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Influence of salicylic acid and micronutrients on yield attributes of tomato in summer

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ABSTRACT

To evaluate the production of summer tomato with the application of salicylic acid (S_0: 0 mM Salicylic acid, S_1: 0.25 mM Salicylic acid, S_2: 0.5 mM Salicylic acid), micronutrients (M_0: 0, M_1: 20 mg of zinc, M_2: 2 mg of boron, M_3: 10 mg zinc + 1 mg boron, M_4: 20 mg zinc + 2 mg boron) and to find out the combined effect of salicylic acid and micronutrients for higher yield of tomato in summer season. In case of salicylic acid, the maximum yield per plant (1260.40 g) was found in S_2 and the minimum yield (1099.50 g) was found in S_0. In micronutrients, the highest yield per plant (1691.50 g) was found in M_4 and the lowest yield was (793.50 g) found in M_0. The interaction effect of salicylic acid and micronutrients influenced all most all parameters and yielded attributing tomato characters, where the maximum yield was (1872.22 g) found in S_4M_4 and the minimum yield (736.04g) was found in S_0M_0. These results suggest that salicylic acid and micronutrients can alleviate summer's detrimental effect to increase tomatoes' yield.

Key Words: *Summer tomato, Salicylic acid, Micronutrients and Yield.*

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I. Introduction

Tomato *(Lycopersicon esculentum)* is one of the most valuable vegetable crops in Bangladesh. It belongs to Solanaceae family. It ranks 2nd, which is next to potato and top the list of canned vegetable. It was introduced in the Subcontinent by the Europeans. Later on, local people also started their consumption due to its popularity. It is now used everywhere in the country in so many forms. Tomato is a good source of carotenoids, in particular, lycopene and phenolic compounds and lessens the risks of cardiovascular disease and certain types of cancer, such as cancers of prostate, lung and stomach. It also contains mineral and vitamins. The popularity of tomato and its different products are increasing day by day. It is a nutritious and delicious vegetable used in salads, soups and processed into stable products like ketchup, sauce, marmalade, chutney and juice. Tomato contains 94.1% water, 23 calories of energy, 1.90 g protein, 1 g calcium, 7 mg magnesium, 1000 IU vitamin A, 31 mg vitamin C, 0.09 mg thiamin, 0.03 mg riboflavin, 0.8 mg niacin per 100 g edible portion (Rashid, 1983). Tomato has high

nutritive value, especially it can meet up some degree of vitamin A and C requirement, adds flavor to the foods, rich in medicinal value and also can contribute to solving malnutrition problem.

Tomato cultivated both summer and winter conditions. Summer tomato is a profitable crop to the farmers. Its profitability is becoming popular and extended to the farmers in different parts of the country for the last 7-8 years. Due to the excellent nutritional and processing potentials of tomato, tomato's demand remains high all the year round. Tomato production is low in summer season, but the price is high. In Bangladesh, summer tomato is a high value crop that ascertains higher income from land per unit area (Zaman et al., 2010). However, it is difficult to grow tomato in the summer season due to adverse climatic conditions, such as high temperature, high rainfall, and hail storms. It is susceptible to high temperature, especially the large fruited fresh varieties. High night temperature may lead to a lower fruit set of small and seedless fruit development. The most favorable temperature for fruit set is 25-30°C and high light intensity with high temperature, are decreased fruit sets. The optimum condition for fruit set is available in the winter season.

Endogenous salicylic acid act like a growth regulator. Salicylic acid or ortho-hydroxy benzoic acid and other salicylates affect various physiological and biochemical activities of plants. It functions as an indirect signal stimulating many physiological, biochemical and molecular processes and therefore, it affects plant growth and development (Klessig and Malamy, 1994; Malamy et al., 1990). Salicylic acid affects various physiological and biochemical activities and regulating their growth and productivity (Hayat et al., 2010). In tomato, the fruit yield enhanced significantly when lower concentrations of salicylic acid were sprayed (Larque-Saavedra and Martin-Mex, 2007). Exogenous application of SA increases plant photosynthesis (Fariduddin et al., 2003) on the synthesis of secondary plant metabolites and on antioxidant activity (Eraslan et al., 2007). Salicylic acid is a beneficial effect on plant adaptation (resistance, increase tolerance) to stress factors including heat, salinity etc. (Liu et al., 2006; Shi et al., 2006; Larkindale and Huang, 2005). Foliar application of salicylic acid in the tomato plant enhanced the flowering and pod formation (Kumar et al., 1999). In tomato plant, the fruit yield enhanced significantly when the plants were sprayed with lower salicylic acid concentrations (Larque-Saavedra and Martin-Mex, 2007). So, it is necessary to investigate the effect of salicylic acid and micronutrients (Zn+B) on flowering, fruit formation, and summer tomato yield to increase the total production.

