EFFECT OF NITROGEN AND GIBBERELLIC ACID ON GROWTH AND YIELD OF TOMATO

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EFFECT OF NITROGEN AND GIBBERELLIC ACID ON GROWTH AND YIELD OF TOMATO

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CERTIFICATE

This is to certify that thesis entitled, "**EFFECT OF NITROGEN AND GIBBERELLIC ACID ON GROWTH AND YIELD OF TOMATO**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **MAHMUDA SULTANA**, **Reg. No. 07-2505** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any institute.

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, 2013

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MAHMUDA SULTANA

ABSTRACT

A field experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, during the period from November 2012 to March 2013. Two factors experiment included four levels of nitrogen i.e. N_0 : 0kg, N_1 : 200 kg, N_2 : 225 kg and N_3 : 250 kg N/ha and three levels of GA_3 i.e. G_0 : 0, G_1 : 50 and G_2 : 70 ppm respectively, was outlined in Randomized Complete Block Design(RCBD) with three replications. Application of nitrogen and GA_3 influenced independently and in combination on growth and yield of tomato. For nitrogen the highest yield (47.02 t/ha) was recorded from N_2 and lowest (35.26 t/ha) was from N_0. For GA_3 the highest yield (46.09 t/ha) was recorded from G_1, while the lowest (34.82 t/ha) was from G_0. In case of combined effect, the highest yield (49.29 t/ha) was from N_2G_1, while lowest (35.02 t/ha) from N_0G_0. Economic analysis revealed that N_2G_1 gave maximum benefit cost ratio (2.21). So, it can be concluded that 225 kg N with 50 ppm GA_3/ha is the best for growth and yield of tomato.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ABBREVIATIONS	**ELABORATIONS**
%	Percent
@	At the rate
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BINA	Bangladesh Institute of Nuclear Agriculture
CEC	Cation Exchange Capacity
cm	Centi-meter
CV%	Percentage of coefficient of variation
df	Degrees of Freedom
DMRT	Duncan’s Multiple Range Test
EC	Emulsifiable concentration
et al.	and others
etc.	Etcetera
FAO	Food and Agriculture Organization of United Nations
g	gram

hr.	Hours
j.	Journal
Kg/ha	kiligrams per hectare
kg	kilogram
m	Meter
m^2	square meter
MoA	Ministry of Agriculture
MSE	Mean square of the error
No.	Number
ppm	parts per million
RCBD	Randomized Complete Block Design
Rep.	replication
Res.	research
SAU	Sher-e-Bangla Agricultural University
Sc.	science
SE	Standard Error
Univ.	University
var.	variety

CHAPTER I
INTRODUCTION

Tomato *(Lycopersicon esculentum* Mill.) belonging to the family Solanaceae, is one of the most important vegetable crop grown in Bangladesh. It was originated in tropical America, particularly in Peru, Ecuador and Bolivia. It is popular for its taste, nutritional status and various uses. Tomato is cultivated all over the country due to its adaptability to wide range of soil and climate (Ahmad, 1976). The crop is adapted to a wide variety of climates ranging from the tropics to a few degree of the Arctic Circle. The present leading tomato producing countries of the world are China, United States of America, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (FAO. 2002).

In Bangladesh tomato has great demand throughout the year but its production is mainly concentrated during the winter season. Recent statistics showed that tomato was grown in 17.790 hectares of land and the total production was approximately 202.000 metric tons in Bangladesh during the year 2004-2005. Thus the Average yield of tomato was 11.35 tons/ha (BBS. 2005). While it was 69.41 t/ha in USA, 21.27 t/ha in India , 31.13 t/ha in China and 65.45 t/ha in Japan (FAO. 2004).

The popularity of tomato and different products produced from tomato processing is increasing day by day. It is a nutritious and delicious vegetable used in salads, soups and processed into stable products like ketchup, sauce, marmalade, chutney and juice. They are extensively used in the canning industry for canning.

Nutritive value of the fruit is an important aspect of quality tomato and public demand. Food value of tomato is very rich because of higher contents of vitamins A, B and C including calcium and carotene (Bose and Som, 1990). Tomato adds flavor to the foods and it is also rich in medicinal value.

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 fertilizer management is a vital factor that influences the growth and yield of tomato. Among the different nutrients that were required for tomato cultivation nitrogen is most important nutrients.

On the other hand soils of Bangladesh have been deficient in nitrogen fertilizer. Tomato requires large quantity of readily available nitrogen nutrients (Gupta and Shukla, 1977). In indeterminate type of tomato, vegetative and reproductive stages over lap and the plants need nitrogen up to fruit ripening.

Again GA_3 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); and Adlakha and Verma, (1995); reported that GA_3 (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_3 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 nitrogen in association with application of GA_3 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 nitrogen on the growth and yield of tomato,

ii) To determine the effect of GA_3 on the growth and yield of tomato and

iii) To find out the suitable combination of nitrogen and GA_3 for ensuring the maximum growth and yield of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato *(Lycopersicum esculentum* Mill.) is one of the most important vegetable crops in Bangladesh and received much attention to the researcher throughout the world. Plant growth regulators arc the substances, which affect the growth of plants quite miraculously. GA_3 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 nitrogen on the growth and yield of tomato

A field experiment was conducted at Bhubaneswar, India by Sahoo *et al.* (2002) to study the effects of nitrogen (50, 100, 150 or 200 kg N/ha) and potassium (75 or 150 kg K/ha) on the growth and yield of tomato var. Utkal kumari during the rabi season of 1999-2000.The wide range of variation was marked by the application of nitrogen with respect to growth, development and yield of tomato fruit. The fruit yield increased with each increase in the levels of nitrogen from 50 to 150 kg but further increased of nitrogen beyond 150 kg/ha reduced the yield considerably. They also found that the highest value relating to yield attributing characters like number of fruits per plant and single fruit weight were maximum when potassium was applied at the rate of 75 kg/ha. However, the combination of 150 kg N/ha along with 75 kg K/ha gave best result with respect to tomato from yield and other yield attributing characters.

Sainju *et al.* (2001) conducted an experiment at Agricultural Research Station, Fort Valley State University, Fort Valley to evaluated hairy vetch residue as nitrogen fertilizer for tomato in soilless medium. The ability of hairy vetch

(*Vicia villosa* Roth) residue (l00 g/plant) to supply N and to increase yields of tomato *(Lycopersicon esculentum)* was compared with that of N fertilization (0, 4.1, and 8.2 g N/plant) in a medium containing a mixture of 3 per liter: 1 vermiculite in a greenhouse. Leaf dry weight, leaf and stem N uptake, total dry weight and N uptake of tomato, and Nl4 and inorganic N concentrations in the medium at transplanting were significantly greater with than without residue. Nitrogen fertilization increased fruit number, fresh and dry yields and N uptake, stem, leaf, and root dry weights and N uptake, root length, and total dry weight and N uptake. The residue was as effective in increasing fresh fruit yield, total dry weight, and N uptake as was 4.4 to 7.9 g/plant of N fertilizer. Tomato yield and N uptake per unit amount of N supplied was greater for the residue than for N fertilization.

A study was conducted by Ceylan *et al.* (2001) at Odemis, Izmir, Turkey to assess the effect of ammonium nitrate and urea fertilizers at 0, 12, 24, 36 kg N/ha on nitrogen uptake and accumulation in tomato plants. The total nitrogen, $N0_2$-N and $N0_3$-N contents of leaves and fruits were determined. On the first and second harvest dates, the highest $N0_3$-N and $N0_2$-N amounts in tomato leaves and fruits were obtained upon treatment with 36 kg N/ha. Ammonium nitrate application increased nitrate and nitrite accumulation compared to urea application. The highest yield was recorded upon treatment with 24 kg N/ha.

Two field experiments were conducted in Egypt by Awad *et al.* (2001) to study the effect of intercropping parsley and demsisa with tomato under 4 rates of N fertilizer (100, 120, 140 and 160 kg N/fed). The results showed that increasing N fertilizer rate enhanced total yield and net assimilation rate (NAR) of both mono and mixed crops, earliness index of tomato and NPK uptake of tomato in NAR. Total yield, earliness index and N uptake. The best values were obtained by pure stand planting at the highest N rate (160 kg N/fed), whereas the best P and K uptake were attained at 140 and 120 kg N/fed, respectively. The highest value of N supplementation index (NSI) for tomato was obtained at 100 kg N/fed, whereas the highest values of phosphorus supplementation index (PSI) and potassium supplementation index (KSI) were recorded by plants which received 160 kg N/fed.

A field experiment was conducted by Manoj and Raghav (1998) to evaluating two F_1 hybrids of tomato, three plant spacing (75 cm x 50 cm, 75 cm x 75 cm and 75 cm x 100 cm) and four levels of nitrogen (0, 75, 150, 225 and 300 kg/ha) was conducted during 1995-96 and 1996-97 at the Research Station, Nagina of G.B. Pant University of Agriculture and Technology, Pantnagar (Uttar Pradesh, India) on sandy loam soil. Among the various levels of nitrogen, 300 kg/ha was found to be best in improving the growth and yield.

High ammonium nitrogen (NH_4N) concentration in solution may adversely affect greenhouse tomato yield, but it has been reported that small NH_4N fractions improve yield and may increase vegetative growth and nutrient element uptake. 1 he objective of this study was conducted by Sandoval *et al.* (1999) to determine the tomato yield response to 0 : 100, 10 : 90, 20 : 80, 30 : 70, and 40 : 60 NH_4N : $N0_3N$ratios supplied at the vegetative, vegetative plus flowering, flowering plus fruiting, and fruiting stages, and over the entire plant life cycle. Neither the length of NH_4N supply nor the NH_4N concentration in solution affected tomato yield. Plant height was not affected by NH_4N concentration in either the winter or spring experiments, and neither was fruit firmness measured for fruit at the mature green stage. Fresh and dry weights were unaffected by NH_4N concentration.

Bot *et al.* (2001) carried out an experiment to evaluate the response of adult tomato plants growing in rock wool in a greenhouse to N withdrawal from the nutrient solution was studied over a 6-week period during fruit production.

The major effect of N withdrawal included the impairment of growth of fast growing organs. Fruit growth was impaired, leading to a reduction in yield. The growth of young leaves was also inhibited. The stores of nitrate N were depleted after removal of N in the solution, but it took 45 days for the plants to metabolize completely their nitrate reserves.

Tomato CV. Pusa Gaurav was treated with N at 0, 40, 80 and 120 kg/ha and K at 0, 30 and 60 kg/ha in a field experiment conducted in Madhya Pradesh, India during rabi 1992-93 and 1993-94 by Gupta and Sengar (2000). N application resulted in increases in plant height, number of fruits per plant, fruit weight and fresh yield. Increasing N rate produced a corresponding increase in yield and yield components, except total soluble solids (TSS) content. K increased vegetative growth, yield, and TSS content.

An experiment was conducted in Uttar Pradesh, India, by Singh *et al.* (2000) to determine the suitable rate and application of N fertilizers for obtaining optimum growth and yield of tomato cv. Pusa Hybrid-2. N was applied at 40 kg/ha basal, 40 kg/ha top dressing, 80 kg/ha in 2 splits (40 kg/ha basal + 40 kg/ha top dressing) 50 kg/ha in 2 splits (40 kg/ha basal + 10 kg/ha foliar), 60 kg/ha (40 kg/ha basal + 210 kg/ha foliar), 70 kg/ha (40 kg/ha basal + 30 kg/ha foliar) and 80 kg/ha (40 kg/ha basal + 20 kg/ha top dressing + 20 kg/ha foliar). N at 80 kg/ha applied in 3 splits produced the highest yield and biomass. Increasing N rates resulted in increasing biomass and yield.

