EFFECT OF NITROGEN FERTILIZER AND SPACING ON GROWTH AND YIELD OF MAIZE (*Zea mays* L.)

BY

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CERTIFICATE

This is to certify that thesis entitled, '**EFFECT OF NITROGEN FERTILIZER AND SPACING ON GROWTH AND YIELD OF MAIZE (*Zea mays*.)**' submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in AGRONOMY, embodies the result of a piece of bonafide research work carried out by **MD. ABDUS SALAM** Registration Number 00530 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.

Dated: 30/12/17
Place: Dhaka, Bangladesh

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DEDICATION

This work is dedicated to

My

Beloved parents

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ABSTRACT

An experiment was conducted at Central Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to July 2006 to study the effect of different levels of nitrogen and spacing on growth and yield of maize. The experiment was laid out in two factors Randomized Complete Block Design with three replications. Factor A: Three levels of Nitrogenous (180, 220 and 260 kg N/ha) and Factor B: Different types of spacing (50 cm × 25 cm, 75 cm × 25 cm and 90 cm × 25 cm) were used in the experiment. Incase of nitrogen the maximum number of cobs per plant (1.049), cobs length (16.7 cm), Stover yield (14.744t) and Harvest Index (28.953%) was observed in N_2.The maximum number of grain per cob (271.66), 1000-grain weight (446.444g) and grain yield (6.253t) was recorded from N_3. Incase of spacing number of cobs (1.063), cob length (16.9 cm), 1000- grain weight (440.11g), grain yield (7.354t), Stover yield (15.844t) and Harvest Index (32.142%) was found in S_2. The maximum number of grain per cob (313.667) was recorded from S_3. Incase of treatment combination the maximum number of cobs per plant (1.083) was found in S_3N_2. The maximum cob length (18.8cm), 1000-grain weight (476.7g), grain yield (8.35t), stover yield (17.87t), harvest index (33.77%) and Benefit Cost Ratio (7.748) was found in S_2N_2. The maximum number of grain per cob (331.7) was found in S_3N_3.

CONTENTS

List of Tables

List of Figures

List of Appendices

CHAPTER I

INTRODUCTION

Maize *(Zea mays* L.) is one of the most important grain crops in the world. It has good potentials as a cereal crop like rice and wheat in Bangladesh. As food, it can be consumed directly as green cob, roasted cob or popped grain. Its grain can be used for human consumption in various ways such as corn meal, fried grain and flour. Its grain has high nutritive value containing 66.2% starch 11.1% protein, 7.12% oil and 1.5% minerals. Morever, it contains 90 mg carotene, 1.8 mg niacin 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains (Chowdhury and Islam, 1993). Maize oil is used as the best quality edible oil. Green parts of the plant and grain are used as livestock and poultry feed respectively. Stover and dry leaves are used as fuel (Ahmed, 1994). Maize has a great utility in agro- industry for the production of corn syrup, soft drink, juice, beer, chewing gum, candy, chips corn flakes and starch. This grain of maize contains higher grain protein content than that of our staple food rice.

In Bangladesh, the cultivation of maize has been gaining popularity in the recent years. It is now becoming an important cereal crop for its high productivity and diversified use (Islam and Kaul, 1986). It covers about 2,834 hectares of land producing 3,000 tons of grains annually (BBS, 2005). Maize crop has been included as a major enterprise in the crop diversification and intensive cropping programs (Kaul and Rahaman, 1983). It is one of the most efficient crops which can give high biological yield as well as grain yield in a relatively short period of time due to its unique photosynthetic mechanism as c_4 plant. The agro-climatic condition of Bangladesh is favorable for its cultivation round the year. However, the average yield of maize in the country is comparatively low. The national average yield of maize is only 1.06 $t.ha^{-1}$, whereas the newly released varieties BARI maize 3 has the potential to produce more than 8 $t.ha^{-1}$, (BBS, 2004). Maize may offer a partial solution to the food shortage of Bangladesh if its present yield level and total production can further be raised. The experimental evidence of agronomic requirements for higher yield is rather inadequate. Among the agronomic practices that influence crop growth and grain yield, plant population levels and nitrogen fertilizer management are the prominent ones.

Yield is a function of inter plant or intra plant competition. Competition associated with different spacing alters plant morphology in various ways. Researchers have shown that weaker plants become barren when spacing was closest to a greater extent. These plants utilized water and nutrients under severe competition this produced lower yield. As such there is a considerable scope for increasing yield by adjusting optimum plant spacing. Adjustment of proper plant spacing in the maize field is important to ensure maximum utilization of solar energy by the crop and reduce evaporation of soil moisture. In many cases, 50% or more of this energy reaches the soil surface. Besides nutrient availability in the soil depends on plant spacing. Optimum plant spacing should be maintained to exploit maximum natural resources, such as nutrients, sunlight, soil moisture etc. and to ensure satisfactory yield. High density is undesirable because it encourages inter plants competition for resources. Resource, on the other hand, will simply be misuse under sparse plant spacing (Ahmed and Muhammad, 1999; Sabir *et al.*, 2001).

In the developing countries like Bangladesh, the cultivated land decreases year by year due to population pressure. Maximum exploitation of the yield potential of a crop must be ensured, developing appropriate production technologies, to feed the every increasing population. Maximum effort must be given to realize highest yield from a limited land.

Nitrogen plays an important role in building up of protoplast and protein of plant, which induce cell division and initiate epistemic activities when applied in optimum quantity. There are some reports on nitrogen management (Chen *et al.* 1994; Sanjeev and Bangarwa, 1997) and optimization of plant per unit area for maximum hardest of maize. Further study on the issues of nitrogen management and plant density would enrich the knowledge on development of management tools for high yield per unit area of this crop.

This study was therefore undertaken with the following objectives:

i) to determine the optimum dose of nitrogen fertilizer on growth and yield of maize .

ii) to determine the optimum spacing on growth and yield of maize.

iii) to investigate the interaction effect of nitrogen fertilizer and plant spacing on growth and yield of maize.

CHAPTER -II

REVIEW OF LITERATURE

A number of research works have been carried out on various aspects of management practices for higher productivity of maize. Still intensive research on improving its yield and quality is in progress. The present study is related to grain yield and quality of maize as influenced by various plant spacing and different rates of nitrogen fertilizer. The information available on this area generated from different studies has been reviewed in this chapter.

2. 1. Effect of nitrogen on yield and yield components of maize

Application of nitrogen has been reported to have significant effect on grain yield contributing characters of maize. Dahiya *et al.* (1983) conducted a field trial with silty clay loam soil in greenhouse at Al-Hawija with four levels each of nitrogen (0.05, 100 and 200 ppm). Similarly Singh *et al.* (2000) and Okajima *et al.* (1983) noticed that increasing doses of applied N from 0 to 200 kg/ha increased length of cob, number and weight of grains/cob, cobs/plant, 1000 grain weight and grain yield of maize.

In the study of Hardas and Karagiance -Hrestou (1985) optimum N rate for maize production appeared to be 180 kg N/ha. Boquet *et al.* (1987) conducted and experiment maize hybrid RA 1604 with different N rates 200 or 250 kg N/ha. They stated that application of 250 kg N/ha increased number of cobs, 100-grain weight, number of grains/ear, consequently produced significant increase in grain yield of maize. Application of 180 kg N+ 60 kg P_20_5/ha gave the highest yield of 6.21 t/ha followed by 5.92 t/ha with 120 kg N+30 kg P_20_5/ha in the experiment of Thanki *et al.* (1988).

Nimje and Seth (1988) conducted a field trail with maize grown with 0-120 kg /ha during the winter seasons of 1982-84. They reported that the increasing N rates increased the number of ears/plant, ear size, 1000-grain weight and grain yield. They also found that optimum N rates were 103.4 kg/ha in 1982-83 and 106.8 kg in 1983-84 giving the yields were 6.84 and 5.6 t/ha, respectively. Abdel-Halem *et al.* (1990) noticed that application of 214 kg N/ha resulted with significant increase in the maize yield.

In India (Masharshtra) Khot and Umrani (1992) carried out a field experiment during the Kharif (monsoon) season of 1989. They observed that application of 80, 120 160 and kg N/ha produced seed yield of 2.57, 3.11, 4.81 t/ha, respectively. Germination percentage, vigour index and seedling dry weight was not affected by the treatment. A similar experiment was conducted by Paradka and Sharma (1993) with 80, 160 and 240 kg/ha N on maize. They found that the doses of 160 kg N/ha were, most effective in increasing the plant growth and yield. The longest leaf, width thickness and higher seed yield when pop corn was provided with 300 kg N/ha (Chen *et al.*, 1994).

Seven rates of N between 30 and 150 kg/ ha applied as urea with one third applied at sowing and two-third applied 40 days after emergence in field. The application of 90 kg N/ha resulted with significant increase in the maize seed yield during the first year and showed increasing trend in the second year over 150 kg N/ha (Oliveira, 1997).

Grain and stover yield of maize was increased significantly with the increasing application of N from 0 to 240 kg /ha though the number of grain / ear, 1000-seed weight , grain weight / ear increased significantly up to 180 kg N /ha. (Sanjeev and Bangarwa, 1997). Shivay *et a.l* (1999) conducted from his study that growth parameters, yield attributes, grain yield maize grain equivalent yield and total nitrogen uptake by maize increased significantly with increasing nitrogen application.
Shiraji *et a.l* (2000) carried out a field experiment at Mymensingh district of Bangladesh on four nitrogen levels (0, 50, 100 and 120 kg/ ha) on maize crop.

