EFFECT OF SULPHUR, ZINC AND BORON NUTRIENTS ON GROWTH AND SEED YIELD OF SAU YELLOW CHERRY TOMATO

OMAR FARUK

INSTITUTE OF SEED TECHNOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA- 1207

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BY

OMAR FARUK

REGISTRATION NO. 15-06779

Mobile No. +8801688997581

Email: omar.sau.95@gmail.com

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Approved By:

Dr. Khaleda Khatun Professor Supervisor	**Dr. Tahmina Mostarin** Professor Co-Supervisor

Prof. Dr. Md. Ismail Hossain
Chairman, Examination Committee
&
Director, Institute of Seed Technology
Sher-e-Bangla Agricultural University

Institute of Seed Technology
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Memo no. Dated:

CERTIFICATE

*This is to certify that the thesis entitled, **"EFFECT OF SULPHUR, ZINC AND BORON NUTRIENTS ON GROWTH AND SEED YIELD OF SAU YELLOW CHERRY TOMATO"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **SEED TECHNOLOGY**, embodies the result of a piece of bonafide research work carried out by **OMAR FARUK**, Registration No**. 15-06779** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2022
Place: Dhaka, Bangladesh

____

Dr. Khaleda Khatun
Professor
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

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-Author

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ABSTRACT

A field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from September 2021 to April 2022 in Rabi season to study the effect of sulphur, zinc and boron nutrients on growth and seed yield of SAU Yellow Cherry tomato. The experiment was laid out in randomized complete block design (RCBD) with three replications and consisted of ten treatments *i.e.* T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}. Experimental results revealed that different doses of sulphur, zinc and boron fertilizers application significantly influenced the growth and seed yield of SAU yellow cherry tomato. In case of different treatments, the height number of flowers per cluster (62.91), number of flowers per plant (568.77), number of fruits per cluster (77.11), total number of fruits per plant (499.44), individual fruit weight (12.51 g), height fruit yield per plant (4.58 kg), fruit yield per plot (27.49 kg), fruit yield per hectare (84.84 t), seeds per tomato fruit (98.22), seed yield per plant (19.12 g), seed yield per plot (114.64 kg), seed yield per hectare (353.83 kg), seed germination (90.44 %) and vogority index (3014.20) were observed in T_{10} ($S_{20}Zn_4B_3$ Kg ha^{-1}) treatment whereas the corresponding lowest value were observed in T_{11} treatment.. Therefore, it was suggested that cultivation of cherry tomato through application of $S_{20}Zn_4B_3$ Kg ha^{-1} (T_{10} treatment) would help to influenced plant growth and increase its ability to enhanced better seed yield production of SAU Yellow Cherry tomato.

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LISTS OF ABBREVIATIONS

Abbreviations	Full word
AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
FAO	Food and Agricultural Organization
N	Nitrogen
et al.	And others
TSP	Triple Super Phosphate
MOP	Muriate of Potash
RCBD	Randomized Complete Block Design
DAT	Days after Transplanting
ha^{-1}	Per hectare
g	gram (s)
kg	Kilogram
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
wt	Weight
LSD	Least Significant Difference
0_C	Degree Celsius
NS	Not significant
Max	Maximum
Min	Minimum
%	Percent
NPK	Nitrogen, Phosphorus and Potassium
CV%	Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Cherry tomato (*[Solanum lycopersicum* L. var. *cerasiforme* (Dunnal) A. Gray] belonging to the Solanaceae family is a popular type of table tomato that is considered as an additional genetic intermediate between wild-type tomatoes and home garden tomatoes (Agius *et al*., 2022). Cherry tomatoes are smaller in size (1.5-3.5 cm in diameter), spherical to slightly oblong in shape, and usually red in colour ((Hossain and Rashid, 2021). Cherry tomatoes are grown usually for their edible fruits of superior quality and sweet taste compared to large table tomatoes (Pasorn *et al*., 2018). Cherry tomato is beneficial to human health due to its high content of antioxidant and anti-carcinogenic property, vitamin A and vitamin C, ascorbic acid, and phytochemical compounds, including lycopene, beta-carotene, flavonoids and many essential nutrients (Ali *et al.*, 2020). Cherry tomatoes can be used directly as raw vegetable and as well for preparing convenience foods such as sauce, soup, ketchup, curries, paste, rasam and sandwitch (Saha and Rashid, 2020) but they are preferred as salad tomato to vegetable (Ramaya *et al*., 2016). It is commonly referred to as garden tomato and becoming very popular to many small farmers, special gardeners and green house managers around the world due to its higher commercial value compared to regular tomatoes (Venkadeswaran *et al*., 2018). Cherry tomato is a novel vegetable crop in Bangladesh. Consumers always have a great fascination to new vegetables, whereas cherry tomatoes are also very colorful and their unique size makes them more attractive. Crop performance, yield and quality are the results of genotypic expression, which modulated by continuous interaction with the environment and other factors. The applications of suitable nutrients are most important factor which affects the growth and development of plant. It is necessary to apply the optimum doses of fertilizers to obtain better growth and development of plant for higher yield. Excessive use of chemical fertilizers to meet the crop demand has badly affected the soil health and productivity and is also adding high economic load but at present condition it is not possible to completely eliminate the use of chemical fertilizers. The applications of suitable nutrients are most important factor which affects the growth and development of plant. Application of nutrients like sulphur, magnesium, molybdenum, zinc, copper and boron are advantageous as they furnish availability of nutrients, enhances uptake of applied nutrients.

Application of inorganic S is very essential for better growth and biosynthesis of protein and chlorophyll in plants (Narayana *et al.,* 2020). This important nutrient is available to plants only as sulfate (Chowdhury *et al.,* 2020), hence most S fertilizers consist of sulfate salts. In the last few decades, S requirements for plants have gained special attention due to its increased deficiency in soil and reduction in crop yield and quality (Zenda *et al*., 2021). The deficiency of S resulted in retarded growth, reduced leaf size, and caused leaf chlorosis (Chowdhury *et al.,* 2020). For optimum plant growth, the requirement of S varies between 0.1 and 0.5% of the dry biomass weight (Marschner, 2012). The morphology of chloroplast is generally affected by S deficiency due to the presence of functional chloroplasts which are normally rich in S (Veazie *et al.,* 2020). In addition, photosynthesis has been retarded in a profound way because of S deficiency which can be corrected slowly through the addition of external S (Abadie and Tcherkez, 2019). Positive and beneficial responses to S fertilization had been reported in date palm (Idris *et al*., 2012). Previously, Kumar and Yadav (2007) reported that inadequate level of S prolongs the life cycle of A. vera plant, delays maturity and decreases its economical yield. Thus sulphur plays a key role in growth, yield and quality of tomato production. However, the magnitude of response to sulphur application varies with crop, variety, soil type, soil sulphur status, rate and source of the fertilizer.

Horticultural crops suffer badly by zinc deficiency followed by B, Mn, Cu, Fe (mostly induced) and Mo. Among these, zinc is also an essential micro nutrient to improve growth and yield of a crop and is taken up by the plants in ionic form (Zn^{+2}). Zinc is applied in the form of zinc sulphate that is principal salt used as fertilizers. It is essential for the synthesis of tryptophan, precursor of IAA, which is essential for normal cell division and helps in the formation of chlorophyll. Zn deficiency cause interveinal chlorosis, reduced root growth, shortened internodes and chlorotic areas on older leaves. It is an important for the formation and activity of chlorophyll and play role in the functioning of several enzymes and the growth hormone like auxin. Zinc is an activator of enzyme involves in protein synthesis and has direct effect on the enzymatic regulation in plants (Umair *et al.,* 2020).

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 (Xu *et al*., 2021). 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 (Osman *et al.,* 2019). The improvement in quality parameters of tomato fruit due to boron application could be the result of overall growth and development of the crop (Xu *et al*., 2021).

For sustainable crop production, good quality seed is very important (Umair *et al.,* 2020). If the seed is not of standard quality, use of other inputs is less useful and economic loss is incurred. In developing countries like Bangladesh, the unavailability of good seed is a major problem due to the absence of good variety, inadequate technology for seed production, poor quality control, post handle seed handling etc. In this regard application of sulphur, zinc and boron can be effective in seed production. Hence, keeping all the points in view, the present study entitled, “Effect of sulphur, zinc and boron nutrients on growth and seed yield of sau yellow cherry tomato” was undertaken with the following objectives :

i. To find out suitable combination of sulphur, zinc and boron fertilizers doses for better growth, seed yield and quality of cherry tomato.
ii. To investigate the combined effect of sulphur, zinc and boron fertilizers on growth, seed yield and quality of cherry tomato.

CHAPTER II

REVIEW OF LITERATURE

Attempt has been made in this investigation to study the effect of sulphur, zinc and boron nutrients on growth and seed yield of SAU yellow cherry tomato (Golden Purna). The literature on the use of nutrients in tomato is limited and hence the research work on other closely related crops and their effects on growth, yield and quality components has been reviewed and presented in this chapter.

2.1 Effect of sulphur, zinc and boron on growth and seed yield of tomato

Gopal and Sarangtham (2022) carried out a field experiment at the Research farm of Central Agricultural University, Imphal, Manipur, during the rabi seasons of 2016-17 and 2017-18, to study the interaction effect of Zinc and Boron on growth, yield, and yield attributes of tomato (Pusa Ruby). There were ten treatments viz., T_1 (Zn 0.0+B 0.0), T_2 (Zn 2.5+B 1.0), T_3 (Zn 2.5+B 1.5), T_4 (Zn 2.5+B 2.0), T_5 (Zn 5.0+B 1.0), T_6 (Zn 5.0+B 1.5), T7 (Zn 5.0+B 2.0), T_8 (Zn 10+B 1.0), T_9 (Zn10+B1.5) and T_{10} (Zn 10+B 2.0) with three replications were laid out by FRBD design. The combined effect of zinc and boron showed a significant effect on the number of fruits plant^{-1}, fruit weight plant^{-1}, and yield ha^{-1}, whereas there was no significant effect on plant growth parameters (plant height). Among the treatments, the T_{10} (Zn 10+B 2.0) treatment exhibited a significantly increased in the number of fruits plant^{-1} (35.83 in the first year and 36.52 in the second year), fruit weight plant^{-1} (1.62 kg in the first year and 1.76 kg in the second year.), highest fruit yield (60.06 t ha^{-1} in the first year and in 65.1 t ha^{-1} in the second year) was produced from the treatment combination of 10 kg of Zn ha^{-1} and 2.0 kg B ha^{-1} in both years than the control treatment (Zn 0.0+B 0.0).

Khatri *et al.* (2022) carried out an experiment to investigate the plant performance of tomato var. Manisha under foliar spray of zinc and boron in Randomized Complete Blocked Design with five treatments and four replications. The treatments were control (T_0), two levels of chelated zinc (T_1:30 ppm and T_2:60 ppm), and the two levels of borax (T_3:30 ppm and T4:60 ppm) applied in two installments (15 and 35 DAT by foliar spray). The results showed significance increase in parameters such as plant height (86 cm), plant leaves number (52.47), branches number (8.21), clusters number (19.32), fruits number (22.73), fruit diameter (5.58 cm), fruit weight (59.71

gm) and yield (56.56 t/ha) with the foliar application of chelated zinc at the dose of 30 ppm. Furthermore, early flowering (23.70 days) was observed at borax 30 ppm concentration. The results can recommend the tomato growers to apply chelated zinc and borax at the dosages of 30 ppm which denotes use of 30 mg per liter. The results clearly depict the potential increase in yield and other parameters of tomato cv. Manisha, using easily available source of zinc and boron, i.e. chelated zinc and borax.