Experiment was conducted by Default *et al.* (2000) in Charleston, South Carolina, to determine (1) if supplemental nitrogen (N) at 60 or 120 kg/ha following winter cover crops of wheat. Tomato *(Lycopersicon esculentum* Mill.) and snap bean(*Phaseolus vulgaris* L.) grown in rotation; and (2) the distribution and retention of soil nitrates in the soil profile as affected by N fertilization and cover cropping, Total marketable tomato yield increased as fertilizer N increased to 60 kg/ha in two out of four years and with 120 kg/ha in one out of four years. In all cover crop or fallow plots, as fertilizer N application levels increased, the soil nitrates also increased.

Sainju *et al.* (2000) conducted an experiment on cover crops can influence soil properties and crop yield they examined the influence of legume and N fertilizer application (0, 90, and 180 kg N/ha) on the short and long-term effects on soil C and N and tomato yield and N uptake. N uptake similar to that produced by 90 and 180 kg N /ha. Nitrogen fertilizer application increased

PNM and inorganic N after split application and tomato yield and N uptake but decreased organic C and N and PCM.

Hoffland *et al.* (2000) conducted an experiment to study how nitrogen availability affects within plant allocation to growth and secondary metabolites. Tomato plants were grown at six levels of 'nitrogen availability. When nitrogen availability increased, plant relative growth rate increased, but tissue carbon/nitrogen ratio in the second oldest true leaf and allocation to large glandular trichomes as well as to the defense compounds rutin, chlorogenic acid decreased but leaf protein concentration increased.

This study was conducted by Chang *et al.* (2000) to investigate the effect of nitrogen supply by NH_4N deposit fertilizer on plant growth and nitrogen uptake of tomatoes. NH_4 deposit fertilizer was applied using the "CULTAN" (Controlled Uptake Long Term Ammonium Nutrition) method. It was prepared by mixing one-third ammonium sulfate and two-thirds urea as nitrogen sources and by combining gypsum as a binder and loamy soil and compost as diffusion regulators in the beaker. In the first experiment, the application of NH_4N, deposit fertilizer with 7.5 g gypsum as a binder resulted in increased tomato fruit yield and nitrogen uptake efficiency compared to control. In the second experiment, the application of NH_4N deposit fertilizer with loamy soil and compost as a diffusion regulator and adjusted C/N ratio to 16 also resulted in increased nitrogen uptake of fruits.

There are few growth studies evaluating within-season effects of N on vegetative growth and N accumulation of tomato conducted by Scholberg (2000). Growth analysis of field grown tomato for a number of Florida (USA) locations and management systems is presented here. Severe N stress resulted in fewer and smaller, but thicker, leaves. With increasing N, average leaf area index increased from 0.75 to 3.0, but radiation use efficiency (RUE) typically increased less than 30%. Lower RUE under N limited conditions reflected a decrease in N concentration of the most recently matured leaves from 40 mg/g to as little as 15 mg/g. Over the life of well- fertilized crops. Leaf N concentrations dropped from 55 to 65 mg got during initial growth to 20 to 35 mg/g at final harvest. Corresponding N concentrations for fruit and for stems were 30 to 35 mg g-I and 15 to 25 mg/g. Severe N stress affected leaf and stem N concentrations most drastically, whereas N in fruits was less variable.

Rhoads *et al.* (1999) carried out an experiment to evaluate the influence of N rates and ground cover following tomato on soil nitrate-N movement was monitored in spring and fall [autumn] crops grown at the Florida A&M University, Florida, USA. Nitrogen rates varied from 0 to 360 lb/acre in the spring crop and from 0 to 600 lb/acre in fall tomato. Yield ranged from 1900 to 2600 boxes/acre in spring tomato, and from 1300 to 2700 boxes/acre in fall tomato. Fertilizer N rates above, 80 lb/acre were excessive, as shown by yield and residual soil nitrate-N levels. Residual soil nitrate-N was proportional to N application rate. Soil nitrate-N concentration following harvest was highest in the 1 to 3 ft depth range for spring tomato and the 2 to 4 ft depth range for fall tomato.

Hoffland *et al.* (1999) conducted an experiment on tomato plants with varying N availability were grown by adding N daily in exponentially increasing amounts to a nutrient solution at different rates. Leaves of plants grown at low N availability had a high leaf C : N ratio (21 g/g). The level of soluble carbohydrates correlated positively with susceptibility independent of the growth method. It is therefore suggested that the effect of N availability on susceptibility can be explained by variation in levels of soluble carbohydrates which hence may play a role in the infection process.

The effects of low and high water vapor deficit regimes and electrical conductivities of 3.8 or 4.8 ms/cm on the growth and N uptake of 7-month-old tomatoes in NFT were investigated for 3 months by Bellert *et al.* (1998). Growth and N uptake were not modified by the treatments. N accumulated in the aerial biomass in proportion to the dry matter. Total N concentration of the foliage was relatively constant and richer than that of vascular organs and fruits. A model is proposed to link total N concentration to dry matter accumulation.

In field trials on a red ferrallitic soil in northern Havana in 1994-95, tomato cv. Campbel1-28 plants were fertilized with 0, 60, 120, 180 or 240 kg N/ha, starting 38 days after sowing was conducted by Adjanohoun *et al.* (1996). Although increasing rates of applied N had no effect on average fruit weight, they significantly increased fruit numbers although application of 240 kg N/ha was excessive and significantly reduced yield compared with 120 or 180 kg N/ha (the highest yield, obtained with 180 kg N/ha, was 38 t/ha), A mathematical expression describing the curve of yield response is presented, and from it the optimum application rate was determined to be 158 kg N/ha, giving a fruit yield of 38.9 t/ha,

Hohjo *et al.* (1995) The tomato cv. Momotaro was grown using the nutrient film technique (NFT) in 1/2- and 3/4- to full-strength Enshi shoho balanced feed. In the first experiment, nutrient solutions were adjusted to contain $N0_3N$: NH_4N ratios of 10:0, 9:1 and 8:2. Shoot and root FW were increased by an increasing proportion of NH_4N with both strengths of solution, whereas Ca and Mg uptake were decreased by an increasing proportion of NH_4N only with the higher solution strength. Total yield was reduced by increasing the proportion of NH_4N, particularly with the higher strength of solution, a combination that also caused a marked increase in the incidence of blossom-end rot (BER). In the second experiment, $N0_3N$: NH_4N ratios of 10:0 and 8:2 and Ca concentrations of 2, 4 and 6 meq/litre were used. The higher proportion of NH_4N significantly increased shoot and root FW, incidence of BER and leaf contents of N, P and K, whilst decreasing the leaf content of Ca. Increasing the Ca content of the medium caused an increase in early yield and leaf Ca content, and a decrease in BER and leaf Mg content. The combination of 8: 2 $N0_3N$: NH_4N and the lowest Ca concentration reduced total yield and leaf Ca content and significantly increased BER.

Trpevski *et al.* (1992) carried out in trials with 3 N was applied at 0, 40, 80 or 120 kg/ha to soil manure with 40 t FYM/ha in early spring. The 2 higher N rates increased the yield of San Pjer but reduced the yield of the other 2 cultivars. The effects of treatments on fruit N, dry matter, organic acid and vitamin C contents were generally not significant.

An experiment were conducted by Kooner and Randhawa (1990) at Punjab Agricultural University, Ludhiana to study the interaction of rates and sources of N with cultivars on the yield and processing quality of tomatoes in winter and spring seasons. Four rates of N (50, 100, 150 and 200 kg/ha) were applied as 2 sources, calcium ammonium nitrate (CAN) and urea, in a randomized, split plot design. PC produced significantly higher yields (222.7 kg/ha) than PK (208.9 kg/ha) in the spring planting while in the winter planting OS (163.9 kg/ha) and CS (113.9 kg/ha) were the best. Yields increased linearly with increasing N rate up to 150 kg/ha and CAN was the best source of N. TSS, juice percentage, ascorbic acid content and titratable acidity increased with increasing N up to 150 kg/ha.

In a study on the effect of nitrogen fertilization and plant intensification, Midan *et al.* (1985) observed that increasing nitrogen rates linearly increased the number of fruits per plant. However, medium and higher nitrogen rates gave best total yields. With different nitrogen rates, three times of application improved fruit per plant weight and total yield. Patil and Bojappa (1984) conducted an experiment to study the effects of cultivars and graded levels of nitrogen and phosphorus on certain quality attributes of tomato. The experiment consisted of the cultivars Pusa Ruby, Sious and Sweet-72. The plant received nitrogen at 70, 110 and 150 kg/ha and phosphorous (P) at 44 or 61.6 kg/ha with basal dressing of potassium (K) at 49.8 kglha and FYM at 25 t/ha. The highest fruit content of total sugars and next highest dry matter content were in sweet-72 while juice percentage was highest in pusa Ruby. Rising nitrogen rates increased fruit total increased fruit total sugars and juice percentage but decreased the dry matter content. Phosphorous had no appreciable effect as any of the indices studied.

Belichki (1984) reported that nitrogen was the most important nutrient. Flower and fruit numbers per plant were increased by nitrogen up to 240 kg/ha and fruit size was greatest 120 kg/ha. Staneve (1983) conducted an experiment to investigate the effect of nitrogen supply on photosynthesis, leaf area and total dry matter in tomato and found that photosynthesis was inhabited by N deficiency. Leaf development and dry matter accumulation were greatest at 10meq/L N and declined at higher concentrations.

2.2 Effect of GA_3 on the growth and yield of tomato

Shittu and Adeleke (1999) investigated the effects of foliar application of GA_3 (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 GA_3 treatment. Plants treated With GA_3 with 250 ppm were the tallest plant the highest number of leaves.

Tomar and Ramgiry (1997) studied that tomato plant treated with GA_3 showed significantly greater number of branches plant^{-1} than untreated controls.

Gabal *et al.* (1990) found that 100 ppm of GA_3 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 GA_3 at 50, 75 or 100 ppm) and methods of plant growth regulator application on the quality of tomato fruits. Plant growth regulators had profound effects on fruit length, weight and sugar : acid ratio. The effects of presoaking seeds and foliar application of plant growth regulators were more profound than presoaking alone.

Hathout *et al.*(1993) found that application of 10 ppm IAA as foliar sprays or to the growing media of tomato plants had a stimulatory effect on plant growth, development and fruit which was accompanied by increases in endogenous auxin, gibberellins and cytokinin contents. However, IAA at 80 ppm had an inhibitory effect on plant growth and development, which was accompanied by increase in the level and activity of indigenous inhibitors and by low levels of auxms, cytokines and gibberellins.

EI- Habbasha *et al.*(1999) carried out a field experiment with tomato cv. castel rock over two growing seasons (1993-94). The effects of GA_3 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.

Gulnaz *et al.*(1999) reported that seeds of wheat treated with to 10 ppm of GA_3 resulted in 36-43% increase in dry weight at 13.11 dSm^{-1}. Gurdev and Saxena (1991) observed that the growth regulators (GA_3 at 10^{-5} M) increased total dry matter. Application of 10^{-5} M GA_3 on mustard at 40 or 60 days after sowing significantly increased total dry matter (Khan *et al.* 1998).