They found that N at 120 kg/ha significantly increased yield attributes, yield over 60 and 90 kg N/ha as reported by Pandey *et al.* (2000).

2.2. Effect of plant spacing on the yield components of maize

Density of plant per unit area is important to determine yield which is dependent on spacing and number of plants per hill. Spacing of 75 cm X 25 cm with single plant per hill gave the highest yield of maize (Locus and Remison 1984; Quayyum and Raquibullah, 1986). Plant characters may be influenced by different spacing and planting arrangements. Vipawon and Anothai (1985) reported that plant height was increased with increased plants per unit area. On the other hand Pissaio *et al.* (1995) reported spacing had no effect on plant height. Rathore *et al.* (1976) also found that there was no significant difference in plant height in low plant populations. However, Tetio-Kagho and Gardner (1988) observed that plant density influenced the plant height of maize significantly. In the study of Tano *et al.* (1987) high plant density increased plant height. Ogunlela *et al.* (1988) also found that increasing plant density from 25,000 to 75,000 plants ha^{-1} increased height of plant.

Number of cobs may be influenced by planting arrangement and spacing. Kayode and Agboola (1981) found that spacing significantly influenced number of cobs/ plant decreased with increasing plant density.

Sharma and Adamn (1984) concluded from their study that the highest number of cobs/ plant was produced at the lowest plant population (25,000 plant/ha). Similar results were also reported that spacing had no effect on cob number/plant.

BARI (1990) reported that large cobs were obtained from 75 and 60 cm row spacing. The cob length was found to reduce with an increase in plant density Osorio, (1976). Loesch *et al.* (1976) found that length of cob was improved significantly by reducing plant density. Rathore *et al.* (1976) also found that length of cob decreased with increased plant population.

The cob weight differed under different plant densities and decreased when plant density was increased (Vipawon and Anothai 1985). Similar results were reported by Hsu and Huang (1984). Loesch *et al.* (1976) also reported that weight of cobs was improved significantly by reducing plant density.

The number of grains per row was the greatest with 33,333 plants/ha and decreased with increasing plant densities in the study of Babu and Mitra (1989). Hsu and Huang (1984) reported that grains/cob differed under different plant densities and decreased as plant density increased. Tano *et al.* (1987) also found a similar result. Rathore *et al.* (1976) found that number of grains/cob decreased with increasing plant population.

Plant density did not influence grain size (Lapcevic 1985). Vipawon and Anothai (1985) reported that grain weight decreased with increasing plants/hill. Tano *et al.* (1987) found similar result. Sharma and Adamn (1984) also observed the highest grain weight/plant at lowest plant population.
Date of maturity of maize may be influenced by plant density and planting arrangement. Hsu and Huang (1984) reported that day to maturity of maize decreased as plant density increased. Rathore *et al.* (1976) reported that early maturity was obtained at lower density.

Spacing and planting arrangement may have effect on grain yield. Lima and Lodi (1982) responded that the higher grain yields (1.23 and 1.03 t ha^{-1}) were produced by 2 plants/hill at 33 cm between hills. At 25 cm and 33 cm between hills, grain yield was reduced as plant number/hill increased. BARI (1990) stated that maize were grown with different plant spacing in different locations and observed spacing 75 cm x 25 cm gave maximum grain yield.

Araujo *et al.* (1983) conducted an experiment on maize with 0.25, 0.50, 0.75 or 1.00 m between hills with 1, 2, 3 or 4 plants/ hill giving a population of 40,000/ha. They did not find any significant yield difference due to change in planting arrangement.

Bozic (1993) carried out an experiment having different plant density on maize. He reported the highest yield (6.81 t/ha) was obtained with 50,000 plants/ha + 250 kg N/ha in 1990. During the second year the highest yield (14.70 t/ha) was recorded from 80,000 plants/ha along with 150 kg N/ha.

Shah *et al.* (1989) observed that plant spacing and number of plants per hill and significant effect on yield, and the highest yield was obtained from 75 cm X 25 cm plant spacing with three plants/hill.

BARI (1990) reported that there was no significant yield difference due to variation of row spacing in maize. However, maximum grain yield was recorded for 75 cm X 25 cm followed by 75 cm X 30 cm and 75 cm X 20 cm Quayyum and Raquibulah (1986) reported that the highest yield (4.11 t/ha) was obtained from 75 cm row spacing which was identical with that obtained from 30 cm row spacing (4.01 t/ha).

Ahmed and Muhammad (1999) carried out a field experiment at Faisalabad, Pakistan, in rainy season 1996 having different plant spacing 75 X 25 cm (5.33 plants/m^2), 75 X 20 cm (6.67 plant/m^2) and 75 X 15 cm (8.89 plants/m^2). They reported that grain yield, yield, components and quality of maize were significantly affected by plant density. They also observed that population density of 8.89 plants/m^2 (75 X 15 cm) produced higher grain and stover yields but surpassed in protein and oil yield.
Sawheny *et al.* (1989) reported that spacing influenced grain yield significantly. Closer spacing 50 cm X 16 cm or 40 cm X 20 cm resulted in the highest grain yield. Haque (1982) also reported that closer spacing between

rows were better in respect of growth and yield. A similar report of Kolear and Vienovic (1988) also indicates that closer spacing showed the highest yield (8.67 t/ha) for early sowing.

Barthakur *et al.* (1975) found that higher yields (4.53 t/ha) were obtained in rows 50 cm apart than in rows 75 (4.16 t/ha) and 100 cm apart (3.49 t/ha) in summer season. Quayyum and Raquibullah (1986) observed that maize variety Pozarica produced the highest grain yield (4.42 t/ha) at row spacing of 60 cm followed by variety Sadaf (4.35 t/ha) at 75 cm row spacing.

Akka *et al.* (1977) did not find any significant difference among row spacing. Khan and Haque (1989) found maximum yield at 60 cm X 20 cm spacing. The highest yields were obtained from 80,000 plants/ ha with 50 cm X 25 cm spacing by Nagy (1982). Wahua (1983) found 5.08 and 3.29 t/ ha grain yields at 40 cm x 30 cm x 20 cm spacing respectively. Spacing had considerable effect on grain yield of maize and maximum yield was recorded at the row spacing of 45 cm (BARI, 1981).

The grain yield increased with an increase in number of plants per unit area regardless of sowing time (Vasic *et al.* 1988). Senait and Dejene (1992), Simeonov and Tsankova, (1990) also reported similar result. Pestean (1988) observed 13.8-15.1 t/ ha of grain yields of maize with an increase in plant density from 70,000-1, 00, 000 plants/ha .Kolear and Vidennovic (1988) recorded higher grain yield of maize from 28, 571 to 59, 562 plants/ha. A density of eight plants/m^2 proved more effective in increasing yield than lower density (Chazanowska ,1990).

Sabir *et al.* (2001) studied the effect of different plant stands 15, 20, 25,30 and 35 cm plant spacing (1,11,111; 83,333; 66,66; 55,555 and 47,619 plants/ha) with 60 cm constant row spacing of maize during 1999 and 2000 at Faisalabad. They reported that cob length; number of grains per cob and 1000 grain weight were affected significantly by different plant stands. Plant densities of 11,111 plants/ha gave maximum grain yield (7.09 t/ha) and minimum grain yield (2.35 t/ha) was produced by 47,619 plant/ha. They also reported that grain yield was strongly negatively correlated with cob length, number of grains per cob and 1000 grain weight and showed positive correlation with plant population.

Increasing plant density increased grain yield (Desiderio *et al.* 1989). Narayanaswamy *et al.* (1994) also found similar result. However, Vivas *et al.* (1988) reported that plant density was not a critical factor in determining maize. In the study of Amoruwa *et al.* (1987) also found a similar result. Grain yields of 11 hybrids maize tended to decrease as plant density increased from 75000 to 90000 per hectare (Elsashockie, 1977).

Sufian *et al.* (1985) conducted a field experiment on winter maize at Pabna of Bangladesh during rabi season, having six plant population levels (40,000 50,000 53,333 66,666 80,000 and 1, 00,000 plant/ha) with 1 and 2 plants per hill. They concluded that a positive trend of increase in grain yield was noticed with the increase in plant populations from 40,000 to 1, 00,000 plants/ ha.

Tano (1986) reported that grain yields of maize cv. Iperon were significantly increased whenb row spacing was reduced from 70 cm to 50 cm.

Vukadinovic *et al.* (1986) reported that there was no significant effect of plant density on the content of nitrogen, phosphorus and potassium in grains.

Literature on the effect of planting arrangement nutrient uptake is very limited. It appears that spacing and planting arrangement may have effect on nutrient uptake in maize. Kamal *et al.* (1994) reported that planting arrangement had influence on nutrient uptake from 25 cm apart (one plant/ hill) than 50 cm apart (two plants/ hill).

CHAPTER III

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Central Field of the Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh. The experiment was carried out during the period from April to July, 2006. It was located in 24.09^0N latitude and 90.26^0E longitude. The altitude of the location was 8.2m from the mean sea level (The Meteorological Department of Bangladesh, Agargoan, Dhaka-1207).

Climate

The experimental area was situated in the sub-tropical climatic zone, which was characterized by high temperature and heavy rainfall during the month of April to September and moderately low temperature and scanty rainfall during the rest period of the year. Details of meteorological data in respect of temperature (^{0}C), rainfall (cm), and relative humidity (%) during the crop growing period are shown in Appendix-I.