Justice (2021) conducted an experiment during October 2019 to March 2020 in the farm of Sher-e-Bangla Agricultural University to study the effect of zinc and boron fertilization on the yield of BARI tomato 17 (*Solanum lycopersicum* L.). The experiment consisted of two factors: Factor A: three Zn levels viz. Zn_0 (0 kg Zn ha^{-1} ; control), Zn_1 (2 kg Zn ha^{-1}) and Zn_2 (4 kg Zn ha^{-1}) and Factor B: three B levels viz. B_0 (0 kg B ha^{-1} ; control), B_1 (1.5 kg B ha^{-1}) and B2 (3 kg B ha^{-1}). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. BARI tomato 17 was used as plant material. Different zinc and boron levels influenced significantly on most of the recorded parameters. In terms of treatment combination of zinc and boron, the highest number of branches $plant^{-1}$ (9.67), number of flowers $plant^{-1}$ (32.53), number of fruits $plant^{-1}$ (24.80), fruit weight $plant^{-1}$ (1.86 kg) and yield (77.57 t ha^{-1}) were recorded from Zn_1B_1 (2 kg Zn ha^{-1} with 1.5 kg B ha^{-1}) whereas the lowest was recorded from Zn_0B_0 (0 kg Zn ha^{-1} with 0 kg B ha^{-1}). So, the treatment combination of Zn_1B_1 (2 kg Zn ha^{-1} with 1.5 kg B ha^{-1}) can be considered as best compared to the rest of the treatment combinations.

Mustafa *et al.* (2021) experiment was conducted in onion with a randomized block design with four replications. The treatments comprised of 7 combinations (0, 15, 30, 45, 60, 75 and 90 kg S ha^{-1}) in which sulphur was supplied. The results indicated significantly higher bulb yield (61.96 t ha^{-1}) and yield components like average bulb weight, bulb yield per plot and marketable bulb yield was obtained due to application of recommended dosage of fertilizer plus 45 kg S ha^{-1}. The growth components viz., plant height, number of leaves, collar thickness and neck thickness showed significant with the application of result in the recommended dosage of fertilizer plus 45 kg S ha^{-1}.Compared to other levels of sulphur

Singh *et al*. (2021) studied number of branches per tomato plant recorded at 60, 90, and 120 days after transplanting and found that maximum numbers of branches were recorded in ammonium molybdate treatment followed by zinc sulphate. Mixture of all the micro-nutrient have yielded maximum yield of tomato fruits per hectare (632.66 q/ha) followed by Boric acid (557.10 q/ha) and Zinc sulphate (548.08 q/ha).

Panda and Mondal (2020) have studied the effect of different levels (7.5 kg acre^{-1}, 10 kg acre^{-1}, 15 kg acre^{-1} and 20 kg acre^{-1}) of Boronated Sulphur on cauliflower and revealed that the application of 10kg acre^{-1} of Boronated sulphur was the best treatment in terms of growth as well as yield parameters of cauliflower such as maximum plant height (21.77 cm), number of leaves plant^{-1} (18.17), stem diameter (2.34 cm),curd initiation (65.2 days), curd maturity (67.2 days), curd weight (726.83 g), fresh curd yield (17.44 t ha^{-1}),vitamin C (41.47 mgperl00 g) and physiological parameters such as chlorophyll a (2.102 mg/g), chlorophyll b (0.869 mg/g), total chlorophyll (2.970 mg/g) and carotenoids (0.344 mg/g) content and relative leaf water content (82.3%) were recorded with it.

Sanjida *et al*. (2020) conducted a study to investigate the effects of varieties and boron (B) levels on growth and yield of summer tomato (*Lycopersicon esculentum* Mill.) at the Germplasm Centre in the Department of Horticulture, Patuakhali Science and Technology University, Patuakhali during the period from May, 2018 to September, 2018. Fifteen treatments were comprising (i) three summer tomato varieties (BARI hybrid tomato 4, 8 and 10) and (ii) five levels of boron as boric acid (0, 1, 2, 3 and 5 kg B ha^{-1}) in all combinations. Randomized complete block design with three replications was used in the earthen pot (0.79 ft3) experimentation. The effects of varieties and boron levels showed significant variations ($p<0.05$) on growth and yield of summer tomato at different days after transplanting. Among the boron levels at final count plant^{-1}, early flowering (29.67 days), the maximum no. of flower clusters (18.44), no. of flowers (89.11), no. of fruits (46.22) and total weight of fruits (2364.29 g) were recorded in 2 kg B ha^{-1} treatment; the maximum plant height (96.50 cm), no. of leaves (102.89), no. of branches (28.11), longest fruit length (42.89 mm) and maximum fruit width (46.78 mm) and weight of individual fruit (51.74 g) were obtained in 3 kg B ha^{-1} treatment. Conversely, delayed flowering (34.67 days), minimum plant height (83.50 cm), no. of leaves (87.56), no. of branches (21.78), no. of flower clusters (15.89), no. of flowers (63.56), no. of fruits (40.33), shortest fruit length (31.78 mm) and minimum fruit width (34.67 mm), weight of individual fruit

(47.47 g) and total weight of fruits (1936.00 g) were recorded in control (0 kg B ha^{-1}) treatment.

Xu *et al.* (2021) conducted an experiment under greenhouse conditions to know the effect of application methods with different boron levels on the growth, fruit quality and flavor of tomato (Solanum lycopersicum L., cv. 'Jinpeng No.1') Seven treatments used included two application methods (leaf and root application) with four boron levels (0, 1.9, 3.8 and 5.7 $mg \cdot L^{-1}$ H_3BO_3). Experimental outcomes revealed that both application methods significantly increased net photosynthetic rate and chlorophyll content, and stabilized leaf structure of tomato. Leaf spray of 1.9 $mg \cdot L^{-1}$ H_3BO_3 was more effective at improving plant growth and photosynthetic indices in tomato compared to other treatments. Additionally, root application of 3.8 $mg \cdot L^{-1}$ H_3BO_3 resulted in better comprehensive attributes of fruit quality and flavor than other treatments in terms of amounts of lycopene, β-carotene, soluble protein, the sugar/acid ratio and characteristic aromatic compounds in fruit. The appropriate application of boron can effectively improve the growth and development of tomato, and change the quality and flavor of fruit, two application methods with four boron levels had different effects on tomato.

Osman *et al*. (2019) observed the influence of boron and zinc on the growth, yield and yield contributing traits of tomato. Three levels of boron (viz., 0, 1 and 2 kg per ha) and zinc (viz., 0, 1 and 2 kg per ha) were applied for each experiment. Results stated that boron had a significant effect on all yield attributes and yield of tomato. Application of 2 kg borax per ha produced the highest tomato yield (79.2 t/ha) through increasing plant height, number of leaves per plant, number of branches per plant, number of flower clusters per plant, number of fruits per plant, weight of fruits per plant, fruit weight, individual fruit length, fruit diameter and yield per ha of fruits. On the other hand, the maximum yield of tomato was obtained from 2 kg of zinc sulphate per ha. A combination of 2 kg borax and 2 kg zinc sulphate per ha gave the highest yield of tomato (83.50 t/ha). So, application of 2 kg borax and 2 kg zinc sulphate per ha was the best for growth and yield of tomato.

Rahman *et al*., (2019) in an experiment found that the effect of different levels of zinc and GA_3 on growth parameters of tomato. The experiment included three levels of zinc i.e. Z_0=control, Z_1= 0.5 kg ha^{-1}, Z_2= 1 kg ha^{-1} and four levels of Gibberellic acid

(GA_3) i.e. G_0= control, G_1= 50 ppm GA_3, G_2 = 75 ppm GA_3, G_3 = 100 ppm GA_3 respectively. The effect of different levels of zinc in respect of flower cluster plant-1 was statistically significant. The maximum number of flower clusters plant^{-1} (12.67), highest number of flowers cluster^{-1} (10.33) was found from Z_1 (0.5 kg Zn ha^{-1}).

Bhalekar *et al*. (2018) reported that, the sulphur levels @ 15-45 kg ha^{-1} gives significantly increased in plant height (77.78), number of leaves (11.78) and neck thickness (1.34) of onion crop.

Choudhary and Choudhary (2018) studied that, the response of sowing date and sulphur levels on growth and yield of garlic and reported that sowing of garlic crop on 25th October along with application of sulphur @60 kg/ha significantly increased polar diameter of bulb (4.31), average weight of bulb (32.16g) and bulb yield (170.23q/ha).

Dixit *et al*. (2018) conducted a field experiment to evaluate the possible effect of some macro and micro nutrients with different concentration levels as a foliar application on the vegetative growth, flowering and yield of tomato cv. 'Arka Rakshak'. The experiment was carried out under Randomized Complete Block Design with three replicates. The research included essential parameters such as plant height (cm), plant circumference, days to first flowering, days to first fruitage, days to maturity, number of fruits by plant, fruit length (cm), fruit diameter (cm) and yield (q/ha). Although all the treatments have shown a positive impact on development, flora and yield, T_5 (mixture of $FeSO_4$, $ZnSO_4$, calcium nitrate and boron @ 0.2 percent) has shown the greatest effect on all parameters studied compared to T_1 (control). Foliar application is therefore an appropriate method to feed the tomato crop to improve growth, blooming and marketability.

Farooq *et al.* (2018) studied the impact of sulphur (S) and boron (B) on yield and yield component of broccoli and revealed that yield and yield parameter increased with increasing levels of S and B with higher head diameter, head yield, flower diameter and plant height were observed when 40 kg ha^{-1} S and 1.5 kg ha^{-1} B were applied which was on parity with 20 kg ha^{-1} applied S but significant from control.

Laxmi *et al*. (2018) studied that, the influence of sulphur, zinc and boron on growth, yield and quality of onion, reported that application of sulphur @ 30 kg/ha significantly increased the plant height (62.75 cm), number of leaves (9.75), neck thickness (2,49 cm) when applied with zinc (4 kg/ha) and boron (2 kg/ha).

Prasad and Subbarayappa (2018) conducted an experiment and found that effect of soil application of zinc on growth attributes of tomato. The result of that study showed that soil application of zinc at 20 kg $ZnSO_4$ per ha. along with RDF in all the zinc fertility levels of the soils expressively increased plant height (115.29 cm).

Solanki *et al*. (2018) performed a field trial in randomized block design at Uttar Pradesh to analyze the effect of boron (0, 0.5, 1.0, 1.5, 2.0 kg ha^{-1}) on yield, quality and uptake of nutrients in vegetable crops (carrot, onion and cauliflower). The findings suggested that increased the yield and dry matter production significantly with supplement of 1 kg B ha^{-1} then gradual decrease beyond that limit and the greater response in carrot. A significant upsurge in nutrient concentration, yield, uptake of nutrients, apparent recovery of boron, B:C ratio in vegetable crops.

Babaleshwar *et al*. (2017) reported that, application of 60 kg S/ha resulted in highest plant height (43.71 cm), number of leaves per plant (7.25), bulb diameter (36.27mm), number of cloves/bulb (27.75), 10 cloves weight (10.23 gm) and average bulb weight (11.75 gm) of garlic.

Bubarai *et al.* (2017) reported the beneficial effect of boron as an influential factor for growth and boron availability in soil. They suggested that boron helped in maintenance of cell membrane metabolic function and worked as a constituent of cell wall.

Haleema *et al*. (2017) in an experiment observed that the effect of zinc, calcium and boron on growth and fruit production of tomato. The plant height increased consistently with increasing concentration of Zn. The plant height was 80.61 and 83.61 cm with with 0 and o.25% Zn application that significantly increased to 86.53 cm with increasing the Zn concentration to 0.5%.

Solanki *et al.* (2017) found that levels of sulphur @ 40 kg/ha enhanced growth parameters viz., plant height, plant spread, number of branches per plant and yield attributes viz., number of umbels per plant, number of umbellate per umbel, number of seeds per umbellate, seed weight per plant, test weight, seed yield (1534 kg/ha) over control in coriander.

