EFFECT OF FOLIAR APPLICATION OF ZINC AND GIBBERELLIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO

MD. JUNAID SAKI

DEPARTMENT OF AGRICULTURAL BOTANY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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BY

MD. JUNAID SAKI

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Approved by:

______________________	__________________________
(Professor Dr. Md. Ashabul Hoque) **Supervisor**	**(Professor Dr. Kamal Uddin Ahamed)** **Co-supervisor**

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Dr. Md. Ashabul Hoque
Professor &
Chairman
Examination Committee

Professor Dr. Md. Ashabul Hoque
Department of Agricultural Botany
Sher-e-Bangla Agricultural University
Dhaka, Bangladesh

Ref: Date:

CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF FOLIAR APPLICATION OF ZINC AND GIBBERELLIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO"** submitted to the Department Of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURAL BOTANY**, embodies the result of a piece of bona fide research work carried out by **MD. JUNAID SAKI,** Registration No. **09-03490** under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma**.**

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

Dated:
Dhaka, Bangladesh

____

(Professor Dr. Md. Ashabul Hoque)
Supervisor
Department of Agricultural Botany
Sher-e-Bangla Agricultural University
Dhaka- 1207, Bangladesh

DEDICATED TO MY BELOVED PARENTS

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EFFECT OF FOLIAR APPLICATION ZINC AND GIBBERELLIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO

ABSTRACT

The experiment was conducted at experimental plot of Sher-e-Bangla Agricultural University in Dhaka city., during the period from October, 2015 to March, 2016. Two factors experiment included three levels of Zinc i.e. Foliar application of Zinc Z_0= control, Z_1 = 0.5 kg/ha, Z_2= 1 kg/ha and four levels of GA_3 i.e G_0 = control, G_1= 50 ppm GA_3, G_2 = 75 ppm GA_3, G_3= 100 ppm GA_3 respectively, was outlined in Randomized Complete Block Design (RCBD) with three replications. Application of Zinc and GA_3 influenced independently and in combination on growth, yield and quality of tomato. Individual application of Z_1 @ 0.5 kg/ha gave the highest plant height, no. of leaves per plant, flower clusters per plant, flowers per cluster, fruit per cluster, fruit per plant, fruit weight per plant (2.519 Kg), fruit weight per plot (26.35 Kg), fruit yield (73.19 t/ha), TSS% (7.683), β-carotene (0.3600 mg per 100g), vitamin-C (104.8 mg per 100g) and G_2 @ 75 ppm gave the highest plant height, number of leaves per plant, flower clusters per plant, fruit per plant, fruit weight per plot (22.62 kg), fruit yield (62.84 t/ha), TSS% (7.500), β-carotene (0.3344 mg per 100g), vitamin-C (97.44 mg per 100g). In case of combined effect, Z_1G_2 (Z_1 @ 0.5 kg/ha + G_2 @ 75 ppm) gave the highest plant height, no. of leaves per plant, flower clusters per plant, flowers per cluster, fruit per cluster, fruit per plant, fruit weight per plant (3.027 Kg), fruit weight per plot (33.31 Kg), fruit yield (92.54 t/ha), TSS% (8.00), β-Carotene (0.3967 mg per 100g), vitamin-C (114.1 mg per 100g). So, it can be concluded that Z_1G_2 (Z_1 @ 0.5 kg/ha + G_2 @ 75 ppm) is the best for growth, yield and quality of tomato.

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LIST OF ACCRONYMS AND ABBREVIATION

ABBREVIATION	ELABORATION
SAU	Sher-e-Bangla Agricultural University
Z	Zinc
GA_3	Gibberellic Acid
RCBD	Randomized Complete Block Design
et al.	and others
FAO	Food and Agricultural Organiztion
m	Meter
kg ha^{-1}	Kilogram per hectare
ppm	Parts per million
t ha^{-1}	Ton per hectare
kg	Kilogram
No.	Number
TSS	Total Soluble Solids
β	Beta
IU	International Unit
g	Gram
mg	Milligram
BBS	Bangladesh Bureau of Statistics
i.e	id est
cv.	Cultivar
%	Percent
mg L^{-1}	Milligram per litre
mg kg^{-1}	Milligram per kilogram

LIST OF ACCRONYMS AND ABBREVIATION (Cont'd)

ABBREVIATION	ELABORATION
q ha^{-1}	Quintal per hectare
Rs	Real shit
ml	Millilitre
gm^{-3}	Gram per mitre cube
sq. m	Square meter
FYM	Farm Yard Manure
dSm^{-1}	Decisiemens per metre
i.e.	id est (L), that is
^{0} C	Degree Centigrade
BARI	Bangladesh Agricultural Research Institute
@	At the rate
nm	Nanometre
DMRT	Duncan's Multiple Range Test
DAT	Days After Transplanting
m^2	Square Metre
Fig.	Figure
j.	Journal
Sci.	Science
Hort.	Horticulture
p.	Page
pp.	Particular pages
Agri.	Agriculture
Exp.	Experimental

LIST OF ACCRONYMS AND ABBREVIATION (Cont'd)

ABBREVIATION	ELABORATION
Bot.	Botany
Res.	Research
ed.	Edition
Assoc.	Association
Amer.	American
Soc.	Society
Univ.	University
Agron.	Agronomy
BAU	Bangladesh Agricultural University
Dept.	Department
M. Sc.	Master of Science
Nucl.	Nuclear
Vol.	Volume
Advan.	Advance
Cont'd	Continued
Prog.	Progressive
mol m^{-3}	Mole per metre cube
wt.	Weight

CHAPTER I

Introduction

Tomato (*Solanum lycopersicum*) is a solanaceous self-pollinated vegetable crop. It's chromosome number 2n=24. It is one of the important, popular and nutritious vegetables grown in Bangladesh in both winter and summer season around all parts of the country (Haque *et al*., 1999). It is originated in South American Andes and it's use as a food originated in Mexico. Tomato is one of the most popular, important and widely used vegetable crops as ranked second number vegetable of the world after potato (Dorais *et al.,* 2008; Olaniyi *et al.,* 2010).

Tomato can be grown in any types of soil. But sandy loam soil with adequate supply of organic matter, good moisture holding and drainage capacity are ideal for tomato cultivation. Optimum temperature for seed germination, vegetative growth and reproductive growth is 20^0c, 25^0c, 18-22^0c temperature, respectively. Tomato requires high light intensity. Optimum RH is 60-70%, 9-11 hours day length is required for flowering. Production of tomato depends on many factors, such as quality of seed, plant spacing, planting time, manure, fertilizer, salinity, pruning and management practices etc.

It is cultivated in almost all home gardens and also in the field due to it's adaptability to wide range of soil and climate (Ahmed, 1976). Salinity constitutes the most agricultural problem in many parts of the world (Ramage, 1980). In Bangladesh, the recent statistics shows that tomato was grown in 63000 acres of land and the total production was approximately 255000 metric tons during the year 2011-2012 and the average yield of tomato was 4035kg/acre (BBS, 2012*)*. Tomato is very rich in nutrients, especially potassium, folic acid, vitamin C and contains a mixture of different carotenoids, including vitamin A, effective β-carotene as well as lycopene (Wilcox *et al*. 2003). It contains Calories 97, Iron 2.7

mg, Protein 4.5 g, Riboflavin 0.15 mg, Calcium 50 mg, Niacin 3.2 mg, Phosphorus 123 mg and Ascorbic acid 102 mg per 1 pound edible portion (Lester, 2006). Tomato (*Solanum lycopersicum*) is a rich source of lycopene and vitamins. Lycopene may help counteract the harmful effects of substances called "free radicals". Lycopene one of nature's most powerful antioxidant, is present in tomatoes and especially when tomatoes are cooked, had been found beneficial in preventing prostrate cancer. The consumption of tomatoes rich in lycopene leads directly to a decreased incidence of cancer in mouth, pharynx, esophagus, stomach, large intestine and rectum (Franceschi *et al*. 1994).The yield of tomato in our country is not satisfactory in comparison to its requirement (Aditya *et al.,* 1999*).* However, the yield of the crop is very low compared to those obtained in some advanced country (Sharfuddin and Siddique, 1985). The low yield of tomato in Bangladesh, however, is not an indication of low yielding ability of this crop, but of the fact that low yielding variety, poor crop management practices and lack of improved technologies. Tomato is cultivated generally in winter season in Bangladesh. Now a days it is also cultivated in summer.

Adequate supply of micronutrients also plays an important role in tomato production. Among the micro elements, Zinc plays an important role directly and indirectly in improving the yield and quality of tomato in addition to checking various diseases and physiological disorders. It gives a rosette appearance and yellowing between veins of new growing leaves occur in plant (Marchner, 1995). Zn is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes (Grotz and Guerinot, 2006). Zinc deficiency is thought to restrict RNA synthesis, which in turn inhibits protein synthesis (Katyal and Randhawa, 1983). In the salt affected areas, zinc application could alleviate possible Na and Cl injury in plants. (Mehmet *et al.,* 1998)

Currently, a large number of growth regulators are available in the market but basically they are two types i.e. growth promoters and growth inhibitors or retardants. The Gibberellic acid is one of the most important growth stimulating substances used in agriculture since long. It may promote cell elongation, cell division and thus helps in growth and development of tomato plant. Gibberellic acid when applied to flowers controlled fruit drop in tomato (Feofanova, 1960). Fruit set in tomato can be increased by applying plant growth regulators to compensate the deficiency of natural growth substances required for its development (Singh and Choudhury, 1966). The use of Growth regulators and micro elements improved the production of tomato including other vegetables respect of better growth and quality which ultimately lead general interest among scientist and farmers for commercial application of these substances. It is, therefore, highly desirable to explore possible ways and means to enhance the productivity of this important crop employing cost effective and easy to use techniques. In this regard, the effect of spray of gibberellic acid (GA_3) at very low concentrations could be exploited beneficially as its natural occurrence in plants in minute quantities is known to control their development. It is an established phytohormone used commercially for improving the productivity and quality of a number of crop plants. It is necessary to find out the effective dose of Zinc and Growth regulators (GA_3) in promoting.

Although, tomato is the second major crop of the world after potato, but there is lack of research, particularly under field conditions, to show interactive effects of zinc and Gibberellic acid on tomato.

Keeping the above point of view, the present study was undertaken to evaluate the effect of zinc and gibberellic acid (GA_3) on tomato with the following objective:

- To study the effect of different levels of zinc and GA_3 on growth and yield of tomato.

- To investigate the effect of different levels of zinc and GA_3 on quality of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato *(Solanum lycopersicum*) is one of the most important vegetable crops in Bangladesh and received much attention to the researcher throughout the world. Zinc and plant growth regulators are the substances, which affect the growth of plants quite miraculously. Application of this Zinc and growth regulator has different modifying influences on growth, yield and yield contributing characters of tomato as well as other vegetables. Some of the available research works in this connection have been reviewed with the hope that these may contribute useful information to the present study. In these chapter morphological characters, growth, yield and biochemical parameters have been reviewed as follows:

2.1 Effect of zinc on growth, yield and quality of tomato

Cakmak *et al.* (1989) found that plant growth is severely depressed by zinc deficiency, but high concentration of zinc also reduces dry weight of crop.

Singh *et al.* (1990) examined that Zn deficiency may enhance boron absorption and transport to such an extent that boron may possibly accumulate to toxic levels in plant tops.

Dongre *et al.* (2000) conducted an experiment and that showed that the highest percentage of TSS (3.12 %) content was attained in fruits treated with foliar application of 50 mg/L Zn+100 mg/L Fe and the lowest was achieved in control . Also highest pH was attained in fruits treated with 200 mg/L foliar Fe. Increase in Zn and Fe concentration significantly increased TSS content when accompanied by Zn and Fe alone or in combination, and the highest and lowest values of this parameter were found at 50 mg/L Zn+100 mg/L Fe and control, respectively .

Swan *et al.* (2001) found that balance fertilization of macro and micro nutrients i.e. Nitrogen, Phosphorus, Zinc is essential for the production of high yield and quality products.

Hall (2002) found that copper and zinc are actively involved in the cellular metabolism because both of them, mostly zinc, are present in many proteins.

Kaya and Higgs (2002) stated that zinc may be required for chlorophyll production, pollen function and fertilization.

Imtiaz *et al.* (2003) observed that zinc is essential for normal plant growth and development as carbohydrates, protein metabolism and sexual fertilization also depend on zinc.

Kumari and Sharma (2006) was carried out an experiment to determine the effects of boron, zinc, molybdenum, copper, iron and/or manganese, applied as foliar sprays, on the growth and fruit and seed yield of tomato. All the treatments were applied at 100 ppm starting 30 days after transplanting and repeated twice at 10-day interval. The recommended NPK rate (100 kg N, 75 kg P2O5 and 55 kg K_2O/ha) were uniformly applied in all the treatments including the control where no spraying of micronutrients was carried out. Variations in plant height, number of days taken to first flowering, number of branches per plant, number of fruits per plant, fruit yield per plant, yield/ha, seed yield and 1000-seed weight were observed. Foliar application of boron at 100 ppm resulted in the highest growth and seed yield, with net returns of Rs. 150 811.44/ha and cost: benefit ratio of 1:2.13.

