INFLUENCE OF SALICYLIC ACID AND MICRONUTRIENTS ON MORPHOPHYSIOLOGY AND YIELD ATTRIBUTES OF TOMATO IN SUMMER

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CERTIFICATE

*This is to certify that the thesis entitled" **INFLUENCE OF SALICYLIC ACID AND MICRONUTRIENTS ON MORPHOPHYSIOLOGY AND YIELD ATTRIBUTES OF TOMATO IN SUMMER"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **HORTICULTURE,** embodies the results of a piece of bona fide research work carried out by **ABIDA SULTANA,** Registration. No. **11-04307** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

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INFLUENCE OF SALICYLIC ACID AND MICRONUTRIENTS ON MORPHOPHYSIOLOGY AND YIELD ATTRIBUTES OF TOMATO IN SUMMER

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ABSTRACT

A pot experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from April 2016 to September 2016. The two factors experiment was laid out in Complete Randomized Design with four replications. Factor A is different doses of salicylic acid viz. S_0: Control, S_1: 0.25 mM Salicylic acid, S_2: 0.5 mM Salicylic acid and factor B is different levels of micronutrients viz. M_0: Control, M_1 : 20 mg of zinc, M_2 : 2 mg of boron, M_3 : 10 mg zinc + 1 mg boron, M_4 : 20 mg zinc + 2 mg boron. The experimental results showed that micronutrients and salicylic acid significantly affects morphology, physiology, yield contributing characters and yield of tomato. In case of salicylic acid, the highest yield per plant (1260.40 g) was found in S_2 and the lowest yield (1099.50 g) was found in S_0. In case of micronutrients, the highest yield per plant (1691.50 g) was found in M_4 and the lowest yield (793.50 g) was found in M_0. The interaction effect of salicylic acid and micronutrients influenced all most all parameters of morphophysiological and yield attributing characters of tomato, where the highest yield was (1872.22 g) was found in S_4M_4 (20 mg zinc + 2 mg boron and 0.5 mM salicylic acid) and the lowest yield (736.04 g) was found in S_0M_0 (Control Condition). These results suggest that salicylic acid and micronutrients can alleviate the detrimental effect of summer to increase the yield of tomato.

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LIST OF ACRONYMS

AEZ	:	Agro- Ecological Zone
Anon	:	Anonymous
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
B	:	Boron
BINA	:	Bangladesh Institute of Nuclear Agriculture
BRRI	:	Bangladesh Rice Research Institute
CV	:	Coefficient of Variance
cv.	:	Cultivar (s)
DAT	:	Days After Transplanting
^{0}C	:	Degree Centigrade
et al.		And others
FAO	:	Food and Agriculture Organization of United Nations
HI	:	Harvest Index
IRRI	:	International Rice Research Institute
i. e.	:	That is
K_2O	:	Potassium Oxide
SE	:	Standard of error
M_OP	:	Muriate of potash
NS	:	Non significant
P_2O_5	:	Phosphorus Penta Oxide
SA	:	Salicylic Acid
SAU	:	Sher-e- Bangla Agricultural University
SRDI	:	Soil Resources Development Institute
t ha^{-1}	:	Ton per hectare
TSP	:	Triple Super Phosphate
var.	:	Variety
Zn	:	Zinc

CHAPTER I

INTRODUCTION

Tomato *(Lycopersicon esculentum)* is one of the most valuable vegetable crops in Bangladesh. It is a worldwide cultivated crop. It belongs to *Solanaceae* family. It ranks 2nd which is next to potato. It was introduced in Subcontinent by the Europeans. Later on local people also started its consumption due to its popularity. It is now used everywhere in the country in so many forms. Tomato is a good source of carotenoids, in particular lycopene and phenolic compounds and lessens the risks of cardiovascular disease and certain types of cancer, such as cancers of prostate, lung and stomach. It also contains mineral and vitamins.

The popularity of tomato and its different products are increasing day by day. It is a nutritious and delicious vegetable used in salads, soups and processed into stable products like ketchup, sauce, marmalade, chutney and juice. Tomato contains 94.1% water, 23 calories energy, 1.90 g protein, 1 g calcium, 7 mg magnesium, 1000 IU vitamin A, 31 mg vitamin C, 0.09 mg thiamin, 0.03 mg riboflavin, 0.8 mg niacin per 100 g edible portion (Rashid, 1983). Tomato has high nutritive value especially it can meet up some degree of vitamin A and C requirement, adds flavor to the foods, rich in medicinal value and also can contribute to solve malnutrition problem.

Tomato also cultivated both summer and winter conditions. Summer tomato is a profitable crop to the farmers. Due to its profitability, cultivation of summer tomato is becoming popular and extended to the farmers in different parts of the country for the last 7-8 years in Bangladesh. Summer tomato is a high value crop that ascertains higher income from per unit area of land (Zaman *et al*., 2010).

But it is difficult to grow tomato in summer season due to adverse climatic conditions, such as high temperature, high rainfall, and hail storms. It is susceptible to high temperature, especially the large fruited fresh varieties. High night temperature may lead to lower fruit set of small fruit development. Most favorable temperature for fruit set is 25-30°C. High light intensity with high temperature are decrease fruit set. Optimum condition for fruit setting is available in winter season.

Endogenous salicylic acid act like a growth regulator. Salicylic acid or ortho-hydroxy benzoic acid and other salicylates are known to affect various physiological and biochemical activities of plants. It functions as an indirect signal stimulating many physiological, biochemical and molecular processes and therefore it affects the plant growth and development (Klessig and Malamy, 1994; Malamy *et al*., 1990). Salicylic acid affect various physiological and biochemical activities and regulating their growth and productivity (Hayat *et al.*, 2010). In tomato, the fruit yield enhanced significantly when lower concentrations of salicylic acid sprayed (Larque-Saavedra and Martin-Mex, 2007).

Exogenous application of SA increases plant photosynthesis (Fariduddin *et al*., 2003) on the synthesis of secondary plant metabolites and on antioxidant activity (Eraslan *et al*., 2007). Salicylic acid is the beneficial effect on plant adaptation (resistance, increase tolerance) to stress factors including heat, salinity etc. (Liu *et al*., 2006; Shi *et al.*, 2006; Larkindale and Huang, 2005). Foliar application of salicylic acid in tomato plant enhanced the flowering and pod formation. (Kumar *et al.*, 1999). In tomato plant, the fruit yield enhanced significantly when the plants were sprayed with lower concentrations of salicylic acid (Larque-Saavedra and Martin-Mex, 2007). So, it is necessary to investigate the effect of salicylic acid and micronutrients (Zn+B) on flowering, fruit formation and yield of summer tomato to increase the total production.

Micronutrients have different functions in tomato plant. It plays a key role in the physiological processes of plants such as maturation, cell elongation and cell division, nucleic acid metabolisms, cytokinin synthesis, auxin and phenol metabolisms (Lewis, 1980). Boron has a role on quality of tomato fruits such as size, shape, color, firmness and chemical composition. Due to the application of micronutrients quality parameter of tomato fruit enhanced (Naresh, 2002).

Foliar applications of micronutrients have a significant role of vegetative growth, fruit set and yield of tomato. (Adams, 2004). Zinc and boron are important micronutrients for tomato plant. Zinc has a vital effect on growth and development of tomato such as carbohydrates and protein metabolism (Vasconcelos *et al.,* 2011). Boron efficiency increases yield and quality of tomatoes (Davis *et al.,* 2003).Foliar application of micronutrients is also a secured way (Aghtape *et al.,* 2011). Boron has a key role on accumulation of photosynthates that has correlation with fruit weight (Shukha, 2011). Zinc and boron has a role on physiological attributes of tomato and its involvement of protein metabolism, pectin synthesis, maintaining water relation in plant, and translocation of sugar at development of the flowering and fruiting stages (Bose and Tripathi, 1996).

OBJECTIVES:

i) To investigate the morpho-physiology and production of summer tomato with the application of salicylic acid;

ii) To investigate the morpho-physiology and production of summer tomato with the application of micronutrients (zinc + boron) and

iii) To find out the combined effect of salicylic acid with zinc and boron for higher yield and quality of tomato in summer.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most popular and widely grown vegetables of the world and also important vegetable crops in Bangladesh, which received much attention to the researcher throughout the world. The production level of summer tomato never meets the demand of Bangladesh. High temperature and dry whether round the year lead the loss of production. An attempt has been made in this chapter to present relevant review of literature on the research works performed till to date in Bangladesh and other part of the world in relation to the effects of micronutrients and salicylic acid on growth and yield of tomato in summer.

2.1. Literatures on Salicylic Acid

Salicylic acid (SA) is a phenolic compound and natural constituent of plant. Salicylic acid was recognized as an endogenous regulator in plants. It is a secondary plant product performs important actions in the growth and development processes of plants.

Kirti and Kumar (2016) carried an experiment in order to increase the germination of tomato seeds under high temperature stress conditions seed priming by salicylic acid was investigated. The experiment was conducted to study the effect of salicylic acid on the tomato vegetative growth, yield and fruit quality. These factors included salicylic acid in three levels (0.25 mM, 0.5 mM and 0.75 mM) applied on tomato. Results indicated that germination and vegetative & reproductive growth of tomato severely reduced by high temperature. Seeds primed with 0.5mM salicylic acid not only improved germination percent but also reduced germination time under stress conditions. The TSS, TA, vitamin C and lycopene content of tomato fruit had significantly affected by application of salicylic acid. The exogenous applications of salicylic acid improved the yield contributing factors that resulted in significant increases in tomato fruit yield.

Alam (2015) carried an experiment to evaluate effort of varieties and salicylic acid on morph-physiology and yield of mustard. Factor A: Mustard varieties (5 varieties)–V_1: Tori 7, V_2: BARI Sarisha 13, V_3: BARI Sarisha 14 and V_4: BARI Sarisha 15, V_5: BARI Sarisha 16. Factors B: Levels of salicylic acid (3 levels) – S_0: 0 mM SA (control), S_1: 0.2 mM SA, S_2: 0.4 mM SA; it replicated three times. The highest plant height, leaf number and number of branches per plant were found in V_5 (BARI Sarisha 16). The lowest transpirational water loss (%) was recorded in V_5. Due to different mustard varieties, the highest number of siliqua per plant (185.23) was observed from V_5, whereas the lowest number (85.00) was found from V_2. The salicylic acid showed significant reduction of days required to flowering and harvesting. The highest number of siliqua per plant (113.88) the highest seed yield (1.74 t/ha) was found from S_2, while the lowest number (107.78), the lowest seed yield (1.47 t/ha) was observed from S_0. For the interaction effect of mustard varieties and levels of salicylic acid, the highest number of siliqua per plant (192.23), the highest seed yield (2.30 t/ha) was observed from S_2V_5 and the lowest number of siliqua per plant (73.33), the lowest seed yield (1.01 t/ha) was from S_0V_4 treatment combination.

Amira and Qados, (2015) conducted an experiment to investigate the effect of salinity stress on growth, chemical constituents and yield, and to examine whether salinity stress can be offset by the exogenous application of SA on sweet pepper (*Capsicum annuum* L). Salinity stress (2000, 4000 or 6000 ppm) decreased plant growth and marketable yield but SA (250 ppm) treatment as foliar spray counteracted significantly the harmful effects of low and moderate salinity stress levels (2000 and 4000 ppm) and partially counteracted the harmful effects under the highest salinity stress level (6000 ppm).

Mahdi, *et al.* (2014) stated that the influence of SA on some quality characters of tomato at different concentration of SA (10^{-2}, 10^{-4}, 10^{-6}, 10^{-8} M and control) was done in seedling stage as foliar application. Measured characters was including number of cluster in a bush, yield, fruit number in cluster, fruit number, fruit weight and fruit diameter. Obtained results of this study show that SA significantly affected number of cluster in a bush, yield, fruit number in cluster, fruit number in bush, fruit weight and fruit diameter. Among foliar application, the highest rate of tomato yield with mean of 3059.5 g obtained in SA_3 (SA at 10^{-6} M), highest numbers of cluster in tomato bushes with mean of 31.25 measured in SA_1 (SA at 10^{-2} M). The highest fruit number in cluster and highest fruit number in bush obtained by mean of 3.5 and 66.75 in SA_1 (SA at 10^{-2} M), respectively and minimum amount of all this characters was recorded in control treatment and the highest amount of fruit weight and also fruit diameter was measured in control treatment with mean of 61.50 g and 51.75 mm, respectively.

Guzmán-Téllez *et al*. (2014) reported that plant tolerance to stress may be chemically induced with applications of salicylic acid (SA). The aim of this study was to determine the change of leaf concentration of tomato over time in response to SA spraying in greenhouse condition. Two days after the first application, the SA foliar concentration reached the maximum of 8 μg/g, equivalent to twice the amount observed in the control plants. A second application showed actually the same response, but with a faster decline of SA in two days. According to the results of this assay, SA applications on tomato should be performed within a minimum interval of eight days in order to maintain the SA concentration related with the increase in plant tolerance to environmental stress.

Karim *et al,* (2013) conducted a study in order to examine the effect of salicylic acid on growth, yield and yield components of strawberry plants with four replications this factor included of salicylic acid in 3 levels (0.25,0.5 and 75mM) spray on strawberry. Results showed that salicylic acid 0.25m M significantly affected on growth, yield and yield components of strawberry plants.

