EFFECT OF ZINC AND BORON ON THE GROWTH AND YIELD OF BARI TOMATO-15

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This is to certify that the thesis entitled, ***" EFFECT OF ZINC AND BORON ON THE GROWTH AND YIELD OF BARI TOMATO-15"*** *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. SAJEDUR RAHMAN,*** *Registration No.* ***19-10328*** *under my supervision and my 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.

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BY

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ABSTRACT

An experiment was carried out at the Soil Science research field, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from November 2020 to April 2021 to find out the effect of micronutrients (Zn and B) on the growth and yield of BARI Tomato-15. The experiment was laid out in a Randomized Completely Block Design (RCBD) having twelve (12) treatments with three replications. The unit plot size was 6 m^2. There were 12 different combination of zinc and boron treatments (T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11} and T_{12}) they were distributed randomly in individual plots. The total number of plots was 36. Different levels of zinc and boron as micronutrient had significantly varied the all yield and growth parameters. It was clearly found that, the maximum plant height (99.50 cm), number of branches $plant^{-1}$ (11.73), number of leaves(160.67), number of cluster $plant^{-1}$ (9.80), number of fruits $cluster^{-1}$ (5.00), number of $fruitsplant^{-1}$(42.45), diameter of a fruit (18.88 cm), single fruit weight $plant^{-1}$ (79.63 g), weight of fruits $plant^{-1}$ (3.47 kg) and yield (101.43 t ha^{-1}) were observed from T_8 ($B_{150\%}$ + $Zn_{50\%}$)treatment. On the other hand, the minimum plant height (81.67 cm), number of branches $plant^{-1}$ (9.07), number of leaves (146.40), number of cluster $plant^{-1}$ (8.07), number of fruits $cluster^{-1}$ (4.20), number of $fruitsplant^{-1}$ (30.21), diameter of a fruit (17.33 cm), single fruit weight $plant^{-1}$ (61.30 g), weight of fruits $plant^{-1}$ (1.85 kg) and yield (55.52 t ha^{-1}) were observed from T_1treatment that was control. The results of the present investigation revealed that tomato can be grown successfully at the use of 150% of boron and 50% of zinc, tomato gave more yield. The findings of the present investigation clearly indicated that the efficient use of boron and zinc doses and growing tomato is a viable option for increasing income of farmers.

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LIST OF ABBREVIATIONS

Abbreviation	**=**	**Full word**
%	=	Percent
N	=	Nitrogen
P	=	Phosphorus
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
IRRI	=	International Rice Research Institute
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 Nation Development Program
$^{W}/_{V}$	=	Weight per Volume
$^{W}/_{W}$	=	Weight per Weight
wt.	=	Weight
BE	=	Biological efficiency
MRR	=	Mycelium Running Rate
NMDEC	=	National Mushroom Development and Extension Center
MCC	=	Mushroom Culture Centre
mg	=	Milligram
CHO	=	Carbohydrate
Conc.	=	Concentration

CHAPTER I

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the most popular, important and widely used vegetable crops as ranked number two vegetable of the world after potato (Dorais *et al*., 2008; Olaniyi *et al*., 2010). It is considered as a perennial crop, but for commercial productions it is cultivated as an annual crop (Mohamed *et al.,* 2010). It is a major vegetable crop grown all over the world and also a popular vegetable in Bangladesh due to its taste and nutritional status. It belongs to the family Solanaceae. It is one of the most popular, important and nutritious vegetables grown in Bangladesh mainly during the Rabi season. The food value of tomato is very high because of higher contents of vitamins (A, B, C), minerals and carotene (Bose *et al*., 1990). Therefore, it can meet up some degree of vitamin A and C requirement, add flavor to the foods. It is rich in medicinal value and also can contribute to solve malnutrition problem. The best growing areas of tomato in Bangladesh are Chittagong, Comilla and Rajshahi (Sharfuddin *et al.,* 1985) and it ranks fourth in respect of production and fourth in respect of area (BBS, 2020). 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 most logical way to increase the total production at the national level from our limited land resources is to increase yield per unit area. The demand of tomato in both domestic and foreign markets increased manifold in recent years. Adequate supply of nutrient can increase the quality fruit and seed yield. For harnessing the higher seed yield, supplementation of micronutrients is essential. Amongst the vegetables, tomato is very responsive to the application of micronutrients. It is realized that productivity of crop is being adversely affected in different areas due to deficiencies of micronutrients (Bose *et al*., 1996).

Micronutrients 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. Micronutrients 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). Micronutrients 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). 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). 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.

Among micronutrients, Zn and B are important for plant nutrition. Tomato requires both major and micronutrients for its proper plant growth (Sainju *et al.,* 2003). Zn plays important role on growth and development as well as carbohydrates, protein metabolism and sexual fertilization of plant (Imtiaz *et al*., 2003; Vasconcelos *et al*., 2011) while B deficiency reduced yield and quality in tomatoes (Davis *et al*., 2003). Zinc is indispensable for normal growth and development of plants. It is effective for the synthesis of plant hormones like auxin and carbohydrate formation (Pankaj *et al*., 2018). It plays a fundamental role in several critical functions in the cell such as protein metabolism, gene expression, structural and functional integrity of bio-membranes and photosynthetic metabolism (Sanju *et al*., 2003). Zinc is also a constituent of ribosomes and is essential for their structural integrity (Trivedi et al., 2013). It promotes starch formation, seed maturation, production, enhances seed viability and seedling vigor. Zinc is helpful in reproduction of certain plants and various enzymatic activities. It also plays a vital role in sulphur and nitrogen metabolism (Pandev *et al*., 2016). Its deficiency causes interveinal chlorosis of older leaves then leaves turn grey-white and fall prematurely or die. Stunted growth, distortion in shape and clustering of leaves on short branches known as rosette. The tomato crops are highly sensitive to Zn deficiency.

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). Boron 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. 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).

Considering these facts in mind, the present research work was conducted to optimize different levels of Zn and B on growth and yield of tomato. Keeping the above stated fact in view, the present study was undertaken in achieving the following objectives:

Objectives:

1. To observe the effect of Zn and B on the growth and yield of BARI Tomato 15.
2. To find out the complete dose of Zn and B for better growth and yield of BARI Tomato 15.

CHAPTER II

REVIEW OF LITERATURE

This chapter an attempt has been made to review the available information in home and abroad regarding the study on effect of Zn and B on the growth and yield contributing characteristics of Tomato (*Solanum lycopersicum* L.). Many research organizations of our country have information about the effect of micronutrients such as Zinc and Boron on 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. However, some of the literatures related to this investigation are reviewed in this chapter are given below:

3.1. Effect of micronutrients on the growth and yield of Tomato.

Micronutrients are present in lower concentrations in soil than macronutrients but are equally significant in plant nutrition, since, plants grown in micronutrient-deficient soils show similar reductions in productivity as those grown in macronutrient-deficient soils (Havlin *et al.,* 2005). The prerequisite criteria for improved growth yield and quality of solanaceous vegetables is balanced fertilization. However, nutrients can be applied either by conventional methods or by foliar application but the major advantage of foliar application the instant availability of nutrients to plants. Micronutrients play a catalytic role in nutrient absorption and balancing other nutrients (Singh and Kalloo, 2000).

Mohammed *et al.,* 2014 observed that the highest fruit weight of tomato (73.17 g) was recorded with the application of nitrogen, phosphorus and potash at 46.29, 37.02 and 37.02 g/m^2, respectively + farmyard manure 1.5 kg/m^2 + micronutrients 2.5 ml/l, while the highest number of fruits per plant (84.33), yield per plant (6.008 kg) and total yield per plastic house (3.172 t/220 m^2) was obtained through the application of nitrogen, phosphorus and potash at 46.29, 37.02 and 37.02g/m^2 , respectively + farmyard manure 2.5 kg/m^2 + micronutrients 2.5 ml/l.

Yuanxin *et al.* (2009) reported that boron and manganese at low concentrations significantly reduced fruit yield and the antioxidative content but at its high concentrations increased fruit yield and antioxidative capacity in tomato.

3.2 Effect of Zinc on the growth and yield of Tomato.

Micronutrients such as iron, zinc, manganese, copper and boron are the important elements with specific and essential physiological functions in plants; required in small quantities for normal growth and development of plants. Among them Zinc and Boron is vital once. Zinc is an essential component of a number of enzymes, i.e., dehydrogenase, aldolase, isomerases, proteinase, peptidase and phosphohydrolase (Mousavi, 2011). It is directly involved in the synthesis of indol acetic acid (IAA) and proteins. The principal function is a metal activator of enzymes in plants. Zinc deficiency may be related to weather conditions, as it increases in cold and wet weather, which might be due to the limited root growth incool soils, or reduced activity of microorganisms and release of zinc from organic materials (Abdou *et al.,* 2011; Alam *et al.*, 2010; Terhan and Sekhon, 1977). Its deficiency symptoms appear generally on younger leaves starting with interveinal chlorosis.

According to Harris and Lavanya (2016) foliar application of zinc at 250 ppm results the maximum plant height, total dry weight, number and freshweight of fruits/plant and yield of tomato.