Silspour and Omidghaemi (2006) conducted an experiment to study on the effects of different irrigation water quantities and use of Fe and Zn on yield and water use efficiency of tomato. Treatment comprise of three irrigation water regimes based on evaporation from pan class A (60 , 80 and 100 percent evaporation) and four fertilizer treatments (NPK , NPKZn , NPKFe and NPKFeZn) in clay loam soil on tomato yield were studied and result showed that use of Zn and Fe increase yield and water use efficiency significantly . In general, use of NPK +Fe + Zn and irrigation based on 100 100% evaporation was best treatment with 48.1 t/ha.

Cakmak (2008) found that Zinc also plays an important role in the production of biomass.

Salam *et al.* (2010) conducted a field experiment 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) 0 kg B + 0 kg Zn/ha, ii) 1.5 kg B + 2.0 kg Zn/ha, iii) 2.0 kg B + 4.0 kg Zn/ha , iv) 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). The highest pulp weight , dry matter content, TSS, acidity, ascorbic acid, lycopene content, chlorophyll a, chlorophyll-b, marketable fruits at 30 days after storage and shelf life were recorded with the combination of 2.5 kg B + 6 kg Zn/ha and recommended dose of NPK fertilizers (N= 253, P= 90, and K= 125 kg/ha).

Aghtape *et al.* (2011) stated that foliar application of micronutrients to plant is the most effective and safest way.

Irshad (2011) conducted a study on the effect of organic manures and inorganic fertilizers on biochemical constituents of tomato. In this study tomato plants were treated with organic manures (F.Y.M, Sewage sludge) and inorganic fertilizers (N.P.K, Zn, S) were analyzed for biochemical composition. T.S.S, lycopene, carbohydrate, vitamin C, acidity and carotenoid content exhibited an increase at all the test concentrations and were found maximum in sewage sludge treated along with N.P.K, followed by @ FYM along with NPK.

Salam *et al*. (2011) investigated the effect of boron, zinc, and cow dung on quality of tomato. There were 16 treatments comprising four rates of boron and zinc viz., B0Zn0, B1.5Zn2,B2Zn4 and B2.5Zn6 kg/ha and four rates of cowdung viz., CDo, CD10, CD15, and CD20 t/ha. Every plot received at the rate of 253 kg N, 90 kg P, 125 kg K, and 6.6 kg S per hectare. The results revealed that the highest pulp weight , dry matter content , ascorbic acid. lycopene content, chlorophyll-a, chlorophyll-b, marketable fruits at 30 days after storage and shelf life were recorded with the combination of @2.5 kg B/ha + 6 kg Zn/ha, and 20 t/ha cowdung.

Naga *et al.* (2013) conducted a study to find out the effect of Foliar Application of Micronutrients on growth parameters in tomato (*Lycopersicon esculentum* Mill.).The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese and mixture. 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 UtkalKumari, the fruit yield per plant ranged from 1.336 kg to1.867.

2.2 Effect of GA_3 on growth, yield and quality of tomato

Gustafson (1960) worked with different concentration of GA and observed that when 35 and 70 ppm GA were sprayed to the flowers and floral buds of the first three clusters, percentage of fruits set increased but there was a decrease in the total weight. When only the first cluster was sprayed, the number of fruit set and the total weight per cluster was increased, but this response did not occur in subsequent clusters.

Adlakha and Verma (1964) sprayed GA in concentration of 50 and 100 ppm on flower cluster at anthesis and noticed that the application of GA at 100 ppm could appreciably increase fruit size, weight, protein, sugar and ascorbic acid contents.

Adlakha and Verma (1965) observed that when the first four clusters of tomato plants were sprayed three times at unspecified intervals with GA at 50 and 100 ppm, the fruit setting, fruit weight and total yield increased by 5, 35 and 23%, respectively with the higher concentration than the lower.

Jansen (1970) reported that tomato plants treated with GA neither increased the yield nor accelerated fruit ripening. He mentioned that increasing concentration of GA reduced both the numbers and size of the fruits.

Choudhury and Faruque (1972) stated that the percentage of seedless fruit increased with an increase in GA_3 concentration from 50 ppm to 100 ppm and 120 ppm. However, the fruit weight was found to decrease by GA_3 effects.

Hossain (1974) reported the effect of gibberellic acid along with parachlorophenoxy acetic acid on the production of tomato. He found that GA_3 applied at 50, 100 and 200 ppm produced an increased fruit set. However, GA_3 treatment induced a small size fruit production. A gradual increase in the yield per plant was obtained with higher concentration of GA_3.

Kaushik *et al.* (1974) carried out an experiment with the application of GA_3 at 1, 10 or 100 mg/L on tomato plants at 2 leaf stage and then at weekly interval until 5 leaf stage. They reported that GA_3 increased the number and weight of fruits per plant at higher concentration.

Mehtha and Mathi (1975) reported that treatments with NAA at 0.1 or 0.2 ppm improved the yield of tomato irrespective of planting date. Maximum fruit set, early and total yield, fruit number and weight were obtained in response to 4-D at 5 ppm followed by NAA at 0.2 ppm. He also reported that GA treatments at 10 or 25 ppm improved the yield of tomato cv. Pusa Ruby irrespective of planting date. GA gave earlier setting and maturity.

Mozer (1980) reported that GA_3 enhance plant height and leaf area. The promoting effect of GA_3 on DNA, RNA and protein synthesis and ribose and polyribosome multiplication.

Saleh and Abdul (1980) conducted an experiment with GA_3 (25 or 50 ppm) which was applied 3 times in June or early July. They reported that GA_3 stimulated plant growth. It reduced the total number of flowers per plant, but increased the total yield compared to the control. GA_3 also improved fruit quality.

Onofeghara (1981) conducted an experiment on tomato sprayed with GA at 20-1000 ppm and NAA at 25- 50 ppm. He observed that GA promoted flower primodia production and the number of primordia and NAA promoted flowering and fruiting.

In China, Wu *et al.* (1983) sprayed one month old transplanted tomato plants with GA at 1, 10 or 100 ppm. They reported that GA at 100 ppm increased plant height and leaf area.

Leonard *et al.* (1983) observed that GA application directly on the inflorescence promoted inflorescence development in tomato plants (cv. King plus) grown under a low light regime.

Groot *et al.* (1987) reported that GA was indispensable for the development of fertile flowers and for seed germination, but only stimulated in later stages of fruit and seed development.

Sumiati (1987) reported that tomato cultivars, "Gondol", "Meneymaker", "Intan" and "Ratan" sprayed with 1000 ppm chlorflurenol, 100 ppm IAA, 50 ppm NAA or 10 ppm GA_3 or left untreated, compared with controls, fruit setting was hastened by 4-5 days in all cultivars following treatment with 100 ppm IAA or 10 ppm GA3

Gabal *et al.* (1990) investigated that 100 ppm of GA_3 was more effective treatment in increasing leaf number compared to control.

Hathout *et al.*(1993) found that application of 10 ppm IAA as foliar sprays or to the growing media of tomato plants had a stimulatory effect on plant growth, development and fruit which was accompanied by increases in endogenous gibberellins contents.

Patel and Saxena (1994) reported that presoaking of seed of gram in varying concentrations of GA_3 showed the best results on dry weights.

Davies (1995) stated that the most widely available plant growth regulator is GA_3 or gibberellic acid, which induces stem and internode elongation, seed germination, enzyme production during germination and fruit setting and growth.

El-Abd *et al.* (1995) studied the effect of plant growth regulators for improving fruit set of tomato. Two tomato cv. in pots, Alicante crops were produced in the greenhouse. When the third flower of the second cluster reached anthesis, the second cluster was sprayed with IAA, GA_3 or ABA at 10-4, 10-6 or 10-8 M each and ACC at 10-9, 10-10 or 10-11 M. All concentrations of IAA, GA_3, ACC and ABA induced early fruit set compared with controls sprayed with distilled water.

Sanyal *et al.*(1995) studied that the effects of plant growth regulators (IAA or NAA at 15, 25 or 50 ppm or GA_3 at 50, 75 or 100 ppm) and methods of plant growth regulator application on the quality of tomato fruits. Plant growth regulators had profound effects on fruit length, weight and sugar : acid ratio. The effects of presoaking seeds and foliar application of plant growth regulators were more profound than presoaking alone.

Singh (1995) stated that the effect of spray of gibberellic acid (GA_3) at very low concentrations could be exploited beneficially as its natural occurrence in plants in minute quantities is known to control their development. It is an established phytohormone used commercially for improving the productivity and quality of a number of crop plants.

Takano *et. al* (1995) experimented that application of GA_3 at 50 and 100 ppm in french bean increased leaf number .

Tomar and Ramgiry (1997) observed that number of branches/plant, plant height, number of fruits/plant and yield are significantly greater than untreated control when plants treated with GA_3 . Application ofGA_3 treatment at the seedling stage gives valuable scope for obtaining higher commercial tomato yields.

Khan *et al.(* 1998) observed that application of 10^{-5} M GA_3 on mustard at 40 or 60 days after sowing significantly increased total dry matter .

EI- Habbasha *et al.*(1999) carried out a field experiment with tomato cv. castel rock over two growing seasons (1993-94). The effects of GA_3 on fruit yield and quality were investigated. It increased fruit set percentage and total fruit yield, but also the percentages of parthenocarpic and puffy fruits compared to the controls.

Gulnaz *et al.*(1999) reported that seeds of wheat treated with GA_3 (10 ppm) resulted in 36-43% increase in dry weight at 13.11 dS/m.

Shittu and Adeleke (1999) investigated the effects of foliar application of GA_3 (0, 10, 250 or 500 ppm) on development and growth of tomatoes cv, 158-3 grown on pots. Plant number and height of leaves were significantly increased by GA_3 treatment. Plants treated with GA_3 (250 ppm) were tallest and the highest number of leaves.

Sun *et al.* (2000) reported the role of growth regulators on cold water for irrigation reduces stem elongation of plug-grown tomato seedlings. The effect of growth regulators (abscisic acid, gibberellic acid (GA), paclobutrazol, ethephon, IAA and silver thiosulfate) and cold water irrigation at different temperatures (5, 15, 25, 35, 45 and 55 °C) on the reduction of stein elongation of plug-grown tomato seedlings was investigated. Paclobutrazol, ethephon and GA reduced the stem length of the tomatoes at several water temperatures. Cold water irrigation with the addition of 1.8 ppm GA or irrigation at room temperature could promote stem elongation. Irrigation at room temperature with the addition of 10 ppm paclobutrazol (GA_3 biosynthesis inhibitor) or cold water irrigation could inhibit stem elongation. The reduction in stem elongation in plug-grown tomato seedlings was due to the relationship of GA_3 metabolism and sensitivity.

Rafeekher *et al.* (2002) found that Gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters, quality of plant .

Sheeja and Mandel (2004) reported that GA found to be the best among all treatments for producing calli with very good growth from leaf and stem explants of tomato cultivars. Callus induction was observed within 8-10 days of culturing the leaf explants source.

Sasaki *et al.* (2005) studied the effect of plant growth regulators on fruit set of tomato *(Lycopersicon esculentum* cv. Momotaro) under high temperature and in a field (Japan) under rain shelter. Tomato fruit set reduced by high temperature.

Khan *et al.* (2006) observed the effect of 4 levels of gibberellic acid spray on the growth, leaf-NPK content, yield and quality parameters of 2 tomato cultivars *(Lycopersicon esculentum* Mill.*),* namely “Hyb-SC-3” and “Hyb-Himalata”. They stated that irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters, especially in the case of “Hyb-SC-3”.

CHAPTER III

MATERIALS AND METHODS

This chapter includes location of the experiment, characteristics of soil, climate, materials used, land preparation, manuring and fertilizing, transplanting and gap filling, stalking, after care, harvesting and collection of data.

3.1 Location of the experiment field

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207 during the period from October, 2015 to March, 2016. The location of the experimental site was at $23^{0}74^{/N}$ latitude and $90^{0}35^{/E}$ longitude with an elevation of 8.45 meter from the sea level. This Experiment focus to find out the effect of different concentration of zinc and GA_3 on the growth, yield and quality of tomato.

3.2 Climate of the experimental area

The experimental area was subtropical in nature. It is characterized by heavy rainfall, high temperature, high humidity and relatively long day during kharif season (April to September) and a scanty rainfall associated with moderately low temperature, low humidity and short day period during rabi season (October to March). Meteorological data details in respect of monthly maximum, minimum and average temperature, rainfall, relative humidity, average sunshine hours and soil temperature during the period of experiment were presented in Appendix II.

3.3 Soil of the experimental field

Study site soil was silty clay loam in texture. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5. The soil sample collected from the experimental area were analyzed in the Soil Resources and Development Institute (SRDI), Soil Testing Laboratory, Farmgate, Dhaka and the characteristics was presented in Appendix III.