Ghasemi-Fasaei, (2013) revealed that foliar application of SA decreased mean dry weight of cucumber by 31%, while its effect on mean dry weight of chickpea was negligible. Foliar application of SA reduced mean uptake of Cu and Fe in chickpea shoot by 31 and 18%, respectively. The effect of SA on mean Zn uptake in chickpea shoot was negligible. Foliar application of SA caused an increase in mean Mn uptake of chickpea shoot by about 7%. The influence of SA levels on mean dry matter weight in chickpea was uncertain. The effects of SA levels on the uptakes of Mn was insignificant. Application of 4 mg SA/kg increased mean uptakes of Fe, Cu and Zn by 7.1, 8.5 and 9.6%, respectively. Application of 4 mg SA/kg increased mean uptakes of metal micronutrients compared to the control although the increase for Fe uptake was negligible. Application of 4 mg SA/kg increased mean uptakes of Mn, Cu and Zn by 18.7, 100, and 18.6%, respectively. In chickpea shoot, the uptakes of all metal micronutrients other than Fe were significantly correlated with each other. According to the results of present study it appears that SA was efficient to be recommendable for correcting metal micronutrients deficiency under micronutrients deficient conditions.

Salwa, *et al.* (2013) investigated that the effect of SA on growth criteria (shoot height and shoot dry weight), soluble sugars and protein, antioxidant enzymes (SOD, APX and GR) activities and specific activities, lipid peroxidation, electrolyte leakage and yield criteria (Pod weight, seed weight, seed number and 100 gm seed weight). The obtained results showed that salt treatments provoked oxidative stress in faba bean plants as shown by the increase in lipid per oxidation and electrolyte leakage and consequently negatively affected growth and yield criteria. Foliar spray with SA at the concentration of 2 mM followed by 1 mM mitigated the harmful effects of salt stress through the enhancement of the protective parameters, such as antioxidant enzymes, soluble sugars and proteins and consequently improved growth and yield criteria.

Sadeghipour and Aghaei (2012) conducted an experiment to investigate the influence of foliar SA application on some traits of common bean under water stress conditions in Iran during 2011. Results showed that drought decreased plant height, leaf area index (LAI) and protein yield but increased seed protein content. Nevertheless, seeds soaking in SA (especially 0.5 mM) diminished drought damages and increased plant height, LAI and protein yield in both water stress and optimum conditions. SA application also reduced seed protein content. Results indicate that exogenous application of this phytohormone can act as an effective tool in improving the growth and production of common bean under water stress conditions.

El-Yazied (2011) conducted a field experiment to study the effect of foliar application with 50 and 100 ppm of SA and 50 & 100 ppm chelated Zn and their combination on some growth aspects, photosynthetic pigments, minerals, endogenous phytohormones, fruiting and fruit quality of sweet pepper cv. California Wonder during autumn 2009 and 2010 seasons. Results indicated that different applied treatments significantly increased all studied growth parameters, namely, number of branches and leaves per plant, leaf area per plant and leaf dry weight. Furthermore, the highest early, marketable and total yields as well as physical characters of sweet pepper fruits were obtained with 100 ppm SA plus chelated 50 ppm zinc followed by 50 ppm SA plus 100 ppm Zn.

Hayat *et al.* (2008) reported that *Lycopersicon esculentum* L. cv. K-25 plants under water stress condition and water holding for 10 days at 20 (WS I) and 30 (WS II) days after sowing (DAS). Seedlings were sprayed with 10^5 M salicylic acid (SA) at 45 DAS. The water stress at earlier stage of growth (20 day stage) was more inhibitory as compared to the later stage (30 day stage). A follow-up treatment with SA protected against the stress generated by water and significantly influenced several parameters. However, proline content and antioxidant enzymes increased under drought as well as under SA treatments.

Gutierrez-Coronado *et al. (*1998) concluded that SA has a growth-stimulating effect in soybean plants. When soybean plants treated with 10 µM, 100 µM, and up to 100 µM SA, shoot and root growth increase 20% and 45% respectively, at seven days after application.

2.2 Literatures on micronutrients

Micronutrients assist the photosynthesis and the synthesis of chlorophyll in green plants. Quality and yield potential of tomato can be enhanced by maintaining adequate level of nutrients by soil or by foliar application of micronutrients. It becomes promptly available to crop plants.

Sivaiah *et al.* (2013) was conducted field experiment during rabi-2010 to find out the response of foliar application of micronutrients on vegetative and reproductive growth attributes, in two varieties of tomato viz-Utkalkumari 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 micronutrients except manganese at 50 ppm were applied at 100 ppm in three sprays at an interval of ten days starting from 30 days after transplanting. 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 in both the varieties out of which application of micronutrients mixture showed the maximum effect. In tomato cv. UtkalKumari, 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%). In Utkal Kumari, the fruit yield per plant ranged from 1.336 to1.867kg and in Utkal Raja, it ranged from 1.500 to 1.967 kg. In both the varieties, combined application of micronutrients produced the maximum fruit yield followed by application of boron and zinc.

Gurmani *et al*. (2012) conducted a glasshouse pot experiment to study the effect of soil applied zinc @ 0.5, 10 & 15 mg kg $^{-1}$) on the growth, yield and biochemical attributes in two tomato cultivars; VCT-1 and Riogrande. The result showed that 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 Zn application at

10 mg kg^{-1} Soil. Application of 5 mg Zn kg^{-1} had lower dry matter production as well as fruit yield when compared with Zn 10 and 15 mg kg$^{-1.}$ The percent increase of fruit yield at 5 mg Zn kg^{-1} was 14 and 30% in VCT^{-1} and Riogrande, respectively. In the same cultivars, Zn application @ 10 mg Zn kg^{-1} caused 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 Zn. Zn application at 10 and 15 mg kg^{-1} significantly increase chlorophyll, sugar, soluble protein, superoxide dismutase and catalase activity in leaf of both cultivars. The result of the study suggested that soil application of 10 mg Zn kg^{-1} soil have a positive effect on yield, biochemical attributes and enzymatic activities of both the tomato cultivars.

Naz *et al*. (2012) conducted an experiment to study the effect of boron on the growth and yield of tomato at Horticultural Research Farm, NWFP Agricultural University, Peshwar during 2008-09. They used different doses of B (0, 0.5, 1.0, 2.0, 3.0 and 5.0 kg ha^{-1}) with constant doses of nitrogen, phosphorus and potash was incorporated at the rate of 150, 100 and 60 kg ha^{-1}. Boron showed a significant effect on the growth and yield of tomato. In the experiment 2 kg ha^{-1} resulted in maximum numbers of flower clusters per plant, fruit set percentage, total yield and total soluble solid. 'Rio Grand' cultivar of tomato showed significant effect on all parameters. Maximum number of flower clusters per plant, fruit set percentage and total yield were recorded with 'Rio Grand' cultivar of tomato. They have further mentioned that 2 kg B ha^{-1} significantly affected flowering and fruiting of 'Rio Grand'cultivar.

Sbartai *et al.* (2011) conducted a field experiment to evaluate the response of tomato plants (*Lycopersicon esculentum* L. var. Rio Grande) treated with zinc. This is done by analyzing the effect of zinc on the rate of chlorophyll and enzyme activity involved in the antioxidant system. Plants previously grown on a basis nutrient solution is treated by increasing concentrations of $ZnSO_4$ (0, 50, 100, 250, 500 M) for 7 days. The result showed that Zn does not affect the amount of chlorophyll at 50 and 100 microns, while it seems to inhibit the higher concentrations (250 and 500 microns). On the other hand, treatment with Zn induced the activity of enzymes studied for higher concentrations. Finally, the determination of Zinc in the roots and leaves of tomato shows a greater accumulation in the roots compared to leaves.

Salam *et al*. (2010) carried an experiment at the vegetable research farm of the Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydevpur, Gazipur during the period 2006-2007 to investigate the effects of boron and zinc in presence of different level of NPK fertilizers on quality of tomato. There were twelve treatment combination which comprised for level of boron and zinc viz., i) B_0Zn_0 = 0 kg B + 0 kg Zn/ha ii) $B_{15}Zn_{20}$ = 1.5 kg B + 2.0 kg Zn/ha iii) $B_{20}Zn_{40}$ = 2.0 kg B + 4.0 kg Zn/ha iv) $B_{25}Zn_{60}$ = 2.5kg B + 6.0 kg Zn/ha and three levels of NPK fertilizers viz., i) 50% less than the recommended NPK fertilizer dose (50%< RD), ii) Recommended NPK fertilizer dose (RD), iii) 50% more than the recommended NPK fertilizer dose (50% >RD). The highest pulp weight (88.14%), dry matter content (5.34%), TSS (4.50%), ascorbic acid (10.95mg/100gm), lycopene content (112.00 µg/100gm), chlorophyll-b (56.00 µg/100g), marketable fruits at 30 days after storage (67.48%) and shelf life (16 days) were recorded with the combination of 2.5 kg B + 6 kg Zn/ha and recommended dose of NPK fertilizers (N = 253. P = 90 Kg and K = 125kg/ha).

Patil *et al.* (2010) evaluated that the effect of foliar application of micronutrients on flowering and fruit-set of tomato. They have showed the flowering parameters like days required for initiation and 50% flowering, number of clusters, number of flowers, total number of flowers and fruit setting percentage per plant were influenced significantly due to different treatments. The minimum number of days (30.00) for initiation of flowering and 50% flowering (38.86) were recorded with B 50ppm and 100ppm while the maximum number of days were recorded in control. The treatment B 100 ppm + Fe 200ppm + Zinc 200ppm was most effective in increasing number of clusters (13.85) and number of flowers (51.24) per plant. Maximum number of flowers per cluster and percent fruit setting (47.76%) was recorded with B 50 ppm + Fe 100ppm + Zn 100ppm, while minimum was recorded in control.

Patil *et al.* (2008) conducted a field experiment to study the effect of foliar application of micronutrients on growth and yield of tomato (Megha) during 2005-06 and 2006-07 at the All India Coordinated Vegetables Improvement Project (AICVIP) in the University of Agricultural Sciences, Dharward. The results based on two years mean revealed that out of nine different treatments, the application of boric acid @ of 100 ppm resulted in maximum number of primary branches (18.30), yield per plant (2.07 kg) and fruit yield (30.50 t/ha). Followed by best treatment was the mixture of micronutrients (B, Zn, Mn and Fe @100 ppm and Mo @ 50 ppm) recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatments. The maximum benefit ratio of 1.80 was obtained with application of boron recording Rs 97.850/ha of net returns followed by the mixture of micronutrients (1.74) recording (1.74) recording Rs 88.900/ha net returns compared to control (1.40) which recorded minimum net returns of Rs 53.250/ha.

Basavarajeshwari *et al.* (2008) studied the effect of foliar application of micronutrients on growth and yield of tomato at the all Indian Coordinated Vegetables Improvement Project (AICVIP) in the University of Agricultural Sciences, Dharwad. The result based on two years mean revealed that out of nine different treatments, the application of boric acid @ of 100 ppm resulted in maximum number of primary branches (18.30), yield per plant (2.07 kg) and fruit yield (30.50 t/ha). Followed by the best treatment was the mixture of micronutrients (Bo, Zn, Mn and Fe 100ppm and Mo @ 50ppm recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatments.

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

Gurmani *et al*. (2012) conducted a glasshouse pot experiment, with two tomato cultivars VCT-1 and Riogrande, to assess the effects of four levels of soil application of B (0, 0.5, 1.0 and 1.5 mg kg^{-1}) in the form of borax on plant growth, biochemical content, antioxidant activity and fruit yield. Higher plant growth and fruit yield in both cultivars were achieved by the B1.0 and 1.5 mg kg^{-1} soil application respectively. Application of 0.5 mg Bkg^{-1} had lower dry matter production as well as fruit yield when compared with B 1.0 and 1.5 mg kg^{-1}. The percent increase of fruit yield at 0.5 mg Bkg^{-1} was 12 and 10, in VCT-1 and Riogrande respectively. In the samecultivars, B application @ 1.0 mg B kg^{-1} caused the fruit yield by 23 and21% while 1.5 mg B kg^{-1} enhanced by 22 and 20% respectively. Boron levels of B up to 250 ppm concentration in leaf, fruit and root increased with the increasing level of Boron application at 1.0 and 1.5 mg kg^{-1} significantly increased chlorophyll, sugar and protein content in both cultivars. Superoxide dismutase and catalase activity was significantly increased by the soil application of 1.5 mg B kg^{-1} in both cultivars of tomato. The study results showed that soil application of 1.0 mg B kg^{-1} soil have positive effect on plant growth, yield and biochemical.

Luis *et al.* (2012) studied the effect of boron on two variety of tomato. The objective of this research was to study the how B toxicity (0.5 and 2 m MB) affects the time course of different indicators of abiotic stress in leaves of two tomato genotypes having different sensitivity to B toxicity (cv. Kosaco and cv. Josefina). Under the treatments of 0.5 and2 m MB, the tomato plants showed a loss of biomass and foliar area. At the same time, in the leaves of both cultivars, the B concentration increased rapidly from the first day of the experiment. These results were more pronounced in the cv. Josefina, indicating greater sensitivity than in cv. Kosaco with respect to excessive B in the environment. The levels of (O_2 and anthocyanin presented a higher correlation coefficient (r>0.9) than did the levels of B in the leaf, followed by other indicators of stress, such as GPX, chlorophyll b and proline (r>0.8). Their results indicate that these parameters could be used to evaluate the stress level as well as to develop models that could help to prevent the damage inflicted by B toxicity in tomato plants.

