EFFECT OF PRUNING AND NITROGEN ON GROWTH AND YIELD ON TOMATO

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This is to certify that thesis entitled, **"EFFECT OF PRUNING AND NITROGEN ON GROWTH AND YIELD ON TOMATO"** submitted to the Dept. of Horticulture, 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 **JANNATUL FERDOUS NODI** Registration No. **05-01800** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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Dedicated to

My

Beloved Parents

EFFECT OF PRUNING AND NITROGEN ON GROWTH AND YIELD ON TOMATO

By
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ABSTRACT

A field experiment was conducted to study the effect of different levels of pruning and nitrogen on the growth and yield of tomato cv. BAR1 Tomato-14 at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2011 to March 2012. There were three nitrogen levels, viz., 0, 115, 161 kg N ha^{-1} and three pruning levels, viz., no pruning, single pruning and double pruning. The experiment was laid out in a RCBD with three replications. Nitrogen and pruning showed significant influence on the growth and yield contributing characters of tomato. The plant height, number of cluster per plant, flower per plant, fruit cluster per plant, fruit per plant, fruit diameter, length of individual fruit, weight of fruit per plant and yield (48.4 t/ha)were the highest when 161 kg N/ha was applied. For pruning, maximum yield (45.5 t/ha) was obtained from double pruned plants and the minimum (34.6t/ha) from no pruned plants. The combination of nitrogen and stem pruning also exhibited significant variation in all the yield component and yield. The combination of 161 kg N/ha and double pruning produced the highest yield (52.7 t/ha) and lowest (32.2 t/ha) from 0 kg N/ha and no pruning.

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ABBREVIATIONS, ACRONYMS AND SYMBOLS

AEZ	Agro-Ecological Zone
ANOVA	Analysis of Variance
BARI	Bangladesh Agricultural Research Institute
DAT	Days After Transplanting
DMRT	Duncan's Multiple Range Test
FAO	Food and Agricultural Organization
SAU	Sher-e-Bangla Agricultural University

CHAPTER I

INTRODUCTION

Tomato *(Lycopersicon esculentum* Mill.), a member of the family Solanaceae is one of the most important and quality vegetables grown in Bangladesh. It ranks next to potato and sweet potato in the world vegetable production and toped the list of canned vegetable (Chowdhury, 1979). It was originated in tropical America (Salunkhe *et al*., 1987) particularly in Peru, Ecuador, and Bolivia (Kallo, 1986). It is cultivated in almost all home gardens and also in the field due to its adaptability to wide range of soil and climate (Ahmed, 1976).

Tomato is popular as salad in the new state and is used to make soups, juice, ketchup, pickles, sauces, conserved puree, paste, powder and other products (Ahmed, 1976*)*. Tomato is highly nutritious as it contains 94.1% water, 23 calories energy, 1.90 g protein, 1 g calcium, 7 mg magnesium, 1,000 IU vitamin A, 31 mg vitamin C, 0.09 mg thiamin, 0.03 mg riboflavin, 0.8 mg niacin per 100 g edible portion (Rashid, 1983). The leading tomato producing countries of the world are China, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (FAO, 2002).

The recent statistics shows that tomato was grown in 16,342 hectares of land and the total production was approximately 1,32,000 metric tons during the year 2008-2009, and the average yield of tomato was 8.85 t ha^{-1} in Bangladesh (BBS, 2009*)*, which is very low in comparison to that of other countries namely, India *(*15.67 t ha^{-1}), Japan *(*52.82 t ha^{-1}) and USA (63.66 t ha^{-1}) (FAO, 1995). The yield of tomato in our country is not satisfactory in comparison to its 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 low yielding variety, poor crop management practices and lack of improved technologies.

In Bangladesh, there is a huge possibility of increasing tomato yield per unit area with the proper use of fertilizer. Tomato requires large quantity of readily available fertilizer nutrients (Gupta and Shukla, 1977). To get one ton fresh fruit, plants need to absorb on average 2.5-3.0 kg N, 0.2-0.3 kg P and 3-3.5 kg K (Hedge, 1997). In indeterminate type of tomato, vegetative and reproductive stages over lap and the plants need nitrogen up to fruit ripening. Nitrogen is essential for building up protoplasm and protein, which induce cell division and initial meristematic activity when applied in optimum quantity (Singh and Kumar, 1969). Increase in nitrogen levels and spacing resulted in the production of fruits. Adequate nitrogen increases fruit quality, fruit size, keeping quality, colour and taste (Shukla and Nair, 1993). Nitrogen has the largest effect on yield and quality of tomato (Xin *et al.*, 1997). It also promotes vegetative growth, flower and fruit set of tomato (Bose and Som, 1990). It significantly increases the growth and yield of tomato (Banarjee *et al.*, 1997).

Proper pruning practices may lead to the production of relatively large sized fruit with better quality, increased yield, early harvest, easy harvesting of fruits and conveniences in intercultural operation without damage to the fruited plants. Appropriate pruning method gives the best quality and early fruit in tomato (Lopez and Chan, 1974). In a fertile soil with favourable environmental condition, tomato plants particularly of indeterminate type grow continuously and produce large number of branches. In this case, pruning is necessary because the branch bend down to the ground due to heavy load of fruits. Tomato plant can be severely pruned without affecting the yield (Patil *et al.*, 1973). Pruning could reduce production costs, increase yield and improve the quality of fruits (Davis and Estes, 1993).

Pruning and training in tomato plants are practiced in certain areas of the United State, especially in some parts of the Southern States and in few other regions (Thompson and Kelly, 1983). But majority of the tomato growers of Bangladesh have little knowledge about the advantage of pruning in tomato production.

Usually the farmers of Bangladesh cultivate tomato without pruning and even they do not maintain proper plant density. Where it has been reported that the single stem tomato plants gave early yield but closely planted plants produced higher yield (Vesselinov, 1977).

The present study was undertaken in view of the following objectives:

- To find out the effect of different levels of nitrogen for higher growth and yield of tomato.
- To find out the suitable pruning practices for higher yield.
- To determine the suitable combination of nitrogen level and pruning practices for ensuring the maximum yield.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field and greenhouse condition, which received much attention of the researchers throughout the world. The response of tomato to different levels of nitrogen and pruning practices for its successful cultivation has been investigated by numerous investigators in various parts of the world. In Bangladesh, there have not enough studies on the influence of either nitrogen of pruning or both in combination on the growth and yield of tomato. However, the available research findings in this connection over the world have been reviewed in this chapter under the following headings.

2.1 Lietarature of pruning on growth and yield contributing characters of tomato

Effects of pruning on the growth, yield and yield attributes of tomato has been presented below:

Hossain (2007) conducted a field experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 2006 to March, 2007 in order study the effects of nitrogen and stem pruning on the yield of tomato cv. Pusa Ruby. The experiment consisted of four doses of nitrogen, viz., 85, 171, 256 and 342 kg N ha^{-1} and three levels of pruning, viz., single stem, double stem and triple stem. Different pruning methods showed significant effects on most of the characters. Maximum yield (82.21 t ha^{-1}) was obtained from double stem pruned plants and the minimum yield (68.15 t ha^{-1}) was obtained from single stem pruned plants. The combination of nitrogen and stem pruning also exhibited significant variation in all the yield components and yield. The combination of 256 kg N ha^{-1} and double stem pruning produced the highest yield of tomato (90.70 t ha^{-1}).

Tomato fruit yield of 10995 kg^{-1} 667 m^2 was obtained by re-growth pruning of overwintered cultivated plants. Re-growth pruning of overwintered cultivated tomato plants also increased fruit yield by 46.6%, which was mainly due to increase in the number of spices, flower and fruits. However, the treatment did not increase fruit weight, Re-growth pruning increased the N, P, K, Mg, Fe and Cu uptake of the crop and also increased the N, P and K content in the plants by 59.1, 37.5 and 61.8%, respectively (Chen, 2005).

A significant difference was observed between different treatments for number of fruit trusses $plant^{-1}$, average fruit weight and fruit yield of cherry tomato, but plant height was not influenced significantly by the different levels of plant spacing, stem pruning and training. The highest number of fruit-bearing trusses (30.33 $plant^{-1}$) was recorded under the widest spacing with two main stems on each plant, while the greatest average fruit weight (10.1 g $fruit^{-1}$) was recorded when the crops was planted at the widest spacing with single main stem on each plant. Although, the highest fruit yield $plant^{-1}$ (5.1 kg $plant^{-1}$) was obtained from plants with two main stems on each plant adjusted at the widest spacing, the highest fruit with two main stem on each plant adjusted at the widest spacing, the highest fruit yield ha^{-1} (912.0 q ha^{-1}) was obtained when the cherry tomato plants with two main stems were grown at the closest spacing for long duration under semi-controlled greenhouse conditions in Delhi, India (Balraj and Mahesh, 2005).

A field experiment was conducted by Basunia (2004) to study the effect of different levels of nitrogen and pruning on the growth and yield of tomato cv. BAR1 Tomato-6 at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October 2003 to March 2004. There was four nitrogen levels, viz., 0, 100, 200, 300 kg N ha^{-1} and three pruning levels, viz., no pruning, single stem and double stem pruning. The maximum plant height, length, diameter and weight of individual fruit were observed in single stemmed plant. The total number of leaves, number of green leaves plant^{-1} at final harvest, days to first flowering, number of flower cluster^{-1}, flowers plant^{-1}, number of fruit cluster^{-1} and fruits plant^{-1} were maximum in unpruned plants. But the highest number of flowers cluster^{-1}, fruits cluster^{-1}, yield of tomato plant^{-1}, plot^{-1} as well as hectare^{-1} was obtained from double stemmed plants. The combined effect of nitrogen and pruning exhibited significant variation on plant height at 35, 50 and 65 DAT and at harvest, number of leaves, other yield contributing attributes and fruit yield of tomato. The plants pruned with double stem produced the highest yield (61.25 g ha^{-1}) compared to other pruning practices. The highest fruit yield (79.17 t ha^{-1}) was achieved from the treatment combination of 300 kg N ha^{-1} with double stem pruned plants.

A field experiment was conducted by Navarrete and Jeannequin (2000) to determine the effect of optimum deshooting frequency on vegetative growth and yield of tomato, in order to help the growers. They worked with four deshooting frequencies and compared these on two cultivars: every 7 (control) 10, 14 and 21 day. When deshooting was performed seldom (every 21 day), a decreasing trend was found in stem diameter and fruit m^2, leading to lower yield. But when the auxiliary buds were eliminated frequently (7 day), even those located near the apex, it reduced only vegetative growth. From a biological point of view, they concluded that the optimum deshooting frequency lies between 7 and 14 day.

Cuifen and Yanping (1997) were studied the effect if leaving 2, 3 or 4 fruits on spring tomato plants on subsequent fruit but development and yield in greenhouse experiments in China. Leaving up to 4 fruits had no significant effects on fruit bud development and give higher yields than leaving 2 or 3 fruits.

A experiment was conducted with tomato cv. BARI Tomato-2 (Ratan) to find out the effect of mulching and pruning in respect of vegetative growth and yield of tomato (Hossain *et al*., 1996). They found insignificant interaction effect. However, the treatment combination of mulching with black polythene and two times pruning at 21 and 35 DAT gave the highest yield (76.32 t ha^{-1}). They also found maximum individual fruit weight (62.64 g) with three times pruning at 21, 35 and 49 DAT.

Dhar *et al.* (1993) reported the role of pruning and number of plants $hill^{-1}$ on tomato. It was found that highest yield (96.25 t ha^{-1}) was produced in the double branched plants followed by that in unpruned plants (66.21 t ha^{-1}) and single branched (61.29 t ha^{-1}) plants. In case of number of plants $hill^{-1}$, three plants $hill^{-1}$ produced the highest yield (75.51 t ha^{-1}) followed by that from two plants (62.58 t ha^{-1}). The interaction effect was found significant for fruit size, weight and yield of tomato.

