# EFFECT OF SULPHUR AND BORON FERTILIZER ON THE GROWTH AND YIELD OF BARI TOMATO-2 (*Lycopersicon esculentum*)

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## A Thesis

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*Dedicated*

*To My*

*Beloved Parents*

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## *CERTIFICATE*

*This is to certify that the thesis entitled,"* ***EFFECT OF SULPHUR AND BORON FERTILIZER ON THE GROWTH AND YIELD OF BARI TOMATO-2 (Lycopersicon esculentum)"*** *submitted to the Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of Master of Science in Soil Science, embodies the result of a piece of bona fide research work carried out by* ***MD. HARUN AR RASHID*** *Registration No.* ***19-10329*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

*I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.*

**Dated: December, 2021**

**Place: Dhaka, Bangladesh**

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**ABSTRACT**

An experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2020 to April 2021 to find out the effect of different levels of sulphur and boron fertilizer doses on the growth and yield of BARI Tomato-2. The experiment was laid out in a Randomized Complete Block Design (RCBD) having twelve treatments with three replications. The unit plot size was 6 $m^2$. A total of 12 treatments combination of Sulphur and Boron were distributed randomly in individual plots and total number of plots was 36. The maximum plant height (84.50 cm), number of branches $plant^{-1}$ (9.73), number of leaves (147.67), number of cluster $plant^{-1}$ (8.30), number of fruits $cluster^{-1}$ (4.30), diameter of a fruit $plant^{-1}$ (17.68 cm), number of fruits $plant^{-1}$ (37.45), weight of fruits $plant^{-1}$ (2.48 kg) and yield (89.49 t $ha^{-1}$) were observed from $T_8$ ($S_{22kg/ha}$ + $B_{1kg/ha}$) treatment. On the other hand, the minimum plant height (66.67 cm), number of branches $plant^{-1}$ (7.07), number of leaves (113.40), number of cluster $plant^{-1}$ (8.07), number of fruits $cluster^{-1}$ (3.70), diameter of a fruit (16.13 cm), number of fruits $plant^{-1}$ (25.21), weight of fruits $plant^{-1}$ (1.54 kg) and yield (46.33 t $ha^{-1}$) were observed from $T_1$ treatment that was control. The results of the present investigation revealed that tomato can be grown successfully at the use of 22 kg $ha^{-1}$ of sulphur and 1 kg $ha^{-1}$ of boron. The findings of the present investigation clearly indicated that the efficient use of sulphur and boron doses is a viable option for increasing the production of tomato.

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# LIST OF ABBREVIATIONS

| **Abbreviation** | **=** | **Full word** |
|---|---|---|
| % | = | Percent |
| N | = | Nitrogen |
| P | = | Phosphorus |
| K | = | Potassium |
| S | = | Sulphur |
| B | = | Boron |
| RDF | = | Recommended Doses of Fertilizer |
| @ | = | At the rate |
| °C | = | Degree Centigrade |
| Anon. | = | Anonymous |
| BARI | = | Bangladesh Agricultural Research Institute |
| BAU | = | Bangladesh Agricultural University |
| BBS | = | Bangladesh Bureau of Statistics |
| CV | = | Coefficient of Variance |
| cv. | = | Cultivar (s) |
| DAI | = | Days After Inoculation |
| HSD | = | Honestly Significant Difference |
| e.g. | = | (For example) example gratia |
| *et al.* | = | (And Others) et alibi |
| etc. | = | Etcetera |
| FAO | = | Food and Agriculture Organization |
| G | = | Gram |
| hr | = | Hour (s) |
| i.e. | = | That is |
| ISTA | = | International Seed Testing Agency |
| kg | = | Kilogram |
| LSD | = | Least Significant Difference |
| no. | = | Number |
| SAU | = | Sher-e-Bangla Agricultural University |
| T | = | Treatment |
| NPK | = | Nitrogen, Phosphorus and Potassium |
| t/ha | = | Ton per Hectare |
| UNDP | = | United Nations Development Program |
| wt. | = | Weight |
| Mg | = | Milligram |
| CHO | = | Carbohydrate |
| Conc. | = | Concentration |

# CHAPTER I

# INTRODUCTION

Tomato (*Lycopersicon esculentum mill*) belongs to the family Solanacea, genus *Lycopersicon*, sub family Solanoideae and tribe Solaneae. It is widely cultivated in tropical, subtropical and temperate climates and ranks third next to potato and sweet potato in terms of world vegetable production (FAOSTAT, 2019). With estimated annual area coverage and total production of 182metrics million tons in 2017 which was harvested from 4.8 million hectares (FAO, 2014). Among vegetable crops, tomato is the most important edible and nutritious worldwide (FAOSTAT, 2019). Tomato plays an important role in human nutrition by providing essential amino acids, vitamins, minerals, sugars and dietary fibers (Kanyomeka and Shuvite, 2005). The fruit also contains antioxidant carotenoids that contribute to human nutrition and give the red color for most existing cultivars on the market (Rocha and Silva, 2011).

The edaphic and climatic conditions of Bangladesh are congenial for tomato cultivation. The production of tomato in our country in 2017-18 was 385 thousand metric tons whereas it was only 190 thousand metric tons in 2009-10 (BBS, 2018). Although the production of tomato in Bangladesh is increasing day by day but it is not enough to fulfill the demand of the peoples; thus, every year the country needs to import tomato. The lower yield of tomato in Bangladesh, however, is not an incidence of the low yield potentiality of this crop, but, the fact that the lower yield may be attributed to a number of reasons viz. unavailability of quality seeds of improved varieties, fertilizers management, disease infestation and improper moisture management. Among them fertilizer management is a vital factor that influence the growth and yield of tomato. Balance fertilizations in crops will act as an insurance against possible nutrient deficiencies that may be created by the respected use of a single nutrient (Manang *et al.*, 1982).

Sulphur is a plant nutrient with a crop requirement similar to that of phosphorus. Sulphur is known as the fourth major plant nutrient (Gowswamy, 1986). It is essential constituent of sulphur containing amino acids cystine, cysteine and methionine and plays vital role in regulating the metabolic and enzymatic process including photosynthesis, respiration and symbiotic N fixation, besides being responsible for the synthesis of vitamins such as biotin, thiamine, vitamin B and certain coenzymes (Chadha, 2003, Kumar and Singh, 2009). The sulphur-deficient tomato plants had, however, a remarkable capacity for stem elongation; and although the stems were woody and thin they increased in length, but not in diameter, as rapidly as the stems of the complete-nutrient plants.Also tomato plants were extremely high in carbohydrates, and contained much more nitrate than the plants which received the complete nutrient solution.

Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants (Yadav *et al*., 2018). The requirement of micronutrients (boron, iron, copper, zinc, manganese, chloride and molybdenum) is only in traces, which is partly met from the soil through chemical fertilizer or through other sources. Its play an eminent role in plant growth, development and plant metabolism. However, their deficiencies may induce several physiological disorders/ diseases in plants and later, can reduce the quality as well as quantity of vegetable crops (Sharma and Kumar, 2016). These are not only essential for better growth, yield and quality, but also important like other major nutrients in spite of their requirement in micro quantity. These are required by plants in very small quantities, yet they are very effective in regulating plant growth due to enzymatic action (Sathya *et al.,* 2010). It also helps in uptake of major nutrients and also vital to the growth of plants acting as catalyst in promoting various organic reaction from cell development to respiration, photosynthesis, chlorophyll formation, enzyme activity, hormones synthesis and nitrogen fixation. These also improve the chemical composition and general condition of vegetable crops and are known to act as catalyst in promoting various organic reactions in plants (Karthick *et al*., 2018). The incidence of their deficiencies in crops has increased markedly in recent years due to intensive cropping, soil erosion, losses of nutrients through leaching, liming of acid soils, unbalanced fertilizer application including NPK and no replenishment (Aske *et al*., 2017). The production and productivity of crop is being adversely affected in areas due to deficiencies of micronutrients. Micronutrients have an important role in the plant activities and foliar application can improve the vegetative growth, fruit set and yield of tomato (Adams, 2004) by increasing photosynthesis of green plants (Mallick and Muthukrishnan, 1980).

Among micronutrients, boron plays an important role directly and indirectly in improving the yield and quality of tomato in addition to checking various diseases and physiological disorders (Magalhaes *et al.,* 1980). The increase in vegetative growth of tomato could be attribute to physiological role of boron and its involvement in the metabolism of protein, synthesis of pectin, maintaining the correct water relation within the plant, resynthesis of adenosine triphosphate (ATP) and translocation of sugar at development of the flowering and fruiting stages (Bose and Tripathi, 1996). Boron also has effect on many functions of the plant such as hormone movement, active salt absorption, flowering and fruiting process, pollen germination, carbohydrates, nitrogen metabolism and water relations in the plants. Boron deficiency causes reduced root growth, brittle leaves and necrosis of shoot apex. The improvement in quality parameters of tomato fruit due to boron application could be the result of overall growth and development of the crop (Naresh, 2002). Boron also affects the quality of tomato fruit, particularly size and shape, color, smoothness, firmness, keeping quality and chemical composition. Demoranville and Deubert (1987) reported that fruit shape, yield and shelf life of tomato were also affected by boron nutrition.

Therefore, the present study has been undertaken to investigate the effect of Sulphur and Boron fertilizer on the growth, yield attributes and yield of Tomato. Keeping the above stated fact in view, the present study was undertaken in achieving the following objectives:

**Objectives:**

The study aims to attain the following objectives:

i. To investigate the effect of Sulphur and Boron fertilizer on the growth, yield attributes and yield of BARI Tomato-2
ii. To find out optimum doses of Sulphur and Boron to attain higher yield of BARI Tomato-2

# CHAPTER II

# REVIEW OF LITERATURE

In this chapter an attempt has been made to review the available information in home and abroad regarding the study on effect of sulphur and boron fertilizers on the growth and yield of tomato. Many research organizations of our country has limited information on the S and B fertilizers on the growth and yield of tomato. But in foreign countries there are more numbers of relevant data. A review of the previous research and findings of researchers having relevance to this study which were gathered from different sources like literature, journals, thesis, reports, newspaper etc. will be represented by this chapter.

## 2.1 Effects of sulphur on plant growth and yield of tomato

Devi *et al.*, (2012) studied the effect of sulphur and boron fertilization on yield, quality and nutrient uptake by tomato under upland condition. The study revealed that yield attributing characters like number of branches plant$^{-1}$, branch spread, fruits plant$^{-1}$and fruits weight and yield were increased with the application of sulphur and boron as compare to control. The overall result revealed that application of 30 kg sulphur hectare$^{-1}$ was found to be the optimum levels of sulphur for obtaining maximum yield attributes, yield, and total uptake of sulphur of soybean under upland condition as compare to other levels of sulphur.

Orman and Huseyin (2012) conducted a pot experiment study to evaluate the effects of Boron and Sulphur on straw and grain dry weight of tomato grown in a calcareous clay loam soil. Sulphur was applied at 0, 10, 50, 150 kg S kg ha$^{-1}$ (as $CaSO_4.2H_2O$) and Boron at 0, 5 mg B kg ha$^{-1}$(as Boric acid) to the soil. The results suggest that application of sulphur and zinc could be a good approach for the nutrition of tomato plants.