3.4 Plant materials used

In the experiment, Tomato variety "BARI Tomato-14" was used. It was a high yielding, heat tolerant and indeterminate type variety. The seeds were collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Raising of seedlings

Tomato seedlings were raised in the seedbed situated on a relatively high land at Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was 3 m x 1 m. The soil was well prepared with the help of 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 on 15 october, 2015 and after sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg/ha around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 5 to 6 days after sowing. Necessary shading by banana leaves was provided over the seedbed so that the young seedlings were safe from scorching sun or heavy rain. Weeding, mulching and irrigation were done from time to time as and when required and no chemical fertilizer was used in the seedbed.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:-

3.6.1 Factor A: Mentioned below with alphabetic symbol.

Zinc level (kg/ha)	Alphabetic symbol
0	Z_0
0.5	Z_1
1	Z_2

3.6.2 Factor B: It included four different doses of GA_3(Gibberellic Acid) which are mentioned below with alphabetic symbol.

Doses of GA_3 (ppm)	Alphabetic symbol
0	G_0
50	G_1
75	G_2
100	G_3

Total 12 treatment combinations were as follows:

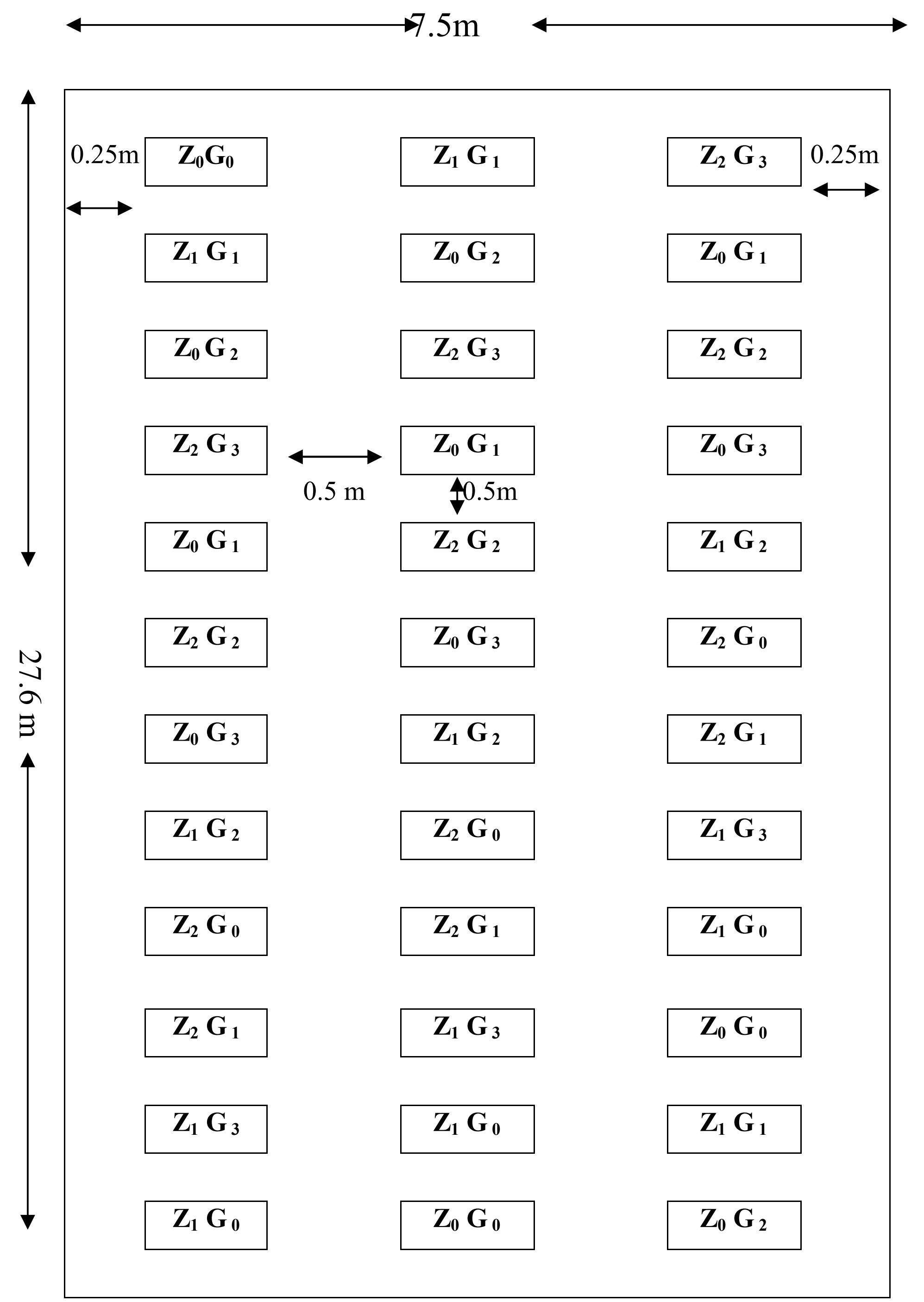
$Z_0 G_0$	Z_0G_2
Z_1G_0	Z_1G_2
Z_2G_0	Z_2G_2
Z_0G_1	Z_0G_3
Z_1G_1	Z_1G_3
$Z_2 G_1$	$Z_2 G_3$

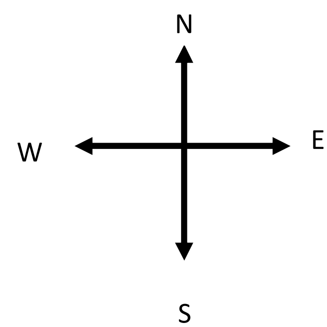
3.7 Design of the experiment

Field layout was done after final land preparation. The experiment was laid out in a Randomized Complete Block Design (RCBD) having two factors with three replications. The treatment combinations were accommodated randomly in the unit plots.

3.8 Layout of the experiment

An area of 27.6 m x 7.5 m was divided into three equal blocks. Each block consisted of 12 plots where 12 treatments were allotted randomly. There were 36 unit plots altogether in the experiment. The size of each plot was 2 m x 1.8 m. The distance between two blocks and two plots were 0.5m and 0.5 m respectively. (Figure 1)





Plot size: 2.0 m X1.8 m
Spacing: 60 cm X 50 cm
Spacing between Plots: 0.5 m
Spacing between blocks: 0.5 m

Fig. 1: Layout of the experimental plot

3.9 Cultivation procedure:

3.9.1 Land preparation:

The experimental field was thoroughly ploughed and cross ploughed and cleaned prior to seed sowing and application of fertilizers and manure were done in the field.The soil was well prepared and good tilth was ensured for tomato crop production. The land of the experimental field was ploughed with a power tiller. Later, the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed. Finally the land was properly leveled before transplanting. Then plots were prepared as per the design. The unit plots were prepared as 15 cm raised beds. Twelve pits were made in each plot with row to row and plant to plant spacing of 60cm X 50 cm.

3.9.2 Manuring and Fertilizing:

Manure and fertilizers such as cowdung, urea, triple super phosphate (TSP) and muriate of potash (MOP) were applied in the experimental field as per recommendation of BARI (2005).

Table1. Fertilizer and manure applied for the experimental field preparation. Manure and fertilizers were used as recommended by BARI (2005).

Manure/ Fertilizer	Rate/ha	Application (%)			
		Basal	20 DAT	30 DAT	40 DAT
Cowdung	20 ton	100	–	–	–
Urea	As treatment	–	33.33	33.33	33.33
TSP	200 kg	100	–	–	–
MOP	175 kg	100	–	–	–

The sources of N, P_2O_5 , K_2O as urea, TSP and MP were applied, respectively. The entire amounts of TSP and MP were applied during the final land preparation. Urea was applied in three equal installments at 20, 30 and 40 days after seedling transplanting. Well-rotten cowdung 20 t/ha also applied during final land.

3.9.3 Transplanting of seedlings

Healthy and uniform 35 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 05 November, 2015 maintaining a spacing of 60 cm x 50 cm between the rows and plants, respectively. This allowed 12 plants in each plot. The seedbed was watered before uprooting the seedlings to minimize damage to the roots. The seedlings were watered after transplanting. For shading purpose banana leaf sheath was used for three days to protect the seedling from the hot sun and removed after seedlings were established. For gap filling, Seedlings were also planted around the border area of the experimental plots.

3.9.4 Preparation of GA_3

The stock solution of 1000 ppm of GA_3 with small amount of ethanol to dilute and then mixed in 1 litre of water turn as per requirement of 50 ppm, 75 ppm and 100 ppm solution of GA_3. 50, 75 and 100 ml of stock solution were mixed with 1 litre of water.

3.9.5 Intercultural operation

After seedlings transplanting , various intercultural operations such as irrigation, weeding, staking and top dressing etc. were accomplished for better growth and development and quality of the tomato seedlings.

3.9.5.1 Gap filling

Gap filling was done as and when needed.

3.9.5.2 Weeding and mulching

Weeding was done whenever it was necessary. To help in soil moisture conservation, mulching was also done. Mulching helps for breaking the crust of the soil.

3.9.5.3 Staking

When the plants were well established, staking was given to each plant by bamboo sticks to keep them erect. Within a few days of staking, as the plants grew up, the plants were pruned as per the treatments.

3.9.5.4 Application of Zinc

Application of Zinc was done at 15 , 35 , 50 days after transplanting as per treatment.

3.9.5.5 Application of GA_3

Application of GA_3 was done at 15 , 35 , 50 days after transplanting as per treatment.

3.9.5.6 Irrigation

Light watering was given with watering can immediately after transplanting the seedlings and then flood irrigation was done as and when necessary throughout the growing period upto harvest.

3.9.6 Plant protection

3.9.6.1 Control of pest and disease

Malathion 57 EC was applied @ 2 ml/L against the insect pests like cut worm, leaf hopper fruit borer and others. The insecticide application was made fortnightly for a week after transplanting to a week before first harvesting. Furadan 10 G was also applied during final land preparation as soil insecticide. During foggy weather, spraying Dithane M-45 fortnightly @ 2 g/L taken as precautionary measured against disease infection of tomato, at the early vegetative stage.

3.9.7 Harvesting

Fruits were harvested at 3 days interval during early ripe stage when they developed slightly red color. Harvesting was started from 20 February, 2016 and completed by 10 March, 2016.

3.9.8 Parameters assessed

Randomly five plants were selected and uprooted carefully at the time of collecting data and mean data on the following parameters were recorded :-

Plant height

Number of leaves per plant

Number of flower clusters per plant

Number of flower per cluster

Number of fruit per cluster

Number of fruit per plant

Fruit weight per plant

Fruit weight per plot

Fruit yield (t/ha)

Total soluble solid percent (TSS%)

β-carotine(mg/100g)

Vitamin-C content (mg/100g)

3.9.9 Collection of data

Five plants were selected randomly from each unit plot for data collection in such a way that the border effect could be avoided at the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

Plant height

Plant height was measured from the sample plants in centimeter from the ground level to the tip of the longest stem and means value was calculated. Plant height was recorded 20, 40 and 60 days after transplanting to observe the growth rate.

Number of leaves per plant

The number of leaves of the sample plants was counted at 20, 40 and 60 DAT and the average number of leaves produced per plant was recorded.

Number of flower clusters per plant

The number of flower clusters was counted from the sample plants periodically and the average number of flower clusters produced per plant was calculated.

Number of flowers per cluster

The number of flowers per cluster was calculated as follows:

$$\text{Number of flower per cluster} = \frac{\text{Total number of flowers in sample plant}}{\text{Total number of flowers clusters in sample plants}}$$

Number of fruit per cluster

The number of fruit per clusters was recorded from the five sample plants.

Number of fruits per plant

Total number of fruits was counted from selected plants and their average was taken as the number of fruits per plant.

Fruit weight per Plant

A pan scale balance was used to take the weight or fruits per plot . Fruits of four randomly selected plants are weighted. Their average value recorded.

Fruit weight per plot

A balance was used to record the harvested fruits from 5 randomly selected plants and expressed in kilogram.

Fruit Yield (t/ha):

From the yield per plot, yield per hectare was calculated.

$$\text{Fruit Yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 10000\text{m}^2}{\text{Area of plot in square meter (m}^2\text{)} \times 1000\text{kg}}$$

Measurement of Total Soluble Sugar (TSS %)

One drop ripens tomato juice was used to take the TSS reading in a digital brix meter (ATOGA, JAPAN). Reading from brix meter recorded in percentage.

Measurement of β- carotene

At first 15-20g flesh of ripen tomato was taken and crushed by mortar and pastel. Then 5g paste was taken in a plastic container having airtight lid. There after 50ml mixture (Acetone: n-Hexane = 2:3) was poured in the container by a measuring cylinder and the container was placed in a vertical shaker for 10 minutes. Then the solution was centrifuged at 5000-6000 rpm. After centrifuge, the supernatant (clear transparent) was taken in a glass vial. Then spectrophotometer reading was recorded at four different nanometer length viz. 663nm, 645nm, 505nm and 453nm.

Finally, β- carotene was calculated by the following formula:

β- carotene (mg)= 0.216 (reading of 664nm) + 0.452 (reading of 453nm)-1.22 (reading of 645nm)-0.304(reading of 505nm)

Measurement of Vitamin C

Vitamin C content of green and dry fruits were determined by 2, 6- dichlorophenol indophenols visual titration method. The following reagents were used for the estimation of vitamin C contains.

Reagents

i. **3% Metaphosphoric acid (HPO_3)** Is was prepared by dissolving 30 g of HPO_3 and 80 ml glacial acetic acid in distilled water and volumes made up to one liter.

ii. **Standard ascorbic acid solution** 10 % of L- ascorbic acid solvent was made by dissolving ascorbic acid in 3 metaphosphoric acid solution.

iii. **Dry solution** It was prepared by dissolving 260 mg of sodium salt of 2, 6-dicholophenol indophenols in one liter of distilled water.