Athokpam *et al*. (2016) carried out a trial that among the combination of Boron along with vermicompost on fruit yield and chemical properties of soil. Least quantity of Boron (10 kg ha^{-1}) in combination with highest quantity of vermicompost (20 q ha^{-1}) had a beneficial impact on decreasing no. of days to flowering, 50% of flowering, maturing, 50% of maturing, growth, fruit yield and also soil chemical properties like available Nitrogen, available Phosphorous, available Potassium, Organic carbon in soil.

Sultana *et al*. (2016) performed a field experiment to find out the effectiveness of soil and foliar application of micronutrients on the yield of tomato. In that experiment they used micronutrient zinc in the form of zinc sulphate ($ZnSO_4$) at the rate of 0.05% and boron in the form of boric acid (H_3BO_3) at the rate of 0.03% for foliar application. Among various applications, foliar application of Zn (0.05%) + B (0.03%) found maximum fruit yield (85.5 and 81.7 t ha^{-1} in 2013 and 2014, respectively.)

Ali *et al*. (2015) performed an experiment entitled “Effect of foliar application of zinc and boron on growth and yield of summer tomato” and found that foliar application of zinc and boron [T_0=control, T_1=25 ppm $ZnSO_4$, T_2= 25 ppm H_3BO_3, T_3= 12.5 ppm $ZnSO_4$+12.5 ppm H_3BO_3]. Highest plant height (106.9 cm), number of leaves (68.9/plant), number of branches (11.9/plant), number of clusters (21.6/plant) were observed in foliar treatment of T_3.

Harris and Lanka (2015) investigated the effect of B (0 ppm, 50 ppm, 100 ppm and 150 ppm) with foliar spray on flowering and fruit setting and yield of crop of brinjal (*Solanum melongina* L) in Sri Lanka. They concluded that the number of flower buds per plant (70%), number of flowers per cluster (141%), number of flower clusters per plant (48%), total number of flowers per plant (122%), percentage of flower set (30%), percentage of fruit set (46%), number of fruits per plant (216%) and fresh weight of fruits per plant (88 %) increased with application of 150 ppm B than that of control.

Judita *et al.* (2015) studied the role of sulphur on the content of total polyphenols and antioxidant activity in onion and reported that the polyphenol content increased with increase in sulphur levels.

Shad (2015) reported the influence of B (0.0 1.0. 1.5 and 2.0 kg ha^{-1}) and Zn (0.0, 2.5 and 5.0 kg ha^{-1}) on the growth, yield and nutrient content of BARI Tomato-2 by performing a field trial in a randomized complete block design. They suggested that with an optimum dose of 2.0 kg ha^{-1} contributed to maximum yield (67.36 t ha^{-1}).

Tawab *et al*. (2015) assessed the effect of different degrees of zinc on brinjal cultivars. Zinc levels proved significantly different among growth parameters. Maximum plant height (131.89 cm), number of leaves per plant (437.78), fruit weight (280.11 g) and total yield (15.33 t/ha) were recorded for plants treated with 0.2% zinc.

Ullah *et al*. (2015) in an experiment observed that the zinc, boron and their interaction expressively increased the growth parameters. Among different level of zinc 0.4% showed significant increased in the number of flower cluster $plant^{-1}$ (27.45), number of flowers $cluster^{-1}$ (5.66), number of branches $plant^{-1}$ (7.36).

Verma and Nawange (2015) studied the effects of different levels of sulphur on growth, yield and quality of cabbage at Gwalior and found that sulphur application 60 kg ha^{-1} produced significantly higher plant height, plant spread, stem diameter, width of head, higher weight of head per plant, protein content and yield of cabbage as compared to control.

Hore *et al.* (2014) reported that, the influence of nitrogen and sulphur nutrition on growth and yield of garlic and recorded that application of 60 kg sulphur and 200 kg nitrogen /ha significantly increased plant height, leaf number, equatorial diameter and cloves per plant.

Kashyap *et al*. (2014) conducted an experiment to study the influence of organic manures and inorganic fertilizers on growth, yield and quality of brinjal reported that the application of 25% RDF + 75% neem cake showed a maximum amount of 0.47 % and a minimum of 0.21% of reducing sugars and a maximum amount of 2.63% and a minimum amount of 1.05% of total sugars in the fruits of brinjal.

Saravaiya *et al*. (2014) conducted an experiment to study the effect of foliar application of micronutrients in tomato (*Lycopersicon esculentum* Mill.) cv. Gujarat Tomato-2. The result clearly showed that the yield obtained with treatment T_7 (NPK+mixture of all nutrients) had significantly higher maximum fresh weight of plants (25.65 t/ha), number of fruits/plant (34.26), fruit length (5.52 cm), fruit diameter (4.64 cm), fruit volume (67.53 cm^3), single fruit weight (49.20 g), fruit weight per plant (1.68 kg), and marketable fruit yield/ha (45.62 t/ha). Out of all treatments and over control, this treatment had the highest net return (1,66,757 Rs./ha) and the best B:C Ratio (2.72:1).

Shnain *et al*. (2014) in an experiment observed that the zinc and boron played significant role in directly affecting plant height and number of leaves in tomato, zinc @ 1.25 g recorded maximum plant height (2.93 m) and maximum number of leaves $plant^{-1}$ (39.33).

Silva *et al*. (2014) arranged an experiment in entirely randomized blocks, of which 6 doses of S (0, 20, 40, 60, 80 and 100 mg kg^{-1}) in the form of agricultural gypsum along with 3 repetitions. Into the vessels it was transplanted a tomato plant (Abiru variety), cultivated for 115 days. The fruits were harvested, washed and weighed and the shoots were cropped, weighed and analyzed in relation to levels of carbon, nitrogen and sulfur. The tomato fruit production increased under sulfur doses, obtaining a 23 to 34% raise. The dry mass of the shoot, content and accumulation increased under the application of sulfur doses on the soil. The C/S and N/S relation decreased on the tomato shoot under sulfur doses, with variable values of 92 to 144 for C/S and 2.1 to 3.1 for N/S. The average relation of C:N:S found on the tomato shoot was of 112:2.4:1. The 2.6 N/S relation on the shoot was the one which presented balance of these nutrients on the tomato production obtainment.

Tripathi *et al*. (2013) reported that gypsum application recorded higher plant height, neck thickness, average bulb weight, polar diameter, total bulb yield and TSS than elemental sulphur in onion.

Naga *et al.* (2013) investigated the influence of micronutrients application on growth and seed yield in tomato (*Lycopersicon esculentum* mill.) in two varieties of tomato viz Utkal Kumari and Utkal Raja. The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese, mixture of all and control and the experiment was laid out in RBD with three replications. All the treatments resulted in improvement of plant growth characteristics viz. plant height, number of primary branches, compound leaves, tender and mature fruits per plant. Out of which application of micronutrients mixture showed the maximum effect. In tomato cv. Utkal Kumari, maximum growth rate (85.7 %) was observed with application of zinc, followed by application of micronutrients mixture (78.2 %) and boron (77.5 %). Tomato cv. Utkal Raja, maximum increase in branches per plant was observed with the application of manganese (148.7 %) followed by micronutrient combination (144.1 %).

Sivaiah *et al*. (2013) found in tomato that the highest seed recovery rates of 0.53 % and 0.55 % were recorded application of micronutrients mixture followed by the Boron application with 0.50 % and 0.54 % recovery rates. Maximum seed weight was observed with the application of micronutrient mixture and boron. They also found that among the micro nutrients, only application of boron and mixture of micronutrients enhanced the fruit weight while other micro-nutrients did not show any positive effect. The increase in fruit weight might be due to better mineral utilization of plants accompanied with enhancement of photosynthesis, other metabolic activity and greater diversion of food material to fruits.

Gurmani *et al.* (2012) in an experiment on effect of zinc (0, 5, 10 & 15 mg kg^{-1}) on the growth, yield and biochemical attributes of two tomato cultivars viz., VCT-1 and Riogrande. Zinc application increased the plant growth and fruit yield in both cultivars. Maximum plant growth and fruit yield in both cultivars were achieved by the zinc application @ 10 mg kg^{-1} soil. Application of 5 mg zinc kg^{-1} had lower dry matter production as well as fruit yield when compared with zinc 10 and 15 mg kg^{-1}. The percent increase of fruit yield at 5 mg Zn kg^{-1} was 14 and 30% in cv.VCT-1 and Riogrande, respectively. Zinc application @ 10 mg Zn kg^{-1} increased the fruit yield by 39 and 54%, while 15 mg Zn kg^{-1} enhanced by 34 and 48%, respectively. Zinc concentration in leaf, fruit and root increased with the increasing level of zinc.

Fatma *et al.* (2012) conducted an experiment to study the effect of different nitrogen plus phosphorus and sulphur fertilizer levels on growth, yield and quality of onion and reported that the higher level of N plus P fertilizer (90 kg N ha^{-1} + 45 kg P ha^{-1})

significantly increased plant length, number of green leaves plant^{-1}, bulb and neck dimensions and fresh and dry weights of whole plant and its different organs as compared with the lower level (60 kg N ha^{-1} + 30 kg P ha^{-1}).

Hasan *et al.* (2012) conducted a pot culture experiment to assess the influence of phosphorus and sulphur on yield, yield attributes and biochemical composition of brinjal and reported that plant height, number of branches, number of fruits, fruit length and fruit diameter were maximum at 60 kg ha$^{\mathbf{-1}}$ and 30 kg ha$^{\mathbf{-1}}$ application of phosphorus and sulphur, respectively, along with basal doses of other inorganic fertilizers and organic manures.

Khalid *et al*. (2012) conducted an experiment at two different locations in northern Punjab, Pakistan to assess the effect of different rates (0, 20, 30, 40 kg S ha^{-1}) of sulphur application through various sources i.e. single super phosphate, ammonium sulphate and gypsum on growth of Brassica napus under rainfed conditions and reported that among sulphur sources ammonium sulphate resulted in maximum increase in plant growth and yield parameters, followed by single super phosphate and gypsum. In case of sulphur levels, maximum growth and yield parameters were recorded when sulphur was applied at its higher rate of 40 kg S ha^{-1} which was statistically at par with 30 kg S ha^{-1}.

Naz *et al.* (2012) performed a field trial for two years at Peshawar by taking two varieties of tomato i.e. RioGrand and RioFigue to observe the effect of Boron (B) on the growth and yield. They have applied B @ 0, 0.5, 1.0, 2.0, 3.0 and 5.0 kg ha^{-1} and N: P: K @ 150:100:60 kg ha^{-1}. Growth and Yield increase significantly with the supplement of Boron whereas yield and yield attributing characters are found to be maximum in Boron @ 2 kg ha^{-1}. They concluded that with supplement of 2 kg B ha^{-1} significant positive impact on flowering and fruiting in RioGrand variety.

Raja *et al*. (2012) observed that in tomato plant the maximum number of flower clusters per plant (27.73) and fruit set percentage (55.83) in plants, receiving boron at 2 kg/ha, while minimum number of flower clusters per plant (16.75) and minimum fruit set percentage (39.77) were noticed in control.

Rizk *et al.* (2012) revealed that sulphur application at the rate of 400 kg S fed^{-1}, markedly enhanced all parameters of vegetative growth of onion. The three levels viz., 0, 200, 400 kg S fed^{-1} of sulphur had significant difference on bulb diameter, leaves fresh weight, bulb and whole plant dry weight.

Barche *et al*. (2011) examined that maximum plant height (80.40 cm) and number of branches per plant (34.7) were recorded with combined application of H_3BO_3, $ZnSO_4$ and $CuSO_4$ each at 250 mg kg^{-1} in tomato.