Soil

The experimental site was located in the Modhupur Tract (AEZ-28) and it was medium high land with adequate irrigation facilities. The soil was having a texture of sandy loam with p^H and CEC were 5.6 and 2.64 meq/100g soil respectively. Physical and chemical properties of soils in the experimental field are given in Appendix-II.

Plant materials used in the experiment

The hybrid variety BARI-Maize 3 was used in the experiment. The seeds were collected from Bangladesh Agriculture Research Institute (BARI), Joydebpur, Gazipur.

Design of the experiment

The experiment was conducted by Randomized Complete Block Design (RCBD) factorial with three replications. Two factors were used in the experiment viz. different levels of nitrogen and different types plant spacing.

Factor A: Different levels of nitrogen

N_1= 180 kg N/ha

N_2= 220 kg N/ha

N_3= 260 kg N/ha

Factor B: Different types of spacing

S_1 = 60 cm x 25 cm

S_2 = 75 cm x 25 cm.

S_3 = 90 cm x 25 cm.

The treatment combinations for the experiment were arranged follows:

S_1N_1, S_1N_2, S_1N_3, S_2N_1, S_2N_2, S_2N_3, S_3N_1, S_3N_2, S_3N_3

Lay out of the experiment

The experiment was laid out on 28th March, 2006 according to the experimental design. The field was divided into three blocks to represent three replications. Each block consisted of nine plots. Thus the total number of plots were 27. Different treatment combinations were assigned to each block as per design of the experiment. The size of a unit plot was 5.0m × 4.5m. A distance of 0.5m between the plots and 1.0m between the blocks were kept.

Land preparation

The experimental area was ploughed with the help of power tiller and was leveled carefully to get a well pulverized soil. Plots were also cleaned and weeds were removed. The soil of the plot was treated by Sevin 50WP @ 5kg/ha to protect the young plants from the attack of mole cricket, ants and cutworm.

Fertilization

Fertilizers were given as bellow:

Name of nutrient elements	Amount		Name of fertilizers	Amount	
	Kg/ha	g/plot		Kg/ha	g/plot
N	As per treatment	As per treatment	Urea	As per treatment	As per treatment
P	120	250	TSP	250	520
K	126	262	MP	200	415
S	45	26	Gypsum	250	520
Zn	4	2	ZnO	10	21
B	1.8	0.972	Boric acid	8	17

Source: Fertilizer recommendation Guide-2005, BARC.

Half urea and full doses of TSP, MP, Gypsum, ZnO and Boric acid was broadcasted and incorporated during final land preparation. Remaining urea was applied in two equal installments as top dressing at 8-10 leaf stage (20 DAS) and at taselling stage (45 DAS).

Seed treatment

Seeds were treated by Vitavax-200 @ 5g/ 1kg seeds to protect some seed borne diseases.

Sowing of seeds

Seeds of hybrid variety BARI- Maize 3 was sown on 16th, April, 2006 with different plant spacing according to treatment. The seeds were covered with fine soil to allow uniform germination.

Intercultural operations

1. Gap filling

The seedlings of the crop emerged out within 5-8 days after sowing (DAS). Necessary gap filling was done at 12 days after sowing to maintain desired plant population.

2. Weeding and thinning

First weeding and thinning were done simultaneously on 20 DAS. Only one healthy seedling per hill was kept and the rest were thinned out Second weeding was done at 45 DAS.

3. Irrigation

Irrigation was given by observing the soil moisture condition. Three times light irrigation was done during the growing period of crop. The first irrigation was given at 5 days after sowing, the second after 30 days and the third 60 days after sowing.

4. Pest control

There was no major incidence of insects or disease. So, no pest control measure was taken in the experiment. The experimental crop was grown with proper care and management. During pod filling Parakeets were controlled by local method.

5. Harvesting

The full mature crop was finally harvested on 5th July, 2006. Six square meters areas including two rows of plants were randomly selected from each plot at harvesting for collection of data on plant characters and yield components. The harvested crop of each plot was bundled separately, tagged and taken to the threshing floor and threshed and the grain cleaned properly. Grains and stover were thoroughly dried in the sun for 5-6 days. The grains and stover of each plot were then weighed individually.

Collection data

Data were recorded on the following plant character:

i Plant height (cm)

ii. Number of leaves per plant

iii. Number of cobs/ plant

iv. Length of cob (cm)

v. Number of grains/cob

vi. Weight of 1000-grain (g)

vii. Grain yield (t / ha)

viii. Stover yield (t / ha)

ix. Harvest index (%)

Plant height

The height of five randomly selected plants was measured from the base of the plant to the tip of the tallest leaf. The height of each plant was recorded in cm and the mean values of 5 plants for each plot determined.

Number of leaves per plant:

Total number of leaves produced by each plant was counted at different days after sowing (DAS).

Number of cobs per plant

The number of cobs per plant from five randomly selected plants each plot was counted and mean was determined as per plant basis.

Length of cob

Ten matured cobs were randomly selected from each plot. Then length of cobs was measured and calculated the mean.

Number of grains per cob

Ten cobs then randomly selected from each plot were sun dried. Dried cobs were threshed by hand and grains were separated. The seeds were counted and mean was expressed on per cob basis.

Weight of 1000-grain

For each individual treatment, samples of well dried 1000- grains were counted separately and weighed by a electrical balance and mean weight expressed in grams.

Grain yield

The cobs harvested from each plot were separated from plants, cleaned, dried and weighed separately. Grain yield of each plot was recorded as kg/ha individually and adjusted at 14% moisture content.

Stover yield

After separating the cobs from the plants and drying the harvested plants in the sun. Total weight of stalk of each plot was taken in kilograms and converted into tons per hectare.

Harvest index

The harvest index (HI) was computed as the ratio of grain yield (DM) to the total biological yield.

$$HI (\%) = \frac{\text{Grain yield}}{\text{Total biological yield}} \times 100$$

Benefit cost ratio (BCR)

For benefit cost ratio for each treatment of interaction was calculated on the basis of the price of harvested crop, cost of each treatment and the cost of cultivation.

$$BCR = \frac{\text{Net return}}{\text{Total cost of production}}$$

Statistical analysis

The collected data were analyzed statistically using the " Analysis of variance " technique and mean differences among the treatment were adjusted by using the Duncan's Multiple Range Test (Gomez and Gomez, 1984).

CHAPTER IV
RESULTS AND DISCUSSION

4.1. Plant height

Application of nitrogen exhibited significant influence on the plant height of maize at 55, 75, and 95 days after sowing (DAS) (Fig. 1 and Appendix-IV). At 55 DAS, the plant height ranged from 153.89 cm to 166.33 cm. The tallest plant (166.33 cm) was found in the highest dose of nitrogen application (N_3) and the smallest plant (153.89 cm) was found in N_1. At 75 DAS, plant height ranged from 199.22 cm to 209.56 cm. The maximum plant height (209.56 cm) was recorded from N_3 and the minimum plant height (199.22 cm) was observed in N_1 treatment. At 95 DAS, plant height ranged from 219.56 cm to 230.78 cm. The highest plant height (230.78 cm) was found in N_3 and the lowest plant height (219.56 cm) was found in N_1 treatment. At 120 DAS, the plant height was statistically insignificant due to application of different levels of nitrogen. Plant height ranged from 242.44 cm to 249.56 cm. The maximum plant height (249.56 cm) was found in N_3 and the minimum height (242.44 cm) was found in N_1 treatment. It was revealed that plant height increased with the increased days after sowing (DAS) i.e., 55, 75, 95 and 120 DAS and also revealed that the plant height increased with the increased in nitrogen application as well. This could be due to the synergistic effect of N because it enhanced vegetative growth of maize.

Different plant spacing showed significant influence on the height of maize at 55, 75, 95 and 120 DAS (Fig. 2 and Appendix IV). At 55 DAS, the maximum plant height (173.89 cm) was found in widest spacing (S_3) and minimum plant height (147.11 cm) was observed in closest spacing (S_1). At 75 DAS, the highest plant height (214.22 cm) was recorded from widest spacing (S_3) and the shortest height (194.44 cm) was observed in closest spacing (S_1). At 95 DAS, the highest plant height (238.22 cm) was recorded from widest spacing (S_3) and the smallest height (212.89 cm) was observed in the closest spacing (S_1).

