EFFECT OF GENEMAX ON GROWTH, YIELD AND QUALITY ATTRIBUTES OF TOMATO (*Lycopersicon esculentum* Mill)

BY
MD. SHIRAJUL ISLAM MOLLAH
Registration No. –27597/00746

A Thesis

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Approved by:

(Dr. Satya Ranjan Saha)
Senior Scientific Officer
Plant Physiology Section, HRC
BARI, Joydebpur, Gazipur
Supervisor

(Md. Hasanuzzaman Akand)
Associate Professor
Department of Horticulture and Postharvest Technology
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Co-supervisor

Prof. Md. Ruhul Amin
Chairman
Examination Committee

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Certificate

This is to certify that thesis entitled, " **Effect of Genemax on growth, yield and quality attributes of tomato (*Lycopersicon esculentum* Mill)**" Submitted to the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of bonafide research work carried out by **MD. SHIRAJUL ISLAM MOLLAH** Registration No. 27597/00746 under my supervision and guidance. No part of the t hesis has been submitted for any other degree or diploma.

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

Dated: June 2008

Places:Joydebpur, Gazipur

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Dr. Satya Ranjan Saha
Senior Scientific Officer
Plant Physiology Section, HRC
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur
Supervisor

SOME COMMONLY USED ABBREVIATION AND ACRONYMS

Abbreviation	Full Name
SAU	Sher-e-Bangla Agricultural University
BARI	Bangladesh Agricultural Research Institute
HRC	Horticulture Research Center
BINA	Bangladesh Institute of Nuclear Agriculture
TSS	Total soluble solids
AVRDC	Asian Vegetables Research & Development
DMRT	Duncan's Multiple Range Test
ha	Hectare
4-CPA	4-Chlorophenoxy acetic acid
GA_3	Gibberellic acid-3
NAA	Naphthalene acetic acid
CAA	Carmine acetic acid
PGR	Plant Growth Regulator
df	Degree of freedom
TSP	Triple superphosphate
MoP	Muriate of Potash
OM	Organic matter
RCBD	Randomized Complete Block Design
CV	Coefficient of variation
Kg	Kilogram
g	gram
ml	Millie liter

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EFFECT OF GENEMAX ON GROWTH , YIELD AND QUALITY ATTRIBUTES OF TOMATO (*Lycopersicon esculentum Mill*)

By

Md. Shirajul Islam Mollah

ABSTRACT

The experiment was conducted to evaluate Genemax effect on growth, yield and quality attributes of tomato cv. BARI tomato-9 at the Horticulture Research Centre field, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during 16 October 2007 to March 2008 with plant spacing 60 cm x 40cm. It was conducted in Randomized Complete Block Design (RCBD) with three replications. The five treatments like T_1 = Genemax 1 ml/L, T_2 = Genemax 2 ml/L, T_3= Genemax 3 ml/L, T_4= Genemax 4 ml/L and T_5= No Genemax (control) were applied as foliar application at 15 days interval, two times after the establishment of seedling. Effect of different levels of Genemax was significantly varied.The highest (85 t[illegible]/ha) yield was obtained from T_2 treatment (2 mlL^{-1}) and the lowest yield was found from T_5 treatment(control). Similarly, better performance was observed in spraying of Genemax at 2mlL^{-1} concentration in respect of yield $plant^{-1}$ (6.45 kg), plant height (97.07 cm), No. of leaves $plant^{-1}$ (121.67), leaf length (33.47), No. of branches $plant^{-1}$ (2.97), pollen viability (95.00%), fruit set (63.20%), fruit size (6.75 cm), individual fruit wt. (67.29 g) as well as quality of tomato like TSS(3.96%), shelf life (15 days), weight loss, and fruit loss by number. In case of benefit cost ratio, the highest (2.58) benefit cost ratio was found from T_2 treatment and the lowest (2.25) benefit cost ratio was obtained from T_5 treatment (control). BARI tomato-9 with Genemax (PGR) 2 mlL^{-1} concentration may be recommended to increase the yield and quality of tomato.

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CHAPTER- I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) a member of the family Solanaceae is one of the most important vegetables of Bangladesh. It is popular because of its nutrivative and medicinal value and diversified use (Bose and Som, 1986).

Tomato is the world's largest vegetable crop and known as protective food both because of its special nutritive value and also because of its wide spread production. Tomato is one of the most important vegetable crops cultivated for its fleshy fruits. Tomato is considered as important commercial and dietary vegetable crop. Tomato is protective supplementary food. As it is short duration crop and gives high yield, it is important from economic point of view and hence area under its cultivation is increasing day by day. Tomato is used in preserved products like ketch-up, sauce, chutney, soup, paste, puree etc.

As a favorite and important vegetable, tomato is grown in almost all the home and commercial gardens because of its adaptability to wide range of soil and climate. But the average yield of tomato in Bangladesh 6.98 mt. (BBS, 2001) which is quite low in comparison to the yield of the neighboring countries. Majority of our tomato growers do not get good quality fruit and high yield because of their ignorance about the high yielding varieties along with the improved production technology including use of proper age of seedlings as well as fertilizer management practices.

But their exists a scope to increase the yield and quality of this crops and attempts should have to be undertaken for this purpose. Among the different ways, development of variety and modern production practices are important which also includes the use of plant growth regulators. By using PGR, it is possible to improve the production and quality of tomato.

PGR is one of the most important growth stimulating substances used in agriculture since long ago. It may promote cell elongation, cell division and thus helps in the growth and development of tomato plant. Gibberellic acid when applied to flowers controlled fruit drop in tomato (Feofanova, 1962).

The growth regulator 4- chlorophenoxy acetic acid, (4-CPA) has an important effect on the fruit retention of tomato as well as other horticultural crops and thus increasing the yield substantially (Younis and Tigani, 1977). 4- chlorophenoxy acetic acid is a growth regulator used in reducing pre-harvest fruit drop and resulting in creased number of fruits and yield in tomato crops.

When tomatoes are grown during summer in tropical countries, the usual problem is low fruit set. The problem is due to high night temperature (above 22^0C) and high humidity which result in poor pollination follwed by poor fertilization. Although the problem is solved with the use of heat tolerant varieties, these are inadequate under extreme conditions. Application of plant growth regulators has been shown to improve fruit setting both during summer and winter season (AVRDC, 1990).

In China, application of grwoth substance on tomato plants at the beginning of flowering and at peak flowering incresed fruit set and yileld by 25.35% and also improves the quality of fruits (Singh and Babu 1994).

Genemax is one kind of plant growth regulators of Genetica Company, Bangladesh Ltd., which may promote the yield and quality of tomato. But its influence on the growth, yield and quality including the shelflife has yet not been done. Therefore, the present experiment has been formulated with the following objectives:

i. To determine the effect of genemax on the growth and yield of tomato
ii. To see the effect of genemax on the quality of tomato
iii. To study the shelf life of tomato

CHAPTER-II

REVIEW OF LITERATURE

Tomato (*Lycopersicon esculentum* Mill.) is one of the major vegetables in Bangladesh. It is a relatively cool temperature-loving crop, hence, grown in temperature countries and in the dry winter months of tropical countries. Very little efforts have been given in other part of the world to develop varieties adaptable to the tropics. Such effort is even meager in Bangladesh. Information available in the literature pertaining to the evaluation of hybrids for yield, floral and fruit characters with regards to tolerance to high temperature stress are reviewed and presented in this chapter.

Hidekazu Sasaki and Takayoshi Yano (2005) studied the effects of plant growth regulators on fruit set of tomato (*Lycopersicon esculentum* Mill.) under high temperature were examined in a controlled environment and a field under rain shelter. Tomato plants exposed to high temperature ($34/20^0$C) had reduced fruit set. Treatments of plant growth regulators reduced the fruit set inhibition by high temperature to some extent, especially treatment with mixtures of 4-chlorophenoxyacetic acid (4-CPA) and gibberellins (Gas).

Bodo (1991) conducted an experiment, tomatoes treated with a mixture of 4-CPA and Gas showed increased fruit set and the number of normal fruits (excluding abnormal types such as puffy fruit) were more than the plants treated with 4-CPA.

Phookan *et al.* (1990) conducted an experiment to evaluate 29 varieties in relation to eight different growths and yield attributing parameters under spraying

of NAA during winter season and found rang from 4.00 to 75.00 which are good in agreement with the result of the present study.

Uddin *et al.* (2004) observed that to evaluate the effect of variety and plant growth regulators in MS medium on shoot induction from virus infected calli of tomato plants. Three tomato varieties namely Bahar, Binatomato-2 and Binatomato-3 were used as plant materials in the present study. Callus derived shoots were induced on MS medium supplemented with different concentrations and combinations of plant growth regulators (PGRs). The combination of 0.2 mg L^{-1} IAA+4.0 mg L^{-1} BAP in MS medium was the best for inducing shoots which turned green to dark green after 15 days of culture. Callus derived shoots were fully virus infected which was confirmed by ELISA test. Meristem of plantlet can be used for the production of virus free tomato plant by meristem culture.

