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Influence of Boron and Gibberellic Acid on Growth and Yield of Summer Tomato

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Abstract: Tomato (*Solanum lycopersicum* L.) is a globally significant vegetable crop, valued for its nutritional and economic contributions. However, maximizing its yield and quality, particularly under challenging summer conditions, remains a critical agricultural concern. To assess the influence of boron (B) and Gibberellic Acid (GA_3) on the growth, yield and quality of summer tomato (BARI Hybrid Tomato 8), a field experiment was conducted at the Department of Agriculture, Noakhali Science and Technology University, Noakhali, from May 2023 to August 2023. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment. The unit plot size was 1.0 m × 1.0 m. There were 4 treatments T_0: control (without Gibberellic acid and Boron), T_1: 50 ppm GA_3, T_2: 100 ppm Boron and T_3: combinations of T_1 and T_2 in the experiment comprising Boron (100 ppm) and GA_3 (50 ppm). The effect of boron, gibberellic acid and their combined effect showed significant variations in growth, yield and quality of tomato. In this study between the individual application of Boron @ 100 ppm and GA_3 @ 50 ppm, GA_3 gave the higher plant height, leaf number, fruit weight and yield per plant than Boron. Combined effect of GA_3 and Boron at treatment T_3 (50 ppm GA_3 + 100 ppm Boron) gives the highest plant height (104.23), branch number (18.76), no. of leaves per plant (82.5), flower clusters per plant (14.05), flower per plant (52.1), fruit per plant (17.72), fruiting percentage (34.05), fruit weight per plant (964.21g), total yield (33.06 t ha^{-1}). From this experiment, it can be concluded that the interactive effect of 50 ppm GA_3 with 100 ppm Boron treatment is suitable dose for higher yield of tomato by improving all the parameters numerically.

Keywords: Tomato; Micronutrients; Phytohormone; *Solanum lycopersicum* L.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a herbaceous annually cultivated crop under Solanaceae family. It ranks second in the world's vegetable production, next to potato, placing itself first as processing crop among the vegetables (Yadav, 2018). It originated in tropical America (Salunkhe *et al*., 1987) specially in regions such as Peru, Ecuador and Bolivia which are part of Andes (Kallo, 1986). It is one of the most significant horticultural crops, grown, traded, and consumed worldwide (Fernqvist & Ekelund, 2014). In Bangladesh, it is cultivated due to its adaptability to wide range of soil and climate (Ahmed, 1995). It is simple to cultivate and yields an abundance of fruits. Because of their high nutritional value, tomatoes are absolutely necessary. The tomato is a fundamental component of the widely renowned "Mediterranean diet," which is closely linked with a decreased risk of chronic degenerative diseases (Agarwal and Rao, 2000). Tomato has a significant role in human nutrition because of its rich source of lycopene, minerals and vitamins such as ascorbic acid (vitamin C) and β-carotene (vitamin A) which are antioxidants that promote good health (Waheed *et al*., 2020). Lycopene is responsible for the tomato's red color. Lycopene is a very powerful antioxidant which can help prevent the development of many forms of cancer (Rahman *et al*., 2023). Tomato is highly nutritious as it contains 94.1%

water, 23 calories 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). In Bangladesh the maximum temperature in summer reaches 34-38°C and causes a very poor fruit set. High temperatures, such as those that exceed 32°C during the day and 21°C at night, may affect tomato fruit set because of abnormal stamen formation and pollen dehiscent (Sasaki *et al.*, 2005). At higher temperature, the probability of floral abscission is high after anthesis. Use of high-yielding variety and plant growth regulators is prerequisite for increasing the production of tomatoes especially in summer season. Plant growth regulators (PGRs) and micronutrients play crucial roles in the physiology and development of plants. Studies have revealed the beneficial effect of plant growth regulators and micronutrients have increased the growth, yield, total acids and total soluble solids (Saha, 2009).