Davis and Estes (1993) found that early season yields were the highest using early pruning (lateral shoots were 5-10 cm long) or delayed pruning (when lateral shoots were 30-60 cm long) opposed to no pruning and in row spacing of 46 cm. Total season yields ha^{-1} of pruning plants increased as in row spacing decreased. For unpruned plants, however, total season yields were high at all spacing. Total season yields were lower from delayed pruning plants than from unpruned plants. Unpruned plants produced low yields of fruits >72 mm diameter but their total yield was greater than those of pruning plants. Net return ha^{-1} was the highest when i) plants spaced closely in row spacing were pruned early or ii) plants were spaced 46-76 cm apart and either pruned early or not pruned.

Rahman *et al.* (1994) reported that unpruned plants gave the highest yield (120.5 t ha^{-1}) and the lowest yield (69.0 t ha^{-1}) was obtained from the single stem pruning. Other characters like plant height, first flower opening and first harvesting time were not influenced by the pruning operations. Number of flower clusters, number of flowers and number of fruits plants^{-1} were maximum in unpruned plant, whereas fruit length, fruit diameter and individual fruit weight were the highest from single stem pruned followed by two time pruning (21 and 35 day after transplanting).

Baki (1987) found that pruning showed a significant effect on plant height. Unpruned plants exhibited higher plant height and highest number of inflorescence. Higher number of fruits was also obtained from unpruned plants. But maximum yield of tomato (96.08 t ha^{-1}) was obtained from unpruned plants with two stems at the closest spacing (75 + 50 cm). The pruned plant produced fruits relatively earlier than other treatments.

Campos *et al*. (1987) conducted an experiment to observe the effect of stem pruning and plant population on tomato productivity. They found that stem pruning increased the early yield and fruit weight but decreased both yield and fruit number plant^{-1}. The highest yield of marketable fruits was obtained in the control (54.8 t ha^{-1}) followed by the variant pruned above the 7th truss (53.07 t ha^{-1}). Marketable yields rose from 46.8 t ha^{-1} with 20,000 plants ha^{-1} to 54.49 t ha^{-1} at the highest density.

2.2 Lietareture of nitrogen on growth and yield contributing characters of tomto

Effects of nitrogen on the growth, yield and yield attributes of tomato has been presented below:

Fandi *et al*. (2010) concluded that high concentration of N, P and K in the nutrient solution gave higher total yield and tomato fruit weight than the control nutrient solution in tuff culture grown tomato. High phosphorus concentration (100 ppm) in the nutrient solution gave the highest total and marketable yield, number of marketable fruits and yield plant^{-1}, while low phosphorus concentration (20 ppm) gave the highest total soluble solids and titratable acids content in tuff culture grown tomato. The control nutrient solution gave the least total soluble solids, titratable acidity content and the highest pH of tomato juice.

Ferreira *et al.* (2010) studied that nitrogen fertilization efficiency of the tomato crop, with organic fertilization, was evaluated in two experiments conducted at two times: spring/summer and autumn/spring. The experiments were carried out at the Horticulture experimental field of the Universidade Federal de Vicosa in a Cambic Red-Yellow Argisol. In both times, the applied N doses, in the form of nitrocalcium, were 0.0, 93.3, 187.0, 374.0 and 748.0 kg ha^{-1} and the doses of organic fertilization, in the form of cattle manure compost, were 0 and 8 t ha^{-1} of dry matter. The weight and the number of marketed tomatoes $plant^{-1}$ increased with the increase of N level in the soil. The percentage of commercially discarded fruits was larger in the spring/summer than in the autumn/spring. The nitrogen fertilization efficiency in tomato crop was higher in the autumn/spring than in the spring/summer. In the spring/summer, the efficiency was higher without the addition of organic matter to the soil, whereas in the autumn/spring the opposite took place.

Greenhouse field experiments on tomato were carried out at Shouguang by **Tao** Ren *et al*. (2010) in Shandong province, over four double cropping seasons between 2004 and 2008 in order to understand the effects of manipulating root zone N management (RN) on fruit yields, N savings and N losses under conventional furrow irrigation. About 72% of the chemical N fertilizer used in conventional treatment (**CN**) inputs could be saved using the RN treatment without loss of yield. The cumulative fruit yields were significantly higher in the RN treatment than in the CN treatment. Average seasonal N from irrigation water (118 kg N ha^{-1}), about 59% of shoot N uptake, was the main nitrogen source in treatments with organic manure application (MN) and without organic manure or nitrogen fertilizer (NN). N losses in the RN treatment were lowered by 54% compared with the CN treatment. Lower N losses were found in the MN and NN treatments due to excessive inputs of organic manure and fruit yields were consequently substantially affected in the NN treatment. The critical threshold of **Nmin** supply level in the root zone (0-30 cm) should be around 150 kg N ha^{-1} for sustainable production. April to May in the winter-spring season and September to October in the autumn-winter season are the critical periods for root zone N manipulation during crop growth. However, control of organic manure inputs is another key factor to further reduce surplus N in the future.

Kikuchi (2009) observed that growth and nitrogen content were different among nine tomato cultivars grown under three nitrogen levels (50, 100, 150 mg N/L). Applied nitrogen efficiency to growth was the highest in Odoriko', and the lowest in 'June Pink'. It was suggested that the difference in tomato growth was influenced not only by the difference of nitrogen uptake but also the difference of nitrogen efficiency ratio (dry weight per nitrogen content). A positive correlation between the tomato growth and the content of assimilated nitrogen was observed. Therefore, it was suggested that the ability of nitrogen assimilation was different among the cultivars, and that the difference in ability of nitrogen assimilation influenced the difference in the nitrogen efficiency ratio and growth. They compared 'Odoriko' and 'June Pink' for nitrate (NO_3-) reduction, which is the most important step in nitrogen assimilation. It was shown that there were differences of nitrate reductase (NR) activity and rate of nitrate assimilation between the two cultivars.

An investigation was carried out by Bhadoria *et al*. (2007) to evaluate the effect of methods of *Azotobacter* inoculation in combination with nitrogen rates on the flowering and fruiting behaviour of tomato cv. JT-99. Treatments comprised: three methods of inoculation (no inoculation, soil inoculation and seedling inoculation) and five nitrogen rates (0, 25, 50, 75 and 100 kg ha^{-1}). Seedling treatment with *Azotobacter* recorded the earliest flowering, fruit setting and picking of fruits, as well as higher number of flowers, fruits and yield ha^{-1}. This was followed by soil inoculation with *Azotobacter* and no inoculation. The days to first flowering, number of flowers cluster^{-1}, days to first fruit setting, number of fruits cluster^{-1} and days to first picking of fruits increased with increasing nitrogen rate. The interaction effect of nitrogen rates and *Azotobacter* inoculation showed significant influence on days to first flowering, fruit setting and fruit picking in tomato. The maximum number of flowers, fruits cluster^{-1} and yield ha^{-1} were recorded with the application of 75 kg N ha^{-1} + seedling inoculation with *Azotobacter*. However, the number of flowers and fruits cluster^{-1} were at par with each other upon treatment with 100 kg N ha^{-1} + seedling inoculation with *Azotobacter* and 100 kg N ha^{-1} alone.

Hossain (2007) conducted a field experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October, 2006 to March, 2007 in order study the effects of nitrogen and stem pruning on the yield of tomato cv. Pusa Ruby. The experiment consisted of four doses of nitrogen, viz., 85, 171, 256 and 342 kg N ha^{-1} and three levels of pruning, viz., single stem, double stem and triple stem. The experiment was laid out in RCBD with 12 treatment combinations and three replications. Nitrogen showed significant influence on the growth and yield contributing characters of tomato. The plant height at 50 DAT, number of flower clusters plant^{-1}, flowers cluster^{-1}, flowers plant^{-1}, fruit clusters plant^{-1}, fruits cluster^{-1}, ripe fruits plant^{-1}, fruit diameter, weight of individual fruit, weight of fruits plant^{-1} and fruit yield plot^{-1} were the highest when 256 kg N ha^{-1} was applied. The yield of tomato under this treatment was 84.36 t ha^{-1}. On the other hand, different pruning methods showed significant effects on most of the characters. Maximum yield (82.21 t ha^{-1}) was obtained from double stem pruned plants and the minimum yield (68.15 t ha^{-1}) was obtained from single stem pruned plants. The combination of nitrogen and stem pruning also exhibited significant variation in all the yield components and yield. The combination of 256 kg N ha^{-1} and double stem pruning produced the highest yield of tomato (90.70 t ha^{-1}).

Solaiman and Rabbani (2006) carried out a field experiment was at the Bangabandhu Sheikh Mujibur Rahman Agricultural University farm in Bangladesh, to assess the effects of inorganic and organic fertilizers on vegetative, flowering and fruiting characteristics as well as yield attributes and yield of Ratan variety of tomato. The plots were treated with three levels each of N (62, 100 and 200 kg ha^{-1}), P (11.7, 17.5 and 35 kg ha^{-1}), K (26.7, 40 and 80 kg ha^{-1}), S (5, 7.5 and 15 kg ha^{-1}) and cowdung (5, 10 and 15 t ha^{-1}). The highest plant height and dry weight of shoot, the maximum number of clusters of flowers and fruits $plant^{-1}$ as well as the greatest fruit size and fruit yield $plant^{-1}$, fruit yield ha^{-1} were obtained from the application of the recommended dose of nutrients viz. 200 kg N + 35 kg P + 80 kg K + 15 kg S ha^{-1}, but similar results were obtained from the treatment receiving 5 t cowdung ha^{-1} along with half of the recommended doses of nutrients (100 kg N + 17.5 kg P + 40 kg K + 7.5 kg S ha^{-1}). The effect of 10 t cowdung ha^{-1}, along with one third of the recommended dose of nutrients, was also comparable to the effect of employing the recommended dose of nutrients. It was further observed, from an economic standpoint, that the combination of 5 t cowdung ha^{-1} along with half of the recommended doses of nutrients appeared to be a viable treatment which would offer the maximum benefit concerning cost ratio (4.38) for tomato production in the shallow red-brown terrace soil (AEZ-28) of Bangladesh.

Parisi *et al*. (2006) studied to influence of nitrogen supply (from 0 to 250 kg N ha^{-1}) on yield and quality components of processing tomato grown in 2002-03 in Sele valley (Campania, Italy). Nitrogen fertilizer application from 50 to 250 kg ha^{-1} increased total yield but not marketable yield, because of a strong increase of unmarketable yield. Rates higher 150 kg ha^{-1} did not produce increase in total, ripe and unripe yield. The highest rate supply resulted in less concentrated ripeness, more phytosanitary problems and an increase of viral damage incidence on fruits. High nitrogen supply reduced some important processing characteristics such as pH, soluble solids, glucose and fructose content, as well as sugar/total solids ratio.

Ingole *et al*. (2005) carried out an experiment to evaluate the effect of N and K fertilizers (muriate and sulfate of potash) on the fruit yield and quality of tomato cv. Arkas Vikas. The treatments included N at 75, 100 and 125 kg ha^{-1}; and K at 25, 50 and 75 kg ha^{-1}. K levels did not significantly affect yield. Maximum yield was obtained from 100 kg N ha^{-1} (31.14 t ha^{-1}). Nitrogen @ 125 kg ha^{-1} produced the highest soluble solids content in fruits. Nitrogen at 125 kg ha^{-1} + K at 25 kg ha^{-1} resulted in maximum titratable acidity. Ascorbic acid content was highest with 125 kg N ha^{-1} + 75 kg K ha^{-1} (as sulfate of potash), while lycopene content was highest with 125 kg N ha^{-1} + 50 kg K ha^{-1} (as muriate of potash).

