RESPONSE OF TOMATO TO TRANSPLANTING DATE AND PLANT GROWTH REGULATORS

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RESPONSE OF TOMATO TO TRANSPLANTING DATE AND PLANT GROWTH REGULATORS

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CERTIFICATE

This is to certify that thesis entitled, **RESPONSE OF TOMATO TO TRANSPLANTING DATE AND PLANT GROWTH REGULATORS** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRICULTURAL BOTANY,** embodies the result of a piece of bona fide research work carried out by **ANTORA DEV DRISTY, Registration No.14-06343** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December,2016

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DEDICATED TO
MY
BELOVED PARENTS

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RESPONSE OF TOMATO TO TRANSPLANTING DATE AND PLANT GROWTH REGULATORS

ABSTRACT

The experiment was carried out in the Farm and Lab, of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during November 2014 to March 2015to investigate the response of tomato with plant growth regulators and transplanting date. In this study, variety BARI tomato 14varietywas used as a planting material and the treatments consisted of three different times of transplanting. T_1=First transplanting date (10 December 2014), T_2=Second transplanting (20 December 2014), T_3= Third transplanting (30 December 2014), and four different combination of treatments *viz* Control= no plant growth regulators, Salicylic acid (SA)= o.3mM, Gibberellic acid (GA)= 20 ppm and the combination of (salicylic acid 0.3mM +gibberellic acid 20 ppm). There were 12 treatment combinations. The experiment was laid out in two factors Randomized Complete Block Design(RCBD) with four replication. In this study, 48 pots were used to conduct the experiment. Most of the results of this experiment showed significant difference to the treatments. SA and GA were applied exogenously. The First transplanting time significantly influence both on morphological and yield contributing characters and yield of tomato. The higher values of plant height, cluster plant^{-1}, fruit length, fruit breadth, fruit number, individual fruit weight, yield plant^{-1} was found in first transplanting. The sole or together application of SA, GA and SA+GA showed significant effect on changes in fruit yield of tomato as compared to control. Thus combined effect of date of transplanting and plant growth regulators exhibit significant influence. The highest yield (494 gm/plant) was obtained from the first transplanting date along with salicylic acid and gibberellic acid and the lowest (196 gm/plant) was in third transplanting date along with control. Therefore, results combine application of SA+GA improves the fruit yield of tomato than sole application of SA and GA under SAU environmental condition.

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ACRONYMS AND SYMBOLS

ANOVA	Analysis of Variance
BBS	Bangladesh Bureau of Statistics
BARI	Bangladesh Agricultural Research Institute
CIMMYT	International Wheat and Maize Improvement Center
CT	Canopy Temperature
CV	Co-efficient of Variation
Cm	Centimeter
DAS	Days After Sowing
df	Degrees of freedom
FAO	Food and Agriculture Organization
gm	Gram
ha	Hectare
SAU	Sher-e-Bangla Agricultural University
J	Journal
K	Selection intensity
Kg	Kilogram
MS	Mean Sum Square
MSE	Error Mean Square
No.	Number
CRD	Completely Randomized Block Design
Sci.	Science
WRC	Wheat Research Centre
∑	Sum
^{o}C	Degree Celsius
i.e.	That is
@	At the rate of

CHAPTER I
INTRODUCTION

Tomato (*Solanum lycopersicum*) under solanaceae family and is one of the most important, popular and nutritious vegetable crop in the world including Bangladesh. It ranks third next to potato and sweet potato in terms of world vegetable production (FAO, 2008) and top the list of canned vegetable (Choudhury, 1979). But in Bangladesh, it ranks second which is next to potato (BBS, 2009). It has diversified use as raw like salad, soup and processed into stable products like ketchup, sauce, marmalade, chatney, jelly, jam, pickles, juice, paste, powder and many other products (Ahamd, 1979; Thompson and Kelly, 1983; Bose and Som, 1990)

The popularity of tomato and its products are increasing gradually. Tomato is a rich source of mineral and vitamin. The attractive red colour of the fruit is due to lycopene and the yellow colour is due to carotene. Carotene is a good source of vitamin A. Tomato is highly nutritious as it contains 98 g protein, 320 IU vitamin A, 1.7 mg vitamin C per 100 g ripening edible protein (Bose and Som. 1986; Matin *et al*., 1996). Recent studies have directly linked lycopene to the prevention of certain types of human cancer, particularly prostate cancer and with a lower incidence of heart disease such as arteriosclerosis .Tomato consumption has been associated with decreased risk of breast cancer, head and neck cancers and might be strongly protective against neurodegenerative diseases in human.

In Bangladesh, tomato has great demand round year, but its production is mainly concentrated during the winter season. Recent statistics showed that tomato was grown in 25 thousand hectares of land and the total production was approximately 2.35 lack metric tons. The average yield of tomato was 9.39 t/ha (BBS, 2011)which is very low compared to other tomato growing countries like India (19.5t/ha), Pakistan (9.67 t/ha), China (48.1t/ha) (Anonymous, 2011) and Thailand

(23.79 t/ha). The low yield of tomato in Bangladesh is however, not an indication of low yield potentiality of this crop, but of the fact that the lower yield may be attributed to a number of reasons, *viz.* changeable environmental conditions, unavailability of quality seeds of improved genotypes, lack of knowledge of suitable management operations, days of transplanting, fertilization, and plant growth regulators etc.

It is well known that climate change is a frightening issue on reduction of crop of yield not only in Bangladesh but also all over the world. Presently, drought, changes of temperature, salinity, heavy metal contamination etc affect the growth, development and yield of agricultural crops. In Bangladesh, usually early November is the planting time seems to be best (Hossain *et al*., 1986) and late planting results lower yield and enhanced disease infection in tomato. It was reported that fruit set was abundantly only when night temperature was between 15 and 20 (Went,1984).Curme (1992) also showed that fruit set varies with temperature as low (7.2) and with temperature as high (26.6).Tremendous decline in fruit set due to high as well as low temperature which disturb mechanisms involved in the development of male and female parts of the flowers.

Tomato production in Bangladesh is highly affected by transplanting date. .Different transplanting date has a great effect on chlorophyll content, yield, cluster number, branch, leaf number of tomato. Best result is observed in longest night period time. On the basis of the growth habit and flower production tomato plant grouped into three types *viz.* indeterminate (constancy of three internodes between inflorescences).Tomato grows in the area where temperature ranges from 21-24^{0}C in the monsoon (Krishnamurthy and Subramanian, 1954). For fruit settings

favourable temperature is around 21^0C. Night temperature is over more important for fruit setting than that of the day. In Bangladesh congenial atmosphere remains for tomato production during low temperature winter season that is early

November is the best time for tomato planting in our country (Hossain *et al*., 1986). But recently some summer varieties *viz*. BARI Hybrid- 3 and BARI hybrid-4 have been developed in Bangladesh.

Intercellular communication in higher plants is mediated by the action of chemical messengers called plant growth regulators or plant hormone which influence the growth and development of plant including plant cell division, enlargement and differentiation, photosynthesis, flowering, fruting etc. Numerous studies illustrated that exogenous application of plant bio-regulators improve the morpho-physiology and yield of tomato as a smart agriculture presently, tomato cultivers are also commercially producing tomatoes both at higher and lower temperature with foliar application of PGRs. Batlang (2008) reported that the fruit yield of tomato is influenced by number of fruit in each clusters, size which are improved with PGRs and become popular to tomato growers.In addition, abiotic as well as biotic stresses are being alleviated with numerous plant growth regulators together with absicicacid (ABA), cytokinin (CK), auxin (IAA) gibberellin (GA), jasmonate (JA), salicylic acid(SA). .

Gibberellic acid (also called Gibberellin A3, GA, and GA_3) is a hormone found in plants and fungi (Silvia et. al.2013). Its chemical formula is $C_{19}H_{22}O_6$. When purified, it is a white to pale-yellow solid. However, plants produce low amounts of GA, therefore this hormone can be produced industrially by microorganisms. Camara, *et. al*. 2015.It is a plant hormone stimulating plant growth and development, is a tetracyclic di-terpenoid compound. GAs stimulate seed germination, trigger transitions from meristem to shoot growth, juvenile to adult

leaf stage, vegetative to flowering, determines sex expression and grain development along with an interaction of different environmental factors viz., light, temperature and water. The major site of bioactive GA is stamens that influence male flower production and pedicel growth. However, this opens up the question of how female flowers regulate growth and development, since regulatory mechanisms/organs other than those in male flowers are mandatory. Although GAs are thought to act occasionally like paracrine signals do, it is still a mystery to understand the GA biosynthesis and its movement. It has not yet confirmed the appropriate site of bioactive GA in plants or which tissues targeted by bioactive GAs to initiate their action. Presently, it is a great challenge for scientific community to understand the appropriate mechanism of GA movement in plant's growth, floral development, sex expression, grain development and seed germination. The appropriate elucidation of GA transport mechanism is essential for the survival of plant species and successful crop production

Salicylic acid (from Latin *salix*, *willow tree*) is a monohydroxybenzoic acid, a type of phenolic acid and a beta hydroxy acid. It has the formula $C_7H_6O_3$. This colorless crystalline organic acid is widely used in organic synthesis and functions as a plant hormone.(Grimes, 1999.)It is derived from the metabolism of salicin. Salicylic acid (SA) is a phenolic phytohormone and is found in plants with roles in plant growth and development, photosynthesis, transpiration, ion uptake and transport. SA also induces specific changes in leaf anatomy and chloroplast structure. SA is involved in endogenous signaling, mediating in plant defense against pathogens. It plays a role in the resistance to pathogens by inducing the production of pathogenesis-related proteins. It is involved in the systemic acquired resistance (SAR) in which a pathogenic attack on one part of the plant induces resistance in other parts.

The lower yield of tomato in Bangladesh, however, is not an incidence of the low yielding potentiality of this crop but of the fact that the lower yield may be attributed to a number of reasons viz. unavailability of quality seeds of improved varieties, fertilizer management, disease infestation and improper moisture management. Among them hormone is a vital factor that influences the growth and yield of tomato. Among the different hormone that were required for tomato cultivation GA and Salicylic acid is most important .

GA is also an important factor for tomato good yield. The application of Gibberellic acid had significantly increased the number of fruits plan than the untreated controls. Tomar and Ramgiry,(1997) reported that GA (55 ppm) sprayed on flower cluster resulted is an increase in fruit weight. To increase the yield and to avoid flower and fruit dropping, application of GA at right concentration and right time is important. Gibberellic acid has great effects on plant physiological systems including fruit setting, leaf expansion, germination, breaking dormancy, increasing fruit size, improving fruit quality and in many other aspects of plant growth and thereby increased crop production.

Research on the effect of transplanting date in association with application of GA and SA on the growth and yield of tomato under Bangladesh conditions is limited. Under the circumstances, the present piece of research was undertaken with the following objectives:

i) To find out the effect of transplanting time on the growth and yield of tomato.
ii) To determine the effect of GA on the growth and yield of tomato
iii) To determine the effect of SA on the growth and yield of tomato and
iv) To find out the effect of combination of GA and SA for ensuring the maximum growth and yield of tomato.

CHAPTER - II

REVIEW OF LITERATURE

Throughout the world Tomato *(Solanum lycopersicum*) is one of the most important and popular vegetable crops. It has received much attention to the researcher and a large number of research works have been done on various aspects to improve both quality and quantity of tomato. Several research works have been done to find out to effect on growth, yield and other characters for screening, selection and development of better varieties in different developing countries of the world Plant growth regulators arc the substances, which affect the growth of plants quite miraculously. Salicylic acid is one of them. Application of this 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 sowing date on the growth and yield of tomato

Ali *et al.* 2014 conducted a field trial to study the performance of tomato as influenced by organic manure and sowing date during the 2013 dry season at the Teaching and Research Farm of Samaru College of Agriculture, Ahmadu Bello University, Zaria on the growth and yield of tomato. Treatments consist of control, cow dung, goat manure and poultry manure and sowing date of 8th January, 2013, 22nd January, 2013, 5th February, 2013 and 19th February, 2013 dry season and laid out in a split plot design with organic manure assigned to the main plots; where as sowing date to the sub plots with three replications. Data

were collected on growth and yield parameters; vine length, number of leaves plant^{-1} , number of branches plant^{-1} , leaf area plant^{-1} , number of flowers plant^{-1}, number of fruits plant^{-1}, fruit weight plant^{-1}, fruit yield plot^{-1} and fruit yield hectare^{-1} . Results obtained indicated that growth and yield of tomato was lowest in control treatments which showed that the organic manure and sowing date used in the study especially poultry manure and sowing date of 5th February, 2013 promoted the yield of tomato. Poultry manure and sowing date 5th February, 2013 enhanced tomato vine length, number of leaves plant^{-1}, number of branches plant^{-1} , number of flowers plant^{-1} , number of fruits plant^{-1} , fruit weight plant^{-1} , fruit yield plot^{-1} and fruit yield hectare^{-1} compared to control treatments. There was no significant effect with respect to leaf area plant^{-1}, number of fruits plant^{-1}and fruit weight plant^{-1}.