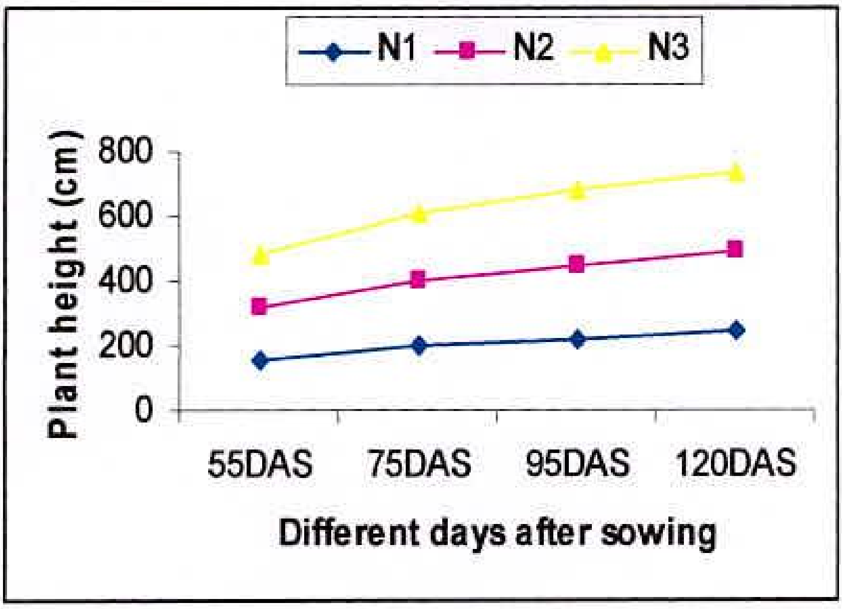

Figure 1 Effect of different levels of nitrogen on plant height at different days after sowing

Where, N_1= 180 kg N/ha, N_2= 220 kg N/ha and N_3= 280 kg N/ha

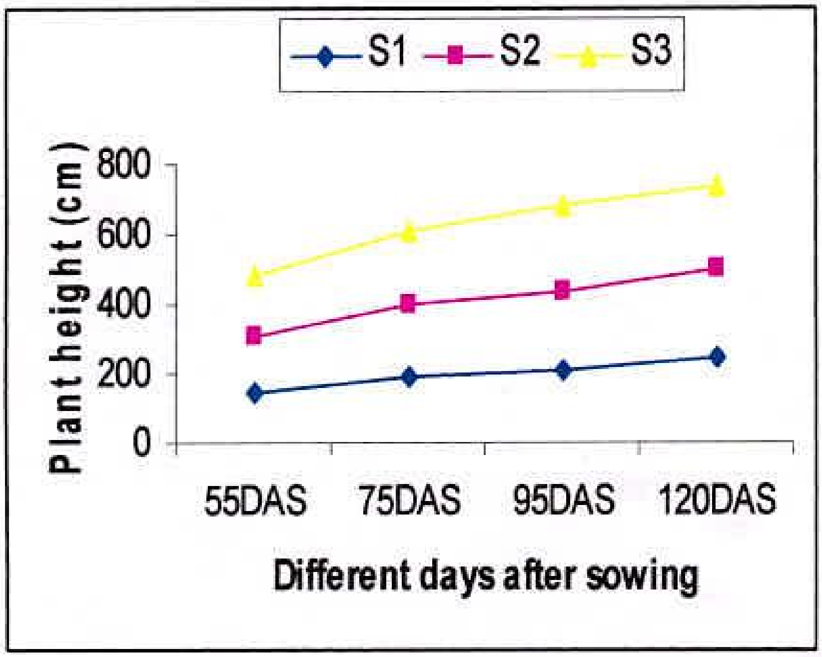

Figure 2 Effect of different spacing on plant height at different days after sowing

Where, S_1= 60cm × 25cm, S_2= 75cm × 25cm and S_3= 90cm × 25cm

At 120 DAS, the maximum plant height (249.00 cm) was recorded from widest spacing (S_3) and the smallest height (244.11 cm) was observed in closest spacing (S_1). It was revealed that the plant height increased with the increased in days after sowing (DAS) and also revealed that the plant height increased with the increased of plant spacing as well. This might be due to receiving sufficient amount of light and nutrients. On the other hand, densely populated plants with lower N rates were shorter at all growth stages.

The plant height was significantly influenced by the treatment combinations at 55, 75 and 95 DAS (Table 1 and appendix IV). At 55 DAS, the maximum plant height (178.30 cm) was recorded from S_3N_3 which was statistically similar to that of S_2N_3, S_3N_1 and S_3N_2 while the minimum height (137.7 cm) was observed in S_1N_1. At 75 DAS, the highest plant height (219.0 cm) was found in S_3N_3 which was statistically similar to that of S_2N_3, S_3N_1 and S_3N_2 while the lowest plant height (189.70 cm) was observed in S_1N_1. At 95 DAS, the highest plant height (242.30 cm) was observed in S_3N_3 which was statistically similar to that of S_2N_2, S_2N_3, S_3N_1 and S_3N_2 while the lowest plant height was found in S_1N_1 (205.70 cm). At 120 DAS, it was found that plant height did not differ significantly due to the combined effect of different levels of nitrogen and spacing. The maximum plant height (252.30 cm) was found in S_2N_2 and the minimum (245.30 cm) was observed in S_2N_3. Earlier works also revealed that plant height of maize increased greatly when the seeds were planted sparsely and sufficient amount of N was applied (Bobreeka *et. al.*, 1995; Pandey *et al.*, 2000 ; Anjum *et al.* 1992).

Table 1. Effect of different treatment combinations on plant height of maize

Treatment combination	Plant height (cm)			
	55DAS	75DAS	95DAS	120DAS
S_1N_1	137.7 e	189.7 e	205.7 d	249.3
S_1N_2	149.3de	193.3 de	215.0 cd	248.7
S_1N_3	154.3 cd	200.3 de	218.0bc	250.3
S_2N_1	155.7 bc	198.7 cd	217.7 bc	249.3
S_2N_2	158.7bc	204.0 bc	229.0 ab	252.3
S_2N_3	166.3 ab	209.3 ab	232.0 ab	245.3
S_3N_1	168.3 ab	209.3 ab	235.3a	248.7
S_3N_2	175.0 ab	214.3 ab	237.0 a	245.7
S_3N_3	178.3 a	219.0 a	242.3a	248.0
CV (%)	8.32	7.52	9.24	6.12

Means in the column followed by different letter (s) differed significantly by DMRT at 5% level of significance

Where,

S_1 = 60 cm × 25 cm N_1 = 180 kg N/ha

S_2 = 75 cm × 25 cm N_2 = 220 kg N/ha

S_3 = 90 cm × 25 cm N_3 = 280 kg N/ha

4.2. Number of leaves per plant

Application of nitrogen showed a significant influence on number of leaves per plant at 55, 75, and 95 days after sowing (DAS) (Fig 3 and Appendix-IV). At 55 DAS, number of leaves per plant ranged from 10.0 to 13.44.The maximum number of leaves (13.44) per plant was found in the highest dose of nitrogen application (N_3) and the minimum number of leaves (10.0) was found in N_1. At 75 DAS, number of leaves per plant ranged from 9.88 to17.0. The maximum number of leaves per plant (17.0) was recorded from N_3 and the minimum number of leaf (9.88) was observed in N_1 treatment. At 95 DAS, number of leaves per plant ranged from 14.11 to 19.55. The highest number of leaves per plant (19.55) was found in N_3 and the lowest number of leaves per plant (14.11) was found in N_1 treatment. At 120 DAS, number of leaves per plant was statistically insignificant due to application of different levels of nitrogen. Number of leaves per plant ranged from 22.44 to 26.11. The maximum number of leaves (26.11) was found in N_3 and the minimum number of leaves (22.44) was found in N_1 treatment. It was revealed that number of leaves per plant increased with the increased of days after sowing (DAS) i.e., 55, 75, 95 and120 DAS and also revealed that the number of leaves per plant increased with the increased in nitrogen application as well. This could be due to the synergistic effect of N because it enhanced vegetative growth of maize.

Different plant spacing showed significant influence on the number of leaves per plant at 55, 75, 95 and 120 DAS (Fig.3 and Appendix IV). At 55 DAS, the maximum number of leaves per plant (13.88) was found in the widest spacing (S_3) and the minimum number of leaves (8.77) was observed in closest spacing (S_1). At 75 DAS, the highest number of leaves per plant (15.88) was recorded from widest spacing (S_3) and the lowest number of leaves (10.77) was observed in closest spacing (S_1). At 95 DAS, the highest number of leaves per plant (22.22) was recorded from widest spacing (S_3) and the lowest number of leaves per plant (12.33) was observed in the closest spacing (S_1).

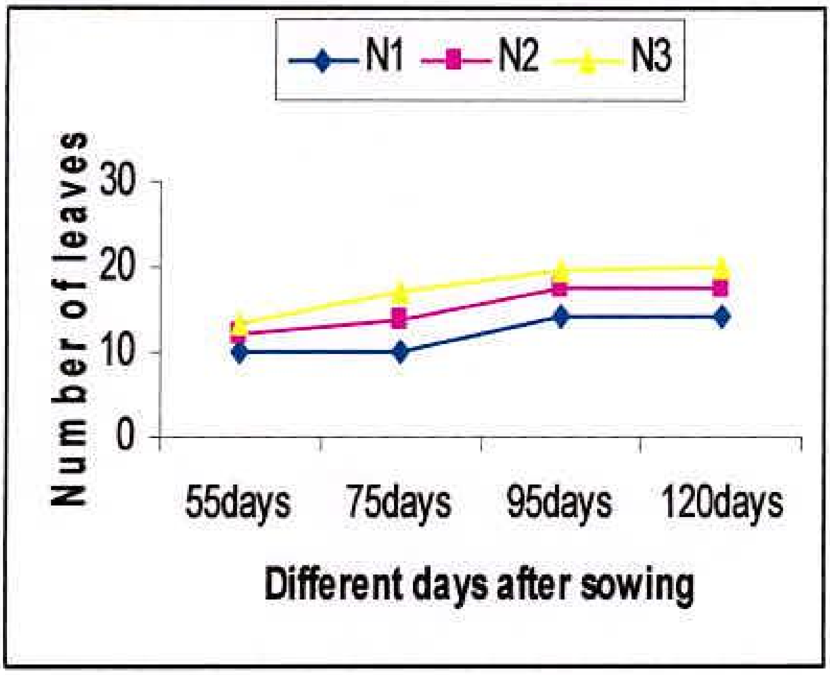

Figure 3 Effect of different levels of nitrogen on number of leaves per plant at different days after sowing