Saravaiya *et al*., 2014 concluded that the main objective to study the influence of foliar application of micronutrients on Tomato (*Lycopersicon esculentum* Mill.) cv. “Gujarat Tomato 2” at ASPEE, ARDF, Tansa during Rabi 2013-2014. The experiment consists of eight treatments involving T_1 (RD NPK through chemical fertilizers N: P_2O_5 : K_2O_5 kg ha^{-1} (75 : 37.5 : 62.5), T_2 (T_1+ 100 ppm B; i.e. Boric acid 0.571 g l^{-1}), T_3 (T_1+100 ppm Zn; i.e. Zinc sulphate 0.246 g l^{-1}), T_4 (T_1 + 100 ppm Cu; i.e. Copper sulphate 0.420 g l^{-1}), T_5 (T_1+100 ppm Fe; i.e. Ferrous sulphate 0.515 g l^{-1}), T_6 (T_1 +100 ppm Mn; i.e. Manganese sulphate 0.320 g l^{-1}) and T_7 (T_1 + mixture of all micronutrients) and T_8 (T_1 + Multiplex 4 ml l^{-1}) by mixing with simple water were imposed. The foliar application was made by using equipment knapsack sprayer (ASPEE) in the evening hours. The thrice times foliar spray were made at 10 days intervals starting from 40 days after transplanting seedling. The data clearly showed that the yield obtained with treatment

T_7 had significantly plant height (132.77 cm), number of branches plant^{-1} (5.96), fresh weight of plants (25.70 t ha^{-1}), dry matter yield of plants (7669.04 kg ha^{-1}), maximum days to last picking (166.01), number of fruits plant^{-1} (34.43), fruit length (5.47 cm), fruit diameter (4.57 cm), fruit volume (65.94 cm3), single fruit weight (49.00 g), fruit weight plant-1 (1.69 kg), number of locules fruit^{-1} (3.01), pericarp thickness (6.27 mm), fruit yield plot-1 (70.86 kg), fruit yield ha^{-1} (46.87 t.) and marketable fruit yield ha^{-1} (45.68 t). This treatment had maximum net return (1, 66,752 Rs/ ha) and B: C Ratio 2.71: 1 out all other treatments than control.

3.3 Effect of Boron the growth and yield of Tomato.

On the other hand, Boron helps in the absorption of water and carbohydrate metabolism (Haque *et al.,* 2011), translocation of carbohydrates in plants, DNA synthesis in meristems, cell division and elongation, active salt absorption, fertilization, water relation and photosynthesis and involves indirectly in metabolism of nitrogen, phosphorous, fat and hormones. Boron also plays an important role in flowering and fruit formation (Nonnecke, 1989). Due to the lack of boron, there is hypertrophy, degeneration and disintegration of cambium cells in the meristematic tissues. Its deficiency may cause sterility, small fruit size, and poor yield (Davis *et al*., 2003) and affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins.

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 20 kg/ha 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).

Sivaiah *et al*. (2013) recorded the higher growth rate (77.5%) with the application of boron in tomato. The plant height of tomato increased significantly with 50 and 75 kg $ZnSO_4$ ha^{-1} in combination with NPK over NPK alone (Reddy *et al*., 1985).

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 per plant (44.0), number of fruits per plot (704.0), yield per plant (0.79 kg), yield per plot (12.78 kg) and yield/ha (319.50 quintal) were obtained with 0.20% boron, whereas the greatest fruit weight (27.27 g) was recorded for 0.10% boron.

Sharma (1995) reported that borax at 20kg/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 (1999) stated that application of borax 20kg/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).

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.

Rab and Haq (2012) observed that foliar application of $CaCl_2$ (0.6%) and borax (0.2%) in combination resulted in the maximum number of flowers per cluster (32.36), fruits per plant (96.37), fruit weight (96.33g), fruit yield (21.33 t/ha), fruit firmness (3.46 kg/cm^2) and total soluble solids (6.10%) and the lowest blossom end rot incidence (6.25%) of tomato.

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, 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 2 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) studied the effects of 0, 1, 2, 3, 4 and 5 kg B/ha on the yield and biochemical properties of tomato cultivars Roma VF and Dandino. 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 2 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.

Amarchandra and Verma (2003) conducted an experiment during the rabi seasons of 1998 and 1999 at Jabalpur, Madhya Pradesh, India, to evaluate the effects of boron and calcium on the growth and yield of tomato cv. Jawahar Tomato 99. Boron (1, 2, and 3 kg/ha, calcium carbonate), along with phosphorus (60 kg/ha) and potassium (40 kg/ha), were applied before transplanting, whereas nitrogen (100 kg/ha) was applied in split doses at 25 and 50 days after transplanting. Data were recorded for plant height, number of branches per plant, fruit yield and seed yield. Application of 2 kg B/ha + 2 kg Ca/ha recorded the highest yield.

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 to determine 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.
Again Verma *et al*. (1973) observed that spray of boron 1ppm significantly increased the fresh and dry weight of root (28.5 g and 6.25 g, respectively) in tomato. The application of boron 1 ppm significantly increased seed content in tomato fruits (Arora *et al*., 1982).

Cardozo *et al.* (2001) concluded the effects of Ca and B fertilizers on the productivity of tomato cv. Debora Max were investigated in Espirito Santo do Pinhal, Sao Paulo, Brazil from April to July 2000. Aminobor at 300 ml/100 litres gave the highest value for fruit weight, while Ca at 60 g/100 litres and B at 150 g/100 litres recorded the highest number of fruits.

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).

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.

Alpaslan and Gunes (2001) investigated a greenhouse study to determine interactive effects of NaCl salinity and B on the growth, sodium (Na), chloride (Cl), boron (B), potassium (K) concentrations and membrane permeability of salt-35 resistant tomato (*Lycopersicon esculentum* cv. Lale F1) and salt-sensitive cucumber (*Cucumis sativus* cv. Santana F1) plants. Plants were grown in a factorial combination of NaCl (0 and 30 mM for cucumber and 0 and 40 mM for tomato) and B (0, 5, 10 and 20 mg kg^{-1} soil). Boron toxicity symptoms appeared at 5 mg kg^{-1} B treatments in both plants. Salinity caused an increase in leaf injury due to B toxicity, but it was more severe in cucumber. Dry weights of the plants decreased with the increasing levels of applied B in nonsaline conditions, but the decrease in dry weights due to B toxicity was more pronounced in saline conditions especially in cucumber. Salinity x B interaction on the concentration of B in both plants was found significant. However, increase in B concentrations of tomato decreased under saline conditions when compared to nonsaline conditions. Contrary to this, B concentration of cucumber increased as a result of increasing levels of applied B and salinity. Salinity increased Na and Cl concentrations of both plants. Potassium concentration of tomato was not affected by salinity and B treatments, but K concentration of cucumber was decreased by salinity. Membrane permeability of the plants was increased by salinity while toxic levels of B had no effect on membrane permeability in nonsaline conditions. Membrane permeability was significantly increased in the presence of salinity by the increasing levels of applied B.

Singaram and Prabha (1999) conducted a pot experiment using calcareous soil with tomato hybrid cv. Naveen (115 days duration) and non-hybrid cv. Co 3 (105 days duration), to investigate the effects of B application either to the soil or as a foliar spray on B uptake, biomass and fruit yields. Application of borax increased B concentration of the shoot at both flowering and final harvest in both cultivars 37 whereas in the roots, the treatments involving the soil application of borax produced higher concentration of B than the foliar spray of borax. The B concentration of the fruits was influenced by the treatments. The foliar application of borax was generally associated with higher B uptake in shoots as a result of the twin effects of high concentration in shoots combined with enhanced shoot dry matter. The application of borax generally increased the dry weight of tomato shoots at both the flowering and harvest stages. At 50% flowering and harvest application of borax at 20-30 kg/ha, or as foliar applications at 0.2-0.3% produced the highest dry weights. Fruit yield was highest in the hybrids but the response was similar to Co 3 whereas the maximum fruit yield, in contrast to shoot and root dry weight, and was obtained with the spray of 0.2-0.3% borax.

Delibas and Akgun (1996) evaluated the effects of irrigation water with 0.5, 1.0, 2.5 or 4.0 ppm B on the growth and yield of tomato in Turkey under field conditions. The irrigation water with 1.0 ppm B was suitable for onion based on plant height, number of branches, stem radius, number of fruits, fruit yield, maturity, radius of fruit and fruit weight. Higher concentrations of B significantly reduced the evaluated parameters.

Vasil *et al*. (1997) observed in the field experiments during 1994 and 1995 at the Agricultural Institute in Strumica, Republic of Macedonia, tomato cv. AT-70-14 on a low carbonate alluvial soil on 21 sq. m plots and given the following treatments: (1) control (no fertilizer); (2) N100 P100 K150; (3) NPK as (2) + 1% Mg; (4) NPK + 0.5% B; (5) NPK + 1% Mg + 0.5% B. Treatments 2-5 gave the higher yields than the control treatment in both years. The NPK + Mg + B fertilizer was calculated to be the most profitable treatment and is recommended for production of industrial tomatoes in Strumica.

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).

3.4 Combination effect of Zn and B on the growth and yield of Tomato.

Ilyas *et al*., 2019 was conducted to investigate the effect of boron and zinc on the growth and yield of tomato. Three levels of boron (viz., 0, 1 and 2kg H_3B0_3 ha^{-1}) and zinc (viz., 0, 1 and 2kg $ZnS0_4$ ha^{-1}) were applied for each experiment. Results revealed that boron had significant effect on all yield attributes and yield of tomato. Application of 2kg H_3B0_3/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 2kg $ZnS0_4$ ha^{-1}. A combination of 2kg H_3B0_3 and 2kg $ZnS0_4$ ha^{-1} gave the highest yield of Tomato (83.50 t ha^{-1}). So, application of 2kg H_3B0_3 along with 2kg $ZnS0_4$ ha^{-1} was the best for growth and yield of tomato.

Khatun *et al*., 2020 reported that a combination of 6 kg zinc 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 of the investigation suggested that, high seed yield and good quality seed of tomato can be obtained with the application of 6 kg zinc and 2.5 kg boron per hectare in combination with 30 fruits were retained per plant.

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, $ZnSO_4$ and $CuSO_4$ at 250 ppm each in tomato (Barche *et al.*, 2011).

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 + zinc sulphate + copper sulphate at 250 ppm each as a foliar spray in tomato.

Chude and Oyinlola (2001) concluded that plant responses to soil and applied boron varies 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.

Foliar application of boron, zinc, copper, iron and manganese mixture each at 100 ppm and molybdenum at 50 ppm thrice at 10 days' interval starting from 40 days after transplanting of tomato significantly enhanced fruit yield to the extent of 28.67% over control (Kumar *et al*., 2012).