Zhao *et al.*2014 carried out an experiment to extend the growing season and protect high-value horticultural crops. High tunnels have been used for many years worldwide and their popularity has increased in Mississippi recently. A planting date study of 'Roma' tomato (*Solanum lycopersicum*), 'Legend' tomato, 'Ichiban' eggplant (*Solanum melongena* L.), 'Sweet Banana' pepper (*Capsicum annuum* L.), 'Benary's Giant' zinnia (*Zinnia elegans* L.), and 'Potomac Red' snapdragon (*Antirrhinum majus* L.) was conducted in 2010 in three high tunnels in Starkville, Mississippi. Each vegetable and cut flower cultivar was treated as an independent study. There were two planting dates for all the cultivars: 12 March 2010 and 2 April 2010. Only for zinnias, yield (272 stem/plot) of first planting date was higher than planting date two (106 stem/plot). A significant block effect was observed with 'Legend' tomato and 'Ichiban' eggplant where one high tunnel had significantly higher yield than the other two high tunnels. Harvesting of tomato, eggplant, and pepper from high tunnels was a month earlier than the field-grown crops. High tunnels can extend the growing season to provide produce to the market at earlier harvest dates in Starkville, Mississippi.

Hossain *et al*. 2013 was conducted experiment at Agricultural Research Station, Thakurgaon, Bangladesh during October 2009 to March 2010 to observe the effect of sowing dates on yield of tomato genotypes. Three sowing dates viz. October 1, October 15 and October 30 were considered as factor A and tomato variety viz., BARI omato-2, BARI Tomato-3, BARI Tomato-4, BARI Tomato-9 and BARI Hybrid Tomato-4 considered as factor B. The experiment was laid out in RCBD (Factorial) with three replications. Early flowering (52.40 days) as well as early fruit harvesting (119.13 days) was occurred in October 1 sowing, where as sowing on October 30 resulted in delayed flowering (71.73 days) and fruit harvesting (140.67 days), respectively. Number of fruits per plant was also the highest (27.40) in October 1 sowing and the lowest (13.73) was in October 30 sowing. Seed sowing of October 1 was found better in respect of yield (74.75 ton^{-1}) compared to October 15 (58.55 ton^{-1}) and October 30 (24.60 ton^{-1}) sowing. Among the variety, BARI Tomat-2 produced the highest (68.12 ton^{-1}) marketable yield followed by BARI Tomato-9 (56.16 ton^{-1}) and BARI Tomato-3 while BARI Tomato-4 gave the lowest (36.91 ton^{-1}) marketable yield.

Adil *et al.* 2013 carried out a study was to elucidate the effect of different sowing dates and temperature on growth, yield and quality of two important cultivars of *Gladiolus grandiflorus* L. Rose supreme and White prosperity .The results showed that different planting dates have significant effect on number of days taken by gladiolus corm to germinate. A significant superiority of T1 5.5 days over T2 with 9.10 days on all the treatments was observed. Among the treatments maximum sprouting percentage was recorded in T2 with 94.66 % followed by T3 82.19 % on all the treatments. The days to 6-leaves stage depict highly significant difference in variance of treatments, interactive effect of treatments and cultivars. The maximum plant height (115.33cm) was recorded in T2 followed by T3 with 111.04cm. Mean values of number of leaves indicated significant superiority of T2 with 8.02 leaves and T3 with 7.93 leaves on all other

treatments. The maximum chlorophyll contents 71.60 were recorded in T2 followed by T3 with 67.65 on all the treatments. Spike length showed highly significant difference in variance of treatments, interactive effect of treatments and cultivars. The maximum number of florets (17.16) was recorded in T2 followed by T3 with 15.83 florets. Among the treatments maximum corm diameter (6.19 cm) was recorded on T2 and T6 showed maximum number of cormels (5.96 cm). It is suggested that proper planting date reduce the production cost by reducing the crop time and also produce elite flowers with increased market value.

Alam *et al.* 2011 carried out an experiment at the Olericulture field of Horticulture Research Centre of BARJ, Joydebpur, Gazipur during September 2006 to April 2007 to investigate yield and yield attributes of sweet pepper as influenced by plant spacing and sowing time. There were altogether 21 treatments comprising seven sowing dates viz. 1 September, 15 September, 1 October, 15 October, 30 October, 15 November, 30 November and three spacing viz. 50 × 50 cm, 50x40 cm, and 50 × 30 cm. The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. The results of the experiment showed that majority of the yield and yield components significantly varied with variation of spacing and sowing time. Only number of fruits per plant and fruit yield per plant resulted significantly higher which reflected higher yield for 1 October sowing. The number of branches per plant, number of fruits per plant, fruit length, individual fruit weight, yield per plant were found significantly increased with the increasing plant spacing but other parameters were found to be significantly increased with the decreasing plant spacing. The combined effect of sowing date and plant spacing also had significant effect on different growth and yield parameters and yield. The highest yield (19.36 t/ha) of fruit was recorded from the earlier sowing (1 October) with

the closest spacing (50 × 30 cm). But reasonable yield could be obtained up to 30 October with same spacing.

Islam 2007 carried out an experiment at the Horticultural farm of the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, during September 2006 to April 2007 to investigate growth and yield of sweet pepper as influenced by sowing date and spacing. There were altogether 21 treatments comprising seven levels of sowing date viz. September 1, September 15, October 1, October 15, October 30, November 15, November 30 and three levels of spacing viz. 50x50 cm, 50x40 cm, 50x30 cm. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on various parameters and statistically analyzed. The results of the experiment demonstrated that the majority of growth parameters and yield components were significantly increased at the earlier sowing (October 1). The plant spacing had significant variation in almost all the growth and yield components except pericarp thickness. Number of branches per plant, number of leaves per plant, stem girth, number of fruits per plant, days to first harvest, fruit length, individual fruit weight, yield per plant were found to be significantly increased with the increasing of plant spacing but plant height at different stages, number of fruits per plot, days to 50% flowering, fruit breadth, yield per plot and yield per hectare were found to be significantly increased with the decreasing plant spacing. The combined effect of sowing date and plant spacing also had significant effect on different growth and yield parameter and yield. The highest yield (19.36 t/ha) of fruit was recorded from the earlier sowing (October 1) with the closest spacing (50x30 cm) which also gave the highest benefit cost ratio (4.58). Considering the yield of fruits per hectare, cost of production and net return, the treatment combinations of October 1 sowing along with 50x30cm spacing appeared to be recommendable for the cultivation of sweet pepper.

Bevacqua and Vanleeuwen (2003) reported that Chile pepper *(Capsicum annuum* L.) yields were highly variable and were strongly influenced by disease and weather. The goal of two field experiments was to evaluate crop management factors, especially planting date, that could contribute to improved and more consistent crop production. Current practice in New Mexico is to direct seed the crop from 13 to 27 March. In the first experiment, chili pepper was direct seeded on three planting dates, 13, 20, and 27 March 2000, without or with a fungicide treatment of pentachloronitrobenzene and mefenoxam for the control of damping off. The results indicate planting date had no effect on stand establishment or yield. Fungicide treatment, significantly reduced stand, but had no effect on yield. In the second experiment, chili pepper was direct seeded on six planting dates, 13, 20, 27 March and 3, 10, 17, April.2001, with or without an application of phosphorus fertilizer, Pat 29.4 kg.ha'1, banded beneath the seed row. During the growing season, this experimental planting suffered, as did commercial plantings in New Mexico, from high mortality and stunting due to beet curly top virus, a disease transmitted by the beet leafhopper. The results indicated that planting date had a significant effect on crop performance. The best stand establishment and the highest yield were associated with the earliest planting date, 13 March. This date also resulted in the least viral disease damage. Phosphorus fertilizer had no effect on stand establishment or yield

Russo (1996) found that planting date, fertilizer rate, and timing of harvest can affect yield of Jalapeno and banana peppers *(Capsicum annuum*L.). Seedlings of the Jalapeno 'Mitla' andLong yellow wax 'Sweet Banana 504' were transplanted in April and July 1995 into beds fertilized with either a recommended or a higher rate. Fruits were harvested either three times or once, the latter corresponding to the last of several harvests. Significantly higher yields were produced from the July planting of both cultivars and with once over harvesting. The recommended

rate of fertilizer increased yield of 'Sweet banana 504' and decreased that of' Mitla' compared to the higher rate.

Cebula (1995) conducted a field experiment in plastic tunnels near NowySacz in 1993 and 1994 using six *Capsicum* cultivars. Plants were set out in late April or early May in each year. Good light conditions in this area promoted early fruiting. Cultivars Oasis FI and Spartacus F(gave the highest marketable yields of 7.66 and 7.20 kg/m^2, respectively. Average fruit weights were also high (310 and 255 g, respectively). Yields were higher from planting in late April.

2.2 Effect of Gibberellic Acid on the growth and yield of tomato

Rahman *et al.* 2015 carried out an experiment in pots at Bangladesh Institute of Nuclear Agriculture, Bangladesh to evaluate influence of different concentrations of GA3 on biochemical parameters at different growth stages in order to maximize yield of summer tomato var. Binatomato-2. The concentrations of GA3 were 0, 25, 50, 75 and 100 ppm. They were applied at three stages, namely root soaking of seedlings before transplanting, vegetative and flowering stages. The experiment was laid out in a randomized complete block design with four replications. Results indicated that the highest chlorophyll and soluble protein contents were recorded when GA3 was applied through root soaking followed by vegetative stage and the lowest was found at the flowering stage. In contrast, the highest nitrate reductase activity was observed when GA3 was applied at the vegetative stage and the lowest activity was recorded at the flowering stage. The applications of 50-75 ppm GA3 had significantly encouraged the bio-chemical parameters studied at 50 DAT. The amount of GA3 applied at different stages had significant influence on the yield and yield attributes of summer tomato. The

highest plant height was recorded when 50 ppm of GA3 was applied at the vegetative stage. While, the longest time to first fruit setting was required when the roots of the seedlings were soaked in 100 ppm GA3 solution. The application of 50 ppm GA3 by root soaking had significantly increased the number of flowers, fruits and fruit yield per plant but similar results were achieved when only 25 ppm GA3 was applied at the flowering stage. The fruit yield of tomato per plant increased linearly with the increased number of flowers and fruits per plant

Mehraj *et al.* 2014 carried out an experiment at Horticultural farm of Sher-e-Bangladesh Agricultural University, Dhaka, Bangladesh to assess the response of foliar application of GA3 with different concentrations to cherry tomato plants. The assessment expressed that the foliar application of 200-ppm gibberellic acid solution provided maximum number of leaves (16.7), and brunch. tallest plant (70.0 cm), early flower bud initiation (13.0 days), early flowering (16.0 days) and early fruiting (20.3 days); utmost fruit diameter (25.9 mm) and number of fruits (105.0 fruits) per plant; maximum single fruit weight (11.1 g) and total fruit weight (1.2 kg) per plant, whereas the control was lowest.