Where, N_1= 180 kg N/ha, N_2= 220 kg N/ha and N_3= 280 kg N/ha

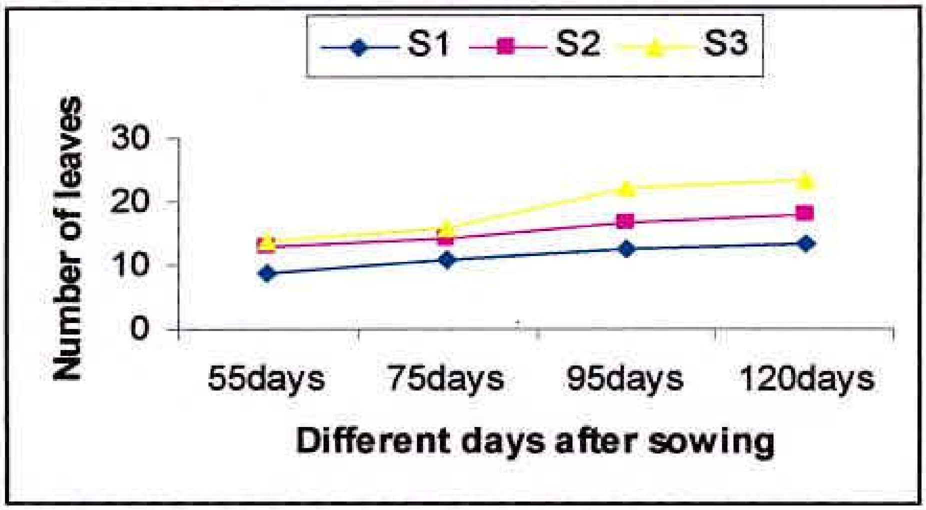

Figure 4 Effect of different spacing on number of leaf per plant at different days after sowing

Where, S_1= 60cm × 25cm, S_2= 75cm × 25cm and S_3= 90cm × 25cm

At 120 DAS, the maximum number of leaves per plant (24.22) was recorded from widest spacing (S_3) and the lowest number of leaves (23.77) was observed in closest spacing (S_1). It was revealed that the number of leaves per plant increased with the increased in days after sowing (DAS) and also revealed that the number of leaves per plant increased with the increased of plant spacing as well. This might be due to receiving sufficient amount of light and nutrients. On the other hand, densely Populated plants with lower N rates were shorter at all growth stages.

The number of leaves per plant was significantly influenced by the treatment combinations at 55, 75 and 95 DAS (Table 2 and Appendix IV). At 55 DAS, the maximum number of leaves per plant (16.0) was recorded from S_3N_3 while the minimum number of leaves per plant (7.33) was observed in S_1N_1. At 75 DAS, the highest number of leaves per plant (20.0) was found in S_3N_3 and the lowest number of leaves per plant (8.33) was observed in S_1N_1. At 95 DAS, the highest number of leaves per plant (24.67) was observed in S_3N_3 which was statistically similar to that of S_3N_2 while the lowest number of leaves (9.33) per plant was found in S_1N_1. At 120 DAS, it was found that the number of leaves per plant did not differ significantly due to the combined effect of different levels of nitrogen and spacing. The maximum number of leaves per plant (26.67) was found in S_3N_3 and the minimum (23.33) was observed in S_2N_2 and S_3N_2. Earlier works also revealed that the number of leaf per plant increased greatly when the seeds were planted sparsely and sufficient amount of N was applied (Bobrecka *et.al.*, 1995; Pandey *et al.*, 2000; Anjum *et al.*,1992).

Table 2. Effect of different treatment combinations on the number of leaves of maize plant

Treatment combination	No. of leaves/plant			
	55DAS	75DAS	95DAS	120DAS
S_1N_1	7.33 d	8.33 e	9.33 e	24.67
S_1N_2	8.66 d	11.0 d	12.67d	24.0
S_1N_3	10.33 c	14.0 c	15.0 cd	25.67
S_2N_1	11.0 c	10.67 d	13.67 d	24.0
S_2N_2	13.67b	14.67 c	17.67 bc	23.33
S_2N_3	14.0b	17.0 b	19. 0b	26.0
S_3N_1	11.67c	11.67d	19.33 b	24.67
S_3N_2	14.0b	16.0 bc	22.67 a	23.33
S_3N_3	16.0a	20.0 a	24.67 a	26.67
CV(%)	7.26	8.52	6.58	5.98

Means in the column followed by different letter (s) differed significantly by DMRT at 5% level of significance

Where,

S_1 = 60 cm × 25 cm N_1 = 180 kg N/ha

S_2 = 75 cm × 25 cm N_2 = 220 kg N/ha

S_3 = 90 cm × 25 cm N_3 = 280 kg N/ha

4.3. Number of cobs per plant

It was found that the number of cobs per plant did not differ significantly due to the effect of different levels of nitrogen (Table 3 and Appendix-IV). Numerically maximum number of cobs per plant (1.04) was observed in N_2 and the minimum number of cobs per plant (1.0) was found in both N_1 and N_3. It was revealed that number of cob increased with the increase of nitrogen. This might be caused that nitrogen helps to photosynthesis, energy storage, cell division and cell enlargement.

Plant spacing did not show any significant variation in respect of number of cobs per plant (Table 4 and Appendix-VI). Numerically maximum number of cobs (1.06) was found in S_2 and the minimum number of cob (1.03) was recorded from S_1.

The number of cobs was not significantly influenced by treatment combination (Table 5 and appendix VI). Numerically maximum number of cobs (1.08) was found in S_2N_2 and the minimum number of cobs (1.00) was observed in S_1N_1. Similar results were also reported by Nimje and Seth (1998). The reason for producing greater number of cobs/plant by the higher N application might be due to greater nutrients uptake by the maize plant enabling the plants to undergo more reproductive growth. The findings are in agreement with those of Ahmed and Muhammad (1999).

4.4. Cob length

It was found that the cob length did not differ significantly due to the effect of different levels of nitrogen (Table 3 & Appendix-IV). Numerically maximum cobs length (16.7 cm) was observed in N_2 and the minimum cob length (15.93 cm) was found in N_1. It was revealed that cob length increased with the increase of nitrogen. This might be caused that nitrogen helps to photosynthesis, energy storage, cell division and cell enlargement.

Table 3. Effect of different levels of nitrogen on number of cobs per plant, cob length, no. of grains/cob and 1000-seed wt. of maize

Nitrogen	No. of cob/plant	Cob length (cm)	No. of Grains/cob	1000-seed wt.(g)
N_1	1.00	15.93	238.66 c	255.44 c
N_2	1.04	16.7	257.55 ab	446.11 a
N_3	1.04	16.2	271.66 a	424.44 ab
CV(%)	6.43	5.45	7.83	11.25

Means in the column followed by different letter (s) differed significantly by DMRT at 5% level of significance

Where, N_1= 180 kg N/ha, N_2= 220 kg N/ha and N_3= 280 kg N/ha

Table 4. Effect of different types of spacing on number of cobs per plant, cob length, no. of grains/cob and 1000-seed wt. of maize

Spacing	No. of cob/plant	Cob length (cm)	No. of Grains/cob	1000-seed wt.(g)
S_1	1.03	15.86	153.88 c	250.44 c
S_2	1.06	16.90	300.33 ab	440.11 a
S_3	1.05	16.06	313.66 a	420.44 b
CV(%)	5.35	6.20	8.32	10.23

Means in the column followed by different letter (s) differed significantly by DMRT at 5% level of significance

Where, S_1= 60 cm × 25 cm, S_2= 75 cm × 25 cm and S_3= 90 cm × 25 cm

Plant spacing did not show any significant variation in respect of cob length (Table 4 and Appendix-VI). Numerically maximum cob length (16.9 cm) was found in S_2 and the minimum cob length (15.867 cm) was recorded from S_1.

The cob length was not significantly influenced by treatment combination (Table 5 and Appendix VI). The maximum cob length (18.8 cm) was found in S_2N_2 and the minimum cob length (15.5 cm) was observed in S_1N_1. Similar results of applied N fertilizer to maize were reported by Vedepetch and Bandista (1984). Similar trend was also reported by Khan (1976) for maize crop.

4.5. Number of grains/cob

Nitrogen exhibited a significant influence on number of grain per cob of maize (Table 3 & Appendix-VI). Number of grains per cob ranged from 238.66 to 271.66. The maximum number of grain per cob (271.66) was recorded from N_3 which was statistically similar to that of N_2 while the minimum number of grain per cob (238.66) was observed in N_1. It was revealed that there was the increased number of grain per plant with the increased of nitrogen application. Such effect of nitrogen was due to the fact that nitrogen was mainly responsible for increasing metabolic activities of maize plant.

Plant spacing exerted significant influence on the number of grains per cob (Table 4).The number of grains per cob ranged between 153.88 and 313.66. The maximum number of grain per cob (313.66) was recorded from S_3 while the minimum number of grain per cob (153.88) was observed in S_1. However, number of grains per cob decreased linearly with the increase in density. The results are in general agreement with the findings of Tetio-Kagho and Gradner (1988). Increase in grains per cob from lower planting density might be due to the lower competition for radiation and nutrients that allowing the plants to accumulate more biomass with higher capability to cover more photosynthesis into sinks resulting in more grains per cob.