Brahma *et al*., 2010 reported that the combined application of micronutrients produced the maximum fruit yield of tomato followed by individual application of boron and zinc. The application of NAA 10 ppm and boron 1 ppm at first flowering stage recorded the highest per cent fruit set, number of fruits per plant and average fruit weight among all the treatments, whereas, untreated control (water spray) recorded the lowest values for all the characters.

Salam *et al*. (2010) recorded maximum number of seeds per fruit (96) with combined application of boron 2.5 and zinc 6 kg/ha and recommended dose of NPK followed by 94 seeds per fruit at boron 2 and zinc 4 kg/ha along with recommended dose of NPK as compared to control (79).

Meena *et al*., 2015 was conducted an investigation to find out the response of zinc and boron on improvement of growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Azad T-6. The experiment was layout in Randomized Block Design with three replications and 12 treatments. Treatment combinations are T_0 -Control (water spray), T_1 -Zinc (50 ppm), T_2 -Zinc (100 ppm), T_3 -Zinc (150 ppm), T_4 -Boron (50 ppm), T_5 - Boron (100 ppm), T_6 -Boron (150 ppm), T_7 -Zinc (50 ppm) + Boron (50 ppm), T_8 - Zinc (100 ppm) + Boron (100 ppm), T_9 -Zinc (150 ppm) +Boron (150 ppm), T_{10}-Zinc (100ppm) + Boron (50 ppm), T_{11}-Zinc (150 ppm) + Boron (50 ppm). It was found that the vegetative growth in terms of plant height and number of branches at various stages (30, 60 and 90 Days after transplanting) was greatly influenced by the application of micronutrients Zn and B. Among them treatment T_5 -Boron (100 ppm) significantly increased the plant height (61.23 cm at 90 DAT) and number of branches (16.17 $plant^{-1}$ at 90 DAT) compared to others. Whereas, application of zinc and boron each at 100 ppm (T_8) caused early flowering (31.95 DAT) as well as showed maximum number of flowers (75.21) and fruit yield (93.10 t ha^{-1}). It was also revealed that the treatment T_8 improved the physio-chemical qualities of tomato fruits specially improved the TSS: acid ratio (10.98). Thus, the study indicated that application of boron and zinc 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.

Sivaiah (2012) evaluated that application of different treatment combination (boron, zinc, molybdenum, copper, iron, manganese), resulted the improvement in plant growth characteristics viz., plant height, number of primary branches and fruits/plant in tomato.

Sarker *et al.,* (2019) concluded that the application of Zn 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 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 Zn but combined application of both Zn and B showed the highest response by tomato. Only Zn 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 Zn and B.

Magalhaes *et al*., 1980 reported that Zn and B play an important role in improving the growth, yield and quality of tomato in addition to checking various diseases and physiological disorders

Saravaiya *et al*. (2014) observed that foliar application of micronutrients (RDF + B, Zn, Cu, Fe, Mn) had significantly enhanced the plant height (131.73 cm), number of branches/plant (5.81), number of fruits/plant (34.26), fruit length (5.52 cm), fruit diameter (4.64 cm), fruit volume (67.53 cm^3), fruit yield/ ha (46.78 t) and marketable fruit yield/ ha (45.62 t) in tomato.

Application of micronutrients particularly Zn and B 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 Zn and B, @ 4.0 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 Zn, which might be due to its content in soils, environmental factors and different management practices. Furthermore, Zn and B fertilizers recommendation in future should be site, location and variety specific (Supti Mallick *et al*., 2020)

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

Ingle *et al*. (1993) recorded the maximum plant height (78.53 cm) and number of branches per plant (9.73) in treatment of naphthalene acetic acid (NAA 10 ppm) + urea (1%) + $ZnSO_4$ (0.2%) as compared to control (70.93 cm and 8.13, respectively). The increased fresh weight and dry matter accumulation in shoots of tomato by foliar application of micronutrients viz., B, Zn, Mo, Cu, Fe, Mn and mixture of all occurs due to greater accumulation of photosynthates by vegetative parts in the plants (Bhatt and Srivastava, 2005). The application of NPK 100:100:50 kg/ha +Azospirillum + PSB each @ 125 g/ha as root dipping along with $ZnSO_4$ (0.2%) spray recorded significantly higher plant height, number of branches per plant and number of leaves per plant (Kiran *et al*., 2010).

Swetha *et al*., 2018 investigation entitled "Effect of micronutrients on fruit quality, shelf life and Economics of Tomato (*Solanum lycopersicum* L.) cv. PKM-1" was under taken at vegetable research field, Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology & Sciences (SHIATS), Allahabad during rabi season (2015-2016). The experiment was laid out in Randomized block design with 13 treatments and each replicated thrice. The treatments consist of different combinations of micronutrients i.e., zinc, boron, copper and iron. Among these thirteen treatments, treatment T_{12} ($ZnSO_4$ +B_3HO_3 +$CuSO_4$ +$FeSO_4$ @500ppm) was recorded the maximu fruit yield per ha (33.62t) followed by treatment T_{11} ($ZnSO_4$ +B_3HO_3 +$CuSO_4$ +$FeSO_4$ @250ppm). Among the quality parameters TSS (5.00Brix) was found maximum in treatment T_{11}($ZnSO_4$ +B_3HO_3 +$CuSO_4$ +$FeSO_4$ @250ppm) followed by treatment T_{12}($ZnSO_4$ +B_3HO_3 +$CuSO_4$ +$FeSO_4$ @500ppm) whereas juiciness (31.24%), titrable acidity (1.06%), Ascorbic acid content (26.67mg/100 g fruit juice) and shelf life (11.39) days at normal room temperature was recorded maximum in treatment T_{11}($ZnSO_4$ +B_3HO_3 +$CuSO_4$ +$FeSO_4$ @250ppm) followed by T_{12}($ZnSO_4$ +B_3HO_3 +$CuSO_4$ +$FeSO_4$ @500ppm). Maximum gross returns (Rs.3, 37,700 ha^{-1}), net returns (Rs. 2, 14,925 ha^{-1}) and B: C ratio (2.75:1) was found to be best with treatment with T_{12} ($ZnSO_4$ +B_3HO_3 +$CuSO_4$ +$FeSO_4$ @500ppm).

Singh and Verma (1991) observed that the application of potassium 120, zinc 10 and boron 2 kg/ha alone or in combination resulted in optimum plant growth of tomato. Besides, application of Zinc increased significantly the dry biomass, fruit yield, fruit fresh weight and numbers of fruits per plants (Gurmani *et al*., 2012).

On the other hand, Bose and Tripathi (1996) reported an improvement in growth parameters (plant height 81.56 cm and number of branches per plant 19) of tomato when micronutrients (Zn, Mn, Fe and B) were applied in combination at 30 and 60 days after transplanting. In chilli, foliar application of liquid fertilizer 'Polyfeed and Multi' containing most of macro- and micronutrients alongwith NPK significantly improved the growth and number of branches per plant over straight NPK fertilizers (Sharma *et al.,* 2000).

Haleem *et al.* (2017) found that the interaction of B and Zn increases the plant height, number of primary and secondary branches, number of leaves/plant, number fruits/plant 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).

Bhatt and Srivastava (2005) investigated the effects of the foliar application of boron (boric acid), zinc (zinc sulfate), molybdenum (ammonium molybdate), copper (copper sulfate), iron (ferrous sulfate), manganese (manganese sulfate), mixture of these nutrients, and Multiplex (a commercial micronutrient formulation) on the nutrient uptake and yield of tomato (Pusa hybrid-1) in Pantnagar, Uttaranchal, India, during the summer of 2002 and 2003. Zinc, iron, copper, boron and manganese were applied at 1000 ppm each, whereas molybdenum was applied at 50 ppm. Foliar spraying was conducted at 40, 50 and 60 days after transplanting. All treatments significantly enhanced dry matter yield, fruit yield and nutrient uptake over the control. The mixture of the micronutrients was superior in terms of dry matter yield of shoot (53.25 g/ha); dry matter content of shoot (27.25%); nitrogen (152.38 kg/ha), phosphorus (47.49 kg/ha), potassium (157.48 kg/ha), sulfur (64.87 kg/ha), zinc (123.70 g/ha), iron (940.36 g/ha), copper (72.70 g/ha), manganese (359.17 g/ha) and boron (206.58 g/ha) uptake by shoots; total fruit yield (266.60 kg/ha); dry matter yield of fruit (16.98 kg/ha); and nitrogen (78.78 kg/ha), phosphorus (8.51 kg/ha), potassium (34.31 kg/ha), sulfur (16.14 kg/ha), iron (141.81 g/ha), copper (23.13 g/ha), zinc (63.06 g/ha), manganese (34.08 g/ha) and boron (95.23 g/ha) uptake by fruits.

Singh *et al*. (2014) obtained higher yield (23.10 and 18.33 t/ha) of tomato with the application of different micronutrients (boron and zinc) in combination and at different concentrations (0.2 and 0.4%) as compared to control (14.52 t/ha) where micronutrients were not applied. The highest number of flower clusters per plant (12.33), number of fruits per cluster (7.17), number of fruits per plant (88.33), yield per plant (6.33kg) and total yield (113.628 t/ha) was registered with combinedapplication of boron 1.25 g/l + zinc 1.25 g/l in tomato under agro-climatic conditions of Allahabad (Shnain *et al*., 2014).