Sakamoto (2012) conducted a study to demonstrate the only role of B in plants as the structural maintenance of cell wall. The author concluded that soil B, as boric acid, is acquired through roots and then distributed around the plant via the passive and active transport pathway. To adapt variations in the environmental B status, the active B transport system is tightly regulated at the molecular level in plants. In agriculture, both deficient and excess levels of soil B impair plant growth, resulting in the reduction of quantity and quality of crops. The major causes of B toxicity in plants contain oxidative stress, metabolism alteration and deoxyribonucleic acid damage.

Ejaz *et al.* (2011) studied conclude the efficacy of micronutrient of foliar application on tomato. The present research project was executed during 2008–2009, to evaluate the effect of Zn, B (micronutrients) in combination with N (macro-nutrient) for the tomato grown under high tunnel. Macro/micro-nutrients solutions were provided by4B Group of Fertilizers, Pakistan. The experiment was arranged in Completely Randomized Design (CRD) with five treatments and four replications. Foliar application of individual nutrients such as N (2%), B (5%) and Zn (6%) were used along with their combined mixture. In addition, a control treatment was also run as check. After the statistical analysis it was found that individual application of nutrient provide better results as compared to control but their combined effect (Zn = 6%, B = 5%, N = 2%) provided substantial results in plant heights, no. of leaves, no. of flowers, no. of fruits, average fruit weight and yield per plant. It is confirmed from the results that combination of macro-nutrients and micro-nutrients as foliar application has the ability to enhance the growth and yield of tomato positively.

Nada *et al*. (2010) conducted a study to clarify a critical concentration of excess boron (B) in nutrient solution for hydroponically cultured tomato. The study also concluded that the influences of excess B on growth, photosynthesis and fruit maturity. In tomato topped at the first truss, B concentrations higher than 2 ppm in nutrient solution resulted in a significant increase in leaf B concentration. At the fruit developmental stage, fresh weights of leaf and fruit were suppressed at 8 ppm and 4 ppm B in nutrient solution, respectively. Photosynthetic rate, respiration rate and stomatal conductance decreased with excess B at 4 ppm or higher concentration from the first truss flowering stage to fruit developmental stage. When tomato was topped at the second truss and limited to two fruits in each truss, excess B did not affect fruit growth or maturation in the first truss. However, fruit size and brix were reduced in the second truss. These may be caused by decrease in the photosynthate distribution to fruit in the second truss because of the decrease in photosynthetic activity. Furthermore, excess B could promote fruit maturity in the second truss because of production of ethylene with increase in injured leaves. Based on these results, the authors suggest that the critical concentration of B in nutrient solution is 4 ppm for long-term hydroponic cultivation of tomatoes.

Salam *et al.* (2010) carried a study at the Vegetable Research Farm of the Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur to investigate the effects of boron and zinc in presence of different levels of NPK fertilizers on quality of tomato. There were twelve treatment combinations which comprised four levels of boron and zinc viz. i) $B_0 Zn_0$ = 0 kg B + 0 kg Zn/ha, ii) $B_{1.5} Zn_2$ = 1.5 kg B + 2.0 kg Zn/ha, iii) $B_2 Zn_4$ = 2.0 kg B + 4.0 kg Zn/ha , iv) $B_{2.5} Zn_{6.0}$ = 2.5 kg B + 6.0 kg Zn/ha and three levels of NPK fertilizers viz., i) 50% less than the recommended NPK fertilizer dose (50% <RD), ii) Recommended NPK fertilizer dose (RD), iii) 50% more than the recommended NPK fertilizer dose (50% >RD). The highest pulp weight (88.14%), dry matter content (5.34%), TSS (4.50%), acidity (0.47%), ascorbic acid (10.95 mg/100g), lycopene content(112.00 μg/100g), chlorophyll-a (41.00μg/100g), chlorophyll-b (56.00 μg/100g), marketable fruits at 30 days after storage (67.48%) and shelf life (16 days) were recorded with the combination of 2.5 kg B+ 6 kg Zn/ha and recommended dose of NPK fertilizers.

Hossein (2008) studied a field experiment at Horticultural farm, BAU, Mymensingh during 2007-2008 to evaluate the effect of Zn and B on the growth and yield of Tomato. The treatments were four levels of Zn (0, 0.5, 1.0 and 1.8 kg ha^{-1}) and four levels of B (0, 0.1, 0.3 and 0.6 kg ha^{-1}). The highest fruit yield (74.88 t ha^{-1}) was obtained due to the application of 1.8 kg Zn and 0.1kg B ha^{-1}.

Kamruzzaman (2007) conducted a field experiment on tomato at the field laboratory of Crop Botany Department, BAU, Mymensingh. The experiment comprised of four levels of boron viz. @ 0, 0.4, 0.6 and 0.8kg B ha^{-1} as foliar application. Application of standard dose of boron 0.4kg B ha^{-1} was found to produce highest fruit yield (2166.6 kg ha^{-1}).

Sathya (2006) carried out an experiment to evaluate the various levels of B on yield of PKM1 tomato. The results revealed that the highest fruit yield of 33 t ha^{-1} was recorded in treatment that received borax @ 20 kg ha^{-1} and was found to be significantly superior to rest of the treatments (0, 5, 10, 15 and25 kg ha^{-1}). The yield increase was about 33.6 per cent over control.

Yadav *et al.* (2006) concluded the effects of boron (0.0, 0.10, 0.15, 0.02, 0.25, 0.30 or 0.35%), applied to foliage after transplanting, on the yield of tomato cv. DVRT-1 in Allahabad, Uttar Pradesh, India, during 2003-04. The highest number of fruits per plant (44.0), number of fruits per plot (704.0),yield per plant (0.79kg), yield per plot (12.78kg) and yield ha^{-1} (319.50 quintal) were obtained with 0.20% boron, whereas the greatest fruit weight(27.27g) was recorded for 0.10% boron.

Bhatt and Srivastava (2005) reported that the effect of the foliar applications of boron (boric acid), zinc (zinc sulfate), molybdenum (ammonium molybdate), copper (copper sulfate), iron (ferrous sulfate), manganese(sulfate), mixture of these nutrients, and Multiplex (a commercial micronutrient formulation) on the nutrient uptake and yield of tomato (Pusahybrid-1) in Pantnagar, Uttaranchal, India, during the summer of 2002 and2003. Zinc, iron, copper, boron and manganese were applied at 1000 ppm each, whereas molybdenum was applied at 50 ppm. Foliar spraying was conducted at 40, 50 and 60 days after transplanting. All treatments significantly enhanced dry matter yield, fruit yield and nutrient uptake over the control. The mixture of the micronutrients was superior in terms of dry matter yield of shoot (53.25 g ha^{-1}); dry matter content of shoot (27.25%),nitrogen (152.38 kg ha^{-1}), phosphorus (47.49 kg ha^{-1}), potassium (157.48 $kgha^{-1}$), sulfur (64.87 kg ha^{-1}), zinc (123.70 g ha-1), iron (940.36 g ha^{-1}), copper(72.70 g ha^{-1}), manganese (359.17 g ha^{-1}) and boron (206.58 g ha^{-1}) uptake by shoots; total fruit yield (266.60 kg ha^{-1}); dry matter yield of fruit (1698 $kgha^{-1}$); manganese (34.08 g ha^{-1}) and boron (95.23 g ha^{-1}) uptake by fruits.

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

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

Singh and Gangwar (1991) conducted an experiment to find out the boron effect on tomato plants and found that boron had effects on many functions of the plant, such as hormone movement, active salt absorption, flowering and fruiting process, pollen germination, carbohydrates, nitrogen metabolism and water relations in the plants.

Boron deficiency occurs in vegetable crops having high boron requirements when grown on alkaline soils with free lime and on sandy soils with low organic matter content. Boron deficiency causes reduced root growth, brittle leaves and necrosis of shoot apex. Cracking of surface of tomato fruit results in large losses.

Bose and Tripathi (1996) conducted an experiment to find the physiological role of boron and its involvement in the metabolism of proteins and found that the increase in vegetative growth of tomato could be attributed to physiological role of boron and its involvement in the metabolism of proteins, 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. Boron also plays an important role in flowering and fruit formation.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from April 2016 to September 2016. The materials and methods those were used and followed for conducting the experiment have been presented under the following headings.

3.1 Experimental site

A pot experiment was conducted at the horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April 2016 to September 2016.The location of the experimental site is 23°74′N latitude and 90°35′E longitude at an altitude of 8.6 meter above the sea level. (Anon., 2004)

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28 (Anon 1998). The characteristics of the soil under the experiment were analyzed in the Laboratory of Soil Science Department, SAU, Dhaka and details of soil characteristics have been presented in Appendix I.

3.3 Climate

The experimental site is situated in the subtropical monsoon climatic zone, which is characterized by heavy rainfall during the months from April to September (Appendix II) and scanty of rainfall during rest of the year (Rabi season).

3.4 Pot Soil collection and preparation

The soil was collected one month prior to setting the experiment. The top soil was collected from the Horticulture Farm Area of North-East corner, mixed thoroughly and makes it clean by removing stones, grass, roots and other debris.

3.5 Planting materials

BARI Hybrid Tomato-4 were used. The seedlings of tomato were grown at the nursery of Horticulture Farm in Sher-e-Bangla Agricultural University. BARI Hybrid Tomato-4, a high yielding variety of Tomato was developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. It was released in 2006.

3.6 Treatments of the experiment

The experiment consisted of two factors.

Factor A: Different doses of salicylic acid

S_0 = Control

S_1 = 0.25 mM

S_2 = 0.5 mM

Factor (B): Different levels of micronutrients (Zn and B)

M_0= Control

M_1 = 20 mg/l of Zn

M_2 = 2 mg/l of B

M_3 = 10 mg/l Zn + 1 mg/l B

M_4 = 20 mg/l of Zn + 2 mg/l B

3.7 Design and layout of the experiment

The two factorial experiment was laid out in Complete Randomized Design (CRD) with five levels of micronutrients and three levels of salicylic acid. Four replications were maintained in this experiment. The total number of pot was 60 (15×4). Each pot was 35 cm (14 inches) in diameter and 30 cm (12 inches) in height. The experiment was placed under poly house which was made by bamboo with polythene roof.

3.8 Seedling raising

A common procedure was followed in raising of seedlings in the seedbed. The size of the seedbed was 3 m×1 m. The soil was well prepared with spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cowdung was applied during seedbed preparation. The seeds were sown in the seedbed at 30 April 2016. Germination was visible 4 days after sowing of seeds. After sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg ha^{-1} around each seedbed as precautionary measure against ants and worm. Weeding, mulching and irrigation were done from time to time as and when required and no chemical fertilizer was used in this seedbed.

3.9 Pot preparation

A ratio of 1:3 well rotten cow dung and soil were mixed and pots were filled 15 days before transplanting. Silty loam soils were used for pot preparation. All 60 pots were filled on May 2016. Weeds and stubbles were completely removed from the soil.

3.10 Uprooting and Transplanting of Seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seedbed and were transplanted in the experimental pots in the afternoon of 30 May 2016 maintaining two seedlings in each pot. The seedbed was watered before uprooting the seedlings from the seedbed so as to minimize damage to roots with ensuring maximum retention of roots. The seedlings were watered after transplanting.

3.11 Application of the treatments

All the treatments were applied considering the design of experiment. First application was done at 25 DAT when all plant was matured. Second and third treatment was applied at 20 days interval. A specific concentration of the each nutrient solution was maintained. All the nutrient were made at 1 L solution separately for each time of the application and it was sprayed on the leaves of the plant.

3.12 Intercultural operations

3.12.1 Irrigation

After transplanting, light irrigation was provided. Irrigation was given at early morning and sometimes also in evening throughout the growing period. But the frequency of irrigation became less in harvesting stage.

3.12.2 Staking

Staking was given to each plant by bamboo sticks for support to keep them erect.

3.12.3 Weeding

Weeding was done whenever it was required, mostly in vegetative stage.

3.12.4 Plant Protection Measures

Pesticide admire and sulcrop were sprayed @ 1ml per liter of water and fungicide ridomil @ 1ml of water for 3 times at 20, 40 and 60 DAT of seedlings in the all plants.

3.13 Harvesting

Fruits were harvested during early ripe stage when they developed slightly red color. Harvesting was started from 2 August, 2016 and was continued up to mid September 2016.

3.14 Recording of Data

Experimental data were recorded from 15 days after transplanting and continued until harvest. The following data were recorded during the experimental period.

A. Morphological characters

1. Plant height

Plant height was measured at 15, 30, 45, 60 and 75 DAT. The height of the plant was determined in centimeter by measuring the distance from the soil surface to the tip of the highest leaf.

2. Leaf no. plant^{-1}

Leaf number was counted at 30, 45, and 60 DAT. The number of leaves plant^{-1} was counted from each plant.

3. No. of branches plant^{-1}

The total number of branches plant^{-1} was counted from each plant at 45 DAT, 60 DAT and 75 DAT. There is no option to make average value from collected value due to only one plant was maintained per pot.

4. Leaf area plant-^{1}

Leaf area was measured by non-destructive method using CL-202 Leaf Area Meter, (USA).

B. Physiological characters

5. Chlorophyll content-SPAD reading

Leaf chlorophyll content was measured using a hand-held chlorophyll content SPAD meter.

6. Dry matter content of plant

After taking the fresh weight they were cut into small pieces and sun dried. Then they were collected and placed in an oven for 72 hours at 60^0 c temperature. Weight was taken after collecting from the oven.

7. Dry matter content of 100 g fresh fruit

100 g fresh fruit was collected and then they were oven dried and sun dried. After drying the final weight was recorded were expressed in percentage.

