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Impact of foliar boron application on the growth and yield of summer tomato

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Abstract: Tomato (Solanum lycopersicum) is one of the most significant vegetable crops in the world, due to increasing demand. To promote the availability of boron to the plant throughout crucial growth phases, which eventually leads to increased plant growth and greater yields, foliar boron spray is intended to promote plant growth and yields in summer tomatoes. For tomato plants, boron is a key component, and deficits can cause stunted growth, substandard fruit development, and lower yields. By giving the plant an easily accessible supply of the nutrient, boron application on the leaves can assist in addressing boron shortages in the plant. BARI Tomato-4 in the Bangladeshi district of Noakhali, we used four treatments, B_0 (control), B_1 (H_3BO_3 125 ppm), B_2 (H_3BO_3 150 ppm) and B_3 (H_3BO_3 175 ppm) so as to find out what factors have a substantial impact on summer tomato growth and output. Following those treatments produced the highest plant height (153.66 cm), number of branches per plant (10.66), no. of clusters per plant (7.66), no. of flowers per cluster (8.33), weight of each fruit (83.66 gm), number of fruits per plant (34.33), and yield (22.43 tone) (H_3BO_3 150ppm). Treatment T_0 (control) produced the lowest plant height (143.33 cm), number of branches per plant (6.66), number of clusters per plant (6.66), number of flowers per cluster (6.67), weight of each fruit (79.33 g), number of fruits per plant (31) and yield (21.33 tons), followed by treatments B_1 (H_3BO_3 125 ppm), B_2 (H_3BO_3 150 ppm), and B_3 (H_3BO_3 175 ppm). In our study showed that development and productivity of summer tomatoes, growers higher by the use of boron at 175 ppm.

Keywords: BARI Tomato 4; Boric acid; *Solanum lycopersicum*.

INTRODUCTION

One of the most significant horticultural crops, the tomato (*Solanum lycopersicum*), is grown, traded, and consumed worldwide (Fernqvist & Ekelund, 2014). It is a member of the Solanaceae family and is used virtually universally in restaurants, pubs, and homes to pique hunger and enhance flavour (Sowley & Yahaya, 2013). Depending on the situation, tomatoes can be classified as either a fruit or a vegetable. Tomatoes are a fruit, but supermarkets designate them as vegetables because of their flavour and nutritional value, according to Encyclopedia Britannica. Regarding area produced, yield, and commercial usage as well as consumer demand, tomatoes rank among the most significant crops (Mohamad & Khalil, 2015). The Andes of South America are where tomatoes first appeared. The cultivated tomato was introduced by the Spanish to Europe in the sixteenth century, and from there it was spread to Southern and Eastern Asia, Africa, and the Middle East. Wild tomatoes have more recently been introduced to various regions of South America and Mexico (Kanwal & Rana, 2020). Different region in the world tomato known as different name like Tomate (Spain, France), Pomodoro or golden apple (Italy), Faan Ke'e (China), Jitomate (Mexico) (Peralta *et al.*, 2006). In Bangladesh Tomato is known as ''Bilatibegun, Gurbegun, Tok begun''also.

Tomatoes have a high water content of 94.1%, 23 calories from energy, 1.90 g of protein, 1 g of calcium, 7 mg of magnesium, 1,000 IU of vitamin A, 31 mg of vitamin C, 0.09 mg of thiamine, 0.03 mg of riboflavin, and 0.8 mg of niacin per 100 g of edible part (Moaaz Ali *et al.*, 2020). Because solanine, a glycoalkaloid steroidal that is present in all green plant parts, is hazardous and cannot be destroyed even by regular cooking methods, the stem and leaves should not be consumed. The antioxidant lycopene, which aids in removing potentially harmful free radicals from the body that might damage our cells, is largely responsible for the interest in tomatoes. Lycopene may improve the skin's capacity to defend itself against UV radiation and aid in the prevention of several tumour types.