Ali *et al.* (2015) examined an experiment to increase the yield of BARI hybrid tomato 4, cultivated in summer season of Bangladesh, foliar application of zinc and boron [T_0: control; T_1: 25-ppm $ZnSO_4$ (Zinc Sulphate); T_2: 25-ppm H_3BO_3 (Boric Acid) and T_3: 12.5-ppm $ZnSO_4$ + 12.5-ppm H_3BO_3] was done. Maximum plant height (106.9 cm), number of leaves (68.9/plant), leaf area (48.2 cm^2), number of branches (11.9/plant), number of clusters (21.6/plant), number of fruits (1.8/clusters and 33.6/plant), fruit length (5.3 cm), fruit diameter (5.1 cm), single fruit weight (60.4 g) and yield (1.9 kg/plant, 25.7 kg/plot and 58.3 t/ha) were found from foliar application of 12.5-ppm $ZnSO_4$ + 12.5-ppm H_3BO_3 while minimum from control. Early flowering (49.3 days) and minimum diseased infested plant (9.4%) were also found from foliar application of 12.5-ppm $ZnSO_4$ + 12.5-ppm H_3BO_3.Combined foliar application of zinc and boron was more effective than the individual application of zinc or boron on growth and yield for summer season tomato (BARI hybrid tomato 4).

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, Zn and mixture) have been reported by Naga *et al*. (2013).

Salam *et al.* (2011) investigated that the combination of boron and zinc @ 2.5 kg B/ha + 6 kg Zn/ha, resulted the highest pulp weight, dry matter content, ascorbic acid, lycopene content, chlorophyll content in tomato.

Yadav *et al.* (2001) designed a study during 1990 and 1991, in Hisar, Haryana, India, to evaluate the effect of different concentrations of zinc and boron on the vegetative growth, flowering and fruiting of tomato. The treatments comprised five levels of zinc (0, 2.5, 5.0, 7.5, and 10.0 ppm) and four levels of boron (0, 0.50, 0.75, and 1.0 ppm) as soil application, as well as 0.5% zinc and 0.3% boron as foliar application. The highest fruit length, fruit breadth and fruit number were obtained with the application of 7.5 ppm zinc and 1.0 ppm boron.

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 5.5 g/100ml, boron 5 g/100ml and zinc 5 g/100 ml as compared to other treatments. Foliar application of zinc (100 mg/l) + iron (200 mg/l) resulted in maximum number of flowers per cluster (18.14), fruits per cluster (8), fruits per plant (90.14), fruit weight (95.14g) and yield (25.14 t/ha) in tomato (Kazemi, 2013).

CHAPTER III

MATERIALS AND METHODS

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 Soil Science research field, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from November 2020 to April 2021. Geographically the experimental field is located at 23°46' N latitude and 90° 22' E longitude at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract (BBS, 2011). 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 depths 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 Yard, Bangladesh Meteorological Department, and presented in Appendix III.

3.4 Description of crop sample

In the experiment planting material used as BARI Tomato 15 that was developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur in 2009. High yielding winter variety. Thick skin and edible flesh having very good self-life. fruit oval shape, less seeded fruits with 65-70g in weight, Attractive red flesh color, 40-45 fruit/plant, life time 100-110 days. Planting season and time Rabi, and October.

Medium to late variety. Harvesting time within 60-70 days after transplantation fruit harvest start and harvest up to 25-30 days. Yield should be 80-85 t/ha.

3.5 Treatments under investigation

There were four levels of zinc (0,1,2,3 kg/ha) and three levels of boron (0,1,1.5 kg/ha). So, treatment combinations were as follows:

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$

$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$

$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$

$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$

$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$

$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$

$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$

$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$

$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$

$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$

$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$

$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

Recommended Doses:

N_{140} P_{45} k_{65} S_{22} kg/ha

3.6 Land preparation

Seed bed preparation was done on 14th 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 14th November and 11th December, 2020, respectively. Experimental land was divided into unit plots following the design of experiment.

3.7 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD). All the treatments were replicated three times. There were altogether 36 = (12×3) unit's plots.

3.8 Layout of the experimental plots

Total number of plots	:	36
Individual plot size (2×1.5) m^2	:	3 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

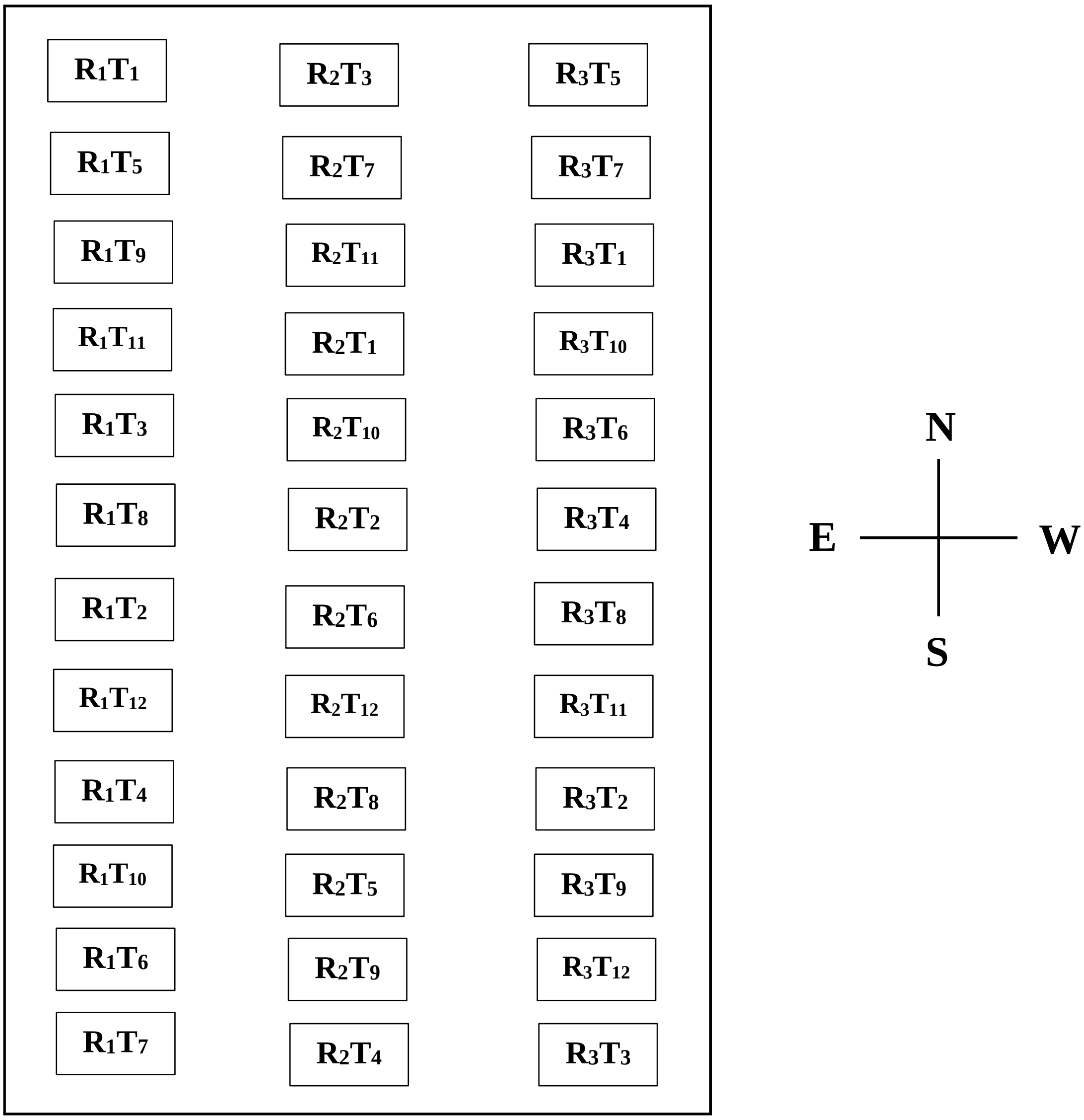

Fig. 1. Field layout of the experiment

3.9 Fertilizer application

Boric acid and zinc sulphate were applied as the sources of boron and zinc respectively. Doses of boron and zinc were applied as per treatments of the experiment. The whole amount of Boric acid and zinc sulphate and also TSP, Gypsum as the sources of phosphorus and Sulphur, 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 sulphur were 140, 45, 65 and 22 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 17 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 were done on 25 December, 2020.

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 watering was given with water can immediately after transplanting the seedlings and then 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 23 January, 2021.

3.11.5 Protruding

Attach bamboo stick tying with plant by rope was done on 27 January, 2021.

3.12 Plant protection

3.12.1 Insect pests

Malathion 57 EC was applied @ 2 ml L^{-1} of water 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. Furadan lOG was also applied during final land preparation as soil insecticide.

3.12.2 Diseases

During foggy weather precautionary measure against disease attack of tomato was taken by spraying Diathane M-45 fortnightly @ 2 gm per litre of water, at the early vegetative stage. Ridomil gold was also applied @ 2 g per litre of water against blight disease of tomato.

3.13 Sampling and harvesting

Fruits were harvested at 4-5-days interval during early ripe stage when they developed slightly red color. Harvesting was started from 21th March, 2021 and was continued up to 10thApril, 2021.

3.14 Data collection

Five plants in each plot were selected and tagged. All the growth data (except dry weight) were recorded from those five selected 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. Single fruit weight plant^{-1} (g)
ix. Fruit weight/plant (kg)
x. Yield (t/ha)

3.15 Procedure of data collection

3.15.1 Plant height (cm)

The plant height was recorded at harvest only. The plant height was taken from the ground level to the tip of the largest leaf of the plants. Plant height 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 45 and 63 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 Single fruit weight plant^{-1} (kg)

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

3.15.9 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).

3.15.10 Yield (t/ha)

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).

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 kept in plastic container to determine the physical and chemical properties of soil. Analyzed data's 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

An experiment was conducted to determine the effect of Zn and B on the growth and yield of BARI Tomato-15. The data have been depicted in various tables and figures. Results are discussed and possible explanations have been given under the following sub heads.

4.1 Effect of B and Zn micronutrients on growth, yield contributing characters and yield of BARI Tomato 15.

4.1.1 Plant height (cm)

The plant height was measured from the sample plants in cm. from the ground level to the longest stem and mean value was calculated. Plant height was recorded at final harvest only (Figure 2). Sincerely the longest plant (99.50 cm) was recorded at T_8 treatment where $B_{1.5\ kg/ha}$ + $Zn_{1\ kg/ha}$ applied. Whereas the shortest plant height (81.67 cm) was recorded from T_1 treatment which was control. Haleem *et al.* (2017) found that the interaction of B and Zn increases the plant height in tomato.