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 GA_3 showed the best results on dry weights. Application of GA_3 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).

Gain in dry matter per unit assimilatory area per unit time is the NAR. It was established that NAR become higher during vegetative stage and then decline rapidly as season progressed (Kollar *et al.,* 1970) possibly due to mutual leaf shading and increase of old leaves which could have lower photosynthetic efficiency (Pandey and Singh. 1978). The NAR was positively correlated with CGR (Majumder *et al.*, 1980).

Relative growth rate is the increase in plant weight per unit plant weight per unit of time represents the efficiency of the plant as a producer of new material. i.e. efficiency index of dry weight production (Hunt, 1978). It was positively correlated with biomass production in field pea (Pandy *et al*, 1983*).*

The rate of increase of dry matter per unit time per unit land area is the CGR. CGR increased with LAI (Goldshworthy, 1984). Crop growth rate is positively correlated with LAI (Khan, 1981) and net assimilation rate (Bhardwaj *et. al.* 1987).

Leaf area index measures leafiness and photosynthetic surface area of a crop and it depends on the leaf growth number of leaf, plant density and leaf senescence (Khan, 1981).

Lilov and Donchev (1984) observed that by the application of GA_3 at 20, 40 or 100 mg/L the yields were reduced compared with the non-treated control.

Leonard *et al.* (1983) reported that inflorescence development in tomato plants grown under low light regimes was promoted by GA_3 application directly on the inflorescence.

Onofegharn (1981) carried out an experiment with tomato and sprayed GA_3 at 25- 1000 ppm. He observed that GA_3 promoted flower primordia production and the number of primordia produced or the panern of primordia production over time.

Saleh and Abdul (1980) performed an experiment with GA_3 *(*25 or 50 ppm) applied 3 times in June or early July. They reponed that GA_3 stimulated plant growth. The substance reduced the total number of flowers plant $^{-1}$ but increased the total yield compared with the control. GA_3 also improved fruit quality.

Chern *et al.* (1983) presented that one month old transplanted tomato plants were sprayed with 1, 10 or 100 ppm GA_3 and observed that GA_3 at 100 ppm increased leaf area, plant height and stem fresh and dry weight but 10 ppm inhibited growth.

Wu *et al.* (1983) sprayed one-month old transplanted tomato plants with GA_3 at 1, 10 or 100 ppm and reported that GA_3 100 ppm increased plant height and leaf area.

Briant (1974) sprayed GA_3 on the growth of leaves of young tomato plants and observed that total leaf weight and area were increased by GA_3.

Bora and Selman (1969) working with tomato demonstrated that four foliar sprays of GA_3 (0, 5, 50 or 500 ppm) applied at 7, 17, 22, 27 or 37^0 increased the leaf area, weight and height of tomato plants. The best treatment was 5 ppm GA_3 at 22^0C.

Jansen (1970) reported that tomato plants treated with GA_3 neither increased the yield nor accelerated fruit ripening. He also mentioned that increasing concentration of GA_3 reduced both the number and size of fruits.

Mehta and Malhi (1970) reported that GA_3 application at 25 ppm improved the yield of tomato. GA_3 produced earlier fruit setting and maturity.

Hossain (1974) investigated the effect of GA_3 along with 4-CPA on the production of tomato. He found that GA_3 applied with 50, 100 and 200 ppm produced an increased fruit set. However, GA_3 treatment induced small size fruit production A gradual increase in the yield plant $^{-1}$ was obtained with higher concentration of GA_3.

Sawhney and Greyson (1972) reported that application of GA_3 non flowering plants of tomato induced multilocular, multicarpellary ovaries which were larger at anthesis than control upon pollination produced fruits which were significantly larger with higher fresh weight.

Adlakha and Verma (1964) observed that when the first four clusters of tomato plants were sprayed three times at unspecified intervals with GA_3 at 50 and 100 ppm, the fruit setting increased by 5% with higher concentration.

Kaushik *et al.* (1974) in an experiment applied GA_3 at 1, 10 or 100 mg/L on tomato plants at two leaf stage and then at weekly interval until 5 leaf stage. They reported that GA_3 increased the number and weight of fruits plant $^{-1}$ at the highest concentration.

Chowdhury and Faruque (1972) reported that the percentage of seedless fruit increased with the increase in GA_3 concentration from 50 ppm to 100 ppm. However the fruit weight was found to decrease by GA_3.

Gustafson (1960) sprayed tomato flower and flower buds of the first three clusters with GA_3 (35 and 70 ppm) and found that GA_3 improved fruit set but reduced fruit weight of tomato.

Rapport (1960) noted that GA_3 had no significant effect on fruit weight and size either at cool (11^0 C) or warm (23°C) night temperatures; but it strikingly reduced fruit size at an optimum temperature (17^0 C).

CHAPTER III

MATERIALS AND METHODS

The details of the materials and methods of this research work were described in this chapter as well as on experimental materials, site, climate and weather, experimental design, layout, materials used for experiment, raising of seedling, treatments, land preparation, manuring and fertilizing, transplantation of seedlings, intercultural operations, harvesting, collection of data and statistical analysis which are given below:

3.1 Experimental site

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka. The location of the site was $23^{o}74^{/}$ N latitude and 90^{o} $35^{/}$ longitude 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 2012 to March 2013. Seedlings were sown on 05 November, 2012 and were harvested upto 25 March, 2013.

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-II)

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.

3.6 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. Twenty grams of seeds were sown in each seedbed. The seeds were sown in the seedbed on 15 October, 2012. Seeds were then covered with finished 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. 7 Treatments

The two factor experiment consisted of four levels of nitrogen (Factor A) and three levels of Gibberellic acid (Factor B). The factors were as follows:

Factor A: levels of Nitrogen	**Factor B: levels of GA_3**
N_0 = 0 kg/ha	G_0 = 0 ppm
N_1 = 200 kg/ha	G_1 = 50 ppm
N_2 = 225 kg/ha	G_2 = 70 ppm
N_3 = 250 kg/ha	

There were all together 12 treatments combination used in each block were as follows: N_0G_0 , N_0G_1 , N_0G_2 , N_1G_0 , N_1G_1 , N_1G_2 , N_2G_0 , N_2G_1 , N_2G_2 , N_3G_0 , N_3G_1 , N_3G_2

3.8 Experimental design and layout

Field layout was done after final land preparation. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole plot was divided into three blocks each containing twelve (12) plots of 2m x 1.8m size, giving 36 unit plots. The space was kept 1 m between the blocks and 0.5m between the plots were kept. The distance between row to row and plant to plant was 60 cm and 40 cm, respectively. The layout of the experiment is shown in Figure 1.

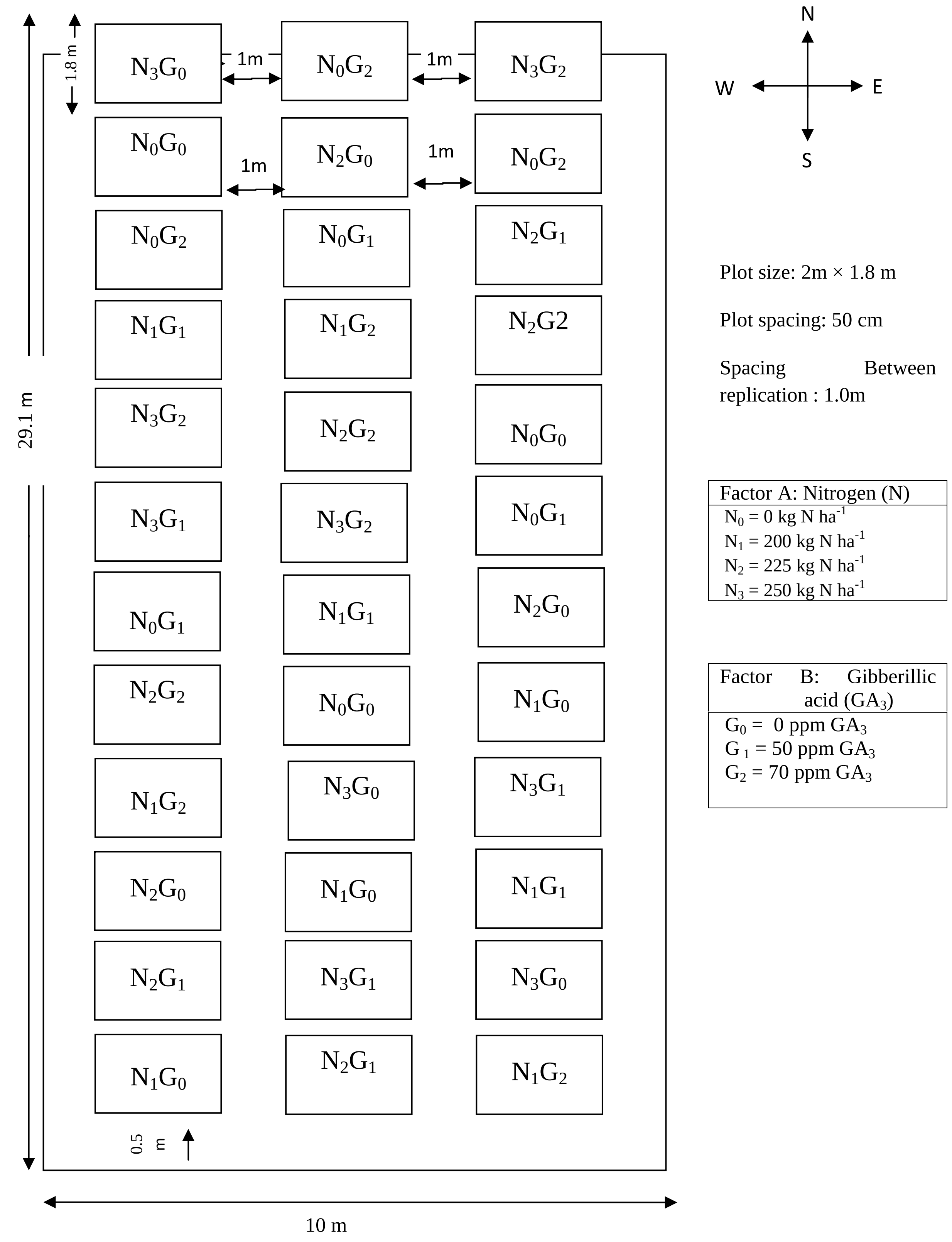

Fig. 1: Layout of the experimental plot

3.9 Land preparation

The experimental field was thoroughly ploughed and cross ploughed and cleaned prior to seed sowing and application of fertilizers and manure were done in the field. The experimental field was prepared by thorough ploughing followed by laddering to have a good tilth. Finally the land was properly leveled before transplanting. Then plots were prepared as per the design.

3. 10 Application of manure and fertilizers

The sources of N, P_2O_5 , K_20 as urea, TSP and MP were applied, respectively. The entire amounts of TSP and MP were applied during the final land preparation. Urea was applied in three equal installments at 20, 30 and 40 days after seedling transplanting. Well-rotten cowdung 20 t/ha also applied during final land.