Davis *et al.* (2003) reported that foliar and /or root applied B increased fresh market tomato and root dry weight, plant tissue concentrations and plant uptake of N, Ca, K and B improved fruit set, total yields, marketable yields, fruit shelf life and fruit firmness.

As fruit size increased by plant growth regulator, consequently individual fruit weight increased. Generally average fruit weight increased 10 to 45% by the plant growth regulator treatment (AVRDC, 1982). Ahmad (2002) also found that the range of individual fruit weight 10 to 72 g among 25 varieties. PGR helps maintain membrane stability (Yanouchi *et al.* 1991).

Rai, *et al.* (2002) observed that the effect of plant growth regulators (PGRs) and commercially available micronutrient mixtures on growth, yield and quality of tomato cv. Gobi (F1 Hybrid). The treatments consisted of 2 concentrations (25

and 75 ppm) each of IAA and NAA, and micronutrients Humaur at 2000 ppm and Multiplex at 2500 ppm. PGRs were applied in the form of foliar sprays at intervals of 26 and 29 days, respectively, and micronutrients were applied as a spray at 30 days after planting. Which was conducted at Allahabad, Uttar Pradesh, India, during 1998-99. Aung (1976) reported that an extent of increased flower number depends on NAA .

Rai, *et al.* (2002) were conducted an experiment effect of plant growth regulators (IAA & NAA) and micronutrient mixtures (Humaur and Multiplex) on growth, yield and quality of tomato (Lycopersicon esculentum Mill.) to determine the effect of plant growth regulators (PGRs) and commercially available micronutrient mixtures on growth, yield and quality of tomato cv. Gobi (F1 Hybrid). Application of IAA at 75 ppm along with Multiplex at 2500 ppm resulted in the highest plant height and yield, and IAA at 75 ppm alone in the highest number of branches (Stevens, 1979).

Nothmann (2002) found that Growth regulator treatments (2,4-D, 2.5 ppm) were given to winter tomato cultivars with different growth and flowering characteristics. The plants were grown in the cool season flower drop is frequent and fruit development is slow and sometimes stops very early. All cultivars tested reacted favorably to 2, 4-D applications, each in its own distinct way. Fruit set and development were much improved, especially in cultivars whose development was more affected by the unfavorable growing conditions of the cool season. Differential responses in fruit set and in fruit growth were recorded, but fruit growth was improved very much even when the effect on fruit set was restricted. Only on 2, 4-D treated plants did all or most of the fruits reach adequate size.

Rodrigues, *et al.* (2001) found that the effects of growth regulators and truss sequence on the tomato hybrid Rajashree were investigated in Maharashtra, India during the kharif season. Treatments consisted of application of 2 growth regulators (NAA at 10 ppm or parachlorophenoxy acetic acid (PCPA) at 50 ppm), and 8 truss sequences (pollination in 1st and 2nd, 3rd and 4th, 5th and 6th, 7th and 8th, 9th and 10th, 11th and 12th, 13th and 14th and 15th and 16th flower). NAA application resulted in higher seed germination percentage, vigour index and seed yield than PCPA. The 1000-seed weight, however, was highest with PCPA. Irrespective of the growth regulator, the highest seed germination percentage (94.66%), vigour index (1606) and seed yield (0.39 g per plant) were obtained at the 1st and 2nd flower truss. Pollination at the 3rd and 4th flower truss showed a seed germination percentage (93.98%) that was at par with that obtained in the initial flower truss. The interaction between the growth regulator and flower truss sequence was significant for vigour index and 1000-seed weight. The highest vigour index (1716.46) was observed for NAA and pollination at the 1st and 2nd flower truss. Similar flower truss sequence, combined with PCPA, produced the greatest 1000-seed weight (3.95 g).

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Siviero, *et al.* (2001) were recorded that the tomato hybrid Perfect peel was sprayed in an Italian trial in 2000 with 0.5 kg Fruttor AG/ha. Fruttor AG is a mixture of 0.2% GA3, 1.5% alpha -naphthaleneacetamide (NAD) and 2.5% 2-naphthoxyacetic acid (BNOA). Ergostim (acetyl-thioproline + folic acid) was also applied at 0.5 litre/ha. The treatment resulted in fewer flower bud losses, higher crop yield, and better fruit quality.

Fluid drilling (gel-seeding) has helped to decrease the time from planting to emergence of many small-seeded vegetables and improved the final plant stand of many crops (Orzolek and Laplan 2001). Unfortunately, 100 per cent final stands, as well as uniform seed emergence (synchrony) within 72 hours, have not yet been achieved consistently in the field. Incorporation of GA_3 and Nutra Phos 3-15 (foliar fertilizer) in the gel prior to the addition of germinated tomato seeds significantly reduced time to final emergence by 3.2 days. Incorporation of Enersol, Amplify, Nutra-Phos 24 and the combination of Enersol plus-Phos 3-15 in gel significantly increased the total useable fruit yield by 30% compared to the control. The combination treatment of GA_3 and Nutra-Phos 3-15 appeared antagonistic and resulted in significantly lower fruit yield and delayed maturity. However, GA_3 and Nutra-Phos 3 – 15 treatments alone produced higher fruit yields than the combination with no effect on fruit maturity compared to the control.

In this study 0, 15, 30, 60 and 90 ppm doses 4-CPA were aplied by one or twice on opened flowers of F-144 (Fantastic) tomato variety grwon under greenhouse (Ozguven, 2000). At the end of experiment, the yield per plant, fruit shape and quality were incestigated. In addition to these, these amounts of 4-CPA residue into ripened fruits were analyzed by using densitometric TLC method. According

to the results, the highest yield per plant and good quality fruits was obtained 60-ppm doses of 4-CPA applied twice, 4-CPA analyses determined by densitomeric method after TLC has shown that 4-CPA in the ripened fruits were not detectale at ng level.

Park, *et al.* (2000) observed that A nationwide fact-finding survey was conducted to provide basic information for establishing the rational plant growth regulator scheme. The treatment method was spraying using a small applicator, and the application dose was dependent on plant growth phase or situation. The farmer needed fruit drop inhibitors in fruit trees, such as apricot and sweet persimmon, and fruit thickening regulators and fruiting stimulants in fruit vegetables, such as tomato and cucumber.

Park, *et al.* (2000) reported that a nationwide fact-finding survey was conducted to provide basic information for establishing the rational plant growth regulator scheme. The most popular plant growth regulators on farms were gibberellins, followed by tomatoton. Gibberellins were commonly used for fruit thickening in watermelon and squash, and tomatoton for fertilization and fruiting in tomato and watermelon. The growth regulators are chosen through the farmers' experience. The treatment method was spraying using a small applicator, and the application dose was dependent on plant growth phase or situation. The farmer needed fruit drop inhibitors in fruit trees, such as apricot and sweet persimmon, and fruit thickening regulators and fruiting stimulants in fruit vegetables, such as tomato and cucumber.

Borkowski *et al.* (1998) conducted an experiment that, Tomato plant cv. Eurocross was treated with 0.2% of Ethrel in a greenhouse experiment.

Treatments consisted of spraying leaves, spraying fruits and drenching only. Ripening of fruits was hastened by spraying of leaves or fruits. Leaves treatment increased the number of ripe fruits from each cluster and these were harvested earlier. In the case of leaves treatments, the etephon content in the ripe fruits increased slowly up to 12 days after spraying, then increased rapidly in next 2 days, and then sharp decline was observed. Residues of etephon in tomato fruits resulting from leaves treatment were 1.7 times higher, than those from fruit spraying, and about 10 times higher than in the case of drenching. Etephon residues reached maximum level 4 days earlier when fruits were sprayed, as compared with leaves spraying.

Khalid (1999) conducted an experiment with two winter (Ratan and Bahar) and three summer (BINA Tomato-2, BINA Tomato-3 and E-6) varieties of tomato during the winter season of 1998-99 at the Horticulture Farm, BAU, Mymensingh. He observed that, the highest yield/plant was obtained from BINA Tomato-2 (1.77 kg), followed by BINA Tomato-3 (1.67 kg). but the yield of these varieties were statistically similar to reach other.

Pereira and Reisser (1998) found in a trial I Pelotas, Rio Grande do Sul, Brazil, the hybrid tomato Empire was sown in a plastic greenhouse on 15 or 30 December 1994 and 16 January 1995. The earliest sowing date resulted in the highest early (end of May) yield (113.9 t/ha) and the highest total yield (163.0 t/ha).

While working with some tomato varities (Pusa Early Dwarf, HS 102, Hisar Arun (Sel 7) and Punjab Chhuhara) in northern Idia, Kalloo (1998) reported that,

HS 102 and Punjab Chhuhara were fit for summer cultivation and Pusa Early Dwarf and Hisar Arun were suitable for getting early fruits.

Ramin, (1998) carried out the experiments on fall 1998 to test the effectiveness of plant growth regulator, auxin (4-Chlorophenoxy acetic acid), on fruit set in field grown tomato under unfavorable temperatures. The commercial auxin (4-CPA) was sprayed during early flowering with 20, 50 and 100 ppm followed by two additional application at 3 days intervals on tomato racemens cv. Early Urbana. The control plants treated with distilled water. At harvest, treated racemes with CPA were longer, with thicker stems, and had more, large fruits than did control racemes.