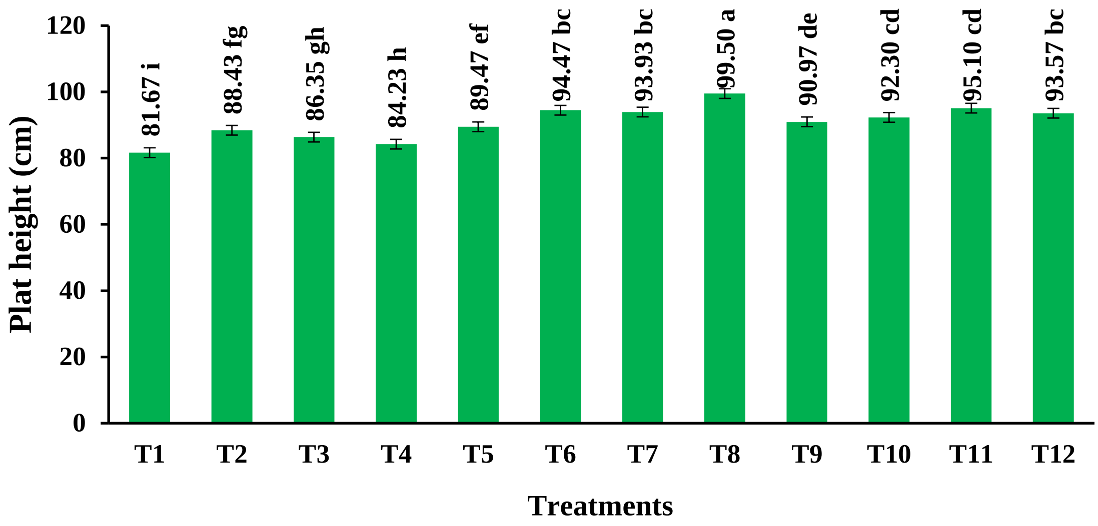

Figure 2. Effect of B and Zn micronutrients on the plant height of BARI Tomato 15 at harvest

Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$

$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$

$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$

$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$

$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$

$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$

$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$

$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$

$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$

$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$

$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$

$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

It was also found that the vegetative growth in terms of plant height was greatly influenced by the application of micronutrients Zn and B (Meena *et al.*, 2015). Naresh (2002) stated that B also had positive effects on plant height in tomato. Similar findings were observed from the current study.

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

Number of branches plant^{-1} is an important growth parameter for evaluating growth characteristics of tomato cultivation. As evident from table 1 the growth character like number of branches per plant were increased significantly with the application of boron and zinc.

Table 1: Effect of B and Zn micronutrients on the number of branches/plant and number of leaves/plant of BARI Tomato 15.

Treatments	Number of branches/plant	Number of leaves/plant
T_1	9.07 g	146.40 k
T_2	9.80 f	150.83 hi
T_3	9.40 g	149.60 ij
T_4	9.20 g	148.33 jk
T_5	10.15 ef	152.23 gh
T_6	11.15 bc	158.33 bc
T_7	11.05 c	157.50 cd
T_8	11.73 a	160.67 a
T_9	10.25 e	152.97 fg
T_{10}	10.67 d	154.67 ef
T_{11}	11.47 ab	159.87 ab
T_{12}	10.88 cd	155.67 de
LS	**	**
CV (%)	1.22	0.44

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

***Significant at 1% probability level.*
** Significant at 5% probability level.*
LS= Level of significance
CV= Co-efficient of variance
Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$
$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$
$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$
$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$
$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$
$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$
$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$
$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$
$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$
$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$
$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$
$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

The maximum number of branches per plant (11.73) was noticed where plants were fertilized with $B_{1.5\ kg/ha}$ + $Zn_{1\ kg/ha}$ that was T_8 treatment. The lowest number of flower clusters per plant (9.07) was noticed at $B_{0\ kg/ha}$ + $Zn_{0\ kg/ha}$ (control) which followed by T_4 and T_3 treatments. It was reported that 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). This result also supported by Ilyas *et al*., 2019; Sivaiah (2012); Saravaiya *et al*. (2014); 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 of BARI tomato 15 showed significant variation among the treatments. Maximum number of leaves was counted from T_3 (160.67/plant) followed by T_{11} (159.87/plant) and T_6 (158.33/plant) while minimum from T_1 (146.40/plant) (Table 1). Number of leaves increased due to the foliar application of Zn and B (Singh and Tiwari, 2013). Also, the number of leaves per plant increased with the interaction of B and Zn reported by Haleem *et al.* (2017). The results were most closely corroborated with Ali *et al.* (2015) and Oyinlola (2004).

4.1.4 Number of cluster plant^{-1}

The number of cluster plant^{-1} was significantly influenced by the application of different level of both micronutrients such as boron and zinc (Table 2). The maximum number of cluster plant^{-1} (9.80) was found in the treatment T_8 ($B_{1.5\ kg/ha}$ + $Zn_{1\ kg/ha}$) treatment was followed by T_{11} ($B_{1.5\ kg/ha}$ + $Zn_{2\ kg/ha}$) 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 ($B_{0\ kg/ha}$ + $Zn_{0\ kg/ha}$). Naz *et al*. (2012) reported that application of boron @ 2 kg/ha enhanced number of flower clusters per plant. Again Singh *et al*. (2014) obtained the highest number of flower clusters per plant of tomato with the application of different micronutrients (boron and zinc) in combination. Md. Mosharaf Hossain Sarker *et al*., (2019) was found that only Zn responsive for fruit clusters per plant in tomato. These results are in line with Singh *et al*. (2014).

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 boron and zinc fertilizer. The comparison of treatments means reveal that maximum number of fruits cluster^{-1}(5.00) was recorded from T_8 treatment which was statistically varied among treatments. The minimum number of fruits cluster^{-1}(4.20) was recorded from plot where only recommended fertilizer was applied except boron and zinc (T_1). The highest number of fruits cluster^{-1} of tomato with the application of different micronutrients (boron and zinc) in combination reported by Singh *et al*. (2014). Foliar application of zinc resulted fruits per cluster in tomato (Kazemi, 2013).

Table 2: Effect of B and Zn micronutrients on the number of cluster/plant and number of fruits/cluster of BARI Tomato 15.

Treatments	Number of cluster/plant (no.)	Number of fruits/cluster (no.)
T_1	8.07 f	4.20 h
T_2	8.38 def	4.53 ef
T_3	8.25 ef	4.43 fg
T_4	8.12 f	4.33 gh
T_5	8.47 cdef	4.62 de
T_6	9.37 ab	4.83 abc
T_7	8.88 bc	4.80 bc
T_8	9.80 a	5.00 a
T_9	8.53 cdef	4.67 cde
T_{10}	8.63 cde	4.72 bcd
T_{11}	9.40 a	4.87 ab
T_{12}	8.80 cd	4.77 bcd
LS	*	*
CV (%)	1.93	1.25

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
***Significant at 1% probability level.*
** Significant at 5% probability level.*
LS= Level of significance
CV= Co-efficient of variance
Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$
$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$
$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$
$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$
$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$
$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$
$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$
$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$
$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$
$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$
$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$
$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

4.1.6 Number of fruits/plant^{-1}

The data regarding number of fruitsplant^{-1} is presented in Table 3. There was a considerable variation among the different treatment on the number of fruitsplant^{-1}.

Maximum number of fruitsplant^{-1} was found from T_8 (42.45/plant) while minimum from T_1 (30.21/plant). Combined application of zinc and boron increased the number of fruits plant^{-1} in tomato (Yadav *et al*, 2001). Only Zn was found responsive for number of fruits per plant reported by Md. Mosharaf Hossain Sarker *et al.,* (2019) and B also 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 bySingh and Tiwari, 2013; Singh *et al*. (2014); Ali *et al.* (2015) and Oyinlola and Chude (2004).

Table 3: Effect of B and Zn micronutrients on the number of fruits/plant and diameter of a fruit of BARI Tomato 15.

Treatments	Number of fruits/plant (no.)	Diameter of a fruit (cm)
T_1	30.21 i	17.33 i
T_2	33.14 fgh	17.70 fg
T_3	31.71 ghi	17.55 gh
T_4	30.67 hi	17.45 hi
T_5	34.12 efg	17.80 f
T_6	40.04 ab	18.65 b
T_7	37.73 bc	18.40 c
T_8	42.45 a	18.88 a
T_9	34.91 def	17.88 ef
T_{10}	36.07 cde	18.05 de
T_{11}	40.80 a	18.77 ab
T_{12}	37.02 cd	18.15 d
LS	*	**
CV (%)	2.50	0.36

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

***Significant at 1% probability level.*

** Significant at 5% probability level.*

LS= Level of significance

CV= Co-efficient of variance

Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$

$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$

$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$

$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$

$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$

$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$

$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$

$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$

$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$

$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$

$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$

$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

4.1.7 Diameter of a fruit (cm)

The application of different level of micro nutritional treatments affects the diameter of a fruit significantly similar (Table 3). The highest statistically superior diameter of a fruit was 18.88 cm recorded in the treatment T_8 ($B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$) which closely followed with T_{11} ($B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$). On the other hand, the lowest diameter of a fruit

17.33 cm was obtained in the plot where no micronutrient was applied and followed by treatment T_5 ($B_{1.5\ kg/ha}$ + $Zn_{0\ kg/ha}$). These results in close conformity with the findings of Saravaiya *et al*. (2014); Ilyas *et al*. (2019) and Ali *et al.* (2015).