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

Manure / Fertilizers	**Rate/ha**	**Application (%)**			
		Basal	20 DAT	30 DAT	40 DAT
Cow dung	20 ton	100	-	-	-
Urea	As treatment	-	33.33	33.33	33.33
TSP	200 kg	100	-	-	-
MP	175 kg	100	-	-	-

3.11 Preparation and application of GA_3

The stock solution of 1000 ppm of GA_3 with small amount of ethanol to dilute and then mixed in 1 litre of water turn as per requirement of 50 ppm and 70 ppm solution of GA_3. 50 and 70 ml of stock solution were mixed with 1 litre of water. Application of GA_3 at 15 day interval were done at 20, 35 and 50 days after transplanting.

3.12 Transplanting of seedlings

Healthy and uniform 20 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 05 November, 2012 maintaining a spacing of 60 cm x 40 cm between the rows and plants respectively. This allowed an accommodation of 15 plants in each plot. 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. Shading was provided using banana leaf sheath for three days to protect the seedling from the hot sun and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.13 Gap filling

Gap filling was done as and when needed.

3.14 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.

3.14.1 Irrigation and drainage

Over-head irrigation was provided with a watering cane to the plots once immediately after transplanting seedlings in every alternate day in the evening up to seedling establishment. Further irrigation was provided when needed. Excess water was effectively drained out at the time of heavy rain.

3.14.2 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.

3.14.3 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.

3.14.4 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. Earthening up operation was done immediately after top-dressing with nitrogen fertilizer.

3.14.5 Control of pest and disease

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

3.15 Harvesting

Fruits were harvested at 3 day intervals during early ripe stage when they attained slightly red color. Harvesting was started from 26 February, 2012 and was continued up to 25 March, 2013.

3.16 Collection of data

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

3.16.1 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 20, 30, 40, 50 and 60 days after planting to observe the growth rate.

3.16.2 Number of leaves

Number of leaves was measured from the sample plants in centimeter from the ground level to the tip of the longest stem and mean value was calculated. Number of leaves was recorded from 20, 30, 40, 50 and 60 days of planting to observe the growth rate of the plants.

3.16.3 Number of flower clusters per plant

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

3.16.4 Number of flowers per cluster

The number of flowers per cluster was calculated as follows:

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

3.16.5 Number of fruit in clusters per plant

The number of fruit clusters was recorded from the five sample plants, and the average number of fruit clusters produced per plant was recorded.

3.16.6 Fruit Diameter

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 20 selected marketable fruits from each plot and their average was calculated in centimeter. Diameter or fruit was measured at the middle portion of 20 selected marketable fruits from each plot with a slide calipers and their average was calculated in centimeter.

3.16.7 % Dry matter content in leaves

After harvesting, randomly selected 100 g plant leaf sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60°C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of leaf were computed by the following formula:

$$\text{\% Dry matter content of leaf} = \frac{\text{Dry weight of leaf (g)}}{\text{Fresh weight of leaf (g)}} \times 100$$

3.16.8 % Dry matter content in fruit

After harvesting, randomly selected 100 g fruit sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60°C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of fruit were computed by simple calculation from the weight recorded by the following formula:

$$\text{\% Dry matter content of fruit} = \frac{\text{Dry weight of fruit (g)}}{\text{Fresh weight of fruit (g)}} \times 100$$

3.16.9 Fruit yield per plant

A pan scale balance was used to take the weight or fruits per plot. It was measured by totaling of fruit yield from each unit plot during the period from first to final harvest and was recorded in kilogram.

3.16.10 Fruit yield per hectare

It was measured by the following formula:

$$\text{Fruit Yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg) x } 10000m^2}{\text{Area of plot in square meter } (m^2) \text{ x l 000kg}}$$

3.17 Analysis of data

The data in respect of growth, yield contributing characters and yield were statistically analyzed to find out the statistical significance. The means for all the treatments were calculated and the analysis of variance for all the characters was performed by F test. The significance of the difference among the means was evaluated by Duncan’s Multiple Range Test (DMRT) according to Gomez and Gomez, (1984) for interpretation of the results at 5% and 1% level of probability.

3.18 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of nitrogen and GA_3. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple interest rate. The market price of tomato was considered for estimating the cost and return. Analysis were done according to the procedure determining by Alam *et al.*, (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the effect of nitrogen and GA_3 on the growth and yield of tomato**.** The effects due to different levels of nitrogen and GA_3 and their interaction on the growth, yield contributing attributes and yield have been presented in Tables 2 to 3 and Figures 2 to 5. The results of each parameter studied in the experiment have been presented and discussed under the following headings.

4.1 Plant height

Plant height of tomato varied significantly due to the application of different levels of nitrogen at 20, 30, 40, 50, and 60 DAT (Appendix III). At 20 DAT the longest (27.73 cm) plant was recorded from N_2 (225 kg/ha), while the shortest (21.44 cm) plant was recorded from N_0 (0 kg N/ha). The longest (47.18 cm) plant was recorded from N_2 and the shortest (40.94 cm) plant was recorded from N_0 at 30 OAT. At 40 DAT the longest (77.62 cm) plant was recorded from N_2, while the shortest (71.05 cm) plant was recorded from N_0. The longest (98.40 cm) plant was recorded from N_2, while the shortest (91.27 cm) from N_0 at 50 DAT. At 60 DAT the longest (106.6 cm) plant was recorded from N_2, while the shortest (100.2 cm) plant was recorded from N_0 (Table 2). Probably all micro and macro nutrients for 225 kg N/ha ensured the favorable condition for growth of tomato plant and the ultimate results is the tallest plant whereas above this level of nitrogen hinder the growth and plant height decreases. Melton and Dufault (1991) found that plant height of tomato was increased as highest level of nitrogen. Similar results were reported by Chung *et al.* (1992).

Plant height of tomato varied significantly due to the application of different level of GA_3 at 20, 30, 40, 50, and 60 DAT. At 20 DAT (Appendix III) the longest (26.79 cm) plant was recorded from G_1 (50 ppm GA_3), while the shortest (22.63 cm) plant was recorded from G_0 (0 ppm GA_3). The longest (46.93 cm) plant was recorded from G_2 and the shortest (42.19 cm) plant was recorded from G_0 at 30 DAT. At 40 DAT the longest (76.85 cm) plant was recorded from G_1, while the shortest (72.11 cm) plant was recorded from G_0. The longest (97.26 cm) plant was recorded from G_1, while the shortest (93.02 cm) from G_0 at 50 DAT. At 60 DAT the longest (106.5 cm) plant was recorded from G_1, while the shortest (101.2 cm) plant was recorded from G_0 (Table 2). Shittu and Adeleke (1999) reported similar findings.

Due to combined effect of nitrogen and GA3 showed statistically significant variation on plant height at 20, 30, 40, 50 and 60 DAT (Appendix III). At 20 DAT the longest (29.44 cm) plant was recorded from N_2G_1 (225 kg N/ha x 50 ppm GA_3) and the shortest (19.41 cm) plant was recorded from N_0G_0 (0 kg N/ha x 0 ppm GA_3). The tallest plant (50.11 cm) was recorded from N_2G_1 (225 kg N/ha x 50 ppm GA_3) and the shortest (39.33 cm) was recorded from N_0G_0 (0 kg N/ha x 0 ppm GA_3) at 30 DAT. At 40, 50 and 60 DAT the similar trends of results was found on plant height due combined effect of nitrogen and GA_3 (Table 3).

Table 2. Effect of nitrogen and GA_3 on plant height of tomato

Treatments	Plant height(cm)				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Nitrogen					
N_0	21.44 d	40.94 c	71.05 c	91.27 c	100.2 c
N_1	24.91 c	45.02 b	74.80 b	95.36 b	104.7 b
N_2	27.73 a	47.18 a	77.62 a	98.40 a	106.6 a
N_3	26.09 b	46.04 ab	75.54 b	96.21 b	105.5 ab
% LSD	1.102	1.761	1.992	1.803	1.032
GA_3					
G_0	22.63 c	42.19 b	72.11 c	93.02 b	101.2 b
G_1	26.79 a	46.93 a	76.85 a	97.26 a	106.5 a
G_2	25.72 b	45.26 a	75.30 b	95.64 a	105.1 a
% LSD	1.039	1.771	1.003	1.824	1.989
% CV	7.23	5.66	6.75	7.99	8.23

N_0 = 0 kg N ha^{-1}

N_1 = 200 kg N ha^{-1}

N_2 = 225 kg N ha^{-1}

N_3 = 250 kg N ha^{-1}

G_0 = 0 ppm GA_3

G_1 = 50 ppm GA_3

G_2 = 70 ppm GA_3

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

Table 3. Combined effects of nitrogen and GA_3 on the plant height of tomato

Treatments	Plant height(cm)				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
N_0G_0	19.41 f	39.33 g	68.67 g	89.33 g	94.67 e
N_0G_1	22.46 e	42.37 ef	72.70 ef	93.03 ef	103.0 d
N_0G_2	22.45 e	41.11 fg	71.78 f	91.45 f	102.8 d
N_1G_0	22.54 e	43.21 de	72.88 ef	94.21 de	102.9 d
N_1G_1	27.31 c	46.98 b	76.98 c	97.31 c	107.0 ab
N_1G_2	24.88 d	44.88 cd	74.55 d	94.55 de	104.2 cd
N_2G_0	25.21 d	42.88 def	73.55 de	95.21 d	104.2 cd
N_2G_1	29.44 a	50.11 a	80.44 a	100.4 a	108.4 a
N_2G_2	28.55 ab	48.55 ab	78.88 b	99.55 ab	107.2 ab
N_3G_0	23.34 e	46.77 b	73.34 de	93.34 e	103.0 d
N_3G_1	27.93 bc	43.34 de	77.27 c	98.27 bc	107.6 ab
N_3G_2	27.00 c	48.27 ab	76.00 c	97.03 c	106.0 bc
% LSD	1.174	1.878	1.209	1.676	1.792
% CV	7.23	5.66	6.75	7.99	8.23

N_0 = 0 kg N ha^{-1} G_0 = 0 ppm GA_3

N_1 = 200 kg N ha^{-1} G_1 = 50 ppm GA_3

N_2 = 225 kg N ha^{-1} G_2 = 70 ppm GA_3

N_3 = 250 kg N ha^{-1}

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

4.2 Number of leaves

Number of leaves of tomato varied significantly due to the application of different level of nitrogen at 20, 30, 40, 50, and 60 DAT (Appendix III). At 20 DAT the maximum number of leaves (6.74) was observed in N_2 (225 kg/ha), while the minimum number of leaves (4.17) was obtained from N_0 (0 kg N/ha). The maximum number of leaves (8.94) was recorded from N_2 and the minimum number of leaves (7.112) was recorded from N_0 at 30 DAT. At 40 DAT the maximum number of leaves (15.11) was recorded from N_2, which is statistically similar to N_1 (13.96) and the minimum number of leaves (11.69) was recorded from N_0. The maximum number of leaves (21.74) was observed in from N_2, while the minimum (18.80) from N_0 at 50 DAT. At 60 DAT the maximum number of leaves (35.20) was found from N_2 and the minimum (31.18) was obtained from N_0 (Table 4). Melton and Dafult (1991) reported similar result.

