EFFECT OF NITROGEN FERTILIZER ON MORPHOLOGY, GROWTH AND YIELD OF TOMATO

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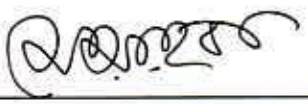

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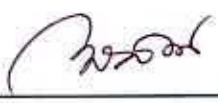

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF NITROGEN FERTILIZER ON MORPHOLOGY, GROWTH AND YIELD OF TOMATO" submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in AGRICULTURAL BOTANY, embodies the result of a piece of bonafide research work carried out by MILTON BISWAS Registration No. 041293 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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Dated:

Place: Dhaka, Bangladesh

Dedicated to

My

Beloved Parents

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ABSTRACT

A field experiment was carried out to study effect of nitrogen fertilizer on morphology, growth and yield of tomato at the farm of Sher-e-Bangla Agricultural University , Dhaka during October 2008 to March 2009 with four varieties, viz., BARI Tomato-4, BARI Tomato-5, BARI Tomato-7, BARI Tomato-9 of tomato and four levels of nitrogen viz., 0, 100, 150 and 200 kg N/ha using Randomized Complete Block Design (RCBD) with three replications. The total yield of tomato differed significantly due to the different varieties imposing different doses of nitrogen. The maximum yield of fruits per hectare (95.75 t/ha) was obtained from BARI Tomato-7 but the minimum yield of fruits per hectare (19.58 t/ha) was obtained from BARI Tomato-5. Different nitrogen had also significant influence on yield of tomato imposing 150 kg N/ha (N_2) resulted in the highest yield (61.42t/ha) over control (41.00 t/ha). In respect of combined effect, BARI Tomato-7 with 150 kg N/ha produced the highest yield per hectare (106.3 t/ha). On the other hand the lowest yield (14.33 t/ha) obtained from the BARI Tomato-5 without nitrogen application. Considering the above findings, BARI Tomato-7 with 150 kg N/ha seems to be recommendable for tomato production.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
HRC	=	Horticulture Research Centre
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Tomato (*Solanum lycopersicum* Mill.), belonging to the family Solanaceae, is one of the important, popular and nutritious vegetables grown in all parts of Bangladesh (Haque *et al.*, 1999) but now it also cultivated in summer. The origin of tomato is South America (Salunkhe *et al.*, 1987) particularly the Peru-Ecuador-Bolivia areas of Andes. It is adapted to a wide range of climates. At present, tomato ranks third, next to potato and sweet potato, in terms of world vegetable production (Anon., 2002). The leading tomato producing countries of the world are China, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (Anon., 1999).

Its food value is very rich because of higher contents of vitamins A, B and C including calcium and lycopene (Bose and Som, 1990). It is much popular as salad in the raw state and is made into soups, juice, ketchup, pickles, sauces, conserved puree, paste, powder and other products (Ahmed *et al.*, 1986; Thompson and Kelly, 1983 and Bose and Som, 1990).

Bangladesh produced 102 thousand tons of tomato in 15,790 thousand hectares of land during the year 2008-2009 and the average yield being 6.46 t ha^{-1} (Anon., 2010), which is very low in comparison with that of other countries, namely India (15.67 t/ha), Japan (52.82 t/ha) and USA (63.66 t/ha). The yield of tomato in Bangladesh is not satisfactory enough in comparison to requirement (Aditya *et al.*, 1999). The low yield of tomato in

Bangladesh, however, is not an indication of low yielding ability of this crop, but of the fact that the tomatoes grown here are not always of high yielding cultivars and that the cultural practices commonly used by the growers are not improved. Since the soil and climatic conditions of Bangladesh during the winter season are congenial to proper growth of tomato, it is expected that improved management practices would augment the yield considerably.

The meteorological data for the 10 years indicate that the crop suffer from cold injury during the month of January (Anon, 2007) which result shy yield of this crop. In some areas of the country particularly in the northern part the night temperature falls even below 10-12°C which results tremendous yield loss in tomato. This is why it is important to identify an appropriate planting time for successful production of tomato. The yield of tomato also depends on variety. By this time BARI released a good number of varieties viz., BARI Tomato-4, BARI Tomato-5, BARI Tomato-7 and BARI Tomato-9.

In Bangladesh, there is a great possibility of increasing tomato yield per unit area with the proper use of fertilizer. The profit from the use of commercial fertilizer has been so often demonstrated by experiment that there is no doubt about the necessity of using the right fertilizer dose and the economic returns resulting from then.Scientists also indicated the positive response of fertilizer application in increasing yield of different species of tomato. Tomato requires large quantity of readily available fertilizer nutrient (Gupta and Shukla, 1977). In determine type of tomato, vegetative and productive

stages overlap and the plants need nutrients up to fruit ripening. To get one ton fresh fruit, plant need to absorb on average 2.5-3 kg N. 0.2-0.3 kg P, and 3-3.5 kg K (Hedge, 1997). Nitrogen is essential for building up protoplasm and protein, which induces cell division and initial meristematic activity when applied in optimum quantity (Sing and Kumar, 1969). Nitrogen has the largest effect on yield and quality of tomato (Xin *et al.* 1997). It also promotes vegetation growth, flower and fruit set of tomato (Bose and Som, 1990). It significantly increases the growth and yield of tomato (Banerjee *et al.* 1997).

Though effect of different fertilizers for yield of tomato was studied earlier in Bangladesh but the specific dose of Nitrogen affecting yield and storage behavior of tomato fruits was not standardized so far it was reviewed.

Considering the above situation, the present experiment was designed to study doses of nitrogen on morphological changes and growth and Yield of tomato varitieties.

CHAPTER II

REVIEW OF LITERATURE

2.1 Effect of variety on growth and yield of tomato

Hamid *et al.* (2005)conducting research under Rawalakot conditions during the year 2003. The results indicated that maximum plant height and size of fruit were observed in variety Raickoi Naclazdenie, whereas maximum number of flower clusters and fruits per plant were observed in 'Patris'. Minimum plant height, number of flower clusters and fruits were noted in Novichok, where as minimum number of branches and fruit weight/plant was noted in Local Kashmir. Varieties Ceberckoi ckorocepali and Patris gave maximum fruit weight of 4.96 and 4.85 kg/plant compared to the minimum of 1.60 kg/plant by local check and Novichok. Exotic varieties Patris and Ceberckoi ckorocpali are recommended for commercial cultivation due to high production.

Rashid *et al.* (2000) carried out an experiment to evaluate thirty seven tomato varieties or lines for resistance to bacterial wilt in the sick bed in replicated trial. He observed that 26, 66, 33.33 and 30% incidence of wilt in BARI Tomato-4, BARI Tomato-6 and BARI Tomato-10 respectively.

Khalid (1999) conducting 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 observed the highest yield/plant from BINA Tomato-2 (1.74 kg), followed by BINA Tomato-3 (1.67 kg). But the yields of these varieties were statistically similar to each other.

In Nepal, an experiment was conducted by Lohar and Peat (1998) to study the floral characteristics of heat-tolerant and heat sensitive tomato cultivars at high temperature. They observed that, flowering was earliest in Pusa Ruby at 28/23° C (day/night) and latest in CL-1131 at 15/10° C (day/night). They also indicated that, cv. CL-1131 was suiable for cultivating at high temperature and producing an earlier crop. Cultivar Pusa Ruby produced fewer flowers and fruits at high temperature than CL-1131, but not in 15/10° C regime.

An experiment was conducted with tswo summer tomato varieties (BINA Tomato-2 and 3) to study the yield performance at 3 locations (Magura, Comilla and Khulna) during the summer season (BINA, 1998). It was obsertved that, BINA Tomato-2 produces higher fruit yield at Magura (38 t/ha) and Khulna (17 t/ha), while BINA Tomato-3 gave higher yield (29 t/ha) at Comilla. However, mean fruit yield from three locations showed that, the variety BINA Tomato-2 produced higher fruit yield than BINA Tomato-3.

Singh and Sahu (1998) conducted a field experiment at Keonjhar, Orissa, India during rabi 1991-92 and 1992-93 to evaluate 23 tomato cultivars to find out a suitable variety for winter season cultivation. They reported that, BT 12 produced the highest yield (34.09 t/ha) closely followed by BT 17, PED, BT14, Sel 120, BT 1 and Punjab Chhuhara. The variety Sel 120 had the highest weight and girth of fruit, whereas Punjab chhuhara produced the maximum number of fruit/plant and took less time to mature. The variety Arka Alok was earliest and large fruits. Marglobe had the maximum vegetative growth.

A field trial was conducted in Jordan 1993 to study the yield of 13 local and introduced open pollinated tomato cultivars, and to compare the yields to that of 3 common hybrids (Maisara F_1, 898 F_1 and GS12F_1) in relation to seasonal distribution of marketable and unmarketable yield and fruit number. The cultivars varied in their marketable yield during the harvested period (10 weeks from 22 June 1993). The results indicated that the cultivars Rio Grande, Nagina and T_2 improved were superior to the hybrids (Ajlouni *et al.,* 1996).

An experiment was conducted at Wooster, USA with the hybrid processing tomato Ohio Ox 38 (Berry *et al,* 1995). It was observed that, the yields of this variety in 1992 and 1993 were higher (70.3 and 80.4 t/ha, respectively) compared to other cultivars.

Bhangu and Singh (1993) conducted a field trial with some tomato cultivars (Punjab Kesari, Punjab Chhuhara, Punjab Tropic, PNR-7, S-12, Pusa Ruby and the Hybrid THL-2312) in 1990 and 1992. Mean annual yield was highest in Punjaab Kesari and lowest in Punjab Tropic. The number of fruits per plant was highest in Punjab Kesari (123). Punjab Tropic produced the largest fruits (66.69g).

Kallo (1989) worked with some tomato varieties (Pusa Early Dwarf, HS 102, Hisar Arun (Sel 7) And Punjab Chhuhara) in northan India, and he repored that, HS 102 and Punjab Chhuhara were fit for summer cultivation, and Pusa Early Dwarf and Hisar Arun were suitable for getting early fruits.

Ahmed *et al.* (1986) aassessed eight F-7 lines of tomato at the Horticulture Farm, Bangladesh Agricultural University, Myensingh. All the lines had shown indifference in plant height and fruit size. In contrast, fruit number had shown significant difference among the varieties. The line 0014-60-3-9-1-0 gave the highest yield of fruit (56.9 t/ha), followed by 0013-52-10-27-32-0 (50.0 t/ha).

An experiment was carried out under a BARC financed project BVRD, at its Joydebpur Sub-Centre, 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 and 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 Haque, 1984).

An investigation was carried out by Sarker and Hoque (1980) to compare the yielding ability and to assess the distinguishing external morphological characters of seven varieties of tomato viz. during the period from October, 1977 to March 1978, Master No. 2, Ramulas, Roma, Rambo, Marmande, Bigo and World Champion. They reported that, the Rambo produced the highest yield (28.28 t/ha), followed by Bigo (24.63 t/ha), World Champion (23.38 t/ha), Master No. 2 (21.98 t/ha), Roma (21.03 t/ha) and Ramuas (20.21 t/ ha).

An experiment was conducted by Thomas *et al.* (1979) in India with some tomato varieties to study the yield and fruit characters. They reported that dwarf money maker was the highest yielder (50 t /ha) having the longest fruiting period. The cultivar V. 687 and Parc-5 also gave higher yields than Gaamed, Punjab Chhuhara and Roma.

Prasad and Prasad (1977) carried out an experiment with 8 tomato varieties in India. The highest yield was obtained from Kalyanpur Angurlate followed by kolyanpur T_1 and Sioux. The kolyanpur T_1 had the highest fruit.

In 1969-70, a yield trial was conducted with five varieties of tomato (Oxheart, Sinkurihara, L-7, Marglobe and Bulgaria) at the Vegetable Division of Agricultural Research Institute, Dhaka. The experiment was repeated in 1971-72. In both years, the varieties Oxheart and Sinkrihara were found to be similar and significantly higher yielder than the other (Hoque *et al.*, 1975).

Hossain and Ahmad (1973) conducted a varietal trial at the Bangladesh Agricultural Research institute, Joydebpur With six tomato varieties, namely, Roma, Bulgaria, USA, Anabik, Oxheart and Sanmarzano. They observed that, cv, Sanmarzano was the highest yielder (28.98 t/ha), followed by Oxheart, Roma, Bulgaria, USA, and Anabik.

An investigation was carried out at Joydebpur to determine the optimum time of planting for BARI developed hybrid tomatoes during summer (BARI, 1998). There were four dates of planting, namely, 15 May, 15 June, 15 July and 15 August and three tomato varieties, namely, TM 0836, TM 0831 and TM 0832. It was observed that, planting time did not result any significant variation on the plant characters, except TSS. However, the maximum yield was found, when the crop was planted on 15 August. On the contrary, TM 0832 was the highest yielding hybrid (59 t/ha), which was significantly different from other hybrids.

While working with seven tomato cultivars (BTI, Arka Alok, LE79, VC 48-1, Best of All, Arka Abha and AC 238), Phookan *et al.* (1997) mentioned that, the varieties were planted in March and July under a plastic cover at Jorhat, Assam, India. The highest fruit set of 27.85% was observed in BTI in the March planting and 22.38% in July planting.

Hanson *et al.* (1996) conducted a field experiment to assess the seasonal variation in fruit yields among 22 determinate tomato inbred lines grown during the simmer and a dry season at Los Banos, Philippines and Kamphaengsaen, Thailand. The lines, MTi, Mapula and CL 5915-93D4-1-0-3 performed well in both seasons, although they had small fruits. Marikit had the highest mean yield in both locations in the dry season, but did not perform well in the summer season.

Singh and Tripathy (1995) stated that, a field experiment was conducted at Regional Research Station, Orissa, India during the rainy season of 1992 to study the growth and yield of four tomato genotypes (Pusa Ruby, LE79, BT1 and Arka Alok). The cultivars showed significant genotypic variation for vegetative growth, fruit characters and yield when sown on different dates (20 June, 5 and 20 July and 5 and 20 August). The line LE97 gave the highest fruit yield (12.2 t/ha) and Arka Alok produced significantly larger fruits (20.3 cm in diameter and 136 g in weight). Sowing on 20 June was significantly favourable for fruit yield as well as its contributing characters, like fruits weight (60.8 g), length (9.8cm) and girth (16.2 cm).