Application of PGRs like GA_3 brings the possibility of tomato production under adverse environmental conditions. It is one of the most significant growth-stimulating substances used in agriculture for a long time. It is a well-known phytohormone that is used in agricultural industry to raise the quality and productivity of various crop plants. By using plant growth regulators to make up for the lack of natural growth chemicals needed for tomato development, fruit set can be improved (Singh and Choudhury, 1966). It may promote cell division and elongation, which aids in the tomato plant's growth and development. When sprayed on flowers, GA_3 reduced tomato fruit drop (Feofanova,1960). It has been reported that macronutrients are consumed in larger quantities and are present in plant tissue in quantities from 0.2% to 4.0% (on a dry matter weight basis) whereas micro nutrients are present in plant tissue in quantities measured in parts per million (ppm) ranging from 5 to 200 ppm or less than 0.02% dry weight. Among these micronutrients one of the important micronutrients is Boron. Bose and Tripathi, (1996) reported that the enhanced growth of tomato plants can be linked to the vital role of Boron (B) in various physiological processes. Boron plays a crucial part in protein metabolism, pectin synthesis, regulating water balance within the plant, facilitating ATP synthesis, and facilitating the movement of sugars during the flowering and fruiting phases. Additionally, boron affects a wide range of plant processes, including hormone production, active salt absorption, fruit and flowering development, pollen germination, carbohydrate metabolism, nitrogen metabolism, and water relations (Shireen *et al.*, 2018). Boron has been shown to positively connect with fruit weight, flower bud, and flower number in tomato plants (Bose *et al.*, 2002). The youngest leaves of boron-deficient plants turn a pale green color, losing more pigment at the base of the leaf than at the tip. Symptoms of a boron deficit can include thickened, wilted, or curled leaves; petioles and stems that are thickened, cracked, or saturated in water; and fruit, tubers, or roots that are discolored, cracked, or rotting (Tisdale *et al.*, 1985). The study aimed to evaluate and compare the impression of GA_3, Boron and their combination on growth and yield of summer tomato.

MATERIALS AND METHODS

Experimental site and soil

The experiment was carried out at the research field of the Department of Agriculture, Noakhali Science and Technology University, Noakhali during the period from May 2023 to August 2023. The experimental site is located at 22°47′31″N Latitude and 91°06′07″ Longitude. The Agro-Ecological Zone of the research area was the Young Meghna Estuarine Floodplain (AEZ-18). The experimental area is under subtropical climate and it has significant rainfall in most months, with a short dry season. In Noakhali, the average temperature is 26.5° and average annual rainfall is about 3,302 mm, according to Bangladesh Meterological Department (climate Division). The soil of experimental site was slightly Alkaline with pH 8.30. The soil was tested by Soil Resource Development Institute, Noakhali. According to test report, it was found that amount of N is 0.04%, which is very low. P is present at 27.79 μg/g soil which is optimum at upland and higher in wet land. K is present at 0.18 mEq/100g soil which is lower in upland and medium in wetland. The soil has EC 1.3dS/m which means the soil is not saline. The organic matter content of soil is 0.64% which is very low.

Experimental material and experimentation

The tomato variety BARI Hybrid Tomato-8 (summer) was used in the experiment. It is developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh by hybridization method. It is heat tolerant hybrid tomato variety, medium round attractive. Fruit color is red. Seed was collected from BADC, Feni. The experiment comprised four treatments namely, T_0 = Control (without GA3 and boron), T_1 = 50 ppm GA3, T_2 = 100 ppm boron, T_3 = Combination of 50 ppm GA_3 and 100 ppm boron. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combinations of doses of boron (B) and gibberellic acid (GA_3). The 4 treatment combinations of the experiment were assigned at random into 12 plots. The size of each unit plot was 1.0 m × 1.0 m. The space was kept 0.5 m between the blocks and 0.5m between the plots were kept. The distance between row to row and plant to plant was 60 cm and 40 cm, respectively.