Muthanna*et al.*, (2017) carried out an investigation to study the effect of boron and sulphur application on plant morphology and yield of tomato during 2015-16 and 2016-17. The maximum plant height and yield of marketable tubers (17.99 t ha$^{-1}$ and 27.00 t ha$^{-1}$) were recorded in the plants treated with RDF + 2 kg B + 40 kg S during both year of investigation. RDF + 2 kg B + 40 kg S was also found statistically at par with the maximum values under characters *viz*., stem diameter and number of marketable fruits plant$^{-1}$.

## 2.2 Effects of Boron on plant growth and yield of tomato

Naz *et al*. (2012) studied the effect of Boron (B) on the flowering and fruiting of tomato and reported that application of boron @ 2 kg/ha, enhanced number of flower clusters per plant, fruit set percentage, total yield, fruit weight loss and total soluble solids.

Application of micronutrients particularly sulphur and Boron play an important role to boost up tomato production in micronutrient deficient areas of Bangladesh. It can be summarized from the present study that combined application of S and B @ 22.0 and 2.0 kg ha$^{-1}$, respectively has a significant positive effect on growth and yield of tomato fruits. However, there were some inconsistencies in results, particularly for the application of different levels of sulphur, which might be due to its content in soils, environmental factors and different management practices. Furthermore, sulphur and Boron fertilizers recommendation in future should be site, location and variety specific (Supti Mallick *et al*., 2020).

Khatun *et al*. (2020) reported that a combination of 26 kg sulphur and 2.5 kg boron per hectare demonstrated was better result in respect of plant growth and fruit and seed of tomato and the results also suggested that high seed yield and good quality seed of tomato can be obtained with the application of 26 kg sulphur and 2.5 kg boron per hectare in combination with 30 fruits were retained per plant.

Ilyas *et al*., (2019) was conducted to investigate the effect of boron and sulphur on the growth and yield of tomato. Three levels of boron (viz., 0, 1 and 2kg $H_3BO_3$ ha$^{-1}$) and sulphur (viz., 0, 22 and 44kg $CaSO_4.2H_2O$ ha$^{-1}$) were applied for each experiment. Results revealed that boron had significant effect on all yield attributes and yield of tomato. Application of 1 kg $H_3BO_3$ per ha produced the highest tomato yield (79.2 t ha$^{-1}$) through increasing plant height, number of leaves per plant, number of branches per plant, number of flower clusters per plant, number fruits per plant, weight of fruits per plant, fruit weight, individual fruit length, fruit diameter and yield $ha^{-1}$ of fruits. On the other hand, maximum yield of tomato was obtained from 22kg $CaSO_4.2H_2O$ $ha^{-1}$. A combination of 1 kg $H_3BO_3$ and 22kg $CaSO_4.2H_2O$ $ha^{-1}$ gave the highest yield of Tomato (83.50 t $ha^{-1}$). So, application of 1 kg $H_3BO_3$ along with 22kg $CaSO_4.2H_2O$ $ha^{-1}$ was the best for growth and yield of tomato.

Mosharaf *et al.,* (2019) concluded that the application of S and B influenced different growth and yield parameters while the other four micronutrients tested: i.e. Cu, Mn, F and Mo, did not have any effect. The application of micronutrient package having S, Zn, B, Cu, Mn, Fe and Mo is beneficial for better plant growth. Fruit yield of tomato was affected significantly by the application of only S but combined application of both S and B showed the highest response by tomato. Only S was found responsive for fruit yield per plant, fruit clusters per plant and number of fruits per plant. Similar to fruit yield, protein concentration and almost all nutrient uptake were affected by the application of both S and B.

Haleem *et al.* (2017) found that the interaction of B and S increases the plant height, number of primary and secondary branches, number of leaves $plant^{-1}$, number fruits $plant^{-1}$ in tomato. Spraying boron 1 ppm significantly increased the number of leaves per plant (68.9) and height of the plant (128.8 cm) compared to control in tomato (Verma *et al*., 1973).

The plant height (112.92 cm) increased considerably with the foliar spray of boron 0.5% at 50 per cent flowering in tomato (Hamsaveni *et al*., 2003). The soil application of boron 1 kg $ha^{-1}$ increased plant height (60.53) and the number of branches (7.6) in tomato by promoting root growth, which enhanced nutrients absorption (Sathya *et al.,* 2010). In tomato, foliar application of borax alone significantly enhanced the number of branches per plant and higher plant height (Rab and Haq, 2012).

Bhatt *et al.* (2004) concluded that the mixture of boron,sulphur, zinc, iron and manganese at 100 ppm resulted in maximum number of branches (9.61) and leaves per plant (132.16) in tomato.

Yadav *et al.* (2006) evaluated the effects of boron (0.0, 0.10, 0.15, 0.20, 0.25, 0.30 or 0.35%), applied to foliage after transplanting, on the yield of tomato cv. DVRT-1 in Allahabad, Uttar Pradesh, India, during 2003-04. The highest number of fruits plant$^{-1}$ (44.0), number of fruits plot$^{-1}$ (704.0), yield plant$^{-1}$ (0.79 kg), yield plot$^{-1}$ (12.78 kg) and yield ha$^{-1}$ (319.50 quintal) were obtained with 0.20% boron, whereas the greatest fruit weight (27.27 g) was recorded for 0.10% boron.

Sharma *et al.* (2000) reported that borax at 2 kg/ha and calcium carbonate at 10 kg/ha applied alone or in combination showed best results in for plant height (189.2 cm) and number of branches per plant (9.2) and concluded that boron 20 kg/ha showed pronounced beneficial effect on test weight (3.94 g) and per cent seed germination (96.5) as compared to boron 10 kg/ha (3.41 g and 94.33%, respectively) in tomato.

Again Sharma *et al.* (2016) stated that application of borax 2kg/ha gave the maximum plant height (70.6 cm) and number of branches per plant (6.9), while the control registered the least plant height (59 cm) and number of branches per plant (5.8).

Singh *et al*. (2014) obtained higher yield (23.10 and 18.33 t/ha) of tomato with the application of boron and sulphur in combination. The highest number of flower clusters plant$^{-1}$ (12.33), number of fruits cluster$^{-1}$ (7.17), number of fruits plant$^{-1}$ (88.33), yield plant$^{-1}$ (6.33kg) and total yield (95.628 t ha$^{-1}$) was registered with combined application of boron 1.25 g/l + sulphur 22 kg in tomato under agro-climatic conditions of Allahabad (Shnain*et al*., 2014).

Shoba *et al*. (2005) conducted a field experiment in Tamil Nadu, India, during the 2002 rabi season, to investigate the effects of calcium (Ca) and boron (B) fertilizer and ethrel [ethephon] applications and 45x45 and 65x45 spacings against fruit cracking in the tomato genotypes LCR 1 and LCR 1 x H 24. Between the 2 genotypes, the fruit cracking percentage was low in LCR 1 x H 24. Among the 2 spacings, closer spacing showed less fruit cracking and among the different nutrient treatments, the spraying of B with Ca was effective in controlling fruit cracking.

Oyinlola (2004) conducted a field trial in the Sudan savanna ecological zone in Nigeria to identify the effects of 0, 1, 2, 3, 4, and 5 kg B/ha on the growth, dry matter yield and nutrient concentration of tomato cultivars Roma VF and Dandino. Application of boron significantly (P>0.05) increased the number of leaves and dry matter yield of the crop. Nutrient concentrations of potassium and phosphorus in the plant tissue fell within the deficiency range established for tomato plants, while calcium, magnesium, boron, sulphur, zinc, manganese and copper concentrations fell within and iron concentrations above the sufficient nutrient range. Significant correlation existed between growth, yield parameters and nutrient concentrations and also among the nutrient concentrations. Plants supplied with 1 kg B/ha recorded the highest number of leaves and dry matter yield in both years. Cultivar Dandino recorded higher number of leaves and dry matter yield than cv. Roma VF.

Oyinlola and Chude (2004) found that application of Boron significantly (P>0.05) increased the number of leaves and dry matter yield of the crop. Matured ripe fruits were analysed for biochemical properties such as ascorbic acid, reducing sugar and total soluble solid content and titratable acidity. Boron rates significantly (P <0.01) increased the yield and yield attributes of the crop such as number of fruits and average weight of fruits, as well improved the biochemical properties of the fruits. In both years, the highest fruit yield and best fruit quality were obtained at 1 kg B/ha. Fruit yield increased by 121 and 72% relative to the control in 1992/93 and 1993/94, respectively. Cultivar Dandino recorded higher ascorbic acid, total soluble solids, titratable acidity, reducing sugars and yield compared to cv. Roma VF, whereas cv. Roma VF flowered earlier than Dandino. Fruit yield correlated with all the yield attributes and biochemical properties determined for both years.

In tomato cv. Utkal Raja, maximum increase was observed with the application of manganese (148.7 %) followed by micronutrient combination (144.1 %). Significant increase in number of branches per plant has been reported by application of boron (Basavarajeswari*et al.,* 2008), Zinc (Kiran *et al.,* 2010) and micronutrient mixture (Hatwar*et al.,* 2003).In tomatoes, combined application of micronutrients produced the maximum fruit yield followed by application of boron and zinc. Increased yield due to micronutrient application may be attributed to enhance photosynthesis activity, resulting into the increased production and accumulation of carbohydrates and favorable effect on vegetative growth and retention of flowers and fruits, which might have increased number and weight of fruits. Increased yield in response to micronutrients (B, S and mixture) have been reported by Naga *et al*. (2013).

Salam *et al.* (2011) investigated that the combination of boron and sulphur @ 2.5 kg B/ha + 22 kg S/ha, resulted the highest pulp weight, dry matter content, ascorbic acid, lycopene content, chlorophyll content in tomato.

Davis *et al*. (2003) carried out an experiment to compare the effects of foliar and soil applied B on plant growth, fruit yield, fruit quality, and tissue nutrient levels. Regardless of the application method, B was associated with increased tomato growth and the concentration of K, Ca, and B in plant tissue. Boron application was associated with increased N uptake by tomato in field culture, but not under hydroponic culture. In field culture, foliar- and/or soil-applied B similarly increased fresh-market tomato plant and root dry weight, uptake, and tissue concentrations of N, Ca, K, and B, and improved fruit set, total yields, marketable yields, fruit shelf life, and fruit firmness. The similar growth and yield responses of tomato to foliar and root B application suggests that B is translocated in the phloem in tomatoes. Fruits from plants receiving foliar- or root-applied B contained more B, and K than fruits from plants not receiving B, indicating that B was translocated from leaves to fruits and is an important factor in the management of K nutrition in tomato.