Monteiro (1998) has performed and experiment that auxin, gibberellin and an electric vibrator were applied to the flowers of tomato plants (*Lycopersicon esculentum* Mill., cv. Montecarlo) grown in a polyethylene greenhouses without heating in spring, with minimum temperatures ranging from 9.0 to 15.4^0 C. The vibrator production high number of normal seeds per fruit, while auxin treated plants had mainly big fruits with aborted seeds, and the control plants had small fruits some of them seedless. Every growth curve of fruit diameter had a sigmoid form, with big fruits growing faster than small ones. The higher the number of seeds the faster was the growth. Growth rate rather than the final diameter was influenced by number of seeds. For the same growth rate the auxin treated fruits were bigger than those treated with the vibrator.

Time required for fruit set, fruit maturity, mean fruit weight and fruit yield/plant were affected by different tomatotone (4-CPA) concentrations. Both fruit set and maturity were earlier at 2% concentration (AVRDC, 1997).

A field trial was conducted in Jordon 1993 to study the yield of 13 local and introduced open pollinated cultivars, and to compare the yields to that of three common hybrids (Maisara F_1, 898 F_1 and GS 12 F_1) in relation to seasonal distribution of marketable and unmarketable yield and fruit number. The cultivars varied in their marketable yield during the harvesting period (10 weeks from 22 June 1993). The results indicated the cultivars Rio Grande, Nagina and T_2 improved were superior to the hybrids (Ajlouni *et al.*, 1996).

Carbonell *et al.* (1996) conducted an experiment and the aim of this study was to know the earliness and yield of different cultivar of tomato after GA_3 application as substitute of verbalization, as soon as planting distance answer. The possible infection with tomato spotted wilt virus (TSEV) also was considered. Two seed propagated cultivar (Lorca, A-106) and another one of vegetative propagation "Blanca de Tudela" was tried. The results show that GA_3 treatments, especially 25 ppm dose, are very effective to promote earliness in Blanca de Tudela" cultivar, whereas the action was smaller in seed propagated cultivars. The increase of planting distance raised earliness of cv. Blanca de Tudela, whereas the effect was smaller in Lorca and A-106 cultivars. In the trial conditions cv. A-106 was the most sensible to TSWV disease.

Scott *et al.* (1995) reported that Equinox, a determinate, heat-tolerant, fresh-market tomato hybrid that sets a high percentage of marketable fruit in spring and autumn in Florida. Under 30-33^{0}C day/night temperature, fruit set is superior to that of the most large fruited cultivars, but flowers abort in the early trusses.

Baki and Stomuel (1993) studied levels of heat tolerance in the genotypes of tomato by determining percent fruit set under the high temperature regimes. They found that, under optimum temperature $27^0/23^0$C (day/night), fruit set in the heat sensitive genotypes ranged from 41 to 84% and in the tolerant genotypes from 45 to 91%. Under high temperature $35^0/23^0$C (day/night), no fruit set was observed in the heat sensitive genotypes, where as fruit set in the heat-tolerant genotypes ranged from 45% to 64%.

Cheema *et al.* (1993) worked to extend the growing period and availability of tomato in northwest India. a study was carried out in the field during 1989-90 to identify genotypes having extended fruit setting ability at high temperature (40^0C day/25^0C nights). Nine genotypes were rated as heat tolerant, having an average of 60-83% fruit set. Individual fruit weighed 20-40g. Marketable yield was low (110-1040g/plant) due ot disease pressures.

Dane *et al.* (1991) reported that selected tomato genotypes were evaluated for fruit-setting ability under high temperature field and greenhouse conditions. Most of the Asian Vegetable Research and Development Centre (AVRDC) selections could be considered heat-tolerant. Small-fruited, abundantly flowering genotypes were less affected by heat stress than larger-fruited cultivars. Prolonged periods of high temperature caused drastic reductions in pollen fertility in most genotypes.

Synthetic plant growth regulators (PGRs) such as 4-chlorophenoxyacetic acid (4-CPA) now used commercially in Korea, Japan and China are known to influence fruit setting in tomatoes. These are applied at 50 mg/liter as a spray on flower

cluster when they are in bloom. Spraying is usually done on each cluster at 7 to 14 days interval. It is claimed that, the treatment increases fruit set and fruit size and induces early yield. However, it may cause puffy fruits at high concentrations or under high temperatures (AVRDC, 1990).

Tomato (Lycopersicon esculentum Mill.) is seldom grown in summer in Bangladesh, because of high temperatures, high humidity and heavy rainfall. An attempt was made in 1991 to grow a summer tomato crop by growing tomatoes on raised beds, using heat-tolerant lines, chemical application for improving fruit set and wild species as root stock to control diseases. Tomatoes transplanted in June on raised beds gave an excellent crop stand and growth compared to transplanting into flat plots. Two lines, TM 0111 and TM 0367, from the Asian Vegetable Research and Development Center (AVRDC) set some fruit in summer, but further increase fruit set were obtained by use of the plant growth regulator 'Tomato'. Plants sprayed at flowering stage with 2% tomatotone resulted in an average 760-940 g parthenocarpic fruits/plant (AVRDC, 1990).

An experiment was carried out under a BARC financed project BVRD, at its Joydebpur sub-center, Gazipur during the summer season of 1976 with three tomato varieties. It was found that, the variety Hope-1 was more adapted to our summer climate than the other two. Although Hope-1 produced smaller fruits, it produced the highest number of fruits (16) per plant, as well as the highest yield (9.24 t/ha), indicating that the variety could tolerate heat and high humidity of Bangladesh better than the other two varieties (Hossain and Hoque, 1984).

Difference existed among the cultivars in their ability to transmit their fruit setting ability under high temperature to their hybrid progenies. hybrid progenies appeared to have better consistency of performance especially under less than optimal growing conditions (Yordanov, 1983).

Chen *et al.* (1982) reported that genotypic differences for their performance in the field were more related to their adaptability to high temperature. They conclude that, selection in a breeding program should be based on selecting those genotypes with higher heat adaptability rather than those with high pre-acclimation levels of heat hardiness, which was found to decline within a narrow temperature range and becomes less efficient at temperature above 30^0C.
Abdullah and Verkerk (1968) reported that high temperature (both day and night), rainfall, humidity, and light intensity are the basic limiting factors of tomato production.

High or low spray of PGR reduced the size of tomato flower with small anthesis and abortive pollens, as well as auxin content (Saito and Ito, 1967).

Iwahori (1967) stated that high or low spray of PGR increased the probability of floral abscission after anthesis in tomato. High spray of PGR reduced the size of tomato flower with small anthesis and abortive pollens, as well as auxin content (Saito and Ito, 1967).

CHAPTER -III

MATERIALS AND METHODS

3.1 Experimental Site

The research work was carried out at the Horticulture Research Central research, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during October 2007 to March 2008.

3.2 Soil: The experimental field was a piece of well drained with moderately even topography. The area belongs to Madhupur tract (AEZ- 28) clay loam in texture, having low organic matter, moderately slow permeability and deficient in nitrogen, potassium and sulphur in comparison with the standard nutrient status. The soil is acidic in nature having PH between 5.9 to 6.1. The soil belongs to the Chita soil series of red brown terrace (Anon., 1998; Brammer, 1971 and Shaheed, 1984). The soil for vegetable research purpose was later developed by riverbed silt.

3.3 Climate

The area is located at the latitude of 23.5^0 and longitude of 90.2^0E at an altitude of about 9 m above the sea level. The climate condition of Joydebpur has unimodal rainfall pattern; most of the rainfall occurs during the months of May to September. The average rainfall is usually higher than 200 mm during May to September and lower than 100 mm during November to March. The warmer months are April, May and June with mean maximum temperature of $31\text{-}34^0$ C and the cold months are November, December and January when the temperature ranges from 10^0 C to 19^0 C. The weather data (air temperature and humidity) during the study period is presented in Appendix I.

3.4 Planting Materials Used for Experiment

The seeds of BARI Tomato-9 were collected from the Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Used Spray Materials

Trade name: Genemax

Appearance: dark brown/black liquid, Smell: light pungent odour, origin: 100% from Organic substances, Solubility: 100% soluble, Analysis % (gram/100cc)trade name Genemax which was supplied by the company Genetica, House no. 25, Road no.4, Block –F, Bannani, Dhaka.