The tomato's red colour is due to lycopene (Siddique, 2019). The tomato is grown year-round in Bangladesh, although it is most popular in the winter and summer. When compared to demand, the tomato production in our country falls short (Mazed *et al*., 2015). However, Bangladesh's poor tomato yield is not a reflection of the low yielding capacity of this crop, but rather reflects the fact that local tomato cultivars are not necessarily high yielding cultivars, and local producers' cultural methods have not been improved (Ruan *et al*., 1995). Tomatoes require a lot of heat, water, and light, especially in regions with short growing seasons. The tomato plant need at least seven hours of sunshine every day to produce adequate energy to produce fruit (Peet & Welles, 2005). In the best soil and climatic conditions, tomato plants may grow and develop properly. Temperatures between 20 and 27 °C are ideal for tomato growth. Fruit doesn't set well when the average temperature is above 30 °C or below 10 °C (Adams *et al.*, 2001). The lower yield characteristic of this crop namely, the absence of high-quality seeds of better varieties, inappropriate management of fertilizers, irrigation, disease control, and a lack of appropriate pruning techniques is caused by the crop's low yield potentiality. Due to its resilience to a variety of soil and climatic conditions, tomatoes are grown across Bangladesh (Sarker *et al.*, 2009).

The price of inorganic fertilizers has skyrocketed, as is already widely known, to the point where small and marginal farmers often cannot afford them. Consequently, farmers typically do not have the financial means to apply synthetic macro nutrients in sufficient or big amounts (Mehdizadeh *et al*., 2013). Consequently, a different option is to foliar-apply a tiny quantity of these nutrients. The main jobs of micronutrients are to help green plants with their photosynthesis and chlorophyll production. The elements, such as nitrogen, boron, copper, and zinc, are considered as important macro- and micro-nutrients and are necessary for healthy plant development, growth, and production. Additionally, by maintaining a sufficient amount of nutrients in the soil or by foliar treatment, tomato quality and yield potential can be improved.

Micronutrient boron (B) is crucial for crop productivity. One crop that benefits from B treatment is the tomato. Tomato blossom end rot is a result of the B deficient condition, which lowers the tomato's market value. Growers frequently fail to detect a boron deficit in fresh-market tomatoes (Lycopersicon esculentum Mill). However, widespread boron deficit can result in significant productivity decreases and irregular ripening of tomato fruit (Davis *et al*., 2003). With rising soil pH, plants have reduced access to boron. Boric acid, also known as hydrogen borate, boracic acid, and orthoboric acid, is a monobasic Lewis acid of boron that is weak. Its chemical formula is H_3BO_3. Since boric acid makes up 17.4% of the substance by weight, 1 tsp of boric acid produces 0.31 mg of boron. Without the management issues associated with delivering B as a dry formulation, continuous foliar spraying of B on tomatoes assures a consistent supply of B throughout the growth season. B is applied directly to the root zone via drip irrigation, and it may also be absorbed through the leaves using foliar treatments. The goal of this study was to find out whether adding B to tomato leaves and/or roots in a liquid formulation would increase yields, fruit quality, and nutritional content. Considering the above circumstances an experiment was carried out to find the effect of boron on tomato plant growth and observe the yield after foliar application of boron.

MATERIALS AND METHODS

From June 26 to November 7, 2019, the experiment was carried out in plots at the experimental location of Nobogram Agro Farm, Mannan nogor, Sonapur, Noakhali. The supplies utilised and the procedures employed during the experiment are covered in this chapter. It includes a brief description of the materials used, the experimental site's location, the soil's characteristics, the weather, the raising of seedlings, the application of manures and fertilizers, the transplanting of the seedlings, intercultural operations, harvesting, yield, the collection of data, statistical analysis etc.

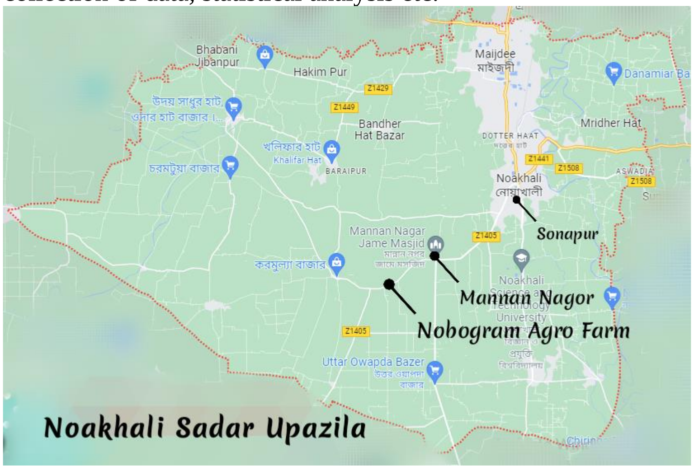

Fig 01: Map showing the experimental site under the study.