Procedure

Standardization of dye solution

Dilute 5 ml of standard ascorbic acid solution with 5 ml of Meta phosphoric acid. A micro burette was loaded with dye solution and the mixed solution was titrated with dye solution using phenolphthalein as indicator to a the pink colored end point which insisted for at least 15 sec.

Dye factor was enumerated using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of sample

Five grams of fresh fruit and dry fruits was taken in a 100ml beaker with 50 ml 3% metaphosphoric acid and then it was transferred to blender and homogenized with same concentration of metaphosphoric acid. First blending then it was filtered and centrifuged at 2000 rpm for 5 minutes. The homogenized liquid was transferred to a 100 ml volumetric flask and was made up to the mark with 3 % metaphosphoric acid.

Titration

Five ml of the aliquot was taken in conical flask and titrated with 2, 6-dicholophenol indophenols dye, phenolphthalein was used as indicator to a ping colored end point, which persisted at least 15 seconds. The ascorbic acid content (Vitamin C) of the sample was calculated by using the following formula:

$$\text{Ascorbic acid (mg/100g)} = \frac{T \times d \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titre value (ml)

D = Dye factor

V_1 = Volume to be made (ml)

V_2 = Volume of extract taken for titration (ml)

W = Weight of sample taken for estimation (gm)

3.9.10 Analysis of data

Data were statistically analyzed by a computer program MSTAT-C software and Duncan's multiple range tests was used to analyze the growth, yield and quality contributing characters of tomato to find out the statistical significance. The significance of the difference was evaluated by Duncan's Multiple Range Test (DMRT) according to Gomez and Gomez, (1984) for interpretation of the results at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to find out the effect of Zinc and GA_3 on growth, yield and quality of tomato. Data on different growth,yield and quality contributing characters were recorded to find out the optimum dose of Zinc and GA_3 for "BARI Tomato-14". The results of each parameter studied in the experiment have been presented and discussed under the following headings.

4.1 Plant height

Plant height of tomato varied significantly due to the application of different levels of zinc at 20, 40 and 60 DAT. At 20 DAT, the longest (13.48 cm) plant was recorded from Z_1 (0.5 kg/ha), while the shortest (10.83 cm) plant was recorded from Z_0 (0 kg/ha). The longest (65.44 cm) plant was recorded from Z_1 and the shortest (62.14 cm) plant was recorded from Z_0 at 40 DAT. At 60 DAT the longest (99.25 cm) plant was recorded from Z_1 , while the shortest (93.48 cm) plant was recorded from Z_0. (Table 2)

Table 2. Effect of zinc on plant height of tomato

Treatment	Plant height (cm)		
	20 DAT	40 DAT	60 DAT
Z_0	10.83 a	62.14 b	93.48 c
Z_1	13.48 b	65.44 a	99.25 a
Z_2	11.18 c	62.63 b	97.46 b
$Lsd_{0.05}$	0.5164	0.9181	1.559
CV (%)	2.37	0.85	0.95

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Plant height of tomato varied significantly due to the application of different level of GA_3 at 20, 40 and 60 DAT. At 20 DAT ,the longest (14.03 cm) plant was recorded from G_2 (75 ppm GA_3), while the shortest (11.76 cm) plant was recorded from G_3 (100 ppm GA_3). The longest (67.04 cm) plant was recorded from G_2 and the shortest (61.31 cm) plant was recorded from G_0 (Control) at 40 DAT. At 60 DAT, the longest (101.1 cm) plant was recorded from G_1, while the shortest (94.22 cm) plant was recorded from G_0.(Table 3). Shittu and Adeleke (1999) reported similar findings, which is supported to the present study.

Table 3. Effect of GA_3 on plant height of tomato

Treatment	Plant height		
	20 DAT	40 DAT	60 DAT
G_0	12.27 c	61.31 c	94.22 c
G_1	13.27 b	62.51 b	95.97 b
G_2	14.03 a	67.04 a	101.1 a
G_3	11.76 c	62.74 b	95.61 bc
$Lsd_{0.05}$	0.5164	0.9181	1.559
CV (%)	2.37	0.85	0.95

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

G_0=0 ppm GA_3

G_1=50 ppm GA_3

G_2=75 ppm GA_3

G_3=100ppm GA_3

Combined effect of zinc and GA_3 showed statistically significant variation on plant height at 20, 40 and 60 DAT . At 20 DAT, the longest (15.67 cm) plant was recorded from Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) and the shortest (9.367 cm) plant was recorded from Z_2G_3 (1 kg Zn/ha and 100 ppm GA_3). The tallest plant (71.53 cm) was recorded from Z_1G_2 and the shortest (59.27 cm) was recorded from Z_2G_3 at 40 DAT. At 60 DAT, the longest (107.7 cm) plant was recorded from Z_1G_2 and the shortest (88.40 cm) plant was recorded from Z_2G_3 . (Table 4)

Table 4. Combined Effect of zinc and GA_3 on plant height of tomato

Treatment	Plant height		
	20 DAT	40 DAT	60 DAT
Z_0G_0	13.50 d	60.63 f	92.07 e
Z_0G_1	14.00 cd	61.37 ef	92.53 e
Z_0G_2	14.40 bc	62.87 d	93.03 e
Z_0G_3	14.83 b	63.70 d	96.30 d
Z_1G_0	12.77 e	61.70 e	91.87 e
Z_1G_1	14.40 bc	63.27 d	95.30 d
Z_1G_2	15.67 a	71.53 a	107.7 a
Z_1G_3	11.07 g	65.27 c	102.1 b
Z_2G_0	10.53 h	61.60 e	98.73 c
Z_2G_1	11.40 g	62.90 d	100.1 c
Z_2G_2	12.03 f	66.73 b	102.6 b
Z_2G_3	9.367 i	59.27 g	88.40 f
$Lsd_{0.05}$	0.5164	0.9181	1.559
CV (%)	2.37	0.85	0.95

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.2 Number of leaves

Number of leaves of tomato varied significantly due to the application of different level of Zinc at 20, 40 and 60 DAT. At 20 DAT, the maximum number of leaves (7.667) was observed in Z_1 (0.5 kg/ha), while the minimum number of leaves (5.167) was obtained from Z_2 (1 kg/ha) which was statistically similar with Z_0. The maximum number of leaves (15.42) was recorded from Z_1 and the minimum number of leaves (11.42) was recorded from Z_2 at 40 DAT. At 60 DAT, the maximum number of leaves (34.75) was recorded from Z_1 and the minimum number of leaves (31.00) was recorded from Z_0. (Table 5)

Table 5. Effect of zinc on the number of leaves of tomato

Treatment	No. of Leaves/plant		
	20 DAT	40 DAT	60 DAT
Z_0	5.417 b	12.75 b	31.00 b
Z_1	7.667 a	15.42 a	34.75 a
Z_2	5.167 b	11.42 c	31.08 b
$Lsd_{0.05}$	1.031	1.248	1.138
CV(%)	10.02	5.58	2.08

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Z_0 = 0 kg/ha

Z_1 = 0.5 kg/ha

Z_2 = 1 kg/ha

Number of leaves of tomato varied significantly due to the application of different level of GA_3 at 20, 40 and 60 DAT . At 20 DAT, the maximum number of leaves (7.111) was recorded from G_2 (75 ppm GA_3), while the minimum (5.444) was found from G_0 (0 ppm GA_3). The maximum number of leaves (14.33) was recorded from G_2 which is statistically identical to G_1 (13.56) and the minimum (12.11) was recorded from G_0 at 40 DAT. At 60 DAT, the maximum number of leaves (33.22) was recorded from G_2, which is statistically identical to G_1 (32.44), while the minimum (31.56) plant was obtained from G_0. Briant, R.E.(1974) found similar result with application GA_3 in tomato. (Table 6**)**

Table 6. Effect of GA_3 on the number of leaves of tomato

Treatment	No. of Leaves/plant		
	20 DAT	40 DAT	60 DAT
G_0	5.444 b	12.11 c	31.56 b
G_1	5.889 b	13.56 ab	32.44 ab
G_2	7.111 a	14.33 a	33.22 a
G_3	5.889 b	12.78 bc	31.89 b
$Lsd_{0.05}$	1.031	1.248	1.138
CV(%)	10.02	5.58	2.08

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

G_0=0 ppm GA_3

G_1=50 ppm GA_3

G_2=75 ppm GA_3

G_3=100 ppm GA_3

Combined effect of Zinc and GA_3 showed statistically significant variation for no. of leaves at 20, 40 and 60 DAT . At 20 DAT, the maximum no. of leaves (9.333) was recorded from Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) and the minimum (4.333) was recorded from Z_0G_0 (0 kg Zn/ha and 0 ppm GA_3) and Z_2G_3 (1 kg Zn/ha and 100 ppm GA_3). The maximum no. of leaves (18.33) was recorded from Z_1G_2 and the minimum (6.79) was recorded from Z_2G_3 at 40 DAT. At 60 DAT the maximum no. of leaves (37.00) was recorded from Z_1G_2 and the minimum(29.33) was recorded from Z_0G_0 and Z_2G_3(Table7).

Table 7. Combined Effect of zinc and GA_3 on the number of leaves of tomato

Treatment	No. of Leaves/plant		
	20 DAT	40 DAT	60 DAT
Z_0G_0	4.333 g	10.67 f	29.33 g
Z_0G1	4.667 fg	12.67 e	30.33 fg
Z_0G_2	6.667 bcd	13.33 cde	31.67 de
Z_0G_3	6.000 de	14.33 bcd	32.67 cd
Z_1G_0	6.333 cde	14.67 bc	33.67 bc
Z_1G_1	7.667 b	15.00 b	34.67 b
Z_1G_2	9.333 a	18.33 a	37.00 a
Z_1G_3	7.333 bc	13.67 bcde	33.67 bc
Z_2G_0	5.667 def	13.00 de	31.67 de
Z_2G_1	5.333 efg	13.00 de	32.33 d
Z_2G_2	5.333 efg	11.33 f	31.00 ef
Z_2G_3	4.333 g	8.333 g	29.33 g
$Lsd_{0.05}$	1.031	1.248	1.138
CV(%)	10.02	5.58	2.08

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.3 Number of flower clusters per plant

The effect of different levels of zinc in respect of flower clusters per plant was statistically significant . The maximum number of flower clusters per plant (12.67) was found from Z_1 (0.5 kg Zn/ha) and the minimum (8.750) was found from Z_0(0 kg Zn/ha) which was statistically similar to Z_2 which was 10.25. (Table 8)

The number of flower clusters per plant was significantly influenced by GA_3 . The highest number of flower clusters per plant (11.44) was found from G_2 (75 ppm GA_3) which is statistically similar with G_1 and G_3 ; the lowest number of flowers clusters per plant (9.778) was found from G_0 . Onofeghara (1981) also found similar result (Table 9) which is supported to the present investigation.

There was statistically significant difference among the treatment combinations in respect of number of flower clusters per plant. It was evident that the treatment combination of Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) gave the maximum number of flower clusters per plant (14.67) and the minimum number of flower cluster per plant (6.667) was recorded from the treatment combination of Z_0G_0 (0 kg N/ha and 0 ppm GA_3) (Table 10).

4.4 Number of flowers per cluster

A significant variation in the number of flowers per cluster was observed due to effect of different levels of zinc. The highest number of flowers per cluster (10.33) was found from Z_1 (0.5 kg Zn/ha) and the minimum (7.417) was produced at Z_0 (0 kg Zn/ha) which was statistically similar with Z_2 (Table 8).

The variation in number of flowers per cluster at different GA_3 levels was not statistically significant. The highest number of flowers per cluster (9.667) was produced in G_2 (75 ppm GA_3) and the lowest number (7.889) was obtained from G_0 (control). Saleh and Abdul (1980) also agreed the findings of present study (Table 9).

Combined effect or different levels or zinc and GA_3 on number of flowers per cluster were found to be significant. The maximum number of flowers per cluster (13.00) was observed in the treatment combination of Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) and the minimum (6.000) from Z_0G_0 (0 kg N/ha and 0 ppm GA_3) (Table 10).

4.5 Number of fruit per cluster

The number of fruit per cluster at different levels of zinc was found to be significant. The maximum number of fruit clusters per plant (8.417) was produced by Z_1 (0.5 kg Zn/ha) and the control treatment Z_0 (0 kg Zn/ha) produced the minimum number of fruit clusters per plant (6.083) (Table 8).

There was no significant difference among the different GA_3 levels on the number of fruit per clusters. The maximum value in G_2 is 7.778 and minimum value in G_1 and G_3 which is 6.556 (Table 9).

But there was significant interaction effect between different Zinc levels and GA_3 in case of number of fruit per cluster. . The maximum number of fruit per cluster (11.00) was observed in the treatment combination of Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) and the minimum (5.00) from Z_0G_0 (Table 10).

4.6 Number of fruit per plant

A significant variation in the number of fruit per plant was observed due to effect of different levels of zinc. The highest number of fruit per plant (62.75) was found from Z_1 (0.5 kg Zn/ha) and the minimum (40.75) was produced at Z_0 (0 kg Zn/ha) (Table 8).