Singh *et al*. (2005) conducted an experiment to study the effects of N, P, and K at 200:100:150, 350:200:250, and 500:300:350 kg ha^{-1} on the growth and yield of tomato hybrids Rakshita, Karnataka, and Naveen in New Delhi, India during the early winter of 2000-02. Naveen had the highest number of flower clusters per plant and the earliest picking period and fruit setting. On the other hand, Karnataka produced the highest yield during both years (2.85 and 3.07 kg $plant^{-1}$). Plant height, number of leaves $plant^{-1}$, leaf length, stem thickness, number of flower clusters $plant^{-1}$, and picking period were the highest with the application of 500:300:350 kg NPK ha^{-1} during both years. Fruit yield (30.2 and 34.8 kg ha^{-1} in 2000-01 and 2001-02, respectively) and number of pickings (14 during both years) were the highest with the application of 350:200:250 kg NPK ha^{-1}.

A field experiment was conducted in Agra, Uttar Pradesh, India during the rabi season by Singh *et al*. (2005) in 1996-99 to determine the effects of different N rates (0, 100, 200 and 300 kg ha^{-1}) and plant spacing (75 x 50, 75 x 75 and 75 x 100 cm) on the yield and yield attributes of tomato cultivars Naveen (indeterminate) and Rupali (determinate). The number of fruits plant^{-1}; fruit weight, diameter and specific gravity; fruit yield plant^{-1}; and total yield increased with increasing plant spacing and N rates up to 200 kg ha^{-1}, and decreased thereafter. The number of fruits plant^{-1}, fruit yield plant^{-1} and total yield were higher in Naveen, whereas fruit weight, diameter and specific gravity were higher in Rupali.

Badruddin and Dutta (2004) reported that N requirement based on nitrate reductase (NR) induction, N accumulation and productivity. N fertilizer was applied at 0, 75, 100, 125, 150 and 175 kg ha^{-1}, in 2 split-doses (24 and 40 days after transplanting). Fruit yield increased compared to the control. Nitrogen @ 175 kg ha^{-1} produced the highest straw yield. Straw N content was the highest (3.11%) with 100 kg N ha^{-1} in Mymensingh, while the highest N content (3.07%) in Rangpur was obtained with 125 kg N ha^{-1}. The highest fruit N accumulation (156 kg ha^{-1}) in Mymensingh was obtained with 175 kg N ha^{-1}, while 150 kg N ha^{-1} produced the highest fruit N accumulation (170 kg ha^{-1}) in Rangpur. There was a significant NR activity throughout the growing period of Bahar, which maintained the highest NR activity.

A field experiment was conducted by Basunia (2004) to study the effect of different levels of nitrogen and pruning on the growth and yield of tomato cv. BAR1Tomato-6 at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from October 2003 to March 2004. There was four nitrogen levels, viz., 0, 100, 200, 300 kg N ha^{-1} and three pruning levels, viz., no pruning, single stem and double stem pruning. The results of the experiment revealed that plant height, total number of leaves, number of green leaves plant^{-1} at final harvest, days to first flowering, number of flower clusters, flower cluster^{-1}, flower plant^{-1}, fruits cluster^{-1}, fruits plant^{-1}, length and diameter of fruit, individual fruit weight and fruit yield were significantly influenced by the different levels of nitrogen. The combined effect of nitrogen and pruning exhibited significant variation on plant height at 35, 50 and 65 DAT and at harvest, number of leaves, other yield contributing attributes and fruit yield of tomato. The highest fruit yield (70.12 t ha^{-1}) was obtained from the highest level of nitrogen (300 kg ha^{-1}) followed by 200 kg ha^{-1} (59.58 t ha^{-1}), 100 kg N ha^{-1} (47.22 t ha^{-1}) and control (36.10 t ha^{-1}).

Kaur Harne *et al.* (2003) observed the effect of nitrogen and potassium application on the growth, yield and quality of spring crop of tomato cv. Punjab Upma. Treatments consisted of 16 combinations of 4 levels each of N (100, 140, 180, 220 kg ha^{-1}) and K (40, 60, 80, 100 kg ha^{-1}). Increasing the N level from 100 to 140 kg ha^{-1} and the K level from 40 to 60 kg ha^{-1} significantly increased marketable and total yields. Significant increase in juice content, ascorbic acid content, N and K concentrations in leaves was observed when the N level increased from 100 to 140 kg ha^{-1}. There was also a significant increase in the concentration of K in leaves when K level was increased from 40 to 60 kg ha^{-1}.

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^{-1}) and potassium (75 or 150 kg ha^{-1}) on the growth and yield of tomato var. Utkal kumara 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^{-1} reduced the yield considerably. They also found that the highest value relating to yield attributing characters like number of fruits $plant^{-1}$ and single fruit weight were maximums when potassium was applied at the rate of 75 kg ha^{-1}. However, the combination of 150 kg N ha^{-1} along with 75 kg K ha^{-1} gave best result with respect to tomato from yield and other yield attributing characters.

Ceylan *et al*. (2001) conducted an experiment at Odemis, Izmir, Turkey to observe the effect of ammonium nitrate and urea fertilizers at 0, 12, 24, 36 kg N ha^{-1} on nitrogen uptake and accumulation in tomato plants. The total nitrogen, NO_2-N and NO_3-N contents of leaves and fruits were determined. On the first and second harvest dates, the highest NO_3-N and NO_2-N amounts in tomato leaves and fruits were obtained upon treatment with 36 kg N ha^{-1}. Ammonium nitrate application increased nitrate and nitrite accumulation compared to urea application. The highest yield was recorded upon treatments with 24 kg N ha^{-1}.

Sharma and Thakur (2001) carried out a field trial at Nauni, India during the summer season of 1995 and 1996 to investigate the effect *Azotobacter* biofertilizer (M_4 Strain and commercial formulation of Natrin) in combination with various levels of nitrogen (0, 50, 75 and 100 kg N ha^{-1}) on the growth and yield of tomato cv. Yashwant. They reported that among individual treatments, the application of Natrin results in significant improvement in plant height number of branches and fruits $plant^{-1}$, fruit yield $plot^{-1}$, yield ha^{-1}, nitrogen uptake at flowering stage and root biomass. Similarly the maximum values for all these parameters were recorded at 100 kg N ha^{-1}. Among treatment combinations the maximum $yield^{-1}$ was obtained when Natrin (*Azotobacter*) was applied in combination with 100 kg N ha^{-1}.

From the above review of literature we can say that application of nitrogen and stem pruning has an undoubted immense importance on the growth and yield of tomato. Increasing rate of nitrogen up to a certain level drastically increase plant height, number of flowers and fruit $plant^{-1}$, fruit length, fruit diameter as well as yield ha^{-1}.

On the other hand, stem pruning plays an important role for obtaining larger fruit size, individual fruit weight and ultimately yield ha^{-1}. In the most of the cases it was reviewed that double stem pruned plants showed better yield. So, it is necessary to select the proper dose of nitrogen and optimum stem pruning level for better yield of tomato.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experiment, characteristics of soil, climate, materials used, land preparation, manuring and fertilizing, transplanting and gap filling, staking, after care, harvesting and collection of data.

3.1 Location of the experiment field

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2011 to March 2012 to find out the effect of different doses of nitrogen and pruning on the growth and yield of tomato. The location of the experimental site is at 23.75 N latitude and 90.34 E longitudes with an elevation of 8.45 meter from the sea level (Anon., 1989).

3.2 Climate of the experimental area

The climate of the experimental area was subtropical in nature. It is characterized by heavy rainfall, high temperature, high humidity and relatively long day during kharif season (April to September) and a scanty rainfall associated with moderately low temperature, low humidity and short day period during rabi season (October to March).

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, ECE 25.28 (Haider, 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka.

3.4 Plant materials used

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

3.5 Raising of seedlings

Tomato seedlings were raised in three seedbeds situated on a relatively high land at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was 3 m x l m. The soil was well prepared with spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cowdung was applied during seedbed preparation. The seeds were sown on the seedbed on 25 October, 2011 to get 30 days old seedlings. Germination was visible 3 days after sowing of seeds. After sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg ha^{-1} around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 5 to 6 days after sowing. Necessary shading by banana leaves was provided over the seedbed to protect the young seedlings from scorching sun or heavy rain. Weeding, mulching and irrigation were done from time to time as and when required and no chemical fertilizer was used in the seedbed.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A: The experiment consisted of three different level of nitrogen which are mentioned below with alphabetic symbol.

Doses of N (kg ha^{-1})	Alphabetic symbol
Control treatment (No fertilizer)	N_0
115 kg	N_1
161 kg	N_2

Factor B: It is consisted of three levels of pruning which are mentioned below with alphabetic symbol.

Pruning	Alphabetic symbol
Control treatment (No pruning)	P_0
Single pruning	P_1
Double pruning	P_2

Total 9 treatment combinations were as follows:

P_0N_0: No pruning + No N

P_0N_1: No pruning + 115kg N ha^{-1}

P_0N_2: No pruning + 161 kg N kg ha^{-1}

P_1N_0: Single pruning + No N

P_1N_1: Single pruning + 115 kg N ha^{-1}

P_1N_2: Single pruning + 161 kg N ha^{-1}

P_2N_0: Double pruning + No N

P_2N_1: Double pruning + 115 kg N ha^{-1}

P_2N_2: Double pruning + 161 kg N ha^{-1}

The experiment was laid out in Randomized complete Block Design (RCBD) having two factors with three replications. The treatment combinations were accommodated in the unit plots.

3.7 Layout of the experiment

An area of 31.5 m x 11.2 m was divided into three equal blocks. Each block consisted of 09 plots where 09 treatments were allotted randomly. There were 27 unit plots altogether in the experiment. The size of each plot was 2 m x 1.8 m. The distance between two blocks and two plots were l m and 0.5 m respectively. Seedlings were transplanted on the plots with 60 cm x 40 cm spacing.

3.8 Cultivation procedure

3.8.1 Land preparation

The soil of the experiment field was first opened on 02 October, 2011 in order to get well prepare and good tilth for tomato crop production. The land of the experimental field was ploughed with a power tiller. Later on the land was ploughed three times followed by laddering to obtain untill desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed. Finally, the unit plots were prepared as 15 cm raised beds. Fifteen pits were made in each plot with in row-to-row and plant to plant spacing of 60 cm X 40 cm.

3.8.2 Manuring and Fertilizing

Manure and fertilizers such as Cowdung, Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were applied in the experimental field as per recommendation of BARI (1996).

Manure/Fertilizer	Dose per hectare	Dose unit plot (2m x 1.8m)
Cow dung	10 ton	3.6 kg
Triple Super Phosphate (TSP)	175 kg	63 g
Muriate of Potash (MoP)	150 kg	54 g

The entire amount of well-decomposed cow dung was applied just after opening the land and the total Amount TSP was applied as basal dose during final land preparation. Urea and MoP were applied in two installments by the ring placement. The first ring placement was done three weeks after transplanting and the remaining was done two weeks after the first ring placement.

3.8.3 Transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 25 November, 2011 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 to 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.

3.8.4 Intercultural operations

After transplanting the seedlings, different intercultural operations were accomplished for better growth and development of the plants, which are as follows.

3.8.4.1 Gap filling

A few gap filling was done by healthy seedlings of the same stock where planted seedlings failed to survive. When the seedlings were well established, the soil around the base of each seedling was pulverized.

3.8.4.2 Weeding and mulching

Weeding was done whenever it was necessary. Mulching was also done to help in soil moisture conservation.

3.8.4.3 Stalking and pruning

When the plants were well established, stalking was given to each plant by bamboo sticks for support to keep them erect. Within a few days of stalking, as the plants grew up, the plants were pruned. In single pruned plants five side shoots were removed at 30 DAT. In case of double pruned plants second time the same branches were pruned at 45 DAT .

3.8.4.4 Irrigation

Light watering was given with watercan immediately after transplanting the seedlings and then flood irrigation was done as and when necessary throughout the growing period up to before 7 days of harvesting.

3.8.4.5 Plant protection

Insect pests: Melathion 57 EC was applied @ 2 ml L^{-1} of water against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly after transplanting and stopped before second week of first harvest. Furadan lOG was also applied during final land preparation as soil insecticide.

Disease: During foggy weather precautionary measure against disease attack of tomato was taken by spraying Diathane M-45 fortnightly @ 2 gm per litre of water, at the early vegetative stage. Ridomil gold was also applied @ 2 g per litre of water against blight disease of tomato.