Micronutrients have different functions in tomato plant. It plays a key role in plants' physiological processes such as maturation, cell elongation and cell division, nucleic acid metabolisms, cytokine synthesis, auxin and phenol metabolisms (Lewis, 1980). Due to the application of micronutrients quality parameter of tomato fruit was enhanced (Naresh, 2002). Foliar applications of micronutrients have a significant role in vegetative growth, fruit set, and tomato (Adams, 2004). Zinc and boron are important micronutrients for tomato plants. Zinc has a vital effect on tomatoes' growth and development such as carbohydrates and protein metabolism (Vasconcelos et al., 2011). Boron efficiency increases yield and quality of tomatoes Davis et al., (2003). Foliar application of micronutrients is also a secured way (Aghtape et al., 2011). Boron has a key role in accumulating photosynthesis that correlate with fruit weight (Shukha, 2011). This study aimed to investigate the production of summer tomato with the application of salicylic acid, micronutrients, and the combined effect of salicylic acid with zinc and boron for higher yield and quality of tomato in summer.

II. Materials and Methods

The experiment was conducted at the horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, from April 2017 to September 2017. The two factorial experiments was laid out in Complete Randomized Design (CRD) with three levels of salicylic acid (S_0: 0 mM, S_1: 0.25 mM, S_2: 0.5 mM) and five levels of micronutrients (M_0: 0, M_1: 20 mg of zinc, M_2: 2 mg of boron, M_3: 10 mg zinc + 1 mg boron, M_4: 20 mg zinc + 2 mg boron). Four replications were maintained in this experiment. BARI Hybrid Tomato-4 variety was used. The total number of pots was 60 (15×4) and placed under poly house. Seeds were sown on seedbed on 30 April and seedlings were transplanted 30 May, maintaining two seedlings in each pot. Three foliar sprays were done. The first application was done at 25 DAT, Second and third treatment was applied at 20 days intervals. All intercultural operations are done as per guidelines.

The following data were recorded during the experimental period. Plant height, No. of branch plant^{-1}, No. of leaves plant^{-1}, flower cluster^{-1}, flower plant^{-1}, fruit cluster^{-1}, fruit plant^{-1} Length of fruit, Diameter of fruit, Weight of individual fruit and yield per plant. Fruits were harvested at two days interval during early ripe stage when they developed slightly red color. The recorded data on different parameters were statistically analyzed using statistix10 software.

III. Results

The highest plant height (103.55 cm), leaves per plant (23.67), branch per plant (7.89), flower cluster^{-1} (6.20), flowers plant^{-1} (34.53) (Table 01), fruit cluster^{-1} (4.48), fruit plant^{-1} (28.67), length of fruit (3.84), diameter of fruit (3.78 cm), individual fruit weight (40.93 g) (Table 02) and the maximum yield plant^{-1} (1260.40 g) was found from S_2 (Figure 01) and the lowest plant height (99.00 cm), branch/plant (6.18), flower/cluster (5.05), flowers/plant (29.71), fruit/cluster (4.35), fruit/plant (26.88), length of fruit (3.72), diameter of fruit (3.65), individual fruit weight (37.77 g) and the minimum yield/plant (1099.50 g) was obtained from S_0 (Figure 01).

In case of micronutrients, the maximum plant height (124.67 cm), branch per plant (4.63), leaves per plant (30.42), flower per cluster (6.22), flower per plant (42.00) (Table 01), fruit per cluster (4.85), fruit per plant(35.00), length of fruit (4.08 cm), diameter of fruit (3.88 cm), individual fruit weight (45.51 g) and the maximum yield plant^{-1} (1691.50 g) was found from M_4 and the minimum plant height (84.24 cm) were obtained from M_4 and M_1, branch per plant (4.63), no. of leaves per plant (20.08), flower/cluster (4.38), flower/plant (24.33), fruits/cluster (3.66), fruit/plant (19.59), length of fruit (3.61 cm), diameter of fruit (3.56 cm), individual fruit weight (28.36 g) (Table 02) and the minimum yield /plant (793.50 g) was recorded from M_0 (Figure 02).