C. Yield contributing and yield characters

8. No. of flower clusters plant^{-1}

The number of flower cluster was counted and recorded at 45, 60 DAT and the average number of flower clusters produced per plant was calculated.

9. No. of flowers cluster^{-1}

The number of flowers per cluster was taken from sample plants at 45 and 60 DAT, and was calculated as follow:

$$\text{Number of flowers per cluster} = \frac{\text{Total number of flower/plant}}{\text{Total number of flower cluster/plant}}$$

10. No. of flowers plant^{-1}

The number of flower plant^{-1} was counted and recorded from the plant periodically and the average number of flower plant^{-1} was calculated.

11. No. of fruits per cluster^{-1}

The number of fruits cluster^{-1} was counted from the plant at different date and then calculated as follow:

$$\text{Number of fruit per cluster} = \frac{\text{Total number of fruit/plant}}{\text{Total number of fruit cluster/plants}}$$

12. No. of fruit per plant^{-1}

The number of fruit plant^{-1} was counted from four sample plants and then the average number of fruit produced plant^{-1} was calculated.

13. Length of fruit

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 fruits from each plant and their average was taken and expressed in cm

14. Diameter of fruit

Diameter of fruit was measured at middle portion of 10 fruits from each plant with a slide calipers. Their average was taken and expressed in cm.

15. Weight. of individual fruit

Among the total number of fruit during the period from first to final harvest, the fruits, except the first and final harvest was considered for determining the individual fruit weight by the following formula:

$$\text{Weight of individual fruit (g)} = \frac{\text{Total weight of fruits}}{\text{Total number of fruits}}$$

16. Yield per plant

Yield plant^{-1} of tomato fruits was calculated by total fruit yield from each plant during the period from harvest to final harvest and recorded in gram (g).

3.15 Statistical Analysis

The recorded data on different parameters were statistically analyzed using statistix 10 software and mean separation was done by LSD test at 5% level of probability.

CHAPTER IV

RESULT AND DISCUSSION

The chapter comprises the presentation and discussion of the consequences of salicylic acid and micronutrients on morpho-physiological characteristics of tomato in summer. Some data expressed in table and possible interpretations have been made in this chapter.

4.1. Plant height

Plant height of tomato varied significantly due to the application of different concentrations of salicylic acid at 15, 30, 45, 60 and 75 DAT (Appendix III). At 15DAT, the longest plant (24.60 cm) was observed in S_2 and control treatment (S_0) gave the shortest plant (22.25 cm). The longest (57.30 cm) was recorded from S_1which was statistically similar to S_2 (57.20 cm) while the shortest (53.00cm) was recorded from S_0 at 30 DAT. AT 45 DAT, the longest plant(80.30cm) was also observed in S_1 and the shortest plant (76.55cm) was observed in S_0. At 60 DAT, the longest (106.55 cm) and the shortest (96.05 cm) plant were recorded from S_2 and S_0 respectively (Fig. 1). At 75 DAT, the longest (103.55 cm) and the shortest (99.00 cm) plant were recorded from S_2 and S_1 which was statistically similar to S_0 (99.30). Hayat, *et al.* (2005) concluded that SA application increases cell division and cell enlargement. In Bangladesh, tomato production is restricted in summer season but salicylic acid help to mitigate this condition and increase production.

Plant height of tomato varied significantly varied due to the application of different concentrations of micronutrients at 15, 30, 45, 60 and 75 DAT (Appendix III) At 15 DAT, the longest plant (26.09 cm) was observed in M_3 and the shortest plant (20.83 cm) from M_1. The longest plant (62.33 cm) was recorded from M_4 while the shortest plant (51.00 cm) was recorded from M_1 at 30 DAT. At 45 DAT, the longest plant (85.58 cm) was also observed in M_3 and the shortest plant (72.42 cm) was observed in M_0. At 60 DAT, the longest (120.92 cm) and the shortest (81.08 cm) plant were recorded from M_4 and M_1 respectively. At 75 DAT, the longest (124.67 cm) and the shortest (84.24 cm) plant were recorded from M_4 and M_1, respectively (Fig. 2) The effect of micronutrients on the growth of tomato plant is reflected firstly in plant height. Singh and Tiwari (2013) determined that foliar application of different micronutrients responses plant height. Application of Zinc and Boron increased tomato plant height. (Hatwar *et al.*, 2003).

Combined effect of salicylic acid and micronutrients significantly varied on plant height at 15,30,45,60 and 75 DAT (Appendix III). At 15 DAT, the longest plant (27.75cm) was observed in S_2M_3 and S_1M_3 whereas the shortest plant (19.75 cm) was found in $S_0M_{1.}$ The longest plant (67.50 cm) was recorded from S_2M_4 while the shortest (43.25 cm) was recorded from S_0M_1 at 30 DAT. At 45 DAT, the longest plant (90.75cm) was also found in S_2M_3 and the shortest plant (69.50 cm) was found in S_2M_0. At 60 DAT, the longest plant (125.00 cm) was observed in S_2M_4whereas the lowest plant (66.75 cm) was found in S_0M_1. At 75 DAT, the longest plant (129.75 cm) was found in S_2M_4 and the shortest plant (82.75 cm) was found in S_1M_1 (Table 1) which was statistically similar to S_0M_1 (84.75 cm) and S_2M_1 (85.25).

4.2 Number of leaves per plant

Number of leaves per plant of tomato significantly varied due to the application of different levels of salicylic acid at 45 and 60 DAT and nonsignificant at 30 DAT (Appendix IV). At 30 DAT, the maximum number of leaves per plant (23.67) was found in S_2 which was statistically identical to S_1 (22.57) while the minimum leaf number (21.72) was found in S_0. At 45 DAT, the highest leaf number per plant (27.10) was obtained from S_2 and the lowest (22.45) from S_0. At 60 DAT, the highest leaf number per plant (26.75) was counted from S_2 whereas, the lowest (24.45) was from S_0 (Table 2) Fathy *et al*., (2000) mentioned that foliar application of salicylic acid increased the number of leaves per plant. These results showed that salicylic acid increase the number of leaves/plant in summer condition.

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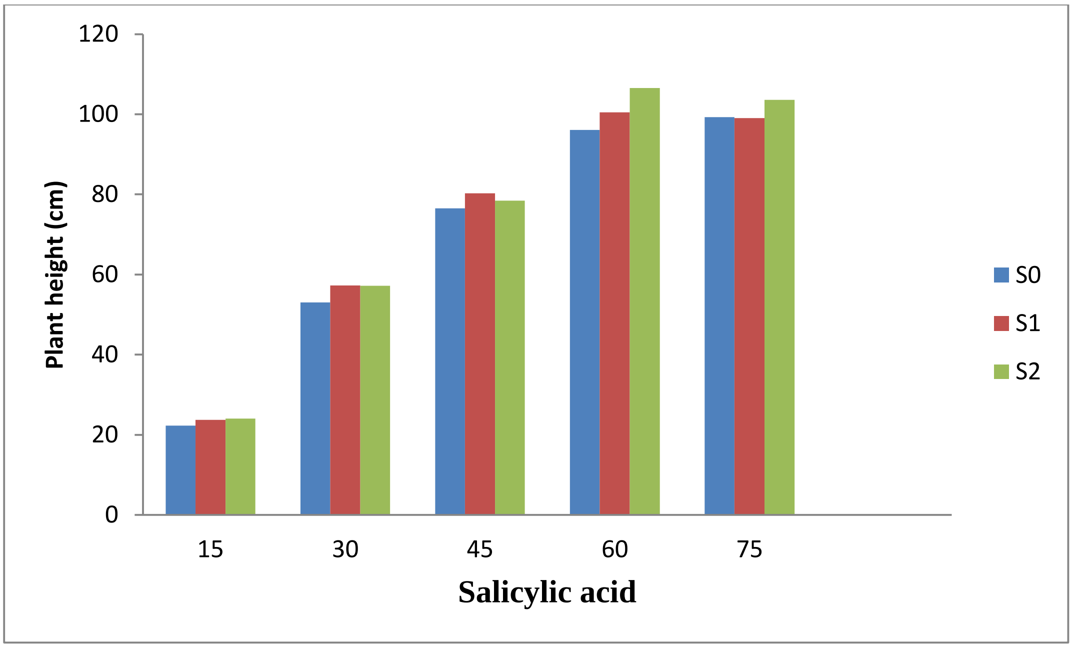
Number of leaves per plant of tomato was significantly varied due to the application of different levels of micronutrients at 45, 60 DAT and non significant at 30 DAT

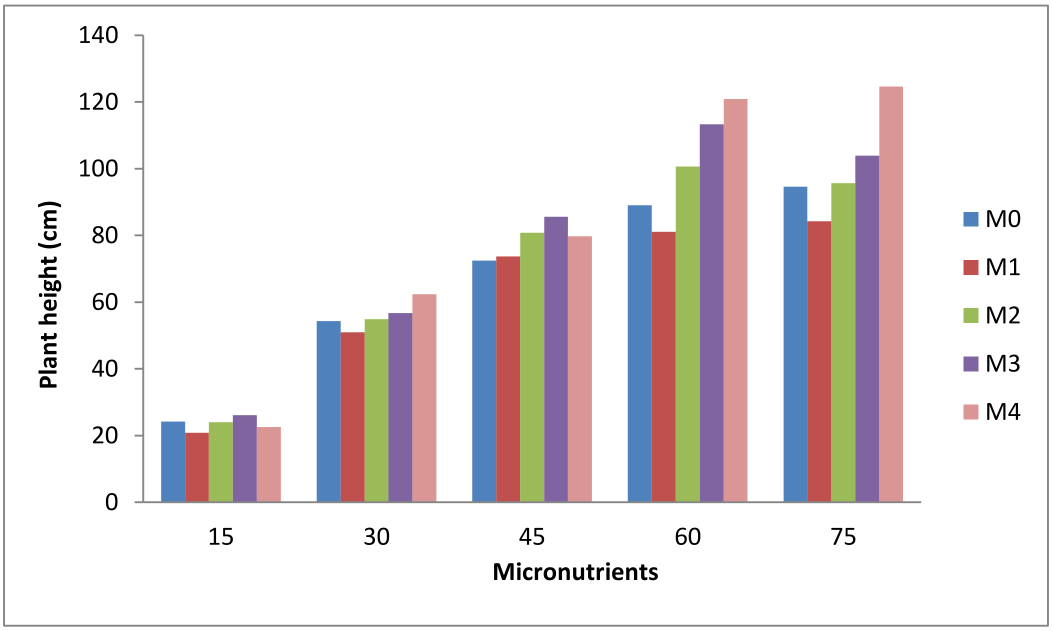
(Appendix IV). At 30 DAT, the maximum number of leaves per plant (24.00) was observed in M_4 while the minimum number of leaves (20.90) was observed in M_0. At 45 DAT, the maximum number of leaves per plant (30.17) was also found in M_4 and the minimum number of leaves per plant (23.08) was found in M_0 which was statistically identical to M_1 (23.08) At 60 DAT, the maximum number of leaves per plant (30.42) was obtained from M_4 while the minimum (20.08) was obtained from M_0 (Table 2). Number of leaves per plant was increased due to the foliar application of Zinc and Boron (Singh and Tiwari, 2013). These results showed that micronutrients increase the number of leaves/plant.

Combined effect of micronutrients and salicylic acid illustrated statistically significant differences on number of leaves per plant at 45and 60 DAT (Appendix IV). At 45 DAT, the maximum number of leaves per plant (37.50) was found in S_1M_4 and the minimum number of leaves per plant (18.00) was found in S_0M_3. At 60 DAT, the highest leaf number per plant (37.50) was obtained from S_1M_4 whereas, the lowest leaf number (19.25) was obtained from S_0M_0 which was statistically similar to S_2M_0 (Table 3). At 30 DAT, insignificant variation was observed. The maximum number of leaves per plant (24.98) was found in S_2M_4 and the minimum number of leaves per plant (19.62) was found in S_0M_0. Rawaa *et al.,* (2014) obtained that higher number of leaves in tomato at the concentration of combined application of zinc and boron.



(S$_0$ = control, S$_1$= 0.25 mM Salicylic acid, S$_2$ = 0.5 mM Salicylic acid)

Figure 1. Effect of salicylic acid on plant height



(M$_0$= control, M$_1$ = 20 mg zinc, M$_2$ = 2 mg boron, M$_3$ = 10 mg zinc + 1 mg boron, M$_4$ = 20 mg zinc + 2 mg boron)

Figure 2. Effect of micronutrient on plant height

Table 1. Combined effect of salicylic acid and micronutrients on plant height of tomato

Treatments	Plant height (cm)				
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**
S_0M_0	21.75 c-e	50.75 f	73.75 f	94.25 gh	95.50 gh
S_1M_0	23.50 bc	55.50 cd	74.00 f	87.25 i	90.25 i
S_2M_0	27.25 a	56.75 b-d	69.50 g	85.75 i	98.00 fg
S_0M_1	19.75 e	43.25 g	70.25 g	66.75 j	84.75 j
S_1M_1	21.25 c-e	58.75 bc	73.75 f	85.00 i	82.75 j
S_2M_1	21.50 c-e	51.00 f	77.00 de	91.50 h	85.25 j
S_0M_2	25.75 ab	56.25 cd	78.00 de	92.50 h	97.50 fg
S_1M_2	20.50 de	51.50 ef	88.75 a	96.00 g	93.00 hi
S_2M_2	25.75 ab	57.00 bcd	75.50 ef	113.50 de	96.50 fg
S_0M_3	22.75 cd	60.00 b	83.00 b	110.00 f	98.75 f
S_1M_3	27.75 a	56.50 b-d	83.00 b	113.00 ef	104.75 e
S_2M_3	27.75 a	53.75 d-f	90.75 a	117.00 c	108.25 d
S_0M_4	21.25 c-e	54.75 de	77.75 de	116.75 cd	120.00 c
S_1M_4	25.75 ab	64.75 a	82.00 bc	121.00 b	124.25 b
S_2M_4	20.75 de	67.50 a	79.50 cd	125.00 a	129.75 a
LSD (0.05)	2.66	3.55	2.75	3.34	3.13
CV (%)	7.92	4.45	2.45	2.32	2.18

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc + 1 mg boron, M_4 = 20 mg zinc + 2 mg boron

4.3 Number of branch per plant

The variation in number of branch per plant at different levels of salicylic acid was also significant at 45, 60 and non significant at 30 DAT (Appendix V). At 30 DAT, the maximum number of branches per plant (4.50) was observed from M_4 and the minimum number of branches (3.97) was found in S_0. At 45 DAT, the highest number of branches per plant (7.05) was counted from S_2 whereas, the lowest number (5.55) was counted from S_0. At 60 DAT, the highest (7.89) and lowest (6.18) number of branches were also obtained from S_2 and S_0, respectively (Table 3). Fathy *et al*. (2000) mentioned that salicylic acid increased plant height, number of branches and leaves per plant.