3.8.4.6 Harvesting

Fruits were harvested at 3-days interval during early ripe stage when they developed slightly red color. Harvesting was started from 28 February and was continued up to March, 2012.

3.9 Parameters assessed

Five plants were selected at random and uprooted carefully at the time of collecting data of root from each plot and mean data on the following parameters were recorded:-

- Plant height (cm)
- Number of clusters per plant
- Number of flowers per plant
- Number of fruits per plant
- Length of fruit (cm)
- Diameter of fruit (cm)
- Yield per plant (kg)
- Yield per hectare (t ha^{-1})

3.10 Data collection

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

Plant height (cm):

The plant height was recorded at 14 days interval starting from 28 days of transplanting up to 70 days. Plant height was taken at 28, 42, 56 and 70 days after transplanting to record the growth rate of plants.

Number of clusters per plant:

The number of fruit clusters was counted from the sample plants and the average number of clusters borne per plant was recorded at the time of final harvest. The data of cluster/plant is presented only 45 and 63 DAT.

Number of flowers per plant:

Total number of flowers was counted from selected plants and their average was taken as the number of flowers per plant at the time from open flower bud up to 63 DAT. As all the plants show the 1st flower open after the 49 DAT. The data of flower/plant is presented only 45 and 63 DAT.

Number of fruits per plant:

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

Length of fruit (cm):

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

Diameter of fruit (cm):

Diameter of fruit was measured at the middle portion of 10 selected marketable fruit of 100 g with slide-calipers and their average was taken in cm as the diameter of fruit.

Yield per plant (kg):

The fruits were harvested from 5 sample plants and they were measured with the help of measuring balance and average was taken by following formula:

$$\text{Yield per plant (kg)} = \frac{\text{Total weight of fruits in 5 sample plants (kg)}}{5}$$

Yield per hectare (ton):

The yield per hectare was calculated out from per plot yield data.

3.11 Statistical analysis

The data in respect of growth and yield components were statistically analyzed to find out the significance of the experimental results. The means of all the treatments were calculated and the analysis of variance for each of the characters under study was performed by F test. The difference among the treatment means was evaluated by Least Significant Difference (LSD) test (Gomez and Gomez, 1984) at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the effect of pruning and nitrogen on the growth and yield of tomato. The effects due to different levels of pruning and nitrogen and their interaction on the growth, yield contributing attributes and yield of tomato have been presented in Figures 4.1- 4.14 and Appendices 4.1 - 4.8 and table 4.1 - 4.4. The results of each parameter studied in the experiment have been presented and discussed under the following headings.

4.1 Plant height

There had a significant variation among different levels of pruning in respect of plant height at 42 DAT which was found by double pruning (Fig. 4.1 and App. 4.1). Plant height increased gradually in all pruning levels. The highest plant height (7.67 cm at 28 DAT, 42.56 cm at 42 DAT, 63.56 cm at 56 DAT and 99.65 cm at 70 DAT) was recorded from double stem pruning and the lowest plant height (7.56 cm at 28 DAT, 36.11 cm at 42 DAT, 55.67 at 56 DAT and 85.89 cm at 70 DAT) was recorded from unpruned plants (Fig. 4.1 and App. 4.1).

Different levels of nitrogen exhibited significant variation in respect of plant height at different days after transplanting (Fig. 4.2 and App. 4.2). In case of nitrogen doses, it was recorded that plant height increased gradually with time (Fig. 4.2 and App. 4.2). At 28 DAT, the maximum height was found at 161 kg N ha^{-1} and the minimum was measured in control treatment. Similary maximum plant height at 42 DAT, 56 DAT and 70 DAT were found from 161 kg N ha^{-1} and the lowest was observed at control nitrogen.

The plant height was increased possibly due to the readily available nitrogen, which might have encouraged more vegetative growth and development. Chung *et al.* (1992)

reported that plant height increased with increasing nitrogen rate. Kuksal *et al.* (1977) also reported that nitrogen application at higher rate increased plant height. Similar options were put forward by Sharma and Mann (1972), Basunia (2004) and Hossain (2007).

The interaction effect of nitrogen and pruning in respect of plant height was found non-significant at 28 DAT, 42 DAT and 70 DAT (App. 4.3). The maximum plant height at 42 DAT and 56 DAT were recorded from the treatment combinations of 161 kg N ha^{-1} at double stem pruning and the minimum was found from the treatment combination of 0 kg N ha^{-1} and unpruned plants. While at 28 DAT, the maximum plant height was recorded from the treatment combination of 161 kg N ha^{-1} and single stem pruning. A gradual increase in plant height with the age of plant was also noticed in all treatment combinations (App. 4.3). The tallest plant at 70 DAT (96.67) was recorded from the treatment combination of 0 kg N ha^{-1} and double stem pruning, and the shortest plant (79.00 cm) was obtained from the treatment combination of 0 kg N ha^{-1} and no pruning (control). Similar results were recorded by Basunia (2004) and Hossain (2007).

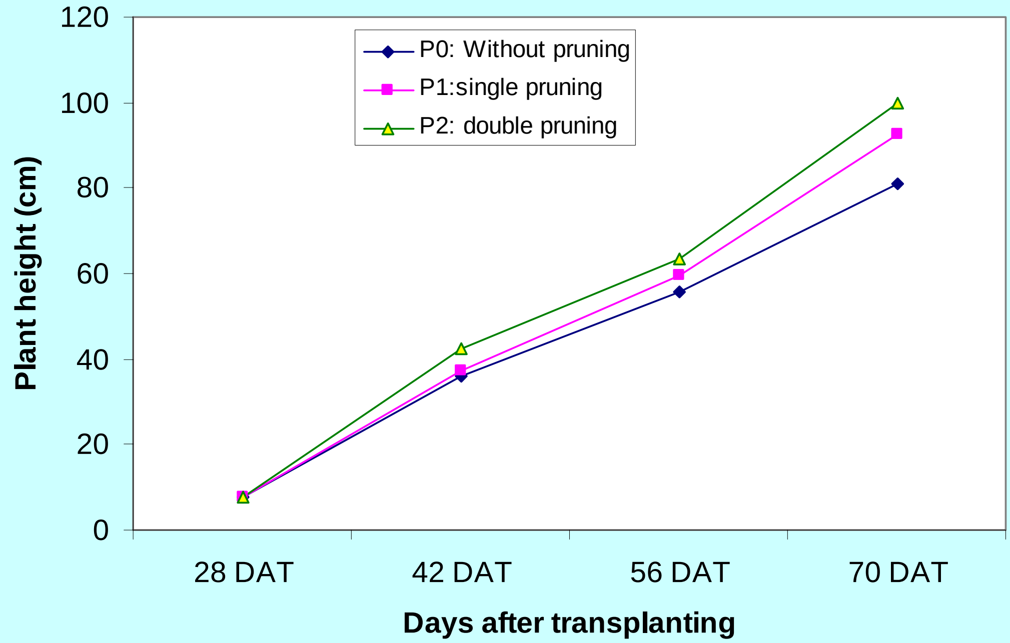


Figure 4.1.Effect of pruning on plant height of tomato at different days after transplanting

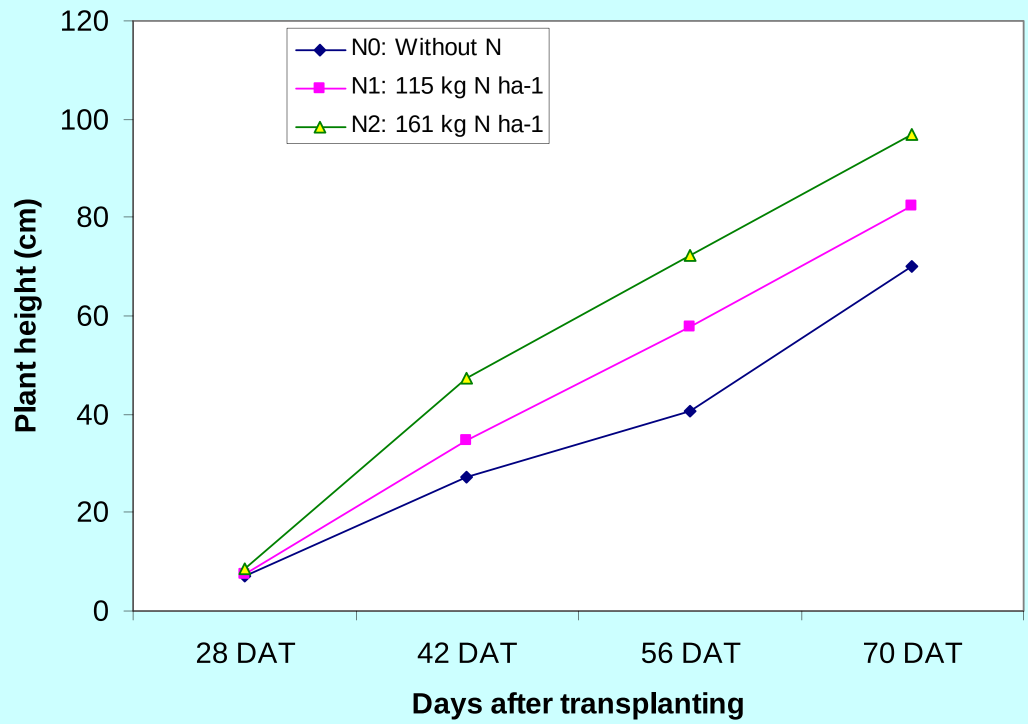


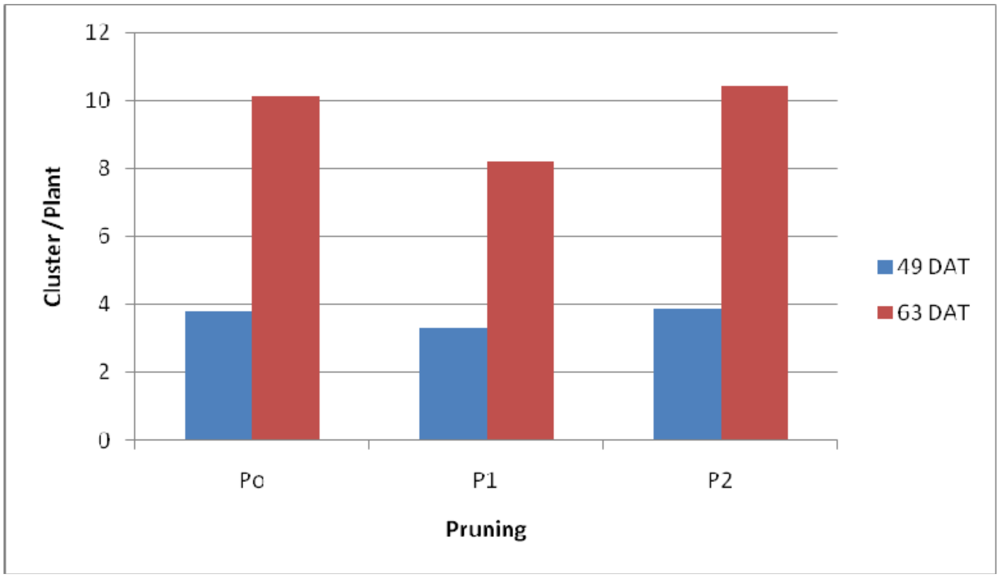
Fig 4.2: Effect of nitrogen on plant height of tomato at different days after transplanting

4.2 Number of cluster plant^{-1}

The number of cluster plant^{-1} was also significantly influenced by pruning practices both at 49 and 63 DAT (Fig. 4.3 and App. 4.4). The highest number of cluster plant^{-1} (10.44) at 63 DAT was found from double pruning which was identical with no pruning, and the lowest number of cluster plant^{-1} (8.22) was found from single pruning. Double pruning produced more number of cluster plant^{-1} at 63 DAT might be due to the presence of side branches. Baki (1987) reported that the highest number of cluster plant^{-1} was produced by unpruned plants.