Haque *et al.* (2011) conducted a field trial for two years in an RBD to investigate the effects of N (0, 60, 120, 180 kg N ha^{-1}) and B (0, 0.4, 0.6 kg B ha^{-1}) on growth and yield of tomato. They observed maximum value of plant height (142.2 cm), flower clusters $plant^{-1}$ (12.67), flowers $cluster^{-1}$ (11.67), fruits $cluster^{-1}$ (6.33), fruits $plant^{-1}$ (67.33), fruit weight $plant^{-1}$ (1.953 kg), fruit weight $plot^{-1}$ (23.20 kg) and fruit yield (58.59 t ha^{-1}) with the application of 0.6kg B ha^{-1} in combination with 120 kg N ha^{-1}.

Kumar *et al.* (2011) conducted a field experiment on sandy loam soil at Allahabad using two sulphur sources (gypsum and elemental sulphur) on the performance of spring sunflower (*Helianthus annus* L.) and recorded significant increase in growth parameters with increase in sulphur levels from 0 to 45 kg/ha through gypsum as compared to elemental sulphur.

Dursun *et al*. (2010) performed an experiment for 2 years to investigate the influence of Boron (0, 1, 2, 3, and 4 kg B ha^{-1}) on yield and quality parameters of 3 vegetables i.e. tomatoes (*Lycopersicon esculentum* L.), pepper (*Capsicum annum* L.), and cucumber (*Cucumissativus* L.). They observed that the content soil B of 0.33, 0.34 and 0.42 mg kg^{-1} obtained by the application of 2.3, 2.6, 2.4 kg B ha^{-1}. Due to increase in B application, N, Ca, Mg content reduced but P, K, Zn, Cu, Fe, Mn concentration increased. They concluded that2.5 kg B ha^{-1} can raise the soil Boron to sufficient levels.

Jamre *et al.* (2010) conducted a field experiment at Gawalior (M.P.) on sandy loam soil to study the response of cauliflower to different levels of sulphur and zinc. The growth and yield increased significantly with increasing levels of sulphur and zinc. However, a significant reduction in days taken to curd initiation and curd maturity was observed at highest tested level of S.

Menna (2010) reported that soil application of boron at 2.0 kg/ ha in tomato enhanced the maximum percentage of fruit set (63.01 %) compared with control (40.97 %).

Rashid (2010) reported that application of sulphur @ 30 kg ha^{-1} gave the highest bulb yield of onion. Almost all the parameters were significantly influenced by treatments of sulphur. The maximum bulb dry matter content and bulb yield were obtained from the application of sulphur @ 30 kg ha^{-1} in onion.

Sathya *et al.* (2010) investigated the end result of soil and foliar applied Boron on growth, quality and fruit yield of PKM 1 tomato. They concluded that with application of 20 kg borax ha^{-1} recorded maximum fruit yield of 33 t ha^{-1} with an increase of 33.6 % over control and was observed to be significantly higher over other treatments. Maximum yield was obtained by supplement of 18.36 kg ha^{-1} and 18.29 kg ha^{-1}. Borax at its physical and economic optimum level.

Basavrajeshwari *et al.* (2008) observed that application of boron @ 100 mg kg^{-1} increases plant height and number of primary branches (77.33 cm and 18.35, respectively) as compared to control (65.00 and 16.95) in tomato.

Jyolsna and Mathew (2008) reported that the combined application of RDF (75:40:25 kg/ha) + FYM (25 t/ha) + B (1.5 kg/ha) significantly increased the tomato plant height (98.46 cm) and number of primary branches (12.3) over the other treatments.

Ghosh *et al.* (2007) reported that application of 40 kg S ha^{-1} increased the plant height, number of branches per plant, seed weight, and seed yield in soybean.

Singh *et al.* (2007) reported that plant height, total plant biomass, canopy area, fruit length, diameter and average fruit weight improved significantly with increased levels of fertility.

Channagoudar and Janawade (2006) reported that significantly higher plant height (38.41 cm), number of leaves per plant (8.4), leaf area (274.64 cm^2) and leaf area index (2.44) at harvest was observed @ 40 kg S ha^{-1} over to lower doses in onion.

Mani *et al.* (2006) conducted an experiment to assess the effect of ammonium sulphate and DAP on yield of mustard, reported that the application of 40 kg ha^{-1} of P along with 30 kg ha^{-1} of S increased the plant height by 5.02% and seed yield by 28.74% over the control.

Sriramachandrasekharan and Ravichandran (2006) studied the effect of sources and levels of sulphur on the yield of brinjal and found that yield of brinjal increased with S levels. Further, maximum beneficial effect with respect to plant height, dry matter production, number of fruits $plant^{-1}$, fruit length, individual fruit weight and fruit yield was observed with 150 kg S ha^{-1}. The percent increase with respect to fruit yield (78%), fruit weight (29.8 %) and number of fruits (33%) was noticed over control.

Singh *et al.* (2006) in an experiment at Hissar, Hrayana studied the effects of gypsum on growth and yield of cauliflower cv. Snow Ball-16 and reported a significant increase in growth and yield (152.23 q ha^{-1}) of cauliflower with the addition of gypsum.

Thakre *et al*. (2005) opined that fresh brinjal yield increased with increasing levels of S and P while, increasing levels of K did not show any significant effect on fresh fruit yield. The highest yield of 150.60 q ha^{-1} was recorded with the application of S at 40 kg ha^{-1}, followed by 146.04 q ha^{-1} with P at 75 kg ha^{-1}.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka to investigate the effect of sulphur, zinc and boron nutrients on growth and seed yield of sau yellow cherry tomato. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Experimental period

The experiment was conducted during the period from September 2021 to April 2022 in the Rabi season.

3.2 Description of the experimental site

3.2.1 Geographical location

The experiment was conducted both in the Central laboratory and Agronomy field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meters above sea level.

3.2.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. For a better understanding of the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2.3 Soil

The soil texture was silty clay with pH 6.1. The morphological, physical, and chemical characteristics of the experimental soil have been presented in Appendix-II.

3.2.4 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April, and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity, and rainfall during the experiment period was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-III.

3.3 Experimental materials

The 'Golden Purna' tomato variety seed was used in the experiment. Seed were collected from Department of Horticulture of Sher-e-Bangla Agricultural University, Dhaka.

3.4 Seed treatment

To protect against seed-borne diseases, seeds were treated with Provax 200WP @ 3g/1kg seeds.

3.5 Seedbed preparation and seed sowing

On September 3, 2021, the raised seed bed of 1.5 m length, 1.0 m width and 15 cm height were prepared in the garden soil. Tomato seeds were placed one centimeter deep in the rows spaced at 5 to 6 cm and covered with thin layer of sand and then covered with dry grass mulch. The seed bed was watered daily during evening hours. The 25 days old healthy seedlings were transplanted in the main experimental plot.

3.6 Experimental treatment

The experiment consisted of 11 Treatments with 3 Replications. The details of treatments are given below.

T_1= $S_0Zn_4B_2$ Kg ha^{-1}
T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}
T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}
T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}
T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}

$T_6 = S_{20}Zn_2B_2$ Kg ha^{-1}

$T_7 = S_{20}Zn_6B_2$ Kg ha^{-1}

$T_8 = S_{20}Zn_4B_0$ Kg ha^{-1}

$T_9 = S_{20}Zn_4B_1$ Kg ha^{-1}

$T_{10} = S_{20}Zn_4B_3$ Kg ha^{-1}

$T_{11} = S_0Zn_0B_0$ Kg ha^{-1}

3.7 Design and layout of experiment

The single factor experiment was laid out in randomized block design consisting 11 treatments. Each treatment was replicated in three times. The treatments were allotted randomly to different plots using random number tables of Fishers and Yates (1963). There are 11 treatments and total 33 unit plots. The unit plot size was 1.25 m × 1.8 m = 2.25 m^2. The distance between block to block and plot to plot were 1 m and 0.5 m respectively. Plant spacing maintaining by 60 cm × 50 cm and each plot had 6 plants.

3.8 Field preparation

The experiment plot was opened with a power tiller in the third week of september 2021 and left exposed to the sun for a week. After one week, the land was harrowed, ploughed, and cross-ploughed several times before laddering to achieve good tilth. Weeds and stubbles were removed, and a desirable tilth of soil was obtained for seedling transplantation. Drainage channels were built around the land to avoid water logging caused by rainfall during the study period. When the plot was finally ploughed, the soil was treated with Furadan 5G at a rate of 15 kg ha^{-1} to protect the young seedlings from cut worm attack. The final land preparation was done in 27th September 2021.

3.9 Application of fertilizers

The N, P, K, S, Zn and B nutrients were applied through urea, Triple super phosphate (TSP), Muriate of potash (MoP) Gypsum, $ZnSO_4$ and Boric acid, respectively. Zinc (Zn) and boron (B) was applied as per treatment where rest of the nutrients was applied according to Krishi Projukti Hat Boi, BARI, 2019. Name and doses of nutrients were as follows:

The fertilizer doses listed below are recommended for tomato production.

Plant nutrients	Fertilizers	Doses (kg/g plot^{-1})
--	Cowdung	3.38 kg
N	Urea	25 g
P	TSP	20 g
K	MoP	15 g
S	Gypsum	As per treatment requirement
Zn	$ZnSO_4$	As per treatment requirement
B	Boric acid	As per treatment requirement

One third of whole amount of Urea and full amount of TSP, MoP, Gypsum, $ZnSO_4$ and boric acid were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments - at 20 days after transplanting (DAT) and 50 DAT respectively.

3.10 Transplanting of seedlings

Healthy and uniform sized 25 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 28 September, 2021 maintaining a spacing of 60 cm × 50 cm. The seedlings were watered after transplanting. Shading was provided by piece of banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of the same crop was established around the experimental field as border crop to do gap filling and to check the border effect.

3.11 Intercultural operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the tomato.

3.11.1 Gap filling

Seven days after transplanting the gap filling was done with fresh seedlings in order to maintain cent per cent plant population in all treatments.

3.11.2 Thinning

Fifteen days after transplanting thinning was done manually by removing weaker seedlings from each hill and retaining one healthy seedling per hill.

3.11.3 Weeding

The experimental plot was kept free from weeds by regular hand weeding and inter-cultivation operations.

3.11.4 Irrigation

Irrigation was given as and when required by the crop. Generally, irrigation was given once in a week depending upon crop water requirements.

3.11.5 Plant protection

To control the pest and diseases, necessary plant protection measures were taken as and when required. To control tomato fruit borer (*Helicoverpa armigera*) carbaryl was sprayed @ 3g per litre at weekly interval. To again control early blight (*Alternaria solani*) copper oxychloride @ 0.3% (Blitox 50% WP) at 15 days interval.

3.12 Harvesting

Fruits were harvested at 5 days intervals during maturity to ripening stage. The maturity of the crop was determined on the basis of red colouring of fruits. Harvesting was started from 3 March, 2022 and completed by 20 April, 2022.

3.13 Collection of data

Five plants were selected randomly in each treatment for collection of various parameters od data for statistic analysis.