Fertilization and transplanting of seedlings

The sources of N, P_2O_5, and K_2O as urea, TSP and MoP were applied, respectively. The entire amounts of TSP and MoP were applied during the final land preparation. Urea was applied in three equal installments at 25, 35 and 45 days after seedling transplanting (DAT). Well-rotten cow dung 10 tha^{-1} also applied during the final land preparation. Healthy and uniform 25-day-old seedlings were uprooted separately from the seed bed and were transplanted in the

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experimental plots in the afternoon of 05 June, 2023 maintaining a spacing of 60 cm x 40 cm between the rows and plants respectively.

Application of the treatments

All the treatments were applied considering the design of the experiment. First application was made at 15 DAT in the day when first flower initiation was found in the experimental plot and second & third application was made at a 15 days interval which was 30 and 45 DAT.

Intercultural operations

Gap filling was done as and when needed. After transplanting of seedlings, various intercultural operations such as irrigation, weeding, staking and top dressing etc. were accomplished for better growth and development of the tomato seedlings. Over-head irrigation was provided with a watering cane to the plots once immediately after transplanting seedlings in every alternate day in the evening up to seedling establishment. Further irrigation was provided when needed. Excess water was effectively drained out at the time of heavy rain. When the plants were well established, staking was given to each plant by bamboo sticks to keep them erect. Weeding was done to keep the plots clean and easy aeration of soil which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully.

Harvesting

Fruits were harvested at 5 days intervals from maturity to ripening stage. The maturity of the crop was determined on the basis of red coloring of fruits. Harvesting was started from 5 August, 2023 and completed by 30 August, 2023.

Statistical analysis

Statistical analysis was carried out an using excel data sheet and the minitab application (Minitab 17 edition) on the data gathered for the study of various parameters.

RESULTS AND DISCUSSION

Plant height:

The plant height of tomato varied significantly due to the application of different treatments. At final harvest, the highest plant height was observed in treatment T_3 (104.23cm) which was followed by treatment T_1 (102.33cm) where T_2 showed 97.3 cm. On the other hand, the lowest plant height was observed in T_0 (80.56 cm) where no GA_3 and boron were applied. Sanyal *et al.* (1995) reported similar results for GA_3 and Gupta and Cutcliffe (1985) illustrate that Deficiency of boron in tomato and several other crops is responsible for stunted growth. Due to combined effect of GA_3 and boron showed highest plant height.

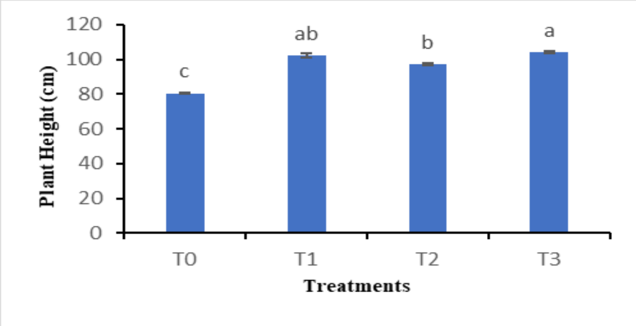

Figure 1. Influence of GA_3 and Boron on plant height of tomato. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability

Number of leaves:

Number of leaves per plant of tomato varied significantly due to the application of Different treatment. The maximum number of leaves (82.5) was obtained from T_3 which was followed by T_1. From T_1 we obtained 82 number of leaves. There was no significant difference between T_2 (73.39) and T_0 (67.04). GA_3 application in tomato plants help in synthesis of protein including various enzymes which increases the rate of photosynthetic capacity, leading to increase total leaf area and leaf dry weight (Mostafa and Saleh, 2006). Briant (1974) found similar result with application GA_3 in tomato. Boron plays an important role in the proper function of cell membranes and the transport of K to guard cells for proper control of internal water balance. Oyinlola (2004) reported that, application of boron significantly increased the number of leaves on tomato plant compared to control.