Number of leaves of tomato varied significantly due to the application of different level of GA_3 at 20, 30, 40, 50, and 60 DAT (Appendix III). At 20 DAT the maximum number of leaves (5.91) was recorded from G_1 (50 ppm GA_3), while the minimum (5.31) was found from G_0 (0 ppm GA_3). The maximum number of leaves (8.61) was recorded from G_1 (50 ppm GA_3) and the minimum (7.54) was recorded from G_0 at 30 DAT. At 40 DAT the maximum number of leaves (14.38) was recorded from G_1, which is statistically identical to G_2 (13.42) while the minimum (13.06) plant was obtained from G_0. The maximum number of leaves (21.13) was recorded from G_1, which is statistically similar to G_2 and the minimum (19.27) from G_0 at 50 DAT. At 60 DAT the number of leaves (35.14) plant was recorded from G_1, and the minimum (31.73) was produced by G_0 (Table 4). Briant. R.E.(1974) found similar result with application GA_3 in tomato.

Combined effect of nitrogen and GA_3 showed statistically significant variation for no. of leaves at 20, 30, 40, 50 and 60 DAT (Appendix III). At 20 DAT the maximum no. of leaves (6.91) was recorded from N_2G_1 (225 kg N/ha x 50 ppm GA_3) and the minimum (3.90) was recorded from N_0G_0 (0 kg N/ha x 0 ppm GA_3). The maximum no. of leaves (9.48) was recorded from N_2G_1 (225 kg N/ha x 50 ppm GA_3) which is statistically similar to N_2G_2 and the minimum (6.79) was recorded from N_0G_0 (0 kg N/ha x 0 ppm GA_3) at 30 DAT. At 40, 50 and 60 DAT the similar trends of results was obtained from the combined effect of different levels of nitrogen and GA_3 (Table 5).

Table 4. Effect of nitrogen and GA_3 on the number of leaves of tomato

Treatments	Number of leaves				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Nitrogen					
N_0	4.17 d	7.11 d	11.69 c	18.80 d	31.18 c
N_1	5.32 c	7.93 c	13.96 ab	19.79 c	33.12 b
N_2	6.74 a	8.94 a	15.11 a	21.74 a	35.20 a
N_3	6.27 b	8.30 b	13.74 b	21.00 b	33.72 b
% LSD	0.1923	0.2896	1.270	0.6653	1.312
GA_3					
G_0	5.31 c	7.54 c	13.06 b	19.27 b	31.73 c
G_1	5.91 a	8.61 a	14.38 a	21.13 a	35.14 a
G_2	5.65 b	8.06 b	13.42 ab	20.61 a	33.04 b
% LSD	0.2020	0.2875	1.296	0.563	1.109
% CV	6.40	8.62	7.21	9.10	8.10

N_0 = 0 kg N ha^{-1}
N_1 = 200 kg N ha^{-1}
N_2 = 225 kg N ha^{-1}
N_3 = 250 kg N ha^{-1}

G_0 = 0 ppm GA_3
G_1 = 50 ppm GA_3
G_2 = 70 ppm GA_3

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

Table 5. Combined effect of nitrogen and GA_3 on the number of leaves of tomato

Treatments	Number of leaves per plant				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
N_0G_0	3.90 i	6.79 g	11.00 f	18.00 i	30.07 g
N_0G_1	4.43 g	7.50 e	12.50 de	19.13 h	32.37 def
N_0G_2	4.17 h	7.04 fg	11.57 ef	19.27 gh	31.10 fg
N_1G_0	4.88 f	7.20 ef	13.30 cd	19.00 h	32.03 ef
N_1G_1	5.76 d	8.65 c	14.70 b	20.60 de	34.40 c
N_1G_2	5.34 e	7.96 d	13.87 bc	19.77 fgh	32.93 de
N_2G_0	6.58 bc	8.25 d	14.40 bc	20.00 efg	33.00 de
N_2G_1	6.91 a	9.48 a	16.37 a	23.10 a	37.93 a
N_2G_2	6.74 ab	9.08 b	14.57 bc	22.13 b	34.67 c
N_3G_0	5.90 d	7.93 d	13.56 bcd	20.07 ef	31.83 ef
N_3G_1	6.55 bc	8.80 bc	13.97 bc	21.67 bc	35.87 b
N_3G_2	6.37 c	8.18 d	13.70 bcd	21.27 cd	33.47 cd
% LSD	0.2060	0.3299	1.169	0.7007	1.177
% CV	6.40	8.62	7.21	9.10	8.10

N_0 = 0 kg N ha^{-1}
N_1 = 200 kg N ha^{-1}
N_2 = 225 kg N ha^{-1}
N_3 = 250 kg N ha^{-1}

G_0 = 0 ppm GA_3
G_1 = 50 ppm GA_3
G_2 = 70 ppm GA_3

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

4.3 Number of flower clusters per plant

The effect of different levels of nitrogen in respect of flower clusters per plant was significant (Appendix III). The maximum number of flower clusters per plant (14.47) was found from 225 kg N/ha and the minimum (10.82) was found from no nitrogen or the control treatment (Table 6). Midan *et al.* (1985) reported similar type result

The number of flower clusters per plant was also significantly influenced by GA_3 (Appendix III). The highest number of flower clusters per plant (14.65) was found from G_1 and the lowest number of flowers clusters per plant (11.73) was found from control (Table 6). Onofeghara (1981) also found similar result.

There was statistically significant difference among the treatment combinations in respect of number of flower clusters per plant. It was evident that the treatment combination of 225 kg N/ha and 50 ppm GA_3 gave the maximum number of flower clusters per plant (16.27) and the minimum number of flower cluster per plant (9.00) was recorded from the treatment combination of 0 kg N/ha and 0 ppm GA_3 (Table 7).

4.4 Number of flowers per cluster

A significant variation in the number of flowers per cluster was observed due to effect of different levels of nitrogen (Appendix III). The highest number of flowers per cluster (5.73) was produced at 225 kg N/ha which was statistically similar to N_3 (5.30) and the minimum (3.84) was produced at 0 kg N/ha (Table 6). The results show that the number of flowers per cluster was gradually increased with increasing levels of nitrogen. Garrison *et al.* (1967) reported that increasing levels of nitrogen increased flower formation of several clusters of processing tomato.

The variation in number of flowers per cluster at different GA_3 levels was significant. The highest number of flowers per cluster (5.50) was produced in 50 ppm GA_3 and the lowest number (4.20) was obtained from control (Table 6). Saleh and Abdul (1980) also agreed the findings of present study.

Combined effect or different levels or nitrogen and GA_3 on number of flowers per cluster were found to be significant. The maximum number of flowers per cluster (6.56) was observed in the treatment combination of 225 kg N/ha and GA_3 and the minimum (3.33) from 0 kg N/ha and no GA_3 (Table 7).

4.5 Number of fruit clusters per plant

The number of fruit clusters per plant at different levels of nitrogen was found to be significant (Appendix III). The maximum number of fruit clusters per plant (6.11) was produced by nitrogen level of 225 kg/ha, which was statistically identical to N_3 (5.52) and the control treatment (0 kg N/ha) produced the minimum number of fruit clusters per plant (3.95) (Table 6). Nassar (1986) also found that high nitrogen level tended to increase average number of fruit clusters per plant.

There was significant difference among the different GA_3 levels on the number of fruit clusters per plant. The highest number of fruit clusters per plant (5.77) was produced by 50 ppm GA_3 plants and the lowest number of fruit clusters per plant (4.53) was recorded in control plants (Table 6). Saleh and Abdul (1980) also found similar trend of result which is support to the present findings.

There was significant interaction effect between different nitrogen levels and GA_3 in case of number of fruit clusters per plant. The plants fertilized with nitrogen at 225 kg/ha with GA_3 50 ppm produced the maximum number of fruit clusters (7.00) and those of 0 kg N/ha with 0 ppm GA_3 plants produced the minimum number of fruit clusters per plant (3.66) (Table 6).

4.6 Fruit diameter

The variation in diameter of fruit among the different doses of nitrogen was found to be statistically significant (Appendix III). The maximum diameter of fruit (7.17 cm) was found from the plants grown with 225 kg N/ha and then decreased gradually with the decreasing rates of nitrogen, while the minimum (5.67) was produced from the control treatment (Table 6). Similar opinions were put by Islam *et al.* (1997). They reported that the breadth of individual fruit was increased with the increased nitrogen levels. Nassar (1986) also reported similar results.

Application of GA_3 had a significant effect in respect of diameter of individual fruit. The maximum fruit diameter (7.15 cm) was obtained from 50 ppm GA_3 plants, which was statistically similar to G_2 (6.55) Whereas, the minimum (5.96 cm) was obtained from control plants (Table 6). Sawhnuy and Greyson (1972) also reported the similar findings.

The combined effect or different levels of nitrogen and GA_3 on the fruit diameter was found to be statistically significant (Appendix III). The maximum fruit diameter (7.66 cm) was found from the treatment combination of 225 kg N/ha and 50 ppm GA_3 and the minimum (5.26 cm) from the combination of 0 kg N/ha and no GA_3 (Table 7).

Table 6. Effects of nitrogen and GA_3 on yield contributing characters of tomato

Treatments	No. of flower cluster / plant	No. of flower / cluster	No. of fruit cluster / plant	Fruit diameter(cm)
Nitrogen				
N_0	10.82 b	3.84 b	3.95 c	5.67 b
N_1	13.57 a	4.42 b	4.82 bc	6.54 ab
N_2	14.47 a	5.73 a	6.11 a	7.17 a
N_3	14.13 a	5.30 a	5.52 ab	6.83 a
% LSD	1.379	0.776	1.088	1.133
GA_3				
G_0	11.73 c	4.20 b	4.53 b	5.96 b
G_1	14.65 a	5.50 a	5.77 a	7.15 a
G_2	13.36 b	4.77 b	5.00 ab	6.55 ab
% LSD	1.161	0.701	1.116	1.080
% CV	7.76	9.36	10.12	10.69

N_0 = 0 kg N ha^{-1}

N_1 = 200 kg N ha^{-1}

N_2 = 225 kg N ha^{-1}

N_3 = 250 kg N ha^{-1}

G_0 = 0 ppm GA_3

G_1 = 50 ppm GA_3

G_2 = 70 ppm GA_3

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

Table 7. Combined effect of nitrogen and GA_3 on yield contributing characters of tomato

Treatments	No. of flower cluster / plant	No. of flower / cluster	No. of fruit cluster / plant	Fruit diameter(cm)
N_0G_0	9.00 f	3.33 g	3.66 e	5.26 f
N_0G_1	12.17 de	4.46 de	4.46 de	6.30 bcdef
N_0G_2	11.30 e	3.73 fg	3.73 e	5.46 ef
N_1G_0	12.33 d	4.00 ef	4.33 de	5.93 def
N_1G_1	14.33 b	5.00 cd	5.33 bcd	7.13 abcd
N_1G_2	14.03 b	4.26 ef	4.80 cde	6.56 abcde
N_2G_0	12.67 d	5.00 cd	5.33 bcd	6.66 abcde
N_2G_1	16.27 a	6.56 a	7.00 a	7.66 a
N_2G_2	14.47 b	5.63 bc	6.00 abc	7.20 abc
N_3G_0	12.93 cd	4.46 de	4.80 de	6.00 cdef
N_3G_1	15.83 a	5.96 ab	6.30 ab	7.50 ab
N_3G_2	13.63 bc	5.46 bc	5.46 bcd	7.00 abcd
% LSD	0.888	0.665	1.086	1.079
% CV	7.76	9.36	10.12	10.69

N_0 = 0 kg N ha^{-1} G_0 = 0 ppm GA_3

N_1 = 200 kg N ha^{-1} G_1 = 50 ppm GA_3

N_2 = 225 kg N ha^{-1} G_2 = 70 ppm GA_3

N_3 = 250 kg N ha^{-1}

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

4.7 Weight of fruits per plant

It was noticed that different levels of nitrogen exhibited significant effect on the weight of fruits per plant (Appendix III). The plant fertilized with 225 kg N/ha produced the maximum weight (1862 g) of fruits which was statistically identical to N_3 (1838 gm) and the minimum weight (1538 gm) was obtained from N_0. Islam *et. al* (1997) reported that the highest fruit weight per plant was produced at 250 kg N/ha (Table 8). Similar effects of different nitrogen levels in respect of' fruit weight per plant have been reported by Varis and George (1985).