The variation in number of fruit per plant at different GA_3 levels was significant. The highest number of fruit per plant (59.56) was produced in G_2 (75 ppm GA_3) and the lowest number (43.00) was obtained from G_0 (control) (Table 9).

Combined effect or different levels or Zinc and GA3 on number of of fruit per plant were found to be significant. The maximum number of fruit per plant (83.33) was observed in the treatment combination of Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) and the minimum (30.33) from Z_0G_0 (0 kg N/ha and 0 ppm GA_3) (Table 10).

Table 8. Effect of zinc on yield contributing characters of tomato

Treatment	Flower clusters/ plant	Flowers/ cluster	Fruit/ cluster	Fruit/ plant
Z_0	8.750 b	7.417 b	6.083 b	40.75 c
Z_1	12.67 a	10.33 a	8.417 a	62.75 a
Z_2	10.25 b	8.417 b	6.167 b	47.08 b
$Lsd_{0.05}$	1.522	1.691	1.316	3.536
CV (%)	8.52	11.45	11.28	4.16

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Z_0 = 0 kg/ha

Z_1 = 0.5 kg/ha

Z_2 = 1 kg/ha

Table 9. Effect of GA_3 on yield contributing characters of tomato

Treatment	Flower cluster/ plant	Flower/ cluster	Fruit/ cluster	Fruit/plant
G_0	9.778 b	7.889 a	6.667 a	43.00 d
G_1	10.56 ab	8.556 a	6.556 a	51.11 b
G_2	11.44 a	9.667 a	7.778 a	59.56 a
G_3	10.44 ab	8.778 a	6.556 a	47.11 c
$Lsd_{0.05}$	1.522	1.691 NS	1.316 NS	3.536
CV (%)	8.52	11.45	11.28	4.16

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

G_0=0 ppm GA_3 G_2=75 ppm GA_3

G_1=50 ppm GA_3 G_3=100ppm GA_3

Table 10. Combined effect of zinc and GA_3 on yield contributing characters of tomato

Treatment	Flower clusters/ plant	Flowers/ cluster	Fruit/cluster	Fruit/plant
Z_0G_0	6.667 e	6.000 f	5.000 g	30.33 j
Z_0G1	8.667 d	7.333 def	6.000 def	35.67 i
Z_0G_2	9.667 cd	8.000 cde	6.667 cde	46.33 g
Z_0G_3	10.00 cd	8.333 cde	7.000 bcde	50.67 ef
Z_1G_0	11.33 bc	8.000 cde	7.000 bcde	42.00 h
Z_1G_1	12.00 b	9.333 bc	7.333 bcd	64.67 b
Z_1G_2	14.67 a	13.00 a	11.00 a	83.33 a
Z_1G_3	12.67 b	11.00 b	8.333 b	61.00 c
Z_2G_0	11.33 bc	9.667 bc	8.000 bc	56.67 d
Z_2G_1	11.00 bc d	9.000 cd	6.333 def	53.00 e
Z_2G_2	10.00 cd	8.000 cde	5.667 efg	49.00 fg
Z_2G_3	8.667 d	7.000 ef	5.333 fg	30.47 j
$Lsd_{0.05}$	1.522	1.691	1.316	3.536
CV (%)	8.52	11.45	11.28	4.16

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.7 Weight of fruits per plant

It was noticed that different levels of zinc exhibited significant effect on the weight of fruits per plant (Table 11). The maximum weight (2.519 kg) of fruits which was found in Z_1 (0.5 kg Zn/ha) and the minimum weight (1.677 kg) was obtained from Z_2 (1kg Zn/ha).

The weight of fruits per plant was not significantly influenced by different levels of GA_3 (Table 12). The highest value is 2.161 which was found in G_2 treatment (75 ppm GA_3) and the lowest value is 2.003 which was found in G_0.

There was significant combined effect of different levels of zinc and GA_3 on the weight of fruits per plant (Table 13). The maximum fruit weight per plant (3.027 kg) was obtained from the treatment combination of Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) which was favorable conditions than other treatment combinations. The lowest (1.340 kg) in this respect was found from the treatment combination of Z_2G_2 (1 kg Zn/ha and 75 ppm GA_3).

4.8 Weight of fruits per plot

Statistically significant variation was recorded on fruit weight per plot due to application of different levels of zinc (Table 11). The highest fruit weight per plot (26.35 kg) was obtained from Z_1 (0.5 kg Zn/ha) and whereas the lowest (14.85 kg) was observed in Z_2 (1kg Zn/ha) treatment.

Statistically significant variation was recorded on fruit weight per plot due to application of different levels of GA_3 (Table 12). The highest fruit weight per plot

(22.62) was obtained from G_2 (75 ppm) and whereas the lowest (18.71 kg) was observed in G_0 (0 ppm) treatment. Lilov and Donchev (1984) also found similar results by the application of GA_3.

Effect of different levels of zinc and GA_3 showed statistically significant variation on fruit weight per plot (Table 13). The highest fruit weight per plot (33.31 kg) was found from Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3), while the lowest fruit weight per plot (12.58) was recorded from Z_2G_3 (1 kg Zn/ha and 100 ppm GA_3).

4.9 Fruit yield per hectare

The fruit yield per hectare was also significantly influenced by different levels of Zinc. The highest yield (73.19 t/ha) was produced due to Z_1 treatment (0.5 kg Zn/ha) and lowest yield (41.26 t/ha) was performed by Z_2 treatment (1kg Zn/ha) (Table 11). Islam (2006) observed the same result in case of Zinc treatment on tomato. Graphical presentation about effect of zinc on yield of tomato shown in figure 2.

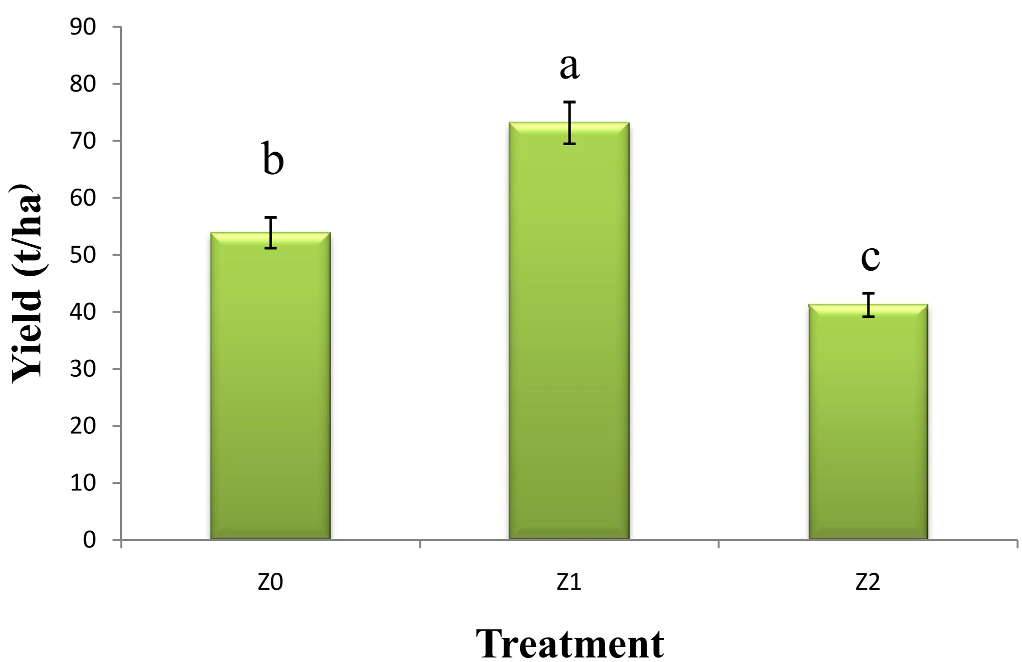


Fig 2: Effect of zinc on yield (t/ha) of tomato

Different levels of GA_3 significantly influenced on the yield of fruit per hectare (Fig.3). It was evident from the highest yield (62.84 t/ha) was recorded from G_2 (75ppm GA_3) and the lowest yield was (51.98 t/ha) from G_0 (control) which is statistically similar to G_1 and G_3 which value is 55.54 t/ha and 54.09 t/ha (Table 12). Kaushik *et al.,* (1974) supported this findings.

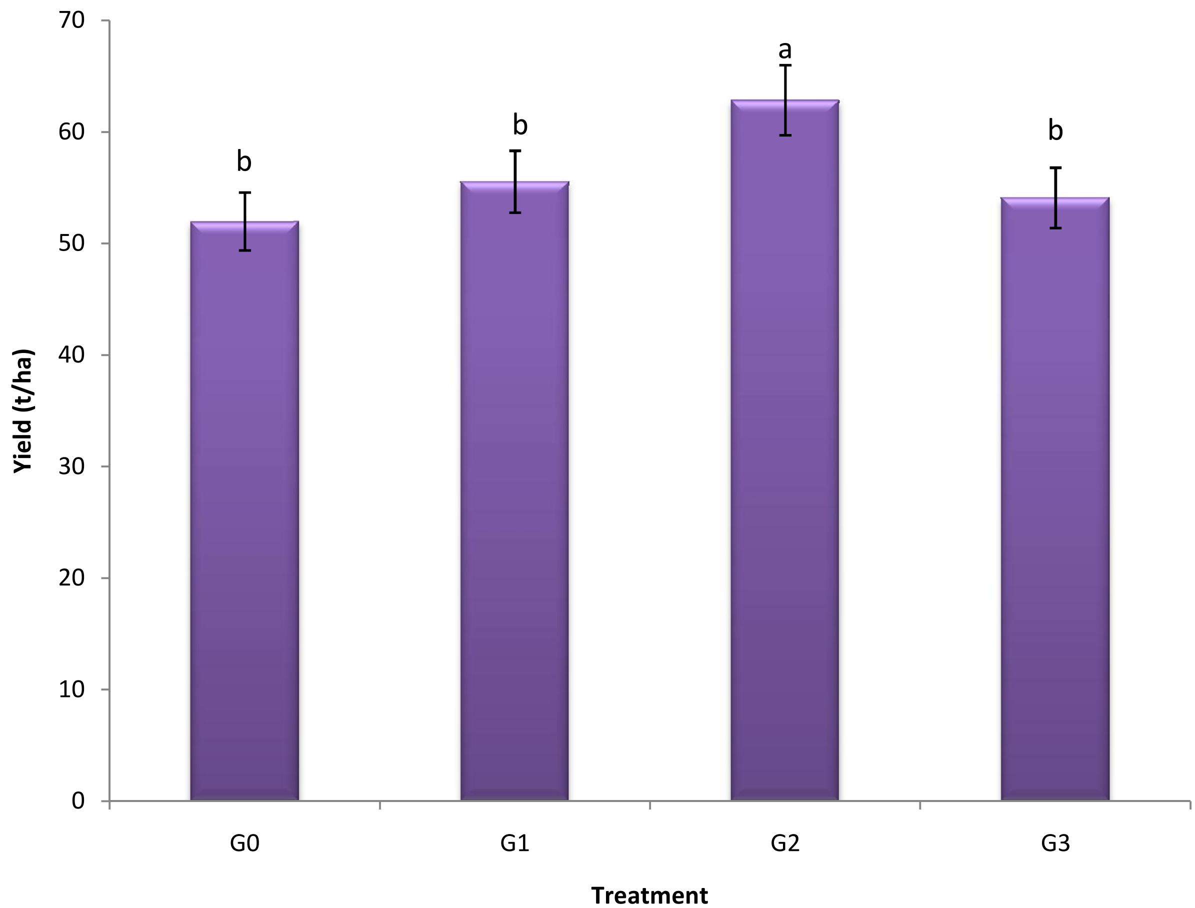


Fig 3: Effect of GA_3 on Yield (t/ha) of tomato

Due to combined effect of different levels of Zinc and GA_3 performed significant effect on yield per hectare. The treatment combination of Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) gave the maximum yield (92.54 t/ha) and the minimum yield (34.94 t/ha) was found from the treatment combination on Z_2G_3(1 kg Zn/ha and 100 ppm GA_3). (Table 13) Graphical presentation about effect of zinc and GA_3 combinedly on yield of tomato shown in figure 4.