Soil and climate

The experimental locations were in the tropical climate zone, where the average annual temperature of 23.75°C is ideal for Bangladeshi tomato cultivation. The soil was sites sandy loam in texture and slightly sandy soil which pH range were 7.8 to 8.5.

Planting materials

One tomato variety was examined; it was procured from the Noakhali branch of the Bangladesh Agricultural Research Institute (BARI). BARI Hybrid Tomato-4 is the brand name for the summer tomato cultivar.

Treatment and Replications

Transplanted seedlings were sown directly in the field after 28 days of germination in the seedbed. In this

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experiment one factor was considered that was the doses of boric acid followed by B_0: Control, B_1:125ppm boric acid, B_2:150ppm boric acid and B_3:175ppm boric acid. The experiment was done three times replications for the variety of BARI Hybrid tomato-4 (V_1). So, Treatment Combinations are V_1+ B_0 : BARI tomato 4+Control, V_1+B_1: BARI tomato 4*125ppm boric acid, V_1+B_2: BARI tomato 4+150ppm boric acid, V_1+B_3: BARI tomato 4+175ppm boric acid

Seedbed

The soil was well-prepared and transformed into loose friable for growing tomato seedlings. The soil was cleared of all weeds and dead grasses, and well-rotted cow manure was added. Soil clods are broken down by hands. Fertilizers and manures are mixed properly with the soil. The seedbed is 3m length and 1m width and 15-20m above from the ground level. For the purpose of shielding the seedlings and seeds from excessive moisture during the rainy season, the seedbed is covered with a bow-shaped structure constructed of bamboo and polythene sheet. The amount of fertilizers required for each seedbed was calculated 165g. 135g. 75g and 4.2kg for Urea, TSP, MP and Cowdung respectively. Each variety's 100 seeds were scattered on the seedbed. The seeds were sown, and then light dirt was applied to them.

Main field preparation

The ground was properly tilled when it was tilted. During the last stage of land preparation, all fertilisers and well-decomposed cow dung (apart from urea) were applied. The experiment was created using RCBD, or random complete block design (in statistical analysis). B_0, B_1, B_2, and B_3 are the plot numbers for the four BARI Hybrid Tomato-4 treatments, which are control, 125 ppm boric acid, 150 ppm boric acid, and 150 ppm boric acid. Each plot measured 77 m^2. Each plot had 30 plants that were separated into three blocks, which corresponded to 3 replications. The spacing between the plants and the rows was 40 cm. (Treatment experiment).

Seedling transplanting in the main field

On July 29, 2019, in the late afternoon, seedlings of a consistent size and health were put into the test beds. The seedlings received adequate watering right away after the transplant.

Manure and fertilizers application

With the exception of N, all fertilizers and cow dung were applied at the last stage of soil preparation. The final stage of land preparation involved applying half of the cow dung, half of the P, and the full amounts of S and B. At 21, 35, and 50 days after transplanting, N and K were administered in three divided dosages. The remaining amount of P and cow dung were applied at line preparation before planting. The total quantity of application of fertilizers is presented in Table 1.

Table 1. Doses of fertilisers and manures utilised in the study.

Sl. No.	Fertilizers/Manures	Dose(quantity/ha)
01	N	253kg
02	P	90kg
03	K	125kg
04	S	22kg
05	Zn	5.4kg
06	B	2kg
07	Cow dung	10 ton

Irrigation

To make up for any water shortage that may have existed after transplanting, each seedling received gentle watering. Watering was carried out as and when required once the seedlings were established.

Gap filling

Healthy seedlings from the same cultivar were used to fill up the gaps left by unsuccessfully transplanted seedlings.

Weeding and Mulching

Mulching and weeding were done to maintain the plots free of weeds, facilitate soil aeration, and retain soil moisture, all of which led to greater growth and development. After the seedlings had been established, all plots had uniform first mulching and weeding. Twenty days following the initial weeding, a second one was carried out. Another weeding was performed for clean cultivation during the fruit growth and maturity stage. When required, the freshly emerging weeds were gently pulled removed. Mulching was used when necessary to break up the soil's cluster.

Supporting

As the plant's development progressed, plastic slicks were employed to offer supporting infrastructure. To hold the plants upright and to guard against harm from any unfavourable circumstances, the sticks were loosely arranged beside the plants.