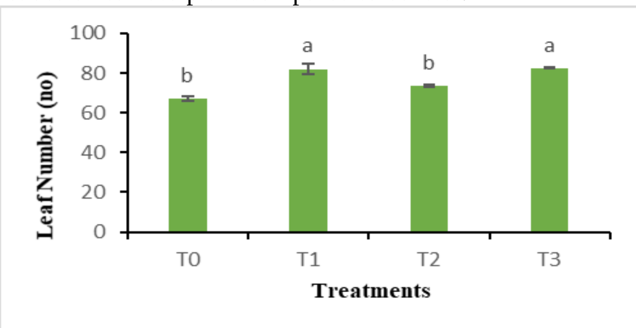

Figure 2. Influence of GA_3 and Boron on leaves number of tomato. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Number of branches per plant:

A significant variation in the number of branches per plant was observed due to effect of GA_3 and Boron. The highest number of branches per plant (18.76) was counted in T_3 which was followed by T_1 (17.83) and T_2 (17.42). The lowest number of branches per plant was found in T_0 (13.29). Tomar and Ramgiry (1997) also reported that

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tomato plant treated with GA_3 showed a significantly greater number of branches per plant than untreated control and Sanjida *et al*. (2020) also found similar result with Boron treatment.

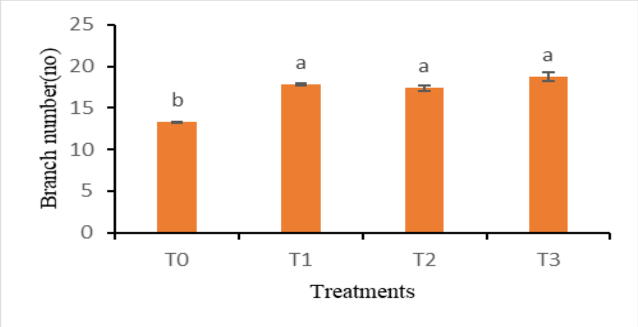

Figure 3. Influence of GA_3 and Boron on branch number of tomato. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Days to first flowering

A significant variation was observed in days to first flowering due to application. The T3 treatment required the earliest days of first flowering (57.5 DAS) which was statistically similar as T_1 (59.44 DAS). T_2 showed a flowering time (61.17 DAS) medium between T_1 and T_0. T_0 treatment was the longest time for first flowering (63.72 DAS).

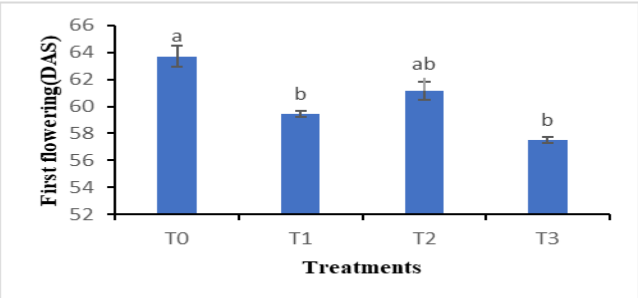

Figure 4. Influence of GA_3 and Boron on flowering time of tomato. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Number of flowers:

Number of flowers per plant of tomato varied significantly due to the application of different treatments. The maximum number (52.1) of flowers per plant was counted from T3, whereas, the minimum number (31.33) was counted from T_0. From this experiment I obtained more flowers from T_1 (51.61) than T_2 (48.89). Onofeghara (1981) illustrated that, GA_3 regulates flower initiation and its development and it is essential for male and female fertility (Griffiths *et al.*, 2006). Naresh (2002) observed that boron also had positive effects on number of flowers per plant resulting in an increase in the number of fruits per plant and total yield.