Naresh (2002) carried out an investigation in Nagaland, India during 1998-2000 observed that the effects of foliar application of boron (50, 100, 150, 200, 250 and 300 ppm) on the growth, yield and quality of tomato cv. Pusa Ruby. Boron improved the yield and quality of the crop. The highest yield (327.18 and 334.58 q/ha) was obtained when the plant was drenched with 250 ppm aqueous solution of boron. B also had positive effects on plant height, number of branches, flowers and number of fruit set per plant, resulting in an increase in the number of fruits per plant and total yield. At lower rates, B improved the chemical composition of tomato fruits and at higher rates increased the total soluble solids, reducing sugar and ascorbic acid contents of the fruits. Acidity of fruits showed a marked increase with increasing levels of B up to 250 ppm. However, the significant effects of B were recorded in the second year only.

Chandra and Verma (2003) found that the application of boron 2 kg and calcium 2 kg/ha to soil prior to transplanting was most effective for obtaining the highest fruit and seed yield in tomato. Foliar spray of boron 0.5% at 50 per cent flowering period significantly increased the number of seeds per fruit (142.83) and seed yield (241 kg/ha). Further, it has resulted in better seed quality parameters, viz., test weight (2.92 g), germination (93.88%), vigour index (1281) with least electrical conductivity (0.98 $dSm^{-1}$) in tomato (Hamsaveni*et al.,* 2003).

The number of fruits per tomato plant (35.67), fruit yield per plant (1.18 kg) and fruit yield (375.94 q/ha) increased significantly with combined application of $H_3BO_3$, Gypsum and $CuSO_4$ at 250 ppm each in tomato (Barche*et al.,* 2011).

Kumari (2012) suggested that foliar application of boron, iron and manganese each at 100 ppm at 30 days after transplanting at an interval of 10 days resulted in maximum seed yield and per cent seed germination (95, 92 and 88%, respectively) in tomato.

Salam *et al*. (2010) recorded maximum number of seeds per fruit (96) with combined application of boron 2.5 and sulphur 26 kg/ha and recommended dose of NPK followed by 94 seeds per fruit at boron 2 and sulphur 24 kg/ha along with recommended dose of NPK as compared to control (79).

Singh and Tiwari, 2013 reported that the maximum number of flowers per plant, number of fruits per plant, yield per plant and fruit yield per hectare was registered with the application of boric acid + gypsum + copper sulphate at 250 ppm each as a foliar spray in tomato.

Ali *et al*. (2013) recorded the maximum per cent fruit set, number of fruits per plant, fruit weight, fruit length, fruit diameter, number of large sized fruits with least number of small fruits, yield per plant and yield per hectare with combined foliar application of nitrogen 5.5g/100ml, boron 5g/100ml and sulphur as compared to other treatments.

Chude and Oyinlola (2001) concluded that plant responses to soil and applied boron vary widely among species and among genotypes within a species. This assertion was verified by comparing the differential responses of Roma VF and Dandino tomato cultivars to a range of boron levels in field trials at Kadawa (11 degrees 39' N, 8 degrees 2' E) and Samaru (11 degrees 12', 7 degrees 37' E) inSudan and northern Guinea savanna, respectively, in Nigeria. Boron levels were 0, 0.5, 1.0, 1.50, 2.0 and 2.5 kg/ha replicated three times in a randomized complete block design. Treatment effects were evaluated on fruit yield and nutritional qualities of the two tomato cultivars at harvest. There was a highly significant (P=0.01) interaction between B rates and cultivars, with Dandino producing higher yields than Roma VF in both years and locations. Total soluble solids, titratable acidity and reducing sugar contents of the two cultivars differed significantly (P=0.05). Generally, Dandino contained higher amounts of these indexes than Roma VF. This cultivar seems to be more B efficient than Roma VF even at low external B level.

Meena *et al*., 2015 was conducted an investigation to find out the response of sulphur and boron on improvement of growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Azad T-6. The study indicated that application of boron and sulphur either solely or in combination is quite beneficial for vegetative growth, flowering and fruiting as well as quality improvement of tomato fruits (Azad T-6) grown under high pH soil (pH 8.2) of Lucknow.

Boron regulates the metabolism of carbohydrates (Haque *et al*., 2011) and increase carbohydrate supply for formation of flowers and fruit set in tomato (Smit and Combrinke, 2005; Desouky *et al*., 2009) as well as decrease flower abscission (Smit and Combrink, 2005). Thus, boron application increased fruits plant$^{-1}$. And boron deficiency results in wilting and leaf drop (Zekri and Obreza, 2003) and adversely affect the quality and yield of many vegetables especially tomato (Imtiaz *et al.,* 2010).

# CHAPTER III

# MATERIALS AND METHODS

In this chapter briefly describes the materials and methods that are used in performing the research work. The chapter is presented under the following heads: Location, Soil characteristics, Climate and weather, Description of crop sample, Treatments, Experimental design, Land preparation, Layout of the experimental plots, Fertilizer application, Source of compost, Sowing of seedlings, Intercultural operations, Harvesting, Data collection, post-harvest soil sampling and Statistical analysis.

## 3.1 Location of the experiment

The field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2020 to April 2021. The experimental field is located at 23°46' N latitude and 90° 22' E longitude at an elevation of 8.2 m above from the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract (BBS, 2018). The location of the experimental site has been shown in Appendix I.

## 3.2 Soil characteristics

The soil of the research field is slightly acidic in reaction with low organic matter content. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. Soil samples from 0-15 cm depth were collected from experimental field. The analyses were done from Soil Resources Development Institute(SRDI),Dhaka. The experimental plot was also high land, having pH 6.00 and particle density 2.68 g/cc. The physicochemical property and nutrient status of soil of the experimental plots are given in Appendix II.

## 3.3 Climate and weather

The climate of experimental site is sub-tropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather station, Bangladesh Meteorological Department, Agargaon, Dhaka and presented in Appendix III.

### 3.4 Description of crop sample

BARI Tomato-2 was used as planting material in the experiment. It was developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur in 1985. Salient features of BARI Tomato-2 are high yielder, plant height 75-80 cm, fruit round and red in color, fruit weight 85-90g, number of fruit /plant 30-35, fruit weight/plant 2.0-2.5 kg, growth duration 105-110 days. This variety is cultivated throughout the Bangladesh. Planting season is Rabi. Medium to late variety. Harvesting time within 75-80 days after transplantation first harvest, up to 20-25 days and 4-5 times fruit harvest. Yield should be 80-85 t/ha and resistance to bacteria wilt disease.

### 3.5 Treatments under investigation

The study consisted of following treatments:

| | |
|---|---|
| $T_1 = S_{0kg/ha} + B_{0kg/ha}$ (Control) | $T_7 = S_{0kg/ha} + B_{2kg/ha}$ |
| $T_2 = S_{22kg/ha}+B_{0.5kg/ha}$ | $T_8 = S_{22kg/ha} + B_{1kg/ha}$ |
| $T_3 = S_{44kg/ha} + B_{2kg/ha}$ | $T_9 = S_{44kg/ha} + B_{0kg/ha}$ |
| $T_4 = S_{0kg/ha} + B_{0.5kg/ha}$ | $T_{10} = S_{0kg/ha} + B_{1kg/ha}$ |
| $T_5 = S_{22kg/ha} + B_{0kg/ha}$ | $T_{11} = S_{22kg/ha} +B_{2kg/ha}$ |
| $T_6 = S_{44kg/ha} + B_{0.5kg/ha}$ | $T_{12} = S_{44kg/ha} + B_{1kg/ha}$ |

Recommended doses of Sulphur and Boron were 22 kg $ha^{-1}$ and 1 kg $ha^{-1}$ respectively.

### 3.6 Land preparation

Seed bed preparation was done on 21$^{th}$ November, 2020. And The main land was irrigated before ploughing. After having 'joe' condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 3 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 21$^{st}$ November and 1$^{th}$ December, 2020, respectively. Experimental land was divided into unit plots following the design of experiment.

### 3.7 Experimental design

Twelve treatments in the experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications total number of plots were 36 = (12×3).

### 3.8 Layout of the experimental plots

| | |
|---|---|
| Total number of plots | : 36 |
| Individual plot size | : 3 $m^2$ (2×1.5 $m^2$) |
| Space between block to block | : 0.75 m |
| Block to border (row) | : 0.50 m |
| Block to border (column) | : 0.50 m |
| Replication | : 3 |
| Drainage size | : 0.50 m |