An experiment was carried out by Bhardwaj *et al.* (1995) to study the effect of planting time (1,10 and 20 May) and spacing on the growth and yield of three tomato cultivars (Solan Gola, Money Maker and Naveen) in Himachal Prodesh of India. They found that, close spacing and early planting increased harvest duration. The yield was not significant affected by planting time and spacing. Naveen had the largest fruits (83.2g) and produced the highest yield (44.1 t/ha). They also found that, the heaviest fruits were produced in 10 May planting.

A varietal trial was conducted by Berenyi (1995) with 16 tomato varieties and hybrids at seven sowing dates on two experimental stations in Vietnum for adaptation. Thirteen varieties were also tested on farmer's plots. Due to climatic conditions and plant physiology, the varieties were not suitable for sowing between 1 May and 8 August. The main sowing seasons were from 30 January to 15 February and from 15 August to 10 December. Four varieties (Chico III, Mobil, Washington

F_1 and Gala F_1) were recommended for the first sowing date, and seven (K. Korai Bibor, Nivo (K-555), Treff, Mobil, Chico III, Peto-98 and UC 134-1-2) for the second planting date.

A field Experiment was conducted by Jamwal *et al.* (1995) at the Regional Research Station, Bajaura, India during the summer of 1990 with two tomato cultivars, Roma and Sioux were planted on 20 April and 20 May. They reported that, yield per hectare was similar for both cultivars; Roma produced significantly more fruits per plant, but had lower individual fruit weight than Sioux. Planting on 20 April gave better result than later planting.

An experiment was carried out by Phookan and Shadeque (1995) at Jorhat, Assam, India in order to test different genotypes of tomato during 4 seasons, viz. early spring, spring, summer and autumn. Out of 29 genotypes, 7 were common in all the 4 seasons. Seedlings of one month age were planted on 7 March, 7 May, 7 July and 7 September in 1991 under plastic rain shelter. The authors reported that the crop planted in September gave the highest yield, being 91.10, 74.66 and 67.88% higher than that planted in May, July and March, respectively. Among the different varieties, the highest yield was recorded in Arka Abha (1.5 kg/plant) followed by Arka Alok (1.19 kg/plant).

Effect of different varieties (Punjab Chhuhara, Pusa Ruby and Pusa Early dwarf) and planting season (summer, Kharif and Rabi) on seed yield and quality of tomato was investigated at maharastra, India during 1988-89 by Meher *et al.* (1994). They

reported that the varieties Pusa Ruby and Pusa Early Dwarf produced the highest fruit yield/ha during all three planting seasons. The Pusa Early Dwarf was able to give substantially high fruit yield during summer season than Pusa Ruby and Punjab Chhuhara. Punjab Chhuhara appeared to be very specific to Kharif and Rabi seasons. The variety and seasonal interactions have been reported by various workers, such as, Gautam *et al.* (1981) and Hossain and Haque (1984).

To study the effect of planting time (15 November, 30 November and 15 December) on the growth and yield of tomato variety Marglobe, Taleb (1994) conducted an experiment at the horticulture farm of Bangladesh Agricultural University, Mymensingh. He found that November 15 planting produced the tallest plants (129.4cm) and maximum yield per plant (4.29 kg), which was statistically different from all other dates of planting.

Akhter (1993) carried out an experiment at the regional Agricultural Research Station, Ishurdi, Pabna during the period from February to July 1992 to study the effect of different doses of NAA and planting dates (1 March and 1 April) on two heat tolerant tomato advance lines (TM 0111 and TM 0367). He observed that, March planting produced significantly higher yield (21.45 t/ha) than April planting (7.81 t/ha). The yield of TM 0111 (15.05 t/ha) was higher than TM 0367 (14.22 t/ha), but that was not statistically significant.

Shukla *et al.* (1990) conducted an experiment with seven diverse tomatos F_1 hybrids, namely Rupaly, Vaishali, Mangala, Karnatka, MTH-1, MTH-2 and MTH-3 compared with a local standard variety Solan Gola at two transplanting dates (May and June). They reported that, Mangala and Solan Gola produced the maximum and

minimum fruit length, respectively. Transplanting in May and widest spacing (90 cmx 45cm) resulted in larger fruit than June transplanting and closer spacing.

Reddy *et al.* (1989) carried out an experiment to study the screened tomato germplasms suitable for summer cultivation in North Indian conditions with early and late plantings during March 1981. They observed that, two genotypes in early planting, two in late planting and one in both planting were earliest of all the genotypes. One accession, Shift had produced commercially acceptable fruit size in the first planting. In the second planting, all the accessions showed very poor performance with respect to fruit setting, fruit weight and yield.

In another experiment, conducted at the Vegetable Section of Bangladesh Agricultural Research Institute (BARI, 1986) with some tomato lines planted at different dates, larger fruits were obtained from late planting. It was also noticed that, tomatoes when planted early in October or November required more time to mature than planted in January.

Hossain *et al.* (1986) conducted an experiment with 15 tomato lines in the grey flood plain soils of the Regional Agricultural Research Station, Jamalpur during the period 1983-84 to study the performance of some tomato lines sown at different dates (2Sep. 2Oct. and 2 Nov.). They reported that, November was the best time for sowing tomato seed in seed beds as compared to October or September sowing. The line TM 0367 gave significantly higher yield (52.2 t/ha) than other lines. They also reported that, early November sowing gave significant higher yield than September

or October sowing. The results in general are in agreement with the findings of a study conducted at Joydebpur (Hoque, 1983). The line TM 0367 produced significantly higher yield (54.2 t/ha) than other lines under study. The line TM 0369 yielded the lowest (27.9 t/ha).

Ravikumar and Shanmugavelu (1983), while investing into the effect of different planting method and time of sowing on yield and quality of some tomato varieties found that, the number of fruits per plant and mean yield per plant decreased with delay in sowing date. Similar results were also reported by Dayan *et al.* (1978). They indicated delayed planting reduced over all yields.

A varietal trial was conducted by Bhuya and Haque (1983) at the Agricultural Research Sub-station, Pahartali, Chittagong to evaluate tomato varieties for winter and summer cultivation. They observed better performance of all the varieties in winter season, while only five varieties survived in the summer season under the excessive rainfall. In the winter season, the yield, however, appeared statistically similar amongst the varieties. However, of the two seasons, yield in summer was lower. The result further suggested that, there were specific genotypes for summer cultivation here in Bangladesh.

Popovic (1977) mentioned in a report that, sowing date affected the duration of developmental phases and total growth period of tomato varieties. Mid April was found to be the optimum time for planting tomato in Yugoslavia. On the other hand, Zakoyan (1974) reported that, the highest yield was obtained from plants transplanted on 20 April.

2.2. Effect of nitrogen fertilizer on growth and yield of tomato

The effect of tillage system and nitrogen application on fruit quality and total fruit yield of tomato *(Solanum lycopersicum)* cultivars was investigated by Rhoads *et al.* (2002). The treatments were either conventional tillage or rye (*Secale cereale*) mulch with or without 50 kg N ha-1. In both tillage systems, the application of 50 kg N ha-1 reduced the concentric cracking of tomato fruit, except for UC82 in conventional tillage and Cherry Express II in rye mulch. When harvested at the same stage of maturity, chroma and hue along with acetic and citric acid concentrations of fruit were not affected by tillage system or N treatment. Fruit yields ranged from 34.0 to 60.6 kg ha^{-1}.

Prabhakar *et al.* conducted a field experiment with tomato during summer 2001, in Bangalore, Karnataka, India. The treatments involved 2 levels of NK fertilization (full and half). Commercial (urea and muriate of potash) and special fertilizers (Multi K) and one level each of full NPK through fertilization in the form of poly feed and soil application of fertilizers through ammonium sulfate, single super phosphate and muriate of potash. All these treatments were repeated with the black polyethylene mulch. In the treatments, which received half of NK fertilization, 50% of NK and full dose of P was given as soil application at the time of transplanting. In all other treatments, except the soil application, the water soluble fertilizers were injected in 10 equal splits at 10 days interval starting from the date of transplanting. Soil application of fertilizers with furrow method of irrigation served as the control. The treatment with half NK fertilization and drip with black polyethylene mulch resulted in the highest yield of 121.3 tones/ha, mean fruit weight of 64.5 g, number

of fruits per plant of 62.0, yield per plant of 4.0 kg, number of branches per plant of 7.7 and number of clusters per plant of 12.3. Black polyethylene mulch resulted in an increase in yield of 7.2 tones/ha. The highest total soluble solids of 5.3 were observed in treatments with soil application of recommended levels of fertilizers and black polyethylene mulch. The fruit dry matter content (41.2%) was the highest with half NK fertilization through Multi K with black polyethylene mulch.

Creamer-NG *et al.* (1996) tested tomato production system at Columbus and Fremont, Ohio: (1) a conventional system; (2) an integrated system - an autumn-planted cover-crop mixture of Vicia villosa, rye, Trifolium incarnatum and barley, mechanically cut before tomato planting and left on the soil surface as a mulch, with reduced chemical inputs; (3) an organic system - a cover-crop mixture with no synthetic chemical inputs; and (4) a no-input system - a cover-crop mixture and no additional management or inputs. Nitrogen in the cover-crop mixture aboveground biomass amounted to 220 kg/ha in Columbus and 360 kg/ha in Fremont. The tomato cultivar used was OH 8245. The number of tomato fruit and flower clusters was highest for the conventional system early in the season. In Fremont, the plants in the conventional system had accumulated most dry matter 5 weeks after transplanting. Yields of red fruits were similar for all systems at Columbus, but the conventional system yielded higher than the other 3 in Fremont. In Columbus, there were no differences in economic return above variable costs among systems. In Fremont, the conventional system had the highest return above variable costs.

Olasantan, (2004) observed the effect of nitrogen rate (0, 30, 60 and 90 kg/ha) with hedgerow pruning applied as mulch in *G. sepium* alley cropping system on weed control and growth and yields of okra cv. NHAe 474 and tomato cv. Ife 1 was

studied in an on-farm experiment in South-western Nigeria in 1993 and 2004. Increasing nitrogen fertilizer rate up to 90 kg/ha with total hedgerow pruning applied as mulch increased the growth of the vegetables, but this was not accompanied by a significant increase in fruit yields beyond 60 kg/ha. When averaged over the two years, however, application of 30 kg/ha gave more economical yield than application of 60 kg/ha. With total foliage from hedgerow pruning applied as mulch, weed dry weight decreased significantly by 70-75 and 60-66% under okra and tomato, respectively, with and without fertilizer. It is concluded that application of small amount (about 30 kg/ha) of nitrogen fertilizer with hedgerow pruning applied as mulch can suppress weed growth and increase fruit yield of okra and tomato under G. sepium alley cropping system.

Hedau *et al.* (2001) tested the effects of N fertilizer (75, 100 and 125 kg/ha) and mulch (black, transparent or silver-black polyethylene and pea straw) on the tomato hybrid cv. Naveen in 2000 at Himachal Pradesh, India .Among the N rates, 125 kg N/ha produced the highest fruit yield (71.67 t/ha). The highest fruit yields of 76.42 and 75.31 t/ha were obtained with silver-black and black polyethylene mulches, respectively. Among the various interactions between N rate and mulch, the highest fruit yield (89.40 t/ha) was recorded for 125 kg N/ha combined with silver-black polyethylene.

Masson *et al.* (1990) observed the effects of nitrogen fertilization on the growth of tomato and lettuce transplants in multi cellular trays with and without supplementary lighting. They were grown under natural or supplementary light (100 micromole m-2 s-1 PAR) and supplied with N at 100, 200, 300 or 400 mg/liter in a complete nutrient

solution. Supplementary lighting increased tomato shoot DW, shoot % dry matter, leaf area, root DW and root: shoot ratio. With lettuce it increased shoot and root DW and leaf area. For both crops, N application increased shoot DW and leaf area, but reduced shoot % dry matter and root: shoot ratio. The greatest increases in tomato and lettuce shoot DW and leaf area with high N doses were generally found in combination with supplementary lighting. Optimum N dosage for tomato was 300 mg in natural light and 400 mg with supplementary lighting; under either condition the optimum for lettuce was 400 mg.

El-Beheidi *et al.* (1990) carried out two experiments on newly reclaimed sandy soil at Khattara, Sharkia Governorate. In the 1985 experiment, tomatoes cv. Peto 86 was surface-irrigated and N (as ammonium sulfate) was applied at 0-90 kg/feddan. In 1986, 3 systems of irrigation (surface, movable sprinkler, fixed sprinkler) and 3 rates of N fertilizer (70, 90 or 110 kg/feddan) were compared. In the first experiment, application of N at 70 kg/feddan was best for DM production and total fruit yield (11.5 t/feddan). In the second experiment, irrigation by fixed sprinklers gave a yield 30 and 36% higher than those of the surface and movable sprinkler systems, respectively. The highest fruit yield, plant height, number of leaves/plant and DM contents were obtained with 110 kg N/feddan under the fixed sprinkler system.

Widders (1991) compared absorption and translocation of foliar applied 15N-labelled S-tetrahydrotriazone (triazone), with other N forms and evaluated in tomato plants (cv. Saladette) in greenhouse. Triazone-N was taken up into leaf tissue in quantities similar to those of urea, ammonium, and nitrate-N when applied at an N concentration of 0.35% w/v. Although >40% of the 15N label was exported from the

treated leaf after 7 days, nearly 50% of the translocated triazone 15N label accumulated in non-treated leaf tissue as compared with only <less or =>10% for the other N sources. The largest percentage of the translocated urea-, ammonium-, and nitrate-15N label accumulated within developing fruit tissue. Multiple (3) foliar applications of trizaone and urea at concentrations of >0.04% and 1.0% N (w/v), respectively, increased both leaf and fruit tissue N concentrations. No growth responses to foliar applied N were observed.