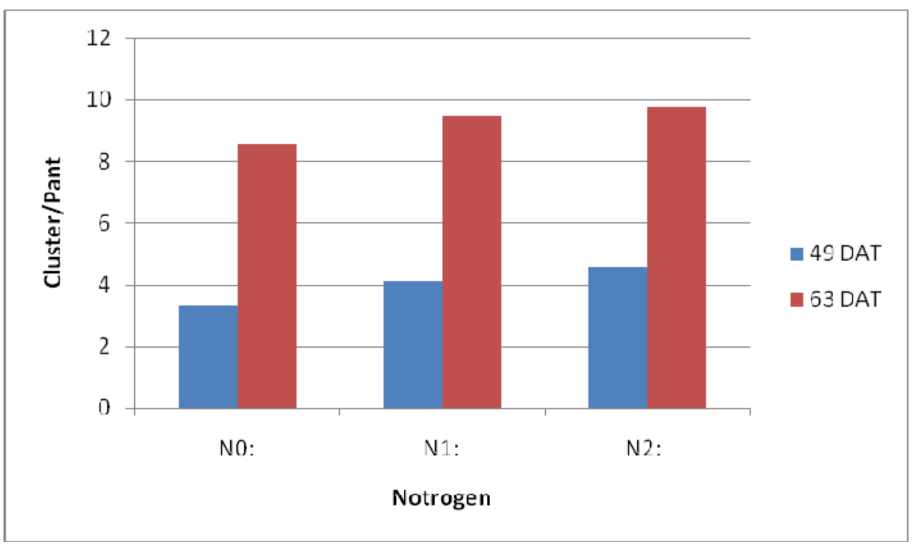
The effect of different doses of nitrogen in respect of c1uster plant^{-1} was significant both at 49 and 63 DAT (Fig4.4 and App. 4.5). The maximum number of cluster plant^{-1} (4.56 at 49 DAT and 9.78 at 63 DAT) was found from 161 kg N ha^{-1} and the minimum number (3.33 at 49 DAT and 8.56 at 63 DAT) was found from no nitrogen or control treatment.

There was no significant difference on number of cluster plant^{-1} both at 49 and 63 (Table 4.1). The treatment combination of 161 kg N ha^{-1} and double pruning gave the maximum cluster number (11.33) at 63 DAT and the minimum number of cluster plant^{-1} (7.33) was recorded from the treatment combination of 115 kg N ha^{-1} and single pruning.



P0: without pruning, P1: single pruning, P2: double pruning

Fig: 4.3 Effects of pruning on cluster/plant of tomato at different days after transplanting (DAT)



N_0: Without N, N_1: 115 kg N ha^{-1} and N_2: 161kg N ha^{-1}

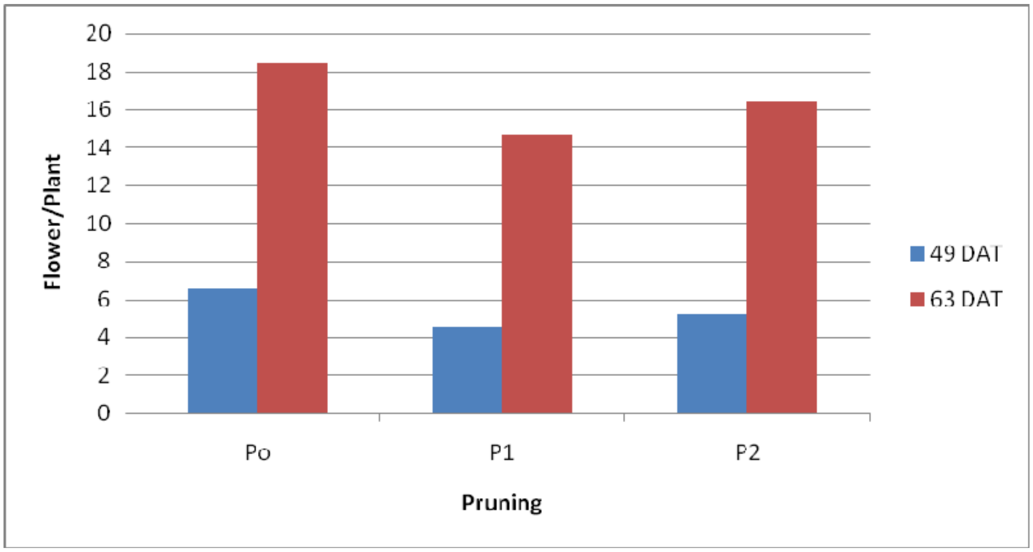
Fig: 4.4. Effects of Nitrogen on cluster/ plant of tomato at different days after transplanting (DAT)

4.3 Number of flower plant^{-1}

Significant variation on the number of flowers plant^{-1} due to the effect of different levels of pruning was observed both at 49 and 63 DAT (Fig. 4.5 and App. 4.4). The highest number of flowers plant^{-1} (19.44) at 63 DAT was found from double pruned plants and the lowest number of flowers plants^{-1} (13.78) was obtained from single stem pruned plants. Similar results were observed at 49 DAT. Probably the above variation was exhibited due to the presence of more side branching giving rise to increased number of flowers.

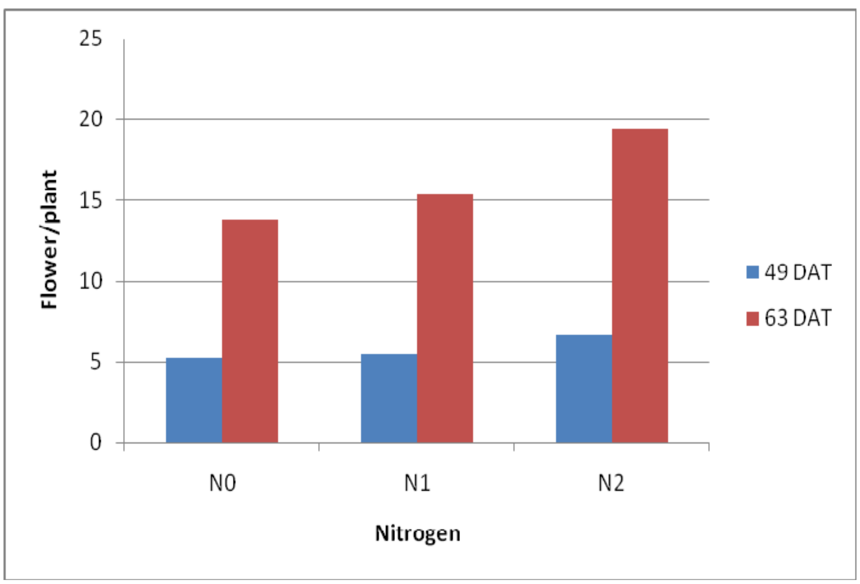
The effect of different levels of nitrogen in respect of number of flowers plant^{-1} was significant at 63 DAT (Fig. 4.6 and App. 4.5). The plant fertilized with 161 kg N ha^{-1} produced the highest number of flowers plants^{-1} (19.44) (Fig. 4.6 and App. 4.5), while the lowest number of flowers plant^{-1} (15.78) was produced by control nitrogen. At 49 DAT, similar results were observed though the effect of nitrogen was not significant. The result clearly showed that the number of flowers plant^{-1} gradually increased with increasing level of nitrogen. The result is almost similar to the findings of Islam *et al*. (1997). They found that the highest number of flowers plant^{-1} was produced from 250 kg N ha^{-1}. Belichki (1984) also reported that the number of flowers plant^{-1} was increased by nitrogen up to 240 kg N ha^{-1}. On the other hand, Fisher (1969) observed that heavy dressing of nitrogen reduced the number of trusses.

The combined effect of different levels of nitrogen and pruning on the number of flowers plant^{-1} was significant both at 49 and 63 DAT (Table 4.1). It was evident from Table 4.1 that the maximum number of flowers plant^{-1} (22.33) was produced from the treatment combinations of 161 kg N ha^{-1} and double pruning, and the minimum (14.33) was obtained from 0 kg N ha^{-1} and single pruning.



P0: without pruning, P1: single pruning, P2: double pruning

Fig: 4.5 Effects of pruning on Flower/plant of tomato at different days after transplanting (DAT)



N_0: Without N, N_1: 115 kg N ha^{-1} and N_2: 161kg N ha^{-1}

Fig: 4.6. Effects of Nitrogen on Flower / plant of tomato at different days after transplanting (DAT)

Table 4.1. Interaction effects of pruning and nitrogen on cluster plant^{-1}, flower plant^{-1},fruit cluster^{-1} and fruit plant^{-1} of tomato at different days after transplanting

Effect of pruning x nitrogen	Cluster plant^{-1}		Flower plant^{-1}		Fruit cluster^{-1}		Fruit plant^{-1}	
	49 DAT	63 DAT	49 DAT	63 DAT	49 DAT	63 DAT	49 DAT	63 DAT
P_0N_o	3.00	9.33b	7.33a	16.00b	2.01	8.67bc	6.67	12.33
P_0N_1	3.67	10.00b	6.33ab	17.67b	2.12	10.00a	8.22	18.33
P_0N_2	4.67	11.00a	6.00b	21.67a	2.20	9.33abc	8.33	19.00
P_1N_o	3.67	9.00b	4.67cd	14.33b	1.77	9.50abc	6.00	15.33
P_1N_1	5.00	10.33b	5.67bc	16.00b	2.10	8.87bc	7.67	15.33
P_1N_2	4.33	11.33a	6.33ab	17.33b	2.10	9.53abc	8.00	19.67
P_2N_o	3.33	7.33b	3.67d	16.67b	2.03	8.00c	7.00	13.33
P_2N_1	3.67	8.00b	4.33d	15.33b	2.08	8.67bc	6.00	14.00
P_2N_2	4.67	7.00b	4.67cd	22.33a	2.23	11.00ab	8.67	19.33
SE (±)	0.54	1.00	0.54	1.81	0.21	0.83	0.96	1.53
LSD (0.05)	1.15	2011	1.15	3.84	0.44	1.75	2.03	3.24
Level of sig.	NS	*	*	*	NS	*	NS	NS
CV (%)	16.7	10.8	12.2	12.9	12.2	10.9	16.0	11.5

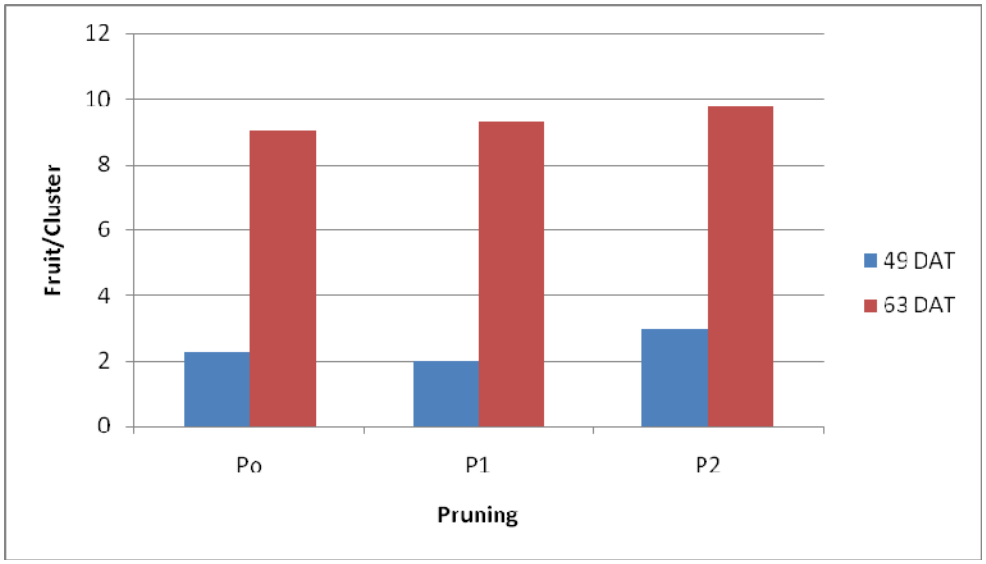
P_0: Without pruning, P_1: Single Pruning ,P_2: Double Pruning
N_0: Without N, N_1:115 kg N ha^{-1} and N_2: 161 kg N ha^{-1}
In a column, the figures(s) having different letter(s) differed significantly
*Significant at 5% level
NS = Non significant

4.4 Number of fruits cluster^{-1}

Non-significant variation was recorded at different levels of pruning on the number of fruit cluster^{-1} (Fig. 4.7 and App. 4.4). The highest number of fruit cluster^{-1} (2.12 at 49 DAT and 9.73 at 63 DAT) was obtained from double stem pruned plants, while the lowest (1.94 at 49 DAT and 8.51 at 63 DAT) was found by single pruned plants.