The combined effect of different levels of nitrogen and spacing exhibited a significant influence on number of grain per cob of maize (Table 5 and Appendix VI). The maximum number of grain per cob (331.7) was found in S_2N_2 while the minimum number of cobs (141.7) was observed in S_1N_1. Similar results were reported by Sulewska (1991); Esechie (1992) and Akcin *et al.* (1994). This might be due to larger cob size and translocation of photosynthesis to the reproductive grains for setting seed. The findings of the present study are in agreement with Sanjeeb and Baggarwa (1997); Thakur *et al.* (1998), Shiraji *et al.*, (2000) and Pandey *et al.* (2000).

4.6. 1000-grain weight

Nitrogen showed a significant influence on 1000- grain weight of maize (Table 3 and Appendix-VI). 1000-grain weight ranged from 341.56g to 389.42g. The maximum 1000-grain weight (389.42g) was recorded from N_3 while the minimum weight of 1000-grain (341.56g) was observed in N_1. It was revealed that there was the increase of 1000-grain weight with the increase in nitrogen application. Such effect of nitrogen was due to the fact that nitrogen was mainly responsible for increasing metabolic activities of maize plant.

Plant spacing exerted significant influence on the 1000-grain (Table 4). The 1000-grain weight ranged from 255.44g to 446.11g. The maximum weight of 1000- grain (446.11g) was recorded from S_2 while the minimum weight of 1000-grain (255.44g) was observed in S_1.

The combined effect of different levels of nitrogen and spacing exhibited a significant influence on 1000- grain weight of maize (Table 5 and Appendix-VI). The maximum weight of 1000-grain (476.7g) was found in S_2N_2 ,which was statistically similar to that of S_2N_3 and S_3N_2 while the minimum weight (248.0g) was observed in S_1N_1. 1000-grain weight altered due to plant spacing and N fertilizer application. Presumably wider plant spacing enhanced production of photosynthesis through higher solar radiation interception as well as greater N uptake leading to better grain development (Khan, 1976).

Table 5. Effect of different treatment combination on number of cobs per plant, cob length, no. of grains/cob and 1000-seed wt. of maize

Treatment combination	No. of cobs	Cob length(cm)	No. of grains/cob	1000-seed wt.
S_1N_1	1.007	15.5	141.7 f	248.0 c
S_1N_2	1.027	16.3	151.7 f	258.3 c
S_1N_3	1.06	17.4	168.3 e	260.0 c
S_2N_1	1.053	16.1	285.0 d	400.0 b
S_2N_2	1.083	18.8	331.7 a	476.7 a
S_2N_3	1.06	17.2	315.0 b	461.7 a
S_3N_1	1.023	16.2	301.0 c	376.7 b
S_3N_2	1.043	16.4	289.3 d	450.0 a
S_3N_3	1.077	15.6	320.0 ab	446.7 a
CV(%)	6.02	5.46	10.58	11.32

Means in the column followed by different letter (s) differed significantly by DMRT at 5% level of significance

Where,

S_1 = 60 cm × 25 cm N_1 = 180 kg N/ha

S_2 = 75 cm × 25 cm N_2 = 220 kg N/ha

S_3 = 90 cm × 25 cm N_3 = 280 kg N/ha

4.7. Grain yield/ha

Nitrogen exerted a significant influence on grain yield of maize (Table 6 and Appendix-VI). Grain yield ranged from 4.72 t $ha^{-1}$to 6.25 t ha^{-1}. The maximum grain yield (6.25 t ha^{-1}) was recorded from N_3 while the minimum yield (4.72 t ha^{-1}) was observed in N_1. It was revealed that there was the increase of grain yield with the increase in nitrogen application. Such effect of nitrogen was due to its role in photosynthesis, energy storage, cell division and cell enlargement and metabolic activities. Selvaraju and Iruthayaraj (1994) obseverd that application of 180 kg N/ha gave significantly higher grain yield of Kharif maize over 100 and 140 kg N/ha. This was also supported by the reports of Kumar *et al.* (1992); Bozic (1993); Thakur *et al.,(1998*) and Singh *et al.* (2000).

Plant spacing exerted significant influence on the grain yield (Table 7).The grain yield ranged between 3.43 t $ha^{-1}$and 7.35 t ha^{-1}. The maximum grain yield (7.354 t ha^{-1}) was recorded from S_2 while the minimum grain yield (3.43 t ha^{-1}) was observed in S_1. A similar trend in yield differences across planting density have been reported by Tyagi *et al.* (1998) and Modarres *et al.* (1988).

The combined effect of different levels of nitrogen and spacing exhibited a significant influence on grain yield of maize (Figure 5 and Appendix-V). The maximum grain yield (8.35 t ha^{-1}) was recorded from S_2N_2, which was statistically similar to that of S_2N_3 and S_3N_3 while the minimum grain yield (2.677 t ha^{-1}) was observed in S_1N_1.

Table 6. Effect of different levels nitrogen on grain yield, stover yield and harvest Index of maize

Nitrogen	Grainyield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest Index (%)
N_1	4.72	13.02	25.69
N_2	6.20	14.74	28.95
N_3	6.25	14.06	28.76
CV(%)	12.50	11.65	9.32

Means in the column followed by different letter (s) differed significantly by DMRT at 5% level of significance

Where, N_1= 180 kg N/ha, N_2= 220 kg N/ha and N_3= 280 kg N/ha

Table 7. Effect of different types of spacing on grain yield, stover yield and harvest Index of maize

Spacing	Grain Yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
S_1	3.43	10.43	23.16
S_2	7.35	15.84	32.14
S_3	6.39	15.55	28.10
CV(%)	11.67	10.56	8.69

Means in the column followed by different letter (s) differed significantly by DMRT at 5% level of significance

Where, S_1= 60 cm × 25 cm, S_2= 75 cm × 25 cm and S_3= 90 cm × 25 cm

4.8. Stover yield/ha

Nitrogen exhibited a significant influence on stover yield of maize (Table 6 and Appendix-VI). Stover yield ranged from 13.02 t $ha^{-1}$to 14.74 t ha^{-1}. The maximum stover yield (14.74 t ha^{-1}) was recorded from N_2 while the minimum stover yield (13.02 t ha^{-1}) was observed in N_1. It was revealed that there was the increase of Stover yield with the increase in nitrogen application. Such effect of nitrogen was due to its role in photosynthesis, energy storage, cell division and cell enlargement and metabolic activities.

Plant spacing exerted significant influence on the Stover yield (Table 7 and Appendix VI).The stover yield ranged between 10.43 t $ha^{-1}$and 15.84 t ha^{-1}. The maximum Stover yield (15.84 t ha^{-1}) was recorded from S_2 while the minimum stover yield (10.43t/ha) was observed in S_1. The results compare a favorable with those of Kumar *et al.* (1992); Sanjeey and Bangarwa (1997) who observed significant and positive linear trends of stover yield in maize to increasing plant spacing.

The combined effect of different levels of nitrogen and spacing exhibited a significant influence on Stover yield of maize (Figure 6 and Appendix-VI). The maximum Stover yield (17.87 t ha^{-1}) was recorded from S_2N_2, which was statistically similar to that of S_2N_1, S_3N_1, S_3N_2 and S_3N_3 while the minimum Stover yield (6.8 t ha^{-1}) was observed in S_1N_1.

