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Effect of foliar application of macro and micro-nutrients on growth, yield and economics of tomato (*Lycopersicon esculentum* Mill.) cv. NS-524

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Abstract
A field experiment was conducted in the Department of Horticulture, Khalsa College, Amritsar during 2017-18 to study the effect of foliar application of macro and micro-nutrients on growth, yield and economics of tomato (*Lycopersicon esculentum* Mill.) cv. NS-524. The investigation was laid out in Randomized Block Design (RBD) with three replication having ten treatments *viz.*, potassium sulphate (0.50%. 0.75%, 1.00%), zinc sulphate (200 ppm, 300 ppm, 400 ppm), boric acid (200 ppm, 300 ppm, 400 ppm) and control (water). The foliar spray was given at three stages first at 30 (DAT), second at 40 (DAT) and third at 50 (DAT). Potassium sulphate application at 0.75% increased plant height (107.51 cm), number of leaves (190.50), number of fruit per plant (28.70), fruit length (4.72 cm), fruit diameter (5.67), fruit weight (86.09 g), fruit volume (94.33 cc), yield per plant (2.47 kg), yield per ha (1054.80 q) and also gave maximum return with B:C ratio of 5.94 as compared to other treatments. In case of micro-nutrients boric acid and zinc sulphate (400 ppm) showed better results over the other concentrations *viz.* more effective in increasing quantitative characteristics and showed better economic returns as compare to control. Therefore, the foliar application of potassium sulphate (0.75%), boric acid (400 ppm) and zinc sulphate (400 ppm) are the most effective treatments to improve growth, yield and economics return of tomato.

Keywords: potassium sulphate, boric acid, zinc suphate, tomato, yield

Introduction
Tomato (*Lycopersicon esculentum* Mill.) is one of the most important solanaceous vegetable crops grown throughout the world because of its wider adaptability, high yielding potential and suitability for variety of uses in fresh as well as processed food industries. It is a tropical day neutral plant and it is mainly self-pollinated, but a certain percentage of cross pollination also occurs. It is a prominent member of solanaceae family with 2n = 24 chromosome number and originated in the premises of western coastal plains of South America [1].

In India, tomato has become an important crop and occupies an area of about 809 thousand hectares with production of 19697 thousand MT [2]. India shares about 7.31% of world tomato production. India rank third in the area but fourth in production. In Punjab, it covers an area of about 8.06 thousand hectares with production of 200.15 thousand MT and major areas of production are Jalandhar and Hoshiarpur [3]. Tomato is an important protective food. Nearly 100 g of tomato encompasses virtually 48 mg Calcium, 27 mg Ascorbic acid, 20 mg Phosphorous, 6.3 g Proteins, 0.8 g Fiber, 0.4 mg Iron, 0.2 g Fats and 20 K calories of energy [4]. It is being realized that the productivity of crop is being affected in different areas due to deficiencies of micronutrients observed primarily due to intensive cropping and imbalanced fertilization [5]. Macro and micro nutrients are vital for the growth of plants, acting as catalyst in promoting various organic reactions taking place within the plant. To maintain sustainability in its production and nutritive value, it is becoming essential to replenish the depleting reserve of the micro and macronutrients in the soil or apply it through foliar spray to meet the immediate need of the crop. Many studies have highlighted the benefits of foliar fertilization in improving plant growth, crop yield, nutrient uptake, and product quality and environmentally safe. This technique can ensures immediate translocation of nutrients to various plant organs via leaf tissues under various nutrient deficiencies. Foliar application method can be another choice to old soil fertilization methods to keep away from the harm of fertilizers by leach down and thereby minimize the earth water contamination [6].

Quality and yield potential of tomato can be enhanced by maintaining adequate level of nutrient by foliar application. Tomato requires both macro and micronutrients for its proper plant growth [7]. Potassium (K) is a key nutrient for enhancing productivity of vegetable crops and its content in vegetables has significant positive relationship with quality attributes.

Potassium has significant contribution in photosynthesis, enzyme activation, cell turgor maintenance and ion homeostasis [8]. Major role of potassium in plant is osmotic adjustment. Under potassium deficient conditions, the fruit will be small in size. Zinc is necessary for formation of tryptophan which is the precursor of IAA, promotes plant growth, metabolism of carbohydrates and protein and sexual fertilization of plant [9]. Boron (B) plays an essential role in the development and growth of new cell in the plant meristem. Boron is needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates. Vitamin B deficiency reduced growth and yield in tomatoes [10]. Balanced fertilization of micro and macronutrients is not only efficient but also secured way. Keeping in view the above facts, effect of foliar application of micro and macro-nutrients were evaluated on tomato growth, yield and economics.