A significant variation was found in the number of branches per plant was observed due to effect of different concentrations of micronutrients at 45, 60 DAT and insignificant variation was observed at 30 DAT (Appendix V) . At 30 DAT, the highest number of branch per plant (5.83) was found in M_4 while the lowest number of branch per plant (2.88) was found in M_0. At 45 DAT, the maximum number of branches (8.42) was also found in M_4 and the minimum (3.83) in M_0. The maximum number of branches per plant (9.20) was obtained from M_4 and the minimum number of branches per plant (4.63) was observed in M_0 at 60 DAT (Table 3). Basavarajeswari *et al.* (2008) stated that boron assists on cell development, cell differentiation and increase number of branch/plant.

There was statistically significant differences among the treatment combinations of salicylic acid and micronutrients in respect of number of branches per plant at 30 DAT and insignificant at 45 and 60 DAT (Appendix V). The highest number of branches per plant (6.05) was obtained from S_1M_4 which was statistically identical to S_2M_4 (5.95) while the lowest number of branches per plant (2.30) was obtained from S_0M_0 at 30 DAT. At 45 DAT, the highest number of branches per plant (9.00) was recorded from S_2M_4whereas, the lowest number of branches per plant (3.00) was found in

S_0M_0. At 60 DAT, the maximum number of branches per plant (10.15) was also counted in S_2M_4 and the minimum (3.80) was observed in S_0M_0 (Table 4)

4.4 Number of flower cluster^{-1}

A nonsignificant variation was observed for number of flower clusters^{-1} of tomato for different levels of salicylic acid (Appendix VIII). The highest flower cluster^{-1} (6.20) was found in $S_2$and the lowest flower clusters^{-1} (5.05) was found in S_0 (Table 5). Flowered come much earlier as compared to the control condition, when they received an foliar application of salicylic acid (Martin-Max *et al.*, 2005). Salicylic acid increase the number of flower cluster^{-1} in summer by reducing stress condition.

There was a significant difference in number of flower clusters^{-1}due to different levels of micronutrients (Appendix VI). The highest number of flower clusters^{-1} (6.22) of tomato was found in 20 mg of zinc and 2 mg of boron (M_4) and the lowest number of flower cluster^{-1} (4.38) was recorded from control treatment (M_0) of micronutrients (Table 5).

Number of flower cluster^{-1} was varied significantly for the interaction of micronutrients and salicylic acid (Appendix VI). The highest number of flower clusters^{-1} (6.63) was found from S_2M_4 which was statistically similar to S_1M_4 (6.37) while the lowest number (4.12) was obtained from S_0M_0 which was statistically similar to S_1M_0 (4.48) and S_2M_0 (4.53) (Table 6).

Table 2. The effect of different levels of salicylic acid and micronutrients on number of leaves plant^{-1} of tomato at different days after transplanting

Treatments	Number of leaves plant^{-1}		
	30 DAT	**45 DAT**	**60 DAT**
Salicylic acid			
S_0	21.72	22.45 c	24.45 b
S_1	22.57	25.70 b	26.35 a
S_2	23.67	27.10 a	26.75 a
LSD (0.05)	NS	1.14	1.22
Micronutrients			
M_0	20.90	23.08 c	20.08 c
M_1	22.68	23.08 c	26.42 b
M_2	22.98	28.33 b	26.58 b
M_3	22.71	20.75 d	25.75 b
M_4	24.00	30.17 a	30.42 a
LSD (0.05)	NS	1.48	1.58
CV (%)	11.27	7.17	7.43

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc + 1 mg boron, M_4 = 20 mg zinc + 2 mg boron;

Table 3. The effect of different levels of salicylic acid and micronutrients on number of branches plant^{-1} of tomato

Treatments	Number of branches plant^{-1}		
	30 DAT	45 DAT	60 DAT
Salicylic acid			
S_0	3.97	5.55 c	6.18 c
S_1	4.32	6.30 b	7.03 b
S_2	4.50	7.05 a	7.89 a
LSD (0.05)	0.09	0.42	0.36
Micronutrients			
M_0	2.88	3.83 e	4.63 e
M_1	3.21	5.08 d	5.63 d
M_2	4.54	7.58 b	8.38 b
M_3	4.85	6.58 c	7.33 c
M_4	5.83	8.42 a	9.20 a
LSD (0.05)	NS	0.53	0.47
CV (%)	3.46	10.35	8.17

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc+ 1 mg boron, M_4 = 20mg zinc+ 2 mg boron

Table 4. Combined effect of salicylic acid and micronutrients on number of leaves number of branches plant^{-1}

Treatments	Number of leaves/plant			Number of branch/plant		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
S_0M_0	19.62	28.25 cd	19.25 h	2.30 j	3.00	3.80
S_1M_0	20.45	21.50 ef	21.75 gh	2.93i	4.00	4.45
S_2M_0	22.62	19.50 fg	19.25 h	3.43 g	4.50	5.63
S_0M_1	21.40	18.25 g	22.00 g	3.28 g-i	4.00	4.38
S_1M_1	22.72	20.00 e-g	27.25 c-e	3.03 hi	5.00	5.55
S_2M_1	23.90	31.00 b	30.00 b	3.33gh	6.25	6.98
S_0M_2	23.67	27.25 d	25.25 ef	4.25 f	7.00	7.78
S_1M_2	22.67	27.50 d	29.75 bc	4.62 d-f	7.50	8.53
S_2M_2	22.57	30.25 bc	24.75 ef	4.75 c-e	8.25	8.85
S_0M_3	21.82	18.00 g	27.25 c-e	4.53ef	6.00	6.50
S_1M_3	22.05	22.00 ef	23.75 fg	5.00 cd	6.50	7.63
S_2M_3	24.25	22.25 e	26.25 d-f	5.03 c	7.25	7.85
S_0M_4	22.08	20.50 e-g	28.50 b-d	5.48 b	7.75	8.45
S_1M_4	24.95	37.50 a	29.25 bc	6.05 a	8.50	9.00
S_2M_4	24.98	32.50 b	33.50 a	5.95 a	9.00	10.15
LSD (0.05)	NS	2.56	2.74	0.23	NS	NS
CV (%)	11.27	7.17	7.43	3.45	10.35	7.17

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5 mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc + 1 mg boron, M_4 = 20 mg zinc + 2 mg boron;

4.5 Number of flower plant^{-1}

Number of flowers/plant also significantly varied for different concentrations of salicylic acids (Appendix VI). The highest number of flowers/plant (34.53) was observed in S_2 and the lowest number of flowers/plant (29.71) was found in S_0 (Table 5) which was statistically identical to S_1 (31.76)

A significant variation was observed in tomato for different concentration of micronutrients (Appendix VI). The highest number of flowers/plant (42.00) was found in M_4 and the lowest number of flower/plant (24.33) was found in M_0 (Table 5)

There was a significant variation observed due to the interaction effect of micronutrients and salicylic acid (Appendix VI). The highest number of flowers/plant (48.25) was found in S_2M_4 and the lowest number of flower/plant (19.75) was found in S_0M_0 (Table 6).

4.6 Leaf chlorophyll content

Salicylic acid has a significant effect on leaf chlorophyll content of tomato plant at different concentrations of vegetative and reproductive stages (Appendix VI). The highest value (54.99 SPAD units) was found from S_2 and lowest value (51.12 SPAD units) was recorded from S_0. At reproductive stages, the highest chlorophyll content (54.42 SPAD units) was found in S_2 and the lowest value (51.94 SPAD units) was recorded from S_0 which was statistically similar (52.40 SPAD units) to S_1 (Table 5).

The effect of micronutrients on leaf chlorophyll content of tomato plant was significantly varied at vegetative and reproductive stages (Appendix VI). At vegetative stage, the highest chlorophyll content of tomato (54.70) was recorded from M_4 which was statistically similar to M_3 (53.77) and M_2 (53.19), the minimum value (51.04) was recorded from M_0 which was statistically similar to M_1 (51.68 SPAD units) (Table 5). At reproductive stage, the highest chlorophyll content (61.81 SPAD units) was recorded from M_4 and the minimum value (48.48) was recorded from M_0 which was statistically similar to M_1 (49.01 SPAD units).

Statistically significant interaction effect of micronutrients and salicylic acid on leaf chlorophyll content of tomato plant at different concentrations (Appendix VI). At vegetative stage, the highest leaf chlorophyll content (58.23 SPAD units) was found from S_2M_4which was statistically similar (56.68, 54.86, 54.69, 53.97, 53.95, 53.22 52.05, 52.74 SPAD units) to S_1M_4, S_0M_4, S_2M_3, S_2M_1, S_1M_3, S_1M_2, S_1M_1, S_0M_3. The lowest value (47.09 SPAD units) was found in S_0M_0 which was statistically identical (49.11 and 49.12 SPAD units) to S_1M_0 and S_2M_0 (Table 6). At reproductive stage, the highest value (62.63 SPAD units) was observed in S_2M_4 which was statistically similar (62.0, 60.76 SPAD units) to S_1M_4, S_0M_4. The lowest value (43.18 SPAD units) was found from S_0M_0 which was statistically identical (44.26 and 45.37 SPAD units) to S_1M_0 and S_0M_1.

4.7 Leaf area

Different levels of salicylic acid affected significantly on leaf area (Appendix VI). The highest leaf area (122.55 cm^2) was found from S_2 where the lower leaf area (118.25 cm^2) was recorded from S_0 (Fig. 3). Salicylic acid is considered to be an endogenous growth regulator of phenolic nature that enhanced the leaf area and dry mass production in fruit. (Khan *et al*., 2010).

For different concentrations of micronutrients leaf area was significantly varied (Appendix VI). The maximum leaf area (139.66 cm^2) was recorded from M_4 treated plant where the minimum leaf area (101.73 cm^2) was found from M_0 (Fig. 4).

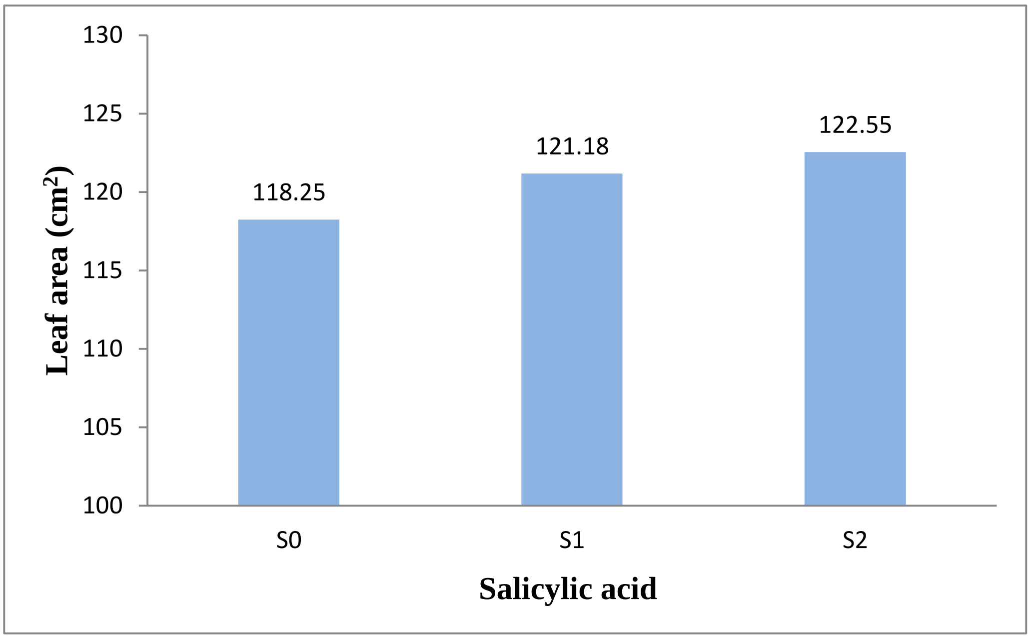
The combined effect of micronutrients and salicylic acid was a significant effect on the leaf area (Appendix VI) The maximum leaf area (189.51 cm^2) was recorded from S_2M_4 which was statistically similar (140.49) to S_1M_4 and S_0M_4 (137.98). The minimum leaf area (100.81cm^2) was recorded from S_0M_0 (Table 6)