Caron *et al.* (1991) developed the Norms for the Diagnosis and Recommendation Integrated System (DRIS) for greenhouse tomato by varying the N concentration (115, 243 and 443 mg N/liter) or the salinity level (1.4, 2.5 and 3.7 dS/m) of the nutrient solution. Foliar samples were taken from cultivars Vendor, Kosei, Parabel and Cantatos at different intervals during the season for total N, P, K, Ca and Mg analysis. Yield of marketable fruit over an 8-week harvest period was quadratically related to N fertilization: 115, 243 and 443 mg N/litre produced 2.9, 3.3 and 2.3 kg/plant, respectively. Larger than critical NII values, 82 days after transplanting, were associated with excess of N, and Mg and Ca deficiencies. In the salinity experiment (cv. Vedettos), marketable yield decreased linearly with salinity: 1.4, 2.5 amd 3.7 dS/m produced 3.3, 2.9 and 2.3 kg/plant, respectively.

Quijada (1990) conducted the experiment to study the effects of various nitrogen concentrations on growth and development of tomato. In spring seeds of cv. Earlymech (UC82) tomato were sown in sand in pots in a greenhouse. The pots were watered daily with 1 of 4 nutrient solutions that supplied the normal N requirement (N), one third or 3 times this rate or no N, a zero N soil control was also used. When

the first 2 true leaves appeared, reducing the N rate to one-third of normal decreased the shoot weight and increased the root weight. N requirements increased after the third true leaf appeared. At the beginning of flowering, growth was greater in the 3N, N and zero N soil treatments than in the no N treatment (sand). The 3N rate reduced root growth and stimulated shoot growth and produced numerous small trusses, which mostly aborted. The zero N soil treatment gave similar results to the 3N treatment until early fruit set, after which N was required for continued normal development. The N and 3N treatments produced the most fruit tissues. The % fruit DM was lowest with the 3N treatment.

Subbiah (1990) observed Nitrogen and Azospirillum interaction on fruit yield and nitrogen use efficiency in tomato in June-July 1987 and Feb.-Mar. 1989 with the cultivar Co.3 on the soil low in available N and P and high in available K. N was applied at 0, 50, 75 or 100% of the recommended dose and Azospirillum brasilense was applied to the soil, the seeds or the seedlings. One half of the N dose + FYM at 10 t/ha + P_2O_5 at 100 kg/ha + K_2O at 100 kg/ha + K_2O at 100 kg/ha were applied before planting 25-day-old seedlings, and the remaining N was applied 30 days after transplanting. Although the fruit yield was increased by the interaction of N and A. brasilense, it was not significantly affected in either season. However, it was observed that at 50% of the recommended N rate (60 kg/ha), *A. brasilense* treatment of seedlings in the June-July season, or soil application of *A. brasilense* in the Feb.-Mar. season resulted in the highest N use efficiency for that season, showing that Azospirillum inoculation not only saved 50% of the recommended N rate but also improved N use efficiency.

Kaniszewski *et al.* (1990) showed that in field trials between 1985 and 1987 with cultivars Najwczesniejszy and Luca, plants received N at rates ranging from 37.5 to 450 kg/ha applied in a single dose (up to 225 kg N/ha) or in 2 split doses (in the case of higher N rates). N had a beneficial effect on yield at rates up to 300 kg N/ha under irrigation and of up to 150 kg N/ha without irrigation. Luca was more demanding of N than Najwczesniejszy. Both cultivars had a similar total yield, but the early and commercial yields were markedly higher in Luca. Irrigation and N at 225 kg/ha applied before planting gave the best fruit quality. Fruits of Luca were larger, firmer and had higher vitamin C content than fruits of Najwczesniejszy which had a higher DM content and better coloration than Luca.

Kooner *et al.* (1990) were conducted an experiment at Punjab Agricultural University, 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. Ostankinski (OS), Punjab Chhuhara (PC) and Punjab Kesri (PK) were used for the spring planting, and OS, PC and Cold Set (CS) for the winter planting. 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/h

From the above mentioned review of literature it appears that the date of planting time and varieties play an important role on the growth and yield of tomato in a particular location. The date if planting time and variety may have variable effects on the extension of picking period of tomato depending upon location, season, and management practices. The present study will be conducted to find out suitable varieties and their optimum planting time to achieve longer picking period and maximum yield of tomato.

CHAPTER 3

MATERIALS AND METHODS

3.1. Location of the experimental plot

The field experiment was conducted at the Farm of Sher-e-bangla Agricultural University, Dhaka, Bangladesh during, October 2008 to March 2009 to find out the effect of different doses of nitrogen fertilizer on morphology, growth and yield of tomato.

3.2. Soil

Initial soil samples from 0-15 cm depth were collected from experimental field. The collected samples were analyzed at Soil Resources Development Institute (SRDI), Dhaka, Bangladesh. The physio-chemical properties of the soil are presented in Appendix I. The soil of the experimental plots belonged to the agro-ecological zone of Madhupur Tract (AEZ-28) as shown in Appendix I.

3.3. Experimental site and growth environment

The area is characterized by hot and humid climate. The average rainfall of the locality of the experimental area is 209.06 mm, the minimum and maximum temperature is 11.10°C and 34.80°C respectively. The average relative humidity was 75.8% during October 2008 to March 2009 (Appendix II).

3.4. Planting materials

The tomato varieties used in the experiments were BARI Tomato-4, BARI Tomato-5, BARI Tomato-7 and BARI Tomato-9. All varieties are semi-indeterminate type and the seeds were collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) at Joydebpur, Gazipurs.

3.5. Raising of seedlings

The land selected for nursery bed was well drained and was of sandy loam type soil. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. All weeds and dead roots were removed and the soil was mixed with well rotten cow dung at the rate of 5 kg/bed. The size of each bed was 3m x 1m rose above the ground level maintaining a spacing of 50cm between the beds. The seedbeds were prepared for raising the seedling. Ten grams of seeds were sown in each seedbed on 28th October 2008. After sowing, the seeds were covered with light soil. Sevin was applied in each seedbed as precautionary measure against ants and worms. Complete germination of seeds took place with 6 days after seed sowing. Necessary shading was made by bamboo mat (chatai) to protect the seedlings from scorching sunshine or rain. Weeding, mulching and irrigation were done as when required. No chemical fertilizer was used in the seedbed.

3.6. Treatments and layout

The experiment considered of two factors: (A) different types of varieties and (B) four different levels of nitrogen. The levels of two factors were as follows:

Factor A: Different types of varieties, **Factor B:** Four levels of nitrogen

Factor A	Factor B
V_1:BARI Tomato 4	No: No nitrogen
V_2: BARI Tomato 5	N1: 100 kg/ha
V_3: BARI Tomato 7	N2: 150kg/ha
V_4: BARI Tomato 9	N3: 200 kg/ha

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The whole field was divided into three blocks each containing 16 plots. In total, there were 48 plots. The treatments were randomly assigned to each unit plot. The size of unit plot was 2m x 1.8 m. The distance between the blocks was 1 m and that between plots was 50 cm.

3.7. Land preparation

The land was first opened with a tractor on 16 November 2008. Ther eafter, it was gradually ploughed and cross-ploughed three times with power tiller. Laddering to break the clods and to level the soil followed each ploughing. During land preparation weeds and other stubbles of previous crop were collected and removed from the land. These operations were done to bring the land under a good tilth condition. Irrigation channels were prepared around the plots.

3.8.Application of manure and fertilizers

In addition to the fertilizer under treatment, 10 tones of cow dung manure, 450 kg of triple super phosphate (TSP) and 250 kg of MP per hectare applied in the experimental plot. Half of the cow dung, the entire quantity of TSP, ½ of MP was applied during final land preparation. The remaining cow dung was applied during pit preparation. The entire urea and the rest of MP were applied in three equal installments at 15, 30 and 50 days after transplanting in the field.

3.9. Transplanting of seedlings

Healthy and uniformed sized 30 days old seedlings were taken separately from the seedbed and were transplanted in the experimental field on 28 November 2008 maintaining spacing of 60 cm and 50 cm between the rows and plants respectively. The seedbeds were watered before uprooting the seedlings so as to minimize damage to the roots and this operation was carried out during late hours in the evening. The seedlings were watered after transplanting. Seedlings were also grown around the experimental area for gap filling and for checking the border effect.

3.10. Intercultural operations

After transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants.

3.10.1 Gap filling

When the seedlings were established, the soil around the base of the seedlings was pulverized. A few gap feeling were done by healthy plants from border whenever it was required.

3.10.2. Weeding

Weeding was done in the plots as and when necessary to keep the crop free from weeds. It also helped for better soil aeration soil moisture conservation.

3.10.3. Staking and pruning practices

When the plants were well established, each plant was staked to keep them erect. Within a few days of staking the plants were pruned uniformly having single stem per plant.

3.10.4. Irrigation

Light irrigation was provided immediately after transplanting the seedlings and it was continued till the seedlings established in the field. Thereafter irrigation was provided.

3.10.5. Plant protection

Insect pests: As preventive measure against the insect pests like Cut worm, Leaf hopper and others, Malathion 57 EC at the rate of 2ml/litre was applied. The insecticide application was made fortnightly from a week after transplanting to a week before first harvesting.

Disease: During the foggy weather precautionary measures against disease infestation were taken. Especially, for late blight of tomato Diethane M-45 was sprayed fortnightly @ 2g/litre.

3.11. Harvesting

Fruits were harvested at 5 days interval during ripening stage. The maturity of the crop was determined on the basis of red coloring of the fruits.

3.12. Data collection

Data on the following parameters were recorded from the sample plants during the course of experiment. The plants were selected

3.12.1. Plant height (cm)

Plant height was measured from 5 randomly selected plants in centimeter from the ground level up to the tip of the longest stem and mean value was calculated. Plant height was also recorded at 50% flowering stage and 100% flowering stage to observe the growth rate of the plants.

3.12.2. Total number of leaves per plant

Total number of leaves from transplant to harvest was counted from 5 randomly selected plants along with leaf scars of shade leaves and their average was taken as the number of total leaves per plant.

3.12.3. Number of branch per plants

The number of branch was counted from the sample plants and the average number of branch was recorded at the time of final harvest.

3.12.4. Number of flowers per cluster

Total number of flowers was counted from selected flowers cluster of sample plant and was calculated by the following formula:

$$\text{Number of flowers per cluster} = \frac{\textbf{Total number of flowers from ten sample plants}}{\textbf{Total number of flowers clusters from ten sample plants}}$$

3.12.5. Number of cluster per plant

The number of clusters per plant was counted from the sample plants and the average number of flower cluster produced per plant was recorded at the time of final harvest.

3.12.6. Length of fruit (cm)

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

3.12.7. Fruit diameter (cm)

Diameter of fruit was measured at the middle portion of 10 selected marketable fruit from each plot with a slide calipers and their average was taken in cm as the diameter of fruit.

3.12.8. Number of fruits per cluster

Total number of fruits was counted from selected cluster of sample plant and was calculated by the following formula:

$$\text{Number of fruits per cluster} = \frac{\text{Total number of fruits from ten sample plants}}{\text{Total number of fruits clusters from ten sample plants}}$$

3.12.9. Total soluble solid content (TSS)

A fruit was sliced into two halves horizontally with a sharp knife and a small quantity of juice from them was used to determine TSS in percentage with Refractometer meter.

3.12.10. Individual fruit weight

Among the total number of fruits harvests during the period from first to final harvest, the fruits, except the first and last harvests, were considered for determining the individual fruit weight in gram.

3.12.11. Yield of fruits per plot (kg)

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

3.12.12. Yield of fruits per hectare (ton)

It was measured by the following formula

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

3.13. Statistical analysis

The recorded data on various parameters were statistically analyzed using MSTAT statistical package programme. The mean for all the treatments was calculated and analysis of variance for all the characters was performed by F-test. Differences between treatment means were determined by Duncan's new Multiple Range Test (DMRT) according to Gomez and Gomes (1984) at 5% level of significance.

CHAPTER IV

Results and Discussion

4.1. Plant height

Plant height at 50% and 100% flowering due to the influence of different varieties was significant (Appendix III). The plant height increased gradually with the advancement of time and continued up to 100 flowering. The variety BARI Tomato-7 had the highest plant height (83.25 cm) at 50% flowering stage which was statistically different from other three varieties. However, the lowest plant height (63.33 cm) was obtained from the variety BARI Tomato-9 (Fig. 1) at 50% flowering stage. At 100% flowering stage the variety BARI Tomato-7 had the highest plant height (101.33 cm) which was statistically different from other four varieties. However, the lowest plant height (69.00 cm) was obtained from the variety BARI Tomato-9 (Fig. 1) at 100% flowering stage. Varietal influence on plant height was also reported by Hossain *et al.* (1986).

Plant height differed significantly due to the application of different level of nitrogen at 50% and 100% flowering stage (Appendix III). Plant height was significantly affected due to the application of different nitrogen treatment. The plant height increased gradually with the advancement of time and continued up to 100% flowering stage and the tallest plant (82.25 cm) was produced by N_2 (150 kg N/ha) and the shortest plant (69.33 cm) was produced by N_0 (0 kg N/ha) at 50% flowering stage. More over 100% flowering stage the tallest plant (91.41 cm) was produced by N_2 (150 kg N/ha) and the

shortest plant (71.50 cm) was produced by N_0 (0 kg N/ha) (Figure 2). The plant height was increased possibly due to the readily available nitrogen, which might have encouraged more vegetative growth and development. Salam (2001) and Chung *et al.* (1992) reported that plant height was increased with nitrogen rate. Grela *et al.* (1988) found that plant height was increased with nitrogen rates up to 160 kg N/ha and then decreased, which also reflect in this experiment.

The interaction among different varieties and different doses of nitrogen was found significant on the plant height (Appendix III). The tallest plant (97.67 cm) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and the shortest plant (56.00 cm) was produced by V_4N_0 (BARI Tomato-9 and 0 kg N/ha) at 50% flowering stage. On the other hand at 100% flowering stage the tallest plant (115.70 cm) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and the shortest plant (60.00 cm) was produced by (BARI Tomato-9 and 0 kg N/ha) (Fig. 3) which was statistically significant from other treatments.