The weight of fruits per plant was significantly influenced by different levels of GA_3 (Appendix III). The maximum weight (1824 gm) was found from G_1 and the minimum weigh (1610 gm) was recorded from G_0 (Table 8). Lilov and Donchev (1984) also found similar results by the application of GA_3.

There was significant combined effect of different levels of nitrogen and GA_3 on the weight of fruits per plant (Appendix III). The maximum fruit weight per plant (2023 g) was obtained from the treatment combination of 225 kg N/ha and 50 ppm GA_3 which was favorable conditions than other treatment combinations. The lowest (1417 g) in this respect was found from the treatment combination of 0 kg N/ha and no GA_3. This result clearly indicated that the weight of fruits per plant was increased with every increment in nitrogen dose up to the highest level (225kg N/ha) with 50 ppm GA_3 (Table 9).

4.8 Dry matter content in leaves

Statistically significant variation was recorded on dry matter content in leaves due to application of different levels of nitrogen (Appendix III). The highest dry matter content in leaves (16.32 %) was obtained from N_2 (225 kg N/ha) whereas the lowest dry matter content in leaves (11.80 %) was observed in N_o treatment (Table 8). Patil and Bojoppa (1984) found similar results with the application of nitrogen.

A statistical significant variation was recorded on dry matter content in leaf due to effect of different concentrations of GA_3 (Appendix III). The highest dry matter content in leaves (16.18%) was obtained from G_1 (50 ppm) whereas the lowest dry matter content in leaves (12.35%) was observed in G_0 (control) condition (Table 8).

Combination effect of different levels of nitrogen and GA_3 showed statistically significant variation on dry matter content in leaves (Appendix III). The highest dry matter content in leaves (19.57 %) was found from N_2G_1 (225 kg N/ha x 50 ppm GA_3)., while the lowest dry matter content in leaves (10.33 %) was recorded from N_0G_0 (0 kg N/ha x 50 ppm GA_3) (Table 9).

4.9 Dry matter content in fruits

Statistically significant variation was recorded on dry matter content in fruits due to effect of different levels of nitrogen (Appendix III). The highest dry matter content in fruits (6.45 %) was obtained from N_2 (225 kg N/ha) whereas the lowest dry matter content in fruits (4.45 %) was found from N_o i.e. control condition (Table 8). Similar results also found from Islam *et al.,* (1997).

A statistically significant variation was recorded for dry matter content in fruits due to different concentrations of GA_3 (Appendix III). The highest dry matter content in fruits (5.94 %) was obtained from G_1 (50 ppm) whereas, the lowest dry matter content in fruits (4.97%) was observed from G_0 i.e. control condition (Table 8). Gabal *et al.,* (1990) also found similar results.

Combination effect of nitrogen and GA_3 showed statistically significant variation for dry matter content in fruits (Appendix III). The highest dry matter content in fruits (7.0 %) was found from N_2G_1 (225 kg N/ha x 50 ppm GA_3), while the lowest dry matter content in fruits (3.96 %) was recorded from N_0G_0 (0 kg N/ha x 50 ppm GA_3) (Table 9).

Table 8. Effect of nitrogen and GA_3 on yield contributing characters and yield of tomato

Treatments	Weight of fruit / plant(g)	Dry matter of leaf (%)	Dry matter of fruit (%)
Nitrogen			
N_0	1538 c	11.80 c	4.45 c
N_1	1646 b	13.66 b	5.40 b
N_2	1862 a	16.32 a	6.45 a
N_3	1838 a	15.33 a	5.42 b
% LSD	83.25	1.345	0.4734
GA_3			
G_0	1610 c	12.35 c	4.97 b
G_1	1824 a	16.18 a	5.94 a
G_2	1729 b	14.30 b	5.38 b
% LSD	71.76	1.179	0.529
% CV	8.82	7.26	5.16

N_0 = 0 kg N ha^{-1}

N_1 = 200 kg N ha^{-1}

N_2 = 225 kg N ha^{-1}

N_3 = 250 kg N ha^{-1}

G_0 = 0 ppm GA_3

G_1 = 50 ppm GA_3

G_2 = 70 ppm GA_3

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

Table 9. Combined effect of nitrogen and GA_3 on yield contributing characters and yield of tomato

Treatments	Weight of fruit per plant (g)	Dry matter % (leaf)	Dry matter % (fruit)
N_0G_0	1417 h	10.33 g	3.96 h
N_0G_1	1550 g	13.17 def	4.96 ef
N_0G_2	1646 f	11.90 f	4.43 g
N_1G_0	1535 g	12.67 ef	4.83 fg
N_1G_1	1661 ef	14.33 d	6.00 bc
N_1G_2	1742 de	13.97 de	5.36 de
N_2G_0	1700 def	13.73 de	6.00 bc
N_2G_1	2023 a	19.57 a	7.00 a
N_2G_2	1863 bc	15.67 c	6.36 b
N_3G_0	1787 cd	12.67 ef	5.10 ef
N_3G_1	1843 bc	17.67 b	5.80 cd
N_3G_2	1884 b	15.67 c	5.36 de
% LSD	83.25	1.230	0.4448
% CV	8.82	7.26	5.16

N_0 = 0 kg N ha^{-1}

N_1 = 200 kg N ha^{-1}

N_2 = 225 kg N ha^{-1}

N_3 = 250 kg N ha^{-1}

G_0 = 0 ppm GA_3

G_1 = 50 ppm GA_3

G_2 = 70 ppm GA_3

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

4.10 Fruit yield per hectare

The fruit yield per hectare was also significantly influenced by different levels of nitrogen (Appendix III). The height yield (47.02 t/ha) was produced due to application of 225 kg N/ha and lowest yield (35.26 t/ha) was performed by control condition (0 kg N/ha). Similarly Islam *et al.*, (1997) reported that 250kg N/ha gave the height fruit yield. Profound influence of nitrogen level to increase tomato yield has been reported by many authors (Doss *et al.*, 1981, Varis and George, 1985, Midan *et al.*, 1985 and Kaniszcwski *et.al* (1987). Kaniszewski *et. al* (1987) found a significant increase in total yield of tomato fruit in the nitrogen fertilization up to 225 kg N/ha. Nassar (1986) reported that the maximum yield was achieved at 296 kg N/ha (Fig. 2).

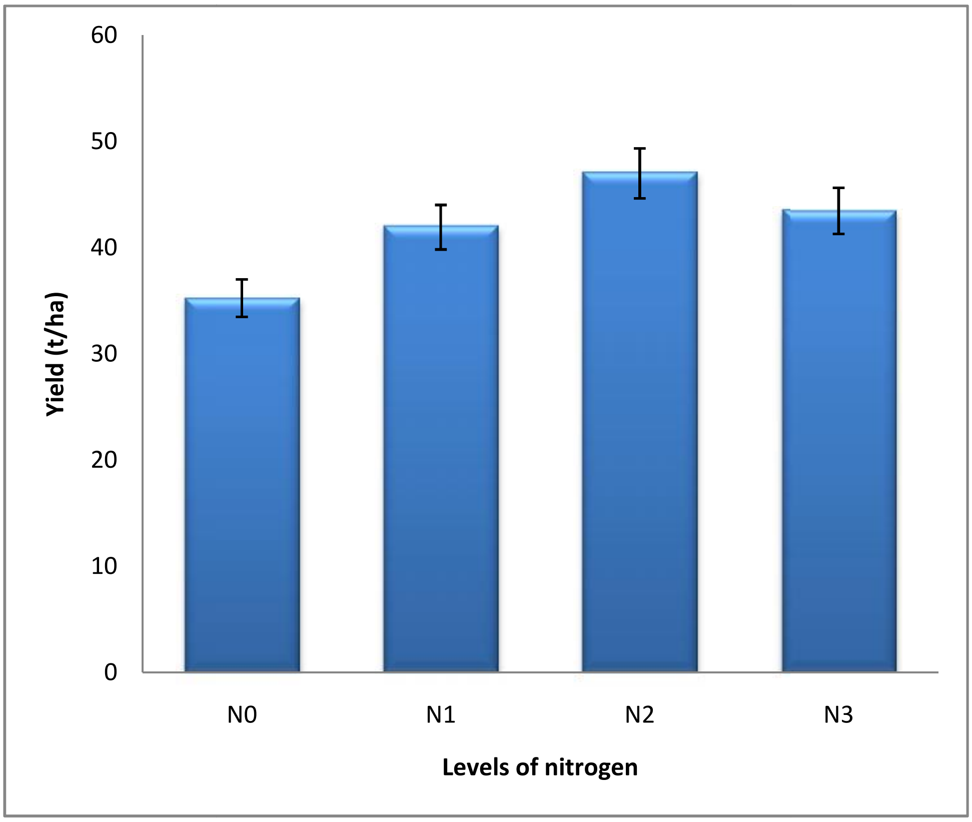

Fig. 2: Effect of nitrogen on the yield of tomato.

Different levels of GA_3 significantly influenced on the yield of fruit per hectare. It was evident from the highest yield (46.09 t/ha) was recorded from 50 ppm GA_3 and the lowest yield was (34.82 t/ha) from control condition (Fig .3). Kaushik *et al.*, (1974) supported this findings.

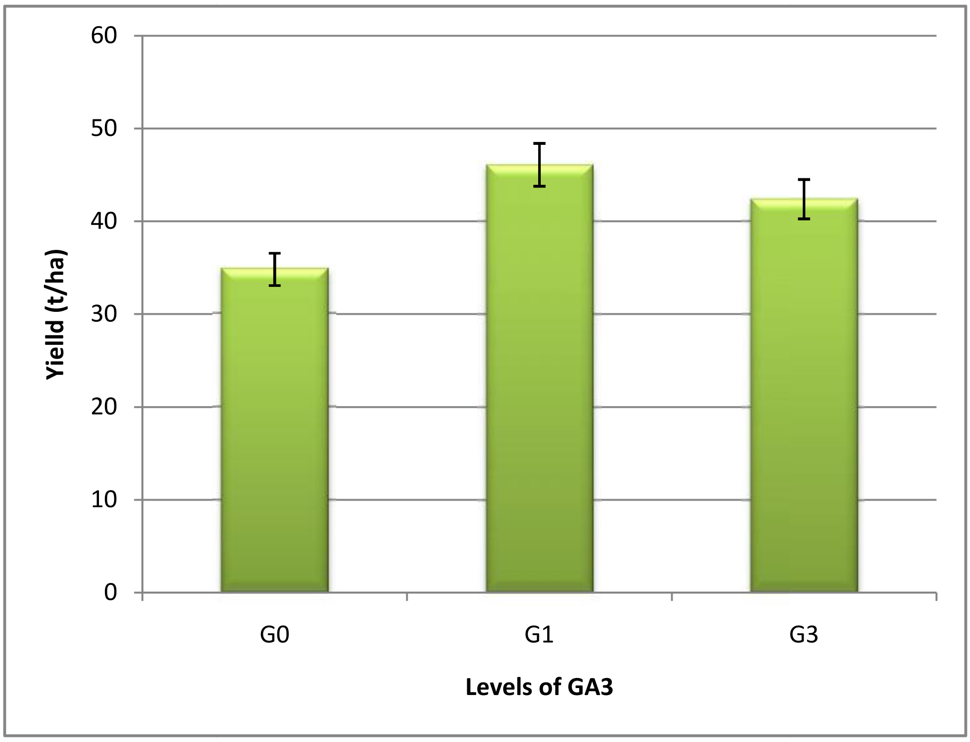

Fig. 3: Effect of GA_3 on the yield of tomato.