Table 3.2 Composition of Genemax

Organic Nitrogen	(N)	1.1-1.133
Organic Phosphorus	(P_2O_5)	0.1-0103
Organic Potassium	(K_2O)	3.9-4.017
Calcium	(CaO)	0.43-0.90
Magnesium	(MgO)	0.43-0.90
Sulphur	(S)	0.11-0.24
Iron	(Fe)	0.11-0.24
Manganese	(Mn)	0.03-0.43
Copper	(Cu)	0.011-0.04
Zince	(Zn)	0.02-0.03
Boron	(B)	0.014-0.025
Iodine	(I)	0.0020-0.0023

Vitamins

B_1, B_2, B_6, B_{12}, Folic Acid, Panthotheni c Acid, Niacin

Amino Acids

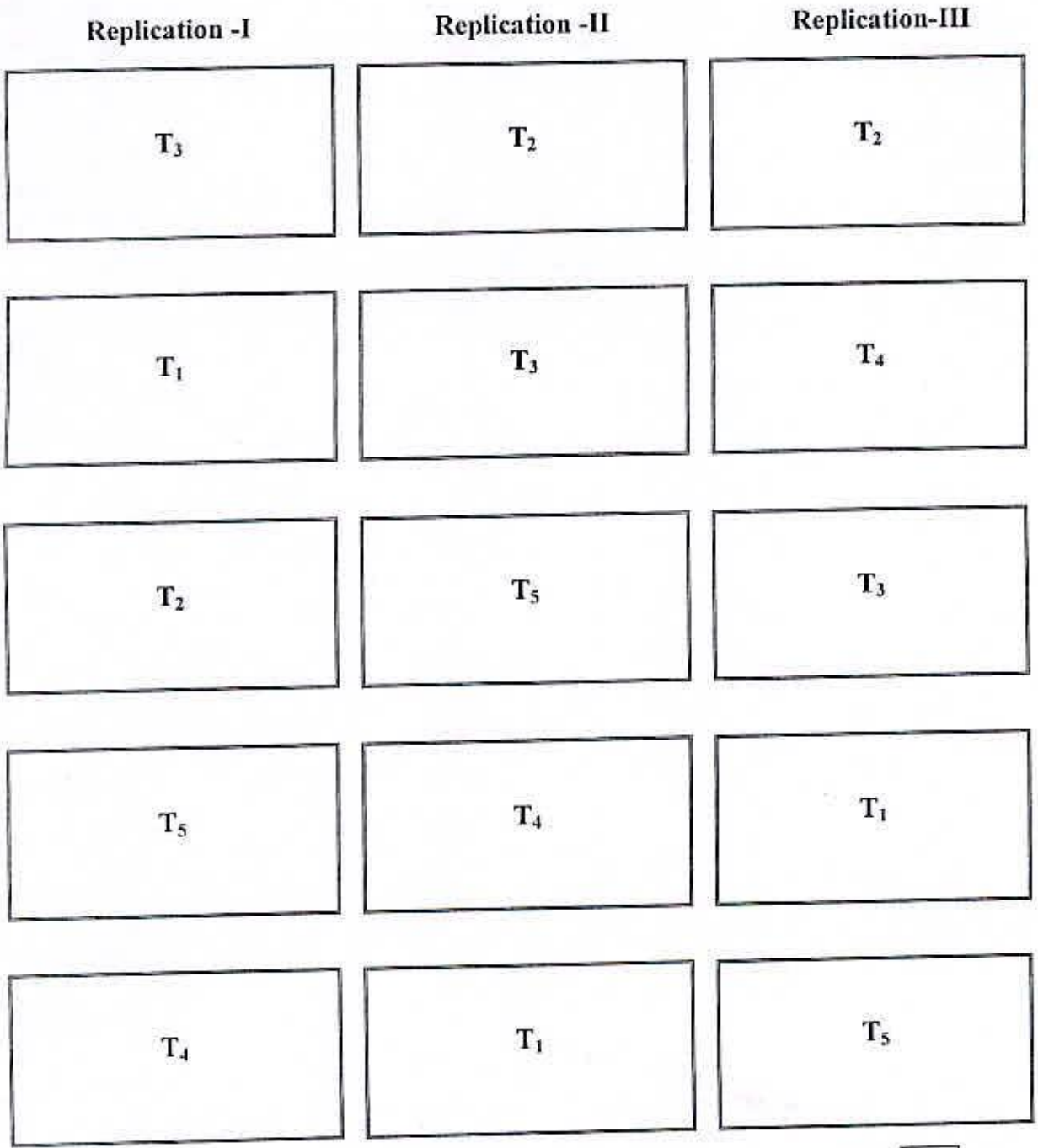
Aspartic Acid, Thronine, Serine, Glutamic Acid, Glycine, Alanine, Proline, Valine, Cystine, Methionine, Iso-Leucine, Leucine, Tyrosine, Phenylalanine, Histidine, Lysine, Arginine, Tryptophan.

3.5 Application of Genemax

The selected growth regulators (Genemax) were sprayed as foliar application at 15 days interval, two times after the establishment of the seedlings in the main plot.

3.6 Design and Layout

The design of the experiment was Randomized Complete Block Design (RCBD) with three replications. The spacing was 60 cm x 40 cm and the unit plot size was 6 m x 1 m. As such there were in total 15 plots in the experiment. There were five levels of Genemax viz. T_1 = Genemax 1 ml/L, T_2 = Genemax 2 ml/L, T_3= Genemax 3 ml/L, T_4= Genemax 4 ml/L and T_5= No Genemax (control)



Legend:

T_1 = Genemax 1 ml/L
T_2 = Genemax 2 ml/L
T_3= Genemax 3 ml/L
T_4= Genemax 4 ml/L
T_5= No Genemax (control)

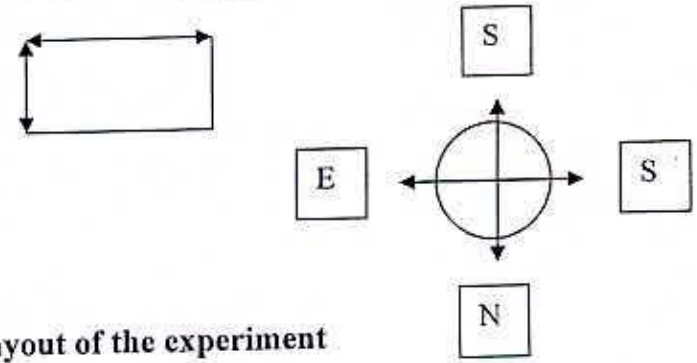


Fig. 3.1 Layout of the experiment

3.7 Land Preparation

The selected land was opened on 10th October, 2007. The land was prepared by ploughing and cross ploughing followed by laddering and harrowing. The weeds and stubble were removed from the plots. Finally, the plots were raised upto 30 cm from the ground level.

3.8 Raising of Seedlings

The seeds of BARI tomato-9 were sown on 16th October, 2007. Watering, mulching, weeding and shading were done as and when necessary. The seedlings were ready for transplanting in the experimental field after 30 days.

3.9 Doses and Methods of Fertilizers and Manure Application

The following doses of manure and fertilizers were applied to the experimental plot as a recommended dose of HRC.

Manures/Fertilizers	Dose/ha
Cowdung	10 tone
Urea	400 kg
TSP	200 kg
MP	150 kg
Gypsum	120 kg

The entire quantity of cowdung, TSP, Gypsum, 1/3 each of urea and MP were applied during final land preparation. The remaining doses of urea and MP were applied as side dressing in two equal installments at 21 and 35 days after transplanting. (Anonymous, 1998)

3.10 Transplanting and Establishment of Seedling

Thirty days old seedlings were transplanted in the main field on 14th November, 2007 at afternoon following the spacing of 60 x 40 cm. Immediately after transplanting, the seedlings were properly watered and then shaded by banana spell to protect seedlings from scorching sunlight. When the plants were well established, the soil around the base of each plant was pulverized. Gap filling was done in place of dead of wilted seedlings in the field after 5 days from transplanting.

3.11 Staking

Supports were given to the growing plants by bamboo sticks to keep the plants erect. One bamboo stick was used per plant for support.

3.12 Preparation of Genemax solution

A stock solution of 1ml was prepared by dissolving in 1 liter of water. Similarly 2, 3 and 4 ml were prepared by dissolving in 1 liter of water respectively.

3.13 Application of Genemax

Freshly prepared genemax solution was sprayed two times on flower cluster of plants at 15 days intervals. Controls plots were not sprayed with that solution and normal tape water was sprayed in control plots.

3.14 Weeding and Mulching

Weeding and mulching were done whenever it was thought necessary to keep the plots free from weeds and to pulverize the soil.

3.15 Irrigation

The plants were initially irrigated by watering cane and as they grew older flood irrigation was given when ever required.

3.16 Pest and Disease Control

No major disease was observed. Two spray of Diazinon 50 E. C were made at 15 days interval at the rate of 90 ml/ha after 15 days of planting to control the fruit borer.

3.17 Harvesting

The fruits were harvested on ripening. Fruit harvesting began from 15th January, 2008. Harvesting was done at seven days interval from every plant of every plot for collecting data.

3.18 Data Collection

Data on different morphological, physiological and yield characters were recorded on the following parameters from the sample plants during the course of experiment. The sampling was done randomly. The plants in the outer two rows & at the extreme end of the middle rows were excluded during randomization. Ten plants were randomly selected from each plot to record data on the following parameters.

1. Plant height at different DAT (cm)
2. Leaves per plant
3. Leaf length (cm)
4. Branches per plant

5. Viable pollen grain (%)
6. Number of flowers per cluster
7. Number of fruits per cluster
8. Fruit set (%)
9. Number of fruits per plant
10. Fruit size (Length and breadth)
11. Yield per plant (kg)
12. Total yield (t/ha)
13. Quality parameters

3.18.1 Plant height at different DAT (cm)

The plant height was measured from the ground level to tip of the plant at 20, 50 and 80 days after transplanting and expressed in cm.