3.14 Data recording

Data were recorded on following parameters from the studied plants during the experiment. The details of data recording are given below on individual plant basis.

i. Plant height (cm)

The five randomly selected plants were used for measuring plant height. It was recorded in centimeters from the base of plant to the terminal growing point of the plant at vegetative stage and flowering stage of tomato.

ii. Number of branch plant^{-1}

The number of branches per plant counted for randomly selected five plants and average was recorded at vegetative stage and flowering stage of tomato.

iii. Number of cluster plant^{-1}

The number of cluster plant^{-1} was counted from five randomly sampled plants. It was done by counting the total number of cluster of all sampled plants then the average data were recorded. Data were recorded at vegetative stage and flowering stage of tomato.

iv. Number of leaves plant^{-1}

The number of leaves per plant counted for randomly selected five plants and average was recorded at vegetative stage and flowering stage of tomato.

v. Number of flower cluster^{-1}

The number of flower clusters was counted from five plants of each plot and the average number of clusters produced per plant was calculated.

vi. Number of flower plant^{-1}

Number of flowers per each plant was recorded in five randomly selected plants and their mean was calculated with total number of flowers divided by number of plants.

vii. Number of fruit cluster^{-1}

Number of fruits cluster^{-1} was recorded in five randomly selected plants and their mean was calculated with total number of fruits divided by number of plants.

viii. Total no. of fruit plant^{-1}

Several pickings were required as all the fruits did not mature at a time. In each picking, fruits were counted and after last picking, the average total number of fruits per plant was calculated.

ix. Weight of individual fruit (g)

The total number of fruits was weighed in a plant and the average fruit weight was worked out and expressed in gram.

x. Fruit yield plant^{-1} (kg)

At first the total weight (kg) of fruit was taken from the 5 selected plants harvested at different dates using an electric balance and then weight plant^{-1} (kg) was calculated by following formula:

$$\text{Fruit yield plant}^{-1}\text{ (kg)} = \frac{\text{Total weight of fruits from selected 5 plants (kg)}}{\text{Number of sample plants}}$$

xi. Fruit yield per plot (kg)

All collected fruits from each plot were brought into farm house and were weighed in kg.

xii. Fruit yield ha^{-1} (ton)

After collection of per plot yield, it was converted to ton per hectare (t ha^{-1}).

xiii. Number of seed fruit^{-1}

Seed number per fruit was counted from 5 average sized ripe fruits selected at random in each treatment

xiv. Seed yield plant^{-1}

Seed yield from each plant were taken expressed as g/plant on about 12% moisture basis. seed moisture content was measured by using a digital moisture tester.

xv. Seed yield plot^{-1} (g)

It was recorded by weighing the total number of seeds from each plot separately

xvi. Seed yield (kg ha^{-1})

Seed yield was recorded from 1 m^2 area of each plot were sun dried properly. The weight of seeds was taken and converted the yield in kg ha^{-1}.

xvii Germination (%)

The germination percentage of seed was calculated with the following formula Germination %= (Number of germinated seeds/Total number of seeds) × 100

xviii. Vigority index

Vigor index was calculated by using following formula of (Abdul-Baki and Anderson., 1970).

$$\text{Vigor index} = \frac{\text{Total seed germination} \times \text{Seedling length}}{100}$$

3.15 Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program Statistix 10 software. The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

3.16 Economic Analysis

The cost of production was calculated to find out the most economic application of different sulphur, zinc and boron nutrients on growth and seed yield of sau yellow cherry tomato. All input cost like the cost for land lease and interests on running capital were computing in the calculation. The interests were calculated @ 13% in simple rate. The market price of sau yellow cherry tomato was considered for estimating the return.

3.16.1 Analysis for total cost of production of sau yellow cherry tomato

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production. Total cost of production (input cost, overhead cost), gross return, net return and BCR are presented in Appendix section.

3.16.2 Gross income

Gross income was calculated on the basis of sale of sau yellow cherry tomato. The price of sau yellow cherry tomato was determined on the basis of current market value of Kawran Bazar, Dhaka at the time of harvesting.

3.16.3 Net return

Net returns were arrived after deducting the cost of cultivation from the gross returns of the marketable produce on hectare basis and expressed in taka per hectare Net returns = Gross returns – cost of cultivation.

3.16.4 Benefit cost ratio (BCR)

It was obtained by dividing gross returns with cost of cultivation per hectare.

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns(Tk/ha)}}{\text{Total cost of production}}$$

CHAPTER IV

RESULTS AND DISCUSSION

This section contains a presentation and discussion of the study's findings on the effect of sulphur, zinc and boron fertilizers on growth and seed yield of SAU yellow cherry tomato. The information have been presented in various tables and figures. The findings have been discussed, and possible interpretations were provided under the headings listed below.

4.1 Plant height (cm)

The plant height of cherry tomato varied significantly at various growth stages due to the application of different doses of sulphur, zinc, and boron fertilizer (Figure 1). Experimental result showed that at vegetative stage the highest plant height (75.33 cm) was observed in T_7 ($S_{20}Zn_6B_2$ Kg ha^{-1}) treatment while the lowest plant height (67.10 cm) was observed in T_{11} ($S_0Zn_0B_0$ Kg ha^{-1}) treatment which was statistically similar with T_5 (67.47 cm) treatment. At flowering stage the highest plant height (102.87 cm) was observed in T_7 ($S_{20}Zn_6B_2$ Kg ha^{-1}) treatment while the lowest plant height (92.55 cm) was observed in T_{11} ($S_0Zn_0B_0$ Kg ha^{-1}) treatment. It might be due to the fact that application of sulphur, zinc, and boron has been reported to improve not only the availability of these nutrients but of other nutrients too, which increases photosynthetic rates and assimilation rates, result in proper for growth and development of cherry tomato. The result was similar with the findings of Gopal and Sarangtham (2022) who reported that increased application of zinc and boron influenced plant height of totamo. Mustafa *et al.* (2021) reported that the height plant height in onion was obtained due to application of recommended dosage of fertilizer plus higher dose of sulphur fertilizer application.

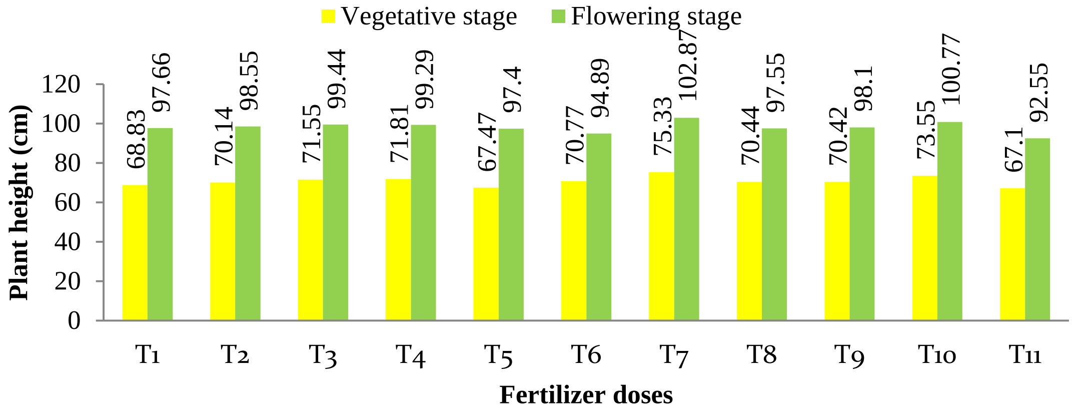

Figure 1. Effect of different doses of fertilizer on plant height of cherry tomato at various growth stage

Here, T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}.

4.2 Number of branches per plant

Due to the use of varying sulphur, zinc, and boron fertilizer doses, cherry tomato plants produced significantly different numbers of branches at different growth stages (Figure 2). According to the experimental results, at the vegetative stage, T_{10} ($S_{20}Zn_4B_3$ Kg ha^{-1}) treatment had the highest number of branches per plant (8.76), which was statistically similar with T_4 (8.37) and T_7 (8.26) treatment, and the T_{11} ($S_0Zn_0B_0$ Kg ha^{-1}) treatment had the lowest number of branches per plant (6.67). At the flowering stage, T_{10} ($S_{20}Zn_4B_3$ Kg ha^{-1}) treatment had the highest number of branches per plant (11.34), which was statistically similar with T_7 (10.66) treatment, and T_{11} ($S_0Zn_0B_0$ Kg ha^{-1}) treatment was recorded the lowest number of branches per plant (8.11). Singh *et al*. (2021) studied number of branches per tomato plant and found that maximum numbers of branches were recorded in ammonium molybdate treatment followed by zinc sulphate. Sanjida *et al*. (2020) reported that application of 2 kg B ha^{-1} significantly influenced branches per plant of tomato. Ghosh *et al.* (2007) reported that increased application of sulphur increased the number of branches per plant of soya bean.

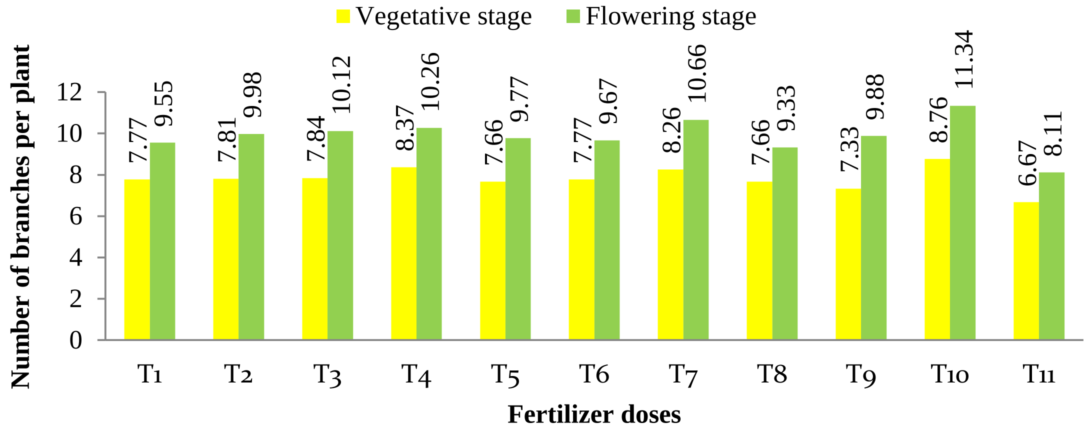

Figure 2. Effect of different doses of fertilizer on number of branches per plant of cherry tomato at various growth stage

Here, T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}.

4.3 Number of cluster per plant

Number of cluster per plant of cherry tomato varied significantly due to application of different doses of sulphur, zinc, and boron fertilizer (Figure 3). Experimental result showed that at the highest number of cluster per plant of cherry tomato (7.77) was observed in T_{10} treatment which was statistically similar with T_7 treatment (7.11), while the lowest number of cluster per plant of cherry tomato (4.56) was observed in T_{11} treatment which was statistically similar with T_6 treatment (5.29). Macro and micronutrients play an important role in many physiological processes and cellular functions in the plants. In addition to that they play a vital role in improving plant growth through biosynthesis of endogenous hormones which is responsible for promoting plant growth. These results were in conformity with the results obtained by Khatri *et al.* (2022) and reported that in tomato the highest clusters number was observed with the foliar application of chelated zinc and borax at the dosages of 30 ppm. Sathya *et al.* (2010) reported that an application of boron along with calcium significantly increased the number of branches per plant, Boron promotes root growth, which also enhances nutrient absorption, mineral uptake and involved in nitrogen metabolism.

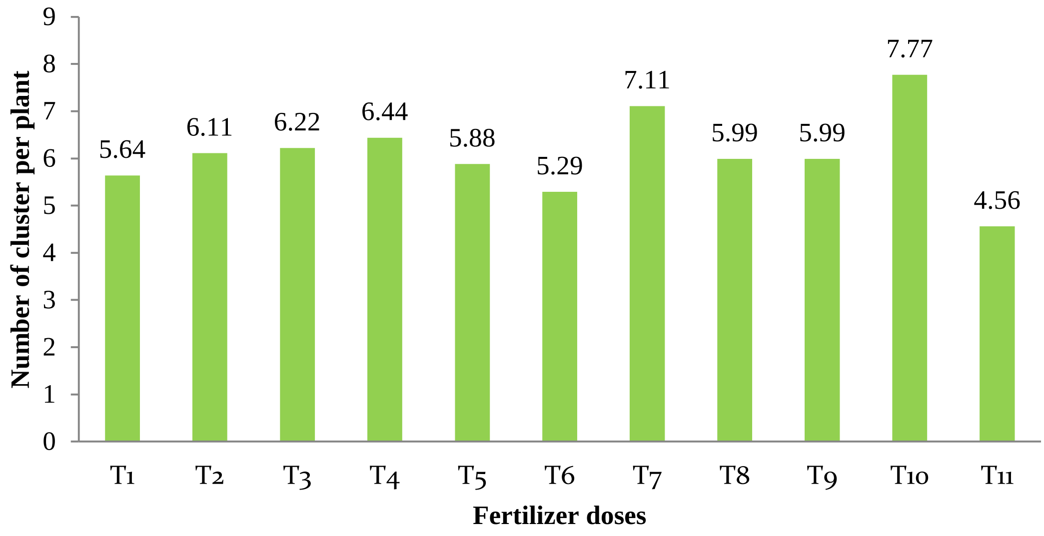

Figure 3. Effect of different doses of fertilizer on number of cluster per plant of cherry tomato at various growth stage

Here, T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}.