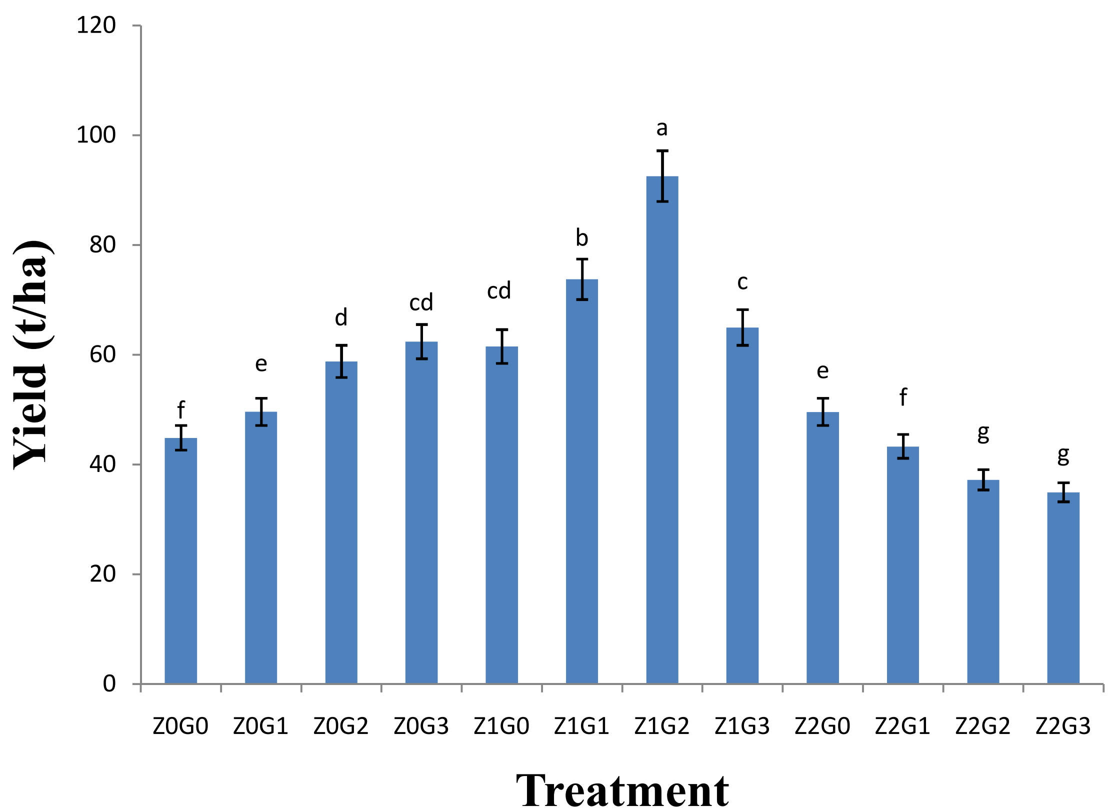


Fig 4: Combined effect of Zinc and GA_3 on Yield (t/ha) of tomato

Table 11. Effect of zinc on yield contributing characters and yield of tomato

Treatment	Fruit wt/ plant (Kg)	Fruit wt/ plot (Kg)	Fruit yield (t/Ha)
Z_0	2.018 b	19.41 b	53.90 b
Z_1	2.519 a	26.35 a	73.19 a
Z_2	1.677 c	14.85 c	41.26 c
$Lsd_{0.05}$	0.1693	1.534	4.264
CV (%)	4.89	4.48	4.49

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Z_0 = 0 kg/ha Z_1 = 0.5 kg/ha Z_2 = 1 kg/ha

Table 12. Effect of GA_3 on yield contributing characters and yield of tomato

Treatment	Fruit wt/plant (Kg)	Fruit wt/plot (Kg)	Fruit yield (t/Ha)
G_0	2.003 a	18.71 b	51.98 b
G_1	2.042 a	20.00 b	55.54 b
G_2	2.161 a	22.62 a	62.84 a
G_3	2.079 a	19.47 b	54.09 b
$Lsd_{0.05}$	0.1693 NS	1.534	4.264
CV (%)	4.89	4.48	4.49

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

G_0=0 ppm GA_3 G_2=75 ppm GA_3

G_1=50 ppm GA_3 G_3=100ppm GA_3

Table 13. Combined effect of zinc and GA_3 on yield contributing characters and yield of tomato

Treatment	Fruit wt/plant (Kg)	Fruit wt/plot (Kg)	Fruit yield (t/Ha)
Z_0G_0	1.727 e	16.15 f	44.86 f
Z_0G1	1.983 d	17.86 e	49.60 e
Z_0G_2	2.117 cd	21.16 d	58.78 d
Z_0G_3	2.247 bc	22.46 cd	62.38 cd
Z_1G_0	2.297 b	22.14 cd	61.50 cd
Z_1G_1	2.413 b	26.55 b	73.74 b
Z_1G_2	3.027 a	33.31 a	92.54 a
Z_1G_3	2.340 b	23.39 c	64.96 c
Z_2G_0	1.987 d	17.85 e	49.59 e
Z_2G_1	1.730 e	15.59 f	43.29 f
Z_2G_2	1.340 f	13.40 g	37.21 g
Z_2G_3	1.650 e	12.58 g	34.94 g
$Lsd_{0.05}$	0.1693	1.534	4.264
CV (%)	4.89	4.48	4.49

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.10 Total soluble solid (%) content

It was noticed that different levels of zinc exhibited significant effect on total soluble solid (%) of tomato fruit. The maximum TSS(%) (7.683) of fruits which was found in Z_1 (0.5 kg Zn/ha) and the minimum TSS(%) (6.958) was obtained from Z_2 (1kg Zn/ha) (Table 14).

Different levels of GA_3 significantly influenced on total soluble solid (%) of tomato fruit. It was evident from the highest TSS(%) (7.500) was recorded from G_2 (75 ppm GA_3) which is statically similar with G_1(50 ppm GA_3) and its value is 7.378 . The lowest TSS(%) was (7.200) from G_3 (100 ppm GA_3) (Table 15).

Combination effect of different levels of Zinc and GA_3 showed statistically significant variation on on total soluble solid (%). The highest TSS(%) (8.000) was found from Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3), while the lowest TSS(%) (6.667) was recorded from Z_2G_3 (1 kg Zn/ha and 100 ppm GA_3) (Table 16).

4.11 β-Carotene content

Statistically significant variation was recorded on β-Carotene in different sample due to application of different levels of zinc. The highest β-Carotene (0.3600 mg/100g) was obtained from Z_1 (0.5 kg Zn/ha) and whereas the lowest (0.2908 mg/100g) was observed in Z_0 (0 kg Zn/ha) treatment (Table 14).

Different levels of GA_3 significantly influenced on β-Carotene amount . It was evident from the highest β-Carotene (0.3344 mg/100g) was recorded from G_2 (75 ppm GA_3) and the lowest β-Carotene was (0.3067 mg/100g) from G_0 (control) (Table 15).

Combination effect of different levels of Zinc and GA_3 showed statistically significant variation on on β-Carotene amount. The highest β-Carotene (0.3967 mg/100g) was found from Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3), while the lowest β-Carotene (0.2633 mg/100g) was recorded from Z_0G_0 (0 kg Zn/ha and 0 ppm GA_3) (Table 16).

4.12 Vitamin C content

The application of different level of zinc show significant variation in case of Vit C content in tomato fruit which is examined by sampling it in proper way. The higher amount Vit C (104.8 mg/100 g) found in Z_1 (0.5 kg Zn/ha) treatment and lower amount Vit C (86.86 mg/100 g) found in Z_0 (0 kg Zn/ha) treatment (Table 14).

The variation in Vit C content of tomato fruit due to different level of GA_3 is significant. The higher amount Vit C (97.44 mg/100 g) found in G_2 (75 ppm GA_3) treatment which is statistically similar with G_1(50 ppm) and G_3(100 ppm) and lower amount Vit C (91.45 mg/100 g) found in G_0 (0 ppm GA_3) treatment (Table 15).

Due to combined effect of different levels of Zinc and GA_3 performed significant effect on Vit C content. The treatment combination of Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA_3) gave the maximum Vit C content (114.1 mg/100 g) and the minimum Vit C content (80.77 mg/100 g) was found from the treatment combination on Z_0G_0 (0 kg Zn/ha and 0 ppm GA_3) (Table 16).

Table 14. Effect of zinc on quality characters of tomato

Treatment	TSS%	β-Carotene (mg/100g)	Vitamin C (mg/100g)
Z_0	7.350 b	0.2908 c	86.86 c
Z_1	7.683 a	0.3600 a	104.8 a
Z_2	6.958 c	0.3150 b	91.67 b
$Lsd_{0.05}$	0.1855	0.0005355	4.451
CV(%)	1.47	1.70	2.78

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Z_0 = 0 kg/ha Z_1 = 0.5 kg/ha Z_2 = 1 kg/ha

Table 15. Effect of GA_3 on quality characters of tomato

Treatment	TSS%	β-Carotene (mg/100g)	Vitamin C (mg/100g)
G_0	7.244 b	0.3067 d	91.45 b
G_1	7.378 ab	0.3267 b	94.44 ab
G_2	7.500 a	0.3344 a	97.44 a
G_3	7.200 b	0.3200 c	94.45 ab
$Lsd_{0.05}$	0.1855	0.0005355	4.451
CV(%)	1.47	1.70	2.78

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

G_0=0 ppm GA_3 G_2=75 ppm GA_3

G_1=50 ppm GA_3 G_3=100 ppm GA_3

Table 16. Combined effect of zinc and GA_3 on quality characters of tomato

Treatment	TSS%	β-Carotene (mg/100g)	Vitamin C (mg/100g)
Z_0G_0	6.800 fg	0.2633 k	80.77 i
Z_0G1	7.633 bcd	0.2900 i	85.90 gh
Z_0G_2	7.733 b	0.3033 h	89.75 fg
Z_0G_3	7.233 e	0.3067 g	91.03 ef
Z_1G_0	7.433 d	0.3167 f	94.87 de
Z_1G_1	7.600 bcd	0.3600 c	102.6 c
Z_1G_2	8.000 a	0.3967 a	114.1 a
Z_1G_3	7.700 bc	0.3667 b	107.7 b
Z_2G_0	7.500 cd	0.3400 d	98.72 cd
Z_2G_1	6.900 f	0.3300 e	94.87 de
Z_2G_2	6.767 fg	0.3033 h	88.46 fgh
Z_2G_3	6.667 g	0.2867 j	84.62 hi
$Lsd_{0.05}$	0.1855	0.0005355	4.451
CV(%)	1.47	1.70	2.78

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October, 2015 to March, 2016 to find out the effect of Zinc and GA_3 on the growth , yield and quality of tomato. The experiment consisted of two factors; Factor A: Z_0 =0 kg/ha, Z_1 =0.5 kg/ha , Z_2=1 kg/ha ; Factor B: Different doses of GA_3 such as G_0= Control, G_1=50 ppm G_2= 75 ppm and G_3=100 ppm; on different growth , yield and quality contributing characters were recorded.

In case of Zinc, The maximum (13.48 cm) plant height was obtained from Z_2 and the minimum (10.83 cm) was recorded from Z_0 at 20 DAT. The longest (65.44 cm) plant was recorded from Z_1 and the shortest (62.14 cm) plant was recorded from Z_0 at 40 DAT. At 60 DAT the longest (99.25 cm) plant was recorded from Z_1 , while the shortest (93.48 cm) plant was recorded from Z_0. At 20 DAT, the maximum number of leaves (7.667) was observed in Z_1, while the minimum number of leaves (5.167) was obtained from Z_2 . The maximum number of leaves (15.42) was recorded from Z_1 and the minimum number of leaves (11.42) was recorded from Z_2 at 40 DAT. At 60 DAT, the maximum number of leaves (34.75) was recorded from Z_1 and the minimum number of leaves (31.00) was recorded from Z_0. The maximum number of flower clusters per plant (12.67) was found from Z_1 and the minimum (8.750) was found from Z_0 which is statistically similar to Z_2 which is 10.25 . The highest number of flowers per cluster (10.33) was found from Z_1 and the minimum (7.417) was produced at Z_0 . The maximum number of fruit clusters per plant (8.417) was produced by Z_1 and the control treatment Z_0 produced the minimum number of fruit clusters per plant (6.083). The highest number of fruit per plant (62.75) was found from Z_1 and the minimum (40.75) was produced at Z_0. The maximum weight (2.519 kg) of fruits which was found in Z_1 and the minimum weight (1.677 kg) was obtained from Z_2 . The highest fruit weight per plot (26.35 kg) was obtained from Z_1 and whereas the lowest (14.85 kg) was observed in Z_2 treatment. The highest yield (73.19 t/ha) was produced due to Z_1 treatment and lowest yield (41.26 t/ha) was performed by Z_2 treatment . The maximum TSS(%) (7.683) of fruits which was found in Z_1 and the minimum TSS(%) (6.958) was obtained from Z_2 . The highest β-Carotene (0.3600) was obtained from Z_1 and whereas the lowest (0.2908) was observed in Z_0 treatment. The higher amount Vit C (104.8 mg/100 g) found in Z_1 treatment and lower amount Vit C (86.86 mg/100 g) found in Z_0 treatment.