3.18.2 Leaves per plant

Total number of leaves of ten randomly selected plants from the each plot was counted and their mean values were calculated.

3.18.3 Leaf length (cm)

The leaf length of ten randomly selected leaves per plant of each plot was measured from the base (ground level) to the tip of the leaf and their mean values were found out in cm.

3.18.4 Branches per plant

The number of branches of ten randomly selected plants of each plot was counted and their mean values were taken.

3.18.5 Viable pollen grain (%)

Fresh anthesised flowers were collected from the field. Pollens from fresh flowers were tested for percent viability with the following method. Dusting of the pollen grains from the anther cone were done on a glass slide. Carmine Acetic Acid (CA) solution (single drop) was used to stain the specimen and was covered with a cover slip. Pollen grains were viewed under a light microscope. The pollen grains which were normal and properly stained were considered as viable while those were not well stained or wrinkled were considered as non-viable pollen grains.

3.18.6 Number of flowers per cluster

At flowering 5 plants (almost same in height and structure) from each plot were tagged and their number of flower were counted from per cluster.

3.18.7 Number of fruits per cluster

The total number of fruits were counted within the base to upper counted flower from per cluster.

3.18.8 Fruit set (%)

The value was calculated by using the following formula-

$$\text{Fruit set}(\%) = \frac{\text{Total number of fruits of } 1^{st} \text{ five clusters}}{\text{Total number of flowers of } 1^{st} \text{ five clusters}} \times 100$$

3.18.9 Number of fruits per plant

The total numbers of fruits were counted within the base to upper counted flower from per plant.

3.18.10 Fruit size (cm)

The length and breadth of ten randomly selected fruits from each plot were measured from the base (ground level) of the plant to the tip of the fruit and their mean values were found out and expressed in cm.

3.18.11Individual fruit weight (g)

Based on the ten representative fruits individual fruit weight in gram was calculated.

3.18.12 Yield per plant (kg)

The selected ten plants were harvested. The harvested tomato was weighted by using balance and their mean values were calculated.

3.18.13 Total yield (t/ha)

By harvesting tomatoes from each plot, the tomato weights were taken and the yield was first converted per plot basis and then extrapolated as t/ha.

3.19 Quality Parameters

3.19.1 Total soluble solids (%)

Total soluble solids (TSS) contents of the fruit was measured by percent using a refract meter.

3.19.2 Weight loss (%)

The weight loss was measured from the total fruit weight which was converted into per cent.

3.19.3 Fruit loss by number (%)

The number of fruit loss was counted from the total fruit lots which convert into per cent.

3.19.4 Shelf life

Self life of the tomato was counted days up to rotten of fruit.

3.20 Statistical Analysis

Data were statistically analyzed using the "Analysis of variance" (ANOVA) technique with the help of computer package program (MSTAT). The mean differences were done following new Duncan's Multiple Range Test (DMRT) as per procedures by Gomez and Gomez (1984).

CHAPTER-IV

RESULTS AND DISCUSSION

The results obtained from the present study along with statistical analysis of data have been presented and discussed in this chapter.. Effect of Genemax on growth and yield contributing parameters of tomato (*cv.* BARI tomato-9) have been shown in Table 1 to 2 and Figure 1 have been described and discussed in this chapter as follows.

4.1 Plant height (cm) at different DAT

The effect of genemax application on plant height was significantly varied except 20 Days After Transplanting (DAT (Table 4.1). Alphabetically similar but the application of genemax at 20 DAT, the highest (26.93 cm) plant height was found at T_2 treatment (2.0mlL^{-1} concentration) which was statistically similar to T_1, T_3, T_4 and T_5 treatments. The lowest plant height was obtained from T_5 treatment .At 50 DAT, the highest (79.93 cm) plant height was observed from (2.0 mlL^{-1}) T_2 followed by T_3 treatment and the lowest (72.07 cm) plant height was found from T_5 (control). At 80 DAT, the highest (97.07 cm) plant height was observed at 2.0 mlL^{-1} followed by 1.0 mlL^{-1}, 3.0 mlL^{-1}, 4.0 mlL^{-1} and 0.0 mlL^{-1} genemax concentration and the lowest (80.67 cm) plant height was obtained from T_5 (control) treatment. Significant influence was found in the plant height due to application of Genemax. This might be due to the aggressive effect of plant growth regulator on the vegetative part of the plant or may be more PGR that increase the vegetative growth. Phookan *et al. (1990)* reported that when tomato was grown in winter with the application of GA_3, plant height ranged

from 46.00 cm to 95.00 cm in an experiment with 29 varieties of tomato and also showed variations among the varieties of tomato in plant height.

4.2 Number of leaves plant^{-1}

The number of leaves plant^{-1} varied significantly due to the application of genemax on plant growth which was presented in Table 4.1. The highest (121.67) number of leaves were found from T_2 treatment (Application of 2 mlL^{-1}). Statistically similar to (1.0 mlL^{-1}) T_1, (3.0 mlL^{-1}) T_3, (4.0 mlL^{-1}) T_4 and (control) T_5 treatments. The lowest (81.00) number of leaves was found from T_5 (control) treatment. Application of PGR has an aggressive effect on vegetative growth as a whole (Ramin, 1998). So, number of leaves per plant increased due to plant growth regulator application.

4.3 Leaf length (cm)

The leaf length of tomato plant was varied significantly due to the application of genemax (Table 4.1). The highest (33.47 cm) leaf length was found from T_2 treatment (2.0 mlL^{-1}), statistically similar to (3.0 mlL^{-1}) T_3 treatment. The lowest leaf length (27.87 cm) was found from T_5 (control) treatment. Leaf length increased at final harvest as plant growth regulator was applied. This might be due to the aggressive effect of plant growth regulator on the vegetative part of the plant or may be PGR that increased the vegetative growth. Phookan *et al.* (1990) reported that when tomato was grown in winter with the application of GA_3, leaf length was ranged from 28.00 cm to 50.00 cm in an experiment with 29 varieties of tomato and also showed variations among the varieties of tomato in leaf length.

4.4 Number of branches plant^{-1}

The number of branches per plant of tomato was varied significantly due to the application of genemax (Table 4.1)

. Application of genemax with 2mlL^{-1} (T_2) produced the maximum number of branches in all the growth stages compared to other treatments of genemax and control. The highest (2.97) number of branches per plant was found from T_2 treatment (2 mlL^{-1} of genemax)and the lowest (2.23) number of branches per plant was found from T_5 treatment. Application of NAA has an aggressive effect on vegetative growth as a whole (Ramin, 1998).

Table 4. 1 Effect of Genemax on plant height at different DAP, Leaves per plant, Leaf length and Branch per plant

Treatment	Plant height (cm)			Leaves/ Plant	Leaf length (cm)	Branches /plant
	20 DAT	50 DAT	80 DAT			
T_1	26.27 a	74.20 b	87.20 b	98.00 b	29.93 b	2.60 b
T_2	26.93 a	79.93 a	97.07 a	121.67 a	33.47 a	2.97 a
T_3	26.40 a	75.47 ab	89.60 ab	109.67 ab	30.20 ab	2.70 b
T_4	26.27 a	73.20 bc	84.93 b	105.00 ab	29.20 b	2.60 b
T_5	25.33 a	72.07 c	80.67 c	81.00 c	27.87 c	2.23 c
Level of Significance	NS	*	*	*	*	*
CV (%)	4.82	7.88	4.67	7.81	4.76	5.75

In a column, values with same letter do not differ significantly at 5% level as per DMRT

* = Significant at 5% level, NS = Non Significant

Where,

T_1 = Genemax 1 ml/L

T_2 = Genemax 2 ml/L

T_3= Genemax 3 ml/L

T_4= Genemax 4 ml/L and

T_5= No Genemax (control)

4.5 Viable pollen grain (%)

The most important character for bearing fruits was pollen viability. Per cent viable pollen grain was varied (Table 4.2.). The highest (95.00%) per cent of pollen viability was observed from T_2 treatment and the lowest (79.23%) per cent was found from T_5 (control) treatment. Statistically result showed that pollen viability increased with the increasing PGR dose upto T_2 treatment. Bodo (1991) obtained that production of viable pollen increased by applying 4-CPA.

4.6 Number of flowers cluster^{-1}

The effect of genemax application on the number of flower cluster^{-1} was significantly varied (Table 4.2). The highest (10.22) value was shown in treatment T_2 (2mlL^{-1}) and the lowest (6.49) value was found from T_5 treatment. The number of flowers per cluster is an important character which has got the significance to determine the yield of tomato fruit. The production of flowers per cluster may be affected by the cultivars and PGR. Aung (1976) reported that an extent of increased flower number depends on NAA which is an agreement with the present findings.

4.7 Number of fruits cluster^{-1}

Effect of different levels of genemax on fruits cluster^{-1} is presented in Table 4.2. Statistically varied, the highest (4.93) value was found from the treatment T_2 (2mlL^{-1}) and the lowest (3.34) value was found from control (T_5). Exogenous plant growth regulator application increased fruit set per cent which resulted number of fruits per cluster. Stevens (1979) reported that an extent of increased fruits number depends on PGR.