Table 5. Effect of salicylic acid and micronutrients on number of flowers cluster^{-1}, flowers plant^{-1} and leaf chlorophyll content

Treatments	Flowers cluster^{-1}	Flowers plant^{-1}	Leaf chlorophyll content	
			Veg	Rep
Salicylic Acid				
S_0	5.05	29.71b	51.12 c	51.94 b
S_1	5.16	31.76 b	52.51 b	52.40 b
S_2	6.20	34.53 a	54.99 a	54.42 a
LSD (0.05)	NS	0.92	1.21	1.01
Micronutrients				
M_0	4.38 c	24.33 e	51.04 c	49.01 d
M_1	4.87 b	28.71 d	51.68 bc	50.78 c
M_2	4.97 b	29.95 c	53.19 ab	61.81 a
M_3	5.26 b	33.00 b	53.77 a	54.51 b
M_4	6.22 a	42.00 a	54.70 a	48.48 d
LSD (0.05)	0.42	1.19	1.56	1.29
CV	12.37	4.98	3.59	2.97

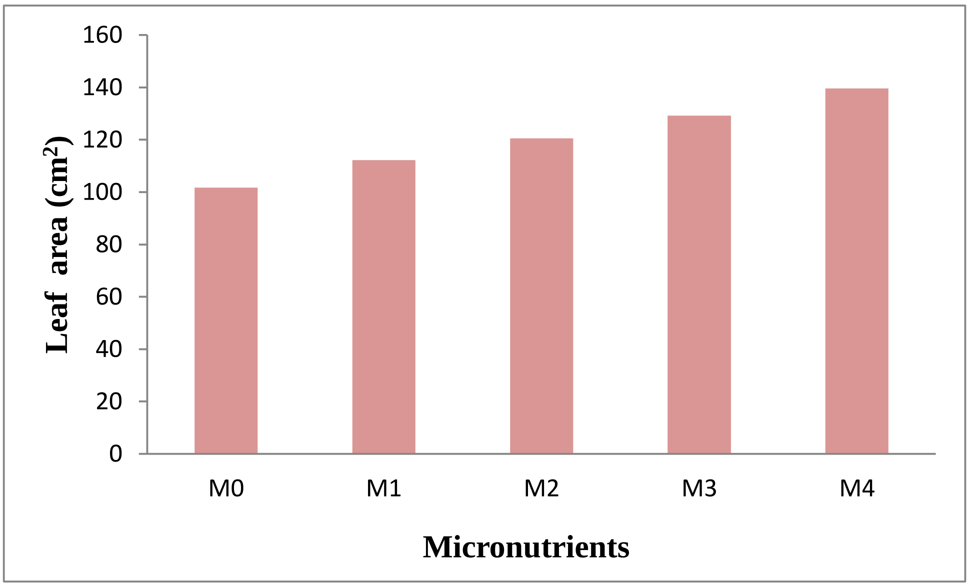
In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc + 1 mg boron, M_4 = 20 mg zinc + 2 mg boron



(S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid)

Figure 3. Effect of salicylic acid on leaf area of tomato plant



(M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc + 1 mg boron, M_4 = 20 mg zinc + 2 mg boron)

Figure 4. Effect of micronutrients on leaf area of tomato plant

Table 6. Combined effect of salicylic acid and micronutrients on number of flower/cluster and number of flowers plant^{-1}, leaf area and leaf chlorophyll content

Treatments	Flowers cluster^{-1}	Number of flowers plant^{-1}	SPAD Value		Leaf Area (cm^2)
			(Veg.)	(Rep.)	
S_0M_0	4.12 d	19.75 j	47.09 h	43.18 h	100.81 g
S_1M_0	4.48 d	25.25 gh	49.12 gh	44.26 h	102.88 g
S_2M_0	4.53 d	25.00 h	49.11 f-h	47.34fg	101.51 g
S_0M_1	5.18 c	25.25 gh	52.05 d-f	45.37gh	107.89 f
S_1M_1	5.17 c	22.75 i	51.64 e-g	49.44ef	111.80 f
S_2M_1	5.56 b	26.14 gh	53.97 b-e	50.24 e	117.06 e
S_0M_2	5.87 b	28.31fg	54.70 b-d	52.95 d	118.03 e
S_1M_2	5.91 b	28.29fg	53.22 c-f	51.29 de	120.40 de
S_2M_2	5.82 b	29.25 ef	51.07 fg	53.39 d	123.08 cd
S_0M_3	5.11 c	30.50 ef	52.74cde	55.66 c	126.53bc
S_1M_3	5.22 b	31.50 e	53.95cde	57.19bc	130.33 b
S_2M_3	5.44 b	34.00 d	54.69 b-d	58.00 b	130.61 b
S_0M_4	5.61 b	37.50 c	54.86 bc	60.76 a	137.98 a
S_1M_4	6.37 a	43.26 b	56.68 ab	62.05a	140.49 a
S_2M_4	6.63 a	48.25 a	58.23 a	62.63 a	140.51 a
LSD (0.05)	0.73	2.06	2.71	2.25	2.48
CV (%)	12.37	4.98	3.59	2.97	1.44

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc + 1 mg boron, M_4 = 20 mg zinc + 2 mg boron

4.8 Number of fruit cluster per plant

Significant variation was observed for number of fruit clusters plant^{-1} of tomato for different levels of salicylic acid (Appendix VII). The highest number of fruit clusters plant^{-1} (6.25) was found in S_2 which was statistically similar to S_1 (6.09) and the lowest fruit clusters plant^{-1} (5.88) was found in S_0 (Table 7)

There was a significant difference in number of fruit clusters plant $^{-1}$ at different levels of micronutrients (Appendix VII). The highest number of fruit clusters plant^{-1} (7.53) of tomato was found in M_4 and the lowest number of fruit cluster plant^{-1} (4.67) was recorded (Table 7) from control treatment (M_0) of micronutrient.

Number of fruit clusters plant^{-1} varied significantly for the interaction of micronutrients and salicylic acid (Appendix VII). The highest number of fruit clusters plant^{-1} (7.75) was found from S_2M_4 which was statistically similar to S_1M_4 (7.58) while the lowest number of fruit clusters plant^{-1}(4.63) was found from S_0M_0 (Table 8) which was statistically similar to S_1M_0 (4.65) and S_2M_0 (4.74)

4.9. Number of fruits per cluster

There was also a significant differences among the different levels of salicylic acid on number of fruits per cluster (Appendix VII) .The highest number of fruits per cluster (4.48) was counted in S_2 while the lowest number (4.35) was observed in S_0 which was statistically similar to S_1 (4.38) (Table 7).

Significant variation was found due the application of different levels micronutrients for the number of fruits per cluster of tomato (Appendix VII).The maximum number of fruits /cluster (4.85) was found from M_4 and the minimum number of fruits /cluster (3.66) was found in M_0 (Table 7). Haque (2007) reported that higher number of fruits per cluster obtained due to the application of boron than control in tomato plant.

Combined effect of micronutrients and salicylic acid differed significantly for number of fruits per cluster (Appendix VII). The highest number of fruits per cluster (4.93) was obtained from S_2M_4which was statistically similar (4.85, 4.80, 4.75, 4.71, 4.58, 4.52, 4.50, 4.49) to S_1M_4, S_0M_4, S_2M_3, S_1M_3, S_0M_2, S_1M_2, S_0M_3, S_2M_2 (Table 8) .The lowest number of fruits/cluster (3.58) was recorded from S_0M_0which was statistically identical to S_1M_0 (3.69) and S_2M_0 (3.71)

4.10 Number of fruit plant^{-1}

Number of fruits/plant was showed statistically significant variation for different levels of salicylic acid (Appendix VII). The highest number of fruits plant^{-1}(28.67) was observed from S_2 and the lowest value (26.88) was recorded from S_0 (Table 7). Due to high temperature number of fruit plant^{-1}was reduced than winter season but SA helps to mitigate this condition.

Due to different concentrations of micronutrients indicated significant variations on number of fruits plant^{-1}(Appendix VII). The highest number of fruits plant^{-1}(35.00) was found from $M_4$and the lowest number (19.59) was observed from M_0 (Table 8) in tomato plants, number of fruits/plant increased by application of zinc and boron. (Yadav. *et al*, 2001)

Statistically significant variation was observed due to interaction of micronutrients and salicylic acid on fruits/plant of tomato at different concentrations (Appendix VII). The highest number of fruits plant^{-1} (36.63) was observed from S_2M_4 (Table 8) and the lowest value (18.08) was recorded from S_0M_0which was statistically similar to S_1M_0 (19.00).

Table 7. Effect of salicylic acid and micronutrients on number fruit cluster plant^{-1}, fruit/cluster, fruit / plant

Treatments	Fruit Cluster/plant	Fruit/cluster	Fruit / plant
Salicylic acid			
S_0	5.88 b	4.35 b	26.88 c
S_1	6.09 a	4.38 b	28.66 b
S_2	6.25 a	4.48 a	28.67 a
LSD (0.05)	0.08	0.07	0.23
Micronutrients			
M_0	4.67 e	3.66 e	19.59 e
M_1	5.33 d	4.30 d	24.03 d
M_2	6.07 c	4.53 c	26.97 c
M_3	6.76 b	4.67 b	30.40 b
M_4	7.53 a	4.85 a	35.00 a
LSD (0.05)	0.11	0.09	0.30
CV (%)	2.27	2.70	1.36

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc+ 1 mg boron, M_4 = 20 mg zinc+ 2 mg boron

Table 8. Combined effect of salicylic acid and micronutrients on number of fruit cluster plant^{-1}, fruit / cluster and fruit /plant

Treatments	Fruit cluster/plant	Fruit/cluster	Fruit /plant
S_0M_0	4.63 i	3.58 f	18.08 k
S_1M_0	4.65 i	3.69 f	19.00 k
S_2M_0	4.74 i	3.71 f	21.70 j
S_0M_1	5.09 h	4.25 e	22.88i
S_1M_1	5.35 gh	4.22 e	23.63i
S_2M_1	5.56 fg	4.46 de	25.58 h
S_0M_2	5.73 ef	4.58 bcd	26.30 gh
S_1M_2	6.02 e	4.52 cde	27.00 fg
S_2M_2	6.47 d	4.49 de	27.60 f
S_0M_3	6.70 cd	4.50 cde	29.50 e
S_1M_3	6.85 c	4.71 abcd	29.88 e
S_2M_3	6.73 cd	4.75 abcd	31.83 d
S_0M_4	7.25 b	4.80 abc	33.50 c
S_1M_4	7.58 ab	4.85 ab	34.87 b
S_2M_4	7.75 a	4.93 a	36.63 a
LSD (0.05)	0.20	0.17	0.53
CV (%)	2.27	2.70	1.36

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid, M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc+ 1 mg boron, M_4 = 20 mg zinc+ 2 mg boron;

4.11. Length of fruit

Salicylic acid has non-significant effect on fruit length of tomato plant (Appendix VIII). The highest value was 3.84 obtained from S_4 and the lowest value was 3.72 obtained from S_o (Table 9).

Different levels of micronutrient exhibited significant variation in fruit length (cm) of tomato (Appendix VIII), it was evident that the maximum fruit length (4.08 cm) was found in M_4 whereas the minimum (3.61 cm) was obtained from M_0 which was statistically similar to M_1 (3.65) (Table 9). Wojcik and Wojcik. (2003) reported that length of fruit enhanced by the application of zinc and boron.

There were non significant interaction effects between micronutrient and salicylic acid at different concentrations in case of fruit length of tomato (Appendix VIII). The highest value was 4.18 obtained from S_2M_4 and the lowest value was 3.37 obtained from M_0S_o (Table 10).

4.12. Diameter of fruit

Diameter of tomato fruit also varied significantly (Appendix VIII) due to the application of different doses of salicylic acid (Appendix VIII). The highest diameter of fruit (3.78cm) was recorded from S_2.The lowest diameter (3.65) was recorded from S_0 which was statistically identical to S_1 (3.67) (Table 9). Javaheri *et al*. (2012) concluded that the diameter of tomato was increased, when lower concentrations of salicylic acid were sprayed.

The variation in fruit diameter among the different concentrations of micronutrients was found statistically significant (Appendix VIII). The maximum diameter of fruit (3.88 cm) was obtained from M_4 whereas, the minimum fruit diameter (3.56 cm) was obtained from M_0 which was statistically identical to M_1 (3.65) (Table 9). Sindhu *et al*. (1999) stated that fruit size is also increased by application of zinc and boron.

There were non significant interaction effects (Appendix VIII) between different levels micronutrient and salicylic acid in case of fruit diameter of tomato (Table10). The highest value was 4.01 recorded from S_2M_4 and the lowest value was 3.47 found in S_0M_0.

4.13 Fresh weight of plant

Weight of tomato plant was varied significantly due to the application of different doses of salicylic acid (Appendix VIII). The highest wt. of plant (265.55 g) was recorded from S_2. The lowest wt. (241.30 g) was recorded from S_0 (Table 9).

The variation in plant weight due to different concentrations of micronutrients was found to be statistically significant (Appendix VIII). The maximum wt. of plant (310.00g) was obtained from M_4 whereas, the minimum wt. of plant (214.08 g) was obtained from M_1. (Table 9).

There were a significant interaction effects (Appendix VIII) between different micronutrient levels and salicylic acid. The highest value was 318.25 g recorded from S_2M_4 and the lowest value was 220.75 g found in S_0M_0 (Table 10).