4.1.8 Single fruit weight/plant (g)

Application of different amount of boron and zinc fertilizers showed the variation for single fruit weight plant^{-1} as gram. A perusal of table 4 shows that maximum single fruit weight plant^{-1} (79.63 g) was obtained in T_8 treatment which was statistically similar to T_{11}, T_6 and T_7 treatments giving single fruit weight plant^{-1} of 78.70 g, 78.00 and 77.47 respectively. The lowest single fruit weight plant^{-1} 61.30 g was recorded from T_1 treatment that was control. Similar type observation has been reported by Ali *et al.* (2015) and Saravaiya *et al*. (2014). Oyinlola and Chude (2004) also found the similar results.

Table 4: Effect of B and Zn micronutrients on the single fruit weight/plant and fruit weight/plant of BARI Tomato 15.

Treatments	Single fruit weight/plant (g)	Fruit weight/plant (kg)
T_1	61.30 e	1.85 j
T_2	70.53 d	2.33 gh
T_3	71.12 d	2.26 hi
T_4	63.53 e	1.95 ij
T_5	71.93 cd	2.45 fgh
T_6	78.00 ab	3.12 bc
T_7	77.47 ab	2.92 bcd
T_8	79.63 a	3.47 a
T_9	73.73 bcd	2.57 efg
T_{10}	74.87 abcd	2.70 def
T_{11}	78.70 a	3.21 ab
T_{12}	76.30 abc	2.82 cde
LS	**	**
CV (%)	2.27	4.00

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

***Significant at 1% probability level.*

** Significant at 5% probability level.*

LS= Level of significance

CV= Co-efficient of variance

Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$

$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$

$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$

$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$

$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$

$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$

$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$

$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$

$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$

$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$

$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$

$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

4.1.9 Fruit weight/plant (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 boron and zinc exhibited significant effect on the weight of fruits per plant (Table 4). The maximum weight (3.47 kg) of fruits per plant was recorded in T_8 ($B_{1.5\ kg/ha}$ + $Zn_{1\ kg/ha}$) which followed by T_{11} ($B_{1.5\ kg/ha}$ + $Zn_{2\ kg/ha}$) treatment that was 3.21 kg whereas the minimum weight (1.85 kg) was obtained from control (($B_{0\ kg/ha}$ + $Zn_{0\ kg/ha}$). Foliar application of B and Zn increase weight (Sindhu *et al.*, 1999). Boron play key role on accumulation of photosynthates that has correlation with fruit weight (Shukha, 2011). Zinc and boron in improve fruit growth by synthesizing tryptophan and auxin (Wojcik and Wojcik, 2003). 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)

It is clear from the Figure 3 that yield was significantly affected by the application of different levels of boron and zinc fertilizer.

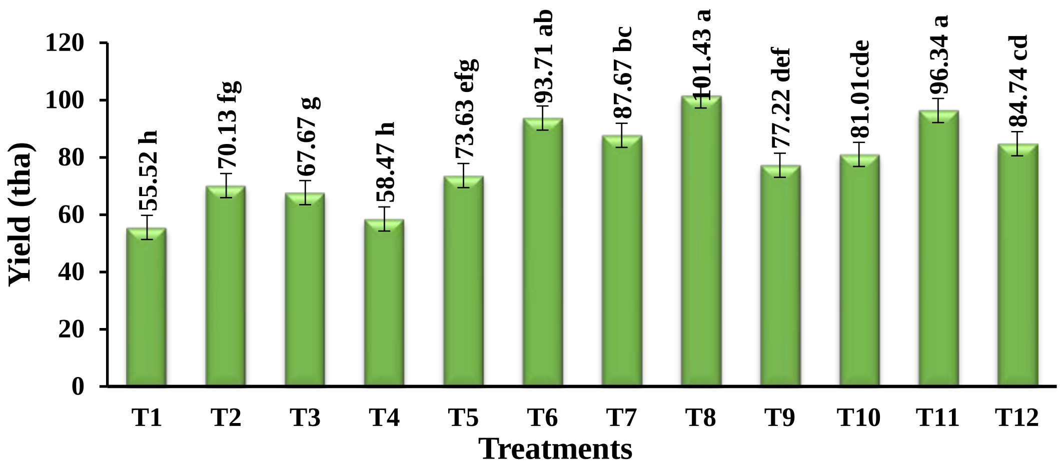

Figure 3. Effect of B and Zn micronutrients on the yield (t/ha) of BARI Tomato 15.

Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$
$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$
$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$
$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$
$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$
$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$
$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$
$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$
$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$
$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$
$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$
$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

All the means of data presented clearly show that significantly highest yield (101.43 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 (55.52 t ha^{-1}) found at treatment (T_1). Ullah *et al*. (2015) showed that application of boron gave higher yield per hectare than untreated control in tomato and Dube *et al.* (2003) also reported that the application of zinc fertilizer significantly increased tomato yield over control. 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 Soil pH

The post-harvest soil was slightly acidic where soil pH ranged from 5.80 to 6.10 (Table 5).

Table 5: Effect of B and Zn micronutrients on the soil pH, organic matter content of the post-harvest soil.

Treatments	Soil pH	Organic matter content (%)
T_1	5.80 d	2.50
T_2	5.95 c	2.64
T_3	6.10 a	2.57
T_4	5.83 d	2.77
T_5	5.93 c	2.62
T_6	5.95 c	2.52
T_7	5.87 cd	2.55
T_8	5.93 c	2.52
T_9	5.83 d	2.61
T_{10}	5.85 d	2.59
T_{11}	6.03 ab	2.71
T_{12}	6.00 ab	2.68
LS	NS	NS
CV (%)	0.61	0.82
Initial Soil	6.00	1.98

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

***Significant at 1% probability level.*

** Significant at 5% probability level.*

LS= Level of significance

CV= Co-efficient of variance

Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$

$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$
$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$
$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$
$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$
$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$
$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$
$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$
$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$
$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$
$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$

Data showing similarly closely different among the treatments of the post-harvest soil. The highest pH value of post-harvest soil was observed 6.10 in T_3 and the lowest 5.80 was recorded in control T_1. The study proved that the application of chemical fertilizer with cowdung slightly increased the soil pH of the post-harvest soil compared to the initial soil.

4.2.2 Organic matter content

The average soil organic matter content of the initial soil was 1.98 % that was slightly lower than the average organic matter of the post-harvest soils. The highest and statistically superior soil organic matter content was 2.77 % that was found in the treatment T_3 and T_{11}. The lowest soil organic matter was 2.50 % which was noticed in T_1 treatment.

4.2.3 Total nitrogen (N) in soil

The total N present in the post-harvest soil should be varied considerably different by plant uptake and leaching loss but here the treatments were not significantly varied in post-harvest soil due to similar amount nitrogen applied (Table 6). And soil nitrogen content of the post-harvest soil was higher than the initial soil. The total nitrogen content of the post-harvest soil ranged between 0.07% and 0.09%. The highest nitrogen (0.09%) was found in $T_{2,}$ T_3 T_{11} and T_{12} treatment. The lowest soil N (0.07 %) content was found in $T_{1,}$ T_4 and T_{10} treatment. Sreelatha *et al.* (2006) also reported that organic manures had a positive influence on total and available N content of soil.

4.2.4 Available phosphorus (P) in soil

The available phosphorus content of the post-harvest soil significantly varied due to similar amount of P applied in all treatments (Table 6). Available phosphorus content in soil varied from 6.12 to 7.10 ppm due to applied different micronutrients (B and Zn) doses. The maximum phosphorus content 7.10 ppm was observed in the treatment T_3, which was (7.07 ppm, 7.05ppm and 7.00 ppm) followed by T_2, T_{11} and T_{12} respectively. The lowest phosphorus content (6.12 ppm) was observed in T_1.

4.2.5 Exchangeable potassium (K) in soil

The exchangeable potassium (K) content of the post-harvest soil not influenced considerably due to same was applied (Table 6).

Table 6: Effect of B and Zn micronutrients on the total N, available P and exchangeable K of the post-harvest soil.

Treatments	Total N (%)	Available P (ppm)	Exchangeable K (mg 100 g^{-1} soil)
T_1	0.07 c	6.12 d	0.15
T_2	0.09 a	7.07 a	0.20
T_3	0.09 a	7.10 a	0.20
T_4	0.07 c	6.20 d	0.15
T_5	0.08 ab	6.67 abc	0.18
T_6	0.08 ab	6.53 bcd	0.16
T_7	0.08 ab	6.53 bcd	0.18
T_8	0.08 ab	6.73 abc	0.17
T_9	0.08 ab	6.87 ab	0.16
T_{10}	0.07 c	6.33 cd	0.15
T_{11}	0.09 a	7.05 a	0.20
T_{12}	0.09 ab	7.00 a	0.20
LS	NS	NS	NS
CV (%)	4.14	2.22	3.14

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

***Significant at 1% probability level.*
** Significant at 5% probability level.*
LS= Level of significance
CV= Co-efficient of variance
Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$
$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$
$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$
$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$
$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$
$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$
$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$
$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$
$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$
$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$
$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$
$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

The exchangeable K content of initial soil was 0.10 mg 100 g^{-1} soil and the values of post-harvest soil ranged from 0.15 to 0.20 mg 100 g^{-1} soil. The highest exchangeable K (0.20 mg 100 g^{-1}) was found in the treatments of T_3, T_2, T_{11} andT_{12}. The lowest value (0.15 mg 100 g^{-1}) was found in the treatments T_1, T_4 and T_{10}. The exchangeable K increased in soils due to the supply of nutrients from cowdung throughout the growing period. A similar observation was made by Horuchi *et al*. (2008) who reported that using compost of pea residues enriched soil NPK and other nutrients in soil.

4.2.6 Available Sulphur (S) in soil

The available sulphur content of the post-harvest soil significantly varied due to similar amount of S applied in all treatments (Table 6). Available Sulphur content in soil varied from 4.50 to 5.20 ppm due to applied different micronutrients (B and Zn) doses. The maximum sulphur content 5.20 ppm was observed in the treatment T_3, which was (5.13 ppm) followed by T_2. The lowest phosphorus content (4.50 ppm) was observed in T_1.