The combined effect of salicylic acid and micronutrients significantly varied on plant height. The highest plant height (129.75cm), branches per plant (10.15), leaf number per plant (37.50) was recorded from S_1M_4 (Table 03). The highest number of flower clusters^{-1} (6.63), flowers/plant (48.25), fruits per cluster (4.93), fruits plant^{-1} (36.63), length of fruit (4.18), diameter of fruit (4.01), weight of individual fruit (52.11 g) and the maximum yield plant^{-1} (1872.22g) was recorded from the treatment combination of 20 mg zinc + 2 mg of boron and 0.5 mM salicylic acid (S_2M_4). The lowest plant height (82.75 cm) was found in S_1M_1 (Table 01) which was statistically similar to S_0M_1(84.75 cm) and S_2M_1 (85.25), lowest no. of branch/plant (3.80), leaf number (19.25), flower/cluster (4.12), flower/plant (19.75), fruits/cluster (3.58), length of fruit (3.37), diameter of fruit (3.47), individual fruit weight (30.68 g) and the minimum yield/plant (736.04 g) was observed in control condition (S_0M_0) (Table 04).

Table 01. Effect of salicylic acid and micronutrients on plant height, number of branches plant^{-1}, number of leaves plant^{-1}, flower cluster^{-1} and flowers plant^{-1}

Treatments	Plant Height (cm)	Number of branches plant^{-1}	Number of leaves plant^{-1}	Flowers cluster^{1}	Flowers plant^{-1}
Salicylic acid					
S_0	99.31	6.18 c	24.45 b	5.05	29.71b
S_1	99.00	7.03 b	26.35 a	5.16	31.76 b
S_2	103.55	7.89 a	26.75 a	6.20	34.53 a
Micronutrient					
M_0	94.58	4.63 e	20.08 c	4.38 c	24.33 e
M_1	84.25	5.63 d	26.42 b	4.87 b	28.71 d
M_2	85.67	8.38 b	26.58 b	4.97 b	29.95 c
M_3	103.92	7.33 c	25.75 b	5.26 b	33.00 b
M_4	124.67	9.20 a	30.42 a	6.22 a	42.00 a
CV (%)	2.18	8.17	7.43	12.37	4.98

Table 02. Effect of salicylic acid and micronutrients on Fruit/plant, length and diameter of fruits and Individual fruit weight

Treatments	Fruit/plant	Length of fruits (cm)	Diameter of fruits (cm)	Individual fruit weight (g)
Salicylic acid				
S_0	26.88 c	3.72	3.65 b	37.77 c
S_1	28.66 b	3.79	3.67b	39.38 b
S_2	28.67 a	3.84	3.78 a	40.93 a
Micronutrient				
M_0	19.59 e	3.61 c	3.56 c	28.36 e
M_1	24.03 d	3.65 c	3.70 b	31.48 d
M_2	26.97 c	3.74 bc	3.65 bc	36.73 c
M_3	30.40 b	3.84 b	3.68 b	39.73 b
M_4	35.00 a	4.08 a	3.88 a	45.51 a
CV (%)	1.36	4.90	3.70	4.01

