 61 annual and 4 perennial vegetable crops belonging to different groups are commercially cultivated in India. In India vegetables occupy an area of 9.40 million hectare (ha) with a production of 162.90 million tonne (t) and stands at second position in the world next only to China (Anonymous, 2015). However, the major concerns are low productivity, diminishing return from farming as a whole and lack of awareness among the vegetable growers regarding scientific crop management and quality product (Chattopadhyay et al., 2007).

Tomato (*Solanum lycopersicum* L.) is one of the most palatable vegetables which usually occupies the maximum number of our daily dishes and also takes its possession in market. Besides as rich source of vitamins and minerals Tomato contains lycopene pigment which is a vital anti-oxidant that helps to fight against cancerous cell formation as well as other kind of health complications and diseases (Kumavat and Chaudhari, 2013). A single tomato can provide 40 % of the daily requirement of Vitamin C and is a rich source of Vitamin K which plays a major role in blood clotting.

The productivity of tomato in India is quite low (18.7 t ha^{-1}) mostly due to the deficiencies of soil micronutrients that occurs because of intensive cropping, decreased availability and use of organic matter and imbalanced fertilization. Tomato being a heavy feeder and exhaustive crop removes substantial amounts of micronutrients from soil. To maintain sustainability in its production and nutritive value, it is becoming essential to apply micronutrients through foliar spray to meet the immediate need of the crop (Agarwal and Rao, 2000). The micronutrients like boron, zinc, copper and iron, if applied through foliar can also improve the vegetative growth and yield of tomato (Arora et al.,1982).

Micronutrients like Zinc, Iron, Manganese, Copper, Boron and Magnesium have an important role in the physiology of tomato crop and are required for physiological activities. (Azeem and Ahmed, 2011). Considerable research work has been done on the aspect of foliar application of micronutrient in different crops and the experimental results indicated not only increase in yield up to 20 per cent but also helpful to sustain crop production. Arora et al. (1979) reported that micronutrients like boron, copper, molybdenum and zinc through foliage can also improve the vegetative growth, fruit set and yield of tomato. Working with tomato, Mallick and Muthukrishnan (1980) reported that the role of micronutrients in the "nutrient element balance" of the plant is of considerable interest.

Looking at the importance of the crop, future scope and heavy demand of tomato fruits for the domestic as well as export business and for processing industry, a field trial of ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India during the kharif 2016 to assess the influence of foliar application of micronutrients on growth, yield and quality parameters related traits.

MATERIALS AND METHODS

A field experiment was conducted at the Regional Horticultural Research Station (RHRS) of Navsari Agricultural University (NAU), Navsari, Gujarat, India (20° 57' North latitude and 72° 54' East longitude) to study the effect of foliar application of micronutrients on the growth parameters, yield and quality of tomato (*Solanum lycopersicum* L.). The experimental site comes under the South Gujarat Heavy Rainfall Agro-climatic Zone, which has tropical climate with average annual rainfall of 1500 millimeters (mm). The field trial was conducted during *kharif* 2016 in the protected condition under natural ventilated polyhouse (NVPH), whereas, the laboratory work was undertaken in the Department of Post-harvest Technology, ASPEE College of Horticulture and Forestry, NAU, Navsari.

Tomato variety was transplanted during *kharif* and the crop was grown with the standard agronomic package of practices. The experiment was laid out in randomized block design with seven treatments (Table 1) and three replications. The source of micronutrients *viz.*, B, Zn, Cu, Fe and Mn were boric acid (0.1 %), zinc sulphate (0.25 %), copper sulphate (0.25 %), ferrous sulphate (0.25 %) and manganese sulphate (0.25 %), respectively. However, for the treatment T_7, general grade 1 % (Fe 5 %, Mn 2.5 %, Zn 3.5 %, Cu 1 %, B 0.65 %, and Mo 0.30 %) was used. Total three sprays of micronutrients were given at an interval of 20 days, starting from 40 days after transplanting.

Observations on different traits were recorded at different period of crop growth by using different methodologies. Plant height (m) was measured from ground level to tip of the main shoot at last picking with the help of meter tape, whereas, the leaf area was measured by leaf area meter (image analyzer). The number of days taken from the date of sowing to date on which first flower appeared in each plot were recorded as days to first flowering. The number of days from the date of transplanting to date on which 50 per cent of the plants flowered was recorded as days to 50 per cent flowering. The number of clusters bearing fruits was counted from the tagged plants and the average number of fruits per cluster was recorded and calculated at the final harvest. The first picking of fruit was started at breaker stage of maturity. The days to first picking

were counted from the date of transplanting to date of first harvest of fruit. Total number of fruits of all the randomly selected and tagged five plants and the average per plant was worked out. The days to last picking were counted from date of transplanting to date of last picking and the randomly selected five fruits were cut horizontally and number of locules were counted and recorded. The total number of fruits from five randomly selected plant were weighed and the average fruit weight was worked out and expressed in grams. Total weight of fruits of the five randomly selected plants was recorded and the average yield of fruits per plant was worked out in kilogram (kg) by summing up of all the pickings. The fruits harvested from each net plot were weighed separately and recorded in kilogram (kg) at each picking. The final fruit yield was obtained by summing up the yield of all the picking and convert into meter square basis.