Materials and Methods

A field experiment was conducted during the rabi season of 2017-18 at an experimental field of Department of Horticulture, Khalsa College, Amritsar located at 31º- 38′ N latitudes and 74º-52′ E longitudes with an elevation of 236 m MSL and represents the sub- tropical climate and humid zone of Punjab region. The soil of an experimental plot was sandy loam in texture with pH 6.5, organic carbon (0.40-0.75%), available nitrogen (160 kg/ha), phosphorous (30 kg/ha) and potassium (330 kg/ha). The entire experimental land was divided into small plots of dimensions 4.75 m × 1.75 m. The seedlings were sown on 1.25 m wide bed with row to row and plant to plant spacing of 75 cm × 50 cm.

The experiment was carried out in randomized block design with 3 replication having 10 treatment with different concentrations of Boric acid (200, 300 and 400 ppm), Zinc sulphate (200, 300 and 400 ppm) and Potassium sulphate (0.50, 0.75 and 1.00%) were applied as foliar spray three times during the season (Table 1). Three sprays of each macro and micro-nutrient were applied at 10 days interval starting from 30 days after transplanting. All the cultural practices were similar for each block including weeding, irrigation, disease and pest control measures. The nutrients solution were made with respective concentrations and were applied with knap sack sprayer as a foliar feeding to each block. The economics in term of Benefit –Cost (B: C) for each treatment was worked out to find most effective and economical treatment.

The data were analyzed as per the standard procedure for Analysis of Variance (ANOVA). The difference in the treatment mean was tested by using critical difference (CD) at 5% level of probability.

Table 1: Treatments used in the present study

Treatment Code	Treatment Details
T_1	200 ppm Boric acid
T_2	300 ppm Boric acid
T_3	400 ppm Boric acid
T_4	200 ppm Zinc sulphate
T_5	300 ppm Zinc sulphate
T_6	400 ppm Zinc sulphate
T_7	0.50% Potassium sulphate
T_8	0.75% Potassium sulphate
T_9	1.00% Potassium sulphate
T_{10}	Control treated with water

Results and Discussion

Vegetative characters

The maximum plant height of 107.51 cm (90 DAT) was recorded under treatment T_8 (0.75% potassium sulphate). Least plant height of 89.04 cm (90 DAT) was observed in control treatment. The above findings are in close conformity with the results reported by Afzal *et al.* [11]. In tomato. In case of foliar application of both boric acid and zinc sulphate maximum height of 95.04 cm and 100.00 cm were found with 400 ppm, respectively. The increase in height was due to role of zinc in the synthesis of Auxin (IAA). Agarwal *et al.* observed that application of zinc sulphate increase the plant height [12]. Likewise, the boron is linked with the development of plant cell wall and differentiation of cells and results in improved shoot growth [13] and thus, increased plant height, which greatly confirmed the present results [14].

Number of leaves per plant

The plants with foliar application with 0.75% potassium sulphate (T_8) occupied maximum number of leaves per plant (190.50). Potassium helps in water and nutrient transportation and also protein and starch synthesis. Increase in leaves per plant, might be due to sufficient amount of potassium provided through foliar application that gave an ideal environment and balanced nutrition to plants. Similar findings are recorded by Akand *et al.*[15]. Minimum number of leaves per plant (164.42) was recorded under control. Among micronutrients maximum number of leaves 185.14 were recorded with 400 ppm of zinc sulphate. Results are similar with findings of Harris and Mathuma who had reported the effect of foliar application of Boron and Zinc on growth and yield of tomato [16].

Number of fruits per plant

The plants treated with 0.75% potassium sulphate recorded maximum number of fruits (28.70). This could be due to the fact that sufficient supplement of K helps plants for efficient photosynthetic activities and translocation of photosynthates from sites of production to storage organs [17, 18]. Among micronutrients application 400 ppm of boric acid and zinc sulphate gave maximum number of fruits 26.32 and 22.63, respectively. However, minimum numbers of fruits per plant (19.39) were found under control (T_{10}). Increase in number of fruits with application of B might be due to better absorption of micronutrients. The results are in accordance with the earlier reported work [19]. Increase in number of fruits with zinc might be due to a positive role in the fruit formation due to their involvement in the metabolism thereby increases the yield parameters. These results are in line with earlier findings [20].