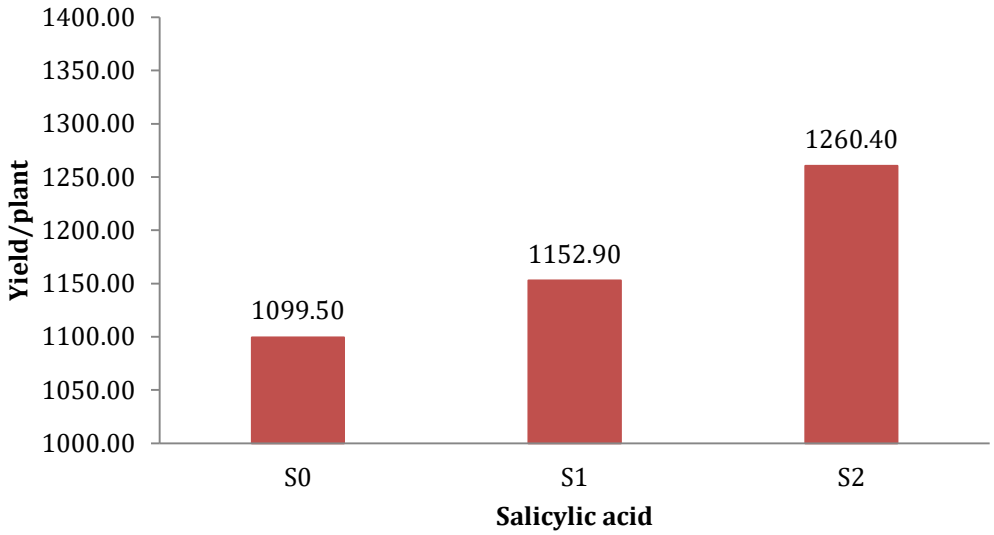

Figure. 01 Effect of salicylic acid on yield plant^{-1}

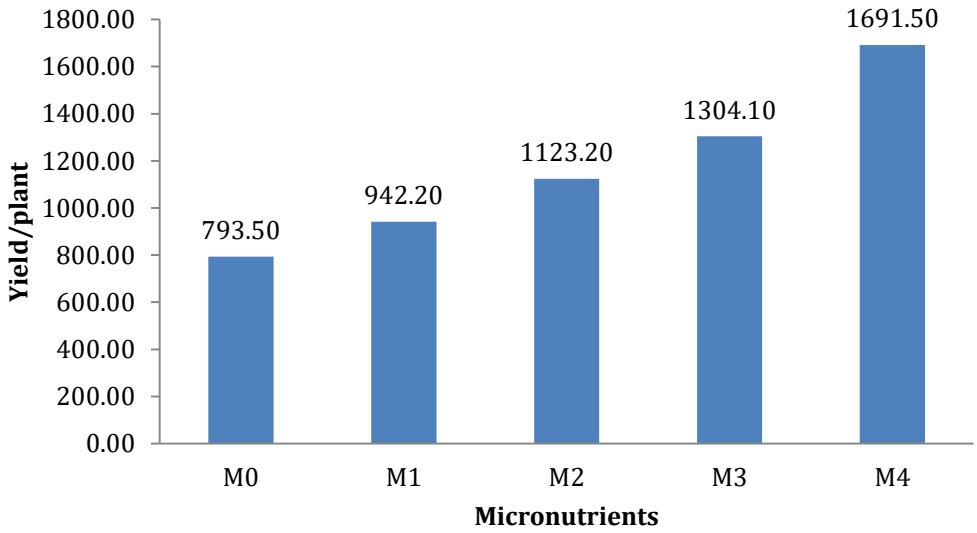

Figure 02. Effect of micronutrient on yield plant^{-1}

Table 03. Combine effect of salicylic acid and micronutrients on growth response of tomato plant height, branch per plant, leaves per plant, flower per cluster and flower per plant.

Treatments	Plant Height	Branch per plant	Leaves/ plant	Flower/ cluster	Flower/ plant
S_0M_0	95.50 gh	3.80	19.25 h	4.12 d	19.75 j
S_1M_0	90.25 i	4.45	21.75 gh	4.48 d	25.25 gh
S_2M_0	98.00 fg	5.63	19.25 h	4.53 d	25.00 h
S_0M_1	84.75 j	4.38	22.00 g	5.18 c	25.25 gh
S_1M_1	82.75 j	5.55	27.25 c-e	5.17 c	22.75 i
S_2M_1	85.25 j	6.98	30.00 b	5.56 b	26.14 gh
S_0M_2	97.50 fg	7.78	25.25 ef	5.87 b	28.31fg
S_1M_2	93.00 hi	8.53	29.75 bc	5.91 b	28.29fg
S_2M_2	96.50 fg	8.85	24.75 ef	5.82 b	29.25 ef
S_0M_3	98.75 f	6.50	27.25 c-e	5.11 c	30.50 ef
S_1M_3	104.75 e	7.63	23.75 fg	5.22 b	31.50 e
S_2M_3	108.25 d	7.85	26.25 d-f	5.44 b	34.00 d
S_0M_4	120.00 c	8.45	28.50 b-d	5.61 b	37.50 c
S_1M_4	124.25 b	9.00	29.25 bc	6.37 a	43.26 b
S_2M_4	129.75 a	10.15	33.50 a	6.63 a	48.25 a
CV (%)	7.17	0.82	7.43	12.37	4.98

Table 04. Combine effect of salicylic acid and micronutrients on Fruit/cluster, Fruit /plant, Length of fruit, Diameter of fruit, Individual Fruit weight and Yield plant^{-1}