Mohammadi *et al.*2014. carried out an experiment at the University of Thessaly during the summer season of 2011, the effect of foliar application of gibberellic acid (GA3) to okra at an early stage of plant growth (3-4 leaves) on plant growth, pod and seed characteristics was studied in relation to harvest time. GA3 was applied at concentrations of 0 (Control), 50, and 100 mg L-1 to four okra cultivars (‘Boyiatiou’, ‘Veloudo’, ‘Clemson’ and ‘Pylaias’) and pods were harvested 30, 35, 40 and 50 days after anthesis (DAA) from the lower part of the plant. From the results it was found that GA3application increased

plant height irrespective of cultivar and GA3 concentration (50 and 100 mg L-1), but without increasing flower induction or pod set. Similarly, GA3 had no effect on pod dimensions (which were determined by genotype) or mean 100 seed weight, except in Boyiatiou. Similarly, GA3 application did not consistently affect seed moisture content, but it did however, increase the number of seeds per pod. Germination was either promoted ('Veloudo'), inhibited ('Boyiatiou') or not affected ('Pylaias', 'Clemson') by GA3. Differences in germination were apparently related to the incidence of hard seeds. Storage of seeds for 18 months improved germination. Overall, pod and seed characteristics were affected more by genotype and harvest time than by GA3 application

Cato *et al*. 2013 carried out a experiment 2013 to evaluate the effect of isolated and combined applications of gibberellic acid (gibberellin), indolbutaric acid (auxin) and kinetin (cytokinin) on vegetative and reproductive development of tomato test plants (*Solanum lycopersicum* cv. Micro- Tom), to better elucidate the interactions among these hormonal classes. The following treatments were accomplished through foliar application: GA3 (5 mg L-1); IBA (5 mg L-1); KIN (9 mg L-1); GA3 + IBA (5 mg L-1 + 5 mg L-1); GA3 + KIN (5 mg L-1 + 9 mg L-1); IBA + KIN (5 mg L-1 + 9 mg L-1); GA3 + IBA + KIN (5 mg L-1 + 5 mg L-1 + 9 mg L-1) and Stimulate® (100 mL L-1). Plants from the control were sprayed with water. Stimulate®, is a commercial liquid formulation containing KIN (90 mg L-1), GA3 (50 mg L-1) and IBA (50 mg L-1). We analyzed the shoot dry matter (g), root dry matter (g); fruit fresh matter (g); fruit dry matter (g) and fruit size (cm). The experimental design was completely randomized with nine treatments and fifteen replications. The treatment means were compared by Tukey's test. Some combined applications of GA3, IBA and KIN or Stimulate® promoted significant increases in the dry matter accumulation of roots and fresh

and dry matter of fruit compared to the control. Besides the perspective to extend such results for commercial tomato production, the relevance of known hormonal interactions for the results obtained is discussed.

Yahaya and Gaya 2012 conducted a field trials on dry seasons to assess the efficacy of various rates of gibberellic acid on the growth and yield of tomato (Lycopersic lycopersicum (L) karst. The treatments consisted of seven rates (0, 50, 100, 150, 200, 250 and 300 ppm) of gibberellic acid. These were laid in a randomized complete block design and replicated three times. Data were recorded on plant height, number of leaves, number of branches, number of flowers and fresh fruit weight. These were subjected to analysis of variance. Where treatment means differed significantly, they were compared using DMRT. Results of the study showed that gibberellic acid concentration had significantly ($P \leq 0.05$) enhanced the growth, yield components as well as total yield of tomato. Best results were recorded from plants treated with 300 ppm gibberellic acid compared to all other rates applied. It is suggested that tomato be treated with 300 ppm gibberellic acid for improved yield.

Roy and Nasir uddin 2011 conducted an experiment to study the effect of GA3 on growth and yield of cabbage. Single factor experiment consisted of four concentrations of GA3, viz., 0, 25, 50 and 75 ppm. Significantly the minimum number of days to head formation (43.54 days) and maturity (69.95 days) was recorded with 50 ppm GA3 and 50 ppm GA3 gave the highest diameter (23.81 cm) of cabbage head while the lowest diameter (17.89 cm) of cabbage head was found in control (0 ppm GA3) treatment. The application of different concentrations of GA3 as influenced independently on the growth and yield of cabbage. Significantly the highest yield (45.22 kg/plot and 104.66 t/ha) was found from 50 ppm GA3.

Gelmesa *et al*. 2010 carried out an Experiment which was conducted at Melkassa Agricultural Research Center, centeral rift valley of Ethiopia from September 2008 to January 2009 with the objective to determine the effects of different concentrations and combinations of 2,4-dichlorophenoxyacetic acid (2,4-D) and gibberellic acid (GA3) spray on fruit yield and quality of tomato. The experiment consisted of two tomato varieties-one processing (Roma VF)and one fresh market(Fetan), three levels of 2,4- dichlorophenoxyacetic acid (2,4- D) (0, 5 and 10 mg l-1) and four levels of gibberellic acid (GA3) (0, 10, 15 and 20 mg l-1) arranged in 2 × 3 × 4 factorial combinations, in randomized completed block design with three replications. The result showed increase in fruit length from 5.44 to 6.72 cm at 10 mg l-1 2,4-D combined with 10 mg l-1 GA3 above the control, increased fruit weight by 13% due to 2,4-D and reduced fruit weight in single orcombined application of GA3 with 2,4-D. Fruit pericarp thickness was increased by about 50% due to 2,4-D and GA3 application above the control. Titratable acidity, total soluble solids and lycopene content were also increased due to combined application of 2,4-D and GA3 spray. Lower fruit pH is another quality attributes of tomato affected by 2,4-D application while that of GA3 has no effect. Final fruit yield were significantly improved above the control even though both varieties responded differently. For Roma VF, GA3 at concentration of 10 and 15 mg l-1 resulted in maximum fruit yield of 69.50 and 67.92ton ha-1, respectively in the absence of 2,4-D. For Fetan, maximum marketable fruit yield of 74.39 and 74.20 ton ha-1 was obtained from treatment combinations of 10 + 15 and 5 + 0 2,4-D and GA3,respectively. Hence, yield increment of about 35% for Roma VF and 18% for Fetan were produced at 10 mg l-1 GA3 and 10 + 15 mg l-1 2,4-D and GA3, respectively over the control. Significant increase in fruitsize and weight due to 2,4-D and increased fruit number due to GA3 spray contributed to increased fruit yield. The results indicated that both PGRs are important in tomato production to boost yield andimprove fruit quality under unfavorable climatic conditions of high

temperature. Therefore, it is important to further investigate application methods and concentrations of the PGRs under concern in different growing conditions on different tomato cultivars.

Khan *et al.* 2006 conducted a pot experiment was performed according to a factorial randomized design at Aligarh to study the effect of 4 levels of gibberellic acid spray (0, 10-8, 10-6 and 10-4 M GA3) on the growth, leaf-NPK content, yield and quality parameters of 2 tomato cultivars (*Ly copersicon esculentum* Mill.), namely Hyb-SC-3 and Hyb-Himalata. Irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters, especially in the case of Hyb-SC-3.

Thomas Casey Barickman 2014 conducted an experiment to evaluate the effects of exogenous ABA applications during plant development on tomato carotenoid pigments, soluble sugars, organic acids, aromatic volatiles, carbohydrates, and mineral nutrient content in ripe fruit, and to assess the impacts of ABA applications on BER by evaluating how exogenous ABA will affect the distribution of Ca between the leaves and fruit. There were a series of three experiments that examined two types of tomato plants, micro tomato and a commercial tomato cultivar 'Mt. Fresh Plus'. ABA was exogenously applied to the foliar and/or root tissue. Leaves were harvested and analyzed for chlorophylls, carotenoids, and Caconcentrations. Fruit tissue was harvested at red ripe maturity and analyzed for yield, BER and fruit quality parameter, such as carotenoids, soluble sugars, organic acids and aroma volatiles. The results indicate that applications of ABA treatments to tomato plants decreased the partitioning of Ca into the leaves while increasing concentrations in the fruit tissue. ABA treatments, in combination with the Ca treatment of 180 mg·L-1 (milligram per liter), decreased the incidence of BER. Further, ABA treatments

decreased BER even in the presents of low Ca in the fertilizer solution. Results indicate that ABA treatments are most effective in the early stages of plant development. This study demonstrated that BA is a viable treatment to significantly improve tomato fruit quality. Specifically, ABA treatments increased tomato fruit carotenoids and soluble sugar, while decreasing organic acid concentrations. However, ABA treatments had a detrimental effect on aroma volatile concentrations. ABA treatment applications in conjunction with low Ca treatments did not prove to be effective in improving tomato fruit quality. This study demonstrated that foliar spray ABA applications are more effective than root ABA applications.

Shittu and Adeleke (1999) investigated the effects of foliar application of GA3 (0, 10, 250 or 500 ppm) on growth and development of tomatoes cv, 158-3 grown on pots. Plant height and number of leaves were significantly enhanced by GA3 treatment. Plants treated With GA3 with 250 ppm were the tallest plant the highest number of leaves

Tomar and Ramgiry (1997) studied that tomato plant treated with GA3 showed significantly greater number of branches plant-1 than untreated controls.
Gabal *et al.* (1990) found that 100 ppm of GA3 was more effective treatment in increasing leaf number plant-1 compared to control.

Sanyal *et al.*(1995) studied that the effects of plant growth regulators (IAA or NAA at 15, 25 or 50 ppm or GA3 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.

EI- Habbasha *et al.*(1999) carried out a field experiment with tomato cv. castel rock over two growing seasons (1993-94). The effects of GA3 and 4-CPA on fruit yield and quality were investigated. Many of the treatments significantly increased fruit set percentage and total fruit yield, but also the percentages of puffy and parthenocarpic fruits compared to the controls.

Total dry matter of a crop is the output of net photosynthesis Patel and Saxena (1994) reported that presoaking of seed of gram in varying concentrations of GA3 showed the best results on dry weights. Application of GA3 at 50 and 100 ppm in french bean increased leaf number over control (Gabal*et al.* 1990). The increased leaf number could intercept most of the incident radiation and result in higher dry matter production in faba bean (Takano *et. al* (1995).

Leonard *et al.* (1983) reported that inflorescence development in tomato plants grown under low light regimes was promoted by GA3 application directly on the inflorescence.

2.3 Effect of Salicylic Acid on the growth and yield of tomato

Ong and Cruz 2016 conduct a study to know the effect of SA treatment on the severity of leaf curl disease of tomato (*Solanum lycopersicum*) was evaluated under screen house conditions in two experimental trials at the Crop Protection Cluster, University of the Philippines Los Baños from 2012 to 2013. The study sought to determine the concentration of SA applied at different time of induction which can effectively reduce the severity of the disease. Healthy seedlings of susceptible tomato variety, Apollo White were treated by spraying with 50, 250 or 500µM SA at 5, 10 or 15 days before inoculation (dbi). At

induction time of 5 dbi, treatment with 250µM SA had lowest leaf curl infection compared with the untreated control, while at 10 and 15 dbi, leaf curl infection was lowest with treatment of 50µM SA. Likewise, treatment with 50µM SA regardless of induction time had consistently delayed and reduced the severity of leaf curl disease. Generally, plants treated with 50µM SA had reduced amount of disease (AUDPC values), lower symptom severity score and lower disease index (DI) than the untreated control. The severity of the disease was also reduced with 250 and 500 µM SA treatment but the effect was more consistent with 50µM.

El-Alwany 2014 carried out an experiment on Salicylic acid (SA) and 2,6-dichloroisonicotinic acid (INA), which have the ability to induce systemic acquired resistance in plants were used in this study to test their effect on radial growth of (*F.o.l*) and (*F.o.c*) in Petri dishes. Results showed that 500 ppm of SA and INA had the greatest radial growth of *F.o.l*and *F.o.c*compared to other concentrations 1000 and 2000 ppm significantly. Inhibition percentage measurements showed also SA and INA 500 ppm had the lowest inhibition percentage (6.8%), (28%) for *F.o.l*and (8.8%), (24.8) for *F.o.c*. respectively. Results of this study and many of other studies conducted for the induction of systemic acquired resistance by these two compounds proved that concentrations less than 500 ppm able to induce the systemic acquired resistance in plants, also their inhibitory influence on radial growth are very few or non-existent in many cases.