4.8 Fruit set (%)

Effect of different levels of genemax on fruit set (%)is presented in Table 4. 2. There was significant effect of Genemax on fruit set (%).The highest (63.20%) value was observed from T_2 treatment ($2mlL^{-1}$) and the lowest (35.11%) value was found from control (T_5.) Application of exogenous PGR maintain the proper level of PGR which increase fruit set. As a result fruit set per cent increased by the PGR application. Baki and Stomuel (1993) reported that the fruit setting is increased particularly in winter varieties by the application of GA_3.

4.9 Number of fruits plant^{-1}

The plant growth regulator influenced significantly on the number of fruits per plant and produced the higher number of fruits per plant than that of non-PGR treatment. Effect of different levels of genemax on fruits plant^{-1} was recorded (Table 4.2). The highest (97.00) number of fruits were produced in treatment T_2 ($2mlL^{-1}$) and the lowest (84.53) number of fruits was found from control (T_5). It has been reported that, in an experiment with 20 F_1 crosses, the NAA treatment observed to have an appreciable effect on the number and weight of fruits of all lines (AVRDC, 1982).

Phookan *et al.* (1990) conducted an experiment to evaluate 29 varieties in relation to eight different growths and yield attributing parameters under spraying of NAA during winter season and found rang from 4.00 to 75.00 which are good in agreement with the result of the present study.

4.10 Fruit size (cm)

. The effect of genemax application on fruit length was significantly varied. The tallest (6.75 cm) fruit length was found in T_2. The dwarf fruit length (5.10 cm) was recorded from T_5 treatment (control). The effect of genemax application on fruit breadth was significant. The highest (4.70 cm) fruit breadth was got in T_2 and the lowest (4.40 cm) was observed from T_5 (control) treatment. Fruit size (length and breadth) may be increased due to increased rate of cell division and cell elongation by PGR. When tomatoes are grown with the application 4-CPA, the treatments are increased fruit set and fruits size (AVRDC, 1990).

Table 4.2 Effect of Genemax on flower per cluster, Pollen viability (%), fruits per cluster, Fruit set (%), fruit size, fruits per plant and yield per plant

Treatment	Pollen Viability (%)	Flower/ Cluster	Fruit/ Cluster	Fruit set (%)	Fruit size (cm)		Fruit/ plant	Yield/ Plant (kg)
					Length	Breadth		
T_1	84.30 b	7.95 ab	3.99 bc	50.05 ab	6.54 ab	4.58 ab	94.33 a	5.43 ab
T_2	95.00 a	10.22 a	4.93 a	63.20 a	6.75 a	4.70 a	97.00 a	6.45 a
T_3	89.73 ab	7.32 b	4.35 ab	50.40 b	6.44 b	4.62 a	92.600 a	5.36 ab
T_4	83.37 bc	7.61 bc	4.30 ab	49.86 b	6.14 bc	4.63 a	95.07 a	5.36 ab
T_5	79.23 c	6.49 c	3.34 c	35.11 c	5.10 c	4.40 b	84.53 b	4.63 b
Level of Significance	*	*	*	*	*	*	*	*
CV (%)	3.70	16.26	9.09	14.75	2.93	2.44	4.87	14.34

In a column, values with same letter do not differ significantly at 5% level as per DMRT

* = Significant at 5% level, NS = Non Significant

Where,

T_1 = Genemax 1 ml/L

T_2 = Genemax 2 ml/L

T_3= Genemax 3 ml/L

T_4= Genemax 4 ml/L and

T_5= No Genemax (control)

4.11 Individual Fruit Weight

The plant growth regulator influenced significantly on individual fruit weight (Table 4.3). The highest (67.29 g) individual fruit weight was observed for spraying of Genemax at 2 ml L^{-1} concentration (T_2 treatment) and the minimum (60.11 g) was measured in non-PGR T_5 treatment. As fruit size increased by plant growth regulator, consequently individual fruit weight increased. Generally average fruit weight increased 10 to 45% by the plant growth regulator treatment (AVRDC, 1982). Ahmad (2002) also found that the range of individual fruit weight 10 to 72 g among 25 varieties which support the findings of the present study.

4.12 Yield Plant^{-1} (kg)

There was momentous effect of PGR on yield per plant which ranged from 4.63 kg to 6.45 kg. The effect of genemax application on yield plant^{-1} (kg) was presented in Table 4.2. The highest (6.45 kg) yield was obtained from the application of Genemax at 2mlL^{-1} concentration and the lowest (4.63 kg) yield was found from non-PGR treatment (T_5). There was a report that the PGR treatments are accelerated fruit setting and increased yield remarkably. PGR appears highly efficient for yield enhancement of good F_1 combinations (AVRDC, 1982). The findings of AVRDC, (1997) also demand that fruit yield per plant increased by applying the plant growth regulator.

4.13 Total yield (t/ha)

Plant growth regulator application significantly influenced fruit yield (t/ha) over non-PGR treatments. The effect of genemax application on total yield (t/ha) was presented in (Fig. 4.1).

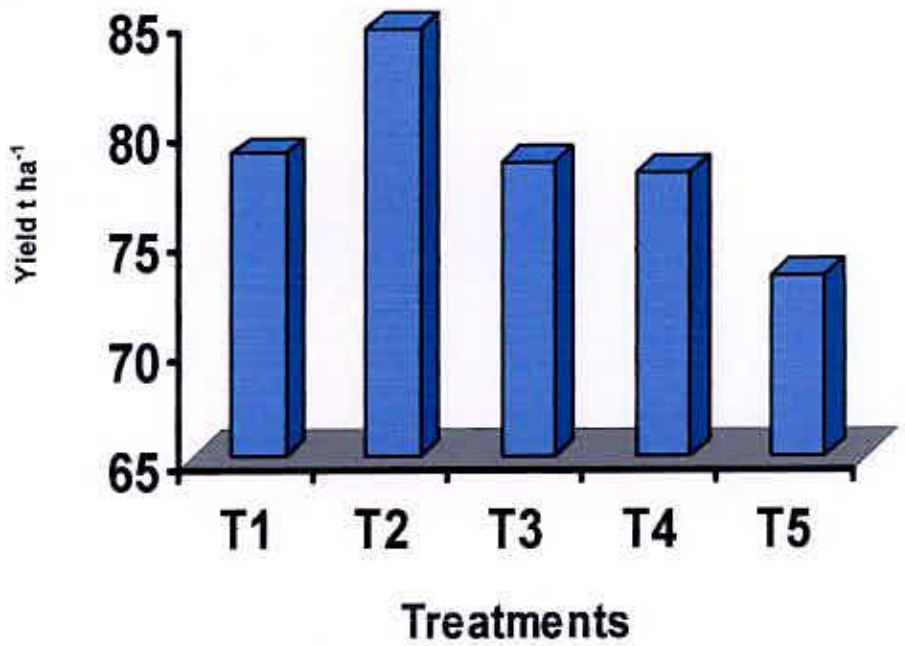


Fig. 4.1 Effect of Genemax on yield of tomato

T_1 = Genemax 1 ml/L, T_2 = Genemax 2 ml/L, T_3= Genemax 3 ml/L, T_4= Genemax 4 ml/L and T_5= No Genemax (control)

The highest (85.00 t/ha) yield was obtained from the application of Genemax at $2mlL^{-1}$ concentration and the lowest (73.00) yield was found from non-PGR treatment (T_5). PGR appears highly efficient for yield enhancement of good F_1 combinations (AVRDC, 1982). The findings of AVRDC (1997) demand that fruit yield per hectare is increased by application of GA_3.

4.14 Quality parameters

4.14.1 Total Soluble Solids (%)

Marked variation was found as to the TSS (%) content of the fruits due to different concentration of Genemax (Table 4.3). T_2 treatment was increased TSS (%) content of the fruits. The highest (3.96%) TSS content was recorded from T_2 treatment whereas the lowest (2.93 %) was observed from T_5 treatment. The fact that the TSS in tomato fruit was low in control treatment may be due to the visible lack of chlorophyll in leaves of the plants. The highest TSS content in T_2 because PGR helps in translocation of metabolites from source to sink. The result was supported by the findings of Ahmed (2002) where TSS (%) was found to vary from 3.00 to 5.50 in an experiment in winter season.

4.14.2 Weight Loss (%)

Weight loss is an important parameter of storage performance. It was recorded at 3 days interval upto 21 days after storage. The weight loss per cent was presented in Fig. 4.2. The highest (49.33%) weight loss was observed from T_5 treatment and the lowest (35.17%) was found from T_2 treatment. This may be due to the effect of Genemax on membranes, cell walls and reduced transpiration. Many studies have shown that PGR helps maintain membrane stability (Yanouchi *et al.* 1991).

4.14.3 Fruit Loss by Number (%)

The effect of genemax application on loss of fruits is recorded at 3 days interval upto 21 days after storage (Fig. 4.3). The highest (51.13%) fruit loss by number was observed from T_5 treatment and the lowest (37.35%) was found from T_2. This may be due to fact that PGR influenced defenses against disease. Borkowski *et al.* (1998) obtained the highest percentage of healthy fruits with 0.3 % NAA.