RESULTS AND DISCUSSION

Influence on vegetative parameters

The results obtained under the vegetative parameters like plant height and leaf area (Table 1) were accentuated and significantly prejudiced by different foliar application of micronutrient under protected culture in the present study. The robust vegetative growth is an essential prerequisite for better yield. The higher plant height (3.61 m) was recorded in the treatment T_7 consisting of combination of RDF + general grade (1%) which was statistically at par with treatments of T_3, T_2 and T_5, T_6 and T_4. Whereas, the lowest plant height (2.85 m) was recorded in the treatment T_1 that did not receive any micronutrient application. The leaf area (cm^2) obtained under different treatments was varied from 730.84 to 761 cm^2 with the higher leaf area (761 cm^2 in the treatment T_7 involving the combinations of RDF and general grade 1 % closely followed by T_6 (754 cm^2) and both were statistically at par with other. Research results pertaining to about vegetative characters as a consequence of foliar application of micronutrients might be due to the improvement in photosynthesis and other metabolic activity which leads to an increase in several plant metabolites responsible for cell division and elongation (Hatwar et al., 2003). The synergetic influence of Zn with P which may serve as a source of energy for the synthesis of auxin in the presence of Zn. Enhanced photosynthetic reaction in the presence of zinc and boron was also reported by Mallick and Muthukrishnan (1979) and explained that presence of zinc activates the synthesis of tryptophan, which is precursor of IAA and it is responsible to stimulate plant growth. Iron plays an important role in promoting growth characters, being a component of ferredoxin, an electron transport protein and is associated with chloroplast. It helps in photosynthesis might have helped in better vegetative growth (Hazra et al., 1987).

The positive Influence of micronutrients on vegetative characters have also been reported by Bose and Tripathi (1996) and Hooda et al. (1984) in tomato. Similarly, other scientists also reported that micronutrients had positive role in improving vegetative growth

Influence on reproductive parameters

Results on different reproductive parameters *viz.*, days to first flowering, days to fifty percent flowering, number of fruits per cluster and no. of locules per fruits (Table 1) and were significantly influenced by different foliar application of micronutrient under the present study.

The minimum days to first flowering (27.33 days) was noticed from the treatment T_7 involving the combinations of RDF + general grade 1 % which was statistically at par with the treatment T_5. In contrast the maximum days to first flowering (38.67 days) was observed under the treatment T_1 (only RDF), the lowest days to 50 % flowering (30.67 days) was achieved from the treatment T_7 which was statistically similar with the treatments T_5 and T_6. However, the maximum days to 50 % flowering (41 days) was observed under the treatment T_1 which indicated the effect of micronutrients in inducing early flowering.

Table 1. Influence of foliar application of micronutrients on growth parameters and yield of tomato

Treatments	Treatments Details	Plant height (m)	Leaf area (cm^2)	Days to first flowering	Days to 50% flowering	No. of fruits per cluster	No. of locules per fruit
T_1	RDF [N:P: K 250:125:125 kg ha^{-1}]	2.85	730.84	38.67	41.00	3.80	2.07
T_2	T_1+ Boric acid (0.1%)	3.22	736.84	36.33	38.67	3.50	2.77
T_3	T_1+ Zinc sulphate (0.25%)	3.35	741.00	35.00	37.67	3.70	2.13
T_4	T_1 + Copper sulphate (0.25%)	3.10	742.00	34.67	37.67	3.67	2.47
T_5	T_1+ Ferrous sulphate (0.25%)	3.21	744.17	31.00	34.67	3.87	2.50
T_6	T_1+ Manganese sulphate (0.25%)	3.15	754.00	33.33	36.00	3.47	2.33
T_7	T_1+ General grade 1% (Fe 5 %, Mn 2.5%, Zn 3.5%, Cu 1%, B 0.65%, Mo 0.30%)	3.61	761.00	27.33	30.67	4.67	3.07
	S.Em. ±	0.13	5.34	1.80	1.86	0.21	0.19
	C.D. at 5%	0.41	16.45	5.55	5.73	0.66	0.58
	C.V. %	7.26	6.24	9.24	8.80	9.76	13.26