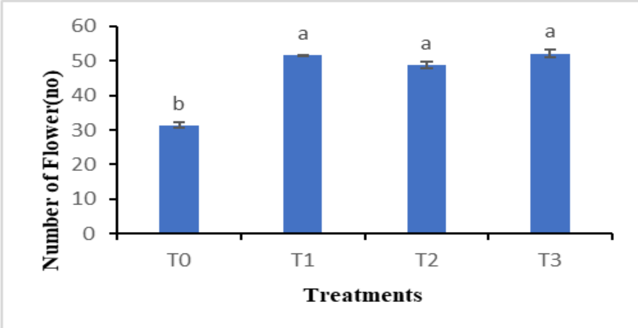

Figure 5. Influence of GA_3 and Boron on number of flower of tomato. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability

Number of flower clusters per plant

A significant variation in the number of flower clusters per plant was observed due to effect of different treatments. The highest number of flower clusters per plant (14.05) was counted in T_3 which was followed by T_1 (13.95) and T_2 showed 13.38 flower clusters per plant. the lowest number of flower clusters per plant was found in T_0 (10.72). Application of GA_3 had increased the number of flower buds and open flowers that reported by Paroussi *et al.* (2002). Sujatha *et al. (*2002) who stated that the number of flowers per cluster increased with combined application of growth regulators and boron combination.

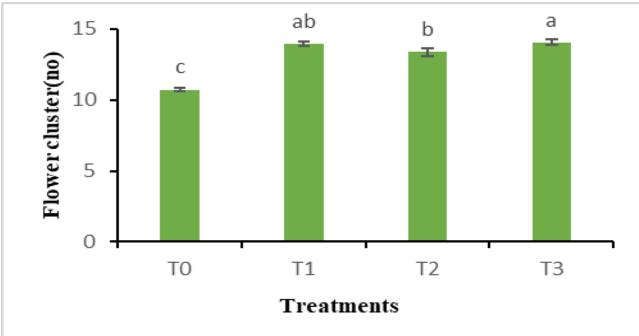

Figure 6. Influence of GA_3 and Boron on flower cluster tomato. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Number of fruits per plant

Statistically significant variation was found in number of fruits per plant due to application of different treatments. Due to the combined effect of GA_3 and boron showed highest number of fruits per plant. The highest number of fruits per plant was recorded in T_3 (17.72) which was statistically different from all other treatments while the

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lowest number of fruits per plant was found in T_0 (3.38). The second highest number of fruits per plant obtained from T_1 (13.73) and statistically similar result from T_2 (12.63). Combined application of GA_3 and boron increased the number of fruits per plant in tomato was reported by Yadav *et al.* (2001).

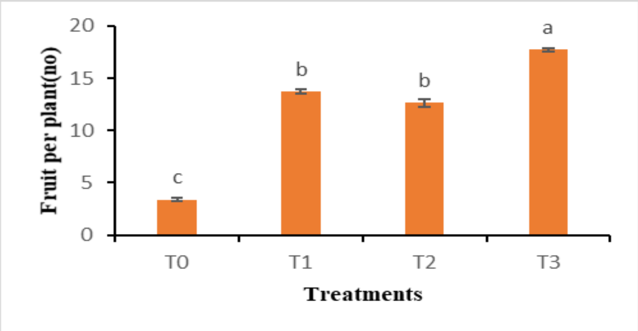

Figure 7. Influence of GA_3 and Boron on fruits number of tomato plant. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Single fruit weight

The weight of individual fruit of tomato varied significantly due to the application of different treatments. The highest weight of individual fruit (54.42 g) was found from T_3. From T_1 and T_2 48.51 g and 41.37 g respectively. Treatment T_0 showed lowest single fruit weight 36.53g. Naeem *et al.* (2001) indicated reduced fruit drop and increased fruit weight due to GA_3 spray.