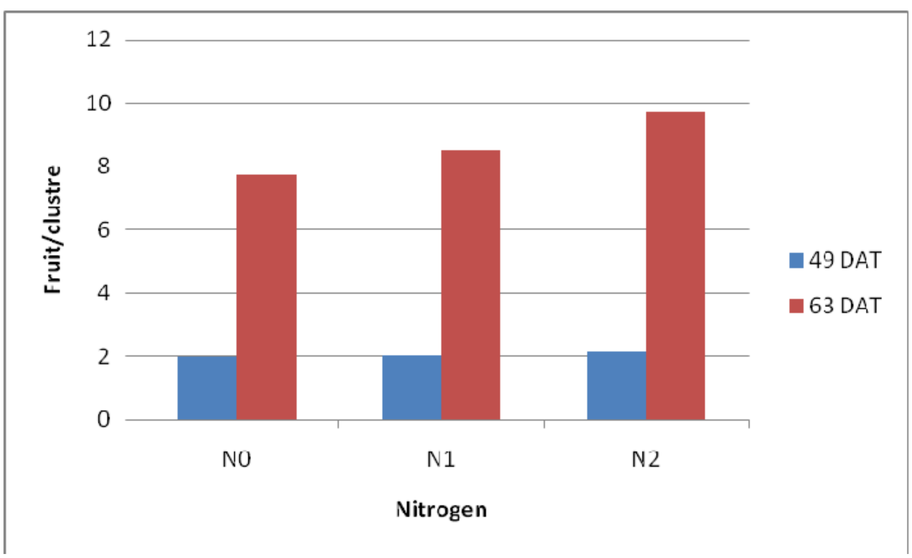
Application of different levels of nitrogen showed non-significant variation on the number of fruit cluster^{-1} (Fig. 4.8 and App. 4.5). The maximum number of fruits cluster^{-1} (2.12 at 49 DAT and 9.73 at 63 DAT) was obtained from the nitrogen level of 161 kg N ha^{-1}, and the minimum (2.01 at 49 DAT and 8.72 at 63 DAT) was found from the control treatment. This is in agreement with Chung *el al.* (1992), as they found that fruit set cluster^{-1} increased with increasing nitrogen application. Varis and George (1985) also concluded that the highest level of nitrogen was the most favourable condition for fruit setting.

There was significant variation among the combinations of nitrogen and pruning at 63 DAT (Table 4.1). The treatment combination of 161 kg ha^{-1} and double stem pruned plants produced the maximum number of fruit cluster^{-1} (2.23 at 49 DAT and 11.00 at 63 DAT), while the minimum number (1.77) was found from the treatment combinations of 0 kg N ha^{-1} and single stem pruning at 49 DAT .



P_0: Without pruning, P_1: Single Pruning ,P_2: Duoble Pruning

Fig: 4.7 Effects of pruning on Fruit/cluster of tomato at different days after transplanting (DAT)



N_0: Without N, N_1:115 kg N ha^{-1} and N_2: 161 kg N ha^{-1}

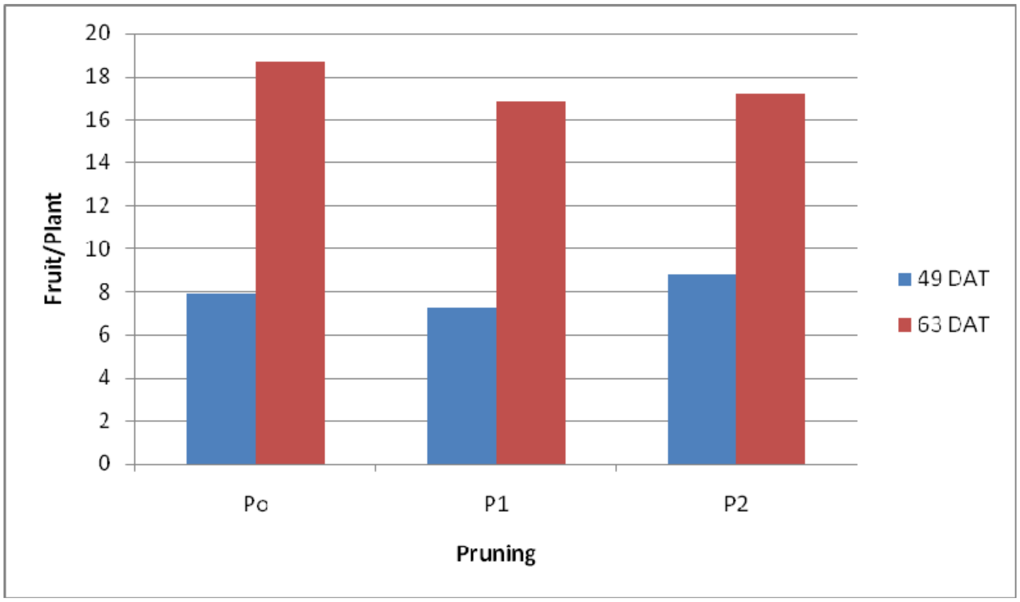
Fig: 4.8 Effects of nitrogen on Fruit/cluster of tomato at different days after transplanting (DAT)

4.5 Number of fruit plant^{-1}

There was significant difference among the pruning levels on the number of fruit plant^{-1} at 63 DAT (Fig. 4.9 and App. 4.4). The highest number of fruit plant^{-1} (18.22) at 63 DAT was produced by double stem pruned plants which identical was without pruning and the lowest number of fruit plant^{-1} (14.78) was recorded in single pruning. Similar higher result was recorded by no pruning at 49 DAT though pruning effect was non-significant.

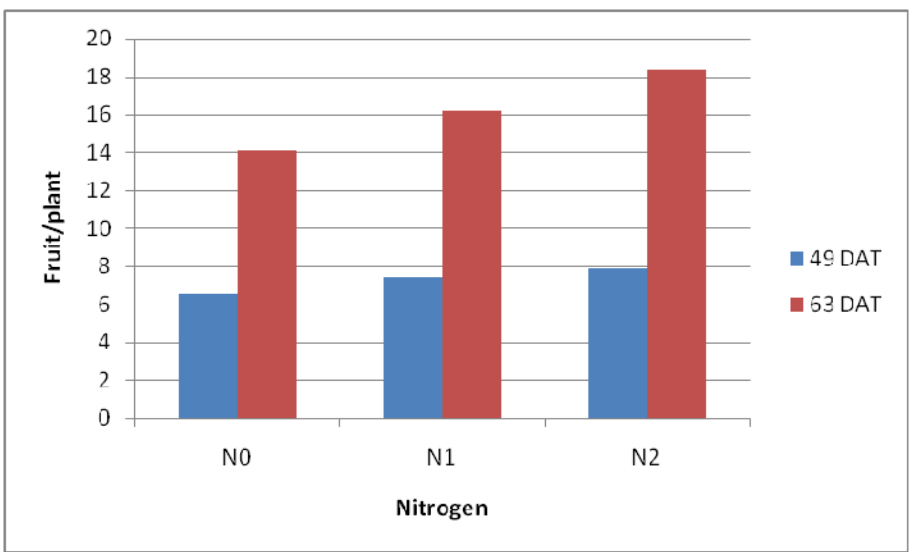
The number of fruit plant^{-1} at different nitrogen levels was found significant at 63 DAT (Fig. 4.10 and App. 4.5). The maximum number of fruit plant^{-1} (18.33) at 63 DAT produced by nitrogen level of 161 kg N ha^{-1} and the control treatment (0 kg N ha^{-1}) produced the minimum number of fruit plant^{-1} (14.11). Nassar (1986) also found that high N level tended to increase average number of fruit plant^{-1}. Such influence of nitrogen has also been reported by Islam *et al*. (1997). They reported that the highest number of fruits plant^{-1} was produced by the application of 250 kg N ha^{-1}. Midan *et al*. (1985) reported the number of fruits plant^{-1} increased as the nitrogen level was also increased.

There was no significant interaction effect between different nitrogen levels and pruning in case of number of fruit plant^{-1} (Table 4.1). The number fruit plant^{-1} ranged from 12.33 to 19.33 at 63 DAT. The plants fertilized with nitrogen at 161 kg N ha^{-1} with double pruning produced the maximum number of fruit (8.67 at 49 DAT and 19.33 at 63 DAT) and those of 0 kg N ha^{-1} with no pruning plants produced the minimum number of fruit plant^{-1} (12.33) at 63 DAT and 0 kg N ha^{-1} with single pruning produced the minimum of fruits plant^{-1} (6.00) at 49 DAT.



P_0: Without pruning, P_1: Single Pruning, P_2: Double Pruning

Fig: 4.9 Effects of pruning on Fruit/cluster of tomato at different days after transplanting (DAT)



N_0: Without N, N_1:115 kg N ha^{-1} and N_2: 161 kg N ha^{-1}

Fig: 4.10 Effects of nitrogen on Fruit/cluster of tomato at different days after transplanting (DAT)

4.6 Fruit length

Pruning practices exhibited significant variation in respect of fruit length of individual fruit (Table 4.2). From Table 4.2, it was evident that the maximum fruit length (5.44 cm) was found from double stem pruned plant, which was identical with single pruning whereas the minimum (4.81 cm) was obtained from unpruned plants. It was found in almost all case that relatively large size fruit were obtained from single stern pruning practices and small size fruit obtained from unpruned plants.

Table 4.2. Effects of pruning on fruit length, fruit diameter fruit yield of tomato

Treatment	Fruit length (cm)	Fruit diameter (cm)
P_0: Without pruning	4.81b	5.69c
P_1: single pruning	5.42a	6.42b
P_2: double pruning	5.44a	7.14a
SE (±)	0.20	0.16
LSD (0.05)	0.43	0.33
Level of sig.	**	**

P_0: Without pruning, P_1: Single Pruning, P_2: Double Pruning
In a column, the figures(s) having different letter(s) differed significantly
**Significant at 1% level
NS = Non significant

Nitrogen had no significant effect on the fruit length (Table 4.3). The longest fruit (5.38 cm) was produced from 161 kg N ha^{-1} and the shortest fruit (5.06 cm) was produced from 0 kg N ha^{-1}. This result showed that fruit height increased gradually with the increasing levels of nitrogen up to 161 kg N ha^{-1}. Nassar (1986) had similar report which supports the present results. Islam *et al* (1997) reported that the length of individual fruit was increased with increased level of nitrogen.

The maximum fruit length (5.57 cm) was found from the treatment combination of 161 kg N ha^{-1} and double stern pruning practices, and the minimum (4.53 cm) was found from 0 kg N ha^{-1} and no pruning.