4.14 Dry weight of plant

Dry weight of tomato plant also varied significantly due to the application of different doses of salicylic acid (Appendix VIII). The highest dry wt. of plant (34.23 g) was recorded from S_2. The lowest dry weight (29.89 g) was recorded from S_0 (Table 9).

The variation in dry wt. of plant among the different concentrations of micronutrients was found to be statistically significant (Appendix VIII). The maximum dry wt. of plant (42.95g) was obtained from M_4 whereas, the minimum wt. of plant (25.91g) was obtained from M_1. (Table 9).

There were a significant interaction effects between different levels of micronutrients and salicylic acid (Appendix VIII). The highest value was 44.93 g recorded from S_2M_3 which was statistically identical to 44.04 and 43.73 g found in S_2M_4 and S_1M_4, the lowest value was 24.42 g found in S_0M_1 (Table 10).

Table 9. Effect of salicylic acid and micronutrients on length and diameter of fruits, plant fresh weight and dry matter content of plant

Treatments	Length of fruits (cm)	Diameter of fruits (cm)	Plant fresh weight (g)	Dry weight of plant(g)
Salicylic acid				
S_0	3.72	3.65 b	241.30 c	29.89 c
S_1	3.79	3.67b	260.25 b	32.13 b
S_2	3.84	3.78 a	265.55 a	34.23 a
LSD (0.05)	0.11	0.08	1.08	1.01
Micronutrient				
M_0	3.61 c	3.56 c	235.75 c	27.61 c
M_1	3.65 c	3.70 b	214.08 e	25.91 d
M_2	3.74 bc	3.65 bc	233.08 d	27.59 c
M_3	3.84 b	3.68 b	285.58 b	36.38 b
M_4	4.08 a	3.88 a	310.00 a	42.92 a
LSD (0.05)	0.15	0.11	1.40	1.27
CV (%)	4.90	3.70	0.67	4.84

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc+ 1 mg boron, M_4 = 20 mg zinc+ 2 mg boron

Table 10. Combined effect of salicylic acid and micronutrients on length of fruit, diameter of fruit, plant fresh weight and dry weight of plant

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Plant fresh weight (g)	Dry weight of plant (g)
S_0M_0	3.37	3.47	220.75 j	26.55fg
S_1M_0	3.70	3.53	251.25 f	29.08 de
S_2M_0	3.76	3.68	235.25 gh	27.22ef
S_0M_1	3.70	3.67	195.75 l	24.42 g
S_1M_1	3.60	3.70	217.00 k	25.92fg
S_2M_1	3.64	3.73	229.50 i	27.40 ef
S_0M_2	3.72	3.63	233.25 h	27.59ef
S_1M_2	3.70	3.54	236.50 g	27.63ef
S_2M_2	3.80	3.77	229.50 i	27.55ef
S_0M_3	3.94	3.75	260.00 e	29.91 d
S_1M_3	3.75	3.59	281.50 d	34.30 c
S_2M_3	3.82	3.70	315.25 b	44.93 a
S_0M_4	3.88	3.72	296.75 c	40.99 b
S_1M_4	4.17	3.90	315.00 b	43.73 a
S_2M_4	4.18	4.01	318.25 a	44.04 a
LSD (0.05)	NS	NS	2.43	2.21
CV (%)	4.90	3.70	0.06	4.84

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc+ 1 mg boron, M_4 = 20 mg zinc+ 2 mg boron

4.15. Individual fruit weight

Application of different levels of salicylic acid also showed significant differences for weight of individual fruit (Appendix IX). The highest individual fruit weight (40.93 g) was found in S_2 (Table 11) while the lowest individual fruit weight (37.77 g) was found in S_0

Weight of individual fruit of tomato varied significantly due to the application of different levels of micronutrients (Appendix IX). The highest individual fruit weight (45.51 g) was found in M_4. The lowest individual fruit weight (28.36 g) was observed from M_0 (Table 11). Boron prefaces on accumulation of photosynthates which has correlation with fruit weight. (Sukha, 2011) Wojcik and wojcik. (2003) stated that micronutrients promotes fruit growth by synthesizing tryptophan and auxin.

Significant variation was recorded due to the combined effect of different levels of micronutrients and salicylic acid for weight of individual fruit (Appendix IX). The highest individual fruit weight (52.11 g) was recorded from S_2M_4wheres, the lowest individual fruit weight (30.68 g) was found from control treatment S_0M_0 which was statistically identical to S_1M_0 (31.57) and S_2M_0 (31.81) (Table 12)

4.16 Dry weight of 100 gm fresh fruits

Statistically significant variation (Appendix IX) was recorded on dry matter content in fruits due to effect of different levels of salicylic acid. The highest (8.13%) and lowest (6.87%) dry matter content of fruit were obtained from S_2 and S_0, respectively (Table 11). Salicylic acid is considered to be an endogenous growth regulator of phenolic nature that enhanced the leaf area and dry mass production in fruit. (Khan *et al.*, 2010)

A statistically significant variation was recorded for dry matter content in fruits due to different concentrations of micronutrients (Appendix IX). The highest dry matter content in fruits (8.40%) was observed in M_4 which was statistically identical to M_3 (8.31%). The lowest dry matter content (7.36%) was found in M_0 (Table 11) which was statistically similar to M_1 (7.13) and M_2 (7.44). Salam *et al.* (2011) also showed that dry matter content of tomato fruits increased with the application of boron than control treatment.

Combination effect of salicylic acid and micronutrients showed statistically non significant variation for dry matter content in fruits (Appendix IX). The highest dry matter content in fruits (9.62%) was observed in S_1M_4 which was statistically similar to S_2M_4 (9.17) and S_0M_4 (9.12) whereas, the lowest (7.60%) was observed in S_1M_1 which was similar to S_2M_0 (7.70 %) (Table 12).

4.17. Total Soluble Solid:

Salicylic acid has a significant effect (Appendix IX) of total soluble solid of tomato at different concentrations. The highest value (12.82) was found from S_0 which was statistically identical to S_1 (12.67) and lowest value (11.78) was recorded from S_2 (Table 11).

The effect of micronutrients on total soluble solid of tomato plant was significantly varied (Appendix IX) at different levels. At the maximum total soluble solid content of tomato (14.58) was recorded from M_4 and the minimum value (10.83) was recorded from M_0. (Table 11)

Statistically significant effect of micronutrients and salicylic acid on total soluble solid content of tomato plant at different concentrations (Appendix IX). At the highest total soluble solid content of tomato (16.42) was found from S_2M_4 **(**Table 12) which was statistically similar (16.32, 15.97, 15.90, 15.67) to S_1M_4, S_0M_4, S_2M_3, S_1M_3. The lowest value (8.97) was found from S_0M_0 which was statistically identical (9.72 and 9.22) to S_1M_0 and S_2M_0 .

4.18. Yield plant^{-1}

Statistically significant variation was recorded for different levels of salicylic acid in terms of yield plant^{-1}**(**Appendix IX). The maximum yield plant^{-1}(1260.40 g) was found in S_2 (Fig.5) and the lowest value (1099.50 g) was obtained from S_0 .Individual fruit weight and number of fruit plant^{-1} was decreased due to summer condition, so the yield plant^{-1}was ultimately decreased but foliar application of salicylic acid helps to mitigate this stress condition and increase yield/plant.

Yield plant^{-1} significantly varied due to different levels of micronutrients **(**Appendix IX). The maximum yield plant^{-1} (1691.50 g) was found in M_4 and the minimum yield /plant (793.50 g) was recorded from M_0 (Fig. 6). Adams (2004) stated that foliar application of micronutrients can improve the vegetative growth, fruit set and yield of tomato. Exogenous application of zinc and boron enhances fruit set, number of fruit/ plant, individual fruit weight, ultimately yield /plant is increases.

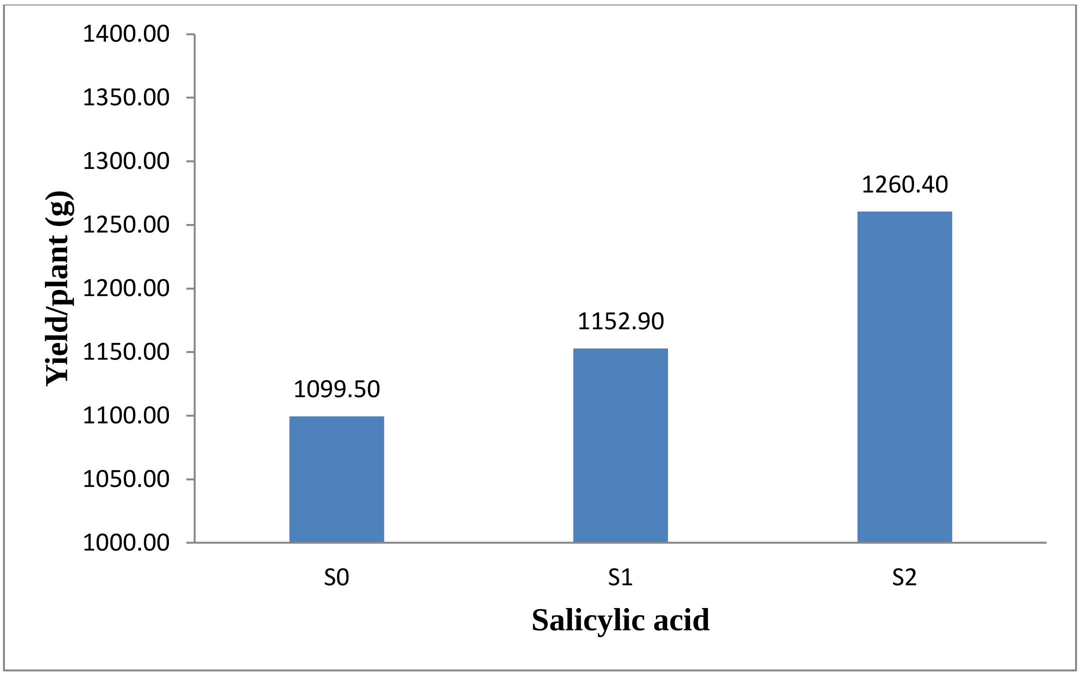
Interaction effect of micronutrients and salicylic acid showed significant differences on yield plant^{-1} of tomato (Appendix IX). The treatment combination of 20 mg zinc + 2 mg of boron and 0.5 mM salicylic acid (S_2M_4) gave the maximum yield/plant (1872.22g) whereas the minimum yield/plant (736.04 g) was observed in control condition (Table 12).

Table 11. Effect of salicylic acid and micronutrients on individual fruit weight, dry matter content and total soluble solids of fruit

Treatments	Individual fruit weight (g)	Dry matter of 100 gm fresh fruit	Total soluble solid (%)
Salicylic Acid			
S_0	37.77 c	6.87c	12.82 c
S_1	39.38 b	7.73b	12.67 b
S_2	40.93 a	8.13a	11.78 a
LSD (0.05)	0.88	0.71	0.63
Micronutrients			
M_0	28.36 e	7.36 c	10.83 e
M_1	31.48 d	7.13 c	9.31 d
M_2	36.73 c	7.44 bc	11.53 c
M_3	39.73 b	8.31 ab	15.85 b
M_4	45.51 a	8.40 a	14.58 a
LSD (0.05)	1.14	0.91	0.51
CV (%)	4.01	19.32	6.20

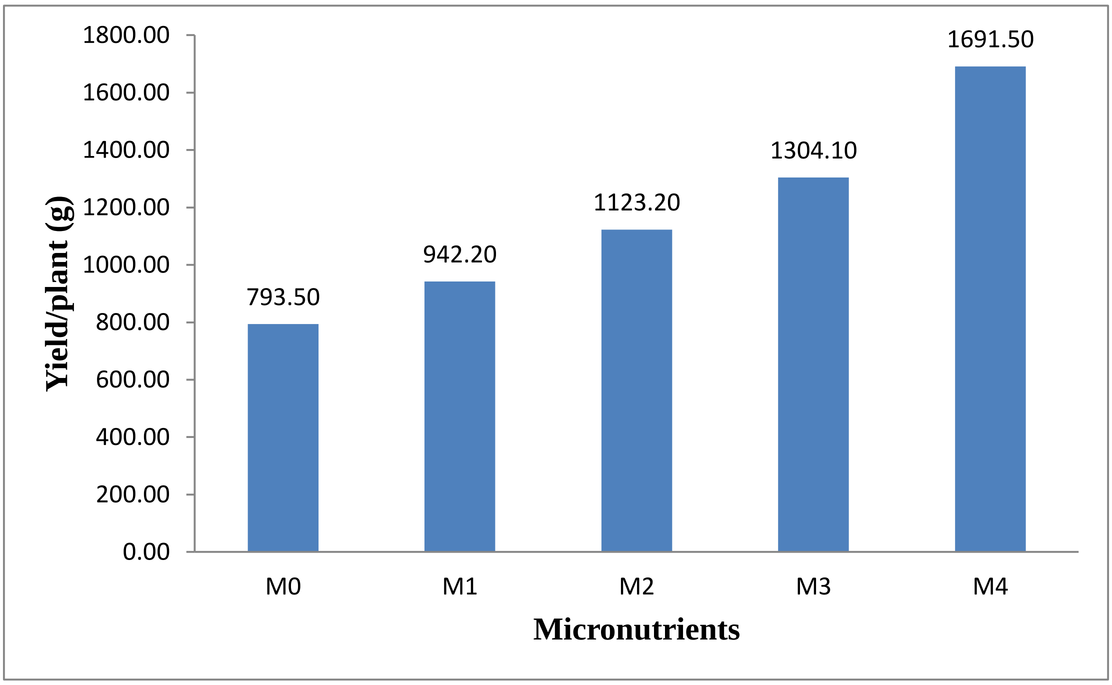
In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc+ 1 mg boron, M_4 = 20 mg zinc+ 2 mg boron