The layout of the experimental plots shown in figure 1

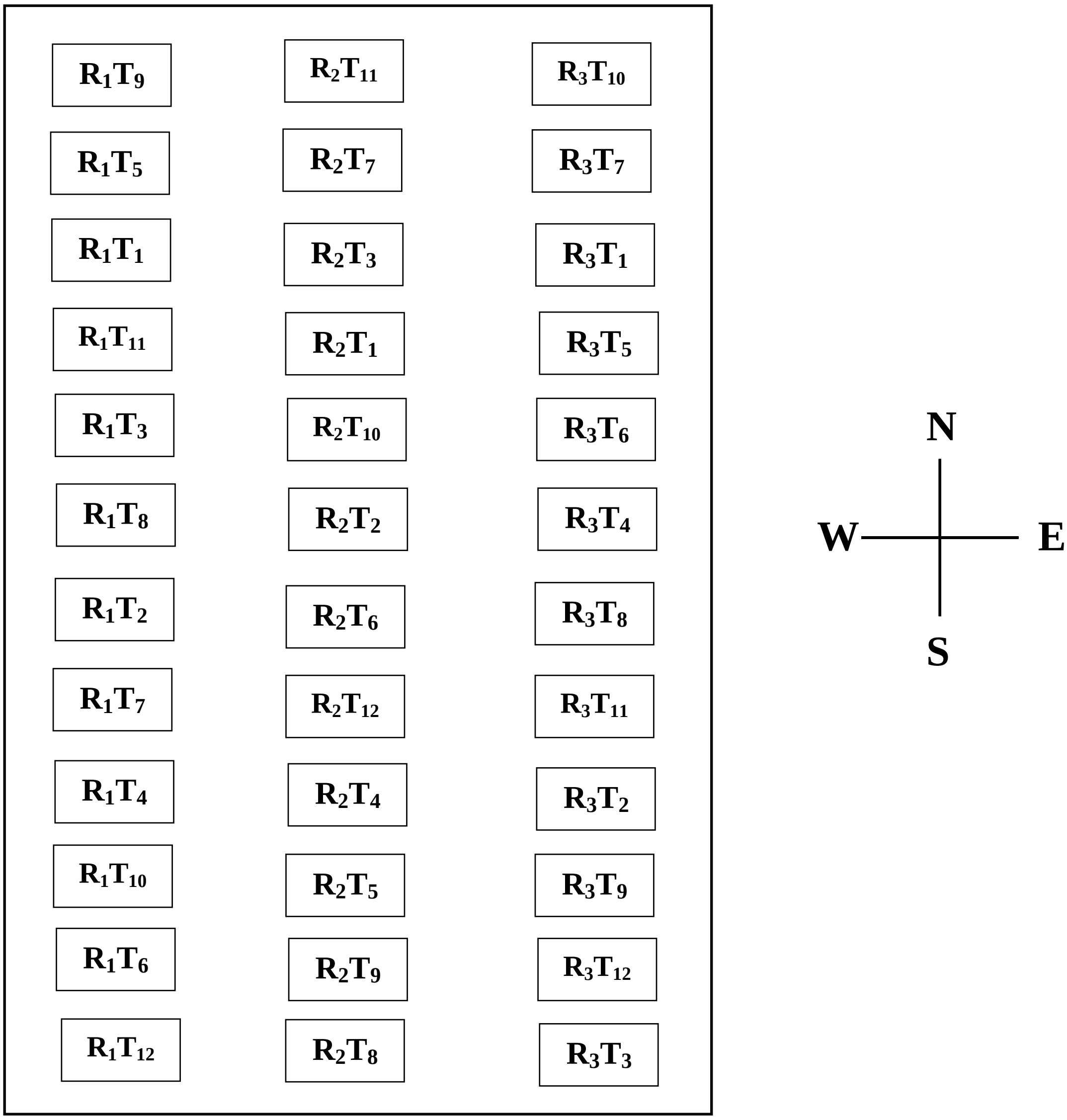


**Fig. 1. Field layout of the experiment**

### 3.9 Fertilizer application

Gypsum and Boric acid as the sources of sulphur (S) and boron (B) respectively. Doses of S and B were applied as per treatment of the experiment. The whole amount of gypsum and boric acid and also TSP, zinc sulphate as the sources of sulphur, boron , phosphorus and zinc, respectively were applied during the final land preparation. Urea and MoP as source of nitrogen and potassium, respectively were applied in two equal installments at 15 and 30 days after sowing (DAS) of seed. The fertilizers were mixed thoroughly with the soil by hand. Recommended fertilizer doses (RFD) of nitrogen, phosphorus, potassium and zinc were 75, 75, 45 and 2.5 kg $ha^{-1}$ respectively.

### 3.10 Sowing of seedlings in the field

Each seedling was sown in each pit at a depth of 5 cm. The seedlings were covered with pulverized soil just after sowing and gently pressed with hands. The sowing was done on 21 November 2020 in rows and at a spacing of 50 cm x 50 cm. The seedlings were covered with loose soil.

### 3.11 Intercultural operations

#### 3.11.1 Gap filling

A few gap filling was done by healthy seedlings of the same stock where planted seedlings failed to survive. When the seedlings were well established, the soil around the base of each seedling was pulverized.

#### 3.11.2 Tagging

Tagging and sticking was done on 18 January, 2021.

#### 3.11.3 Weeding and mulching

Weeding was done whenever it was necessary. Mulching was also done to help in soil moisture conservation.

#### 3.11.4 Irrigation

Light irrigation was given with water immediately after transplanting the seedlings and therefore necessary irrigation was done as and when necessary throughout the growing period up to before 7 days of harvesting. Ring and watering was done on 15 February, 2021.

#### 3.11.5 Protruding

Attach bamboo stick tying with plant by rope was done on 20 February, 2021.

### 3.12 Plant protection

#### 3.12.1 Control of Insect pests

Furadan 5G , Melathion 57 EC was applied @ 2 ml $L^{-1}$ of water on 28 February 2021 against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly after transplanting and stopped before second week of first harvest.

#### 3.12.2 Control of Diseases

During foggy weather precautionary measure against disease attack of tomato was taken by spraying Diathane M-45 fortnightly @ 2 gm $L^{-1}$ of water at the early vegetative stage. Ridomil gold was also applied @ 2 gm $L^{-1}$ of water against blight disease of tomato.

### 3.13 Sampling and harvesting

Fruits were harvested at 4 to 5days interval during early ripening stage when they developed slightly red color. Harvesting was started from 14 April, 2021 and continued up to 3 March, 2021.

### 3.14 Data collection

Five plants in each plot were selected and tagged. All the growth data (except dry weight) were recorded from the selected five plants.

The following data were collected –

i. Plant height (cm)
ii. Number of branches plant$^{-1}$
iii. Number of leaves plant$^{-1}$
iv. Number of cluster plant$^{-1}$
v. Number of fruits cluster$^{-1}$
vi. Number of fruits plant$^{-1}$
vii. Diameter of a fruit (cm)
viii. Fruit weight/plant (kg)
ix. Yield (t $ha^{-1}$)

### 3.15 Procedure of data collection

#### 3.15.1 Plant height (cm)

The plant height was taken from the ground level to the tip of the tallest fruit bunch at maturity. It was recorded from 10 randomly sampled plants, and the mean was calculated and recorded in centimeter (cm).

#### 3.15.2 Number of branches plant $^{-1}$

Average number of branches per plant was found from 5 randomly selected plants per unit plot and the means were found out.

#### 3.15.3 Number of leaves plant $^{-1}$

Average number of leaves per plant was found from 5 randomly selected plants per unit plot and the means were found out.

#### 3.15.4 Number of cluster plant$^{-1}$

The number of fruit clusters was counted from the sample plants and the average number of clusters borne per plant was recorded at the time of final harvest. The data of cluster/plant was presented only 60 DAT.

#### 3.15.5 Number of fruits cluster$^{-1}$

The number of fruits was counted from the sample clusters and the average number of fruits borne per cluster was recorded at the time of final harvest. The data of fruits/cluster was presented only 45 and 63 DAT.

#### 3.15.6 Number of fruits plant$^{-1}$

The number of fruits was counted from the sample plant and the average number of fruits borne per plant was recorded at the time of final harvest.

#### 3.15.7 Diameter of a fruit (cm)

The diameter of a fruit was measured with slide-calipers from the neck to the bottom of 5 selected marketable fruits and their average was taken in cm as the diameter of fruit.

### 3.15.8 Fruit weight plant$^{-1}$ (kg)

Fruit weight plant$^{-1}$ were counted from 5 randomly selected plants of each treatment plant and then were weighed with the help of highly sensitive electronic balance to record fruit weight plant$^{-1}$ and was expressed in kilogram (kg).

### 3.15.9 Yield (t ha$^{-1}$)

Green fruits were harvested at regular interval from each unit plot and their weight was recorded. As harvesting was done at different interval, the total weight of fruits was recorded for each for each unit plot, and was expressed in tons per hector (t ha$^{-1}$).

## 3.16 Post harvest soil sampling

After harvest of crop, soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were analysed and recorded physical and chemical properties of soil. Analyzed data showed in Appendix VI.

## 3.17 Statistical analysis

The recorded data were compiled and analyzed by two factorial design to find out the statistical significance of experimental results by using the “Analysis of variance” (ANOVA) technique with the help of statistics 10 that was an analysis software.

# CHAPTER IV

# RESULTS AND DISCUSSION

The results of the performance of tomato under different integrated effect of different amount of sulphur (S) and boron (B) fertilizer on growth and yield are presented in Table no. 2 to 9 and Figure no. 2 to 4. In this chapter, moreover, the findings of the study and interpretation of the results under different critical sections comprising growth, yield contributing characteristics, yield and quality parameters analysis are presented and discussed in this chapter under the following sub-headings to achieve the objective of the study.

## 4.1. Effect of different doses of Sulphur and Boron fertilizer on growth and yield of tomato.

### 4.1.1 Plant Height (cm)

The application of different doses of S and B fertilizer with others chemical fertilizers showed positive effects on the plant height of tomato at harvest. The application of S and B doses significantly increased the plant height of tomato compared to that found in control where Sulphur and Boron was not applied showed in figure 2.

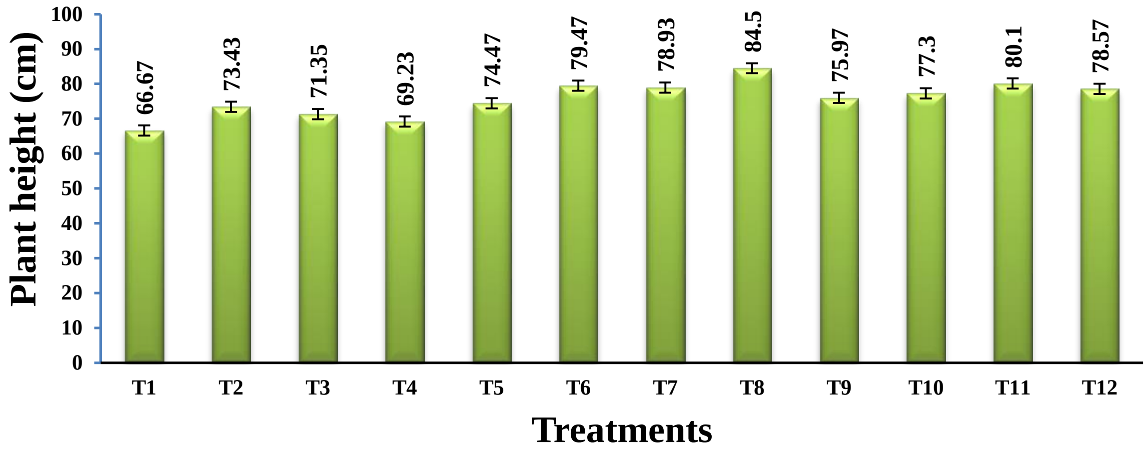


**Figure 2. Effect of different doses of S and B fertilizeron the plant height (cm) of BARI Tomato-2 at harvest**

*Here,*

$T_1 = S_{0\ kg/ha} + B_{0\ kg/ha}$ (Control)

$T_2 = S_{22\ kg/ha} + B_{0.5\ kg/ha}$

$T_3 = S_{44\ kg/ha} + B_{2\ kg/ha}$

$T_4 = S_{0\ kg/ha} + B_{0.5\ kg/ha}$

$T_5 = S_{22\ kg/ha} + B_{0\ kg/ha}$

$T_6 = S_{44\ kg/ha} + B_{0.5\ kg/ha}$

$T_7 = S_{0\ kg/ha} + B_{2\ kg/ha}$

$T_8 = S_{22\ kg/ha} + B_{1\ kg/ha}$

$T_9 = S_{44\ kg/ha} + B_{0\ kg/ha}$

$T_{10} = S_{0\ kg/ha} + B_{1\ kg/ha}$

$T_{11} = S_{22\ kg/ha} + B_{2\ kg/ha}$

$T_{12} = S_{44\ kg/ha} + B_{1\ kg/ha}$

Among fertilizer management treatments, $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) gave the tallest tomato plant (84.50 cm) which was significantly varied from others, while the shortest plant (66.67 cm) was obtained in $T_1$ treatment which was control. Meena *et al.,* (2015) was also found that the vegetative growth in terms of plant height was greatly influenced by the application of Boron. Naresh (2002) stated that B also had positive effects on plant height in tomato.

### 4.1.2 Number of branches plant$^{-1}$

Number of branches plant $^{-1}$ is an important trait for flowers and fruits production and is thereby an important aspect of tomato growth improvement. Effective number of branches plant $^{-1}$ depends primarily on soil physical conditions that were superior due to addition of integrated use of fertilizer showed in Table 1.