4.14.4 Shelf life

Shelf life is an important quality character of tomato. Significant difference was observed as to the shelf life due to genemax application (Fig. 4.4). The highest (15 days) shelf life was recorded from T_2 while the lowest (8 days) was found from T_5 treatment. It might be due to the fact that optimum PGR decreased physiological activities like respiration and transpiration. Many studies show that PGR help maintain membrane stability. Davis *et al.* (2003) reported that folia application of GA_3 improves fruit shelf life.

Table 4.3 Effect of Genemax on quality of tomato

Treatments	TSS (%)	Individual Fruit weight (g)
T_1	3.54 ab	65.48 ab
T_2	3.96 a	67.29 a
T_3	3.45 b	64.01 b
T_4	3.75 ab	63.47 ab
T_5	2.93 c	60.11 c
Level of Significance	*	*
CV (%)	6.45	6.26

In a column, values with same letter do not differ significantly at 5% level as per DMRT

* = Significant at 5% level, NS = Non Significant

Where,

T_1 = Genemax 1 ml/L

T_2 = Genemax 2 ml/L

T_3= Genemax 3 ml/L

T_4= Genemax 4 ml/L and

T_5= No Genemax (control)

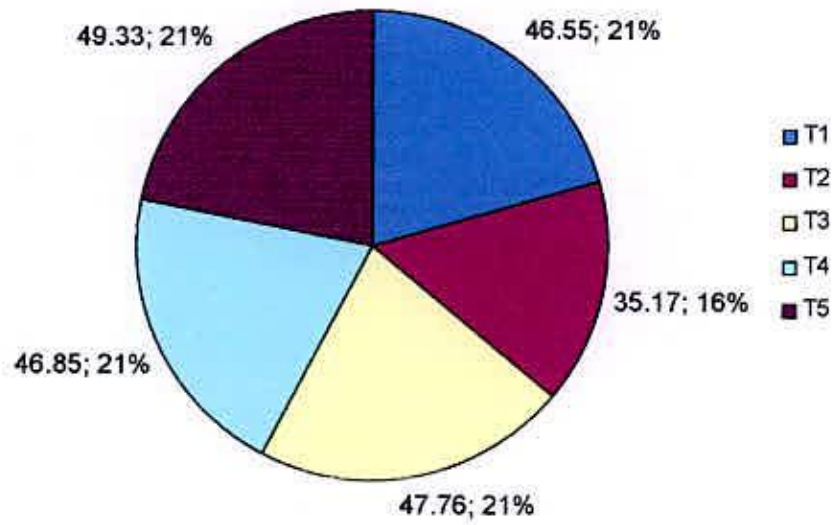


Fig. 4.2 Effect of genemax application on weight loss (%) of tomato

Where,

T_1 = Genemax 1 ml/L

T_2 = Genemax 2 ml/L

T_3= Genemax 3 ml/L

T_4= Genemax 4 ml/L and

T_5= No Genemax (control)

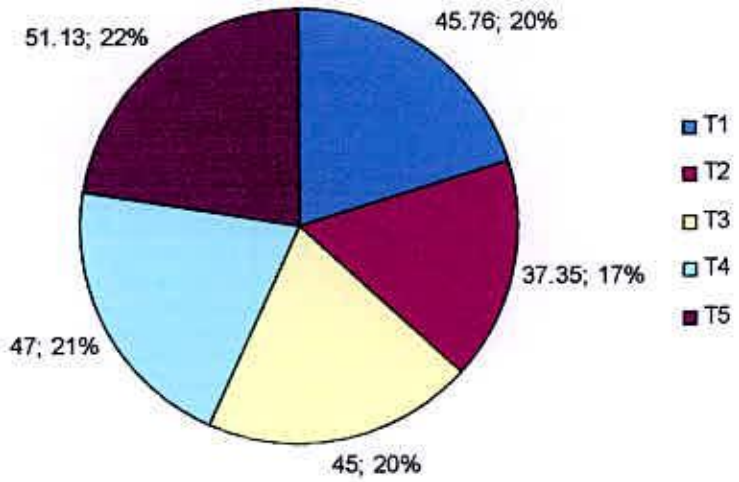


Fig. 4.3 Effect of genemax application on fruit loss by number (%) of tomato

Where,

T_1 = Genemax 1 ml/L

T_2 = Genemax 2 ml/L

T_3= Genemax 3 ml/L

T_4= Genemax 4 ml/L and

T_5= No Genemax (control)

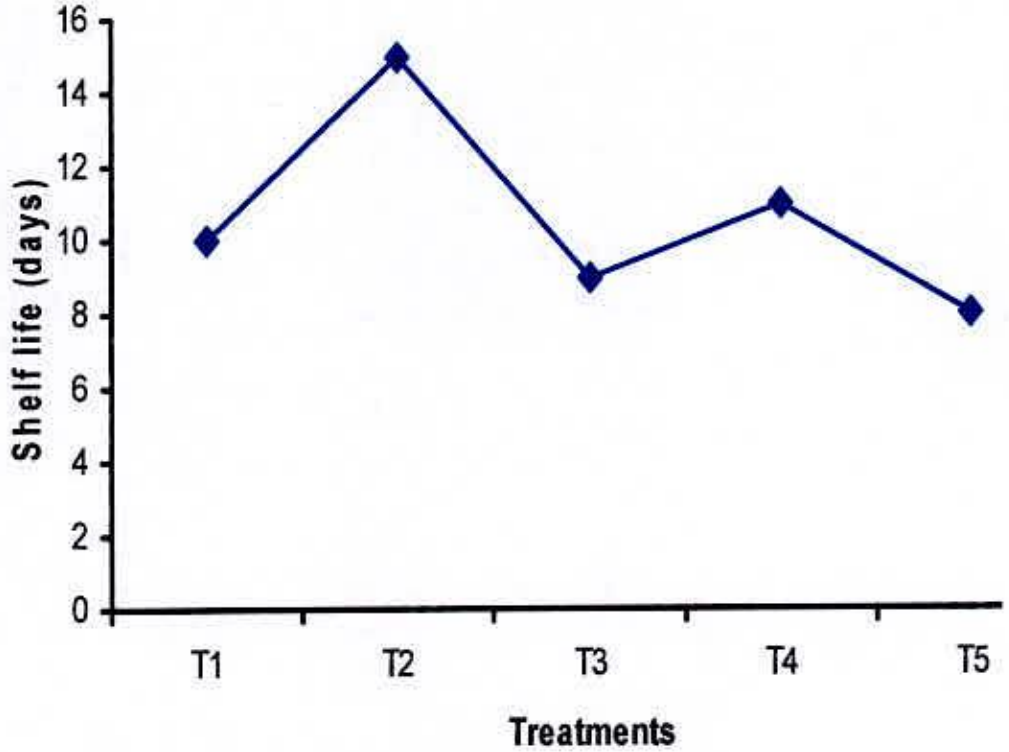


Fig. 4.4 Effect of genemax application on shelf life of tomato

Where,

T_1 = Genemax 1 ml/L

T_2 = Genemax 2 ml/L

T_3= Genemax 3 ml/L

T_4= Genemax 4 ml/L and

T_5= No Genemax (control)

ECONOMICAL ANALYSIS

Economical analysis was done with a view to comparing the cost of tomato production and its benefits under different concentration of Genemax.. For this purpose, the input costs for the land preparation, planting , transplanting, fertilizer, crop protection, spray of Genemax(plant growth regulator) harvesting, lease of the land, man power and miscellaneous were recorded against each treatment. The highest (2.58) Benefit Cost Ratio was found from T_2 treatment and the lowest (2.25) was obtained from T_5 treatment.

Table 5. Economical analysis of different treatment

Treatment	Total cost of production (Tk./ha)[a]	Yield (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	BCR
T_1	163024	80.00	400000	236976	2.45
T_2	163650	84.72	423600	259950	2.58
T_3	164274	79.00	395000	230726	2.40
T_4	164900	78.00	390000	225100	2.36
T_5	162400	73.34	366700	204300	2.25

[a] Details shown in Appendix VI to X

Considering farm gate market price of the tomato Tk. 5000/ton in winter season.

CHAPTER- V

SUMMARY

The experiment was conducted to evaluate genemax effect on growth, yield and quality attributes of tomato cv. BARI tomato-9 at the Horticulture Research Centre field, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during 16 October 2007 to March 2008 with plant spacing 60 cm x 40cm. Five different levels of genemax solution were used as treatment like T_1 (1 mL^{-1}), T_2 ($2mL^{-1}$), T_3 ($3mL^{-1}$), T_4 ($4mL^{-1}$)and T_5 (No Genemax) were undertaken for foliar application. The experimental design was Randomized Complete Block Design (RCBD) with three replications.

The data on plant height at different DAT (cm), leaves per plant, leaf length (cm), branches per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit size (length and breadth), yield per plant (kg) and total yield (t/ha) as well as quality parameters like TSS, Weight loss of tomato, Fruit loss by number , Shelf life and Benefit Cost Ratio were recorded.