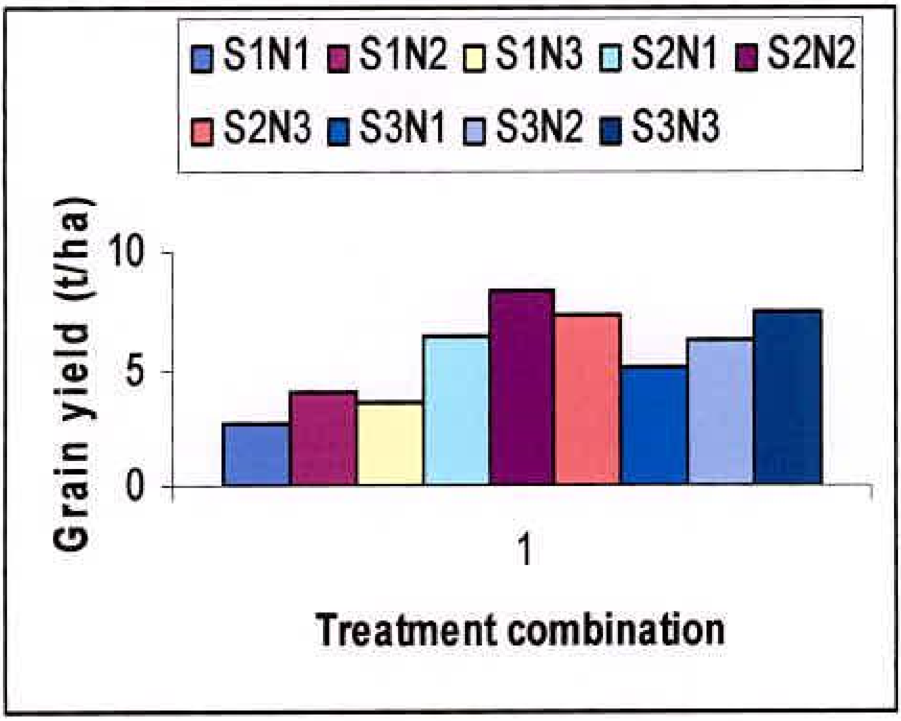

Figure 5 Effect of different treatment combinations on grain yield of maize

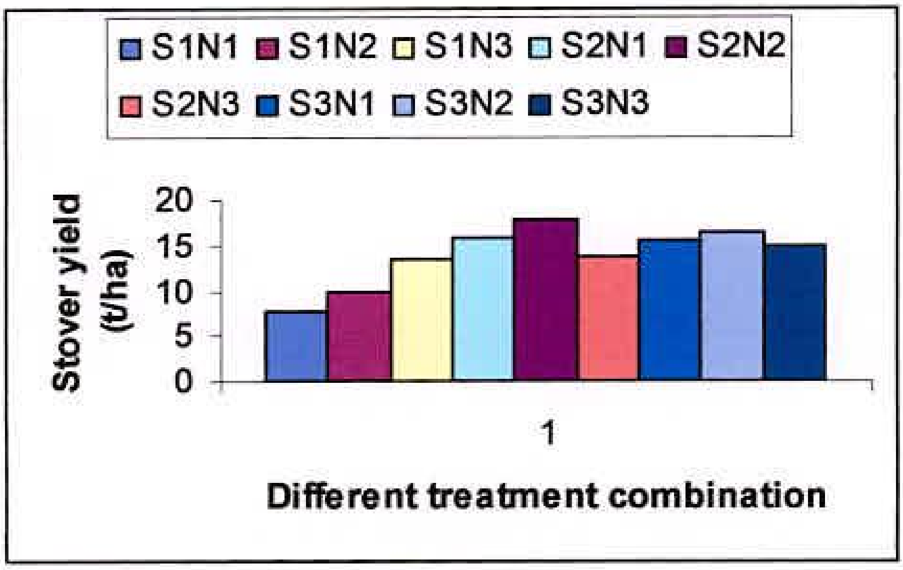

Figure 6 Effect of different treatment combinations on stover yield of maize

4.9. Harvest index

Nitrogen exhibited a significant influence on harvest Index of maize (Table 6 and Appendix-VI). The maximum harvest Index (28.95%) was recorded from N_2 while the minimum harvest Index (25.69%) was observed in N_1. It was revealed that the increase of harvest Index was with the increase in nitrogen application.

Plant spacing exerted significant influence on the harvest Index (Table 7). The maximum harvest Index (32.14%) was recorded from S_2 while the minimum harvest Index (23.16%) was observed in S_1.

The combined effect of different levels of nitrogen and spacing exhibited a significant influence on harvest Index of maize (Table 8 and Appendix-VI). The maximum harvest Index (33.77%) was recorded from S_2N_2, which was statistically similar to that of S_2N_3 and S_3N_3 while the minimum harvest Index (22.70%) was observed in S_1N_1.

Table 8. Effect of different treatment combination on harvest index (%) of maize

Treatment combination	Harvest Index (%)
S_1N_1	22.76 d
S_1N_2	24.43 d
S_1N_3	22.29 d
S_2N_1	30.81 b
S_2N_2	33.77 a
S_2N_3	31.84 ab
S_3N_1	23.5 d
S_3N_2	28.66 c
S_3N_3	32.15 ab
CV(%)	8.63

Means in the column followed by different letter (s) differed significantly by DMRT at 5% level of significance

Where,

S_1 = 60 cm × 25 cm N_1 = 180 kg N/ha

S_2 = 75 cm × 25 cm N_2 = 220 kg N/ha

S_3 = 90 cm × 25 cm N_3 = 280 kg N/ha

4.10. Economic analysis:

The details of economic analysis have been shown in Table 9. The total cost of production per hectare ranged from Tk.17783 to 20414 among the treatment combination. The variation was due to cost of different levels of nitrogen and seed.

Per hectare net return was observed with different treatment combinations ranged from Tk.35757 to Tk.147910. Gross income was the total income through the sale of maize grain @ Tk.20000/t. The economic analysis showed that the highest gross return (Tk 167000/ha) and benefit cost ratio (7.74) were obtained from the treatment combination of S_2N_2 (75cm × 25cm and 220kg N/ha) while the lowest gross return (Tk 53540/ha) and benefit cost ratio (2.01) was found in S_1N_1.

Table 9. Economic analysis of different treatment combination of Maize during April- July, 2006

Treatment combination	Cost of Management (Tk./ha)					Total cost (Tk./ha)	Yield (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
	Land preperation	Seed	Fertilizer	Labor	Irrigation					
S_1N_1	2500	810	8473	4500	1500	17873	2.67	53540	35757	2.01
S_1N_2	2500	810	9007	4500	1500	18317	3.99	79940	61623	3.36
S_1N_3	2500	810	9540	4500	1500	18850	3.63	72600	53750	2.85
S_2N_1	2500	1008	8473	4875	1700	18556	6.43	128600	110044	5.93
S_2N_2	2500	1008	9007	4875	1700	19090	8.35	167000	147910	7.74
S_2N_3	2500	1008	9540	4875	1700	19623	7.28	145660	126037	6.42
S_3N_1	2500	1224	8473	5250	1900	19347	5.08	101600	82253	4.25
S_3N_2	2500	1224	9007	5250	1900	19881	6.25	125000	105119	5.28
S_3N_3	2500	1224	9540	5250	1900	20414	7.84	156940	136526	6.68

Cost of labour: one labour @ 75.00/day
Flood irrigation: @Tk. 500/ha at 90cm x 25cm, 537/ ha at 75cm x 25cm and 634/ha at 60cm x 25cm
Cost of seed: @ Tk. 30/kg
Sell of grain: @ Tk. 20/kg

4.11. Relationship of different characters of Maize with yield

The yield of maize was positively correlated with number of cobs/plant (R^2 = 0.1495), cob length (R^2 = 0.3588), number grains/cob (R^2 = 0.8037), 1000-seed weight (R^2 = 0.9066) and stover yield (R^2 = 0.622).

This indicated that with the increased in the above mentioned characters the yield positively increased. 1000-seed weight (R^2=0.9066) had the most intimate relationship with yield, suggesting that maize producing higher plant height, number of leaves, number of cobs/plant, cob length, number of grain/cob, stover yield and harvest index will produce high economic yield and vice-versa.

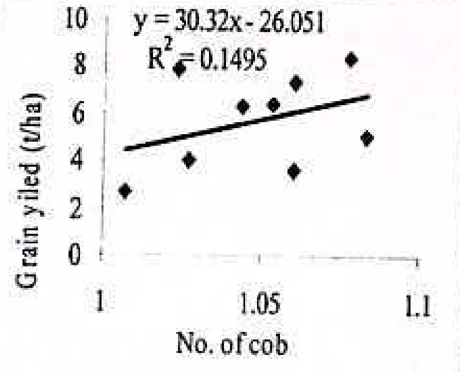

Fig. 9. Correlation between Grain Yield and no of cob

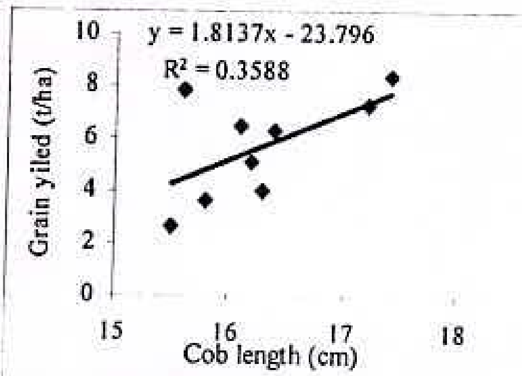

Fig. 10. Correlation between Grain Yield and cob length

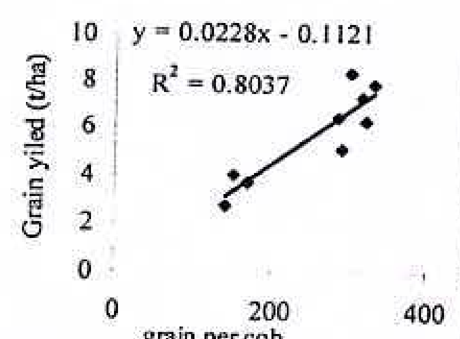

Fig. 11. Correlation between Grain Yield and grain per cob

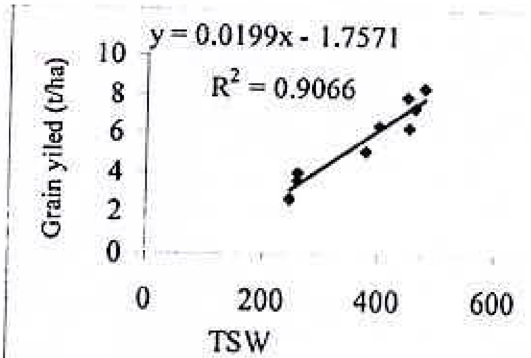

Fig. 12. Correlation between Grain Yield and TSW

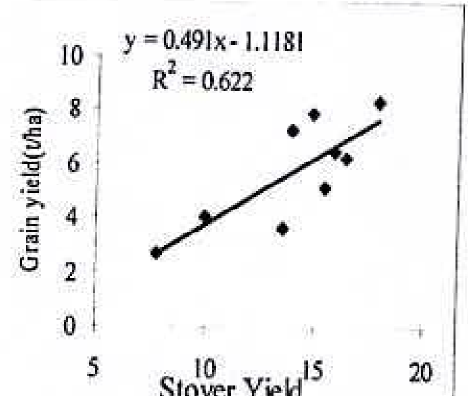

Fig. 13. Correlation between Grain Yield and stover yield

CHAPTER V
SUMMARY AND CONCLUSION

An experiment was conducted to study the effect of different levels of nitrogen and spacing on growth and yield of maize at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to July, 2006. The experiment comprised of 3 levels of nitrogen viz., 180 kg N/ha, 220 kg N/ha and 280 kg N/ha and different types of spacing viz., 60 cm × 25 cm (S_1), 75 cm × 25 cm (S_2) and 90 cm × 25 cm (S_3). The experiment was laid out in a Randomized Complete Block Design (RCBD) factorial with three replications.