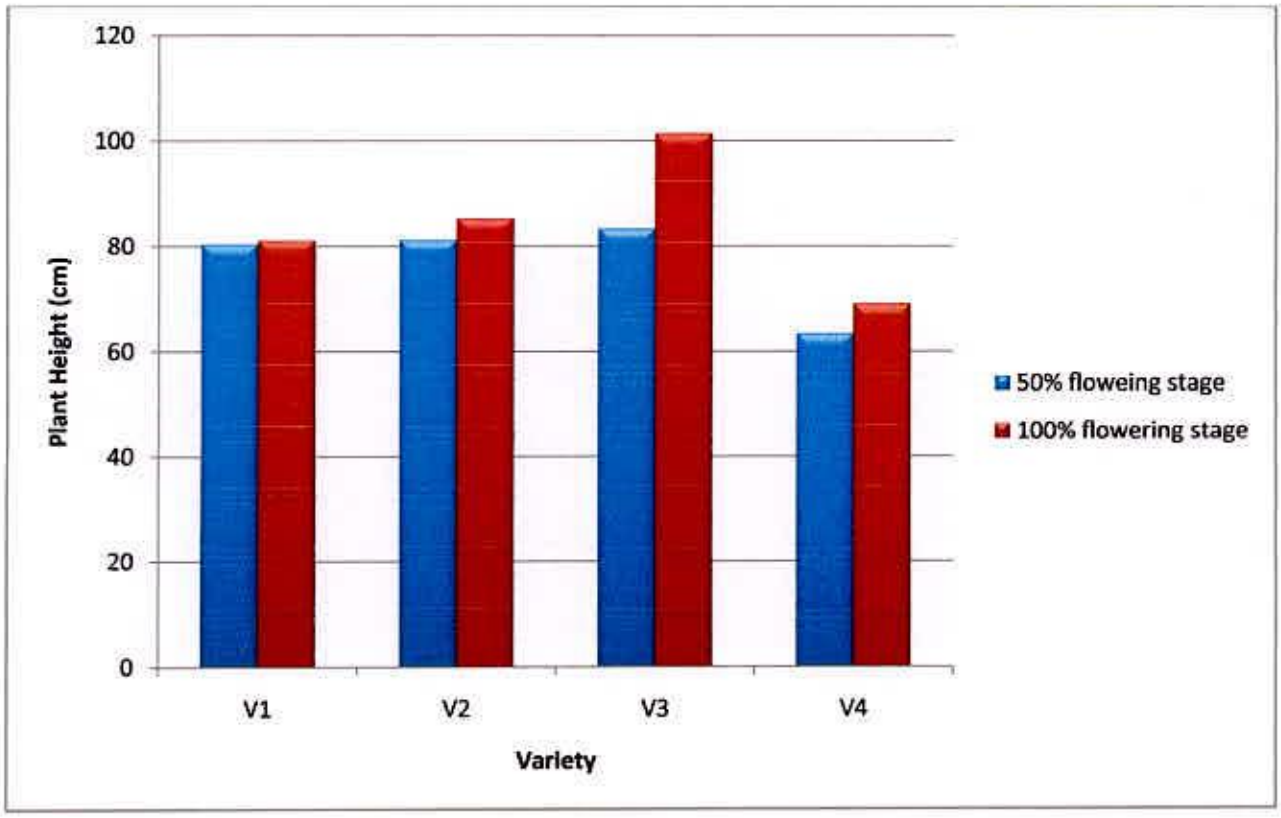

Figure 1. Effect of variety on the plant height of tomato.

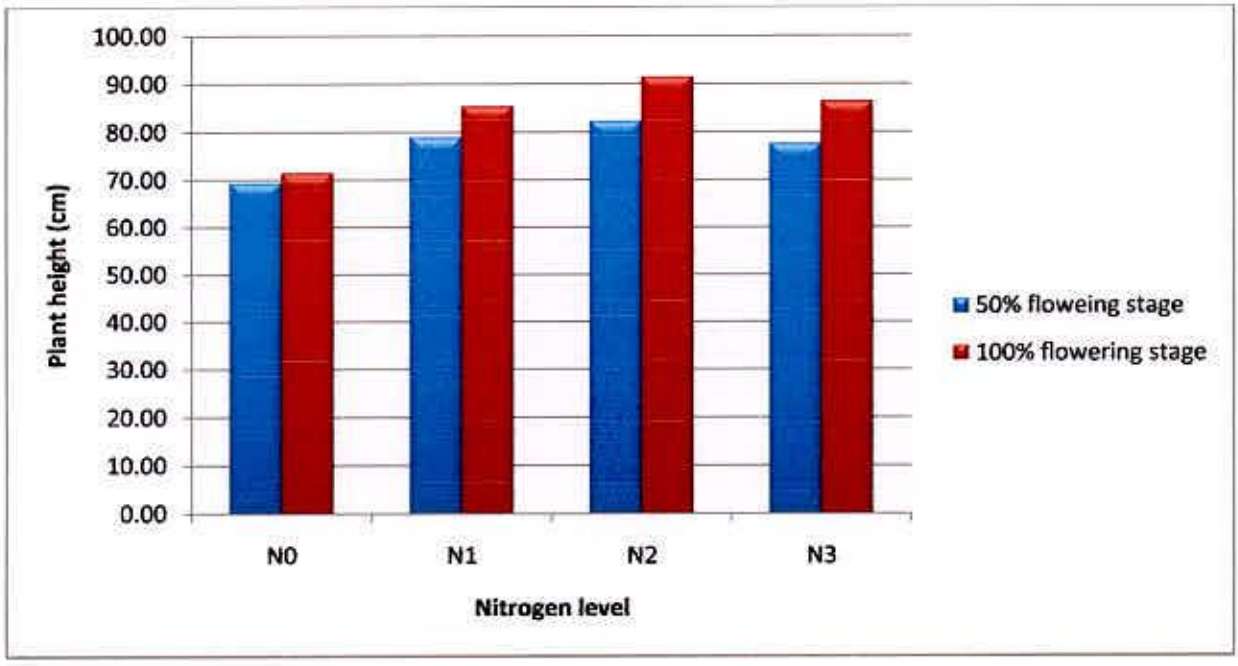

Figure 2. Effect of nitrogen on the plant height of tomato.

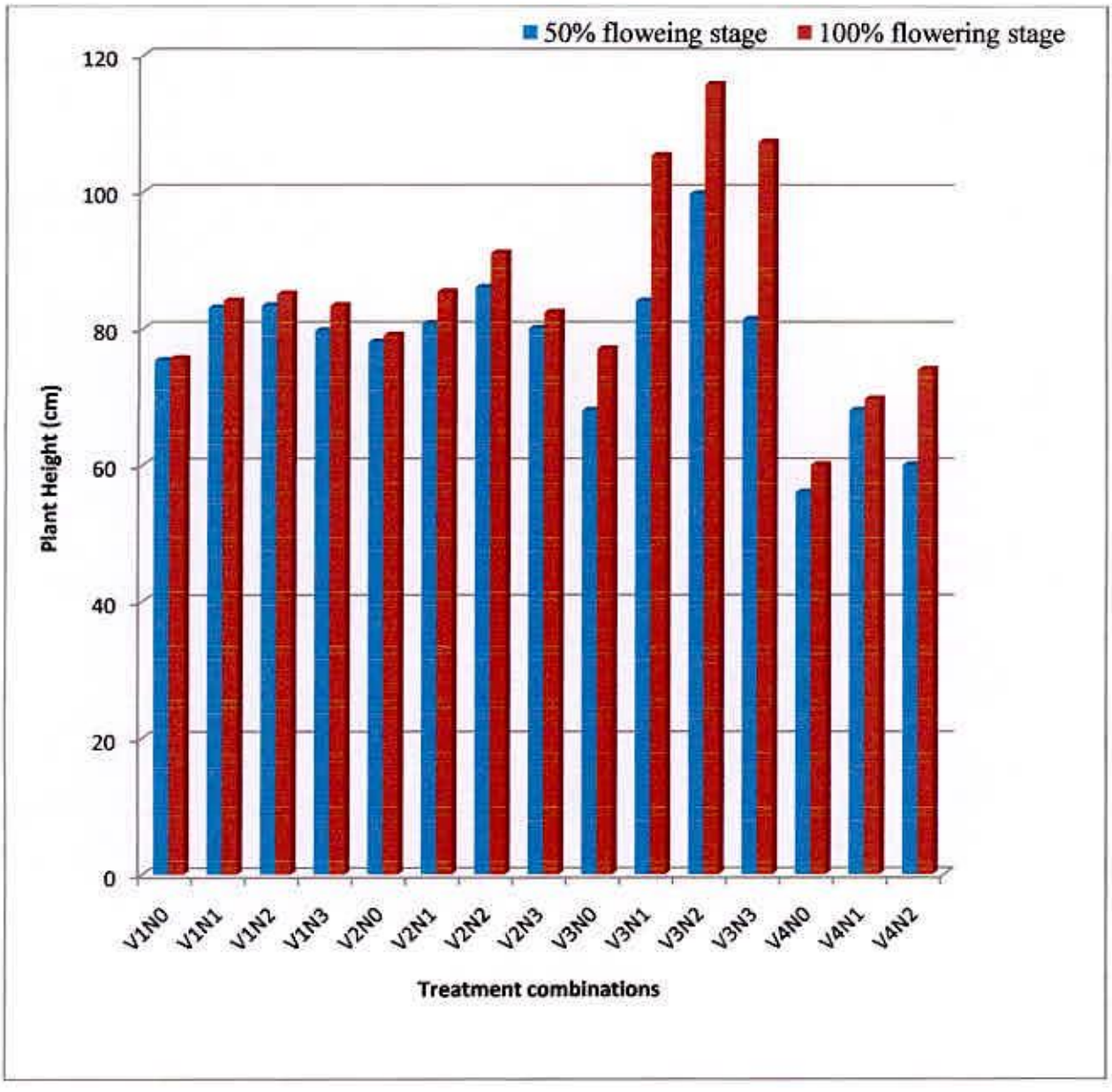

Figure 3. Combined effects of different variety and different level of nitrogen on the plant height of tomato

4.2. Number of leaves per plant

Number of leaves per plant due to the influence of different varieties was significant (Appendix IV). The variety BARI Tomato-7 had the highest number of leaves per plant (114.10) which was statistically different from other four varieties. However, the lowest number of leaves per plant (74.00) was obtained from the variety BARI hybrid Tomato-5 (Fig. 4).

In case of number of leaves per plant, significant difference was observed due to the application of different levels of nitrogen (Appendix IV). The maximum (97.75) number of leaves per plant was recorded from N_2, while N_0 gave the minimum (82.75) number of leaves per plant (fig. 5). Sharma and Mann (1971) also reported that increasing levels of nitrogen application increased the number of leaves per plant (480 kg N/ha).

The interaction between different variety and different doses of nitrogen was found significant on the number of leaves (Appendix IV). The maximum number of leaves (122.00) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and the number of leaves (66.33) was produced by V_2N_0 (BARI Tomato-5 and 0 kg N/ha) (Table 6).