4.4 Number of leaves per plant

When applying different doses of sulphur, zinc, and boron fertilizer, the number of cherry tomato leaves per plant at various growth stages had shown significant effect. (Figure 4). Experimental result showed that at the vegetative stage the highest number of leaves per plant of cherry tomato (55.62) was observed in T_{10} treatment which was statistically similar with T_7 treatment (54.88) treatment. While at the vegetative stage the lowest number of leaves per plant of cherry tomato (44.44) was observed in T_{11} treatment. At flowering stage the highest number of leaves per plant of cherry tomato (65.72) was observed in T_{10} treatment, while the lowest number of leaves per plant of cherry tomato (49.35) was observed in T_{11} treatment. The difference in leaves number might be due to increased intensity of auxins (IAA), may be due to application of macro and micronutrients especially Boric acid and $ZnSO_4$, which promotes growth by cell division and cell elongation. Ali *et al*. (2015) discovered a substantially increased number of leaves per plant (68.9) as zinc and boron concentrations increased. Hore *et al.* (2014) reported that application of 60 kg sulphur and 200 kg nitrogen /ha significantly increased leaf number per plant of garlic.

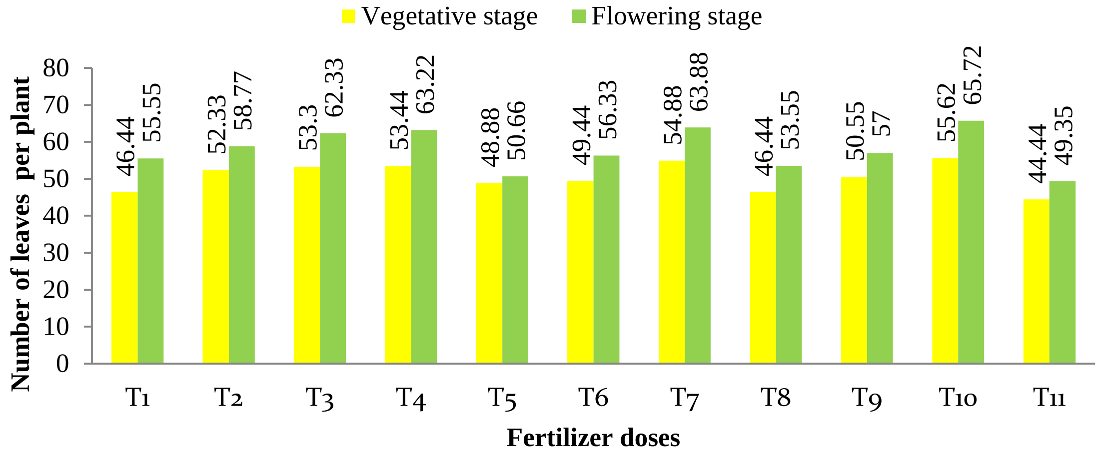

Figure 4. Effect of different doses of fertilizer on number of leaves per plant of cherry tomato at various growth stage

Here, T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}.

4.5 Number of flowers per cluster

Number of flowers per cluster of cherry tomato was significantly influenced due to effect of different fertilizer dose (Table 1). Experimental result showed that the T_{10} recorded the highest number of flowers per cluster (62.91) while the T_{11} was recorded the lowest number of flowers per cluster (46.55). This may be due to increased supply of major and micro nutrients which are required in larger quantities for growth and development of plants. Plant nutrients accelerate the development of growth and reproductive phase and protein synthesis, thus promoting increased number of flowers per cluster of cherry tomato. Osman *et al*. (2019) reported that a combination of 2 kg borax and 2 kg zinc sulphate per ha gave the highest number of flowers per cluster of tomato plant. Ullah, *et al.* (2015) reported significantly increased number of branches per plant (7.36) with increasing concentration of zinc at 0.4% as compared to other treatments in tomato plant. Hasan *et al.* (2012) reported that 30 kg ha^{-1} sulphur application significantly influenced leaf number of brinjal.

4.6 Number of flowers per plant

The effect of different fertilizer doses on the number of flowers per plant of cherry tomato was significant (Table 1). The experimental results revealed that the T_{10}

treatment had the highest number of flowers per plant (568.77) while the T_{11} was recorded the lowest number of flowers per plant (484.11). Zinc and boron is an essential micronutrient which responsible for maximizes flower set. Similar results were reported by Justice (2021) in tomato where significantly increased number of flowers were observed with increasing concentration of 2 kg Zn ha^{-1} and 1.5 kg B ha^{-1} as compared to other treatments.

4.7 Number of fruits per cluster

The effect of various fertilizer doses of sulphur, zinc, and boron fertilizer on cherry tomato plants significantly affected the number of fruits per cluster (Table 1). The results of the experiment revealed that the T_{10} treatment had the highest number of fruits per cluster (77.11) and the T_{11} treatment had the lowest number of fruits per cluster (44.46) which was statistically similar with T_6 (46.44) treatment. The positive response of sulphur with secondary micronutrients with recommended NPK can be attributed to the availability of sufficient amount of plant nutrients throughout the growth period, resulting in better lateral root growth, catalyzing the metabolism of carbohydrates, increase in enzyme activity, other biological oxidation reactions and growth and yield advantage result in increased number of fruits per cluster in tomato plant. The result was similar with the findings of Haque *et al.* (2011) in tomato.

4.8 Total number of fruits per plant

The total number of fruits per plant of cherry tomato plants was significantly influenced by the application of different fertilizer doses (Table 1). The experimental results showed that the T_{10} treatment had the highest total number of fruits per plant (499.44) and the T_{11} treatment had the least total number of fruits per plant (440.44). Boron helps reduce male sterility and increases normal fruit. Sulphur is essential for many growth functions in plants including nitrogen metabolism, enzyme activity and protein and oil synthesis. Zinc is involved in the biochemical synthesis of the plant hormone IAA via a pathway converting tryptophan to IAA, which also improves yield and its properties. Therefore combined use of sulphur, zinc, and boron could help balance nutrient uptake and increase photosynthesis rate, resulting in more fruit per plant. The result was similar with the findings of Gopal and Sarangtham (2022) and Singh *et al*. (2021).

Table 1. Effect of sulphur, zinc and boron fertilizers on number of flowers per cluster, number of flowers per plant, number of fruits per cluster, total number of fruits per plant of cherry tomato

Treatments	Number of flowers per cluster	Number of flowers per plant	Number of fruits per cluster	Total number of fruits per plant
T_1	50.77 d	521.55 f	49.44 f	461.88 e
T_2	56.44 c	530.22 d	61.77 d	473.00 d
T_3	56.55 c	530.88 d	63.33 cd	481.77 c
T_4	57.88 c	538.44 c	64.88 c	486.44 c
T_5	52.10 d	487.77 h	51.99 f	448.77 fg
T_6	57.10 c	498.77 g	46.44 g	446.22 g
T_7	60.13 b	563.78 b	69.02 b	493.66 b
T_8	57.11 c	524.44 ef	50.55 f	452.11 f
T_9	57.33 c	525.44 e	55.44 e	468.77 d
T_{10}	62.91 a	568.77 a	77.11 a	499.44 a
T_{11}	46.55 e	484.11 i	44.46 g	440.44 h
CV%	8.25	7.25	5.36	6.45
$LSD_{(0.05)}$	2.1658	3.4723	2.8382	4.9899

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of significance. Here, $T_1= S_0Zn_4B_2$ Kg ha^{-1}, $T_2= S_{10}Zn_4B_2$ Kg ha^{-1}, $T_3= S_{20}Zn_4B_2$ Kg ha^{-1}, $T_4= S_{30}Zn_4B_2$ Kg ha^{-1}, $T_5= S_{20}Zn_0B_2$ Kg ha^{-1}, $T_6= S_{20}Zn_2B_2$ Kg ha^{-1}, $T_7= S_{20}Zn_6B_2$ Kg ha^{-1} , $T_8= S_{20}Zn_4B_0$ Kg ha^{-1}, $T_9= S_{20}Zn_4B_1$ Kg ha^{-1}, $T_{10}= S_{20}Zn_4B_3$ Kg ha^{-1}, $T_{11}= S_0Zn_0B_0$ Kg ha^{-1}.

4.9 Weight of individual fruit (g)

Weight of individual fruit of cherry tomato plants was significantly influenced by the application of different fertilizer doses (Table 2). The experimental results showed that the lowest individual fruit weight of cherry tomato (5.36 g) was observed in T_{11} treatment. On the other hand the T_{10} treatment had the highest individual fruit weight of cherry tomato (12.51 g). The improvement in this character may be because of better absorption of macro and micronutrient which ultimately increase the accumulation of carbohydrate in the fruits and provide better environment for growth and developmental processes, thus, better results were obtained due to the availability of favorable conditions in these treatments. Similar result also observed by Gopal and Sarangtham (2022) who reported that different treatment of zinc and boron significantly influenced individual fruit of tomato and among among the treatments, the T_{10} (Zn 10 +B 2.0 kg ha^{-1}) treatment exhibited a significantly increased in fruit weight plant^{-1} than the control treatment (Zn 0.0+B 0.0).

4.10 Fruit yield per plant (kg)

The application of various sulphur, zinc, and boron fertilizer doses had shown a significant effect on the fruit yield per plant of cherry tomato (Table 2). According to the experimental findings the T_{11} treatment had the lowest fruit yield per plant of cherry tomato (2.06 kg) which was statistically similar with T_5 (2.22 kg) treatment. While the T_{10} treatment recorded the height fruit yield per plant of cherry tomato (4.58 kg). The increase in fruit yield per plant might be due to more accumulation of photosynthates which were synthesized in the leaf and translocated towards the fruit. An increase in the fruit yield per plant might be due to better vegetative growth of plant on application of different doses of macro and micronutrients. Chatto *et al*. (2019) reported that application of Sulphur @ 45 kg ha^{-1} resulted significant improvement in most of growth, yield and quality parameters of onion. Harris and Lanka (2015) reported that fresh weight of fruits per plant (88 %) increased with application of 150 ppm B than that of control. Ali *et al.* (2015) reported ignificantly increased yield of fruits per plant (1.9 kg) of tomato with increasing concentration of zinc at 25 ppm as compared to other treatments.

4.11 Fruit yield per plot (kg)

The fruit yield per plot of cherry tomato had been significantly influenced by the use of different sulphur, zinc, and boron fertilizer doses (Table 2). The results of the experiment showed that the cherry tomato fruit yield per plot for the T_{11} treatment was the lowest (12.38 kg), which was statistically similar to the yield for the T_5 treatment (13.33 kg). While the T_{10} treatment recorded the height of cherry tomato fruit yield per plot (27.49 kg).