Application of N exhibited significant influence on the height of the maize plants throughout its growing period. There was a progressive increase of height from its young stage (55 DAS) to maturity stage (120 DAS). From 55 DAS to 120 DAS the height of the maize plants increased from 153.89 cm to 244.11 cm at N_1 level and from 166.33 cm to 249.00 cm at N_3 level i.e. N_3 level of nitrogen showed significant influence in the growth of the maize plants.

Different plant spacing i.e. plant density had also significant influence on plant height of maize as measured at its different growing periods (55, 75, 95 and 120 DAS). The height of the maize plants as recorded at all the growing periods were found to be significantly highest at the widest spacing (90 cm × 25 cm) and significantly lowest at the closest spacing (50 cm × 25 cm). Moreover there was a gradual increase of height of plants with the increase of spacing. With narrowest spacing (50 cm × 25 cm) at 55 DAS the plant height ranged from 147.11 cm to 173.89 cm and at harvest (120 DAS) the height ranged from 244.11 cm to 249.00 cm.

In interaction of nitrogen and spacing, nitrogen level of N_3 (280 kg N/ha.) and widest spacing kept significant influence on the height of the plants throughout its growing periods up to harvest.

Number of leaves was found to vary significantly as influenced by nitrogen levels. Highest level of nitrogen (280 kg N/ha) produced significantly the highest number of leaves/plant throughout its physiological period.

Widest spacing (90 cm × 25 cm) providing the favorable environment for growth recorded significantly the highest number of leaves throughout its life period. While significantly the lowest number of leaves/plant were observed in the plants of lowest spacing. At the widest spacing the number of leaves/plant at different periods of life cycle of maize ranged from 13.88 to 24.22 while at the closest spacing the same ranged from 8.77 to 23.77 indicating more difference in the number of leaves at the earlier stage compared to maturity stage.

Highest level of nitrogen (N_3) in combination with the widest spacing (S_3) produced significantly the highest number of leaves/plant throughout its life period.

Nitrogen and spacing both influenced significantly on the number of cobs/plant of maize. But among three levels of nitrogen in place of N_3 i.e., 280 kg N/ha, N_2 i.e. 220 kg N/ha influenced significantly on the number of cobs/plant and in spacing also in place of the widest spacing (90 cm × 25 cm) the medium spacing (75 cm × 25 cm) produced significantly the highest number of cobs/plant. But there was not found significant interaction effect of nitrogen levels and different spacing on the number of cobs/plant. Both N_2 i.e. 220 kg N/ha and S_2 (75 cm × 25 cm) also influenced significantly on the cob length individually but the treatment combination did not effect significantly on cob length.

Number of grains/cob was influenced significantly by nitrogen as well as spacing. N_3 (280 kg N/ha) recorded significantly the highest number of the grains/cob (271.66) while N_1 (180 kg N/ha) recorded the lowest number of grains/cob (238.66). Among the spacing S_3 (90 cm × 25 cm) produced the highest number of grains /cob (313) while the closest spacing produced the lowest (153.89).

Interaction of N_3 and S_3 also kept significant influence on the number of grains/cob. N_3S_3 produced the maximum number of grains/cob (331.70) while the minimum (141.70) was found in N_1S_1.

1000-grain weight was found to be affected significantly by nitrogen levels as well as different spacing. The maximum 1000-grain weight (446.44 g) was recorded from N_2 and minimum from N_1 (255.44 g). Spacing of 75 cm × 25 cm (S_2) recorded the highest grains/cob (440.11 g) while the lowest was from S_1 (50 cm × 25 cm).

The combined effect of N_2 and S_2 affected also significantly on the number of grains/cob, showing the maximum number of grains/cob was (476.70 g) in N_2S_2 while the minimum (248.00 g) from N_1S_1.

Significantly the highest grain yield/ha (6.25 t/ha), stover yield (14.74 t/ha) and Harvest Index (28.95%) all obtained from the nitrogen level N_2 (220 kg N/ha) and similarly from the spacing S_2.

The combined effect of N_2S_2 produced the highest grain yield (8.35 t/ha), stover yield (17.78 t/ha) and harvest Index (33.77%).
The economic analysis showed that the highest gross return (Tk 167000) and benefit cost ratio (7.74) were obtained from the treatment combination of S_2N_2 (75 cm × 25 cm and 220 kg N/ha) while the lowest gross return (Tk 53540) and benefit cost ratio (2.01) was found in S_1N_1.

Nitrogen fertilizer and different plant spacing had significant influence on growth and yield of maize. S_2N_2 (75 cm × 25 cm and 220 kg N/ha) gave the highest yield as well as economic return from maize because the optimum dose of nitrogen was found to be at 220 kg N ha^{-1}. So, at S_3N_3 (90 cm × 25 cm and 280 kg N/ha) there was the maximum of nitrogen and spacing which resulted lower yield as well as lower economic return but the present study was conducted in an individual soil type, further regional trials should be needed for nitrogen fertilizer and appropriate plant spacing recommendation of maize cultivation.

On the basis of the above results it may be concluded that BARI maize 3 would be cultivated with 220 kg N ha^{-1} and 75 cm × 25 cm.

CHAPTER VI

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APPENDICES

Appendix I. Physical properties of soil in the experimental field

Soil physical properties	Analytical data
Soil texture	Sandy loam
Sand (%)	30.65
Silt (%)	38.19
Clay (%)	31.16
Soil Type	Shallow Red Brown Terrace soil
Soil Series	Tejgoan

Source: SRDI, Farmgate, Dhaka

Appendix II. Chemical properties of soil in the experimental field

Soil chemical properties	Analytical data
Soil pH	5.6
Total N (%)	0.078
Available P (ppm)	0.0015
Available K (ppm)	0.0053
Organic matter (%)	0.88
C: N ratio	12: 1

Source: SRDI, Farmgate, Dhaka

Appendix III. Monthly air temperature, rainfall, relative humidity and sunshine of the experimental site during the study period (April – July, 2006)

Month	Air temperature (^0C)			Rainfall **	Relative humidity (%)*	Sunshine (hours) **
	Max.	Min.	Mean			
April	31.40	21.50	26.45	205.90	86.16	185.20
May	29.56	19.55	24.55	10.70	84.27	222.70
June	29.52	19.90	20.21	0.00	80.84	220.20
July	28.44	18.92	17.68	0.00	78.00	213.20
August	27.31	16.41	21.86	11.1	74.71	169.40

* Monthly average

** Monthly total

Source: The Meteorological Department (Weather division) of Bangladesh, Agargoan, Dhaka.

Appendix IV. Analysis of variance for number of leaf at 55, 75, 95 and 120 days after sowing (DAS) of growth stage.

Source of variation	Degrees of Freedom	Mean Square(Number of leaf)			
		55 DAS (cm)	75 DAS (cm)	95 DAS (cm)	120 DAS (cm)
Replication	2	9.148	10.111	10.037	6.259
Spacing	2	66.037*	60.111*	192.926*	0.481^{NS}
Nitrogen	2	27.148*	40.444*	20.259*	31.815*
Spacing × Nitrogen	4	0.926*	0.222^{NS}	1.093*	1.093*
Error	16	0.69	0.611	0.037	0.968
Total	26	-	-	-	-
CV (%)		7.26	8.52	6.58	5.98

CV = Co-efficient of Variation
NS = Non-Significant
* = Significant at 5% level

Appendix V. Analysis of variance for plant height at 55, 75, 95 and 120 days after sowing (DAS) of growth stage.

Sources of variation	Degrees of Freedom	Mean Square(Plant height)			
		55 DAS (cm)	75 DAS (cm)	95 DAS (cm)	120 DAS (cm)
Replication	2	205.481	7.259	14.778	392.926
Spacing	2	1626.815*	1002.815*	1614.111*	328.259^{NS}
Nitrogen	2	169.148*	160.481*	170.333*	343.259*
Spacing × Nitrogen	4	2.481^{NS}	0.815^{NS}	1.111^{NS}	424.204*
Error	16	54.481	30.218*	22.361	339.551
Total	26	-	-	-	-
CV (%)		8.32	7.52	9.24	6.12

CV = Co-efficient of Variation

NS = Non-Significant

* = Significant at 5% level.

Appendix VI. Analysis of variance for plant spacing and N fertilizer on yield and yield attributes of maize

Source of variation	Degrees of Freedom	Mean sum of Square						
		Cob length(cm)	Cobs per plant	Grains per cob	1000 grain weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Replication	2	11.111	0.001	757.37	1358.333	1.231	2.009	6.285
Spacing	2	2.703^NS	0.001*	67960.15*	98076.33*	37.058*	83.321*	137.373*
Nitrogen	2	1.363^NS	0.0001*	1821.815*	7770.778*	5.728*	6.768*	24.15*
Spacing × Nitrogen	4	0.558^NS	0.0001*	94.037*	1226.611*	0.858*	16.243*	9.925*
Error	16	5.611	0.00001	17.162	441.667	0.106	3.509	0.093
Total	26	-	-	-	-	-		
CV (%)		6.02	5.46	10.58	11.32	11.67	10.56	8.69

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