Incase of GA_3 , At 20 DAT ,the longest (14.03 cm) plant was recorded from G2 , while the shortest (11.76 cm) plant was recorded from G3. The longest (67.04 cm) plant was recorded from G2 and the shortest (61.31 cm) plant was recorded from G0 at 40 DAT. At 60 DAT, the longest (101.1 cm) plant was recorded from G1, while the shortest (94.22 cm) plant was recorded from G0 . The maximum number of leaves (7.111) was recorded from G2, while the minimum (5.444) was found from G0 20DAP. The maximum number of leaves (14.33) was recorded from G2 which is statistically identical to G_1 (13.56) and the minimum (12.11) was recorded from G0 at 40 DAT. At 60 DAT, the maximum number of leaves (33.22) was recorded from G2, which is statistically identical to G1 (32.44) while the minimum (31.56) plant was obtained from G0. The highest number of flower clusters per plant (11.44) was found from G_2 which is statistically similar with G_1 and G_3 ; the lowest number of flowers clusters per plant (9.778) was found from G_0. But here is an important fact the variation in number of flowers per cluster at different GA_3 levels was not significant. There was also no significant difference among the different GA_3 levels on the number of fruit per clusters. The highest number of fruit per plant (59.56) was produced in G_2 and the lowest number

(43.00) was obtained from G_0. The weight of fruits per plant was not significantly influenced by different levels of GA3. . The highest fruit weight per plot (22.62) was obtained from G_2 and whereas the lowest (18.71 kg) was observed in G_0 treatment. Highest yield (62.84 t/ha) was recorded from G_2 and the lowest yield was (51.98 t/ha) from G_0. The highest TSS(%) (7.500) was recorded from G_2 which is statically similar with G_1 and its value is 7.378 . The lowest TSS(%) was (7.200) from G_3. The highest β-Carotene (0.3344) was recorded from G_2 and the lowest β-Carotene was (0.3067) from G_0. The higher amount Vit C (97.44 mg/100 g) found in G_2) treatment which is statistically similar with G_1 and G_3 and lower amount Vit C (91.45 mg/100 g) found in G_0 treatment.

In case of different levels of Zinc and GA_3 treatment combination , all parameter show significant response. The higher value found in the combination Z_1G_2 (0.5 kg Zn/ha and 75 ppm GA3). At 20 DAT, the longest (15.67 cm) plant was recorded from Z_1G_2 and the shortest (9.367 cm) plant was recorded from Z_2G_3. The tallest plant (71.53 cm) was recorded from Z_1G_2 and the shortest (59.27 cm) was recorded from Z_2G_3 at 40 DAT. . At 60 DAT, the longest (107.7 cm) plant was recorded from Z_1G_2 and the shortest (88.40 cm) plant was recorded from Z_2G_3. At 20 DAT the maximum no. of leaves (9.333) was recorded from Z_1G_2 and the minimum (4.333) was recorded from Z0G0. The maximum no. of leaves (18.33) was recorded from Z_1G_2 and the minimum (6.79) was recorded from Z_2G_3 at 40 DAT . At 60 DAT the maximum no. of leaves (37.00) was recorded from Z_1G_2 and the minimum (29.33) was recorded from Z_0G_0 and Z_2G_3. The treatment combination of Z_1G_2 gave the maximum number of flower clusters per plant (14.67) and the minimum number of flower cluster per plant (6.667) was recorded from the treatment combination of Z_0G_0 . The maximum number of flowers per cluster (13.00) was observed in the treatment combination of Z_1G_2 and the minimum (6.000) from Z_0G_0. The maximum number of fruit per cluster (11.00) was observed in the treatment combination of Z_1G_2 and the minimum (5.00) from

Z_0G_0 . The maximum number of fruit per plant (83.33) was observed in the treatment combination of Z_1G_2 and the minimum (30.33) from Z_0G_0. The maximum fruit weight per plant (3.027 kg) was obtained from the treatment combination of Z_1G_2 and the lowest (1.340 kg) in this respect was found from the treatment combination of Z_2G_2 . The highest fruit weight per plot (33.31 kg) was found from Z_1G_2 while the lowest fruit weight per plot (12.58) was recorded from Z_2G_3. The treatment combination of Z_1G_2 gave the maximum yield (92.54 t/ha) and the minimum yield (34.94 t/ha) was found from the treatment combination on Z_2G_3. The highest TSS(%) (8.000) was found from Z_1G_2 while the lowest TSS(%) (6.667) was recorded from Z_2G_3. The highest β-Carotene (0.3967 mg/100g) was found from Z_1G_2 while the lowest β-Carotene (0.2633 mg/100g) was recorded from Z_0G_0. The treatment combination of Z_1G_2 gave the maximum Vit C content (114.1 mg/100 g) and the minimum Vit C content (80.77 mg/100 g) was found from the treatment combination on Z_0G_0.

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

- Zinc played important role on the growth and fruit yield of tomato. In respect of growth ,yield and quality analysis, zinc showed better performance at the rate of 0.5 kg zn/ha.

- Except flowers per cluster , fruit per cluster**;** GA_3 showed statistically significant result. The different parameter showed the maximum value due application of 75 ppm GA_3.

- The conclusion from above fact that, 0.5 kg zn/ha and 75 ppm GA_3 is suitable combination for the tomato production. Further investigation may be done to observe in different agro-ecological zones before more conformation of the results.

REFERENCES

Ahmed, K.U. (1976). Phul Phal O Shak-Sabjee. 3rd Edn. Alhaj Kasimuddin Ahmed, Banglow No. 2, Farmgate, Dhaka-15, Bangladesh. pp. 544.

Aghtape, A.A., Ghanbari, A., Sirousmehr, A., Siahsar, B., Asgharipour, M., Tavssoli, A. (2011). Effect of irrigation with wastewater and foliar fertilize application on some forage characteristics of foxtail millet (*Setaria italica*). *Int. J. Plant Physiol. Biochem.* **3**(3): 34-42.

Aditya, T.L., Rahman, L., Shah-E-Alam, M., Ghosh, A.K. (1999). Correlation and Path Coefficient Analysis in Tomato. *Bangladesh Agril Sci Al.* **26**(1):119-122.

Adlakha, P.A. and Verma, S.K. (1964). Effect of gibbellic acid on the quality of tomato fruit. *The Punjab Hort. J.*, **4**(3-4): 148-151.

Adlakha, P. A. and Verma, S. K. (1965). Effect of gibberellic acid on fruiting and yield of tomato. *Science and Culture*, 31: 301-303.

BBS. 2012. Statistical Year Book of Agricultural Statistics of Bangladesh Statistics Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh, Dhaka.

Briant, R.E. (1974). An analysis of the effect of gibberellic acid on tomato leaf growth *.J. Exp. Bot.* 25: 764-771.

Cakmak, I., Marschner, H. and Bangerth, F. (1989). Effect of zinc nutrition status on growth, protein metabolism and levels of Indole-3-acetic acid and other phythohormones in Bean (*Phaseolus vulgaris L.*). *J. Exp. Bot.* **40**(212):405-412.

Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification. *Plant Soil*. 302: 1- 17.

Chaudhury, B. Vegetables. Sixth Revised Edn., The Director, National Book Trust, New Delhi, India. 1979, 46.

Choudhury, S. H. and Faruque, A. H. M. (1972). Effect of PCA and GA on seedlessness of tomato. *Bangladesh Hort*. **1**(1): I3-16.

Davies, P.J. (1995). Plant Hormones, Physiology, Biochemistry and Molecular Biology. Kluwer Academic Publishers, Dordrecht.

Dongre, S.M., Mahorkar, V.K., Joshi, P.S. and Deo, D.D. (2000). Effect of micronutrients spray on yield and quality of chilli (*Capsicum annuum* L.). var. Jayanti. *Agric. Sci. Digest*, **20**(2) : 106-107.

Dorais, M., Ehret, D.L. and Papadopoulos, A.P. (2008).Tomato (Solanum lycopersicum) health components: from the seed to the consumer. Phytochem. Rev. 7:231-250.

El-Abd, S.0., Singer, S.A., Ilelmy, Y.I. and Beltagv, M.S.E. (1995). Plant growth regulators for improving fruit set of tomato. *Egypt J. Hort.,* **22**(2): 163-173.

El-Habbasha, H., Shadeque, A. and Baruah, P. J. (1999). Effect of plant growth regulators on yield and quality of tomato. *Veg. Sci.* **18**(1): 93-96.

Feofanova, N.D. (1960). Effect of gebberelin on fruit development in tomatoes, *Bot. J*. 45: 1781-1786.

Franceschi, S.E., Bidoli, C., La Vacchia, R., Talamini, B., Avanzo, D. and Negri, E. (1994). Tomatoes and risk of digestive-tract cancers. *International Journal of Cancer*. **59**(2) 181-184.

Gabal, G.M., Oben, G. and Marcell, R. (1990). Effect of GA_3 on morpho-physiological characters and yield of kidney beans *(Phasetolus valgaris). J. Agron. Crop Sci.* **160**(2): 91·101.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for Agricultural Research. John wlley and Sons. Inc. New York. PP. 67-215.

Groot, S.P.C., Bruibsma, J. and Karssen, C.M. (1987). The role of endogenous gibberellic in seed and fruit development of tomato (*Lyropersicon esculentum* Mill.). Studies with a gibberellic deficient mutant. Physiologia Planetarium, **71**(2): 184-190.

Grotz, N. and Guerinot, M. L. (2006). Molecular aspects of Cu, Fe and Zn homeostasis in plants. *Biochim. Biophys. Acta*. 1763: 595–608.

Gulnaz, A., Iqbal, J. and Awn, F. (1999). Seed treatment with growth regulators and crop productivity. II. Response of critical growth stages of wheat *(Triticum aestivum* L.) under salinity stress. Cereal Res. Communications, **27** (4):419-426.

Gustafson, F. G. (1960). Influence of gibberellic acid on setting and development of fruits in tomato. *Plant Physiology*, 35: 521-23.

Hall, J.L. (2002). Cellular mechanisms for heavy metal detoxification and tolerance. *J. Exp. Bot*. 53: 1-11.

Haque, M. S., Islam, M. T. and Rahman, M. (1999). Studies on the presentation of semi-concentrated tomato juice. *Bangladesh J. Agril. Sci*., **26**(1): 37-43.

Hathout, T.A., Sheteawi, S.A. and Khallal, S.M. (1993). Effect of mode of application of some hormonal contents Egyptian J. Physiol, Sci. Botany Department. Women's College. Ain Shams University, Cairo, Egypt. **17** (1): 45-62.

Hossain, M.A.E. (1974). Studies on the effect of parachlorophenoxy acetic acid and gibberellic acid on the production of tomato. An M. Sc. Thesis, Dept. of Hort.; BAU, Mymensingh. p. 25.

Imtiaz, M., Alloway, B.J., Shah, K.H., Siddiqui, S.H., Memon, M.Y., Aslam, M. and Khan, P. (2003). Zinc nutrition of wheat: Growth and zinc uptake. *Asian J. Plant Sci.* **2**(2):152-155.

Irshad, A.H. (2011). Effect of organic Manures and Inorganic Fertilizers on Biochemical Constituents of tomato.(*Lycopersicon esculentum* Mill). *Advance in Environmental Biology*. **5**(4):683-685.

Islam, A.T.M.R. (2006). Effect of S, Zn and Boron on yield and quality of BINA moog-5. M.S. thesis. Department of Agril. Chem. BAU, Mymensingh.

Jansen, H. (1970). Effect of gibberellic acid and CCC on the yield of tomato. Gortenbauwissenchaft, 35: 303-306.

Katyal, J.C. and Randhawa, N.S. (1983). Micronutrients. FAO Fertilizer and Plant-Nutrition Bulletin. pp. 3-7.

Kaushik, M.P., Sharma, J.K. and Singh, I. (1974). Effect of alpha naphthalene acetic acid, gibberellic acid, kinetin and norphactin on yield of tomato. *J. plant Sci.,* 6: 51-53.

Kaya, C. and Higgs, D. (2002). Response of tomato (*Lycopersicon esculentum* L.) cultivars to foliar application of zinc when grown in sand culture at low zinc. Sci. Hortic., 93:53-64.

Khan, M.M.A., Champa, G., Eiroz, M., Siddiqui, M.H., Naeem, M. and Khan, M.N. (2006). Effect of gibberellic acid spray on performance of tomato. *Turkish J. Biochem.,* **30**(1): 11-16.

Khan, N.A., Ansari, H.R. and Sanaullah. (1998). Effect of Gibberellic acid spray during ontogeny of Mustard on growth, nutrient uptake and yield characteristics . *J. Agron. Crop Sci.* **181**(1): 61-63.

Kumari,S. and Sharma, S.K . (2006). Effect of micronutrient sprays on tomato (*Lycopersicon esculentum* Mill) seed production. *Indian Journal of Agricultural Sciences*. 76 (11) : 676-678.

Leonard, M., Ki11et, K. M., Bodson, M. and Bemier, G. (1983). Enhanced inflorescence development in tomato by growth substance treatment in relation to C14 assimilates distribution. Physiologia Planetarium. **57**(1): 85-89.

Lester, G.E. (2006). Environmental regulation of human health nutrients (ascorbic acid, β-carotene and folic acid) in fruits and vegetables. Horticultural Science. **41**(1) 59-64.

Lilov, D. and Donchev, T. 1984. Effect of a Bulgarian gibberellin preparation on tomato fruiting Gradinarska, Lozarska Nauka, **21** (1): 49-55.

Marchner, H. (1995). Mineral Nutrition of Higher Plants. 2nd Ed.Academic Press Inc. London., G.B.

Mehmet A., İNAL A., Aydın G., Yakup C. and Hesna O. (1998). Effect of Zinc Treatment on the Alleviation of Sodium and Chloride Injury in Tomato (*Lycopersicum esculentum* (L.) Mill. cv. Lale) Grown Under Salinity. *Tr. J. of Botany*. **23**(1): 1-6.

Mehtha, A. K. and Mathi, D. I. (1975). Effect of growth regulators on summer tomato. *Haryana Hort. Sci.* 4: 167-176.

Mozer, T.J. (1980). Control of protein synthesis in barley aleurone layers by the plant hormones, gibberellic acid and abscisic acid. Cell 20: 479-485.