Table 1: Effect of different doses of S and B fertilizer on the number of branches plant$^{-1}$ and number of leaves plant$^{-1}$ of BARI Tomato-2.

| Treatments | Number of branches plant$^{-1}$ | Number of leaves plant$^{-1}$ |
|---|---|---|
| $T_1$ | 7.07 g | 133.40 k |
| $T_2$ | 7.80 f | 137.83 hi |
| $T_3$ | 7.40 g | 136.60 ij |
| $T_4$ | 7.20 g | 135.33 jk |
| $T_5$ | 8.15 ef | 139.23 gh |
| $T_6$ | 9.15 bc | 145.33 bc |
| $T_7$ | 9.05 c | 144.50 cd |
| $T_8$ | 9.73a | 147.67a |
| $T_9$ | 8.25 e | 139.97 fg |
| $T_{10}$ | 8.67 d | 141.67 ef |
| $T_{11}$ | 9.47ab | 146.87ab |
| $T_{12}$ | 8.88 cd | 142.67 de |
| SE | 0.07 | 0.40 |
| CV (%) | 1.52 | 0.49 |

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
*SE= Standard Error*
*CV= Co-efficient of variance*
*Here,*

$T_1$ =$S_{0\ kg/ha}$ +$B_{0\ kg/ha}$ (Control)
$T_2$ = $S_{22\ kg/ha}$+$B_{0.5\ kg/ha}$
$T_3$ = $S_{44\ kg/ha}$ + $B_{2\ kg/ha}$
$T_4$ = $S_{0\ kg/ha}$ + $B_{0.5\ kg/ha}$
$T_5$ = $S_{22\ kg/ha}$ + $B_{0\ kg/ha}$
$T_6$ = $S_{44\ kg/ha}$ + $B_{0.5\ kg/ha}$
$T_7$ = $S_{0\ kg/ha}$ + $B_{2\ kg/ha}$
$T_8$ = $S_{22\ kg/ha}$ + $B_{1\ kg/ha}$
$T_9$ = $S_{44\ kg/ha}$ + $B_{0\ kg/ha}$
$T_{10}$ = $S_{0\ kg/ha}$ + $B_{1\ kg/ha}$
$T_{11}$ = $S_{22\ kg/ha}$ +$B_{2\ kg/ha}$
$T_{12}$ = $S_{44\ kg/ha}$ + $B_{1\ kg/ha}$

At harvest, the maximum number branches plant$^{-1}$ (9.73) was also found at $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) treatment which was statistically followed by $T_{11}$($S_{22\ kg/ha}$ + $B_{2\ kg/ha}$) treatment that was 9.47. On the other hand, the minimum number branches plant$^{-1}$ (7.07) was also recorded from $T_1$ treatment which was control. It may be concluded that when number of branches increases mostly there was increase in number of leaves. These treatments may be ranked in order of $T_8$> $T_{11}$> $T_6$> $T_7$> $T_{12}$> $T_{10}$> $T_9$> $T_5$> $T_2$> $T_3$> $T_4$> $T_1$. In tomato, foliar application of borax alone significantly enhanced the number of branches per plant (Rab and Haq, 2012). It was reported that significant increase in number of branches per plant has been reported by application of boron (Basavarajeswari *et al.*, 2008) and micronutrient mixture (Hatwar *et al.*, 2003). This result also supported by Ilyas *et al*., (2019); Sathya *et al*., (2010); Bhatt *et al*. (2004); Haleem *et al*. (2017) and Ali *et al*. (2015).

### 4.1.3 Number of leaves plant$^{-1}$

Number of leaves plant$^{-1}$of BARI tomato-2 showed significant variation among the treatments at harvest showed in Table 1. At harvest, the maximum number leaves per plant (147.67) was also found at $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) treatment which was statistically followed by $T_{11}$ ($S_{22\ kg/ha}$ + $B_{2\ kg/ha}$) treatment. On the other hand, the minimum number leaves plant$^{-1}$ (113.40) was also recorded from $T_1$ treatment which was control. The treatments may be ranked in order of $T_8$> $T_{11}$> $T_6$> $T_7$> $T_{12}$> $T_{10}$> $T_9$> $T_5$> $T_2$> $T_3$> $T_4$> $T_1$. The number of leaves per plant increased with the applied of B reported by Haleem *et al.* (2017). Also, the number of leaves increased due to the foliar application of B fertilizer (Singh and Tiwari, 2013). The results were most closely corroborated with Ali *et al.* (2015) and Oyinlola (2004).

### 4.1.4 Number of cluster plant$^{-1}$

Number of flower cluster plant$^{-1}$ is an important yield determining factor in tomato. It affects the number of flower and fruit plant$^{-1}$. The effect of different amount of Sulphur (S) and Boron (B) with others fertilizers was significant as observed on number of flower cluster plant$^{-1}$ at harvest (Table 2). The maximum number of cluster plant$^{-1}$ (8.30) was found in the treatment $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) treatment was followed by $T_{11}$ ($S_{22\ kg/ha}$ + $B_{2\ kg/ha}$) treatment which differ when compared among themselves. On the other hand, the lowest cluster plant$^{-1}$ (8.07) was obtained in the treatment $T_1$ ($S_0$

$_{kg/ha}$ + $B_{0\ kg/ha}$). Naz *et al*. (2012) reported that application of boron @ 2 kg/ha enhanced number of flower clusters per plant who obtained the highest number of flower clusters per plant of tomato with the application of different amount of sulphur and boron in combination. These results are in line with Singh *et al*. (2014).

Table 2: Effect of different doses of S and B fertilizer on the number of cluster plant$^{-1}$ and number of fruits cluster$^{-1}$ of BARI Tomato-2.

| Treatments | Number of cluster plant$^{-1}$ | Number of fruits cluster$^{-1}$ |
|---|---|---|
| $T_1$ | 6.53 f | 3.70 h |
| $T_2$ | 6.88 def | 4.03 ef |
| $T_3$ | 6.75 ef | 3.93 fg |
| $T_4$ | 6.65 ef | 3.83 gh |
| $T_5$ | 6.97 cdef | 4.12 de |
| $T_6$ | 7.87ab | 4.33abc |
| $T_7$ | 7.38 bc | 4.30 bc |
| $T_8$ | 8.30a | 4.50a |
| $T_9$ | 7.03 cde | 4.17 cde |
| $T_{10}$ | 7.13 cde | 4.22bcd |
| $T_{11}$ | 7.90a | 4.37ab |
| $T_{12}$ | 7.30 cd | 4.27bcd |
| SE | 0.01 | 0.03 |
| CV (%) | 2.30 | 1.40 |

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

*SE= Standard Error*

*CV= Co-efficient of variance*

*Here,*

$T_1$ =$S_{0\ kg/ha}$ +$B_{0\ kg/ha}$ (Control)

$T_2$ = $S_{22\ kg/ha}$+$B_{0.5\ kg/ha}$

$T_3$ = $S_{44\ kg/ha}$ + $B_{2\ kg/ha}$

$T_4$ = $S_{0\ kg/ha}$ + $B_{0.5\ kg/ha}$

$T_5$ = $S_{22\ kg/ha}$ + $B_{0\ kg/ha}$

$T_6$ = $S_{44\ kg/ha}$ + $B_{0.5\ kg/ha}$

$T_7$ = $S_{0\ kg/ha}$ + $B_{2\ kg/ha}$

$T_8$ = $S_{22\ kg/ha}$ + $B_{1\ kg/ha}$

$T_9$ = $S_{44\ kg/ha}$ + $B_{0\ kg/ha}$

$T_{10}$ = $S_{0\ kg/ha}$ + $B_{1\ kg/ha}$

$T_{11}$ = $S_{22\ kg/ha}$ +$B_{2\ kg/ha}$

$T_{12}$ = $S_{44\ kg/ha}$ + $B_{1\ kg/ha}$

### 4.1.5 Number of fruits cluster$^{-1}$

Data presented in table 2 show that number of fruits cluster$^{-1}$ of tomato was significantly affected by different levels of sulphur and boron fertilizer. The comparison of treatments means reveal that maximum number of fruits cluster$^{-1}$(4.30) was recorded from $T_8$ treatment which was followed by $T_{11}$ treatments. The minimum number of fruits cluster$^{-1}$(3.70) was recorded from plot where only recommended fertilizer was applied except sulphur and boron fertilizer ($T_1$). The highest number of fruits cluster$^{-1}$ of tomato with the application of different micronutrients such as boron in combination reported by Singh *et al*. (2014).

### 4.1.6 Diameter of a fruit (cm)

Due to the application of different level of S and B fertilizer application affect the diameter of fruit was observed that the fruit diameter varied from 17.68 cm to 16.13 cm. The highest statistically superior fruit diameter was 17.68 cm recorded in the treatment $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) which were very close to $T_{11}$ ($S_{22\ kg/ha}$ + $B_{2\ kg/ha}$) and $T_6$ ($S_{44\ kg/ha}$ + $B_{0.5\ kg/ha}$) treatments. On the other hand, the lowest fruit diameter 16.13 cm was obtained in the treatment $T_1$ (control). These results were close conformity with the findings of Ilyas *et al*. (2019) and Ali *et al.* (2015).

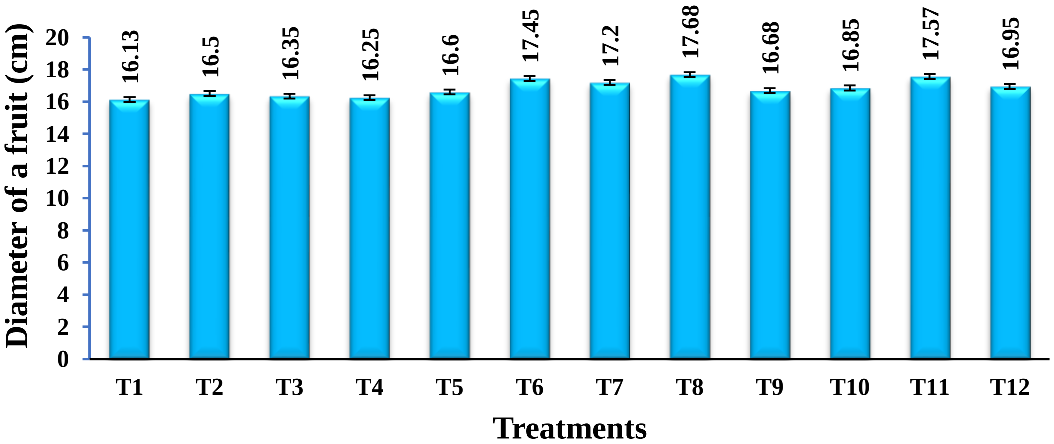


**Figure 3. Effect of different doses of S and B fertilizer on the diameter of a fruit (cm) of BARI Tomato-2.**

*Here,*

$T_1$ =$S_{0\ kg/ha}$ +$B_{0\ kg/ha}$ (Control)