Javaheri *et al.*2012 carried out an experiment to study the effects of salicylic acid on yield quantity and quality of tomato, an experiment was carried out based on randomized complete blocks design with four replications at research center of Shirvan Agricultural Faculty in 2011. Foliar application of five concentrations of salicylic acid (0, 10-2, 10-4, 10-6, 10-8 M) were used. Results showed that

application of salicylic acid affected tomato yield and quality characters of tomato fruits so that tomato plants treated with salicylic acid 10-6 M significantly had higher fruit yield (3059.5 g per bush) compared to non-treated plants (2220 g per bush) due to an increase in the number of bunch per bush. Results also indicated that application of salicylic acid significantly improved the fruit quality of tomato. Application of salicylic acid increased the amount of vitamin C, lycopene, diameter of fruit skin and also increased rate of pressure tolerance of fruits. Fruit of tomato plants treated with salicylic acid 10-2M significantly had higher vitamin C (32.5 mg per 100 g of fruit fresh weight) compared to non treated plants (24 mg per 100g fruit fresh weight). Salicylic acid concentration 10-2 M also increased the diameter of fruit skin (0.54 mm) more than two fold compared to control (0.26 mm). Fruit Brix index of tomato plants treated with salicylic acid 10-2M significantly increased (9.3) compared to non-treated plants (5.9). These results suggest that foliar application of salicylic acid may improve quantity and quality of tomato fruits

Zahra 2010 conducted a research on tomato seeds which planted in pots containing perlite were put in a growth chamber under controlled conditions of 27 ± 2 and 23 ± 2°C temperature, 16 h lightness and 8 h darkness, 15 Klux light intensity and 75% humidity; NaCl concentration of 0, 25, 50, 75 and 100 mM and salicylic acid concentration of 0, 0.5, 1 and 1.5 mM were used in the form of factorial experiment in a complete randomized design (CRD). Salinity increases the soluble sugar in leaf and root tissues, and salicylic acid decreases it. The leaf protein level decreased because of salinity effect, but salicylic acid could increase it. In the root, salinity increases protein, but salicylic acid with 1.5 mM concentration decreases it. Salinity increases the proline level in leaf and root, and salicylic acid did not significantly change in low salinity levels.

Rahmawati *et al.* 2014 conducted an experiment to determine compound from *Clerodendrum japonicum* and *Catharantusroseus* leaf extract, which were

potential as bioactivator and to evaluate the concentration of salicylic acid in tomato cultivars (*Lycopersicon esculentum* cv. Intan and cv. CL 6064) infected by CMV virus after application of plant extracts. The results showed that leaf extract of *C. japonicum* and *C. roseus* contained glyoxylic acid, phytol, and 1,2-benzenedicarboxylic acid which might be potential as plant activator. In tomato plant cv. Intan, leaf extract of *C. japonicum* was more potential to increase salicylic acid production averagely 36.91%, while in cv. CL 60.64, leaf extract of *C.* was more potential to increase salicylic acid production (averagely 27.47%).

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experimental plot, characteristics of soil, climate and materials used for the experiment. The details of the experiment are described below:

3.1 Experimental site

The experiment was conducted at the farmand Lab of Dept.of Agricultural Botany, of Sher-e-Bangla Agricultural University, Dhaka. The location of the site was 23°74 N latitude and 90°35longitude with an elevation of 8.2 meter from sea level.

3.2 Experimental period

The experiment was carried out during the Rabi season from November 2014 to March 2015. Seedlings were sown on pot in three times at November, 2014 and were harvested up to 25 March, 2015.

3.3 Soil type

The experimental site was situated in the subtropical zone. The soil of the experimental site lies in agro-ecological regions of "Madhupur Tract" (AEZ NO. 28). Its top soil is clay loam in texture and olive grey with common fine to medium distinct dark yellowish brown mottles. The pH 4.47 to 5.63 and organic carbon contents is 0.82 (Appendix-I).

3.4 Weather

The monthly mean of daily maximum, minimum and average temperature, relative humidity, monthly total rainfall and sunshine hours received at the experimental site during the period of the study have been collected from Bangladesh Meteorological Department,Agargaon, Dhaka (Appendix-III)

3.5 Materials used for experiment

The tomato, variety BARI Tomato-14 was used for the experiment. Seeds were collected from Bangladesh Agricultural Research Institute, Joydevpur, Gazipur and no of pot is 48.

3. 6 Treatments

The two factor experiment consisted of 3 times of transplanting (Factor A) and 3 levels of hormone Salicylic acid, Gibberellic acid and Combination of Salicylic and gibberillic acid with control (Factor B).

Factor: A: Different days of Transplanting

T_1	Frist transplanting date	10December 2014
T_2	Second transplanting date	20 December 2014
T_3	Third transplanting date	30 December 2014

Factor B: Different doses of plant growth regulators with control

C	Control	No hormone
SA	Hormone Salicylic Acid	o.3 mM
GA	Hormone Gibberellic acid	20 ppm
SA+GA	Hormone(Salicylic Acid+Gibberellic Acid)	0.3mM+20 ppm

Treatment combinations are as follows

First Transplanting Treatments	Second Transplanting Date	Third Transplanting Treatments
T_1CR_1	T_2CR_1	T_3CR_1
T_1CR_2	T_2CR_2	T_3CR_2
T_1CR_3	T_2CR_3	T_3CR_3
T_1CR_4	T_2CR_4	T_3CR_4
T_1SAR_1	T_2SAR_1	T_4SAR_1
T_1SAR_2	T_2SAR_2	T_4SAR_2
T_1SAR_3	T_2SAR_3	T_4SAR_3
T_1SAR_4	T_2SAR_4	T_4SAR_4
T_1GAR_1	T_2GAR_1	T_4GAR_1
T_1GAR_2	T_2GAR_2	T_4GAR_2
T_1GAR_3	T_2GAR_3	T_4GAR_3
T_1GAR_4	T_2GAR_4	T_4GAR_4
T_1 SA+GAR_1	T_2 SA+GAR_1	T_4 SA+GAR_1
T_1 SA+GAR_2	T_2SA+GAR_2	T_4SA+GAR_2
T_1 SA+GAR_3	T_2 SA+GAR_3	T_4 SA+GAR_3
T_1 SA+GAR_4	T_2SA+GAR_4	T_4SA+GAR_4

T_1= First Transplanting, T_2= Second Transplanting, T_3= Third Transplanting.

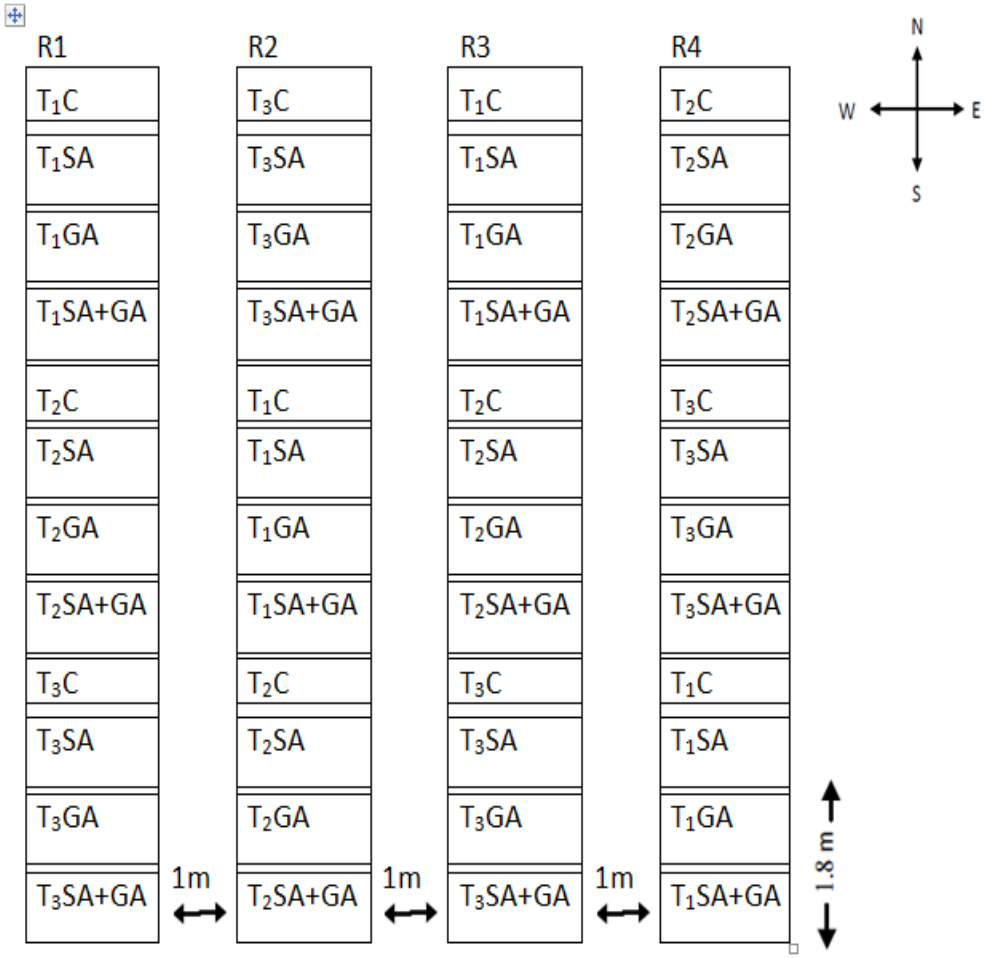
R= Replication.

C=No Hormone

SA= Salicylic Acid

GA= Gibberellic acid

SA+GA= Salicylic acid+Gibberellic acid



$T_{1=}1^{st}$ Transplanting Date
$T_{2=}2^{nd}$ Transplanting Date
$T_{3=}3^{rd}$ Transplanting Date

C= No hormone
SA= Salicylic acid
GA= Gibberellic Acid
SA+GA= Salicylic acid +Gibberellic acid

Fig. 1: Layout of the experimental plot

3.7 Experimental design and layout

The experiment was laid out in a two factor Completely Randomized Block Design (RCBD) with four replications.

3.8 Raising of seedling

Tomato seedlings were raised in two seed beds of 2m X 1m size. The soil was well prepared and converted into loose friable condition in obtaining good tilth. All weeds, stubbles and dead roots were removed. Fifteen grams of seeds were sown in each seedbed. The seedlings were transplanted in the pot on three times at December 10, December 20, December 302014.Then covered with light soil and shading was provided by bamboo mat (chatai) to protect young seedlings from scorching sunshine and rainfall. Light watering, weeding and mulching were done as and when necessary to provide seedlings with a good condition for growth.

3.9 Pot preparation

Sandy loam soil, well dried cowdung and proper amount of fertilizer were mixed as per pot recommendation and then tub was filled with that. Then tubs were placed into lab and arranged through experimental design. The pots were ready for transplanting seedling.

3. 10 Application of manure and fertilizers

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 Tub preparation. Urea was applied in three equal installments at 20, 30 and 40 days after seedling transplanting. Well-rotten cow dung 800g/pot also applied during pot preparation.

Table 1:Rate of manures and fertilizers used in the experiment

Name of the fertilizer	Amount g/pot
Urea	25g
TSP	12g
MP	2g
Cowdung	800g

3.11 Application of SA, GA and combination of SA +GA

The stock solution of 1000 ppm of GA with small amount of ethanol to dilute and then mixed in 1 litre of water turn as per requirement of 20 ppm GA. 0.3mM Salicylic acid from stock solution were mixed with 1 litre of Water and 20 ppm GA and 0.3mM Salicylic acid from stock solution were mixed with 1 litre of water. Application of hormone at 15 day interval were done at 20, 30 and 50 days after transplanting.

3.12 Transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental pot in the afternoon of 10December 2014maintaining experimental design. Each pot contains one healthy plant. Similarly second transplanting was done 10 days interval after first sowing and 3rd transplanting was done 10 days interval after second transplanting. The seedbed was watered before uprooting the seedlings from the seedbed so as to minimize damage of the roots. The seedlings were watered after transplanting.

.3.13 Intercultural operation

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

3.13.1 Irrigation

Over-head irrigation was provided with a watering cane to the pots once immediately after transplanting seedlings in every alternate day in the evening up to seedling establishment. Further irrigation was provided when needed.

3.13.2 Staking

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

3.13.3 Weeding

Weeding was done to keep the plots clean and easy aeration of soil which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully. Mulching for breaking the crust of the soil was done when needed.

3.13.4 Top dressing

After basal dose, the remaining doses of urea were used as top-dressed in 3 equal installments at 15, 30 and 45 DAT. The fertilizers were applied on both sides of plant rows and mixed well with the soil. Earthing up operation was done immediately after top-dressing with nitrogen fertilizer.

3.13.5 Control of pest and disease

Malathion57 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. During foggy weather precautionary measured against disease infection of tomato was taken by spraying DithaneM-45 fortnightly @ 2 g/L, at the early vegetative stage. Ridomil gold was also applied @ 2 g/L against blight disease of tomato.

3.14 Harvesting

Fruits were harvested at 3 day intervals during early ripe stage when they attained slightly red color. Harvesting was started from 26 February, 2015 and was continued up to 25 March, 2015.