(S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid)

Figure 5. Effect of salicylic acid on yield plant^{-1}



(M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc+ 1 mg boron, M_4 = 20 mg zinc+ 2 mg boron)

Figure 6. Effect of micronutrient on yield plant^{-1}

Table 12. Combined effect of salicylic acid and micronutrients on individual fruit weight , dry matter of fruits and yield plant^{-1}

Treatments	Individual Fruit weight (g)	Dry matter of 100 g fresh fruits	Total Soluble Solid (g)	Yield plant^{-1} (g)
S_0M_0	30.68 k	8.70	8.97 g	736.04 n
S_1M_0	31.57 jk	8.67	9.72 e-g	754.23 m
S_2M_0	31.81 jk	7.70	9.22 fg	890.62 l
S_0M_1	33.02 ij	8.20	10.77 c-e	896.14 l
S_1M_1	34.48 hi	7.60	10.15 d-f	922.24 k
S_2M_1	35.92 h	8.57	10.82 cd	1008.31 j
S_0M_2	38.81 g	8.57	11.55 c	1087.93i
S_1M_2	39.29 fg	8.05	11.00 cd	1122.00 h
S_2M_2	41.09 ef	8.70	11.00 cd	1159.84 g
S_0M_3	41.85 de	8.42	12.77 b	1254.64f
S_1M_3	42.63 c-e	8.97	15.67 a	1286.73 e
S_2M_3	43.69 cd	8.80	15.90 a	1370.92 d
S_0M_4	44.47 c	9.12	15.97 a	1522.71 c
S_1M_4	48.93 b	9.62	16.32 a	1679.74 b
S_2M_4	52.11 a	9.17	16.42 a	1872.22 a
LSD (0.05)	1.96	1.57	1.09	7.85
CV (%)	4.01	19.32	6.20	0.47

In a column having similar letter are statistically identical and those having dissimilar letter differ significantly at 0.05 level of probability.

S_0 = control, S_1= 0.25 mM Salicylic acid, S_2 = 0.5mM Salicylic acid; M_0= control, M_1 = 20 mg zinc, M_2 = 2 mg boron, M_3 = 10 mg zinc+ 1 mg boron, M_4 = 20 mg zinc+ 2 mg boron

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University Dhaka 1207, April to September 2016, to find out the mitigation of summer condition by foliar application of micronutrients (Zn and B) and Salicylic acid. Three levels of Salicylic acid viz. S_1= 0 mM, SA, S_2 = 0.25 mM of SA, S_2 = 0.5 mM of SA. Four concentrations of micronutrients viz. M_0 = 0, M_1 = 20 mg of Zn, M_2 = 2 mg of B, M_3 = 10 mg of Zn + 1 mg of B, M_4 = 20 mg of Zn + 2 mg of B. The experiment was carried out in Complete Randomized Design (CRD) with four replications. The crop was harvested from 2 August to 30 August, 2016. Data on growth and yield contributing parameters were recorded and the collected data were statistically analyzed to evaluate the treatment effects. The summary of the results has been presented in this chapter.

There are significant differences among the effect of different levels of salicylic acid in case of almost all the parameters. At 15, 30, 45, 60 and 75 DAT, the highest plant was (24.60, 57.40, 80.30, 106.55 and 103.55 cm) found in S_2 whereas the lowest plant height was (22.25, 53.00, 76.55, 96.50 and 99.30 cm) found in S_0. The highest number of leaves plant^{-1} was (26.75, 27.10, 23.67) found in S_2 and the lowest number was (20.90, 23.08, 20.08) found in S_0 at 30, 45 and 60 DAT, respectively. Maximum number of branch plant^{-1} was (4.50, 7.50 and 7.89) found in S_2 and the minimum number was 3.90, 5.50, 6.18 found in S_0 at 30, 45 and 60 DAT. The highest flower clusters^{-1} 6.20 was found in S_2 treated plants and S_1 treated plants and the lowest flower clusters^{-1} 5.05. The highest number of flower/plant 34.53 was observed in S_2 and the lowest number of flower/plant (29.71) was found in S_0 .The highest fruit cluster plant^{-1}(6.25) was found in S_2 which was and the lowest fruit clusters /plant (5.88) was found in S_0. The highest number of fruits plant^{-1}(28.67) was observed from S_2 and the lowest value (26.88) was from S_0. The highest value of leaf area, leaf chlorophyll content, individual weight of fruit, total soluble solid was found in S_2 and the lowest value was found in S_0. The highest yield plant^{-1} (1260.42 g) was found in S_2 and the lowest value (1099.52 g) was found in S_0.

In case of micronutrients, the highest plant height was 26.09 cm, 62.33 cm, 85.58 cm, 120.92 cm, 124.67 cm. whereas the lowest plant height was 20.83 cm, 51.00, cm, 72.42, 80.08, 84.25 was found at 15, 30, 45, 60, 75 DAT respectively. The highest number of leaves plant^{-1} was (24.00, 30.17 and 30.42) whereas the lowest was (20.90, 23.08, 20.08) at 30, 45, 60 DAT, respectively. Maximum number of branch plant^{-1} was (5.83, 8.42 and 9.20) in M_4 and the minimum number was (2.88, 3.83 and 4.63) in M_0. The highest number of flower cluster^{-1} was 6.22 in $M_4$and the lowest number of flower cluster^{-1}4.38 was recorded from control treatment (M_0). The highest number of flowers/plant (42.00) was found in M_4 and the lowest number of flower/plant (24.33) was found in M_0. The maximum number of fruits /cluster (4.85) was found from M_4 and the minimum number of fruits /cluster (3.66) was found in M_0. The highest number of fruits plant^{-1} (35.00) was found from M_4 and the lowest number (19.59) was observed from M_0.The highest leaf chlorophyll content, individual fruit weight , dry matter content in fruits was found in M_4 while the lowest was found in M_0 (control condition). The highest yield plant^{-1} (1691.51 g) was observed in M_4 and the lowest was (793.52 g) found in M_0.

Interaction between salicylic acid and micronutrients significantly influenced almost all parameters. The highest plant height was found in S_1M_3 (27.75), S_2M_4 (67.50), S_1M_2 (88.75), S_2M_4 (119.00), S_2M_4 (129.75) and the lowest was found in S_0M_1 (19.75), S_0M_1 (43.25), S_1M_0 (69.50), S_0M_1 (66.75) and S_1M_1 (82.75) at 15, 30, 45, 60 and 75 DAT respectively. The maximum number of leaves plant^{-1} was (24.98, 32.50 and 33.50) and the minimum number was (19.62, 18.25 and 19.25) found at 30, 45 and 60 DAT. The maximum number at 30 DAT, the highest number of branches per plant (6.05) was obtained from S_1M_4 while the lowest number of branches per plant (2.30) was obtained from S_0M_0 and there was a non significant relation between salicylic acid and micronutrients interactions at 45 and 60 DAT. The highest number of flower clusters^{-1}(6.63) was found from S_2M_4 which was statistically similar to

S_1M_4(6.37) while the lowest number (4.12) was obtained from S_0M_0.The highest number of flowers/plant (48.25) was found in S_2M_4 and the lowest number of flower/plant (19.75) was found in S_0M_0. Except all this parameters the highest result was obtained from $S_2M_4$and the lowest result was found in S_0M_0 such as the maximum yield plant^{-1}(1872.22 g) was recorded from S_2M_4 whereas the lowest (736.04 g) was observed from S_0M_0.

Conclusion:

The overall results obtained from the study facilitated to draw the following conclusions:

1. Exogenous application of salicylic acid (0.25 mM) can effectively mitigate the adverse effect of temperature in summer season and increase yield.
2. The plants was produced the maximum growth and yield of tomato due to the application of micronutrients (20 mg of zinc and 2 mg of boron)
3. It is concluded that 20 mg of Zinc, 2 mg of Boron and 0.5 mM Salicylic acid are the best combination for tomato production in summer.

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APPENDICES

Appendix I. Physical and chemical composition of soil sample

Characteristics	Value
% Sand	21.75
% Silt	66.60
% Clay	11.65
Textural class	Silty loam
P^H	6.53
Organic matter %	1.28

Appendix II. Monthly record of air temperature, rainfall, and relative humidity of the experimental site during the period from April 2016 – August 2016

Month	Temperature(^{0}c)		Relative Humidity (%)	Rainfall (mm)
	Maximum	Minimum		
April	40	28	70	16
May	37	25	75	14
June	36	30	65	13
July	34	26	82	42
August	35	28	74	26

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargaon, Dhaka- 1207

Appendix III. Analysis of variance of the data on plant height of tomato

Source of variation	DF	Mean square of plant height (cm) at				
		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Replication	3	2.00	4.71	4.02	9.44	10.51
Factor A (S)	2	28.3**	123.47**	70.32*	556.07**	129.52**
Factor B (M)	4	45.94**	208.61**	351.43**	3262.73**	2754.19**
Interaction (AxB)	8	26.81**	102.95**	74.36 **	202.15**	37.58 **
Error	42	3.47**	6.19	3.70	5.49	4.82

** Significance at 1% level of probability
*Significance at 5% level of probability
NS = Non significant

Appendix IV. Analysis of variance of the data on number of leaves plant^{-1} of tomato

Source of variation	DF	Mean square of leaves plant^{-1}		
		30 DAT	45 DAT	60 DAT
Replication	3	0.2502	21.6988	8.594
Factor A (S)	2	14.6207 ^{NS}	19.0152**	113.817**
Factor B (M)	4	43.0862^{NS}	14.9839**	189.542**
Interaction(AxB)	8	0.475 ^{NS}	4.1570**	125.129**
Error	42	0.3303	6.5212	3.237

** Significance at 1% level of probability
* Significance at 5% level of probability
NS = Non significant

Appendix V. Analysis of variance of the data on number of branch plant^{-1} of tomato

Source of variation	DF	Mean square of branch plant^{-1} at		
		30 DAT	45 DAT	60 DAT
Replication	3	0.0766	2.3778	0.2502
Factor A (S)	2	1.4599^{NS}	11.2500**	14.6207**
Factor B (M)	4	17.6038 ^{NS}	41.3167**	43.0862**
Interaction (AxB)	8	0.2186**	0.2292^{NS}	0.4753 ^{NS}
Error	42	0.0217	0.4254	0.3303

** Significance at 1% level of probability
* Significance at 5% level of probability
NS = Non significant

Appendix VI. Analysis of variance of the data on flower per cluster, flower per Plant leaf area and leaf chlorophyll content

Source of Variation	DF	Mean square of				
		Flower /cluster	Flower/plant	Leaf chlorophyll content		Leaf Area (cm^2)
				(Veg.)	(Rep.)	
Replication	3	0.17340	2.188	3.2452	1.993	2.54
Factor A (S)	2	0.117^{NS}	94.060**	77.00**	34.72**	96.85**
Factor B (M)	4	5.48**	642.47**	27.09**	363.61**	2586.35 **
Interaction(AxB)	8	0.458*	42.855**	28.840**	94.82**	11.80**
Error	42	0.26178	2.407	3.6120	2.476	2.86

** Significance at 1% level of probability
* Significance at 5% level of probability
NS = Non significant

Appendix VII. Analysis of variance of the data on fruit/cluster, fruit cluster/plant and fruit/plant of tomato

Source of Variation	DF	Mean square of		
		Fruit cluster/plant	Fruit/cluster	Fruit/ plant
Replication	3	0.32939	0.2630	3.113
Factor A (S)	2	0.0865**	0.6929*	35.743**
Factor B (M)	4	2.52762**	15.2879**	417.305**
Interaction (AxB)	8	0.03310**	0.097*	0.989**
Error	42	0.01412	0.0190	0.138

** Significance at 1% level of probability
* Significance at 5% level of probability
NS = Non significant

Appendix VIII. Analysis of variance of the data on length of fruit, breadth of Fruit, fresh weight and dry matter percent in plant in plant

Source of variation	DF	Mean square of			
		Length of fruit (cm)	Diameter of fruit (cm)	Fresh weight of plant (g)	Dry weight of plant(g)
Replication	3	0.018	0.02078	5.4	2.188
Factor A (S)	2	0.067 NS	0.11407*	3250.9**	94.060**
Factor B (M)	4	0.43**	0.16730**	19448.91**	642.47**
Interaction (AxB)	8	0.070NS	0.02822 NS	633.4**	42.855**
Error	42	0.03434	0.01869	2.9	2.407

** Significance at 1% level of probability
* Significance at 5% level of probability
NS = Non significant

Appendix IX. Analysis of variance of the data on fresh weight and dry weight of fruit , total soluble solid, yield plant^{-1} of tomato

Source of Variation	DF	Mean Square of			
		Individual wt.of fruit (g)	Dry weight of 100 g fresh fruit	Total soluble solid	Yield plant^{-1} (g)
Replication	3	57.437	1.560	1.4316	169
Factor A(S)	2	49.842**	0.302*	6.3605**	134313**
Factor B (M)	4	548.920**	4.111*	88.3727**	1457254**
Interaction (AxB)	8	7.012*	1.581^{NS}	9.8686**	12556**
Error	42	1.898	1.224	0.5924	30

** Significance at 1% level of probability
* Significance at 5% level of probability
NS = Non significant

Appendix X. The experimental plot

Plate 1. Pictorial veiw of my experiment

Plate 2. Pictorial veiw of fruit/plant