Pest and disease control

Insect attack isn't very common in tomato but attack of white fly is seen. This insect is very small and stay at the lower surface of leaves. White fly is the vector of yellow leaf curl of tomato. Diazinon @ 1ml/L at 15 days interval is sprayed to control this insect. It is advisable that spraying must be stopped 15 days before of fruit collection.

Harvesting

At 63 DAT, the first ripe tomato harvest began. Tomatoes were initially collected every three days, and then daily after 75 days. By September 2018, the harvest was done.

Statistical analysis

With the use of SPSS software and an Excel data sheet, the acquired data for the study's various parameters were statistically examined. By using the "t" test, the variance of several parameters was analysed. Least Significant

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Difference (LSD) test was used to get the mean difference (5% threshold of significance) (Gomez & Gomez, 1984)

RESULTS AND DISCUSSION

The result of the study has been presented and discussed in this chapter jointly under the experimental heads and summary of the analyses of variances in respect of different parameters studied has been shown in Table-2 for easy understanding, justification of obtaining such results and for making a conclusion on overall experiment.

Height of each plant (cm)

Significant differences in plant height were seen between the various doses. Result indicated that the tallest plant of 150.66 cm was observed in the B_3 (175 ppm boric acid) followed by the treatments B_2 (150 ppm boric acid) and B_1 (125 ppm boric acid) were observed 147.33 cm and 144 cm. The lowest plant height of 143.33cm was recorded in B_0 (control).

No. of branches per plant

In terms of the number of branches per plant, there was a significant difference between the various doses. Result indicated that maximum no. of branch per plant 10.66 which was observed in the B_3 (175 ppm boric acid) followed by the treatments B_2 (150 ppm boric acid) and B_1 (125 ppm boric acid) were observed 9.66 and 8.33. The lowest no of branch 6.66 was recorded in B_0 (control).

No. of cluster per plant

Data regarding to no. of cluster per plant showed that the variety of BARI tomato-4 was affected by the different doses. Highest cluster per plant (7.66) were recorded for B_3 (175 ppm boric acid) followed by the treatments B_2 (150 ppm boric acid) and B_1 (125 ppm boric acid) were observed 7.33 and 7.33. The lowest no of cluster 6.33 was recorded in B_0 (control).

No. of flowers per clusters

Data regarding to no. of flower per plant showed that the variety of BARI tomato-4 was affected by the different treatments. Highest flower per cluster (8.33) were recorded for B_3 (175 ppm boric acid) followed by the treatments B_2 (150 ppm boric acid) and B_1 (125 ppm boric acid) were observed 7.66 and 7.33. The lowest no flower per cluster (6.66) were recorded in B_0 (control).

No. of fruits per plant

Various treatments resulted in varying numbers of fruits per plant. The B_3 treatment, which included 175 ppm of boric acid, produced the most fruits per plant (34.33), followed by B_2 (150 ppm) and B_1 (125 ppm), which produced 32.66 and 32. Respectively B_0 was found to have the fewest fruits per plant (control).

Weight of each fruit

In terms of each fruit's weight, there was a significant difference between the various treatments. The B_3 treatment (175 ppm boric acid) produced the heaviest fruit, weighing 83.66 gm, which was followed by the B_2 and B_1 treatments, which produced 82.66 gm and 80.33 gm of fruit, respectively. B_0 yielded a plant with the lightest fruit weight, 79.33 gm (control).

Yield

It was observed the differences among the effect of different treatments. The highest yield 22.83 ton was found in B_3 (175 ppm boric acid) followed by the treatments B_2 (150 ppm boric acid) and B_1 (125 ppm boric acid) were observed 22.5 ton and 22.08 ton. The lowest yield was obtained from B_0 (no treatment) was 21.33 ton.

Table 2: Effect of foliar application of boron on growth, flowers and fruit set contributing characters and yield of tomato.