3.15 Collection of data

Plant from each tub was selected and was tagged for the data collection. Some data were collected from sowing to harvesting with 10 days interval and some data were collected at harvesting stage. Data were collected on the following parameters:

1. Plant height (cm) at different growth stages (from 30 DAT, 40 DAT and 50 DAT.
2. No. of leaves per plant at different growth stages (from 30 DAT, 40 DAT and 50 DAT.)
3. No. of branch /plant
4. Numberof flower cluster/ plant(from50 DAT)
5. Number of flower/plant (from50 DAT.)
6. Length of fruit(cm)
7. Breadth of Fruit(cm)
8. Number. of fruits/plant

9. Individual fruit weight(g)

10. Total yield/plant

3.15.1 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 30, 40, and 50 days after transplanting to observe the growth rate.

3.15.2 Number of leaves

Number of leaves was counted from the ground level to the tip of the longest stem and mean value was calculated. Number of leaves was recorded from 30, 40 and 50 days of planting to observe the growth rate of the plants.

3.15.3 Number of branch /plant

Number of Branch was counted from the ground level to the tip of the longest stem and mean value was calculated. Number of branch was recorded from 30, 40 and 50 days of planting to observe the growth rate of the plants.

3.15.4 Number of flower clusters per plant

The number of flower clusters was counted from the sample plants 50 DAT and the average number of flower clusters produced per plant was calculated.

3.15.5 Number of flowers per plant

The number of flowers per cluster was counted 50 DAT and mean value was calculated.

3.15.6 Number of fruit in clusters per plant

The number of fruit was recorded from each plant, and the total number of fruit was produced per plant was recorded.

3.15.7 Fruit Length

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 selected marketable fruits from each plant and their average was calculated in centimeter.

3.15.8 Fruit breadth

Breadth of fruitwas measured at the middle portion of 10 selected marketable fruits from each tub with a slide calipers and their average was calculated in centimeter in gram(g).

3.15.9 Single fruit weight

The weight of fruit was measured with an electric balance from 10 selected marketable fruits from each plant and their average was calculated in gram(g).

3.15.10 Fruit yield per plant

An electric balance was used to take the weight or fruits per plant. It wasmeasured by totaling of fruit yield from each unit tub during the period from first tofinal harvest and was recorded in gram(g).

3.15.12Analysis of data

The data in respect of growth, yield contributing characters and yield were statistically analyzed to find out the statistical significance. The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C following methods and the mean differences were adjusted by Least Significance Difference (LSD) test (Gomez & Gomez, 1986).

CHAPTER IV
RESULTS AND DISCUSSION

The present experiment was carried out with a view to determine the effect of tomato to plant growth regulators and transplanting time. The results have been described and discussed under the following headings.

4.1 Plant height

It is usual that, the effects of different transplanting in relation to temperature of the environment is reflected in plant height (Table 1, Appendix III). Many previous author stated that different days of transplanting changed the height of the plant (Chen *et al* .,1999). In this experiment it was observed that in 30 days after transplanting(DAT) the maximum height was observed in 1st transplanting, 10 December which was (29.31 cm) and the lowest height was observed in 3rd transplanting,30 December which was 26.58 cm. Again in 40 DAT the maximum height 53.63 cm was recorded in 1sttransplanting,10 December and minimum height 39.31 cm was in 3rd transplanting, 30 December. In 50 DAT the maximum height (74.06 cm) was observed in 1sttransplanting,10 December and minimum was in 3rd transplanting,30 December that was (58.94cm). In this study late transplanting of tomato showed a great reduction in plant height as compared to early transplanting.

In this study, different hormone showed an effective influence over plant height. Plant hormone like salicylic acid (SA) and gibberellic acid (GA) used as a mitigating agent of like drought, cold etc. The effect of hormone was found to be significant (Table 2, Appendix III) in different transplanting date. The highest plant height 30.58 cm at 30 DAT was recorded in the combine effect of salicylic acid (SA) and gibberellic acid (GA) and the lowest height 25.68 cm at 30 DAT was in control condition. At the result, the maximum height 50.42 cm at 40 DAT was recorded in the combine effect of salicylic acid(SA) and gibberellic acid

(GA)and the lowest 42.42 cm was in control condition. At 50 DAT the highest value 70.17 cm was recorded in the application of gibberellic acid. The lowest plant height 65.00 cm at 50 DAT was in control. From this findings it is clear that the combine application of salicylic acid (SA) and Gibberellic acid(GA) increases plant height.

The result of the present study showed that interaction effect between transplanting date with different plant growth regulators showed a significant effect on incensement of plant height (Table 3, Appendix III). In 30 DAT, the maximum height 33.50 cm was obtained fromT_1GA and lowest 24.30 cm was in T_1C. In 40 DAT the maximum height 59.75was recorded fromT_3(SA+GA) which was statically similar to T_2(SA+GA).The shortest plant height 37.25 cm was obtained in T_2C. In 50 DAT the highest plant height 75.25 cm was in T_2(SA+GA) which was statistically similar to T_1GA and T_1(SA+GA). The lowest 55.50 cm was in T_1C.

Table.1. Effect of transplanting time of Plant height of tomato at different days after transplanting.

Transplanting Time	Plant height(cm)		
	30 DAT	**40 DAT**	**50 DAT**
T_1	29.31 a	53.63 a	74.06a
T_2	28.94 a	47.06 b	69.69 b
T_3	26.58 b	39.31 c	58.94 c
$LSD_{(0.05)}$	2.105	2.716	3.717
Significant level	**	**	**
CV%	8.62	8.12	7 .67

$T_{1=}$First transplanting, 10 December 2014,

$T_{2=}$ Second transplanting 20 December 2014

T_3 = Third transplanting 30 December 2014

LSD= Least significance difference

CV= Co-efficient of variance

** =Significant at 1%level

Table.2. Effect of salicylic acid (SA) and gibberellic acid (GA) on plant height of tomato at different days after transplanting.

Plant growth regulators	Plant height(cm)		
	30 DAT	40 DAT	50 DAT
Control	25.68 c	42.42 b	65.00 b
SA	27.44 bc	43.75 b	66.00 ab
GA	29.40 ab	50.08 a	70.17 a
S+G	30.58 a	50.42 a	69.08 ab
$LSD_{(0.05)}$	2.43	3.14	4.292
Significant level	**	**	*
CV%	8.62	8.12	7.67

C= Control= No plant growth regulators

SA= Salicylic acid(o.3mM)

GA= Gibberellic acid(20 ppm)

SA+GA= Combination of Salicylic acid (0.3mM) and Gibberellic acid (20 ppm)

LSD= Least significance difference

CV= Co-efficient of variance

* = Significant at 5% level

** =Significant at 1%level

NS= Non significant

Table.3. Combined effect of transplanting time, salicylic acid (SA) and gibberellic acid (GA) on plant height of tomato at different days of transplanting

Treatment Combination	Plant height(cm)		
	30 DAT	**40 DAT**	**50 DAT**
T_1C	24.30 c	39.25 ef	55.5 e
T_1SA	28.00 bc	39.50ef	61.25 de
T_1GA	30.00 ab	50.50 b	73.25 a
T_1(SA+GA)	29.50 ab	49.25 bc	74.75 a
T_2C	26.08 bc	37.75 f	57.00 de
T_2SA	25.50 bc	41.50 def	69.50 abc
T_2GA	33.50 a	52.00 b	71.75ab
T_2(SA+GA)	30.25 ab	59.00 a	75.25 a
T_3C	27.95 bc	40.7def	62.00 cde
T_3S	26.75 bc	44.25 cde	64.25 bcd
T_3G	27.25 bc	46.50bcd	73.00 a
T_3(SA+GA)	30.25 ab	59.75 a	73.25 a
$LSD_{(0.05)}$	4.21	5.43	7.43
Significant level	NS	*	*
CV %	4.62	8.12	5.67

$T_{1=}$First transplanting , 10 December 2014

$T_{2=}$ Second transplanting ,20 December 2014

T_3 = Third transplanting, 30 December 2014

LSD= Least significance difference

CV= Co-efficient of variance

.* = Significant at 5% level

** =Significant at 1%level

C= No hormone

SA= Salicylic acid(o.3mM)

GA= Gibberellic acid (20 ppm)

SA+GA= Combination of Salicylic acid (o.3mM) and Gibberellic acid (20 ppm)

NS=Non significant.

4.2 Number of leaves per plant

The leaf number is a fundamental morphological character for plant growth and development as leaf number is the main photosynthetic organ. To investigate the effect of different days of transplanting of tomato on change in the number of leaves per plant up to 50 DAT were counted. Different days of transplanting showed a significant influenced on the formation of leaves per plant (Table 4, Appendix III). In 30 DAT the maximum number of leaves/plant 8.44 was found in 2nd transplanting, 20 December and lowest 7.06 was in 3rd transplanting,30 December. In 40 DAT the maximum number of leaves/ plant 13.88 was found in 1st transplanting, 10 December and lowest 10.69 was recorded was recorded in 3rd transplanting,30 December. In 50 DAT the maximum number of leaves/ plant was observed in 1st transplanting,10 December and the lowest 17.13 was in 3rd transplanting. Therefore, the presented results are consistent with many other previous publication.

Application of different plant hormone showed an influence on leaves/plant. In 30 DAT the maximum 7.92 leaves/plant was observed in the application of gibberellic acid (GA) and the lowest 6.33 was found in control condition. In 40 DAT the highest leaves/plant was observed in the application of gibberellic acid (GA) which was statistically similar to salicylic acid (SA) and combined application. In 50 DAT the highest value 20.17 was obtained from the combined application of gibberellic acid(GA) and salicylic acid which was statistically similar to salicylic acid and gibberellic acid. The lowest(16.75) was in control.

There were significant interaction effects between transplanting date and different plant hormone (Table 4,Appendix III). At 30 DAT the highest 9.00 leaves/plant was observed from the treatment combination of T_3SA. The lowest 6.50 leaves/plant at 30 DAT was in T_1SA.

Table.4. Effectof transplanting time on of leaves/plant on tomato at different days after transplanting

Transplanting Time	Leaves/plant		
	30 DAT	40 DAT	50 DAT
T_1	7.25 b	13.88 a	20.81 a
T_2	8.44 a	12.50 b	18.19 b
T_3	7.06 b	10.69 c	17.13 b
$LSD_{(0.05)}$	0.53	1.04	1.476
Significant level	**	**	*
CV%	9.83	11.71	10.93

$T_{1=}$ First transplanting, 10 December, 2014,

$T_{2=}$ Second transplanting, 20 December, 2014

T_3= Third transplanting, 30 December, 2014

LSD= Least significance difference

CV= Co-efficient of variance

.* = Significant at 5% level

** =Significant at 1%level

Table.5. Effect of salicylic acid (SA) and gibberellic acid (GA) on leaves/plant of tomato at different days of transplanting

Plant growth regulators	Leaves/plant		
	30 DAT	**40 DAT**	**50 DAT**
Control	6.33 b	10.67 ab	16.75 b
SA	7.83 a	12.67 a	18.67 a
GA	7.92 a	12.83 a	19.25 a
SA+GA	7.25 b	12.25 a	20.17 a
$LSD_{(0.05)}$	0.62	1.20	1.69
Significant level	*	*	**
CV%	9.83	5.71	6.93

C= Control= No hormone

SA= Salicylic acid(o.3mM)

GA= Gibberellic acid (20 ppm)

SA+GA= Combination of Salicylic acid (o.3mM) and Gibberellic acid (20 ppm)

LSD= Least significance difference

CV= Co-efficient of variance

* = Significant at 5% level

** =Significant at 1%level

Table.6. Combined effect of transplanting time and plant hormone on leaves/plant of tomato at different days of transplanting

Treatment combination	Leaves/plant		
	30 DAT	40 DAT	50 DAT
T_1C	7.00 cd	10.50 ef	17.25 cd
T_1SA	6.50 d	9.75 f	21.75 ab
T_1GA	8.25ab	13.00 abcd	22.75a
T_1(SA+GA)	7.00 cd	15.00 a	16.75 cd
T_2C	7.50bcd	11.00 def	21.50 ab
T_2SA	8.00abc	11.75 cdef	17.75 cd
T_2GA	8.50ab	12.75 abcde	19.25 bc
T_2(SA+GA)	7.50bcd	13.50 abc	17.00 cd
T_3C	8.00abc	11.50 cdef	15.25 d
T_3SA	9.00a	12.50 bcde	17.75 cd
T_3GA	7.00cd	12.75 abcde	18.00 c d
T_3(SA+GA)	6.75 d	14.25 ab	19.50 bc
LSD	1.07	2.06	2.932
Significant $level_{(0.05)}$	NS	NS	*
CV%	9.83	5.71	6.93

$T_{1=}$ First transplanting , 10 December, 2014

$T_{2=}$ Second transplanting ,20 December, 2014

T_3 = Third transplanting, 30 December, 2014

LSD= Least significance difference

CV= Co-efficient of variance
.* = Significant at 5% level
NS= Non significant

C= No plant growth regulators
SA= Salicylic acid(o.3mM)

GA= Gibberellic acid (20 ppm)

SA+GA= Combination of Salicylic acid (o.3mM) and Gibbrellic acid (20 ppm)

In 40 DAT the highest no of leaves/plant (15.00) was found in the treatment of T_1(SA+GA) where as the lowest 9.750 was in T_1SA.