Table 2. Influence of foliar application of micronutrients on fruit quality of tomato

Treatments	Treatments Details	Pericarp thickness (mm)	Equatorial diameter (cm)	Polar diameter (cm)	Fruit texture kg cm^{-2}	Shelf life (days)	Total soluble solids (^{0}Brix)	Ascorbic acid (mg 100 g^{-1})	Lycopene content (mg 100 g^{-1})	No. of fruits per plant	Fruit yield per plant kg m^{-2} (kg)	Marketable fruit yield
T_1	RDF [N:P: K 250:125:125 kg ha^{-1}]	5.33	4.67	5.47	2.67	13.00	3.00	11.83	4.12	34.67	3.10	8.85
T_2	T_1+ Boric acid (0.1%)	6.17	6.33	6.67	3.67	16.33	4.00	12.83	4.32	45.00	4.37	12.26
T_3	T_1+ Zinc sulphate (0.25%)	6.07	6.50	6.83	3.67	16.00	4.33	12.10	4.20	39.00	3.80	10.63
T_4	T_1 + Copper sulphate (0.25%)	5.74	6.23	6.17	3.67	16.00	4.00	12.50	4.14	35.00	3.35	9.41
T_5	T_1+ Ferrous sulphate (0.25%)	5.67	6.30	6.37	2.33	15.67	3.67	13.00	4.20	36.33	3.61	10.10
T_6	T_1+ Manganese sulphate (0.25%)	6.23	6.20	6.50	3.33	15.67	3.67	13.50	4.14	36.67	3.57	10.00
T_7	T_1+ General grade 1% (Fe 5 %, Mn 2.5%, Zn 3.5%, Cu 1%, B 0.65%, Mo 0.30%)	8.00	6.83	7.63	4.00	16.67	4.33	14.17	5.01	53.67	5.48	14.56
	S.Em. ±	0.50	0.39	0.29	0.30	0.67	0.26	0.87	0.18	1.72	0.27	0.78
	C.D. at 5%	1.54	1.19	0.89	0.94	2.05	0.79	2.68	0.55	5.29	0.83	2.42
	C.V. %	14.02	10.86	7.71	15.81	7.39	11.55	11.73	7.12	7.42	11.99	12.55

The higher number of fruits per cluster (4.67) was recorded in treatment T_7 which was found to be statistically at par with T_5, whereas, the minimum numbers of fruits per cluster (3.47) was observed under the treatment T_6 (T_1+ Manganese sulphate (0.25%).

The lower days to first picking (60 days) was realized from the treatment T_7 containing the combinations of RDF + General grade 1 % which was statistically at par with T_5. The maximum days to first picking (76) was observed under the treatment T_1 (RDF N: P: K 250:125:125 kg ha^{-1}).

The maximum number of fruits per plant (53.67) was achieved in the treatment of T_7 which were statistically at par with the treatment T_2. The minimum number of fruits per plant (34.67) was observed under the treatment T_1.

The results shown in the Table 8 indicated that the Influence of foliar application of micronutrient was found to be non-significant for days to last picking.

The higher number of locules per fruit (3.07) was achieved from the treatment T_7 consisting the combinations of RDF + General grade 1 % which was statistically at par with the treatments T_2, T_4 and T_5. The minimum no. of locules per fruit (2.07) was observed under the treatment T_1.

Improvement in reproductive characters as a result of foliar application of micronutrients might be due to the enhancement in photosynthesis and other metabolic activity which led to an increase in various plant metabolites responsible for cell division and elongation (Hatwar et al., 2003). The synergetic Influence of Zn with P which may serve as a source of energy for the synthesis of auxin in the presence of Zn. Enhanced photosynthetic reaction in the presence of zinc and boron was also reported by Mallick and Muthukrishnan (1979) explained that presence of zinc activates the synthesis of tryptophan, which is precursor of IAA and it is responsible to stimulate plant growth. Iron plays an important role in promoting growth characters, being a component of ferredoxin, an electron transport protein and is associated with chloroplast. It helps in photosynthesis might have helped in better reproductive characters (Hazra et al., 1987). According to Grewal and Trehan (1979) manganese increases the chlorophyll content and the photosynthetic efficiency and helps translocation of food. Dry matter accumulation in plant is a function of photosynthates produced, which mainly depends on photosynthesis. Thus, application of micronutrients might have resulted in more production of photosynthates and their translocation for dry matter accumulation. The positive Influence of micronutrients on reproductive parameters have also been reported by Bose and Tripathi (1996) and Hooda et al. (1984) in tomato. Similarly, other scientists also reported that micronutrients had positive role in improving reproductive traits.