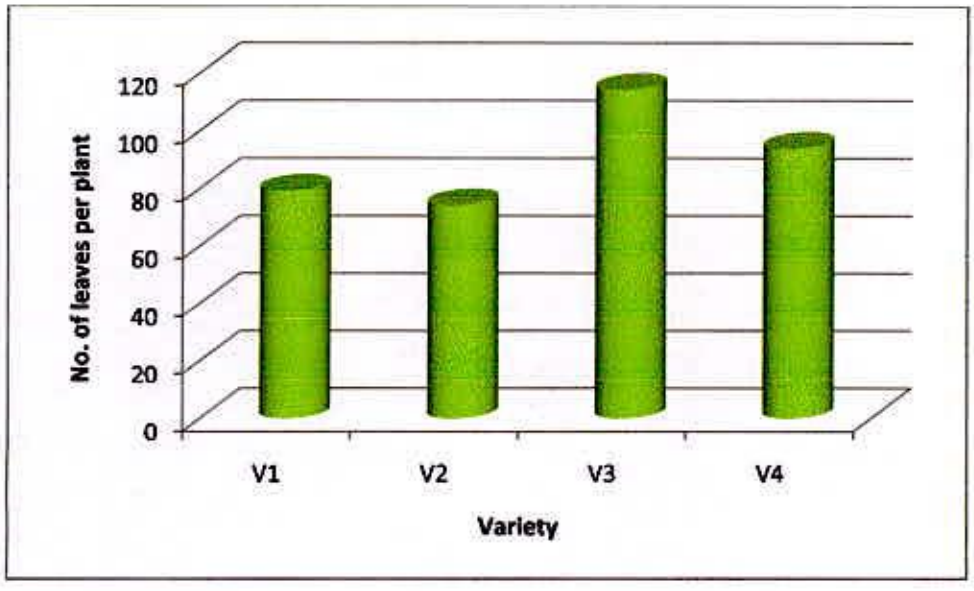

Figure 4. Effect of variety on the no. of leaves per plant

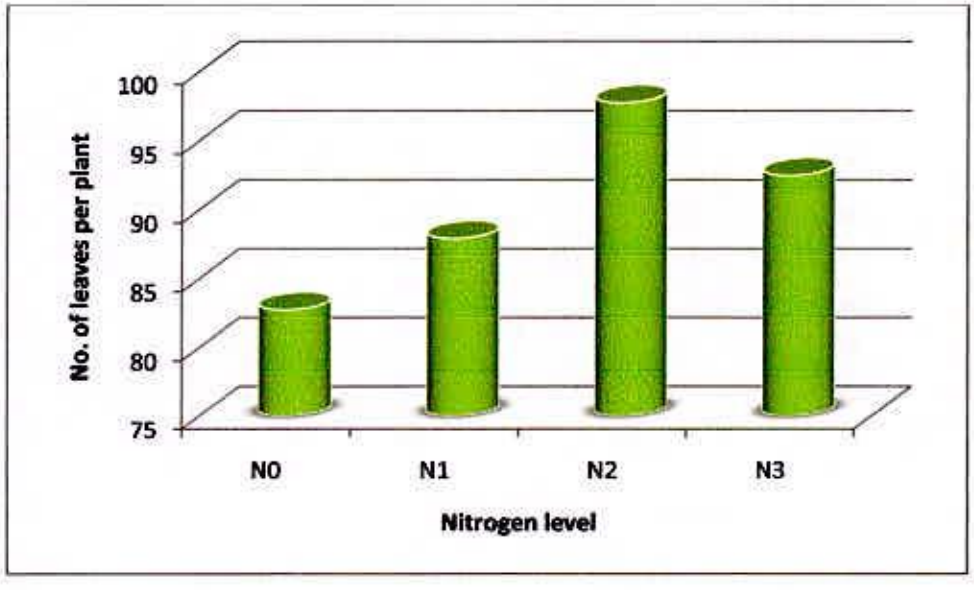

Figure 5. Effect of nitrogen on the no. of leaves per plant

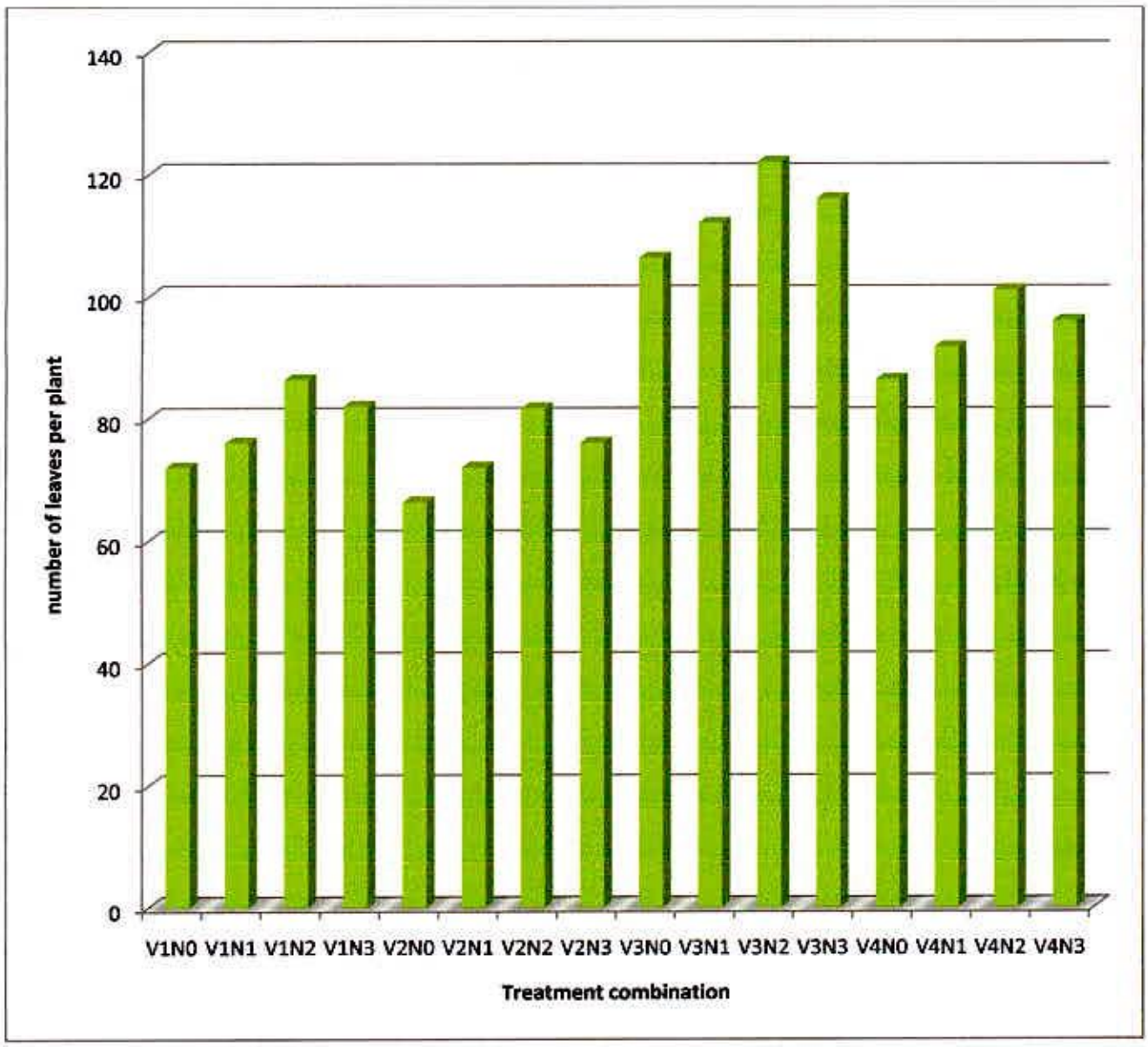

Figure 6. Combined effects of different variety and different level of nitrogen on the No. of leaves per plant of tomato

4.3. Number of branches per plant

There was a significant difference among the varieties in the number of branch per plant (Appendix IV). The variety BARI Tomato-7 had the highest number of branches per plant (10.00) and the lowest number of branches per plant (7.33) was obtained from the variety BARI hybrid Tomato-4 (fig.7).

Number of branch showed significant variation due to the application of different levels of nitrogen (Appendix IV). The maximum (10.67) number of branch was recorded from N_2 (150 kg N/ha), while the control (0 kg N/ha) gave the minimum (5.67) number of branch (fig. 8). These results indicate that nitrogen increases the growth of tomato, which ensured the maximum number of branch than control.

The interaction between different variety and different doses of nitrogen was found significant on the number of leaves (Appendix III). The maximum number of branch (17.00) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) which was statistically differ from all treatments and the lowest number of branch (4.67) was produced by V_1N_0 (BARI Tomato-4 and 0 kg N/ha) (Table 9).

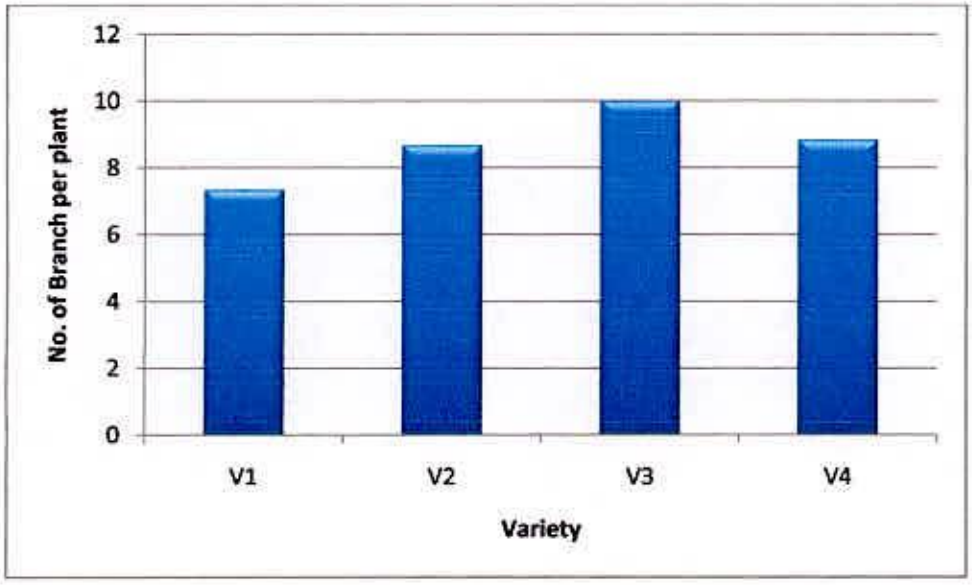

Figure 7.Effect of variety on no. of branch per plant

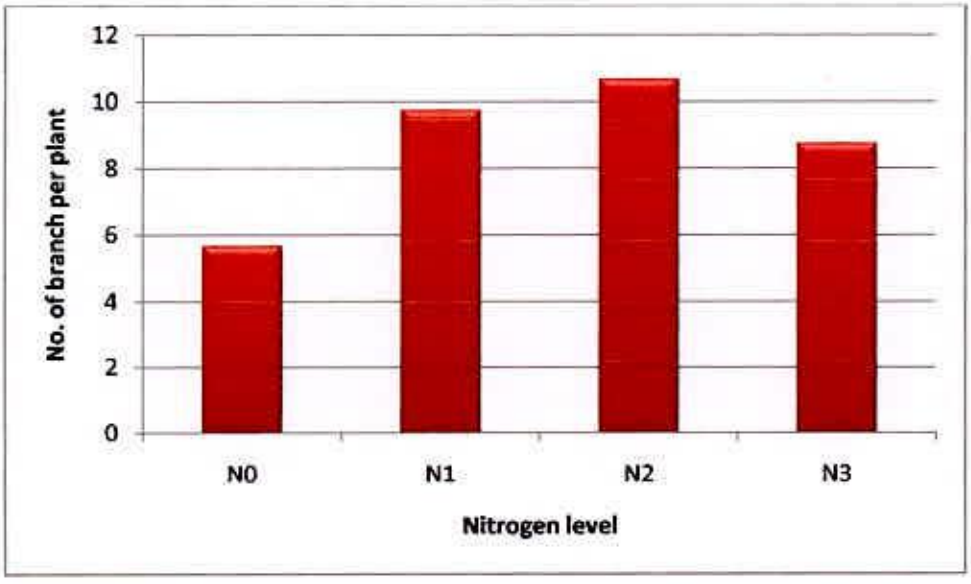

Figure 8. Effect of nitrogen on no. of branch per plant

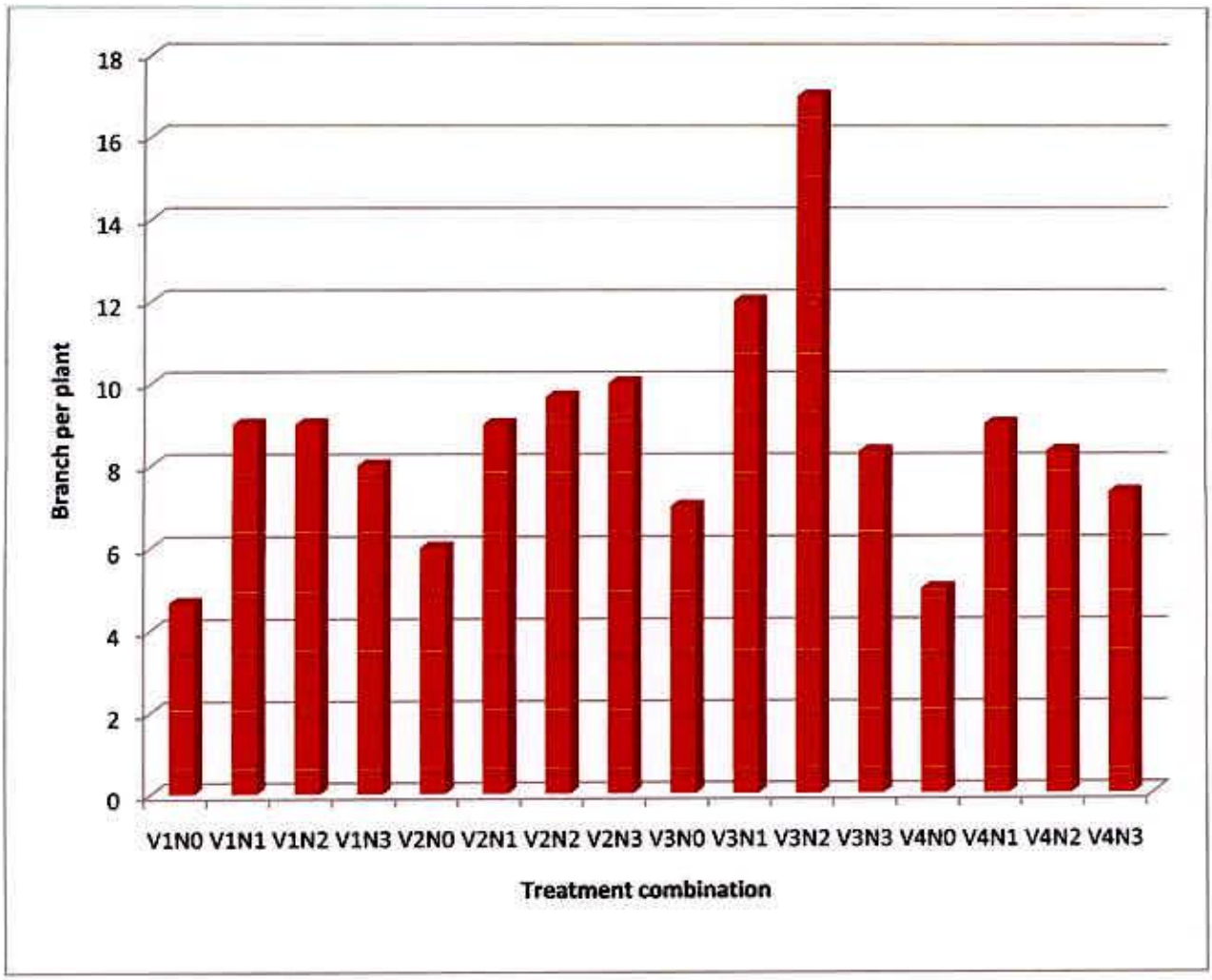

Table 9. Combined effects of different variety and different level of nitrogen on the branch per plant of tomato

4.4. Number of flowers per cluster

There was a significant difference among the varieties in the number of flowers per cluster (Appendix V). As evident from table 1, the maximum number of flowers per cluster (6.08) was produced in BARI Tomato-7, which was statistically similar to BARI Tomato-9. The minimum number of flowers per cluster (5.42) was produced in BARI Tomato-4.

Number of flowers per cluster differed significantly due to the application of different level of nitrogen (Appendix V). The maximum (6.41) number of flowers per cluster was recorded from N_2, while N_0 gave the minimum (5.00) number of flowers per cluster (table 2). The result is almost similar to the finding of Islam *et al.* (1997). They found that highest number of flowers per plant was produced from 480 kg N/ ha. Grela *et al.* (1988) put forwarded almost similar opinion.