In 50 DAT the maximum number of leaves/plant 22.75 was recorded in the treatment combination of T_1GA otherwise the lowest 15.25 was in T_1C. So we can suggest that gibberellic acid has a great influence as the formation of leaf content of tomato.

4.3 Number of branches per plant

Branches/plant of tomato were significantly influenced by transplanting date (Table 7 Appendix IV). In this study, 50 DAT data were taken. In 50 DAT the highest branch/ plant 2.50was recorded in 2nd transplanting where as the lowest 1.94 was in 3rd transplanting.

Application of different plant growth regulators showed an effect on branch/plant on tomato plant (Table 8, Appendix IV). In 50 DAT the maximum noof branch/plant 2.33was recorded in the application of gibberellic acid and the lowest 2.08 was in control.

There were significant interaction between transplanting date and plant growth regulators on branch/plant of tomato (Table 9, Appendix IV). The highest number of branch/plant (3.00) was found in the treatment of T $_1$GA where as the lowest (1.71) was in T_3C treatment.

4.4 Number of flower cluster per plant

The flower cluster/plant of tomato is also influenced by different transplanting ((Table 7, Appendix IV). In this experiment, at50 DAT cluster/plant data were taken. In 50 DAT the highest flower cluster/plant 5.38was found in 1st transplanting time(10 December). The lowest cluster/plant 2.65 was recorded in 3rd transplanting, 30 December. So, it is indicating that transplanting time/temperature has a influence over cluster number.

Plant hormone showed a significant effect on flower cluster/plant of tomato (table 8 appendix IV). In 50 DAT the highest cluster/plant (4.00) was recorded in the application with gibberellic acid which was similar to the application with salicylic acid(SA) and gibberellic acid(GA). The lowest cluster/plant (3.17) was found in control.

There were significant interaction between the combination of transplanting date with plant growth regulators (Table 9, Appendix IV). The highest cluster number (6.00) was recorded in both T_1GA and T_2GA which were statistically similar to T_3GA. The lowest cluster/plant was observed in T_1C and T_2C. So we can say the Gibberellic acid(GA) has a great effect on flower cluster/plant of tomato.

Table: 7. Effect of transplanting time on no branch/plant and flower cluster/plant of tomato at 50 days after transplanting.

Transplanting Time	Branch/plant	Flower cluster/plant
	50 DAT	**50 DAT**
T_1	2.19 b	5.38 a
T_2	2.50a	2.81 b
T_3	1.94 b	2.65 b
$LSD_{(0.05)}$	0.29	0.52
Significant level	**	**
CV %	8.29	4.01

$T_{1=}$First transplanting 10, December 2014,

$T_{2=}$ Second transplanting 20, December 2014

T_3 =Third transplanting 30, December 2014

LSD= Least significance difference

CV= Co-efficient of variance.

* = Significant at 5% level

** =Significant at 1%level

NS= Non significant

Table.8. Effect of salicylic acid (SA) and gibberellic acid (GA) on branch/plant, and cluster/plant of tomato at 50 days after transplanting

Hormone	No. of Branch	No. of flower Cluster
	50 DAT	**50 DAT**
Control	2.08 a	3.17 b
SA	2.17 a	3.44ab
GA	2.08 a	4.00a
SA+GA	2.25 a	3.83a
$LSD_{(0.05)}$	0.33	0.60
Significant level	NS	*
CV %	8.29	7.01

C= Control= No plant growth regulators.

SA= Salicylic acid(o.3mM)

GA= Gibberellic acid (20 ppm)

SA+GA= Combination of Salicylic acid(o.3mM) and Gibberellic acid (20 ppm)

LSD= Least significance difference

CV= Co-efficient of variance

* = Significant at 5% level

** =Significant at 1%level

NS= Non significant

Table.9. Combined effect of transplanting time, SA and GA on branch/plant and flower cluster/plant of tomato at 50 days after transplanting

Treatment Combination	Branch/plant	Flower cluster/plant
	50 DAT	50 DAT
T_1C	2.00bc	2.50 c
T_1SA	2.50ab	2.75c
T_1GA	3.00 a	6.00a
$T_1(SA+GA)$	2.00bc	2.33 c
T_2C	2.25bc	2.50 c
T_2SA	2.50 ab	4.00b
T_2GA	2.75ab	6.00a
T_2 (SA+GA)	2.00bc	2.50c
T_3C	1.72c	3.50bc
T_3SA	2.25bc	3.00bc
T_3GA	2.50bc	5.50 a
$T_3(SA+GA)$	2.00bc	2.75 c
$LSD_{(0.05)}$	0.5790	1.036
Significant level	*	**
CV%	8.29	8.01

$T_{1=}$ First transplanting , 10 December 2014
$T_{2=}$ Second transplanting ,20 December 2014
T_3 = Third transplanting, 30 December 2014
LSD= Least significance difference

CV= Co-efficient of variance
.* = Significant at 5% level
** =Significant at 1%level

C= No plant growth regulators
SA= Salicylic acid(o.3mM)
GA= Gibberellic acid (20 ppm)

SA+GA= Combination of Salicylic acid (o.3mM) and Gibberellic acid (20 ppm)
SA= Salicylic acid(o.3mM)

4.5 Number of flowers /plant

Planting time had significant effect on number of flowers/plant of tomato (Table 10, Appendix IV). The highest number of flowers/plant observed from the second transplanting (T_1) was (9.75) and the lowest number of flowers/plant observed from third transplanting(T_3) was (6.38).From this result it was found that the early transplanted tomato seedlings produce the maximum number of flowers/plant than the late transplanting.

Graphically significant variation was observed for the number of flower plants^{-1} of tomato for different combination of hormone (Figure 1,Appendix IV).

The highest flower/plant (11.33)at 50 DAT was recorded at the together application of salicylic acid(SA) and Gibberellic acid(GA). The lowest number of flower/plant (6.5) was recorded in the control. So, we can assume from this study the combine application of salicylic acid (SA) and gibberellic acid (GA) gives the higher number of flowers/plant.

Interaction effect of transplanting effect and different combination of hormone showed an effective results on flowers/plant (Table 11, Appendix IV). The highest number of flowers/plant (14.50) was recorded in the treatment combination of T_1(SA+GA)and the lowest (5.25) was recorded from the treatment of T_3C. So it can be suggested that early transplanting at T_1 increase the flower number and late transplanting at T_3 time due to temperature condition.

Table.10. Effect of different transplanting date on flowers/plant of tomato at 50 days after transplanting.

Transplanting Time	Flowers/plant
	50 DAT
T_1	9.50 a
T_2	9.00 a
T_3	6.38 b
Significant label	*
LSD	1.71
CV	7.5

.

$T_{1=}$First transplanting, 10 December 2014

$T_{2=}$ Second transplanting, 20 December2014

T_3= Third transplanting, 30 December 2014

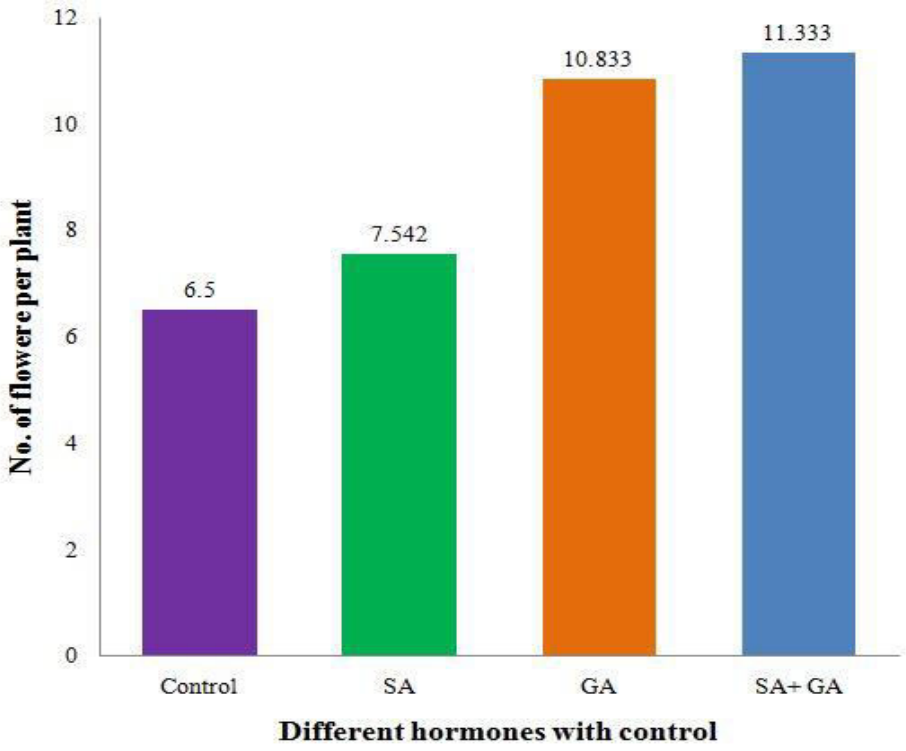
LSD= Least significance difference

CV= Co-efficient of variance

.* = Significant at 5% level

** =Significant at 1%level

NS= Non significant



Control= No plant growth regulators.

SA= Salicylic acid(o.3mM)

GA= Gibberellic acid (20 ppm)

SA+GA= Combination of Salicylic acid (0.3mM) and Gibberellic acid (20 ppm)

Fig. 1:Effect of plant hormone on number of flower / plant at 50 DAT, LSD $_{0.05}$=1.06

Table.11.Combined effect of transplanting time, salicylic acid (SA) and gibberellic acid (GA) on number of flower/plant of tomato at 50 days after transplanting

Treatment Combination	Flower Number
	50 DAT
T_1C	7.25cde
T_1SA	7.25cde
T_1GA	12.75 b
$T_1(SA+GA)$	14.50 a
T_2C	5.75 ef
T_2SA	6.50 def
T_2GA	12.50 b
$T_2(SA+GA)$	13.50ab
T_3C	5.25 f
T_3SA	8.00cd
T_3GA	8.62 c
$T_3(SA+GA)$	11 .50b
LSD	1.743
Significant level	*
CV %	9.10

$T_{1=}$Frist transplanting , 10 December 2014
$T_{2=}$ Second transplanting 20 December 2014
T_3 = Third transplanting, 30 December 2014
LSD= Least significance difference

C= No plant growth regulators.
SA= Salicylic acid(o.3mM)
GA= Gibberellic acid (20 ppm)
SA+GA= Combination of Salicylic acid (0.3mM) and Gibberellic acid (20 ppm)

CV= Co-efficient of variance
.* = Significant at 5% level
** =Significant at 1%level

4.6 Fruit length

As consistent to fruit diameter transplanting time had significant influenced on fruit length(cm) of tomato (Table 12, Appendix V). The highest fruit length 4.34 cm was observed from the 1st transplanting (10 December) which was statistically similar to 2nd transplanting (4.313 cm). The lowest fruit length 3.62 cm was recorded in 3rd transplanting. Different plant hormone showed a great effect on fruit length of tomato (Table 12, Appendix V). The highest fruit length(cm) of tomato 4.31 cm was observed in the together application of salicylic acid(SA) gibberellic acid (GA) which was statistically similar to the application of gibberellic acid(GA). The lowest 3.75 was found in control condition.

Interaction between transplanting date and different combination of hormone showed significant variation in fruit length of tomato. The highest fruit length 4.55 cm was found from the T_1G. The lowest (3.135 cm) was recorded in the treatment combination ofT_3C. So we can say from the above result transplanting date with hormone has a great significance on fruit breadth of tomato.