Treatments	Fruit/ cluster	Fruit/ plant	Length of fruit (cm)	Diameter of fruit (cm)	Individual Fruit weight (g)	Yield plant^{-1} (g)
S_0M_0	3.58 f	18.08 k	3.37	3.47	30.68 k	736.04 n
S_1M_0	3.69 f	19.00 k	3.70	3.53	31.57 jk	754.23 m
S_2M_0	3.71f	21.70 j	3.76	3.68	31.81 jk	890.62 l
S_0M_1	4.25 e	22.88i	3.70	3.67	33.02 ij	896.14 l
S_1M_1	4.22 e	23.63i	3.60	3.70	34.48 hi	922.24 k
S_2M_1	4.46 de	25.58 h	3.64	3.73	35.92 h	1008.31 j
S_0M_2	4.58bcd	26.30gh	3.72	3.63	38.81 g	1087.93i
S_1M_2	4.52cde	27.00fg	3.70	3.54	39.29 fg	1122.00 h
S_2M_2	4.49 de	27.60 f	3.80	3.77	41.09 ef	1159.84 g
S_0M_3	4.50cde	29.50 e	3.94	3.75	41.85 de	1254.64f
S_1M_3	4.71abcd	29.88 e	3.75	3.59	42.63 c-e	1286.73 e
S_2M_3	4.75abcd	31.83 d	3.82	3.70	43.69 cd	1370.92 d
S_0M_4	4.80abc	33.50 c	3.88	3.72	44.47 c	1522.71 c
S_1M_4	4.85 ab	34.87 b	4.17	3.90	48.93 b	1679.74 b
S_2M_4	4.93 a	36.63 a	4.18	4.01	52.11 a	1872.22 a
CV (%)	2.70	1.36	4.90	3.70	4.01	0.47

IV. Discussion

In Bangladesh, tomato production is restricted in the summer season due to climatic conditions, but salicylic acid and micronutrients help mitigate this condition and increase production. Salicylic acid is an endogenous growth regulator and it helps to develop abiotic stress tolerance in plants. Several studies support the major role of SA in modulating the plants' response to various abiotic stresses. Exogenous application of SA enhances plant growth, photosynthesis, cell division and cell enlargement. Flowered come much earlier than the control condition when they received a foliar application of salicylic acid (Larque-Saavedra and Martin-Mex, 2007). Due to high-temperature number of fruit plant^{-1} was reduced than winter season but SA helps to mitigate this condition. Javaheri et al. (2012) concluded that the tomato diameter was increased when lower concentrations of salicylic acid were sprayed. Research findings demonstrated its roles in seed germination, flowering and fruit yield photosynthetic rate and transpiration. Apart from its involvement in the induction of defense-related genes and stress resistance in biotic stressed plants (Kumar, 2014), Salicylic acid-mediated improved plant tolerance to heat stress has also been reported (He et al., 2002; Larkindale et

al., 2005; Khan et al., 2013 a, b). Individual fruit weight and the number of fruit plant-1 were decreased due to summer condition, so the yield plant-1 was ultimately decreased but foliar application of salicylic acid helps mitigate this stress condition and increase production.

Micronutrients are essential for plant growth and play an important role in balanced crop nutrition. Micronutrients have different functions in tomato plants. Foliar application of micronutrients can improve the vegetative growth, fruit set and yield of tomato (Adams, 2004). Foliar application of different micronutrients increases plant height (Sing et al., 2013). Wojcik and wojcik. (2003) stated that micronutrients promote fruit growth by synthesizing tryptophan and auxin.

Zinc is important for the development and function of growth regulators (e.g., auxin) that influence internode elongation and ensure good shoot growth. For maximum flower set, fruiting, fruit ripening and fruit maturity ensure by foliar application of zinc. Boron has an important role in pollen germination and fruit set. Boron is quickly taken up by soil, so it is immobile in the plants for this reason, foliar application is more effective. Boron activates certain dehydrogenese enzymes, involved in carbohydrate metabolism, synthesis of cell wall components, and essential cell division and cell development. Higher number of fruits per cluster was obtained due to boron's application than control conditions in tomato plant (Haque, 2007). Boron prefaces on the accumulation of photosynthates which has a correlation with fruit weight (Sukha, 2011). Application of Zinc and Boron increased tomato plant height. (Hatwar et al., 2003). In tomato plants, the number of fruits/plant increased by applying zinc and boron (Yadav et al., 2001). Wojcik and Wojcik. (2003) reported that the length of fruit enhanced by the application of zinc and boron. Sindhu et al. (1999) observed that the application of zinc and boron also increases fruit size. Exogenous application of zinc and boron enhances fruit set, number of fruit/ plant, individual fruit weight, ultimately yield /plant is increasing.

V. Conclusion

The overall results obtained from the study facilitated to draw the following conclusions- 1. Exogenous application of salicylic acid (0.25 mM) can effectively mitigate the adverse effect of temperature in summer season and increase yield. ð The plants were produced the maximum growth and yield of tomato due to the application of micronutrients (20 mg of zinc and 2 mg of boron) ð It is concluded that 20 mg of Zn, 2 mg of Band 0.5 mM SA are the best combination for the tomato production in summer.

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