Due to combined effect of different levels of nitrogen and GA_3 performed significant effect on yield per hectare (Appendix III). The treatment combination of 225 kg N/ha and 50 ppm GA_3 gave the maximum yield (49.29 t/ha) and the minimum yield (35.02 t/ha) was round from the treatment combination on no nitrogen and no GA_3 (Fig .4).

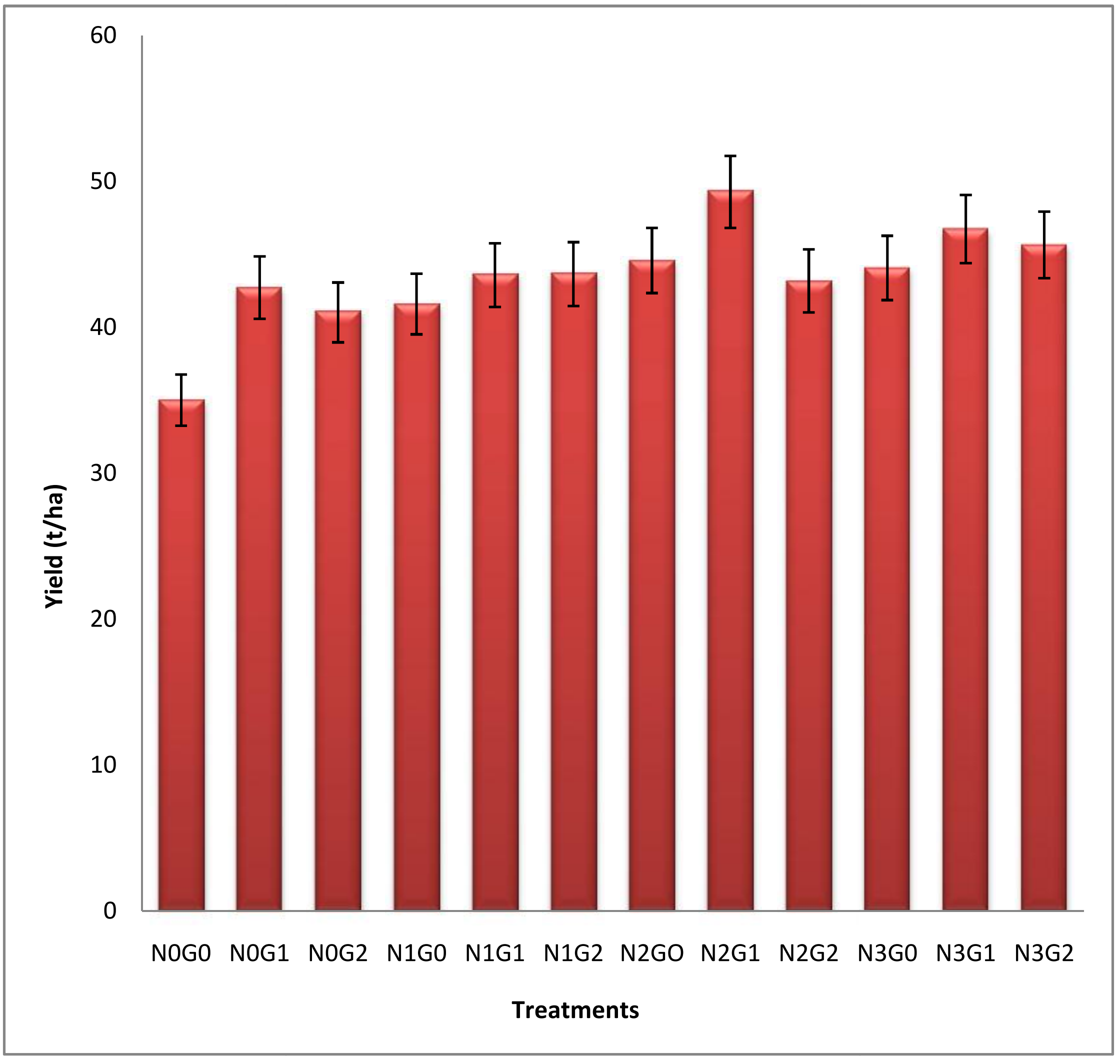

Fig. 4: Combination effect of nitrogen and GA_3 on the yield of tomato.

4.11 Economic analysis

Input costs for land preparation, seed cost, fertilizer & manure cost and man power required for all the operations from transplanting of seedling to harvesting of tomato were recorded for unit plot and converted into cost per hectare. Prices of tomato were considered in market rate basis of Karwan Bazar, Dhaka. The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings:-

4.11.1 Gross return

In the combination of nitrogen and GA_3 showed different gross return under the trial. The highest gross return (Tk. 519349.5/ha) was obtained from N_2G_1 (225 kg N/ha x 50 ppm GA_3) and the second highest gross return (Tk. 495114.5/ha) was obtained from N_1G_1 (200 kg N/ha x 50 ppm). The lowest gross return (Tk, 451950/ha) was obtained from N_0G_0 (Table 10).

4.11.2 Net return

In case of net return different treatment combination showed different values of net return (Table 10). The highest net return (Tk, 283676.5/ha) was obtained from N_2G_1 and the second highest net return (Tk, 263302.5/ha) was obtained from N_1G_1. The lowest net return (Tk, 222926/ha) was obtained from N_0G_0 (Table 10).

4.11.3 Benefit cost ratio (BCR)

The combination of nitrogen and GA_3 for benefit cost ratio was different in all treatment combination (Table 10). The highest benefit cost ratio (2.21) was obtained from N_2G_1 and the second highest benefit cost ratio (2.14) was estimated N_1G_1. The lowest benefit cost ratio (1.98) was obtained from N_0G_0. From economic point of view, it is apparent from the above results that N_2G_1 was more profitable than rest of the treatment combination.

Table 10. Combined effect of nitrogen and GA_3 on total net return contributing characters and yield of tomato.

Treatments	Cost of production (Tk./ha)	Yield of tomato (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
N_0G_0	229024	69.00	451950	222926	1.98
N_0G_1	231812	72.73	476381.5	244369.5	2.05
N_0G_2	234132	72.03	471796.5	237664.5	2.02
N_1G_0	230812	72.61	475595.5	244783.5	2.07
N_1G_1	232012	75.59	495114.5	263302.5	2.13
N_1G_2	236745	73.66	482473	245728	2.04
N_2G_0	234041	75.59	495114.5	261073.5	2.12
N_2G_1	235673	79.29	519349.5	283676.5	2.21
N_2G_2	237452	76.19	499044.5	261592.5	2.11
N_3G_0	232453	74.08	484962	252509	2.09
N_3G_1	236784	76.74	502647	265863	2.13
N_3G_2	238453	75.66	495573	257120	2.08

Rate of tomato (22 Tk/kg) in peak period at Karwan Bazar, Dhaka.

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted in the Horticultural farm of Sher-e-Bangla Agricultural University Dhaka 1207, (Tejgaon series under AEZ No.28) from October 2012 to March 2013, to study the Effect of different levels of nitrogen and different concentrations of GA_3 on the growth and yield of tomato. The soil was silty clay loam in texture having pH 5.71 and organic carbon content of 0.68%. Four levels of nitrogen (0 kg urea, 210 kg urea, 225 kg urea and 240 kg urea) and three levels of GA_3 (0, 50 ppm and 70 ppm) and were used in the study. Levels of these two nutrient elements make 12 treatment combinations. The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 2 m x 1.8 m which accommodated 15 plants. The crop was harvested from 26 February to 24 March, 2013.

Data on growth and yield contributing parameters were recorded, and the collected data were statistically analyzed to evaluate the treatment effects. The summary of the results has been presented in this chapter.

At 60 days after transplantation nitrogen had a significant effect on plant height. Plants grown with higher doses of nitrogen showed a gradual increase in plant height. The tallest plant (106.6 cm) was produced by 225 kg N/ha, while the shortest (100.2 cm) plant was observed from 0 kg N/ha (control).

In case of GA_3, the tallest plant (106.5 cm) was produced by 50 ppm GA_3 and the shortest plant (101.2 cm) was shown by control plant. The treatment combinations demonstrated significant variation in plant height at 20, 30, 40, 50 and 60 DAT. At 60 DAT the tallest plant (108.4 cm) was produced by 225 kg N/ha and 50 ppm GA_3 while the shortest (94.67 cm) was shown from 0 kg N/ha and control GA_3.

At 60 DAT different levels of nitrogen showed significant effect on total number of leaves. The maximum value (35.20) of this character was found at the highest level of nitrogen (225 kg N/ha), and the minimum value was obtained from control (0 kg N/ha*)* treatment. On the other hand this parameter was also significantly influenced by different level of GA_3. The value of this character was the maximum (35.14) in 50 ppm GA_3 plants, but the minimum (31.73) in control 0 ppm plants. The maximum total number of leaves (37.93) was given by the combination of highest dose of nitrogen (225 kg N/ha) and 50 ppm GA_3.

Significant variation was observed in respect of the number of flower clusters and flowers per clusters as influenced by different levels of nitrogen and GA_3. At 60 DAT the highest values of these characters were obtained from 225 kg N/ha, and the lowest were obtained from the control (0 kg N/ha). In case 0f GA_3 the maximum number of flower clusters and flowers per p1ant were found from the 50 ppm GA_3 plants., but the minimum values were obtained from 0 ppm GA_3 plant. The highest number of flower clusters per plant (16.27) and flowers per cluster (6.56) were produced by the plants fertilized with highest doses of nitrogen, (225 kg/h) and 50 ppm GA_3, while the number of flowers per cluster was the minimum (3.33) and the number of flower cluster per plant (9.00) in 0 kg N/ha with 0 ppm GA_3.

At 60 DAT different levels of nitrogen showed significant effect on number of fruit cluster per plant. The maximum values (6.11) of this character was found at 225 kg N/ha and the minimum value (3.66) was obtained from control (0 kg N/ha*)* treatment. On the other hand this parameters was also significantly influenced by different level of GA_3. The values of this character was the maximum (5.77) in 50 ppm GA_3 plants, but the minimum (4.53) in control (0 ppm GA_3) plants.

At 60 DAT different levels of nitrogen showed significant effect on % of dry matter content in leaf and fruit. The maximum values of these characters were found at 225 kg N/ha and the minimum values were obtained from control (0 kg N/ha*)* treatment. On the other hand these parameters were also significantly influenced by different level of GA_3. The values of these characters were the maximum in 50 ppm GA_3 plants, but the minimum in control (0 ppm GA_3) plants. The maximum dry matter content in leaf (19.57 %) and dry matter content fruit (7%) were given by the combination of highest dose of nitrogen (225 kg N/ha) and 50 ppm GA_3.