The effect of genemax application on plant height was significantly varied except 20 DAT. The application of genemax at 20 DAT, the highest plant height (26.93 cm) was found at T_2 treatment which was identically similar to other treatments. On the other hand, at 50 DAT, the highest (79.93 cm) plant height was observed at T_2 (2 mlL^{-1}) treatment. At 80 DAT, the highest (97.07 cm) plant height was observed at 2.0 mlL^{-1} followed by 3.0 mlL^{-1} genemax (T_3) treatment. The number of leaves $plant^{-1}$ significantly varied due to the application of genemax at plant growth. The

highest (121.67) number of leaves was found at T_2 (2.0 mlL^{-1}). The lowest (81.00) number of leaves was found from T_5 (control) treatment.

The leaf length of tomato plants was significantly varied due to the application of genemax. The highest (33.47 cm) leaf length was found from T_2 (2.0 mlL^{-1}) followed by T_3 treatment whereas the lowest (27.87 cm) leaf length was found from T_5 (control) treatment. Application of genemax with $2mlL^{-1}$ T_2 produced the maximum (2.97) number of branches in all the growth stages compared to other treatments of genemax whereas the lowest (2.23) was found in control (T_5) treatment.

The effect of genemax application on flower $cluster^{-1}$ was significantly varied. The highest (10.22) value shows in treatment T_2 ($2mlL^{-1}$) and the lowest (6.49) value was found from control (T_5). Effect of different levels of genemax on pollen viability was statistically different. The highest (95.00%) value shows in treatment T_2 ($2mlL^{-1}$) and the lowest (79.23%) value was found from control (T_5) treatment. Effect of different levels of genemax on fruits $cluster^{-1}$ was significantly varied. The highest (4.93) fruits produced in treatment T_2 $2mlL^{-1}$ and the lowest (3.34) fruits were found in control (T_5) treatment.

The effect of genemax application on fruit set % was significantly varied. The highest (63.20%) was found from T_2 and the lowest (35.11) was recorded from T_5 (control) treatment. The effect of genemax application on fruit size (length and breadth) was significantly varied. The highest fruit length (6.75cm) and breadth (4.70 cm) were found from T_2 treatment respectively. On the other hand, the lowest were found in T_5 (control) treatment respectively.

The effect of genemax application on fruit plant^{-1} was significantly varied. The highest (97.00) fruit plant^{-1} was observed from T_2 and the lowest (84.53) was found from T_5 treatment. The effect of genemax application on yield plant^{-1} (kg) was significantly varied. The highest (6.45 kg) yield was observed from T_2 and the lowest (4.63 kg) was found from (control) T_5. The effect of genemax application on total yield (t/ha) was significantly varied. The highest (84.72 t/ha) yield was found from T_2 treatment, on the other hand the lowest (73.34 t/ha) was observed from T_5 (control) treatment. Treatment T_2 was increased TSS (%) content of the fruits. The highest (3.96%) TSS content was recorded from T_2 whereas the lowest (2.93 %) was observed from control (T_5) treatment. In case of individual fruit weight, the highest weight (67.29 g) was obtained from T_2 treatment and the lowest (60.11 gm) was found from T_5 treatment. The highest weight loss (49.33%) was observed from T_5 and the lowest (35.17%) was found from T_2. Similarly the highest fruit loss by number (51.13%) was observed from T_5 and the lowest (37.35%) was found from T_2 which were significantly varied. Effect of genemax application on shelf life was significantly varied. The highest (15 days) shelf life was recorded from T_2 treatment while the lowest (8 days) was found from T_5 treatment.The highest (2.58) Benefit Cost Ratio was found from T_2 treatment and the lowest 2.25) Benefit Cost Ratio was obtained from T_5 treatment.

CONCLUTION AND RECOMMENDATIONS

The following conclusions have been made on the basis of findings of the present investigation:

- From the study, it might be concluded that among the different concentration of Genemax T_2 treatment (2 mlL^{-1}) was the best concentration in order to increase the growth and yield of tomato in winter season.

- . Better performance was observed with the application of Genemax at $2mlL^{-1}$ concentration in respect of quality of tomato like Total Soluble Solid, weight loss, fruit loss by number as well as Shelf life of winter tomat

- Besides, The highest Benefit Cost Ratio was found from T_2 treatment and the lowest Benefit Cost Ratio was obtained from T_5 treatment.

The following recommendations could be drawn:

- BARI tomato-9 with Genemax (PGR) at 2 mlL^{-1} concentration may be recommended to increase the yield of winter tomato.

- Further study on collection, identification and hybridization may be under taken for developing winter varieties without plant growth regulators.

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APPENDICES

Appendix I. Monthly mean temperature, rainfall and relative humidity during the crop period of (October 2007 to February 2008) at BARI, Gazipur

Year	Month	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)
		Minimum	Maximum	Minimum	Maximum	
2007	October	26.56	31.66	82.66	86.25	137
	November	26.85	32.75	78.86	84.00	175
	December	25.79	32.60	81.82	86.85	185
2008	January	25.60	32.50	74.67	82.89	215
	February	25.67	32.27	69.67	78.29	245

Source: Meteorological Department, Gazipur.

Appendix II: Soil characteristics of Horticulture Farm are analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	HRC, BARI, Gazipur
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: SRDI

B: Physical and chemical properties of the initial soil

Characteristics	Value
Partical size	
% Sand	27
% Silt	43
% Clays	30
Textural class	Silt-clay
pH	5.6
Prganic carbon (%)	0.45
Oranic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100g soil)	0.10
Available S (ppm)	45

Source: SRDI

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Source: SRDI

Appendix III. Analysis of Variance of the data on plant height at different DAP, Leaves per plant, Leaf length and Branch per plant

Source of Variation	df	Mean square					
		Plant height (cm)			Leaves/ Plant	Leaf length (cm)	Branches/ plant
		20 DAT	50 DAT	80 DAT			
Replication	2	13.07	32.10	42.50	48.00	14.13	21.30
Treatment	4	24.01	16.25	67.30	21.07	2.35	13.96
Error	8	30.50	21.15	38.30	35.38	0.03	0.38

Appendix IV. Analysis of Variance of the data on flower per cluster, Pollen viability (%), fruits per cluster, Fruit set (%), fruit size, and fruits per plant and yield per plant

Source of Variation	df	Mean square							
		Flower/ Cluster	Pollen Viability (%)	Fruit/ Cluster	Fruit set (%)	Fruit size (cm)		Fruit/ plant	Yield Plan (kg)
						Length	Breadth		
Replication	2	10.49	79.73	18.33	42.86	22.23	4.70	51.38	10.39
Treatment	4	21.39	48.29	39.19	13.21	43.32	19.18	42.39	43.48
Error	8	15.29	89.94	22.30	28.33	38.58	10.55	33.85	20.11

Appendix V. Analysis of Variance of the data on yield, TSS, Individual fruit weight, weight loss, fruit loss by number and shelf life

Source of Variation	df	Mean square					
		Yield	TSS	Individual fruit weight	Weight loss	Fruit loss by number	Shelf life
Replication	2	43.48	11.29	10.19	49.30	5.39	10.11
Treatment	4	22.33	17.38	0.75	15.89	0.15	0.70
Error	8	15.18	0.91	2.73	3.31	0.07	0.11

Appendix VI. Labour requirements per hectare for various operations to produce winter tomato

SL. No.	Heads for use of labour	No. of Labours
1.	Seedbed & main field preparation	160
2.	Planting and watering	60
3.	Fertilizer and manure application	95
4.	Irrigation	55
5.	Weeding	100
6.	Genemax and insecticide application	60
7.	Harvesting (4 times)	65
8.	Other operations	50

Appendix VII. Cost of fertilizer and manure per hectare

SL. No.	Fertilizer and manure	Cost (Tk.)
1.	Cowdung 15 ton @ 1000 Tk./ton	15000
2.	Urea 450 kg @ 15 Tk./kg	6750
3.	TSP 250 kg @ 40 Tk./kg	10000
4.	MP 160 kg @ 40 Tk/kg	6400

Appendix VIII. Cost of tomato production per hectare in winter season as influence by different concentration of genemax

SL. No.	Category	Cost (Tk.)
1.	Labour 645 man required @ 150 Tk./ Working day	96750
2.	Ploughing (3 times)	15000
3.	Cost of leasing land Tk. 13000 for season (6 months)	6500
4.	Cost of cowdung, Urea, TSP and MP	38150
5.	Cost of Insecticide and fungicide	5000
6.	Cost of seedling	10000

Appendix IX. Cost of genemax for tomato production per hectare in winter season

SL. No.	Application of Genemax	Cost (Tk.)
1.	Genemax application at 1 mlL^{-1}	624
2.	Genemax application at 2 mlL^{-1}	1250
3.	Genemax application at 3 mlL^{-1}	1874
4.	Genemax application at 4 mlL^{-1}	2500
5.	No Genemax (control)	

Appendix X. Total cost of production per hectare in winter season

SL. No.	Treatment wise	Cost (Tk.)
1.	Genemax application at 1 mlL^{-1}	163024
2.	Genemax application at 2 mlL^{-1}	163650
3.	Genemax application at 3 mlL^{-1}	164274
4.	Genemax application at 4 mlL^{-1}	164900
5.	No Genemax (control)	162400