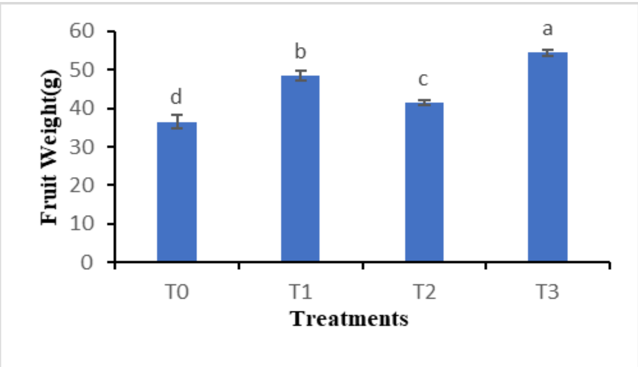

Figure 8. Influence of GA_3 and Boron on weight of tomato. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Fruit diameter:

The variation in fruit diameter among the different treatments was found to be statistically significant. The maximum diameter of fruit (3.97 cm) was obtained from T_3 which was followed by T_1 (3.85 cm). The minimum fruit diameter (3.39 cm) was obtained from control (T_0) plants. The diameter of fruit (3.71 cm) was obtained from T_2. GA_3 induces cell division, cell elongation, cell enlargement and ultimately leads to significantly increase the fruit girth as reported by Sanyal *et al*., Desai *et al.* (2012) found the maximum fruit length and girth in GA_3 at 90 ppm. Sawhnuy and Greyson (1972) also reported the similar findings.

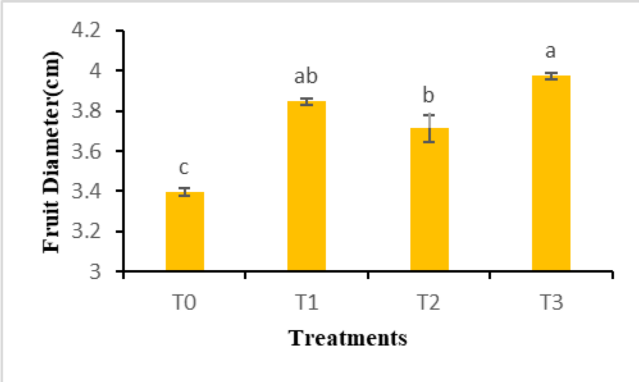

Figure 9. Influence of GA_3 and Boron on the diameter of tomato. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Percentage of fruit setting:

Statistically significant variations were found in % of fruit setting due to application of different treatments. Due to combined effect of GA_3 and boron showed highest % of fruit set. The highest % of fruit setting was recorded in T_3 (34.05%) which were statistically different from all other treatments while the lowest number of % of fruit setting was found in T_0 (10.84%) where the maximum number of flowers were dropped. The second highest % of fruit setting was obtained from T_1 (26.59%) and statistically similar at T_2 (25.82%).

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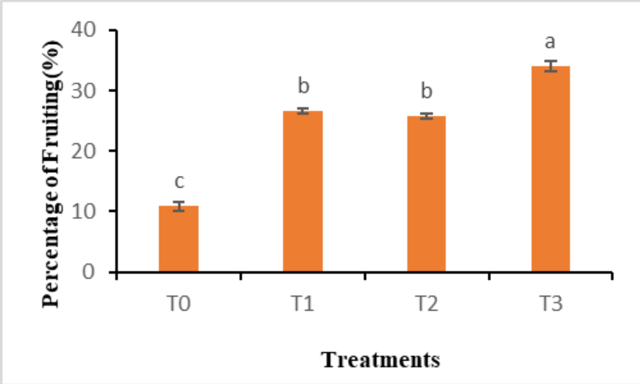

Figure 10. Influence of GA_3 and Boron on fruiting percentage. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Yield plant^{-1}

Due to the application of GA_3 and boron the yield per plant showed positively significant impact on tomato production. The yield plant^{-1} ranges from 122.56 g to 964.21 g. The highest yield plant^{-1} (964.21 g) was recorded from T_3 treatment and the lowest yield plant^{-1} (122.567 g) was recorded from T_0 treatment. It is due to the fact that application of GA3 checks the flowers and fruit drop and ultimately increase the percent of fruit set. Kaushik *et al*. (1974) supported these findings. From T_1 treatment 666.29 g was recorded and from T_2 yield per plant 521.94 g was recorded. Ullah *et al*. (2015) also showed that application of boron gave higher yield per hectare than untreated control in tomato.