The interaction between different variety and different doses of nitrogen was found significant on the number of flowers per cluster (Appendix v). The maximum number of flowers per cluster (6.67) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and the number of flowers per cluster (4.67) was produced by V_1N_0 (BARI Tomato-4 and 0 kg N/ha) (Table 3) which was statistically similar in V_3N_3 (4.67)

Table 1 Effects of variety on the no. of the yield contributing characters of tomato

Treatment	No. of flower per cluster	No. of fruit per cluster	no. of cluster per plant	Fruit Length	Fruit Diameter
V_1	5.42	4.75	7.42	7.50	13.38
V_2	5.67	4.08	15.33	7.08	12.66
V_3	6.08	5.00	17.92	8.42	20.08
V_4	6.00	4.58	10.17	7.83	14.04
CV(%)	13.14	14.21	9.12	12.04	9.60
$LSD_{(0.05)}$	0.44	0.77	3.01	2.00	3.75

Table 2 Effects of nitrogen on the No. of the yield contributing characters of tomato

Treatment	No. of flower per cluster	No. of fruit per cluster	no. of cluster per plant	Fruit Length	Fruit Diameter
N_0	5.00	3.42	7.83	6.08	14.21
N_1	5.83	4.83	12.42	7.75	15.22
N_2	6.42	5.08	15.33	8.00	15.59
N_3	5.92	5.08	15.25	9.00	15.13
CV(%)	13.14	14.21	9.12	12.04	9.60
$LSD_{(0.05)}$	1.89	1.241	3.011	2.838	3.749

Table 3. Combined effects of different variety and different level of nitrogen on the yield contributing characters of tomato

Treatment	No. of flower per cluster		No. of fruits per cluster		no. of cluster per plant		Fruit Length		Fruit Diameter	
V_1N_0	4.67	c	3.33	f	5.33	h	5.67	d	12.57	bc
V_1N_1	6.33	ab	4.33	cdef	8.00	fg	7.33	bcd	13.53	bc
V_1N_2	6.33	ab	4.00	def	8.67	efg	7.00	bcd	13.83	bc
V_1N_3	6.67	a	5.33	abc	7.67	g	9.00	ab	13.57	bc
V_2N_0	5.33	abc	3.67	ef	11.00	cd	6.00	cd	11.53	c
V_2N_1	5.33	abc	5.00	abcd	12.00	cd	7.00	bcd	12.97	bc
V_2N_2	6.33	ab	5.67	ab	19.33	b	7.33	bcd	13.57	bc
V_2N_3	5.67	abc	5.67	ab	19.00	b	8.00	abc	12.57	bc
V_3N_0	5.00	bc	3.33	f	7.00	gh	7.00	bcd	20.17	a
V_3N_1	5.67	abc	4.67	bcde	19.33	b	8.67	ab	20.9	a
V_3N_2	6.67	a	6.00	a	23.00	a	10.00	a	19.53	a
V_3N_3	4.67	c	4.33	cdef	22.33	a	9.00	ab	19.70	a
V_4N_0	5.00	bc	3.33	f	8.00	fg	5.67	d	12.57	bc
V_4N_1	6.00	abc	5.33	abc	10.33	cde	8.00	abc	14.97	b
V_4N_2	6.33	ab	4.67	bcde	10.00	def	8.67	ab	13.93	bc
V_4N_3	6.67	a	5.00	abcd	12.33	c	9.00	ab	14.70	b
CV	13.14%		14.21%		9.12%		12.04%		9.60%	
$LSD_{(0.05)}$	1.232		1.108		1.962		1.85		2.406	

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

V_1:BARI Tomato 4 N_0: 0 kg N/ha

V_2: BARI Tomato 5 N_1: 100 kg N/ha

V_3: BARI Tomato 7 N_2: 150 kg N/ha

V_4: BARI Tomato 9 N_3: 200 kg N/ha

4.5. Number of cluster per plant

Number of cluster per plant due to the influence of different varieties was significant (Appendix V). The variety BARI Tomato-7 had the highest number of cluster per plant (17.92). However, the lowest number cluster per plant (7.41) was obtained from the variety BARI Tomato-4, (Table 3). This result partially agreed with the findings of Hossain M. M. (2001).

Significant variation was found due to the application of different level of nitrogen on the number of cluster per plant (Appendix V). The maximum (15.33) number of cluster per plant was recorded from N_2, which was statistically similar with N_3. While N_0 gave the minimum (7.83) number of cluster per plant (Table 4).

The analysis of variance (Appendix IV) indicated a significant variation among the treatment combinations in number of cluster per plant. The maximum number of cluster per plant (23.00) was found in V_3N_2 (BARI Tomato-7 and 150 kg N/ha) which was statistically similar with V_3N_3. Whereas the minimum number of cluster per plant (5.33) was found in V_1N_0 (BARI Tomato-4 and 0 kg N/ha) (Table 5).

4.6. Fruit length

A significant variation in the length of fruit was found among the varieties (Appendix V). The longest fruit length (8.41 cm) was obtained from BARI Tomato-7 and the shortest fruit length (7.08 cm) was obtained from BARI hybrid Tomato-5 (Table 1). Hossain M. M. (2001), Sing and Sahu (1998) also reported varietal influence on the length of fruit.

Length of fruit had significant variation due to the application of different levels of nitrogen (Appendix V). The maximum (9.00 cm) length of fruit was recorded from N_3, while N_0 gave the minimum (6.08 cm) length of fruit (Table 2). Islam *et al.* (1997) reported that the length of individual fruit was increased with the increased nitrogen levels.

The interaction between different variety and different doses of nitrogen was found significant on the fruit length (Appendix V). The maximum length of fruit (10.00 cm) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and the lowest length of fruit (5.67 cm) was produced by V_1N_0 (BARI Tomato-4 and 0 kg N/ha) and V_4V_0 (BARI Tomato-9 and 0 kg N/ha) which is presented in table 3.

4.7.Fruit diameter

A significant variation in the breadth of fruit was found among the varieties (Appendix V). The largest fruit diameter (20.08 cm) was obtained from BARI Tomato-7, and the shortest fruit diameter (12.66 cm) was obtained from BARI Tomato-5 (Table 1). Hossain M. M. (2001), Singh and Sahu (1998) also reported varietal influence on the breadth of fruit.

Fruit diameter differed non significantly due to the application of different level of nitrogen (Appendix V). The highest (15.59 cm) diameter of fruit was recorded from N_2, while N_0 (0 kg N/ha) gave the minimum (14.21 cm) diameter of fruit (Table 2). Nasser (1986) also reported similar result. Islam *et al.* (1997) reported that the diameter of fruit was increased with the increased nitrogen levels.

The interaction between different variety and different doses of nitrogen was found significant variation on the fruit diameter (Appendix V). The maximum diameter of fruit (20.90 cm) was produced by V_3N_2 (BARI Tomato-7 and 100 kg N/ha) which was statistically similar with V_3N_0, V_3N_2 and V_3N_3 and the diameter of fruit (11.53 cm) was produced by V_2N_0 (BARI Tomato-5 and 0 kg N/ha) (Table 3).

4.8. Number of fruits per cluster

Number of fruits per cluster due to the influence of different varieties was significant (Appendix V). The variety BARI Tomato-7 had the highest number of fruits per cluster (5.00). However, the lowest number of fruits per cluster (4.08) was obtained from the variety BARI Tomato-5, which was statistically with BARI Tomato-4 and BARI Tomato-9 (Table 1). This result partially agreed with the findings of Hossain M. M. (2001).

Number of fruits per cluster showed significant variation due to the application of different levels of nitrogen (Appendix V). The maximum (5.08) number of fruits per cluster was recorded from N_2 which was statistically to N_3, while N_0 gave the minimum (3.42) number of fruits per cluster (Table 2). These results clearly showed that the number of fruits cluster gradually increased with the increasing levels of nitrogen. The result is almost similar to the finding of Islam *et al.* (1997). They found that highest number of fruits per plant was produced from 500 kg N/ ha. Midan *et al.* (1985) reported that the number of fruits per plant increased as the nitrogen level was also increased.

The interaction between different variety and different doses of nitrogen was found significant on the number of fruits per cluster (Appendix III). The maximum number of fruits per cluster (6.00) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and the number of fruits per cluster (3.33) was produced by V_1N_0 (BARI Tomato-4 and 0 kg N/ha), which was similar result found in V_4N_0 and V_3N_0 (Table 3).

4.9. Total soluble solid content (TSS)

No significant variation in the total soluble solid content was found among the varieties (Appendix VI). The maximum total soluble solid content (5.38%) was obtained from BARI Tomato-5 and the minimum total soluble solid content (5.00 %) was obtained from BARI Tomato-4 (Fig. 10).

No significant variation in the total soluble solid content was found different level of nitrogen (Appendix VI). The maximum (5.46%) total soluble solid content was recorded from N_2, while N_0 gave the minimum (5.00%) total soluble solid content (fig. 11).

The variation in total soluble solid content due to combined effect of different level of nitrogen and variety was found statistically significant (Appendix VI). The maximum total soluble solid content (5.77%) was found V_2N_2 (BARI Tomato-5 and 150 kg N/ha). Whereas the minimum total soluble solid content (4.5%) was found in V_1N_0 (BARI Tomato-4 and 0 kg N/ha) (Table 12). BARI (1989) also reported that earlier planting produces tomato with higher TSS.