4.12 Fruit yield per hectare (t)

Different doses of sulphur, zinc, and boron fertilizer application to the experimental plot had shown a significant effect on the fruit yield per hectare of cherry tomato (Figure 5). According to the experimental findings the T_{10} treatment had the highest fruit yield per hectare of cherry tomato (84.84 t), while the T_{11} treatment recorded the lowest fruit yield per hectare of cherry tomato (46.97 t). This might be due to the average fruit weight, polar and equatorial diameter which were superior over other treatments which imparts and increase in the total yield of tomato. Xu *et al.* (2021)

reported that the appropriate application of boron can effectively improve the growth and yield of tomato. Osman *et al*. (2019) a combination of 2 kg borax and 2 kg zinc sulphate per ha gave the highest yield of tomato (83.50 t/ha).

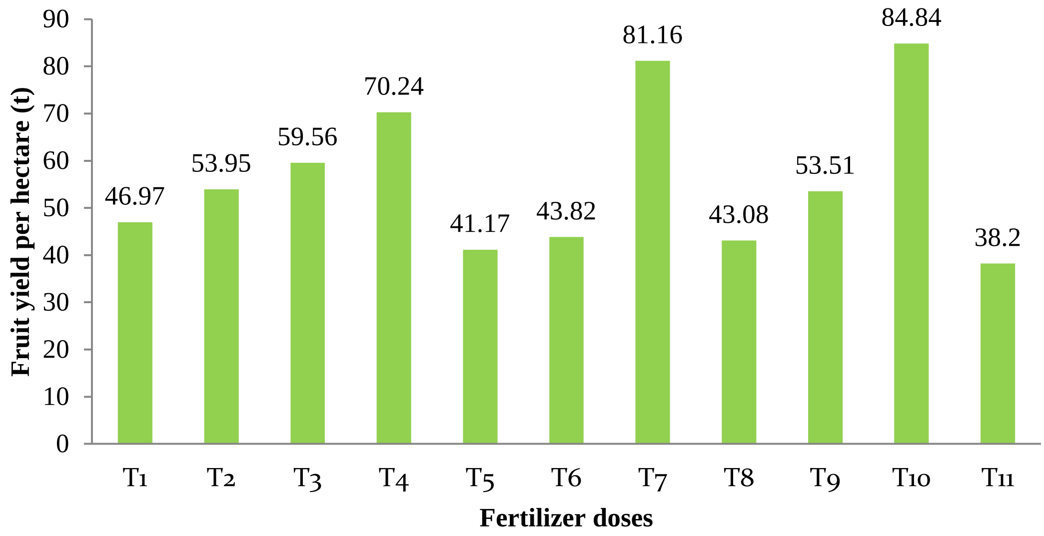

Figure 5. Effect of different doses of fertilizer on fruit yield per hectare of cherry tomato

Here, T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}

4.13 Number of seeds per fruit

Different fertilizer doses of sulphur, zinc, and boron applied to the experimental plot had a significant impact on the number of seeds per cherry tomato fruit (Table 2). According to the experimental results, the T_{10} treatment had the highest seeds per cherry tomato fruit (98.22). While the T_{11} treatment had the lowest seeds per cherry tomato product, (89.22). Sulfur is an essential component and a decidable factor for seed yield and the quality of seeds. Boron is important to cell division and seed development. The function of zinc is to help the plant produce chlorophyll thereby influenced plant growth and seed development. Solanki *et al.* (2017) found that reported that application of sulphur @ 40 kg/ha enhanced number of seeds per umbellate over control in coriander. Naga *et al.* (2013) reported that the application of micronutrients had a significant impact on tomato seeds number.

Table 2. Effect of sulphur, zinc and boron fertilizers on weight of individual fruit, fruit yield per plant, fruit yield per plot, and number of seeds per fruit of cherry tomato

Treatments	Weight of individual fruit (g)	Fruit yield per plant (kg)	Fruit yield per plot (kg)	Number of seeds per fruit
T_1	7.04 fg	2.54 f	15.22 f	91.55 de
T_2	8.13 d	2.91 e	17.48 e	91.88 d
T_3	8.54 d	3.22 d	19.29 d	93.55 c
T_4	9.37 c	3.79 c	22.76 c	96.88 b
T_5	7.28 ef	2.22 gh	13.33 gh	91.66 d
T_6	6.32 g	2.36 fg	14.19 fg	90.55 ef
T_7	11.09 b	4.38 b	26.29 b	96.66 b
T_8	6.56 fg	2.33 g	13.95 g	90.44 f
T_9	7.88 de	2.88 e	17.34 e	91.55 de
T_{10}	12.51 a	4.58 a	27.49 a	98.22 a
T_{11}	5.36 h	2.06 h	12.38 h	89.22 g
CV%	8.25	4.23	4.23	5.25
$LSD_{(0.05)}$	0.8212	0.1931	1.1585	1.0708

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of significance. Here, T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1}, T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}.

4.14 Seed yield per plant (g)

The application of various sulphur, zinc and boron fertilizer doses had shown a significant effect on the seed yield per plant of cherry tomato (Table 3). According to the experimental result the T_{11} treatment had the lowest seed yield per plant of cherry tomato (16.22 g). While the T_{10} treatment recorded the height seed yield per plant of cherry tomato (19.12 g).

4.15 Seed yield per plot

The seed yield per plot of cherry tomato had been significantly influenced by the use of different sulphur, zinc, and boron fertilizer doses (Table 3). The results of the experiment showed that the cherry tomato seed yield per plot for the T_{11} treatment was the lowest (97.3 g). While the T_{10} treatment was recorded the height of cherry tomato seed yield per plot (114.64 kg).

4.16 Seed yield per hectare (kg)

Cherry tomato seed yield per hectare had shown significant impacted by the application of different sulphur, zinc, and boron fertilizer doses (Table 3). Experimental result revealed that the T_{10} treatment was recorded the highest cherry tomato seed yield per hectare (353.83 kg) while the lowest cherry tomato seed yield per hectare (300.30 kg) was measured from the T_{11} treatment. The result was similar with the findings of Ghosh *et al.* (2007) who reported that application of 40 kg S ha^{-1} increased the seed yield in soybean.

4.17 Germination percentage

The application of different of doses of sulphur, zinc, and boron fertilizer on seed germination percentage of cherry tomato was found to be non-significant effect. (Table 3). Experimental result showed that the highest seed germination percentage (90.44 %) was observed in T_{10} treatment. While the T_{11} treatment had the lowest seed germination percentage (84.99 %).

4.18 Vigority index

cherry tomato seed vogority index was shown significant effect due to application of different doses of sulphur, zinc and boron fertilizer. (Table 3). According to the experimental results the highest vogority index of cherry tomato (3014.20) was observed in the T_{10} treatment. However. the T_{11} treatment had the lowest vogority index of cherry tomato (2578.00) which was statistically similar with T_6 (2622.30) treatment.

Table 3. Effect of sulphur, zinc and boron fertilizers on seed yield per plant, seed yield per plot, seed yield per hectare, germination percentage and vigority index of cherry tomato

Treatments	Seed yield per plant (g)	Seed yield per plot (g)	Seed yield per hectare (kg)	Germination percentage	Vigority index
T_1	17.66 e	105.98 e	327.09 e	87.26	2704.10 cd
T_2	17.77 de	106.64 de	329.13 de	87.77	2633.30 e
T_3	17.99 cd	107.98 cd	333.28 cd	88.21	2733.70 c
T_4	18.22 c	109.30 c	337.34 c	88.88	2814.40 b
T_5	16.88 fg	101.30 fg	312.65 fg	86.66	2657.50 de
T_6	16.64 g	99.85 g	308.17 g	86.44	2622.30 ef
T_7	18.77 b	112.64 b	347.65 b	89.88	2846.00 b
T_8	17.12 f	102.64 f	316.79 f	85.77	2632.50 e
T_9	17.66 e	105.98 e	327.09 e	87.11	2703.70 cd
T_{10}	19.12 a	114.64 a	353.83 a	90.44	3014.20 a
T_{11}	16.22 h	97.3 h	300.30 h	84.99	2578.00 f
CV%	6.12	6.12	6.12	7.24	4.25
$LSD_{(0.05)}$	0.3000	1.8001	5.5558	6.03^{ns}	53.830

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of significance. Here, T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}.

4.19 Economic analysis

A crucial factor in choosing the best agricultural community-acceptable solutions that were also economically feasible was economic analysis. The cost of cultivation, net and gross returns, as well as the benefit cost ratio of the different treatments are investigated in the current study are shown in (Table 4)

4.19.1 Cost of cultivation

Economic analysis was a significant criterion in selecting the most efficient agricultural community-acceptable solutions that were also economically viable. The cultivation costs, net and gross returns, and benefit cost ratios of the various treatment combinations examined in the current research are shown in (Table 4). The T_{10} treatment recorded the highest cultivation costs (TK. 190218/-). While the T_{11} treatment recorded the lowest cultivation cost (TK. 172549/-).

4.3.2 Gross Return

Gross returns in the current inquiry varied from Tk. 382000 to Tk. 848400 for various treatments. Out of all the treatments, that were examined, T_{10} treatments provided the greatest gross returns of Tk. 848400 while T_{11} (control) provided the lowest gross returns of Tk. 382000 (Table 4).

4.3.3 Net Return

The T_{10} treatment produced the highest net returns per hectare of Tk. 658182 in SAU yellow cherry tomato cultivation, while the T_{11} (control) treatment combination produced the lowest net returns of Tk. 209451 (Table 4).

4.3.4 Benefit Cost Ratio (BCR)

From all the treatment combinations examined in this experiment, T_{10} treatment produced the greatest benefit-cost ratio of 4.46 while T_{11} (Control) produced the lowest benefit-cost ratio of 2.21 (Table 4).

Table 4. Economic analysis of cherry tomato as influenced by different treatments

Treatments	Fruit yield (t ha^{-1})	Total cost of production (tk)	Gross return/ha (tk)	Net return/ha (tk)	Benefit Cost Ratio (BCR)
T_1	46.97	179304	469700	290396	2.61
T_2	53.95	183783	539500	355717	2.93
T_3	59.56	188262	595600	407338	3.16
T_4	70.24	192742	702400	509658	3.64
T_5	41.17	185418	411700	226282	2.22
T_6	43.82	186840	438200	251360	2.34
T_7	81.16	189684	811600	621916	4.27
T_8	43.08	184352	430800	246448	2.33
T_9	53.51	186308	535100	348792	2.87
T_{10}	84.84	190218	848400	658182	4.46
T_{11}	38.20	172549	382000	209451	2.21

Total cost of production was done in details according to the procedure of Krishitattik Fasaler Upadan O Unnayan (in Bengali), by Alam *et al*. (1988), pp:231-239.

Sale of marketable part @ Tk. 10000/ton

Net return =Gross return - Total cost of production

Benefic cost ration= Gross return ÷ Total cost of production

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from September 2021 to April 2022 in Rabi season to study the effect of sulphur, zinc and boron nutrients on growth and seed yield of SAU yellow cherry tomato. The experiment consisted of ten treatments, and followed Randomized Complete Block Design (RCBD) with three replications. The experiment was laid out in randomized complete block design (RCBD) with three replications and consisted of ten treatments *i.e.* T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}. Experimental results revealed that different doses of sulphur, zinc and boron fertilizers application significantly influenced the growth and seed yield of SAU yellow cherry tomato.

In case of different treatments, the highest plant height, number leaves per plant, number of cluster per plant, number of leaves per plant, were observed in T_{10} ($S_{20}Zn_4B_3$ Kg ha^{-1}) treatment. However this treatment also recorded the highest, number of flowers per cluster (62.91), number of flowers per plant (568.77), number of fruits per cluster (77.11), total number of fruits per plant (499.44), individual fruit weight (12.51 g), height fruit yield per plant (4.58 kg), fruit yield per plot (27.49 kg), fruit yield per hectare (84.84 t), seeds per tomato fruit (98.22), seed yield per plant (19.12 g), seed yield per plot (114.64 kg), seed yield per hectare (353.83 kg), seed germination (90.44 %) and vogority index (3014.20). While the lowest number of flowers per plant (484.11), number of fruits per cluster (44.46), total number of fruits per plant (440.44), individual fruit weight (5.36 g), fruit yield per plant (2.06 kg), fruit yield per plot (12.38 kg), fruit yield per hectare (38.20 kg), seeds per tomato (89.22), seed yield per plant (16.22 g), seed yield per plot (97.3 g), seed yield per hectare (300.30 kg), seed germination percentage (84.99 %) and vogority index (2578.00) were observed in T_{11} treatment.