4.7. Fruit breadth

Fruit breadth has a great contribution on the fruit weight and the fruit yield of tomato. Transplanting time has a great impact on the fruit breadth(cm) of tomato (Table 12, Appendix V). The highest fruit breadth3.72 cm was found in 1st transplanting, 10 December w and the lowest fruit breadth3.44 cm was recorded at 3rd transplanting,30 December. So from this experiment it is proved that early transplanting fruits breadth is higher than the late transplanting.

Plant growth regulators individually showed a great significance on fruit breadth (Table 13, Appendix V).The highest fruit breadth3.63cm was observed in the together application of (SA+GA) which was statistically similar to salicylic acid (3.554 cm) and gibberellic acid 3.527 cm. The lowest fruit breadth (3.20 cm) was recorded in control.

Table. 12. Main effect of plant transplanting time on fruit length, fruit breadth, fruit number, individual fruit weight and total fruit wt. of tomato

Transplanting Time	Fruit Length (cm)	Fruit Breadth (cm)	Fruit Number	Individual Fruit (Wt.)	Total Fruit Weight(g)
T_1	4.34 a	3.72 a	15.13 a	34.64 a	450.6 a
T_2	4.31 a	3.50 ab	11.13 b	30.00 b	376.3 b
T_3	3.62 b	3.44 b	7.93 c	25.95 c	218.6 c
LSD	0.46	0.25	1.226	2.62	29.50
Significant level	*	*	**	**	*
CV %	6.14	9.74	9.00	12.14	11.6

$T_{1=}$First transplanting, 10 December 2014

$T_{2=}$ Second transplanting, 20 December 2014

T_3= Third transplanting, 30 December 2014

LSD= Least significance difference

CV= Co-efficient of variance

.* = Significant at 5% level

** =Significant at 1%level

NS= Non significant

Table. 13. Effect of plant SA and GA on fruit length, fruit breadth, fruit number, individual fruit weight and total fruit wt. of tomato.

Plant growth regulators	Fruit Length (cm	Fruit Breadth (cm)	Fruit Number	Individual Fruit (Wt.)	Total Fruit (Weight (g)
Control	3.75 b	3.20 ab	11.25 b	28.35 b	324.1 ab
SA	4.02ab	3.57 a	10.17 b	29.34 b	333.5 b
GA	4.203 a	3.55 a	13.08 a	29.95 ab	358.9 ab
SA+GA	4.305 a	3.63 a	11.08 b	32.65 b	377.4 a
LSD	0.527	0.288	1.416	3.024	33.48
Significant level	*	*	**	**	**
CV %	7.14	9.74	8.00	10.14	11.6

Control= No plant growth regulators.

SA= Salicylic acid(o.3mM)

GA= Gibberellic acid (20 ppm)

SA+GA= Combination of Salicylic acid (o.3mM) and Gibberellic acid (20 ppm)

LSD= Least significance difference

CV= Co-efficient of variance

* = Significant at 5% level

** =Significant at 1%level

NS= Non significant

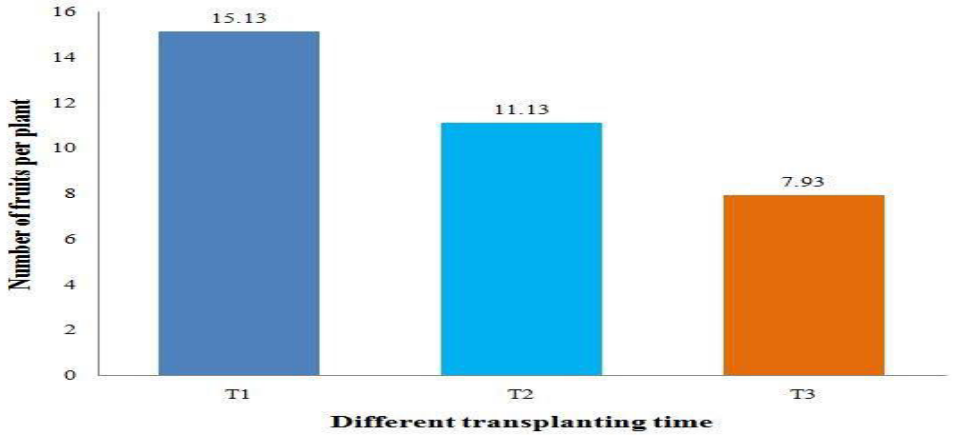
Transplanting date and hormone together had a great interaction over fruit breadth (Table 14, Appendix V). The highest fruit breadth 3.86 cm was recorded in T_1(SA+GA) The lowest fruit breadth (3.00 cm) was found in the treatment combination of T_3C.

4.8. Number of fruits per plant

Number of fruits/plant of tomato showed significant differences in response to transplanting date (figure 2, appendix V) The highest fruits/plant(15.13) was observed from the first transplanting (T_1) the lowest (7.93) was observed in third transplanting (T_3). So from this result we can say that the early transplanting of tomato seedlings give more fruit than the late transplanting due to high temperature (BARI 1989). For this reason it can be easily said that environmental condition regulate the number of fruits/plant.

Stastically significant variation was recorded for fruits/plant of tomato after the application of gibberellic acid (figure 3, appendix V). The maximum number of fruit/plant (13.08) was recorded in the application on gibberellic acid and the lowest (10.17) was in control. From this result it is said that the gibberellic acid increase the number of fruits/ plant.

Interaction between the transplanting date and hormone has a great effect on flowers/plant in tomato (table 17, appendix V). The highest fruit number (19.2) was found in the treatment combination of T_2G and the lowest(7.00) was in T_1C and T_1SA. So from this result it is found that the gibberellic acid has a great combination of the fruits/plant.

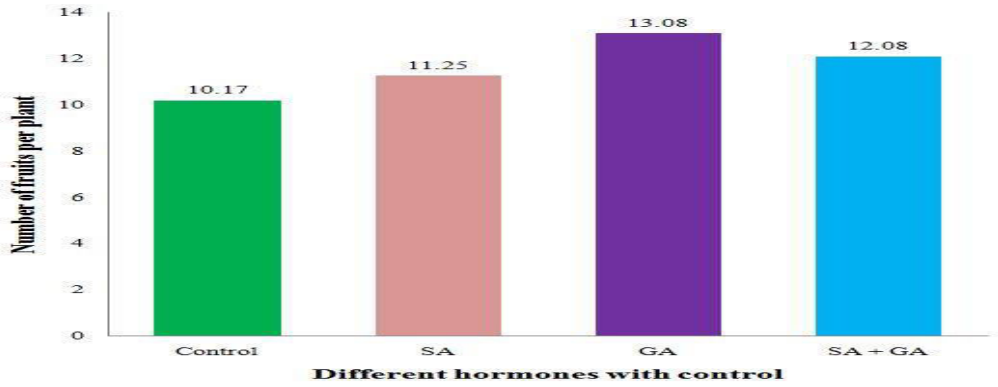


$T_{1=}$Frist transplanting ,10 December 2014,

$T_{2=}$ Second transplanting ,20 December 2014

T_3 = Third transplanting, 30December 2014

Fig.2 Effect of transplanting time on fruit/plant of tomato LSD $_{0.05}$= 1.22



Control= No hormone, SA= Salicylic acid(0.3mM), GA= Gibberellic acid (20 ppm) SA+GA= Combination of Salicylic acid (0.3mM) and Gibberellic acid (20 ppm)

Fig.3 :Effect of SA and GA on fruit/plant of tomato, LSD $_{0.05}$= 1.41

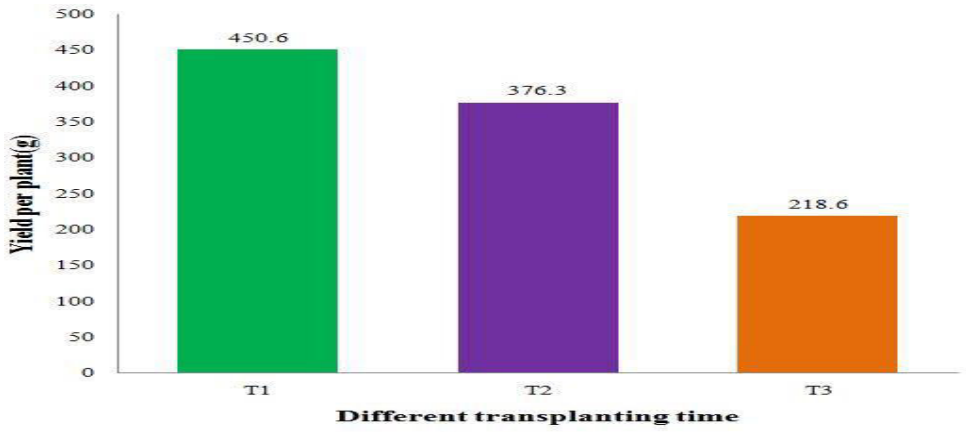
Table.14. Combined effect of transplanting date, salicylic acid (SA)and gibberellic acid (GA) on fruit length, fruit breadth, fruit number, individual fruit weight and total fruit wt. of tomato.

Treatment combinations	Fruit length (cm)	Fruit breadth ((cm)	Fruit number	Individual fruit wt.(g)	Fruit w/plant (g)
T_1C	3.24 c	3.06 c	8.00 f	25.58 f	201.44 d
T_1SA	3.78 b	3.42 b	10.25 de	31.75 bc	325.44 c
T_1GA	4.55 a	3.65 ab	16.750 a	28.07 de	446.50 ab
T_1(SA+GA)	4.37 ab	3.86 a	14.00 b	36.00 a	494.00 a
T_2C	3.29 c	3.13 c	7.00 f	25.09 f	196.00 d
T_2SA	4.35 a	3.66 ab	12.75 c	27.98 de	320.00 c
T_2GA	4.10 ab	3.50 b	14.25 b	30.00 c	435.50**b**
T_2(SA+GA)	4.42 a	3.78 a	14.00 b	35.10 ab	482.04ab
T_3C	3.14 c	3.00 c	7.50 ef	24.54 f	156.00 de
T_3SA	4.35 ab	3.42 b	12.50 cd	26.02 e	331.76c
T_3GA	3.99 a	3.45 ab	13.0 c	32. 0 bc	412.43 b
T_3(SA+GA)	4.52 a	3.70 a	13.75 b	32.80 bc	438.36ab
LSD	0.912	0.498	2.452	5.237	58.00
Significant level	*	*	**	**	**
CV %	8.14	9.74	7.00	10.14	11.6

$T_{1=}$ First transplanting , 10, December 2014
$T_{2=}$ Second transplanting,20, December 2014
T_3 = Third transplanting, 30, December 2014
LSD= Least significance difference

CV= Co-efficient of variance
* = Significant at 5% level
** =Significant at 1%level

C= No hormone
SA= Salicylic acid(o.3mM)
GA= Gibberellic acid (20 ppm)
SA+GA= Combination of Salicylic acid (o.3mM) and Gibberellic acid (20 ppm)

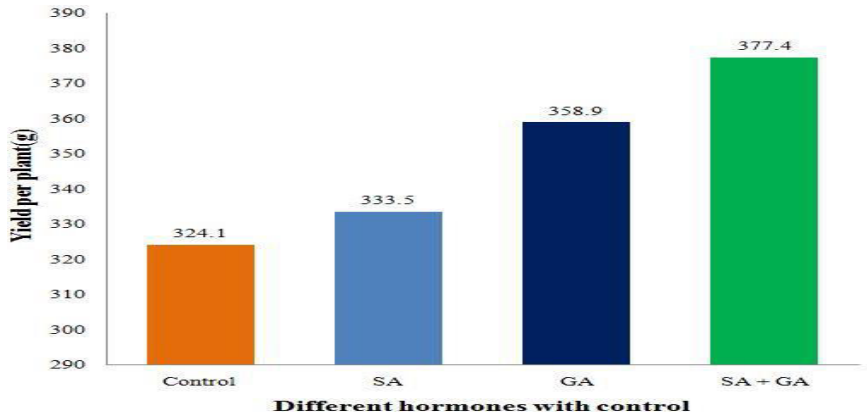


$T_{1=}$First transplanting, 10 December, 2014

$T_{2=}$ Second transplanting, 20 December 2014

T_3 =Third transplanting, 30 December 2014

Fig. 4:Main Effect of Transplanting time on total yield /plant of tomato LSD $_{0.05}$= 29.50



Control= No hormone, SA= Salicylic acid(o.3mM), GA= Gibberellic acid (20 ppm) SA+GA= Combination of Salicylic acid (0.3mM) and Gibberellic acid (20 ppm

Fig. 5: Main Effect of SA and GA on total yield /plant of tomato, LSD $_{0.05}$= 33.48

4.9. Individual fruit weight (g)

Individual fruit weight of tomato is highly influenced by different transplanting date (Table 12, Appendix V). The highest number of fruit weight 34.64 gmwas obtained from the first transplanting (T_1) and the lowest 25.95 gmwas obtained from third transplanting ($T_{3)}$

Plant growth regulators also had a impact over individual fruit weight. The highest fruit weight 32.65 gm was obtained from the together application of salicylic acid (SA) and gibberellic acid (GA). The lowest 28.35 was in control.