Influence on yield parameters

Both the yield attributes *viz.*, fruit yield per plant (Table 2) total fruit yield per m^2 (Table 23) and marketable fruit yield per m^2 (Table 2) were significantly influenced by the application of different treatments of foliar application treatments of micronutrient. Average fruit weight was found non-significant. Results clearly emphasized the impact of foliar application of micronutrients for production of higher yield. Tomato plants fertilized with application of RDF with mixture of all micronutrients (T_7) favorably influenced the growth, reproductive, quality and yield parameters registering the higher values for all the above mentioned yield attributes *viz.*, fruit yield per plant kg (5.48 kg), total fruit yield per m^2 (14.60 kg) and marketable fruit yield per m^2 (14.56 kg) and proved superior to other treatments. However, it was followed with the other treatments (i.e. other combinations of RDF+ micronutrients). Treatment T_1 registered lower fruit yield per plant kg (3.10 kg) and marketable fruit yield per m^2 (8.85 kg) of tomato indicating that the use RDF alone for fulfilling the requirement of total nutrition was inadequate. The consequences shown in the (Table 2) indicated that the influence of foliar application treatments of micronutrient on average fruit weight was found to be non-significant.

Increased yield due to micronutrients application may be qualified to improve photosynthetic activity, resulting into the increased production and accumulation of carbohydrate and advantageous. Influence on vegetative growth and retention of flower and fruits which might have increased number of fruits per plant besides improvement in the fruit size. The increase in dry matter production of fruits may be attributed to greater accumulation of photosynthates by vegetative parts and its subsequent translocation to the sink. Also, role of boron which enhance the movement of sugar borate complex from the leaves to the fruit and ultimately increased the fruit yield according to result given by Singh et al. (2003). Increased yield in response to micronutrients had also been reported by Hazra et al. (1987), Husain et al. (1989), Yadav et al. (1999) as well as Bose and Tripathi (1996) and Azeem and Ahmed (2011).

Influence on quality parameters

The important aspects related to quality *viz.*, pericarp thickness, equatorial diameter, polar diameter, fruit texture kg cm^{-2}, shelf life day, total soluble solids (^{0}Brix), ascorbic acid mg per 100 g and lycopene content mg per 100 g of edible portion differed significantly among the treatments (Table 2).

It is noteworthy that the tomato crop responded well to combine application of foliar application of micronutrients. Interestingly the treatment T_7 consisting of the combination of RDF + General grade 1% mixture of all micronutrients produced the maximum value for the characters *viz.*,pericarp thickness (8 mm), equatorial diameter (6.83 cm), polar diameter (7.63 cm), fruit texture (4 kg cm^{-2}), shelf life (16.67 days), total soluble solids (4.33 ^{0}Brix), ascorbic acid (14.17 mg), lycopene content (5.01 mg) and physiological loss in weight (12.96 %). The lowest values for all these quality fruit characters were recorded in T_1 (RDF [N: P: K 250:125:125 kg ha^{-1}], where only RDF alone was applied. The study clearly indicated that the efficacy of the RDF fertilizers was pronounced when they were combined with foliar application of micronutrients.

Increase in average diameter and polar length due to foliar spray of micronutrients in tomato has been reported by Hazra et al. (1987). The variation in number of flowers per inflorescence, i.e. number of fruits per plant might be due to improvement in translocation of carbohydrate from the site of synthesis to the storage tissue in plant is due to borax in results of Singh et al. (2003). The findings of Brown and Hu (1998) reported that micronutrient namely boron increased the level of sugar on stigma of flower which helps in fruit set due to better pollen germination and pollen tube growth. Substantial increase in the number of bigger size fruits due to application of micronutrients in tomato was also reported by Mallick and Mathukrishnan (1979).

Increase in TSS might be due to increased carbohydrate production during photosynthesis. The findings of the present study are in conformity with that of Mallick and Muthukrishnan (1980) and Hooda et al. (1984).

An increase in ascorbic acid content of tomato fruit by application of zinc and boron salts had earlier been reported by Kumar et al. (2011). The increase in ascorbic acid content might be due to synthesis of some metabolic intermediate materials that promoted greater synthesis of the precursor of ascorbic acid after the spray of micronutrients. The copper is reported to increase the activity of ascorbic acid oxidase enzyme producing marked improvement in ascorbic acid content. Mallick and Muthukrishnan (1980) and Arora et al. (1982), also reported efficacy of micronutrients in increasing the ascorbic acid content of tomato fruits.

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