4.2.7 Available Zinc (Zn) in soil

The available Zinc content of the post-harvest soil varied significantly by different treatments (Table 7). Available zinc content in soil varied from 3.97 to 6.41 ppm due to applied different level of Zn doses. The maximum zinc content 6.41 ppm was observed in the treatment T_3 which different among treatment. The lowest zinc content (3.97 ppm) was observed in T_1.

Table 7: Effect of B and Zn micronutrients on the available S, available Zn and available B of the post-harvest soil.

Treatments	Available S (ppm)	Available Zn (ppm)	Available B (ppm)
T_1	4.50 h	3.97 e	0.10 g
T_2	5.13 ab	5.35 bc	0.29 e
T_3	5.20 a	6.41 a	0.63 a
T_4	4.60 fgh	4.23 de	0.13 g
T_5	5.00 bcd	4.00 e	0.46 cd
T_6	4.73 ef	5.42 bc	0.31 e
T_7	4.87 de	5.32 bc	0.27 ef
T_8	4.65 fg	5.15 cd	0.50 bc
T_9	4.92 cd	5.63 abc	0.17 fg
T_{10}	4.53 gh	4.13 e	0.16 g
T_{11}	5.08 ab	5.50 abc	0.58 ab
T_{12}	5.02 bc	6.13 ab	0.36 de
LS	NS	**	*
CV (%)	0.96	6.14	10.57

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
***Significant at 1% probability level.*
** Significant at 5% probability level.*

LS= Level of significance
CV= Co-efficient of variance
Here,

$T_1 = B_{0\ kg/ha} + Zn_{0\ kg/ha}$	$T_7 = B_{1\ kg/ha} + Zn_{0\ kg/ha}$
$T_2 = B_{1\ kg/ha} + Zn_{1\ kg/ha}$	$T_8 = B_{1.5\ kg/ha} + Zn_{1\ kg/ha}$
$T_3 = B_{1.5\ kg/ha} + Zn_{3\ kg/ha}$	$T_9 = B_{0\ kg/ha} + Zn_{3\ kg/ha}$
$T_4 = B_{0\ kg/ha} + Zn_{1\ kg/ha}$	$T_{10} = B_{0\ kg/ha} + Zn_{2\ kg/ha}$
$T_5 = B_{1.5\ kg/ha} + Zn_{0\ kg/ha}$	$T_{11} = B_{1.5\ kg/ha} + Zn_{2\ kg/ha}$
$T_6 = B_{1\ kg/ha} + Zn_{2\ kg/ha}$	$T_{12} = B_{1\ kg/ha} + Zn_{3\ kg/ha}$

4.2.8 Available Boron (B) in soil

The available Boron content of the post-harvest soil varied significantly by different treatments (Table 7). Available boron content in soil varied from 0.10 to 0.63 ppm due to applied different amount of B doses. The maximum boron content 0.63 ppm was observed in the treatment T_3. The lowest boron content (0.10 ppm) was observed in T_1.

CHAPTER V

SUMMARY AND CONCLUTION

A field experiment was conducted at the Soil Science research field, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from November 2020 to April 2021to evaluate the effect of Zn and B on the growth and yield of BARI Tomato 15 under field condition.

The experiment was laid out in a Randomized Completely Block Design (RCBD) having seven treatments with three replications. The unit plot size was 6 m^2. There were 12 different treatments (T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11} and T_{12}) they were distributed randomly in individual plots. The total number of plots was 36. Zinc and Boron were applied as Zinc sulphate and Boric acid as per treatments. On the other hand, Nitrogen, Phosphorus, Potassium and Sulphur were applied as urea, triple super phosphate, muriate of potash and gypsum at the rate of 100, 45, 75 and 15 kg ha^{-1} respectively. Seed were sown on the 17^{th} November 2019. 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 21^{th} March 2021 and were continued up to 05^{th} April, 2021. Plot wise yield and yield components were recorded.

Different levels of Zinc and Boron as micronutrient had significantly increased the plant height (cm). It was clearly found that, the longest plant was 99.50 cm observed in T_8

($B_{1.5\ kg/ha}$ + $Zn_{1\ kg/ha}$) and the shortest one was 81.67 cm found in the treatment T_1 ($B_{0\%}$ + $Zn_{0\%}$) i.e. control. Again, the number of branches plant^{-1}(no.) also varied by different treatments. The maximum number of branches per plant (11.73) was noticed where plants were fertilized with $B_{150\%}$ + $Zn_{50\%}$ that was T_8 treatment. Number of leaves of BARI tomato-15 showed significant variation among the treatments. Maximum number of leaves was counted from T_3 (160.67/plant) followed by T_{11} (159.87/plant) and T_6 (158.33/plant) while minimum from T_1 (146.40/plant). The maximum number of clusters plant^{-1} (9.80) was found in the treatment T_8 ($B_{1.5\ kg/ha}$ + $Zn_{1\ kg/ha}$) treatment was followed by T_{11} ($B_{1.5\ kg/ha}$ + $Zn_{2\ kg/ha}$) 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 ($B_{0\ kg/ha}$ + $Zn_{0\ kg/ha}$). Also, the comparison of treatments means reveal that maximum number of fruits cluster^{-1}(5.00) was recorded from T_8 treatment which was statistically varied among treatments. The minimum number of fruits cluster^{-1}(4.20) was recorded from plot where only recommended fertilizer was applied except boron and zinc (T_1). There was a considerable variation among the different treatment on the number of fruitsplant^{-1}. Maximum number of fruitsplant^{-1} was found from T_8 (42.45/plant) while minimum from T_1 (30.21/plant). The highest statistically superior diameter of a fruit was 18.88 cm recorded in the treatment T_8 ($B_{1.5\ kg/ha}$ + $Zn_{1\ kg/ha}$) which closely followed with T_{11} ($B_{1.5\ kg/ha}$ + $Zn_{2\ kg/ha}$). On the other hand, the lowest diameter of a fruit 17.33 cm was obtained in the plot where no micronutrient was applied and followed by treatment T_5 ($B_{1.5\ kg/ha}$ + $Zn_{0\ kg/ha}$). Application of different amount of boron and zinc fertilizers showed the variation for single fruit weight plant^{-1} as gram. The maximum single fruit weight plant^{-1} (79.63 g) was obtained in T_8 treatment and the lowest single fruit weight plant^{-1} 61.30 g was recorded from T_1 treatment that was control. The highest Fruit weight per plant (3.47 kg) was obtained in T_8 treatment and the lowest fruit weight per plant (1.85 kg) was obtained in control treatment that was T_0. Finally, it is clear that yield was significantly affected by the application of different levels of boron and zinc fertilizer. All the means of data presented clearly show that significantly highest yield (101.43 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 (55.52 t ha^{-1}) found at treatment (T_1).

In case of chemical properties of the post-harvest soil, soil pH, organic matter content, total N, available phosphorus content, exchangeable potassium (K), available phosphorus content, available Zinc content and available Boron content varied significantly by different treatments. The highest pH value of post-harvest soil was observed 6.10 in T_3 and the lowest 5.80 was recorded in control T_1. The highest and statistically superior soil organic matter content was 2.77 % that was found in the treatment T_3 and T_{11}. The lowest soil organic matter was 2.50 % which was noticed in T_1 treatment. The highest nitrogen (0.09%) was found in $T_{2,}$ T_3 T_{11} and T_{12} treatment. The lowest soil N (0.07 %) content was found in $T_{1,}$ T_4 and T_{10} treatment. The maximum phosphorus content 7.10 ppm was observed in the treatment T_3, which was (7.07 ppm, 7.05ppm and 7.00 ppm) followed by $T_{2,}$ T_{11} and T_{12} respectively. The lowest phosphorus content (6.12 ppm) was observed in T_1. The highest exchangeable K (0.20 mg 100 g^{-1}) was found in the treatments of $T_{3,}$ $T_{2,}$ and T_{11} andT_{12}. The lowest value (0.15 mg 100 g^{-1}) was found in the treatments $T_{1,}$ T_4 and T_{10}.

The maximum sulphur content 5.20 ppm was observed in the treatment T_3, which was (5.13 ppm) followed by T_2. The lowest phosphorus content (4.50 ppm) was observed in T_1. Available zincs content in soil varied from 3,97 to 6.41 ppm due to applied different level of Zn doses. The maximum zinc content 6.41 ppm was observed in the treatment T_3 which different among treatment. The lowest zinc content (3.97 ppm) was observed in T_1. And also the available boron content in soil varied from 0.10 to 0.63 ppm due to applied different amount of B doses. The maximum boron content 0.63 ppm was observed in the treatment T_3. The lowest boron content (0.10 ppm) was observed in T_1.

The results of the present investigation revealed that tomato can be grown successfully at the use of 1.5 kg/ha of boron and 1 kg/ha of zinc, tomato gave more yield. The findings of the present investigation clearly indicated that the efficient use of boron and zinc doses and growing tomato is a viable option for increasing income of farmers.

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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	Soil Science research 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
Partical size analysis	
Sand%	25
Silt%	45
Clay%	30
Textural Classes	Silty -Clay
pH	6.00
Particle density (g/cc)	2.68
Organic carbon (%)	0.47
Organic matter (%)	0.78
Available P (ppm)	22.00
Exchangeable K (meq/100g soil)	0.1

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

Month	Average RH%	Average temperature (C^0)		Total Average Rainfall(mm)
		Min.	Max.	
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 IV: Schedule of cultural operation in the experiment

Serial No.	Cultural preparation	Date
01	Seedbed preparation	14.11.2020
02	Sowing of seed on seedbed	17.11.2020
03	Opening of the main land	05.12.2020
04	Ploughing and cross ploughing	09.12.2020
05	Breaking of clods, laddering and weeding	09.12.2020
06	Layout of the experimental pit and plot	11.12.2020
07	Applications of 2/3rd of nitrogen fertilizer and entire of other fertilizer	11.12.2020
08	Transplanting of seedlings to main field	12.12.2020
09	Gap fillings	17.12.2020
10	1st Irrigation	20.12.2020
11	Tagging	25.12.2020
12	1st Weeding with mulching	30.12.2020
13	2nd Irrigation with urea	01.01.2021
14	2nd Weeding	22.01.2021
15	Ring and watering with urea	23.01.2021
16	Attach bamboo stick with plant	27.01.2021
17	1st Harvesting	21.03.2021
18	2nd Harvesting	31.03.2021
19	3rd Harvesting	05.04.2021
22	Final Harvesting	10.04.2021
23	Collection post-harvest soil	18.04.2021
24	Analysis of soil sample	30.04.2021

Appendix V. Factorial ANOVA tables.