The interaction between the transplanting date and plant growth regulators showed a effective result over individual fruit weight of tomato. The highest individual fruit weight 36.00 gm was obtained from the treatment combination of T_1(SA+GA). The lowest was recorded in the treatment combination of T_3C.

4.10. Fruit weight plant^{-1}(g)/ yield per plant

Transplanting date imposed significant differences in respect to yield per plant. (Table 12, Appendix V). The highest fruit weight/plant 450.6 g was recorded from First transplanting (T_1) and the lowest 218.6 cm was recorded in third transplanting (T_3).

Plant growth regulators also showed a effect on fruit weight/plant or yield. The highest fruit weight/plant 377.4 g was obtained from the together application of salicylic acid (SA) and gibberellic acid (GA)where as the lowest 324.1o g was in control.

Different days of transplanting and plant growth regulators together showed a significant contribution on yield of tomato. The highest yield 494.00g/plant was obtained from the treatment combination of T_1(SA+GA) where as the lower 156.00 g/plant was recorded in T_3C.

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2014 to March 2015 to evaluate the morphological change and yield of Tomato under different Transplanting date and plant hormone. In this experiment, the treatments consist of three different time of transplanting T_1=First transplanting date, 10 December 2014, T_2= Second transplanting date, 20 December 2014, T_3= Third transplanting date, 30 December 2014 and different concentration of salicylic acid (SA)= 0.3mM, gibberellic acid (GA)= 20 ppm and combination of salicylic acid 0.3mM+gibberellic acid 20 ppm. The experiment was laid out in two factors Randomized Complete Block Design(RCBD) with four replications.

There was significant difference among the different time of transplanting in respect of all parameters. The tallest plant height (74.06 cm) was obtained from T_1= First transplanting. The maximum leaves/plant (20.81) was obtained from T_1=First transplanting, In case of lowest plant height, leaves/plant, branch/plant was low in third transplanting (T_3). The maximum number of flower and fruits plant^{-1}9.50 and 15.13 respectively was obtained from first transplanting. The higher fruit length and breadth 4.34 cm and 3.72 cm was obtained from first transplanting ($T_{1)}$. The maximum yield 494.00 gm was obtained from first transplanting.

Plant height of tomato showed significant difference in response of exogenous foliar application of Salicylic acid (SA) and gibberellic acid (GA). The tallest plant height (70.17 cm) was obtained from the application of gibberellic acid. The highest leaves plant^{-1} and branch plant^{-1} 20.17 and 2.25 was obtained from the together application of salicylic acid (SA) and gibberellic acid (GA). The maximum number of flower plant^{-1} was recorded in the together application of

Salicylic acid (SA) and gibberellic acid (GA). The maximum number of fruit plant^{-1}(13.08) was obtained from the application of salicylic acid (SA) and gibberellic acid (GA) combinedly and the highest yield/plant (494.00 g) was recorded in there also.

The combination of time of days of transplanting and salicylic acid (SA) along with gibberellic acid had significant effect in almost all growth and yield contributing parameters. The tallest plant height (75.25 cm) was obtained from the treatment combination of T_2(SA+GA) and lowest was in the combination of T_1C.The result showed significant differences on the number of leaves plant^{-1} And number of branch plant^{-1} which was respectively (22.75) and (3.00) was found from the treatment combination of T_1GA. The number of flower cluster plant^{-1} (T_2GA) and(T_1GA.) The highest flower number plant^{-1}
The highest fruit length 4.55 cm was recorded in the treatment combination of T_1GA. The highest fruit breadth 3.86 cm was obtained from the treatment combination of T_1(SA+GA). The highest fruit number plant^{-1} (19.2) was recorded in the combination of T_2GA. The interaction between transplanting date and plant growth regulators showed maximum highest individual fruit weight (36.00 g) was recorded in T_1(SA+GA). The highest yield plant^{-1} was in the treatment combination of T_1(SA+GA).

Considering the situation of the present study, further studies in the following areas may be suggested.

1. Such study is needed in different agro ecological zones (AEZ) of Bangladesh for analogy the accuracy of the experiment.

2. It needs to conduct more experiments with transplanting time and salicylic acid (SA) and gibberellic acid (GA) to find out whether these can regulate the morpho-physiology and yield of tomato var. BARI Tomato 14.

3. It needs to conduct related experiments with other varieties of tomato.

3. Scope to advance experiments how, transplanting time and salicylic acid and gibberellic acid physiologically increase yield.

Recommendation:

1st transplanting with GA+SA is found to be the best transplanting date and hormonal effect for tomato cultivation in the greater Dhaka region. However, further studies are needed to fine out the optimum sowing date and hormone for the production of tomato under different Agro-ecological Zones of Bangladesh.

CHAPTER VI
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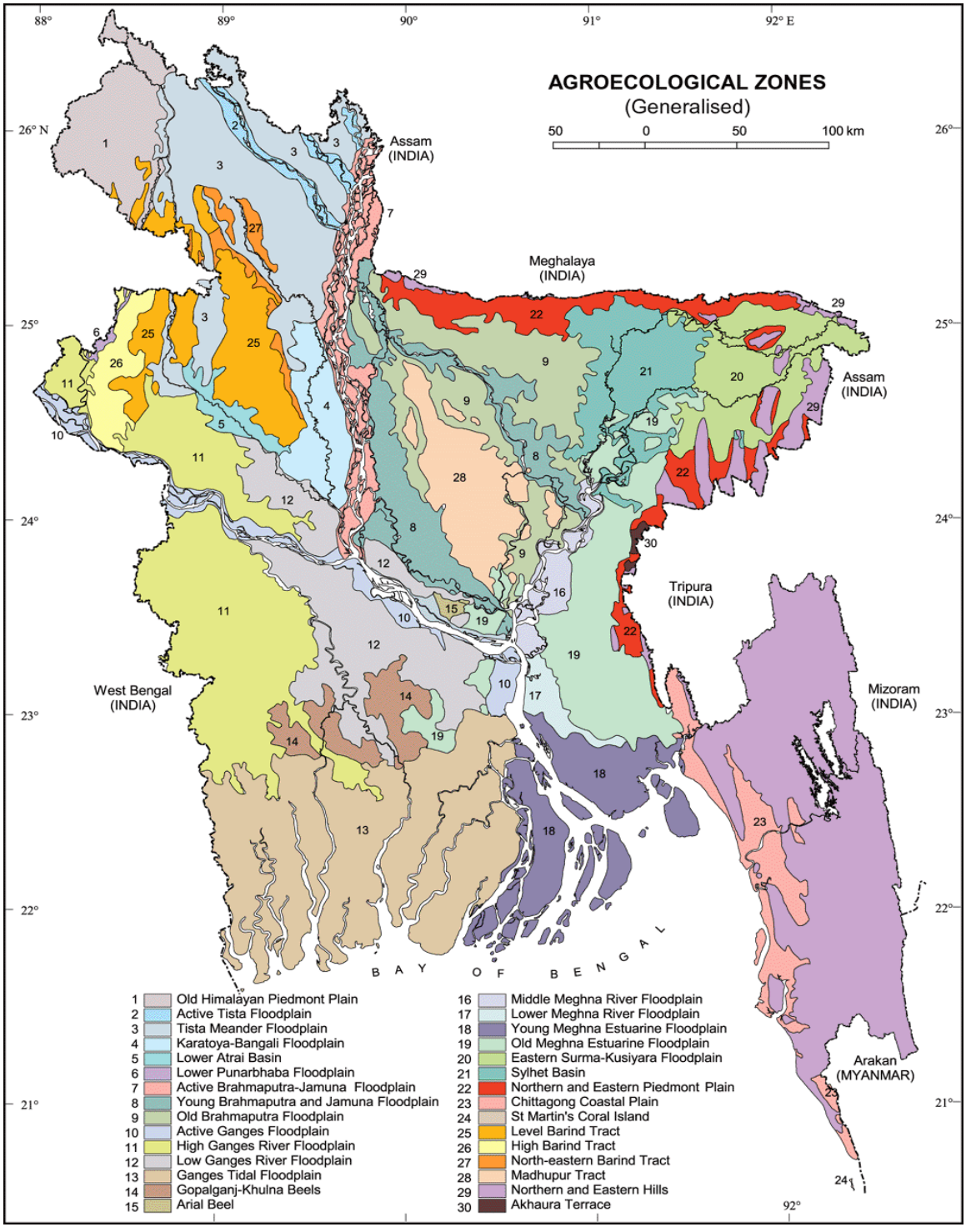
APPENDICES

Appendix I: Experimental location on the map of agro-ecological zones of Bangladesh



Appendix II: **Soil characteristics of Sher-e-Bangla Agricultural University Farm, Dhakaare analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.**

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	**N/A**

Source: Soil Resources Development Institute(SRDI)

B. Physical and Chemical properties of the Initial soil

Characteristics	Value
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
Ph	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: Soil Resources Development Institute (SRDI)

Appendix-III: Analysis of variance of data on plant height, Number of leaves of tomato influenced by different transplanting time and hormone

Source	DF	Mean square					
		Plant Height			Number of Leaves		
		30 DAT	40 DAT	50 DAT	30 DAT	40 DAT	50 DAT
Transplanting time (A)	2	35.07**	821.27**	969.25**	8.89**	40.89**	57.64**
Hormone (B)	3	56.02**	209.22**	72.41*	1.38*	3.24*	25.02**
Interaction (AB)	6	7.95ns	39.32*	16.80*	0.701ns	1.95ns	6.59*
Error	36	5.93	14.34	26.86	0.556	2.09	4.18

** = 1% level of significance, * = 5% level of significance, NS = Not significance

Appendix-IV: Analysis of variance of data on Number of brunches, Number of clusters and no of flowers of tomato influenced by different transplanting time and hormone

Source	DF	Mean square		
		Number of Branches	Number of Clusters	Flower Number
		50 DAT	50 DAT	50 DAT
Transplanting time	2	1.27**	37.45**	821.27**
Hormone (B)	3	0.139*	1.70*	209.22*
Interaction (AB)	6	0.326*	1.55**	39.32**
Error	36	0.163	0.52	14.34

** = 1% level of significance, * = 5% level of significance, NS = Not significance

Appendix-V: Analysis of variance of data on Fruit length, fruit breadth, and fruit number, Total fruit weight, Individual fruit weight, and brix of tomato influenced by different transplanting time and hormone

Source	DF	Mean square				
		Fruit Length	**Fruit Breath**	**Fruit Number**	**Total Fruit Wt.**	**Individual Fruit wt.**
Transplanting time (A)	2	0.714*	0.332*	207.52**	224635.72**	401.00**
Hormone (B)	3	0.088*	0.024*	17.91**	7068.00**	40.69**
Interaction (AB)	6	0.169*	0.192*	19.82**	21151.26**	126.89**
Error	36	0.405	0.121	2.92	1635.44	13.33

** = 1% level of significance, * = 5% level of significance, NS = Not significance

Appendix VI.(A) Records of meteorological information (monthly) during the period from November 2014 to March 2015

Name of the month	Temperature			% Humidity	Day length	
	Max Tem(®C)	Min Tem(®C)	Average tem (®C)		Shortest Day	Longest Day
November	23	14	31	81	10’47’’	12’17’’
December	26	13	31	87	10’32	10.59’’
January	27	12	18	84	10’37	11’6’’
February	27	12	18	82	11’6’’	11’29’’
March	33	20	27	66	12’8’’	12’20’’

Source: Bangladesh Meteorological Department (Climate and weather division) Agargaon, Dhaka