$T_2$ = $S_{22\ kg/ha}$+$B_{0.5\ kg/ha}$

$T_3$ = $S_{44\ kg/ha}$ + $B_{2\ kg/ha}$

$T_4$ = $S_{0\ kg/ha}$ + $B_{0.5\ kg/ha}$

$T_5$ = $S_{22\ kg/ha}$ + $B_{0\ kg/ha}$

$T_6$ = $S_{44\ kg/ha}$ + $B_{0.5\ kg/ha}$

$T_7$ = $S_{0\ kg/ha}$ + $B_{2\ kg/ha}$

$T_8$ = $S_{22\ kg/ha}$ + $B_{1\ kg/ha}$

$T_9$ = $S_{44\ kg/ha}$ + $B_{0\ kg/ha}$

$T_{10}$ = $S_{0\ kg/ha}$ + $B_{1\ kg/ha}$

$T_{11}$ = $S_{22\ kg/ha}$ +$B_{2\ kg/ha}$

$T_{12}$ = $S_{44\ kg/ha}$ + $B_{1\ kg/ha}$

### 4.1.7 Number of fruits plant$^{-1}$

The application of different doses of sulphur (S) and boron (B) fertilizer combinations showed a positive effect on the number of fruit plant$^{-1}$ of tomato. At harvest, Among combination treatments, $T_8$ treatment gave the highest number of fruit plant$^{-1}$(37.45) which was significantly varied from others, while the lowest number of fruit plant$^{-1}$ (25.21) was obtained in $T_1$ treatment. Boron had positive effects on the number of fruits per plant observed by Naresh (2002). Brahma *et al.,* 2010 reported that the combined application of micronutrients produced the number of fruits per plant in tomato. Similar results have been reported by Singh and Tiwari, 2013; Singh *et al*. (2014); Ali *et al.* (2015) and Oyinlola and Chude (2004).

Table 3: Effect of different doses of S and B fertilizer on the number of fruits plant$^{-1}$ and Fruit weight plant$^{-1}$ (kg) of BARI Tomato-2.

| Treatments | Number of fruits plant$^{-1}$ | Fruit weight plant$^{-1}$ (kg) |
|---|---|---|
| $T_1$ | 25.21 i | 1.54 h |
| $T_2$ | 28.14 fgh | 1.99fg |
| $T_3$ | 26.71 ghi | 1.90g |
| $T_4$ | 25.67 hi | 1.63 h |
| $T_5$ | 29.12efg | 2.10efg |
| $T_6$ | 35.04ab | 2.73ab |
| $T_7$ | 32.73bc | 2.54 bc |
| $T_8$ | 37.45a | 2.98a |
| $T_9$ | 29.91 def | 2.21def |
| $T_{10}$ | 31.07 cde | 2.33cde |
| $T_{11}$ | 35.80a | 2.82 a |
| $T_{12}$ | 32.02 cd | 2.44 cd |
| SE (%) | 0.51 | 0.96 |
| CV (%) | 2.90 | 2.27 |

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
*SE= Standard Error*
*CV= Co-efficient of variance*
*Here,*

$T_1 = S_{0\ kg/ha} + B_{0\ kg/ha}$ (Control)
$T_2 = S_{22\ kg/ha} + B_{0.5\ kg/ha}$
$T_3 = S_{44\ kg/ha} + B_{2\ kg/ha}$
$T_4 = S_{0\ kg/ha} + B_{0.5\ kg/ha}$
$T_5 = S_{22\ kg/ha} + B_{0\ kg/ha}$
$T_6 = S_{44\ kg/ha} + B_{0.5\ kg/ha}$
$T_7 = S_{0\ kg/ha} + B_{2\ kg/ha}$
$T_8 = S_{22\ kg/ha} + B_{1\ kg/ha}$
$T_9 = S_{44\ kg/ha} + B_{0\ kg/ha}$
$T_{10} = S_{0\ kg/ha} + B_{1\ kg/ha}$
$T_{11} = S_{22\ kg/ha} + B_{2\ kg/ha}$
$T_{12} = S_{44\ kg/ha} + B_{1\ kg/ha}$

### 4.1.9 Fruit weight plant$^{-1}$(kg)

The weight of fruits was measured with electric balance from the weight of five selected sample plants from each plot, and their average was calculated in kilogram. It was noticed that different levels of sulphur and boron exhibited significant effect on the weight of fruits per plant (Table 3). The maximum weight (2.98 kg) of fruits per plant was recorded in $T_8$ ($S_{22kg/ha}$ + $B_{1kg/ha}$) which followed by $T_{11}$ ($S_{22kg/ha}$ + $B_{2kg/ha}$) treatment that was 2.82 kg whereas the minimum weight 1.54 kg was obtained from control ($S_{0kg/ha}$ + $B_{0kg/ha}$). Boron play key role on accumulation of photosynthesis that has correlation with fruit weight (Shukha, 2011). Present investigation is in close conformity with the findings of Brahma *et al*., 2010; Rab and Haq, 2012 and Ilyas *et al*., 2019

#### 4.1.10 Yield (t ha$^{-1}$)

Tomato fruit yield is a function of interaction among various yield components that were affected differentially by the growing conditions and crop management practices. It is clear from the figure 3 that yield was significantly affected by the application of different levels of sulphur and boron fertilizer. All the means of data presented clearly show that significantly highest fruit yield (89.49 tha$^{-1}$) was recorded from $T_8$ treatment which followed by $T_{11}$ and $T_6$ treatment. On the other hand, the lowest yield (46.33 t ha$^{-1}$) found at control treatment ($T_1$) which differ from other treatments.

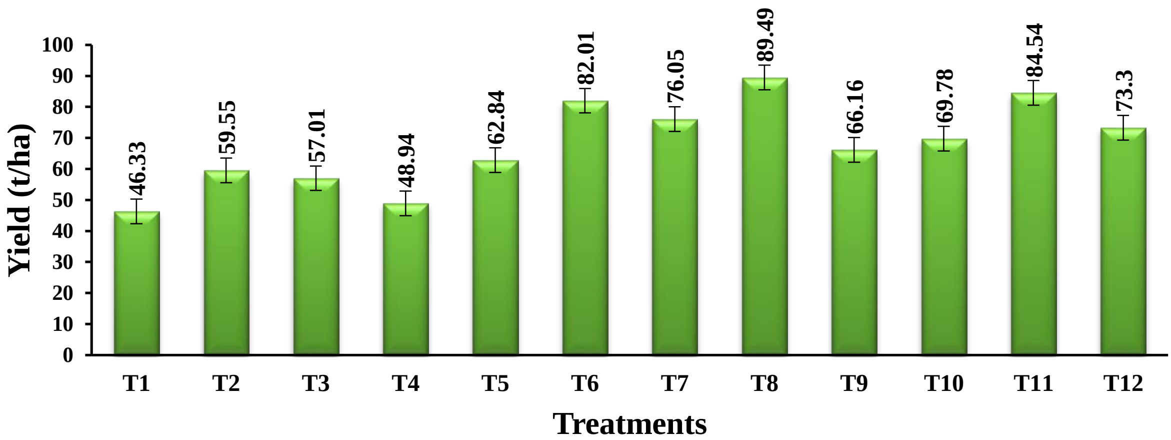


**Figure 4. Effect of different doses of Sulphur and Boron on the yield (t/ha) of BARI Tomato-2.**

*Here,*

$T_1 = S_{0\ kg/ha} + B_{0\ kg/ha}$ (Control)

$T_2 = S_{22\ kg/ha} + B_{0.5\ kg/ha}$

$T_3 = S_{44\ kg/ha} + B_{2\ kg/ha}$

$T_4 = S_{0\ kg/ha} + B_{0.5\ kg/ha}$

$T_5 = S_{22\ kg/ha} + B_{0\ kg/ha}$

$T_6 = S_{44\ kg/ha} + B_{0.5\ kg/ha}$

$T_7 = S_{0\ kg/ha} + B_{2\ kg/ha}$

$T_8 = S_{22\ kg/ha} + B_{1\ kg/ha}$

$T_9 = S_{44\ kg/ha} + B_{0\ kg/ha}$

$T_{10} = S_{0\ kg/ha} + B_{1\ kg/ha}$

$T_{11} = S_{22\ kg/ha} + B_{2\ kg/ha}$

$T_{12} = S_{44\ kg/ha} + B_{1\ kg/ha}$

Ullah *et al*. (2015) showed that application of boron gave higher yield per hectare than untreated control in tomato. Singh and Tiwari, 2013 reported that the maximum yield per hectare was registered with the application of boric acid and zinc sulphate in tomato. Imtiaz *et al.*, 2010 revealed that boron deficiency results in adversely affect the quality and yield of many vegetables especially tomato. This is also in agreement with the findings of Yadav *et al.* (2001); Meena *et al*. (2015) and Khatun *et al*. (2020).

## 4.2 Chemical properties of the post-harvest soil

### 4.2.1 Available Sulphur (S) in soil

The available sulphur content of the post-harvest soil significantly varied due to different amount of S applied in all treatments (Table 4).

Table 4: Effect of different doses of S and B fertilizer on the available S and available B of the post-harvest soil.

| Treatments | Available S (ppm) |
|---|---|
| $T_1$ | 4.50 h |
| $T_2$ | 6.23 ef |
| $T_3$ | 7.43ab |
| $T_4$ | 6.15 fg |
| $T_5$ | 6.10 fgh |
| $T_6$ | 6.50bcd |
| $T_7$ | 6.03 gh |
| $T_8$ | 6.37de |
| $T_9$ | 7.70a |
| $T_{10}$ | 6.42 cd |
| $T_{11}$ | 6.52bc |
| $T_{12}$ | 7.58ab |
| SE (%) | 0.02 |
| CV (%) | 0.73 |

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.

*SE= Standard Error*

*CV= Co-efficient of variance*

*Here,*

$T_1 = S_{0\ kg/ha} + B_{0\ kg/ha}$ (Control)

$T_2 = S_{22\ kg/ha} + B_{0.5\ kg/ha}$

$T_3 = S_{44\ kg/ha} + B_{2\ kg/ha}$

$T_4 = S_{0\ kg/ha} + B_{0.5\ kg/ha}$

$T_5 = S_{22\ kg/ha} + B_{0\ kg/ha}$

$T_6 = S_{44\ kg/ha} + B_{0.5\ kg/ha}$

$T_7 = S_{0\ kg/ha} + B_{2\ kg/ha}$

$T_8 = S_{22\ kg/ha} + B_{1\ kg/ha}$

$T_9 = S_{44\ kg/ha} + B_{0\ kg/ha}$

$T_{10} = S_{0\ kg/ha} + B_{1\ kg/ha}$

$T_{11} = S_{22\ kg/ha} + B_{2\ kg/ha}$

$T_{12} = S_{44\ kg/ha} + B_{1\ kg/ha}$

Available Sulphur content in soil varied from 4.50 to 7.70 ppm due to applied different amount of S and B fertilizer doses. The maximum sulphur content 7.70 ppm was observed in the treatment $T_8$, which was followed by $T_3$ and $T_{12}$ that was 7.43 ppm and 7.58 ppm respectively. The lowest phosphorus content (4.50 ppm) was observed in $T_1$.