At 60 DAT different levels of nitrogen showed significant effect on fruit yield per plant and per hectare. The maximum value (47.02) of this character was found from 225 kg N/ha and the minimum value (35.26) was obtained from control (0 kg N/ha*)* treatment. On the other hand this parameter was also significantly influenced by different level of GA_3. The values of these character was maximum (46.09) in 50 ppm GA_3 plants, but the minimum (34.82) was from control (0 ppm GA_3) plants. The maximum fruit yield (49.29 t/ha) and were given by the combination of highest dose of nitrogen (225 kg N/ha) and 50 ppm GA_3.

The highest gross return (519349.5 Tk/ha), net return (283676.5 Tk/ha), benefit cost ratio (2.21), was recorded from the combination of 225 kg N/ha and 40 ppm GA_3 whereas the lowest gross return (451950 Tk/ha), net return (222926 Tk/ha) and benefit cost ratio (1.98) was recorded from the combination of 0 kg N/ha and o ppm GA_3.

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

- Nitrogen played important role on the growth and fruit yield of tomato. In respect of all the yield attributes and yield, nitrogen showed better performance at the higher level (225 kg N/ha).
- The plants was produced the maximum growth and yield of tomato due application of 50 ppm GA_3.
- It may be drown the conclusion from above fact 225 kg N/ha and 50 ppm GA_3 is suitable combination for the tomato production. Further investigation may be done to observe in different agro-ecological zones before more conformation of the results.

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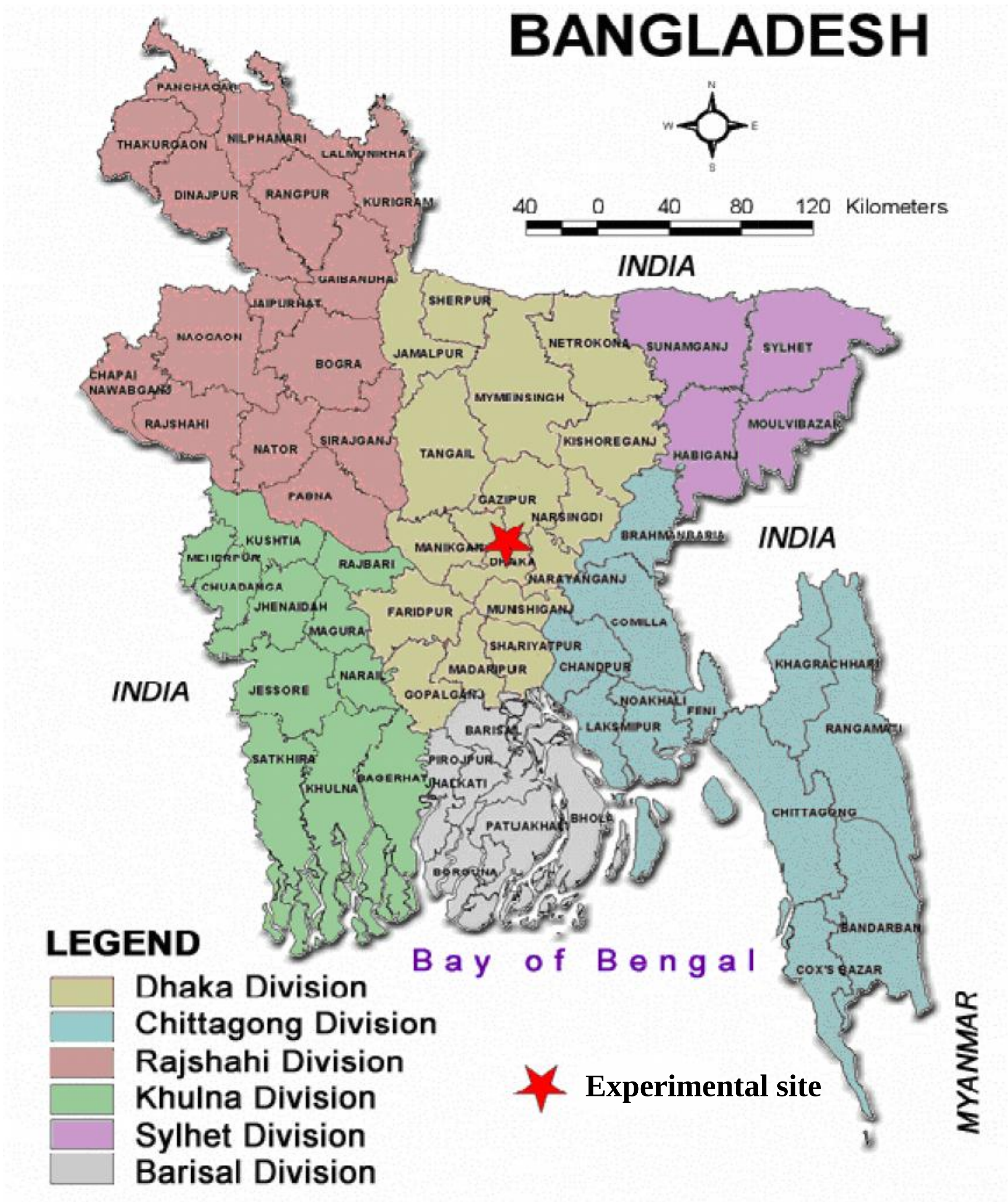
APPENDICES

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



The map of Bangladesh showing experimental site

Appendix II. (A) Records of meteorological information (monthly) during the period from October 2012 to March 2013

Name of Months	Air temperature (^0C)		Relative humidity	Rainfall (mm)
	Maximum	Minimum		
October, 2012	30	18	81	37
November, 2012	25	16	78	0
December, 2012	22	14	74	0
January, 2013	24	12	68	0
February, 2013	27	17	67	3
March, 2013	31	19	56	11

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

(B). Morphological characteristics of soil of the experimental plot

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

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

Source of variation	Degree of Freedom	Mean square				
		Plant Height				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replications	2	384.221	7.109	6.442	14.445	255.724
Treatment	11	75.465**	80.224**	242.481**	277.575**	235.846**
Factor -A (Nitrogen)	3	189.646**	243.345**	606.659**	822.224**	730.032**
Factor-B (GA_3)	2	123.710**	129.843**	426.666**	480.365*	445.463**
Interaction (AxB)	6	7.798**	7.196*	30.335**	19.179**	13.346**
Error	22	0.567	3.136	5.157	3.777	4.061

** Significant at 1% level

* Significant at 5% level

Appendix-III: Continued

Source of variation	Degree of Freedom	Mean square				
		Plant Height				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replications	2	7.437	0.543	1.092	0.332	4.431
Treatment	11	4.436**	3.167**	4.937**	4.108**	5.579**
Factor -A (Nitrogen)	3	18.182**	10.766**	12.786**	15.595**	16.816*
Factor-B (GA_3)	2	10.102**	9.936**	7.623**	7.983*	9.991**
Interaction (AxB)	6	0.636**	0.792**	0.808*	0.271*	0.265*
Error	22	0.816	0.918	0.888	0.782	0.619

** Significant at 1% level

* Significant at 5% level

Appendix-III: Continued

Source of variation	Degree of Freedom	Mean square							
		No. of flower cluster / plant	No. of flowers / cluster	No. of fruits in cluster / plant	Fruit diameter (cm)	Weight of fruit / plant (gm)	Dry matter content in leaf (%)	Dry matter content in fruit (%)	Fruit yield (t/ha)
Replications	2	6.263	7.219	8.017	2.919	3.138	4.743	1.067	0.733
Treatment	11	21.257*	12.777*	7.792**	8.716**	9.910**	8.010**	6.035*	0.817**
Factor -A (Nitrogen)	3	27.270**	21.631**	42.812**	30.394*	4.124**	5.562**	7.717**	0.999**
Factor-B (GA_3)	2	2.999*	7.109**	8.199**	20.370**	5.591**	6.617**	8.135**	1.876**
Interaction (AxB)	6	0.367**	0.855**	0.961*	1.272**	0.960**	4.067**	3.163**	2.122**
Error	22	10.167	0.189	0.789	0.452	0.818	0.776	0.397	

** Significant at 1% level

* Significant at 5% level

Appendix- IV: Production cost of tomato per hectare land

A. Input cost

Treatment	Labour cost	Ploughing cost	Seed cost	Insectic ide/Pest icide	Cowdung	Manure and fertilizers					Sticking	Sub total (A)
						Irrigation	Urea	TSP	MP	GA_3		
N_0G_0	22000	18000	7000	9000	40000	12000	00	13000	8000	00	8000	137000
N_0G_1	22000	18000	7000	9000	40000	12000	00	13000	8000	2000	8000	139000
N_0G_2	22000	18000	7000	9000	40000	12000	00	13000	8000	3000	8000	140000
N_1G_0	22000	18000	7000	9000	40000	12000	8000	13000	8000	00	8000	145000
N_1G_1	22000	18000	7000	9000	40000	12000	8000	13000	8000	2000	8000	147000
N_1G_2	22000	18000	7000	9000	40000	12000	8000	13000	8000	3000	8000	148000
N_2G_0	22000	18000	7000	9000	40000	12000	10000	13000	8000	00	8000	147000
N_2G_1	22000	18000	7000	9000	40000	12000	10000	13000	8000	2000	8000	149000
N_2G_2	22000	18000	7000	9000	40000	12000	10000	13000	8000	3000	8000	150000
N_3G_0	22000	18000	7000	9000	40000	12000	12000	13000	8000	00	8000	149000
N_3G_1	22000	18000	7000	9000	40000	12000	12000	13000	8000	2000	8000	151000
N_3G_2	22000	18000	7000	9000	40000	12000	12000	13000	8000	3000	8000	164000

N_0 = 0 kg N ha^{-1} G_0 = 0 ppm GA_3

N_1 = 200 kg N ha^{-1} G_1 = 50 ppm GA_3

N_2 = 225 kg N ha^{-1} G_2 = 70 ppm GA_3

N_3 = 250 kg N ha^{-1}

Appendix-IV: Continued
B. Overhead cost

Treatment	Cost of lease of land for 6 month (13% of value of land Tk. 8,oo,ooo/year	Miscellaneous cost (Tk. Of the input cost)	Interest on running capital for 6 months (tk. 13% of cost/year)	Sub total (Tk.) (B)	Total cost of production (Tk./ha) Total cost (A)+ overhead cost(B)
N_0G_0	52000	6850	14428	108178	229024
N_0G_1	52000	6950	14456	108226	232012
N_0G_2	52000	7000	14471	108251	234132
N_1G_0	52000	7250	14496	108294	230812
N_1G_1	52000	7350	14525	108343	231812
N_1G_2	52000	7400	14539	108367	236745
N_2G_0	52000	7350	14513	108323	234041
N_2G_1	52000	7450	14542	108372	235673
N_2G_2	52000	7500	14556	108396	237452
N_3G_0	52000	7450	14530	108352	232453
N_3G_1	52000	7550	14559	108401	236784
N_3G_2	52000	7700	14573	108425	238453

N_0 = 0 kg N ha^{-1} G_0 = 0 ppm GA_3
N_1 = 200 kg N ha^{-1} G_1 = 50 ppm GA_3
N_2 = 225 kg N ha^{-1} G_2 = 70 ppm GA_3
N_3 = 250 kg N ha^{-1}