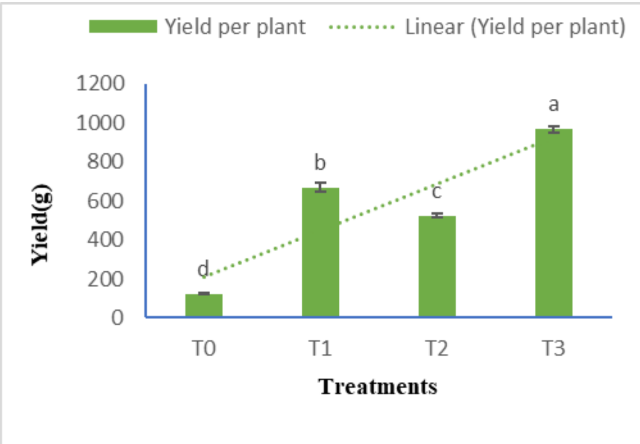

Figure 11. Influence of GA_3 and Boron on yield per plant. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

Yield ha^{-1}

Due to application of GA_3 and boron the yield ha^{-1} showed significant impact on production. The yield ha^{-1} ranges from 4.2 ton to 33.06 ton per ha. The highest yield ha^{-1} (33.06t) was recorded in T_3 treatment and the lowest yield plant^{-1} (4.2 t) was recorded in T_0 treatment. This might be due to that combined GA_3 and Boron application facilitated better reproductive development of plant. 22.84 tha^{-1} and 17.89 t ha^{-1} yield was calculated from T_1 and T_2 respectively. The present finding is agreed with the finding of Haleema *et al.* (2018), Uraguchi *et al.* (2014), Naz *et al.* (2012), Smit *et al.* (2004) and Davis *et al.* (2003).

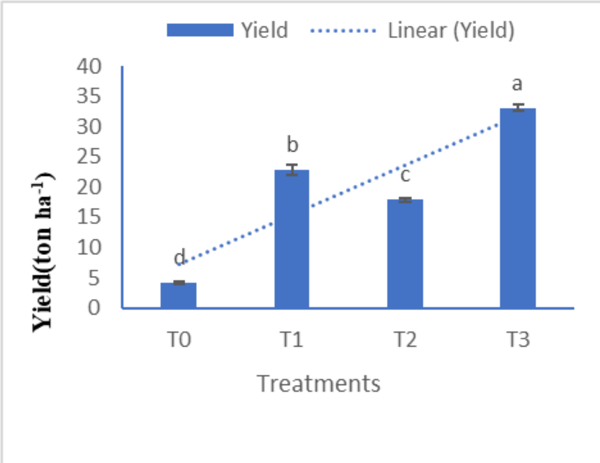

Figure 12. Influence of GA_3 and Boron on tomato yield per hectare. Vertical bars indicate the standard error of the mean against each treatment. The different letter indicates a significant difference among data at 5% level of probability.

CONCLUSION

The highest yield ha^{-1} (33.06t) was recorded in T_3 treatment and the lowest yield plant^{-1} (4.2 t) was recorded in control treatment. Results indicate that boron and GA_3 played an important role in the growth, fruit formation and fruit yield of summer tomato. BARI Hybrid Tomato-8 (summer) showed better performance when treated with GA_3 compared to boron. The plants produced the maximum yield due to the combined application of 50 ppm GA3 and 100 ppm boron over sole application of GA3 and boron. Therefore, these management combinations appears most effective practice for maximizing the fruit yield of summer tomato (BARI Hybrid Tomato-8).

Conflict of Interest

There are no conflicts of interest declared by the authors.

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