# CHAPTER V

# SUMMARY AND CONCLUTION

A field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2020 to April 2021 to evaluate the effect of different level of sulphur (S) and boron (B) fertilizer on the growth and yield of BARI Tomato-2 under field condition.

The experiment was laid out in a Randomized Complete Block Design (RCBD) having 12 treatments with three replications. The unit plot size was 6 $m^2$. A total of 12 treatments combination of Sulphur and Boron were distributed randomly in individual plots and total number of plots was 36. Sulphur and Boron was applied as Gypsum and Boric acid at the rate of 22 and 1 kg $ha^{-1}$ respectively, as per treatments. On the other hand, Nitrogen, Phosphorus, Potassium and Zinc were applied as urea, triple super phosphate, muriate of potash and Zinc sulphate at the rate of 100, 45, 75 and 2.5 kg $ha^{-1}$ respectively. Seedlings were sown on the $21^{th}$ December, 2020. The crop was allowed to grow until maturity and intercultural operations such as gap filling, tagging, weeding and mulching, irrigation, protruding and general observation were done whenever required in order to support normal growth of the crop. The fruits were harvested at $14^{th}$ March, 2021 and were continued up to $03^{th}$ April, 2021. Plot wise yield and yield components were recorded.

Different levels of Sulphur and Boron as combine treatment had significantly increased the plant height (cm). It was clearly found that, the longest plant was 84.50 cm observed in $T_8$ treatment where $S_{22\ kg/ha}$ + $B_{1\ kg/ha}$ applied and the shortest one was 66.67 cm found in the treatment $T_1$ ($S_{0\ kg/ha}$ + $B_{0\ kg/ha}$) i.e. control. Again, the number of branches $plant^{-1}$ (no.) also varied by different treatments. The maximum number branches $plant^{-1}$ (9.73) was also found at $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) treatment which was statistically followed by $T_{11}$ ($S_{22\ kg/ha}$ + $B_{2\ kg/ha}$) treatment that was 9.47. On the other hand, the minimum number branches $plant^{-1}$ (7.07) was also recorded from $T_1$ treatment which was control. Maximum number of leaves was counted from $T_3$ (147.67 $plant^{-1}$) followed by $T_{11}$ (146.87 ab $plant^{-1}$) and $T_6$ (145.33 $plant^{-}$1) while minimum from $T_1$ (113.40 $plant^{-1}$). The maximum number of cluster $plant^{-1}$ (8.30) was found in the treatment $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) treatment was followed by $T_{11}$ ($S_{22}$

$_{kg/ha}$ + $B_{2\ kg/ha}$) treatment which differ when compared among themselves. On the other hand, the lowest cluster plant$^{-1}$ (8.07) was obtained in the treatment $T_1$ ($S_{0\ kg/ha}$ + $B_{0\ kg/ha}$). Also, the comparison of treatments means reveal that maximum number of fruits cluster$^{-1}$ (8.30) was recorded from $T_8$ treatment which was followed by $T_{11}$ treatments. The minimum number of fruits cluster$^{-1}$ (6.53) was recorded from plot where only recommended fertilizer was applied except sulphur and boron fertilizer ($T_1$). The fruit diameter varied from 17.68 cm to 16.13 cm. The highest statistically superior fruit diameter was 17.68 cm recorded in the treatment $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) which were very close to $T_{11}$ ($S_{22\ kg/ha}$ + $B_{2\ kg/ha}$) and $T_6$ ($S_{44\ kg/ha}$ + $B_{0.5\ kg/ha}$) treatments. On the other hand, the lowest fruit diameter 16.13 cm was obtained in the treatment $T_1$ (control). There was a considerable variation among the different treatment on the number of fruits plant$^{-1}$. Maximum number of fruitsplant$^{-1}$ was found from $T_8$ (37.45 plant$^{-1}$) while minimum from $T_1$ (25.21 plant$^{-1}$).

Application of different amount of sulphur and boron fertilizers showed the variation for single fruit weight plant$^{-1}$ as gram. The maximum weight (2.98 kg) of fruits per plant was recorded in $T_8$ ($S_{22\ kg/ha}$ + $B_{1\ kg/ha}$) which followed by $T_{11}$ ($S_{22\ kg/ha}$ + $B_{2\ kg/ha}$) treatment that was 2.82 kg whereas the minimum weight (1.54 kg) was obtained from control ($S_{0\ kg/ha}$ + $B_{0\ kg/ha}$). Finally, it is clear that yield was significantly affected by the application of different levels of S and B fertilizer. All the means of data presented clearly show that significantly highest yield (89.49 t ha$^{-1}$) was recorded from $T_8$ treatment closely followed by $T_{11}$ and $T_6$ treatments, these were superior from other treatments and lowest yield (46.33 t ha$^{-1}$) found at treatment ($T_1$).

The results of the present investigation revealed that tomato can be grown successfully at the use of 22 kg ha$^{-1}$ of sulphur and 1 kg ha$^{-1}$ of boron. The findings of the present investigation clearly indicated that the efficient combine use of sulphur and boron fertilizer doses is a viable option for increasing the production of tomato.

## REFFERENCES


Adams, P. (2004). Effect of nutrition on tomato quality, tomatoes in peat. How feed variations affect yield. Grower, **89**(20), 1142-1145.

Ali, S., Javed, H.U., Rehman, U.R.N., Sabir, I.A., Naeem, M.S., Siddiqui, M.Z., Saeed, D.A. and Nawaz, M.A. (2013). Foliar application of some macro and micronutrients improves tomato growth, flowering and yield. *International Journal of Biosciences*, **3**(10): 280-287.

Amra, C. and Verma,B.K. (2003). Effect of boron and calcium on plant growth and seed yield of tomato. *JNKVV Research Journal of India. Vol*.**37**(2): 13-14.

Barche, S., Singh, P., Mahasagar, H. and Singh, D.B. (2011). Response of foliar application of micronutrients on tomato cv. Rashmi. *Indian Journal of Horticulture*, **68**(2): 278-279.

Basavarajeswari, C.P., Hosamni, R.M., Ajjappalavara, P.S., Naik, B.H., Smitha, R.P, and Ukkund. (2008). Effect of foliar application of micronutrients on growth, yield components of Tomato (*Lycopersicon esculentum* Mill): *Karnataka Journal of Agriculture Science.* Vol. **21**(3): 428-430.

BBS (Bangladesh Bureau of Statistics). (2018). Statistical Year Book, Bangladesh 2017. 37th edition, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Bhatt, L., Srivatsava B.K. and Singh M.P. (2004). Studies on the effect of foliar application of micronutrients on growth, yield and economics of tomato (*Lycopersicon esculentum* Mill.). *Progressive Horticulture,* **36**(2): 331-334.

Bose, U.S. and Tripathi, S.K. (1996). Effect of micronutrients on growth, yield and quality of tomato cv. Pusa Ruby in M.P. *Crop Research*; **12**:61.

Cardozo, V.P., Pizetta, N.V. and Teixeira,N.T. (2001). Manuring to foliate with calcium and boron in the culture of the tomato (*Lycopersicon esculentum* Mill) cv. Debora Max. *Ecossistema*.**26**(1): 39-41.

Chandra, A. and Verma, B.K. (2003). Effect of boron and calcium on plant growth and seed yield of tomato. *JNKVV Research Journal,* **37**(2): 13-16.

Chude, V.O. and Oyinlola, E.Y. (2001). Yield and nutritional qualities of two tomatoes (*Lycopersicon lycopersicum* Karst) varieties as influenced by boron fertilisation in a tropical environment. Plant nutrition: -food security and sustainability of agro ecosystems through basic and applied research. *Fourteenth International Plant Nutrition Colloquium, Hannover, Germany. pp.* 358-359.

Davis, J.M., Sanders, D.C., Nelson, P.V., Lengnick, L. and Sperry, W.J. (2003). Boron improves growth, yield, quality and nutrients contents of tomato. *Journal of American Social and Horticultural Science,***128**(3), 441– 446.

Demoranvillc, C.J. and Deubert, K.H.(1987). Effect of commercial calcium-boron and manganese- zinc formulations on fruit set of cranberries. *Journal of Horticultural Science*,**62**: 163-169.

Devi, K.N., Khomba, Singh, L.N., Singh, M.S., Singh, S.B. and Singh, K. K. (2012). Influence of Sulphur and Boron fertilization on yield, quality, nutrient uptake and economics of tomato (*LycopersiconesculentumMill*.). under upland conditions. *J. Agril. Sci*. **4**(4): 32-35.

FAOSTAT. (2019). Statistical data base of food and agriculture of the write donation Maria, Jose Diez and Fernanoneuzh and book of plant breeding vegetable. Available online: www.fao.org/statistics/databases/en. pp.152-156

Gowswammy, N.N. 1986. In the forward to sulphur research and agricultural production in India. H.L.S. Tondon, F.D.C.O., New Delhi.pp. 28-192.

Haleem, B., Rab, A. and Hussain, S.A. (2017). Effect of Calcium, Boron and Zinc Foliar Application on Growth and Fruit Production of Tomato. *Sarhad Journal of Agriculture.Vol.***34**(1):19-30.

Hamsaveni, M.R., Kurdikeri, M.B., Shekhargouda, M., Shashidhara S.D. and Dharmatti, P.R. (2003). Effect of gypsum and boron on seed yield and quality on tomato cv. Megha. *Karnataka Journal of Agricultural Sciences*, **16**(3): 457-459.

Haque, M.E., Paul, A.K. and Sarker, J.R. (2011). Effect of nitrogen and boron on the growth and yield of tomato (*Lycopersicon esculentum* Mill.). *International Journal of Bio-resource and Stress Management,***2:** 277-282.

Imtiaz, M., Rashid, A., Khan, P., Memon, M.Y. and Aslam, M. (2010). The role of micronutrients in crop production and human health. *Pakistani Journal of Botany*. Vol.**42**(4): 2565-2578.

Karthick R., Rajalingam, G.V., Praneetha, S., Sujatha, K.B., Armungam, T. (2018). Effect of micronutrients on growth, flowering and yield of bitter gourd (*Momordic acharantia*) cv. CO1. *International Journal of Chemical Studies*,**6**(1):845- 848.

Kiran, J., Vyakaranchal, B.S., Raikar, S.D., Ravikumar, G.H. and Deshpande, V.K. (2010). Seed yield and quality of tomato as influenced by crop nutrition. *Indian Journal of Agricultural Research*, **44**(1): 1-7.

Kumar, A., Singh, R.K. and Parmar, A.S. (2012). Effect of foliar application of micronutrients on yield characters and yield of tomato (*Lycopersicon esculentum* Mill). *Technofame: AJournal of Multidisciplinary Advance Research*, **1**(2): 10-14.

Kumari, S. (2012). Effect of micronutrient quality of fruit and seed in tomato (*Solanum lycopersicum* L.). *International Journal of Farm Sciences*, **2**(1): 43-46.