Table 4.3. Effects of nitrogen on fruit length**, fruit diameter and fruit yield of tomato**

Treatment	Fruit length (cm)	Fruit diameter (cm)
N_0: Without N	5.06	6.01c
N_1: 115 kg N ha^{-1}	5.24	6.41b
N_2: 161 kg N ha^{-1}	5.38	6.83a
SE (±)	0.20	0.16
LSD (0.05)	0.43	0.33
Level of sig.	NS	**

N_0: Without N, N_1: 115 kg N ha^{-1} and N_2: 161 kg N ha^{-1}
In a column, the figures(s) having different letter(s) differed significantly
**Significant at 1% level
NS = Non significant

Table 4.4. Interaction effects of pruning and nitrogen on fruit height, fruit diameter and fruit yield of tomato

Treatment	Fruit height (cm)	Fruit diameter (cm)
P_0N_o	4.53	5.17
P_0N_1	4.87	5.63
P_0N_2	5.03	6.27
P_1N_o	5.37	6.07
P_1N_1	5.37	6.37
P_1N_2	5.53	6.83
P_2N_o	5.27	6.80
P_2N_1	5.50	7.23
P_2N_2	5.57	7.40
SE (±)	0.35	0.27
LSD (0.05)	0.74	0.57
Level of sig.	NS	NS
CV (%)	8.2	5.2

P_0: Without pruning, P_1: Single Pruning, P_2: Double Pruning
N_0: Without N, N_1: 115 kg N ha^{-1} and N_2: 161 kg N ha^{-1}
In a column, the figures(s) having different letter(s) differed significantly
NS = Non significant

4.7 Fruit diameter

Pruning practice had significant effect in respect of diameter of individual fruit (Table 4.2). The maximum fruit diameter (7.14 cm) was obtained from double pruning whereas the minimum (5.69 cm) was obtained from unpruned plants. The reduction of fruit size in unpruned plant was probably due the increasing in number of fruit plant^{-1}.

The variation in diameter of fruit among the different doses of nitrogen was found to be statistically significant (Table 4.3). The maximum diameter of fruit (6.83 cm) was found from the plant grown with 161 kg N ha^{-1} and then decreased gradually with the decreasing rate of nitrogen, while the minimum (6.01 cm) was produced from the control treatment (without N). Similar results were found 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.

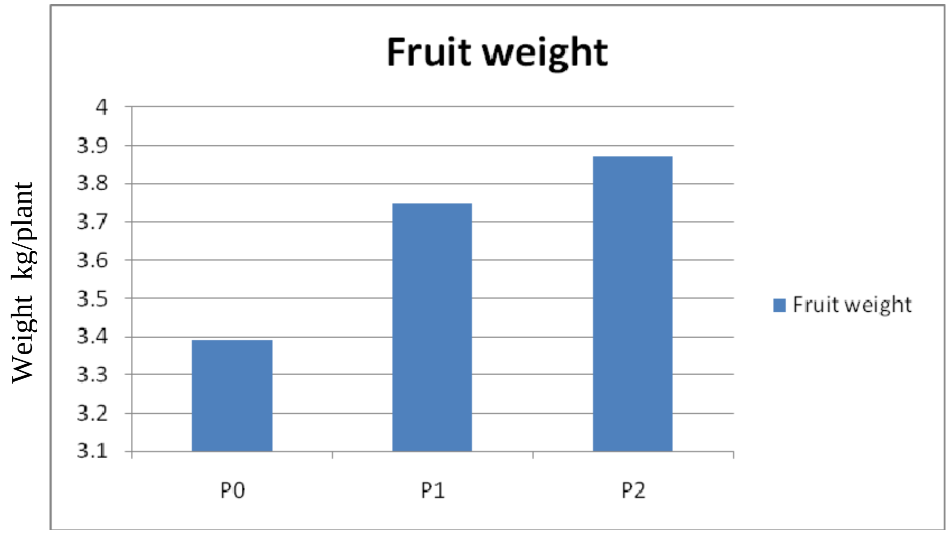
The interaction effect of different levels of nitrogen and pruning on the fruit diameter was found non-significant (Table 4.4). The maximum fruit diameter (7.40 cm) was found from the treatment combination of 161 kg N ha^{-1} and double stem pruning, and the minimum (5.17 cm) from the combination of 0 kg N ha^{-1} and no pruning.

4.8 Fruit weight (kg plant^{-1})

Pruning has no significant effect on fruit weight (kg plant^{-1}) though the highest fruit weight (3.87 kg plant^{-1}) was obtained from double pruning (Fig. 4.11 and App. 4.7).

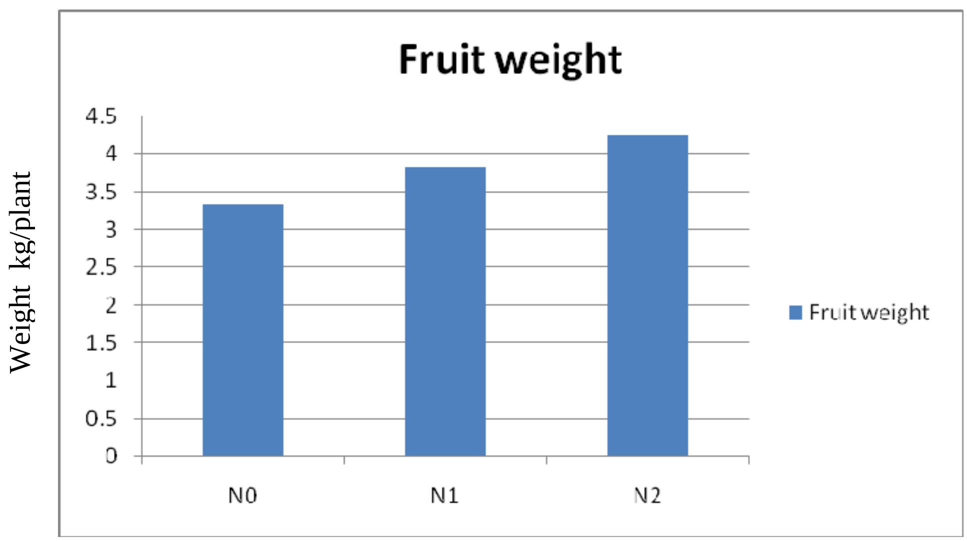
Nitrogen had significant effect on fruit weight of tomato (Fig. 4.12 and App. 4.8). The highest fruit weight was found from 161 kg N ha^{-1} and the lowest was found from no nitrogen.

The highest fruit weight (4.42 kg plant^{-1}) was obtained from the treatment combination of 161 kg N ha^{-1} and double pruning and the lowest was found from 0 kg N ha^{-1} and single pruning App. 4.8).



P_0: Without pruning, P_1: Single Pruning, P_2: Double Pruning

Fig: 4.11 Effects of pruning on Fruit weight of tomato at different days after transplanting (DAT).



N_0: Without N, N_1:115 kg N ha^{-1} and N_2: 161 kg N ha^{-1}

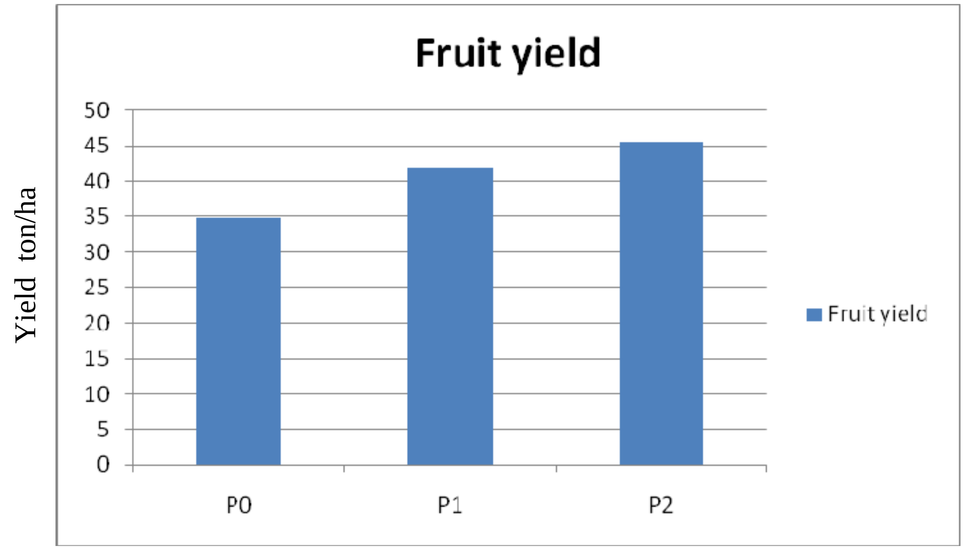
Fig: 4.12 Effects of nitrogen on Fruit weight of tomato at different days after transplanting (DAT)

4.9 Fruit yield (t/ha):

Different levels of pruning significantly influenced on the yield of fruit ha^{-1} (Fig. 4.13 and App. 4.6). It was evident from Fig. 4.13 and App. 4.6, that the highest yield (45.5 t ha^{-1}) was recorded through the practice of double stem pruning compared to single stern pruning practice (44.0 t ha^{-1}) and unpruned plants produced the fruit yield of 37.8 t ha^{-1}. Similar result was found by many authors (Homme, 1965; Ramirez *et aI,* 1979 and Baki, 1987). On the other hand, Rajendra and Patil (1979) reported that higher fruit yield was obtained from unpruned plants compared to pruned plant.

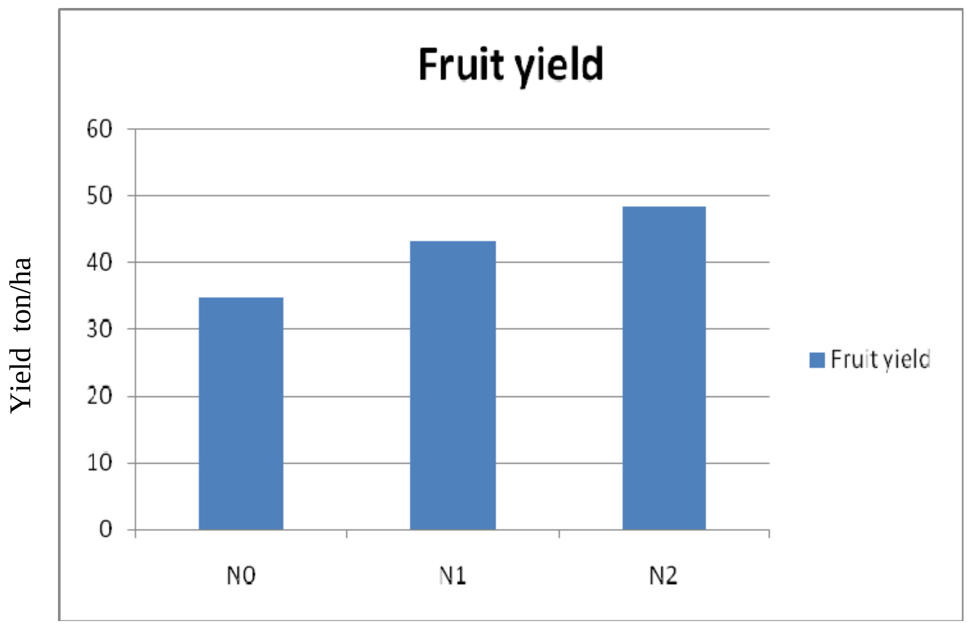
When the total yield of tomato $plot^{-1}$ of each nitrogen level was converted into calculated total yield t ha^{-1}, the figure were 34.6, 43.3 and 48.4 tons ha^{-1} for nitrogen applied at the rate of 0, 115 and 161 kg ha^{-1} (Fig. 4.14 and App. 4.7). The result showed that the yield of tomato fruits increased gradually with the increase dose of nitrogen fertilization up to the highest level (161 kg ha^{-1}). Similarly, Islam *et al.* (1997) reported that 250 kg N ha^{-1} gave the highest fruit yield while the lowest was obtained from the control. Profound influence of nitrogen level to increase tomato yield has been reported by many author (Doss *et al.,* 1981; Varis and George, 1985; Midan *et al.,* 1985 and Kaniszewski *et al.,* 1987). Kaniszeski *et al.* (1987) found a significant increase in total yield of tomato fruit in the nitrogen fertilization up to 225 kg N ha^{-1}. Nassar (1986) reported that the maximum yield was achieved at 296 kg N ha^{-1}.

Non-significant interaction existed between both the variables in relation to yield ha^{-1} (App. 4.8). The treatment combination of 161 kg N ha^{-1} and double stem pruning gave the maximum yield (52.7 t ha^{-1}) and the minimum yield (32.2 t ha^{-1}) was found from the treatment combinations of no nitrogen and no stem pruning. It was clearly indicated that fruit yield ha^{-1} was increased with every increment in nitrogen up to the highest level (161 kg ha^{-1}) with double stem pruning.