Conclusion

Based on the findings experimental results revealed that different doses of sulphur, zinc and boron fertilizers application significantly influenced the growth and seed yield of SAU yellow cherry tomato.

The effect of sulphur, zinc and boron on growth, seed yield of SAU Yellow Cherry tomato (Golden purna) revealed that the maximum parameters were found to give better resulted from T_{10} ($S_{20}Zn_4B_3$ Kg ha^{-1}) treatment while the minimum were found from T_{11} ($S_0Zn_0B_0$ Kg ha^{-1}) treatment.

Therefore, it was suggested that cultivation of cherry tomato through application of $S_{20}Zn_4B_3$ Kg ha^{-1} (T_{10} treatment) would help to influenced plant growth and increase its ability to enhance better seed yield production of SAU yellow cherry tomato.

Recommendations

Considering the results of the experiment, further studies in the following areas are suggested:

- ✓ Different doses of S, Zn and B fertilizer may be taken for further experiments to get more accurate result.
- ✓ Studies of similar nature could be carried out in different agro-ecological zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.

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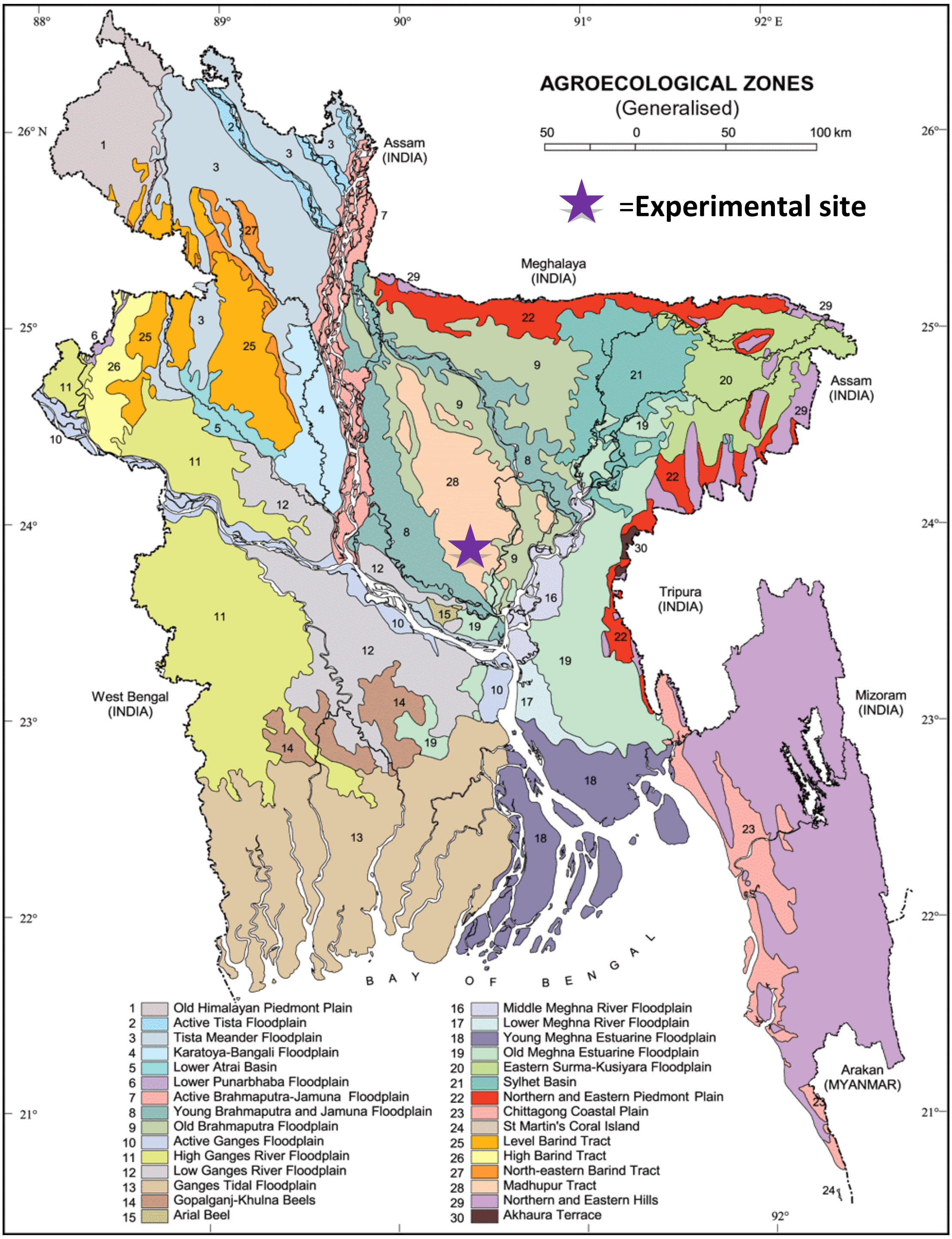
APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	Characteristics
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0-15 cm depth)

Physical characteristics	
Constituents	**Percent**
Clay	29 %
Sand	26 %
Silt	45 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10
Organic carbon (%)	0.45
Organic matter (%)	0.78
pH	5.6
Total nitrogen (%)	0.03

Sourse: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix III. Monthly meteorological information during the period from September 2021 to April, 2022.

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Average rainfall (mm)
		Maximum	Minimum		
2021	September	31.5	25.4	81	252 mm
	October	31.2	23.9	76	52 mm
	November	29.6	19.8	53	00 mm
	December	28.8	19.1	47	00 mm
2022	January	25.5	13.1	41	00 mm
	February	25.9	14	34	7.7 mm
	March	31.9	20.1	38	71 mm
	April	34.6	23.4	67	169 mm

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Per hectare production cost of cherry tomato

A. Input cost

Treatments	Labour	Ploughing	Seed	Irrigation	Pesticides	Manure and fertilizer							Subtotal (A)
						Cowdung	Urea	TSP	MoP	Sulphur	Zinc	Boron	
T_1	30000	12000	5000	10000	6000	15000	4000	4400	2250	0	2400	3300	94350
T_2	30000	12000	5000	10000	6000	15000	4000	4400	2250	3780	2400	3300	98130
T_3	30000	12000	5000	10000	6000	15000	4000	4400	2250	7560	2400	3300	101910
T_4	30000	12000	5000	10000	6000	15000	4000	4400	2250	11340	2400	3300	105690
T_5	30000	12000	5000	10000	6000	15000	4000	4400	2250	7560	0	3300	99510
T_6	30000	12000	5000	10000	6000	15000	4000	4400	2250	7560	1200	3300	100710
T_7	30000	12000	5000	10000	6000	15000	4000	4400	2250	7560	3600	3300	103110
T_8	30000	12000	5000	10000	6000	15000	4000	4400	2250	7560	2400	0	98610
T_9	30000	12000	5000	10000	6000	15000	4000	4400	2250	7560	2400	1650	100260
T_{10}	30000	12000	5000	10000	6000	15000	4000	4400	2250	7560	2400	4950	103560
T_{11}	30000	12000	5000	10000	6000	15000	4000	4400	2250	0	0	0	88650

Note: Urea 1 kg= 20 taka, Tsp 1 kg = 22 taka, Mop 1 kg = 15 taka, Boric acid 1 kg 300 taka, Gypsum 1 kg 70 taka, Zinc sulphate 1 kg 200 taka

B. Overhead cost (Tk./ha)

Treatments	Cost of lease of land for 6 months (13.5%of value of landTk.1000,000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 13.5% of cost/year	Subtotal (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
T_1	67500	4717	12737	84954	179304
T_2	67500	4906	13247	85653	183783
T_3	67500	5095	13757	86352	188262
T_4	67500	5284	14268	87052	192742
T_5	67500	4975	13433	85908	185418
T_6	67500	5035	13595	86130	186840
T_7	67500	5155	13919	86574	189684
T_8	67500	4930	13312	85742	184352
T_9	67500	5013	13535	86048	186308
T_{10}	67500	5178	13980	86658	190218
T_{11}	67500	4432	11967	83899	172549

Here, T_1= $S_0Zn_4B_2$ Kg ha^{-1}, T_2= $S_{10}Zn_4B_2$ Kg ha^{-1}, T_3= $S_{20}Zn_4B_2$ Kg ha^{-1}, T_4= $S_{30}Zn_4B_2$ Kg ha^{-1}, T_5= $S_{20}Zn_0B_2$ Kg ha^{-1}, T_6= $S_{20}Zn_2B_2$ Kg ha^{-1}, T_7= $S_{20}Zn_6B_2$ Kg ha^{-1} , T_8= $S_{20}Zn_4B_0$ Kg ha^{-1}, T_9= $S_{20}Zn_4B_1$ Kg ha^{-1}, T_{10}= $S_{20}Zn_4B_3$ Kg ha^{-1}, T_{11}= $S_0Zn_0B_0$ Kg ha^{-1}.

Appendix V. Analysis of variance of the data on plant length, branches and cluster per plant of cherry tomato

Source of variation	**Degree of freedom**	Plant length (cm)	Plant length (cm)	Branch/plant	Branch/plant	Number of cluster/plant	Number of cluster/plant
		at vegetative stage	at flowering stage	at vegetative stage	at flowering stage	at vegetative stage	at flowering stage
Replication	2	0.4639	0.1755	0.58098	0.52311	0.34126	0.38669
Nutrients	10	17.0213**	22.624**	0.9038**	1.96658**	0.35426 ^{ns}	2.17445**
Error	20	1.0194	1.5212	0.21472	0.25147	0.48205	0.35653

** : Significant at 0.01 level of probability.

Appendix VI. Analysis of variance of the data on number of leaves per plant, flower per cluster, flower per plant, fruit per cluster and total number of fruit per plant

Source of variation	**Degree of freedom**	Number of leaves /plant At vegetative stage	Number of leaves /plant At flowering stage	Number of flower/cluster	Number of flower/plant	Number of fruit/cluster	Total no of fruit/plant
Replication	2	0.1298	0.4857	0.5717	5.35	0.907	2.22
Nutrients	10	41.6087**	89.5974**	61.4263**	2226.12**	319.103**	1228.3**
Error	20	0.3691	0.2819	1.7424	4.09	3	9.33

** : Significant at 0.01 level of probability.

Appendix VII. Analysis of variance of the data on yield characteristics of cherry tomato

Source of variation	**Degree of freedom**	Weight of individual fruit(gm)	Fruit yield/plant (kg)	Fruit yield per plot (kg)	Fruit yield per hectare (ton)	Number of seed/fruit	Seed yield per plant (gm)	Seed yield/plot (gm)	Seed yield/ha (kg)
Replication	2	0.024	0.451	0.864	8.231	0.0332	0.0332	1.1951	11.384
Nutrients	10	2.29592**	13.4853**	82.6531**	787.353**	2.33884**	2.33884**	84.1984**	802.073**
Error	20	0.0119	0.2136	0.4285	4.082	0.03121	0.03121	1.1236	10.703

** : Significant at 0.01 level of probability.

Appendix VIII. Analysis of variance of the data on Germination percentage and vigority index of cherry tomato

Source of variation	**Degree of freedom**	Germination percentage	Vigority index
Replication	2	3.21389	12.4
Nutrients	10	8.40912^{ns}	48233.8**
Error	20	0.65541	1110.4

** : Significant at 0.01 level of probability.