Fruit length and diameter (cm)

Among all the treatments maximum fruit length (4.72 cm) and fruit diameter (5.67 cm) was recorded with T_8 (0.75% potassium sulphate). Amjad *et al.* reported that potassium application significantly induced fruit size [21]. Increasing concentration upto 400 ppm in case of boric acid and zinc sulphate, maximum fruit length (4.44 cm and 4.37 cm) and fruit diameter (5.51 cm and 5.31 cm), respectively was obtained at this peak value. Increase in fruit size by application of micronutrients particularly boron and zinc have been reported by Amarchandra and Verma [22]. Whereas, minimum sized fruit with length (4.16 cm) and fruit diameter with (5.18 cm) yielded from plants under control.

Fruit weight (g)

The tomato plants treated with 0.75% potassium sulphate yielded maximum weighed fruits (86.09 g). Ghourab *et al.* stated that application of adequate K increases fruit weight by increasing translocation of photosynthates to fruit and water use efficiency [23]. In case of foliar application of micronutrients, maximum fruit weight of 83.73 and 80.95 g were recorded at 400 ppm of boric acid and zinc sulphate. Minimum fruit weight (74.13 g) was found under control. The results of present investigation are in accordance with the earlier reported findings [24, 25].

Fruit volume (ml)

The plants under treatment T_8 produced fruits with maximum fruit volume (94.33 ml) than rest of the treatments. Results are in closely conformity with the work reported by Chapagain and Wiesman [26]. In the case of boric acid and zinc sulphate foliar applications maximum fruit volume of 87.00 ml and 82.00 ml obtained with 400 ppm concentration, respectively. The results of present investigation are in accordance with the finding of Dongre *et al.* [27]. The minimum fruit volume (77 ml) was recorded under treatment T_{10}.

Yield per plant (kg) and per hectare (q)

The plants under treatment T_8 with 0.75% potassium sulphate had maximum yield per plant (2.47 kg) and per hectare (1054.80 q/ha) than rest of the treatments. The present findings are in accordance with the finding of Premabatidevi *et al.* [19].

Whereas, minimum yield per plant (1.43 kg) and per hectare (610.68 q/ha) was found in untreated plants (T_{10}). Among the foliar application of micronutrient maximum yield per plant of 2.20 kg per hectare and 1.83 kg per hectare of939.88 q/ha and 781.49 q/ha was recorded at 400 ppm of boric acid and zinc sulphate, respectively. These findings are in accordance with earlier report of Patel and Singh [18].

Economic analysis

Benefit –Cost ratio (B:C) was found to be maximum in T_8 (0.75% potassium sulphate) with a value of 5.94. Whereas minimum B:C ratio recorded under treatment T_{10}. Higher concentration of both boric acid and zinc sulphate showed better returns than other treatments.

Table 2: Effect of foliar application on growth, yield and economics of tomato cv. NS-524

Treatments	Plant height (cm)			Number of leaves per plant	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit volume (ml)	Yield per plant(kg)	Yield per hectare (q)	Total cost(Rs.)	Net returns (Rs.)	B:C
	30 DAT	60 DAT	90 DAT											
T_1	48.20	80.95	90.63	173.62	24.60	4.40	5.30	80.69	83.33	1.98	845.53	182057.40	832339.60	4.57
T_2	53.00	85.37	94.19	179.92	25.41	4.42	5.43	82.12	84.33	2.08	888.25	182141.10	883758.90	4.85
T_3	54.83	86.25	95.04	182.92	26.32	4.44	5.51	83.73	87.00	2.20	939.88	182227.80	945628.20	5.18
T_4	56.46	86.33	94.37	179.05	21.31	4.23	5.26	77.63	80.00	1.65	704.80	181977.00	663783.00	3.64
T_5	57.86	87.33	95.62	183.03	22.04	4.27	5.28	79.23	80.66	1.74	743.05	182020.00	709638.00	3.89
T_6	51.53	88.00	100.00	185.14	22.63	4.37	5.31	80.95	82.00	1.83	781.49	182067.00	755721.00	4.15
T_7	52.06	86.04	91.87	188.03	25.77	4.49	5.52	84.24	87.00	2.17	926.68	182103.00	929967.00	5.10
T_8	59.20	98.12	107.51	190.50	28.70	4.72	5.67	86.09	94.33	2.47	1054.80	182208.00	1083552.00	5.94
T_9	55.20	88.33	91.87	174.98	26.12	4.52	5.56	84.66	89.33	2.21	943.76	182313.00	950103.00	5.21
T_{10}	50.33	77.04	89.04	164.42	19.39	4.16	5.18	74.13	77.00	1.43	610.68	181887.00	550929.00	3.02
Mean	53.87	86.37	96.17	180.16	24.26	4.40	5.41	81.35	84.49	1.97	843.89			
C.D (0.05%)	3.64	3.88	3.12	2.01	1.63	0.04	0.09	1.16	1.72	0.10	40.08			

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