Naga, S.K., Swain, S.K., Sandeep, V.V. and Raju, B. (2013). effect of Foliar Application of Micronutrients on Growth Parameters in Tomato (*Lycopersicon esculentum* Mill.).*Discourse J. Agriculture and food sciences.* **1**(10) : 146-151.

Olaniyi, J.O., Akanbi, W.B., Adejumo, T.A. and Akande, O.G. (2010). Growth, fruit yield and nutritional quality of tomato varieties. *Afr. J. Food Sci.* **4**(6):398-402.

Onofeghara, F. A. (1981). The effects of growth substance on flowering and fruiting of tomato (*Lycopersicon esculentum* Mill.). *Phyton Argentina*. **40**(1): 107-116.

Patel, I. and Saxena, O.P. (1994). Screening of PGRs for seed treatment in green gram and blackgram. *Indian J. Plant Physiol*. **37**(3):206-208.

Rafeeker, M., Nair, S.A., Sorte, P.N., Hatwal, G.P., and Chandhan, P.N., (2002), Effect of growth regulators on growth and yield of summer cucumber. *J. Soils Crops*. **2**(1):108-110.

Ramage, R.T. (1980) Genetic methods to breed salt tolerance in plants. In genetic Engineering of Osmoregulation: Impact on plant productivity for Food, Chemicals and Energy, New York. Plenum Press. pp. 311-318.

Roy, D.S.K., Kabir, J., Chatterjee, R. and Mitra, S.K. (1991). Effect of post harvest foliar spray of some chemicals on storage behavior of onion. Onion for the topics. 3: 23-25.

Salam, M.A., Siddique, M.A., Rahim, M.A., Rahman, M.A. and Saha, M.G. (2010). quality of tomato (*Lycopersicon esculentum Mill.)* as influenced by boron and zinc under different levels of NPK fertilizers. *Bangladesh J. Agril. Res.* **35**(3) : 475 -4 88.

Salam, M.A., Siddique M.A., Rahim M.A., Rahman, M.A. and Goffar, M.A. (2011). quality of tomatoes influenced by boron and zinc in presence of different doses of cowdung. *Bangladesh J. Argils. Res*. **36**(1) : 151-163.

Saleh, M.M.S. and Abdul, K.S. (1980). Effect of gibberellic acid and cycocel on growth, flowering and fruiting of tomato *(Lycopersicen esculentum* Mill.) *Plants Mesopotarma J. Agric.* **15**(1): 137-166.

Sanyal, D., Kar, P.L. and Longkumar, M. (1995). Effect of growth regulators on the physicochemical composition of tomato *(Lycopersicon esculetum* Mill.) *Advances in Hort. And Forestry.* 4:67-71.

Sasaki, H., Yano, T. and Yanrasaki, A. (2005). Reduction of high temperature inhibition in tomato fruit set by plant growth regulators. *JARQ, Japan Agric. Res. Q.* **39**(2): 135-138.

Sharfudin, A.F.M. and Siddique, M.A. (1985). Shabji Biggan. 1st Edition, Bangladesh Agricultural University, Mymensingh. pp. 4.

Sharma, P. and Kumari, P. (2006). Removal of cadmium from aqueous system by shelled *Moringa oleifera* Lam. seed powder. Bioresour Technol. Jan. **97**(2):299-305.

Sheeja, T.E., Mondal, A.B. and Rathore. R.K.S. (2004). Efficient plantlet regeneration in tomato (Lycopersicon esculentum). Plant Tissue Cult., **14**(1): 45-53.

Shittu, G.A. and Adeleke, I.A. (1999). Effect of gibberellic acid on the growth and development of tomato *(Lycopersicon esculetum* Mill.) cultivar. *Global J. Pure Apply Sci.,* **5**(1): 27-30.

Silspour, M. and Omidghaemi, M.R. (2006). Effect of different irrigation water quantities and use of Fe and Zn on yield and water use efficiency of tomato. Iranian J. Soil and Water Sciences. **20**(2):309-318.

Singh, S.P. (1995). Response of tomatoes to growth substances – A review. *Adv Hort Forest.* 4: 73-84.

Singh, S.N. and Choudhury, B. (1966). Effect of various plant growth regulators and their method of application on quality of tomato fruits. *Indian J. Hort*. 23**:** 156-157.

Singh, J.P., Dahiya, D.J. and Narwal, R.P. (1990). Boron uptake and toxicity in wheat in relation to zinc supply. *Fertilizer Research*. 24: 105- 110.

Sumiati, E. (1987). Effects of plant growth rewgulators on flowering and yield of tomatoes in the lembang highlands. *Bulletin Penelition Horticultura*. **15**(1): 134-143.

Sun, Y. W., Chen, I., Tseng, M., Chang, W. and Sheen, T. (2000). The role of growth regulators on cold water for irrigation reduces stem elongation of plug-grown tomato seedlings. *Chinese J. Agro-meteorology,* **7**(4): 61-68.

Swan, Z.M., Hafez, S.A. and Basyony, A.E. (2001). Effect of phosphorus fertilization and foliar application of chelated zinc and calcium on seed, protein and oil yield and oil properties of cotton. *J. Agric. Sci.* 136:191-198.

Takano, K.P., Bialek, K. and Cohen, J.D. (1995). The effect of growth regulators on two spring legumes, protein peas and french beans. Mekedelingen Jan de facutied landbouwwetensch apen Rijksunver siffeit Gent. 52:1259-1266.

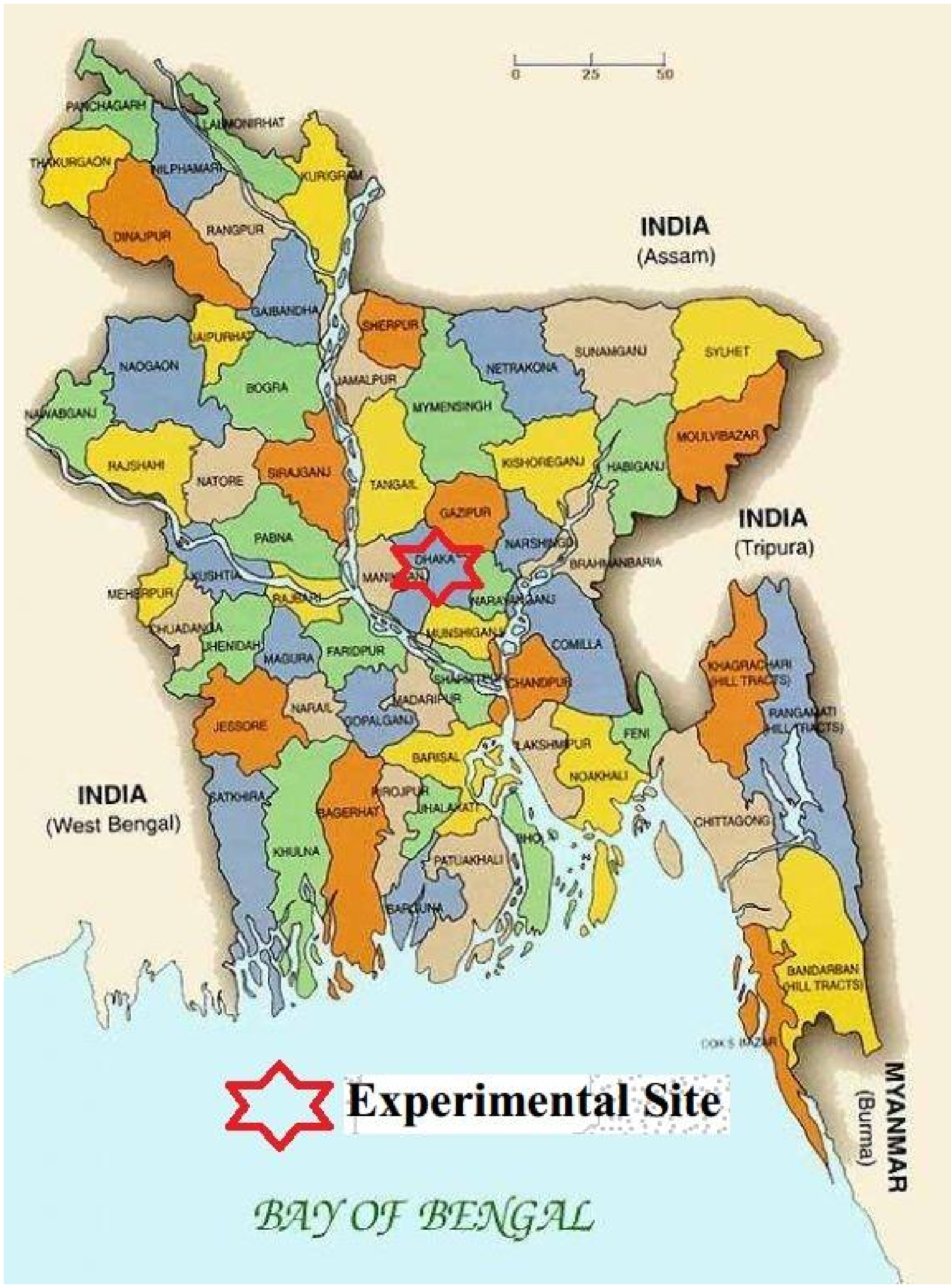
Tomar, I.S. and Ramgiry, S.R. (1997). Effect of growth regulator on yield and yield attributes in tomato (*Lycopersicon esculentum* Mill.). *Adv. Pl. Sci.* **10**(2): 29-31.

Wilcox, J.K., Catignani, G.L. and Lazarus, C. (2003). Tomatoes and cardiovascular health. *Food Science and Nutrition*. **43**(1) 1-18.

Wu, C.W., Lin, I.Y., Tarug, S.F. and Chem, I.R. (1983). Effect of growth regulators on the growth and development of tomato (*Lycopersicon esculentum* Mill). *China J. Agric. Assoc.* 124: 31-42.

APPENDICES

Appendix I: Experimental site at Sher-e-Bangla Agricultural University, Dhaka-1207



The map of Bangladesh showing experimental site

Appendix II: Monthly records of meteorological observation at the period of experiment (November, 2015 to March, 2016)

Name of months	Temperature (^0C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
November, 2015	30	15	66	24
December, 2015	28	13	63	5
January, 2016	26	12	54	8
February, 2016	30	13	49	32
March, 2016	34	14	45	61

Source: Weather Yard, Bangladesh Metrological Department, Dhaka.

Appendix III: Physical properties of soil of the experimental plot

Description	Characteristics
Location	Research farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow Red Brown Terrace Soil
Land Type	Medium high land
Soil Series	Tejgaon fairly leveled
Topography	Fairly level
Flood Level	Above flood level
Drainage	Well drained

Appendix-IV: Analysis of variance of different character of tomato

Sources of variation	Degrees of freedom	Mean sum of square					
		Plant height			No. of leaves per plant		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
Replication	2	0.112	0.677	0.141	0.583	0.028	0.361
Zinc (Z)	2	37.405*	38.114	104.530*	22.750*	49.778*	55.028*
Gibberellic acid (G)	3	9.331*	56.596*	82.245*	4.620*	8.324*	4.778*
Z×G	6	3.801*	17.193*	97.948*	2.343*	12.852*	7.028*
Error	22	0.093	0.294	0.848	0.371	0.543	0.452

DAT= Days after transplanting

* Significant at 5% level

Sources of variation	Degrees of freedom	Mean sum of square			
		Flower clusters per plant	Flowers per cluster	Fruit per cluster	Fruit per plant
Replication	2	1.778	0.361	1.361	7.694
Zinc (Z)	2	46.861*	26.361*	21.028*	1539.111*
Gibberellic acid (G)	3	4.222*	4.852^{NS}	3.185^{NS}	449.213*
Z×G	6	6.528*	8.213*	7.991*	554.741*
Error	22	0.808	0.997	0.604	4.361

* Significant at 5% level

NS= Not Significant

Appendix-IV: (Cont'd)

Sources of variation	Degrees of freedom	Mean sum of square		
		Fruit wt per plant (Kg)	Fruit wt per plot (Kg)	Fruit yield (t ha^{-1})
Replication	2	0.015	1.263	9.750
Zinc (Z)	2	2.155*	401.994*	3102.449*
Gibberellic acid (G)	3	0.041 NS	25.946*	200.334*
Z×G	6	0.335*	45.657*	352.293*
Error	22	0.010	0.821	6.342

* Significant at 5% level

NS= Not Significant

Sources of variation	Degrees of freedom	Mean sum of square		
		TSS %	β-Carotene (mg per 100g) content	Vitamin-C (mg per 100g) content
Replication	2	0.062	0.001	199.998
Zinc (Z)	2	1.580*	0.015*	1035.693*
Gibberellic acid (G)	3	0.166*	0.001*	53.680*
Z×G	6	0.483*	0.002*	164.247*
Error	22	0.012	0.000	6.910

* Significant at 5% level

PLATES

1. Seedbed preparation and raising of seedlings


a **b**


c **d**

2. Land preparation and transplanting

e

f

g

3. Treatment at different doses in different plot

h

i

4. Tomato plants in the plots with flowers and fruits

J

k

l

5. Yield of fruit

m

6. Laboratory work for quality analysis

n