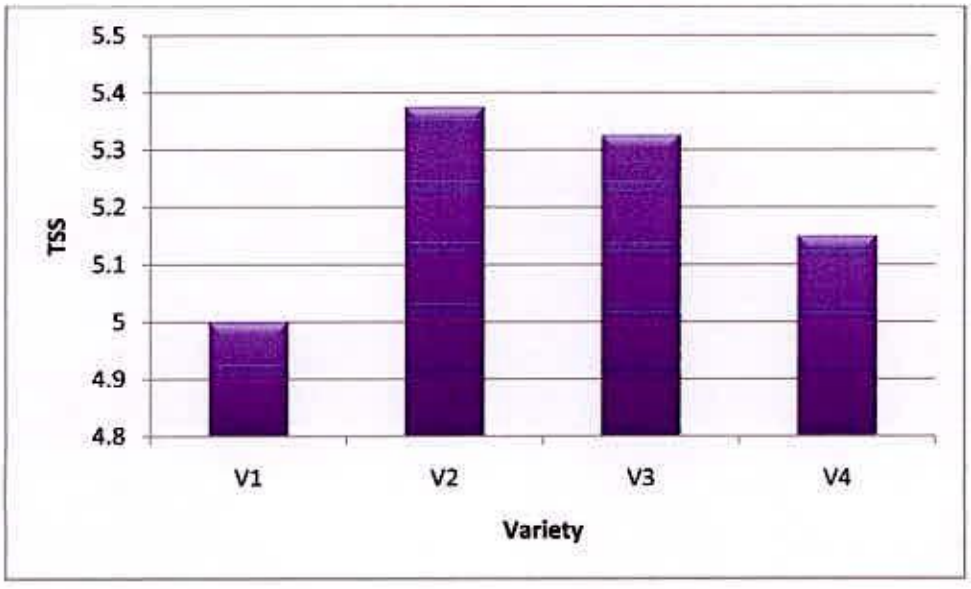

Figure 10. Main effect of variety on the TSS of tomato

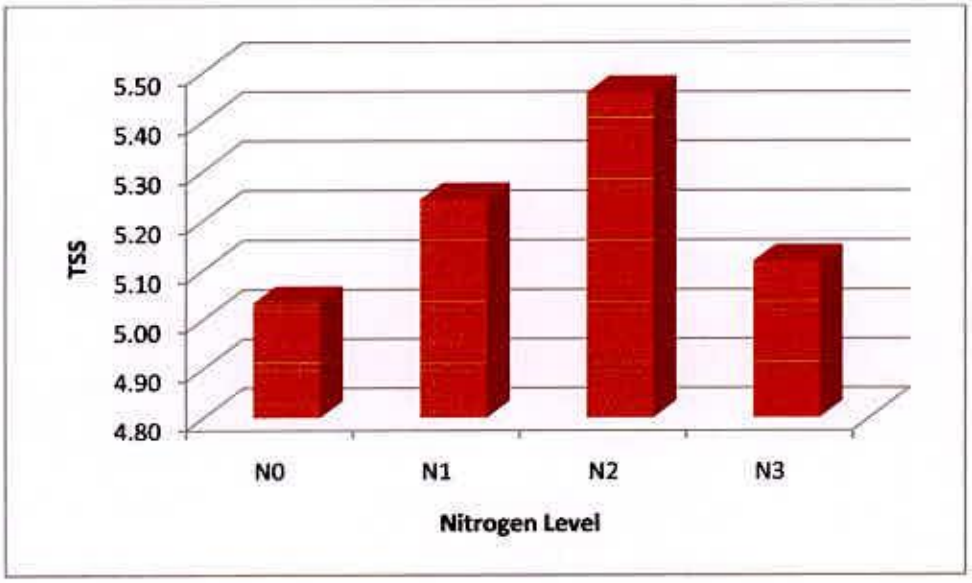

Figure 11. Effect of nitrogen on the TSS of tomato

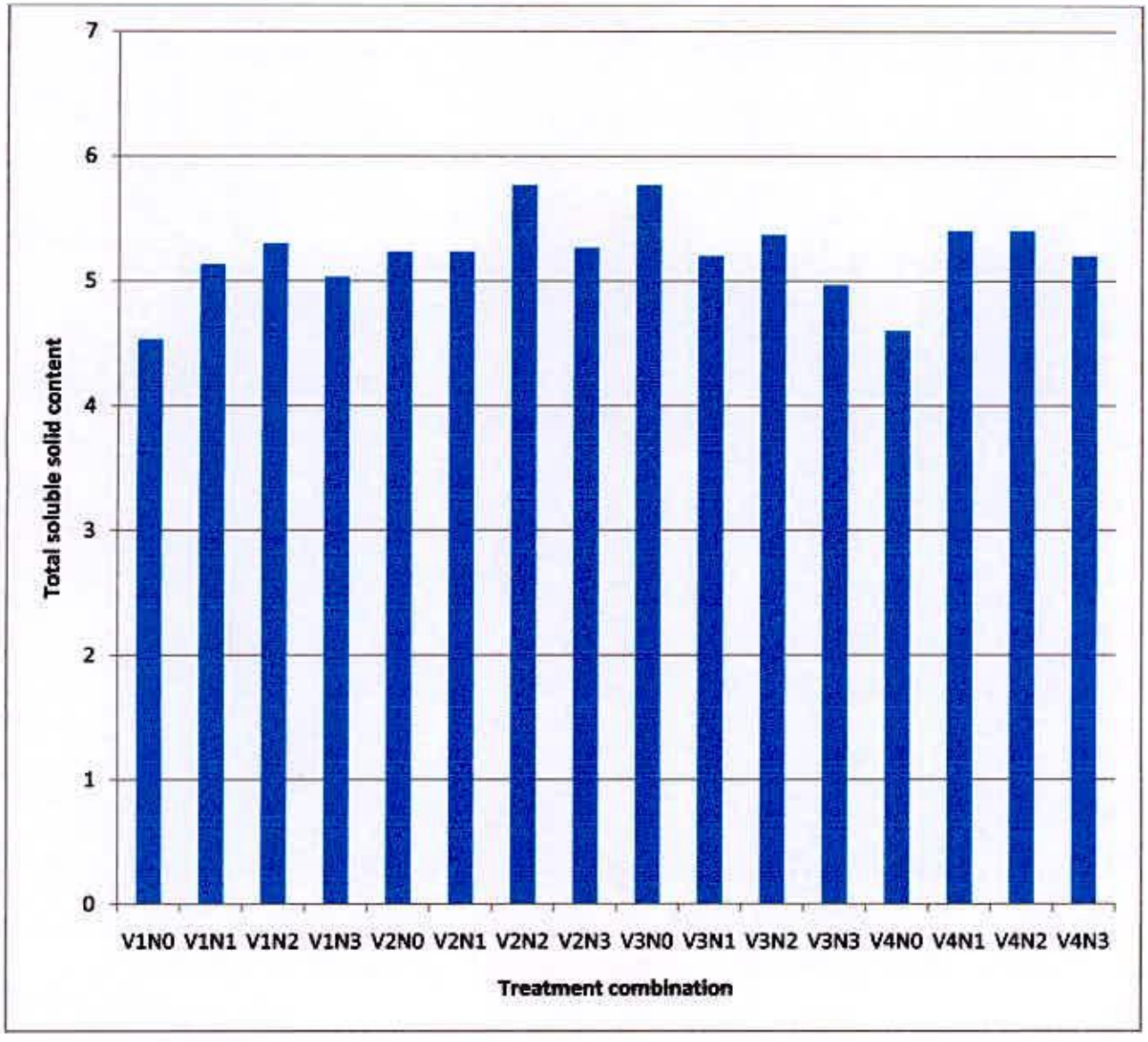

Figure 12. Combined effects of different variety and different level of nitrogen on the TSS of tomato

4.10. Individual fruit weight

The weight of individual fruit weight was significantly influenced by different varieties (Appendix VI). The maximum individual fruit weight (115.92g) was obtained from BARI Tomato-7. The minimum fruit weight (46.00g) was obtained from BARI Tomato-5 (Fig 13). The wide variation among the varieties in respect of individual fruit weight was due to the varietal characteristics. Varietal influence on individual fruit weight was also reported by Hossain *et al.* (1986) and Meher *et al.* (1994).

Weight of individual fruit differed significantly due to the application of different levels of nitrogen (Appendix V). The maximum (73.08 g) weight of ripe fruit was recorded from N_2, while N_0 gave the minimum (60.50 g) weight of fruit (Fig. 14). These results indicate that nitrogen increases the growth of tomato, which ensured the maximum weight of fruits than control.

The interaction between different variety and different doses of nitrogen was found significant on the Weight of individual fruit (Appendix VI). The maximum Weight of individual fruit (138.00 g) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and the minimum weight of individual fruit (40.33) was produced by V_2N_0 (BARI Tomato-5 and 0 kg N/ha (Table 4)

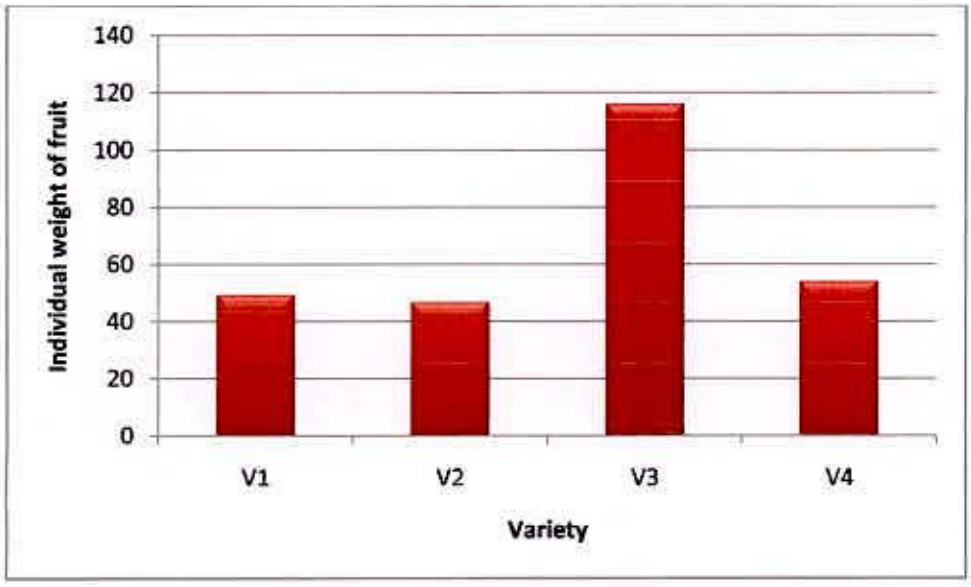

Figure 13. Effect of variety on the individual weight of tomato

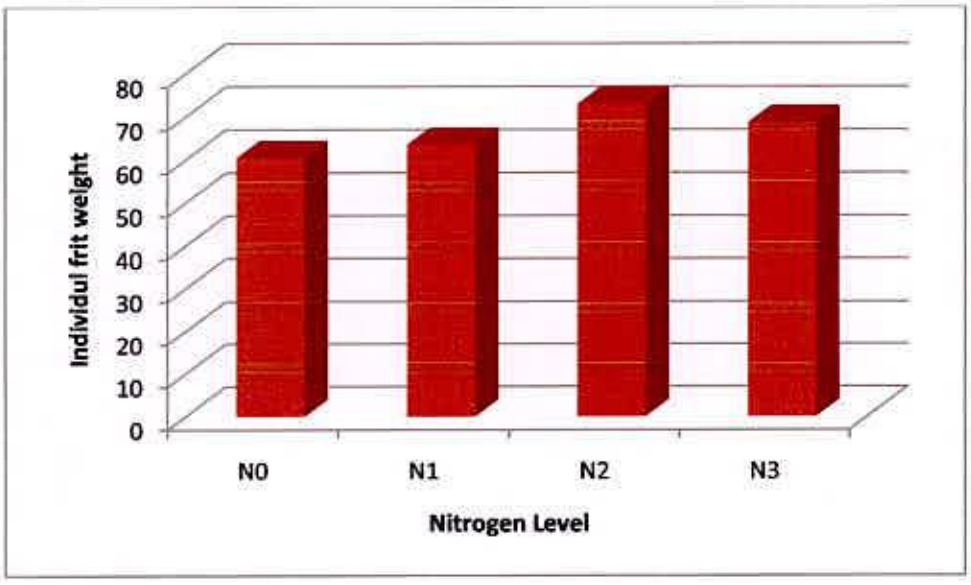

Figure 14. Effect of nitrogen on the individual weight of tomato

Table 4. Combined effects of different variety and different level of nitrogen on the yield contributing characters of tomato

Treatment	Individual fruit weight		Weight of fruit per plot		Yield (t/ha)	
V_1N_0	49	de	4.68	j	13.33	i
V_1N_1	49.67	de	6.99	i	18.67	h
V_1N_2	50	de	8.09	hi	23.67	gh
V_1N_3	40.33	f	7.68	hi	21.00	gh
V_2N_0	50	de	4.57	j	13.00	i
V_2N_1	47	ef	7.80	hi	21.67	gh
V_2N_2	49.33	de	9.24	h	25.33	g
V_2N_3	115	b	7.69	hi	21.33	gh
V_3N_0	120	b	28.21	f	78.33	e
V_3N_1	90.67	c	35.04	c	96.33	b
V_3N_2	138	a	38.64	a	106.30	a
V_3N_3	50.33	de	36.96	b	102.00	a
V_4N_0	55.33	d	25.47	g	70.33	f
V_4N_1	54.67	de	29.28	f	81.00	e
V_4N_2	55.67	d	33.24	d	91.67	c
V_4N_3	50.35	de	31.20	e	86.33	d
CV (%)	6.22		6.48		4.59	
$LSD_{(0.05)}$	6.997		1.814		5.131	

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

V_1:BARI Tomato 4 N_0: 0 kg N/ha

V_2: BARI Tomato 5 N_1: 100 kg N/ha

V_3: BARI Tomato 7 N_2: 150 kg N/ha

V_4: BARI Tomato 9 N_3: 200 kg N/ha

4.11. Weight of fruits per plot

The different varieties of tomato significantly influenced on the yield of fruits per plot (Appendix VI). The maximum yield of fruits per plot (34.71 kg) was obtained from BARI hybrid Tomato-7 and the minimum yield of fruits per plot (6.13 kg) was obtained from BARI Tomato-4 (Fig 15). Varietal influence on the yield of fruits per plant is also reported by Hossain M. M. (2001), Singh and Sahu (1998).

Weight of fruits per plot differed significantly due to the application of different levels of nitrogen (Appendix VI). The maximum (22.30 kg) weight of ripe fruits per plot was recorded from N_2, while N_0 gave the minimum (14.73 kg) weight of fruit per plot (Fig 16). These results indicate that nitrogen increases the growth of tomato, which ensured the maximum weight of fruits/plant than control.

The interaction between different variety and different doses of nitrogen was found significant on the Weight of fruit per plot (Appendix VI). The maximum Weight of fruit per plot (38.64 kg) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and the Weight of individual fruit (4.57 kg was produced by V_2N_0 (BARI Tomato-5 and 0 kg N/ha (table 4) which was statistically similar with V_1N_0.

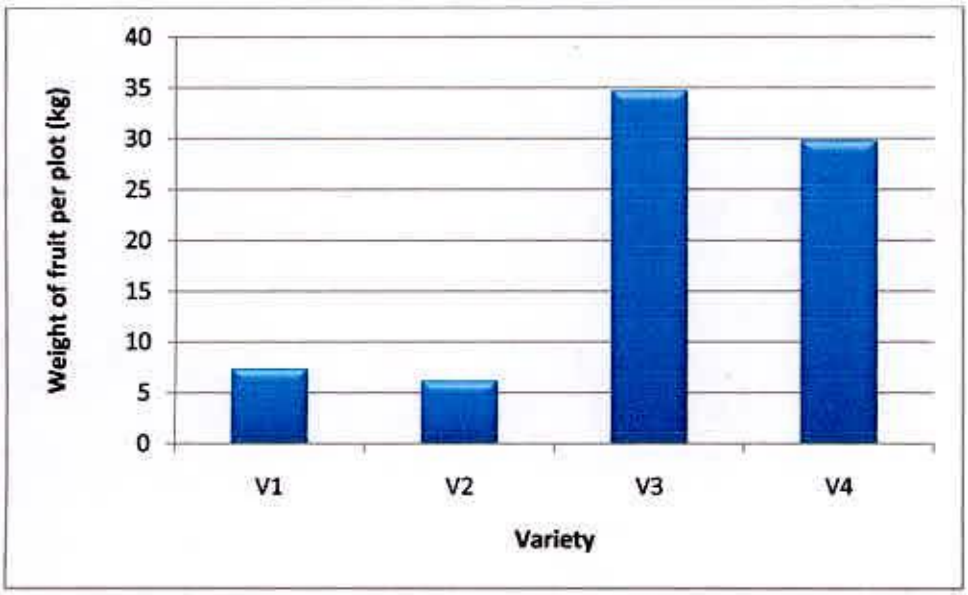

Figure 15. Effect of variety on the weight of fruit per plot of tomato

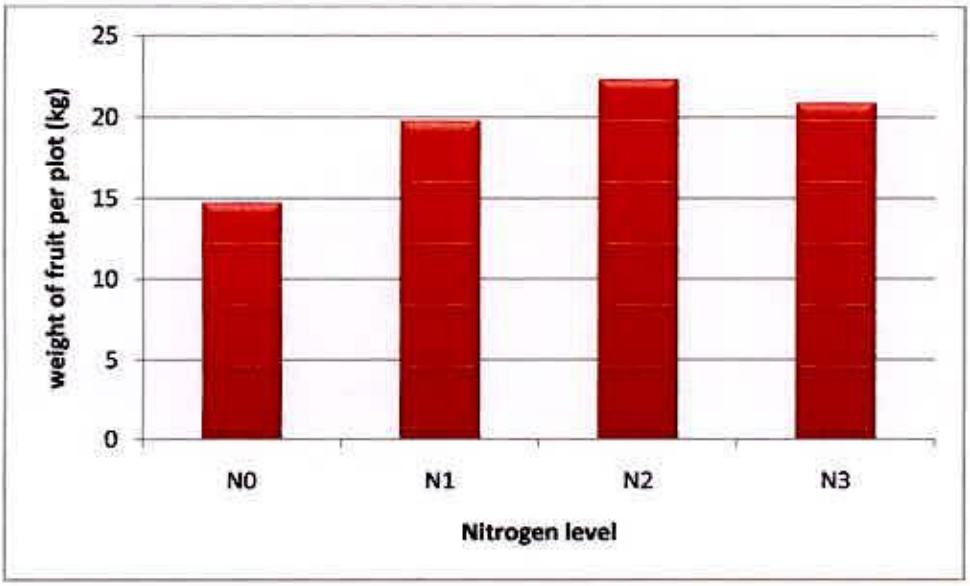

Figure 16. Effect of nitrogen on the weight of fruit per plot of tomato

4.12. Fruit yield

When per plot yield of tomato varieties was converted into yield of fruits per hectare (Appendix VI). The maximum yield of fruits per hectare (95.75 tones) was obtained from BARI hybrid Tomato-7 and the minimum yield of fruits per hectare (19.17 tones) was obtained from BARI Tomato-5, which was statistically similar to BARI Tomato-4 (Fig 17). Hossain M. M. (2001) and Ahmed *et al.* (1986) also reported varietal influence on the yield of fruit per hectare.