Magalhaes, I.R.I.C., Solwa, Dc. C.E.W., Monnerat, P.H. (1980). Levels and methods of boron application in tomatoes. *Prequisa Agropecuria Brasilesia*, **10**(2):135-157.

Magray, M.M., Chattoo, M.A., Narayan, S. and Mir, S.A. (2017). Influence of Sulphur and Potassium Applications on Yield, Uptake and Economics of Production of Tomato. *Int. J. Pure App. Biosci*.**5** (5): 924-934.

Mallick, M.F.R. and Muthukrishnan, C.R. (1980). Effect of micro nutrients on tomato (*Lycopersicon esculentum*Mill.*),* II. Effect on flowering, fruit-set and yield. *South Indian Horticulture*,**28**(1), 14-20.

Md. Mosharaf Hossain Sarker, Abu Zofar Md. Moshleuddding, Jahiruddding, M., Rafiqul Islam M. and RasendraTalukder. (2019). Effect of micronutrient fortified fertiliser application on the growth and yield components of tomato plant in floodplain soils of Bangladesh. *Journal of the National Science Foundation of Sri Lanka*. Vol.**47**(2):161 – 168.

Meena,D.C., Maji, S., Meena,J.K., Govind, Kumawat, R., Meena,K.R., Kumar S. and Sodh K. (2015). Improvement of Growth, Yield and Quality of Tomato (*Solanum lycopersicum* L.) cv. Azad T-6 with Foliar Application of Zinc and Boron. *International Journal of Bio-resource and Stress Management*. Vol.**6**(5):598-601.

Muthanna, M.A., Singh, A.K., Tiwari, A. and Jain, V.K. (2017). Effect of Boron and Sulphur Application on Plant Growth and Yield Attributes of tomato (*Lycopersicon esculentum Mill*.). International Journal of Current Microbiology and Applied Sciences **6**(10): 399-404.

Naresh, B. (2002). Response of foliar application of boron on vegetative growth, fruit yield and quality of tomato var. Pusa Ruby. *Indian Journal of Hill Farm. Vol.***15**(1): 109-112.

Naz, M.B., Muhammad, S., Hamid, A. and Farida, B. (2012). Effect of Boron (B) on the flowering and fruiting of tomato. *Sarhad Journal of Agriculture. Vol.***28**(1):37-40.

Nightingale G.T., Schermerhornl.G., and Robbins W.R. (1932). Effects of sulphur deficiency on metabolism in tomato.*Plant physiology*. Vol: **7**(4).

Oyinlola, E.Y. (2004). Response of irrigated tomatoes (*Lycopersicon lycopersicum* Karst) to boron fertilizer: 2. Growth and nutrient concentration. *Nigerian Journal of Soil Research*, **5**: 62-68.

Oyinlola, E.Y. and Chude,V.O. (2004). Response of irrigated tomato (*Lycopersicon lycopersicum* Karst) to boron fertilizer: 1. Yield and fruit quality. *Nigerian Journal of Soil Research*, **5**: 53-61.

Rab, A. and Haq-Ihsan-Ul (2012). Foliar application of calcium chloride and borax influences plant growth, yield, and quality of tomato (*Lycopersicon esculentum* Mill.) fruit. *Turkey Journal of Agriculture and Forestry*, **36**: 695-701.

Rocha, C.B., and Silva, J. (2011). Atividadeantioxidante total emtomate sproduzido sporcultivo sorgânico e convencional. Braz. J. Food. Technol. **14**, 27–30.

Sathya, S., Mani, S., Mahedran, P.P., Arulmozhiselvan, K. (2010). Effect of application of boron on growth, quality and fruit yield of PKM 1 tomato. *Indian Journal of Agricultural Research*,**44**(4): 274-280.

Sharma, U. and Kumar P. (2016). Extent of deficiency, crop responses and future challenges. *International Journal of Advanced Research*,**4**(4):1402-1406.

Shoba, N., Natarajan,S., Veeraragavathatham, D. and Amarnath,V. (2005). Effect of calcium, boron and ethel on fruit cracking in tomato. *Research Crops*, **6**(2): 369-370.

Singh, D.K., Rudra, B.C. and Gangopadhyaya, P.K. (2014). Role of micronutrients in the Productivity enhancement of tomato. *Journal of Agricultural Technology*, **1**(1): 68-69.

Singh, H.M. and Tiwari, J.K. (2013). Impact of micronutrient spray on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill). *Hort. Flora Research Spectrum*, **2**(1): 87-89.

Swetha, K., Saravanan, S. and LaluNaikBanothu. (2018). Effect of micronutrients on fruit quality, shelf life and economics of tomato (*Solanum lycopersicum* L.) cv. pkm-1.*Journal of Pharmacognosy and Phytochemistry*,**7**(5): 3018-302.

Verma, A.N., Ram, K. and Sharma, R.K. (1973). Growth, yield and quality of tomato (*Lycopersicon esculentum* Mill.) as affected by foliar applications of boron in sand culture. *Journal of Agricultural Science of Soil Science*, **1**(3), 1-5.

Zekri, M. and Obereza,T.A. (2003). Micronutrient deficiencies in citrus: Iron, zinc and manganese. Institute of Food and agricultural Services, *University of Florida, USA*.**3**(1): 10-17.

# APPENDICES

## Appendix I: Map showing the experimental site under study

## Appendix II: Characteristics of soil of experimental field

A. Morphological characteristics of experimental field

| Morphological features | Characteristics |
|---|---|
| Location | Agronomy field , SAU, Dhaka |
| AEZ | Madhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |

B. Physiological properties of the initial soil

| Characteristics | Value |
|---|---|
| Particle size analysis | |
| Sand% | 25 |
| Silt% | 45 |
| Clay% | 30 |
| Textural Classes | Silty -Clay |
| pH | 6.00 |
| Particle density (g/cc) | 2.68 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 1.10 |

**Appendix III. Monthly average of relative humidity, air temperature and total rainfall of experimental site during the period from October 2020 to April 2021**

| Month | Average RH% | Average temperature ($C^0$) | | Total Average Rainfall(mm) |
|---|---|---|---|---|
| | | Min. | Max. | |
| October, 2020 | 51.50 | 9.56 | 26.87 | 00 |
| November, 2020 | 50.45 | 8.56 | 24.87 | 00 |
| December, 2020 | 52.41 | 6.04 | 23.35 | 00 |
| January, 2021 | 59.13 | 12.45 | 21.32 | 00 |
| February, 2021 | 53.66 | 16.34 | 24.12 | 4.34 |
| March, 2021 | 46.37 | 19.41 | 28.54 | 1.22 |
| April, 2021 | 49.16 | 23.21 | 31.42 | 2.17 |

# Appendix V. Factorial ANOVA tables.

| Source | DF | SS | MS | F-Value | P (>F) |
|---|---|---|---|---|---|
| **1. Plant height (cm)** | | | | | |
| Replication | 2 | 0.185 | 0.0926 | | |
| Treatment | 11 | 843.247 | 76.6589 | 120.78 | 0.0000 |
| Error | 22 | 13.963 | 0.6347 | | |
| Total | 35 | 857.396 | | | |
| **2. Number of branches plant$^{-1}$ (no.)** | | | | | |
| Replication | 2 | 0.0418 | 0.02090 | | |
| Treatment | 11 | 26.6041 | 2.41855 | 149.24 | 0.0000 |
| Error | 22 | 0.3565 | 0.01621 | | |
| Total | 35 | 27.0024 | | | |
| **3. Number of leaves plant$^{-1}$ (no.)** | | | | | |
| Replication | 2 | 6.984 | 3.4919 | | |
| Treatment | 11 | 709.462 | 64.4966 | 137.54 | 0.0000 |
| Error | 22 | 10.316 | 0.4689 | | |
| Total | 35 | 726.762 | | | |
| **4. Number of cluster plant$^{-1}$** | | | | | |
| Replication | 2 | 0.3217 | 0.16083 | | |
| Treatment | 11 | 9.9508 | 0.90462 | 32.90 | 0.0000 |
| Error | 22 | 0.6050 | 0.02750 | | |
| Total | 35 | 10.8775 | | | |
| **5. Number of fruits cluster$^{-1}$ (no.)** | | | | | |
| Replication | 2 | 0.00597 | 0.00299 | | |
| Treatment | 11 | 1.82472 | 0.16588 | 49.30 | 0.0000 |
| Error | 22 | 0.07403 | 0.00336 | | |
| Total | 35 | 1.90472 | | | |
| **6. Number of fruits plant$^{-1}$ (no.)** | | | | | |
| Replication | 2 | 3.175 | 1.5876 | | |
| Treatment | 11 | 532.233 | 48.3848 | 60.79 | 0.0000 |
| Error | 22 | 17.511 | 0.7959 | | |
| Total | 35 | 552.919 | | | |

| Source | DF | SS | MS | F-Value | P (>F) |
|---|---|---|---|---|---|
| **7. Diameter of a fruit (cm)** | | | | | |
| Replication | 2 | 0.00096 | 0.00048 | | |
| Treatment | 11 | 9.12282 | 0.82935 | 198.37 | 0.0000 |
| Error | 22 | 0.09198 | 0.00418 | | |
| Total | 35 | 9.21576 | | | |
| **9. Fruit weight/plant (kg)** | | | | | |
| Replication | 2 | 11.36 | 5.679 | | |
| Treatment | 11 | 1120.50 | 101.864 | 37.16 | 0.0000 |
| Error | 22 | 60.31 | 2.741 | | |
| Total | 35 | 1192.17 | | | |
| **10. Yield (t/ha)** | | | | | |
| Replication | 2 | 0.00591 | 0.00295 | | |
| Treatment | 11 | 6.94333 | 0.63121 | 77.49 | 0.0000 |
| Error | 22 | 0.17921 | 0.00815 | | |
| Total | 35 | 7.12846 | | | |
| **11. Soil pH** | | | | | |
| Replication | 2 | 0.00097 | 0.00049 | | |
| Treatment | 11 | 0.33410 | 0.03037 | 23.02 | 0.0000 |
| Error | 22 | 0.02903 | 0.00132 | | |
| Total | 35 | 0.36410 | | | |
| **12. Organic matter content** | | | | | |
| Replication | 2 | 0.01307 | 0.00653 | | |
| Treatment | 11 | 0.23641 | 0.02149 | 47.28 | 0.0000 |
| Error | 22 | 0.01000 | 0.00045 | | |
| Total | 35 | 0.25948 | | | |
| **16. Available Sulphur (S) in soil** | | | | | |
| Replication | 2 | 0.02931 | 0.01465 | | |
| Treatment | 11 | 1.95306 | 0.17755 | 82.48 | 0.0000 |
| Error | 22 | 0.04736 | 0.00215 | | |
| Total | 35 | 2.02972 | | | |
| **16. Available Boron (B) in soil** | | | | | |
| | 2 | 0.10121 | 0.05060 | | |
| Treatment | 11 | 1.06582 | 0.09689 | 79.16 | 0.0000 |
| Error | 22 | 0.02693 | 0.00122 | | |
| Total | 35 | 1.19396 | | | |

## Appendix VI. Some photos document during experiment