Treatment (s)	Height of each plant (cm)	No. of branches per plant	No. of cluster per plant	No. of flower per plant	No. of fruits per plant	Weight of each fruit(gm)	Yield
B_0(control)	143.33	6.66	6.66	6.66	31	79.33	21.33
B_1(H_3BO_3 125 ppm)	144	8.33	7.33	7.33	32	80.33	22.08
B_2(H_3BO_3 150 ppm)	147.33	9.66	7.33	7.66	32.66	82.66	22.5
B_3 (H_3BO_3 175 ppm	150.66	10.66	7.66	8.33	34.33	83.66	22.83
C.V	0.960	9.804	8.889	6.082	4.134	0.737	2.702
Level of significan	**	**	NS	NS	NS	**	NS

The table represents the results of an experiment conducted to study the effect of different concentrations of H_3BO_3 on the growth and yield of plants. The experiment has four treatments, B_0 (control), B_1 (H_3BO_3 125 ppm), B_2 (H_3BO_3 150 ppm), and B_3 (H_3BO_3 175 ppm). The following parameters have been measured: height of each plant (cm), number of branches per plant, number of clusters per plant, number of flowers per plant, number of fruits per plant, weight of each fruit (gm), and yield. The C.V (coefficient of variation) is a measure of the variability of the data. It indicates how much the data deviate from the mean. In this

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experiment, the C.V values are relatively low, indicating that the data are consistent and reliable.

The level of significance is a measure of the probability that the observed differences between the treatments are due to chance. In this experiment, the level of significance is indicated by asterisks (*), where ** indicates a highly significant difference ($p < 0.01$), and NS (not significant) indicates no significant difference between the treatments.

The plants treated with H_3BO_3 have higher growth parameters and yield compared to the control plants. The plants treated with B_3 (H_3BO_3 175 ppm) showed the highest growth parameters and yield among all the treatments. The increase in concentration of H_3BO_3 leads to a gradual increase in growth parameters and yield. The number of flowers per plant shows no significant difference between the treatments, indicating that H_3BO_3 concentration does not affect flower production. The weight of each fruit shows a significant difference between the treatments, indicating that H_3BO_3 concentration affects the size of the fruits. Overall, the results suggest that the application of H_3BO_3 can improve the growth and yield of plants. The optimum concentration of H_3BO_3 for maximum yield and growth could be determined by further experimentation.

CONCLUSION

Boron is an essential micronutrient for the growth and development of plants. It plays a vital role in several physiological processes, including cell wall formation, protein synthesis, carbohydrate metabolism, and nitrogen fixation. As a result, boron has a significant effect on agriculture and crop production. Boron deficiency in plants can result in stunted growth, poor root development, reduced flowering, and reduced fruit set. Therefore, the application of boron as a fertilizer is essential to ensure optimal plant growth and yield. Foliar boron application has been found to have a significant positive effect on the growth and yield of summer tomato plants. The application of boron as a foliar spray has been shown to improve fruit set, fruit quality, and overall plant growth. Boron plays a crucial role in cell wall development and division, which is necessary for healthy plant growth and development.

Additionally, boron is essential for the proper uptake and utilization of other nutrients, particularly calcium, which is essential for the development of strong cell walls and healthy fruit. Foliar boron application can help to correct deficiencies in soil boron levels and improve overall plant health. It is important to note that excessive boron application can have negative effects on plant growth and yield. Therefore, it is crucial to apply boron in the recommended dosage and follow the proper application methods. Foliar boron application can be an effective tool for improving the growth and yield of summer tomato plants, particularly in soils with low boron availability. Proper application of boron can help to ensure healthy and productive tomato plants, leading to increased yields and improved fruit quality. the amount and timing of boron application depend on the soil type, crop type, and environmental conditions. Applying excessive amounts of boron can be toxic to plants, leading to reduced growth, and yield. Therefore, it is essential to follow recommended application rates and methods.

The future of foliar boron application in the growth and yield of summer tomato plants looks promising. Research continues to be conducted on the optimal dosage, timing, and methods of boron application to achieve the maximum benefits on plant growth and yield. The use of boron in combination with other micronutrients, such as zinc and manganese, is being explored to enhance their synergistic effects on plant growth and yield. With increasing demand for sustainable agriculture practices and reducing the use of synthetic fertilizers, foliar boron application offers a cost-effective and environmentally friendly option for improving the productivity of summer tomato plants.

The development of boron-containing nano-fertilizers may enhance the efficiency of boron uptake and utilization by tomato plants, thereby reducing the amount of boron required for application and reducing potential negative environmental impacts. In the end, the use of foliar boron in the production of summer tomatoes appears to have a bright future and may have advantages for efficient and fruitful agricultural practices.

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