The total yield of tomato varied significantly due to the application of different levels of nitrogen (Appendix V). The highest yield of fruit (61.42 t/ha) was obtained from N_2, while (N_0) gave the lowest (41 t/ha,) yield (Fig 18). This result showed that the yield of tomato increased gradually with the increased doses of nitrogen fertilizer. Similarly Islam et al. (1997) reported that 500 kg/ha gave the highest fruit yield while the lowest was obtained from control. The result in conformity of the present study of profound influence of nitrogen levels to increase yield of tomato has been reported by many authors (Dose *et al.* 1981, Vris and George, 1985; Midan *et al.* 1985 and Kaniszewski *et al.* 1987). Combined effect of different variety and different doses of nitrogen had a significant variation in terms of yield of fruit (Appendix V). The maximum (106.3 t/ha) yield of fruit was recorded from V_3N_2 (BARI Tomato-7 and 150 kg N/ha), which was statistically similar with V_3N_3, while V_2N_0 (BARI Tomato-5 and 0 kg N/ha) gave the minimum (13.30 t/ha) yield of fruit (Table 4).

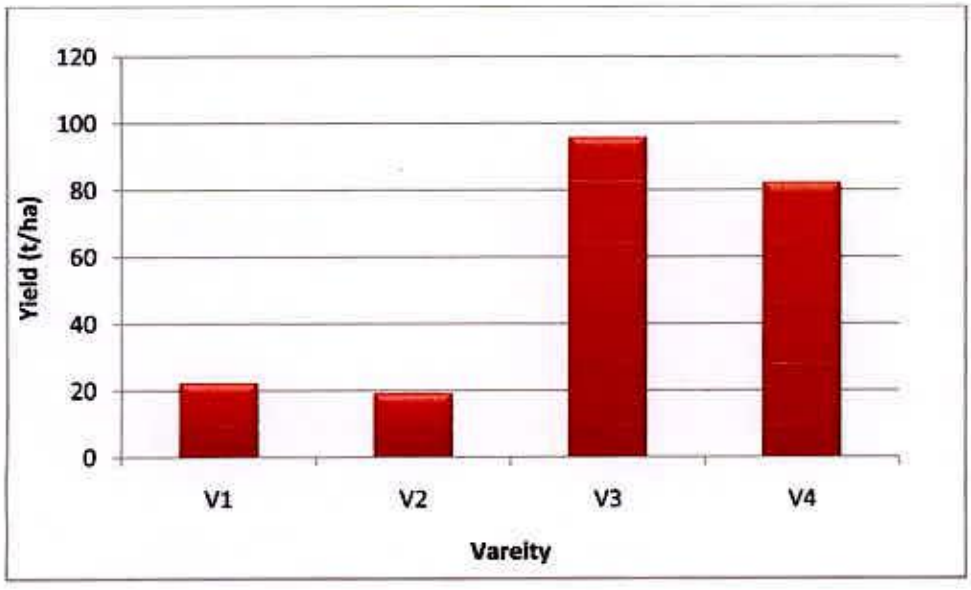

Figure 17. Effect of variety on the yield (t/ha) of tomato

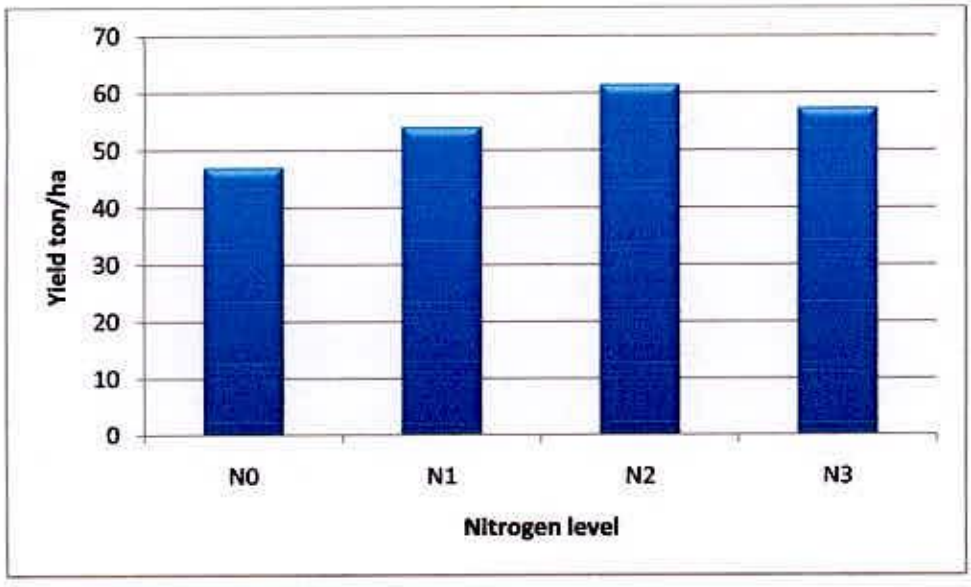

Figure 18. Effect of nitrogen on the yield (t/ha) of tomato

CHAPTER V

Summary and conclusion

The present experiment was carried out at the Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 to find out the effect of different doses of nitrogen fertilizer on morphology , growth and yield of tomato during the period from October 2008 to March 2009. The experiment comprised of four varieties, viz., BARI Tomato-4, BARI Tomato-5, BARI Tomato-7, BARI Tomato-9 and four levels of nitrogen (viz. 0, 100, 150 and 200 kg N/ha).

The experiment two factors was set up in Randomized Complete Block Design (RCBD) with three replications. In total, there were 16 treatment combinations in this study. A unit plot was 2m×1.8 m and the treatments were distributed randomly in each block. The experimental plot was fertilized at the rate of 10 tons cow dung, 450 kg (TSP) and 500 kg of MP per hectare, along with Nitrogen as per treatment. Healthy and uniformed sized 30 days old seedlings were taken separately from the seedbed and were transplanted in the experimental field on 28 November 2008. Five plants were randomly selected for data collection from each plot. Data on growth and yield parameters were recorded and analyzed statistically. The recorded data on various parameters were statistically analyzed. Following MSTAT-C software package programme. Difference between treatment means were adjusted by Duncan`s new Multiple Range Test (DMRT).

Data were taken on growth and yield contributing characters and the collected data were statistically analyzed for evaluation of the treatment effects. The summary of the results has been described in this chapter.

The effect of variety demonstrated that, the variety BARI Tomato-7 produced the tallest plant (83.25 cm) at 50% flowering stage. Significant variation in number of leaves was observed due to variety. The maximum value of the parameter was produces from the variety BARI Tomato-7 (114.10). There was a significant difference among the varieties in the number of branch per plant. The variety BARI Tomato-7 had the highest number of branches per plant (10.00). Significant variation in number of flowers per cluster, number of cluster per plant and number of fruit per cluster was observed due to variety. The maximum values of the parameters were produces from the variety BARI Tomato-7 which was 6.08, 17.92 and 5.00, respectively. The length of fruit and fruit diameter were significantly influence by the variety. The variety BARI Tomato-7 produced largest fruit length (8.42 cm) and fruit breadth (20.08 cm). No Significant variation in total soluble solid content was observed due to variety. The maximum value of total soluble solid content (5.38%) was obtained from the variety BARI Tomato-5. The different varieties exhibited marked influence on fruit yield of tomato. The highest individual fruit weight (115.92g), fruit yield per plot (34.71 kg) and fruit yield per hectare (95.75 tones) were produced by BARI Tomato-7.

Nitrogen had significant influence on the plant height 50% and 100% flowering stage. The highest plant height (82.25 cm and 91.41 cm) were obtained from application of 150 kg N/ha (N_2). Nitrogen had significantly influenced the length of

fruit and diameter of fruit. The maximum fruit length (9.00 cm) was obtained from the application of N_3 and diameter (15.59 cm) was obtained from the application of N_2. Different levels of nitrogen significantly influence number of leaves, branches. The maximum number of leaves (97.75), branch (10.67) per plant were obtained from the application of N_2. Different levels of nitrogen significantly influenced the number of flower and fruits per cluster. The maximum number of flower (6.42) and fruits (26.67) per cluster were obtained from the application of N_2. Significant variation was found due to the application of different level of nitrogen on the number of cluster per plant. The maximum (15.33) number of cluster per plant was recorded from N_2, which was statistically similar with N_3. No significant variation in the total soluble solid content was found different level of nitrogen. The maximum (5.46%) total soluble solid content was recorded from N_2. Different levels of nitrogen also significantly influenced individual fruit weight. The maximum individual fruit weight (73.08 g) was obtained from the application of N_2. The total yield of tomato showed significant difference due to the application of different levels of nitrogen. The highest yield of fruit (22.30 kg kg/plot and 61.42 t/ha, respectively) was obtained from N_2 and the control treatment (N_0) produced the lowest (14.73 kg /plot and 41.00 t/ha, respectively) in this respect.

The interaction between variety and nitrogen was found to be significant in all parameters. The tallest plant (97.67 cm and 115.70 cm at 50% and 100% flowering stage, respectively) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha). The maximum number of leaves (122.00), number of branch (17.00), number of flowers

per cluster (6.67), number of cluster per plant (23.00), length of fruit (10.00 cm), diameter of fruit (15.59 cm), number of flowers per cluster (6.00) were produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha). The maximum total soluble solid content (5.77%) was found V_2N_2 (BARI Tomato-5 and 150 kg N/ha). The maximum Weight of individual fruit (138.00 g) was produced by V_3N_2 (BARI Tomato-7 and 150 kg N/ha). The highest yield of fruit (38.64 kg/plot and 106.3 t/ha, respectively) was obtained from V_3N_2 (BARI Tomato-7 and 150 kg N/ha) and V_2N_0 (BARI Tomato-5 and 0 kg N/ha) gave the minimum (4.57 kg per plot and 13.30 t/ha, respectively) yield of fruit in this respect.

Conclusion

Considering the stated findings, it may be concluded that yield and yield contributing parameters are positively correlated with variety and different nitrogen level. However, BARI Tomato-7 planted and use nitrogen 150 kg per ha would be beneficial for the farmers.

Further studies are suggested for the conformation of these results.

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APPENDIXES

Appendix I: Results of physical and chemical properties of soil of the experimental plot

Physical properties (a)

Constituents	Percent
Sand	32.45
Silt	61.35
Clay	6.10
Textural class	Sandy loam

Chemical analysis (b)

Soil properties	Amount
Soil pH	5.6
Organic carbon (%)	1.32
Total nitrogen (%)	0.075
Available P (ppm)	19.5
Exchangeable K (%)	0.2

Appendix II Monthly Average Air Temperature, Total Rainfall, Relative Humidity and Sunshine hours of the experimental site during the period from September 2008 to March 2009

Year	Month	Average Air temperature (^{0}C)			Total rainfall (mm)	Average RH (%)	Total Sun shine hours
		Maximum	Minimum	Mean			
2008	September	34.8	24.4	81	279	81	34.8
	October	34.8	18.0	77	227	80	34.8
	November	32.3	16.3	69	0	65	32.3
	December	29.0	13.0	79	0	68	29.0
2009							
	January	28.1	11.1	72	1	66	28.1
	February	33.9	12.2	55	1	66	33.9
	March	34.6	16.5	67	45	68	34.6

Source: Dhaka Metrological Centre (Climate Division)

Appendix III: Analysis of variance of the data on plant height of tomato as influenced of different variety and nitrogen fertilizer

Source of variance	Degrees of Freedom	Mean Square	
		Plant height	
		20 DAT	30 DAT
Replication	2	218.146	250.896
Factor A	3	1017.243*	2136.576*
Factor B (Nitrogen)	3	361.41*	871.91*
A × B	9	114.706*	101.132*
Error	30	27.879	25.718

*Significant at 0.05%

Appendix IV: Analysis of variance of the data on number of leaves, number of branch of tomato as influenced of different variety and nitrogen fertilizer

Source of variance	Degrees of Freedom	Mean Square	
		number of leaves	Number of branch
Replication	2	3.146	5.771
Factor A	3	3876.132*	14.306*
Factor B (Nitrogen)	3	492.021*	56.694*
A × B	9	0.669*	18.176*
Error	30	54.39	1.193

*Significant at 0.05%

Appendix V: Analysis of variance of the data on number of flower, number of fruit per cluster, number of cluster per plant, Length of fruit, Diameter of fruit of tomato as influenced of different variety and nitrogen fertilizer

Source	Degrees of Freedom	Mean Square				
		number of flower per cluster	number of fruit per cluster	number of cluster per plant	Length of fruit	Diameter of fruit
Replication	2	0.646	1.583	17.521	3.083	2.112
Factor A	3	1.139*	1.799*	273.917*	3.806*	139.17NS
Factor B (Nitrogen)	3	4.139*	7.687*	148.806*	17.583*	4.144*
A × B	9	0.824*	0.78*	30.935*	1.306*	1.192*
Error	30	0.579	0.428	1.343	0.861	2.082

*Significant at 0.05% NS- non significant

Appendix VI: Analysis of variance of the data on TSS, yield per plot and Yield (t/ha) of tomato as different variety and nitrogen fertilizer

Source	Degrees of Freedom	Mean Square			
		TSS	Individual fruit weight	Weight of fruit per plot	Yield t/h
Replication	2	0.856	34.896	0.434	1
Factor A	3	0.352^{NS}	13145.24*	2655.775*	20358.69*
Factor B (Nitrogen)	3	0.41^{NS}	371.632*	64.904*	446.41*
A × B	9	0.297*	283.039*	4.832*	29.502*
Error	30	0.185	17.074	1.184	9.467

*Significant at 0.05% NS- non significant