P_0: Without pruning, P_1: Single Pruning, P_2: Double Pruning

Fig: 4.13 Effects of pruning on Fruit yield of tomato at different days after transplanting (DAT).



N_0: Without N, N_1:115 kg N ha^{-1} and N_2: 161 kg N ha^{-1}

Fig: 4.14 Effects of nitrogen on Fruit yield of tomato at different days after transplanting (DAT)

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2011 to March, 2012 to find out the optimum levels of nitrogen and suitable pruning practice for maximum growth and yield of tomato cv. BARI Tomato-14. The experiment included three different levels of nitrogen viz., 0, 115 and 161 N kg ha^{-1} and three pruning practices, viz., no pruning, one stem pruning and two stem pruning. The experiment consisted of nine treatment combinations and was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of each unit plot was 2.0 m x 1.8 m, and 15 plants were accommodated in each plot following spacing of (60 cm x 40 cm). For raising the seedlings, tomato seeds cv. BARI Tomato-14 were sown in seed bed on 25 October, 2011 and seedling were transplanted on 25 November, 2011. Harvesting was done during 28 February to 28 March, 2012.

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.

Nitrogen had significant effect on plant height at 28 DAT, 42 DAT and 56 DAT. Plants grown with higher does of nitrogen showed a gradual increase in plant height. The tallest plant was produced by 161 kg N ha^{-1}, while the shortest plant was recorded from 0 kg N ha^{-1} (control). In case of pruning, the tallest plant was produced by double stem pruning and the shortest plant was shown by unpruned plant. The treatment combinations demonstrated highly significant variation in plant height at 42 DAT. There was no significant variation among the treatment combination 28, 56 and 70 DAT.

Significant variation was obtained in respect of the number of cluster plant^{-1}, flower clusters^{-1} and flowers plant^{-1} as influenced by different levels of nitrogen and pruning. The highest values of these characters were obtained from 161 kg N ha^{-1}, and the lowest were obtained from the control (0 kg N ha^{-1}). In case of pruning, the maximum number of clusters plant^{-1} and flower plant^{-1} were found from the unpruned plants. No pruning produced the maximum number of cluster plant^{-1}, but the minimum values were obtained from single pruning. The highest number of clusters plant^{-1} (11.33) was produced by the plant fertilized with the highest doses of nitrogen (161 kg N ha^{-1}) and receiving double pruning.

The number of fruit cluster^{-1} and fruits plant^{-1} were not significantly influenced by nitrogen. The highest values of these characters were found from the highest levels of nitrogen used (161 kg N ha^{-1}). There was an increasing trend in all the parameters with increasing levels of nitrogen. Again, fruit plant^{-1} were significantly influenced by the pruning treatments at 63 DAT. Maximum number of fruit cluster^{-1} and fruits plant^{-1} were produced by the double pruned plants, while single pruning produced the minimum number of fruits cluster^{-1}. The combinations of double pruned plants with161 kg N ha^{-1} gave the maximum number of fruits clusters^{-1} and fruit plant^{-1} (19.33), whereas single pruning plants with 0 kg N ha^{-1} gave the minimum numbers of fruits cluster^{-1} and fruit plant^{-1}.

The length and diameter of individual fruit were the maximum in the highest levels of nitrogen (161 kg ha^{-1}) and double pruning plants. In this respects, the interaction between nitrogen and pruning were found to be non-significant. The maximum fruit length (5.57) and fruit diameter (7.40) of individual fruit were obtained from the combination of double stem pruning and 161 kg N ha^{-1}.

Nitrogen levels exhibited significant variation on fruit yield of tomato plants fertilized with 161 kg N ha^{-1} gave the highest fruit weight $plant^{-1}$ (4.24) as well as yield ha^{-1} (48.4 t). On the other hand, pruning practices also result significant variation in fruit yield ha^{-1}. The fruit weight $plant^{-1}$ (3.87) and fruit yield ha^{-1} (45.5 t) were found from the double stem pruning. These values were the minimum in no stem pruning. The treatment combination of 161 kg N ha^{-1} and double stem pruning gave the highest fruit yield $plant^{-1}$ (4.32) as well as ha^{-1} (52.7 t).

From the results of the present experiment it can be concluded that the increasing the nitrogen doses, increasing the yield of tomato. Higher doses of N with double pruning practices show the better performances.

CHAPTER 6

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APPENDICES

App. 4.1. Effects of pruning on plant height of tomato at different days after transplanting (DAT)

Treatment	Plant height (cm)			
	28 DAT	42 DAT	56 DAT	70 DAT
P_0: Without pruning	7.56	36.11b	55.67	80.89
P_1: Single pruning	7.89	37.44b	59.44	92.44
P_2: Double pruning	7.67	42.56a	63.56	99.65
SE (±)	0.42	1.43	2.26	2.45
LSD (0.05)	0.89	3.67	6.91	7.31
Level of sig.	NS	**	NS	NS

P_0: Without pruning, P_1: Single pruning and P_2: Double pruning
In a column, the figures(s) having different letter(s) differed significantly
**Significant at 1% level
NS = Non significant

App. 4.2. Effects of nitrogen on plant height of tomato at different days after transplanting (DAT)

Treatment	Plant height (cm)			
	28 DAT	42 DAT	56 DAT	70 DAT
N_0: Without N	7.11b	34.11b	55.56b	90.11
N_1: 115 kg N ha^{-1}	7.56ab	34.67b	57.78b	89.33
N_2: 161 kg N ha^{-1}	8.44a	47.33a	65.33a	91.78
SE (±)	0.42	1.43	2.26	2.45
LSD (0.05)	0.89	3.67	6.91	7.31
Level of sig.	*	**	*	NS

N_0: Without N, N_1: 115 kg N ha^{-1} , N_2: 161 kg N ha^{-1}
In a column, the figures(s) having different letter(s) differed significantly
*Significant at 5% level, **Significant at 1% level
NS = Non significant

App. 4.3. Interaction effects of pruning and nitrogen on plant height of tomato at different days after transplanting (DAT)

Treatment combination	Plant height (cm)			
	28 DAT	42 DAT	56 DAT	70 DAT
P_0N_o	7.33	31.28	47.52b	75.31
P_0N_1	7.00	30.67	62.67ab	81.60
P_0N_2	8.33	46.67	63.45ab	88.48
P_1N_o	7.00	31.86	49.11	80.51
P_1N_1	8.00	33.00	55.33bc	87.24
P_1N_2	8.67	46.00	65.57a	94.08
P_2N_o	7.00	38.41	50.77a	83.58
P_2N_1	7.67	40.33	55.33bc	90.58
P_2N_2	8.33	49.33	67.80a	98.21
SE (±)	0.73	3.00	5.65	5.98
LSD (0.05)	1.55	6.35	11.99	12.68
Level of sig.	NS	NS	*	NS
CV (%)	11.6	9.5	11.6	8.1

P_0: Without pruning, P_1: Single Pruning , P_2: Double Pruning
N_0: Without N, N_1: 115 kg N ha^{-1} and N_2: 161kg N ha^{-1}
In a column, the figures(s) having different letter(s) differed significantly
*Significant at 5% level
NS = Non significant

App. 4.4. Effects of pruning on cluster plant^{-1}, flower plant^{-1}, fruit cluster^{-1} and fruit plant^{-1} of tomato at different days after transplanting (DAT)

Treatment	Cluster plant^{-1}		Flower plant^{-1}		Fruit cluster^{-1}		Fruit plant^{-1}	
	49 DAT	63 DAT	49 DAT	63 DAT	49 DAT	63 DAT	49 DAT	63 DAT
P_0: Without pruning	3.78	10.11a	6.56a	18.44a	2.23	9.00	7.89	16.67a
P_1: Single pruning	3.33	8.22a	5.56b	15.67a	1.99	9.30	7.22	14.78b
P_2: Double pruning	3.89	10.44b	7.22c	19.44b	2.94	9.90	8.78	18.22a
SE (±)	0.31	1.03	0.31	1.05	0.12	0.48	0.55	0.88
LSD (0.05)	0.67	2.18	0.67	2.22	0.25	1.01	1.17	1.87
Level of sig.	NS	*	**	*	NS	NS	NS	**

P_0: Without pruning, P_1: Single Pruning , P_2: Double Pruning
In a column, the figures(s) having different letter(s) differed significantly
*Significant at 5% level, **Significant at 1% level
NS = Non significant

App. 4.5. Effects of nitrogen on cluster plant^{-1}, flower plant^{-1}, fruit cluster^{-1} and fruit plant^{-1} of tomato at different days after transplanting (DAT)

Treatment	Cluster plant^{-1}		Flower plant^{-1}		Fruit cluster^{-1}		Fruit plant^{-1}	
	49 DAT	63 DAT	49 DAT	63 DAT	49 DAT	63 DAT	49 DAT	63 DAT
N_0: Without N	3.33b	8.56	5.22	13.78b	1.99	8.72	6.56	14.11c
N_1: 115 kg N ha^{-1}	4.11a	9.44	5.44	15.33b	1.94	8.51	7.44	16.22b
N_2: 161 kg N ha^{-1}	4.56a	9.78	6.67	19.44a	2.12	9.73	7.89	18.33a
SE (±)	0.31	1.03	0.31	1.05	0.12	0.48	0.55	0.88
LSD (0.05)	0.67	2.18	0.67	2.22	0.25	1.01	1.17	1.87
Level of sig.	**	NS	NS	**	NS	NS	NS	**

N_0: Without N, N_1: 115 kg N ha^{-1} and N_2: 161kg N ha^{-1}
In a column, the figures(s) having different letter(s) differed significantly
**Significant at 1% level
NS = Non significant

App. 4.6. Effects of pruning on fruit weight and fruit yield of tomato

Treatment	Fruit weight (kg plant^{-1})	Fruit yield (t ha^{-1})
P_0: Without pruning	3.69	37.8b
P_1: Single pruning	3.85	44.0a
P_2: Double pruning	3.87	45.5a
SE (±)	0.14	1.79
LSD (0.05)	0.29	3.79
Level of sig.	NS	**

P_0: Without pruning, P_1: Single Pruning, P_2: Double Pruning
In a column, the figures(s) having different letter(s) differed significantly
**Significant at 1% level
NS = Non significant

App. 4.7. Effects of nitrogen on fruit weight and fruit yield of tomato

Effect of nitrogen	Fruit weight (kg plant^{-1})	Fruit yield (t ha^{-1})
N_0: Without N	3.33c	34.6c
N_1: 115 kg N ha^{-1}	3.83b	43.3b
N_2: 161 kg N ha^{-1}	4.24a	48.4a
SE (±)	0.14	1.79
LSD (0.05)	0.29	3.79
Level of sig.	**	**

N_0: Without N, N_1: 115 kg N ha^{-1} and N_2: 161kg N ha^{-1}
In a column, the figures(s) having different letter(s) differed significantly
**Significant at 1% level
NS = Non significant

App. 4.8. Interaction effects of pruning and nitrogen on fruit weight and fruit yield of tomato

Treatment combination	Fruit weight (kg plant^{-1})	Fruit yield (t ha^{-1})
P_0N_o	3.37	32.2
P_0N_1	3.70	36.4
P_0N_2	3.99	41.8
P_1N_o	3.25	34.8
P_1N_1	3.87	46.5
P_1N_2	4.42	50.7
P_2N_o	3.36	36.7
P_2N_1	3.92	47.0
P_2N_2	4.32	52.7
SE (±)	0.23	3.10
LSD (0.05)	0.50	6.56
Level of sig.	NS	NS
CV (%)	7.5	9.0

P_0: Without pruning, P_1: Single Pruning, P_2: Double Pruning
N_0: Without N, N_1: 115 kg N ha^{-1} and N_2: 161 kg N ha^{-1}
NS = Non significant