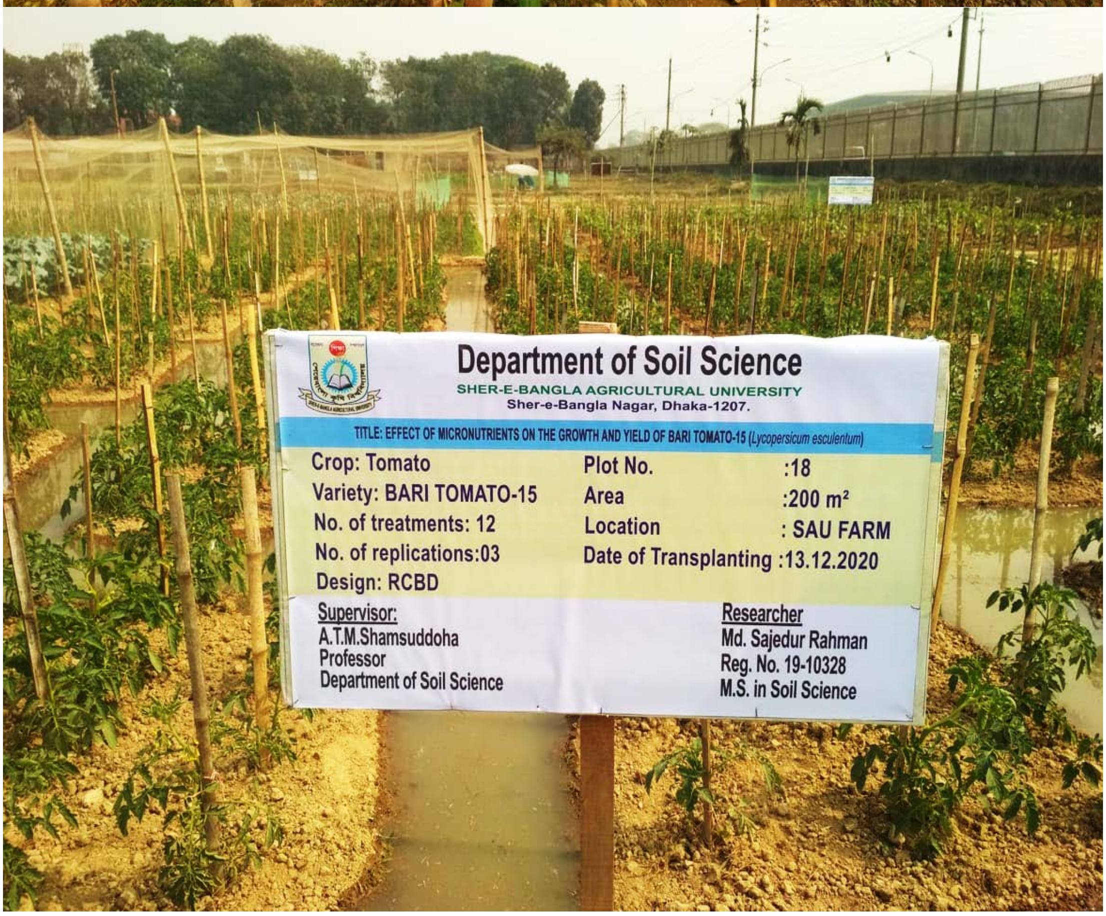
Source	DF	SS	MS	F-Value	P (>F)
1. Plant height (cm)					
Replication	2	0.185	0.0926		
Treatment	11	843.247	76.6589	120.78	0.0000
Error	22	13.963	0.6347		
Total	35	857.396			
2. Number of branches plant^{-1} (no.)					
Rep	2	0.0418	0.02090		
Treat	11	26.6041	2.41855	149.24	0.0000
Error	22	0.3565	0.01621		
Total	35	27.0024			
3. Number of leaves plant^{-1} (no.)					
Rep	2	6.984	3.4919		
Treat	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}					
Rep	2	0.3217	0.16083		
Treat	11	9.9342	0.90311	31.96	0.0000
Error	22	0.6217	0.02826		
Total	35	10.8775			
5. Number of fruits cluster^{-1} (no.)					
Rep	2	0.00597	0.00299		
Treat	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.)					
Rep	2	3.175	1.5876		
Treat	11	532.233	48.3848	60.79	0.0000
Error	22	17.511	0.7959		
Total	35	552.919			

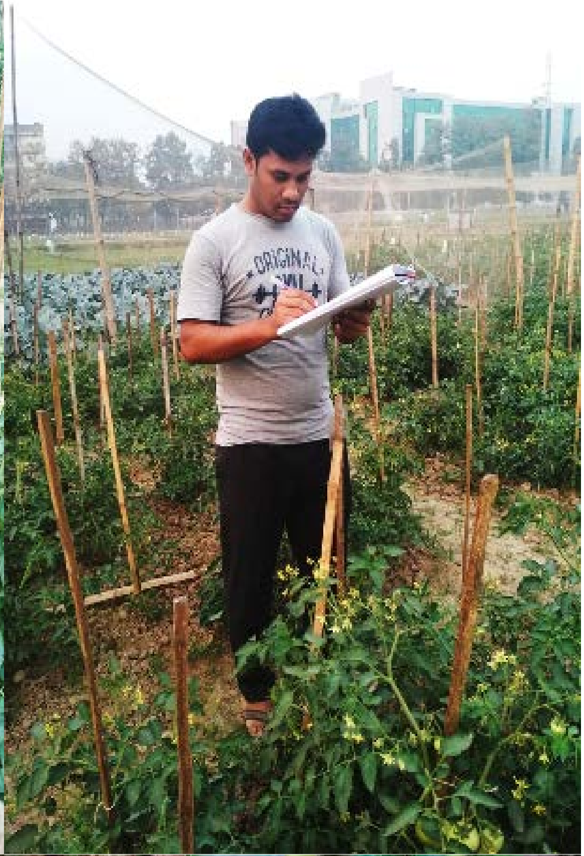
Source	DF	SS	MS	F-Value	P (>F)

Source	DF	SS	MS	F-Value	P (>F)
7. Diameter of a fruit (cm)					
Rep	2	0.00096	0.00048		
Treat	11	9.12282	0.82935	198.37	0.0000
Error	22	0.09198	0.00418		
Total	35	9.21576			
8. Single fruit weight plant^{-1} (g)					
Rep	2	11.36	5.679		
Treat	11	1120.50	101.864	37.16	0.0000
Error	22	60.31	2.741		
Total	35	1192.17			
9. Fruit weight/plant (kg)					
Rep	2	0.00661	0.00330		
Treat	11	8.21764	0.74706	66.93	0.0000
Error	22	0.24555	0.01116		
Total	35	8.46980			
10. Yield (t/ha)					
Rep	2	4.55	2.273		
Treat	11	7033.03	639.366	76.53	0.0000
Error	22	183.80	8.355		
Total	35	7221.38			
11. Soil pH					
Rep	2	0.00097	0.00049		
Treat	11	0.33410	0.03037	23.02	0.0000
Error	22	0.02903	0.00132		
Total	35	0.36410			
12. Organic matter content					
Rep	2	0.01307	0.00653		
Treat	11	0.23641	0.02149	47.28	0.0000
Error	22	0.01000	0.00045		
Total	35	0.25948			
13. Total nitrogen (N) in soil					
Rep	2	8.889E-05	4.444E-05		
Treat	11	1.856E-03	1.687E-04	15.18	0.0000
Error	22	2.444E-04	1.111E-05		
Total	35	2.189E-03			
Source	**DF**	**SS**	**MS**	**F-Value**	**P (>F)**

14. Available phosphorus (P) in soil					
Rep	2	0.29292	0.14646		
Treat	11	3.83854	0.34896	15.82	0.0000
Error	22	0.48542	0.02206		
Total	35	4.61687			
15. Exchangeable potassium (K) in soil					
Rep	2	0.00027	1.361E-04		
Treat	11	0.01436	1.306E-03	43.45	0.0000
Error	22	0.00066	3.005E-05		
Total	35	0.01530			
16. Available Sulphur (S) in soil					
Rep	2	0.02931	0.01465		
Treat	11	1.95306	0.17755	82.48	0.0000
Error	22	0.04736	0.00215		
Total	35	2.02972			
17. Available Zinc (Zn) in soil					
Rep	2	2.9901	1.49507		
Treat	11	22.8799	2.07999	21.20	0.0000
Error	22	2.1584	0.09811		
Total	35	28.0285			
18. Available Boron (B) in soil					
Rep	2	0.10121	0.05060		
Treat	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


Department of Soil Science
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
Sher-e-Bangla Nagar, Dhaka-1207.
TITLE: EFFECT OF MICRONUTRIENTS ON THE GROWTH AND YIELD OF BARI TOMATO-15 (Lycopersicum esculentum)
Crop: Tomato
Variety: BARI TOMATO-15
No. of treatments: 12
No. of replications:03
Design: RCBD
Plot No. :18
Area :200 m²
Location : SAU FARM
Date of Transplanting :13.12.2020
Supervisor:
A.T.M.Shamsuddoha
Professor
Department of Soil Science
Researcher
Md. Sajedur Rahman
Reg. No. 19-10328
M.S. in Soil Science



ORIGINAL