PERFORMANCE OF MAIZE AS INFLUENCED BY DIFFERENT LEVELS OF NITROGEN AND SPACING

BY

MD. SHAHIDULLAH

REG. NO. 08-03238

MASTER OF SCIENCE (MS)
IN
AGRONOMY

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA

JUNE, 2010

PERFORMANCE OF MAIZE AS INFLUENCED BY DIFFERENT LEVELS OF NITROGEN AND SPACING

BY

MD. SHAHIDULLAH
REG. NO. 08-03238

A Thesis
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 (MS)
IN
AGRONOMY
SEMESTER: JANUARY- JUNE, 2010

APPROVED BY:

………………………………..
Sadrul Anam Sardar
Professor
Supervisor

………………………………
Dr. Parimal Kanti Biswas
Professor
Co-supervisor

……………………..…..………………
Prof. Dr. Md. Fazlul Karim
Chairman
Examination Committee

DEDICATED TO

MY

BELOVED PARENTS

Department of Agronomy

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Bangladesh

CERTIFICATE

This is to certify that the research work entitled , **"PERFORMANCE OF MAIZE AS INFLUENCED BY DIFFERENT LEVELS OF NITROGEN AND SPACING"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University , Dhaka, in partial fulfilment for the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY,** embodies the results of a piece of bona-fide research work successfully carried out by **MD. SHAHIDULLAH** bearing Registration No. 08-3238 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Place: Dhaka, Bangladesh

. . . .

Prof. Md. Sadrul Anam Sardar

Supervisor

ACKNOWLEDGEMENT

All praises are devoted to Almighty Allah, who is the supreme authority of this universe, and who enabled the author to complete the research work and submit the thesis for the degree of Master of Science (MS) in Agronomy.

The author would like to acknowledge the untiring inspiration, encouragement and invaluable guidance provided by his respected teacher and supervisor, Professor Md. Sadrul Anam Sardar, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka. His constructive criticism, continuous supervision and valuable suggestions were helpful in completing the research and writing up the manuscript.

The author would like to express his heartiest appreciation, ever indebtedness and deep sense of gratitude to his Co-supervisor, Professor Dr. Parimal Kanti Biswas, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his sincere advice, constant supervision, valuable suggestions and factual comments on upgrading the quality of the research work and preparing the manuscript.

The author would like to express his heartiest appreciation, ever indebtedness and deep sense of gratitude to Professor Dr. Md. Fazlul Karim, Chairman, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his kind permission to allow the departmental and laboratory facilities.

The author expresses his thanks to all other staff and members of the farm of Sher-e-Bangla Agricultural University, Dhaka for their help in conducting the experiment.

The author feel proud to express his unreserved gratitude to Niaz Morshed, Md. Azizur Rahman, Md. Maruf Al Hasan, for their heartfelt cooperation during research period and writing up the manuscript.

The author expresses his boundless, gratitude and deepest appreciation to his beloved father "Moulana Mohammed Sadeq", mother "Momotaj Begum, elder brother "Md. Aby Abdullah", and elder sister "Rahima Akter" for their unlimited prayer, support, sacrifice and inspiration to educate him up to this level.

ABSTRACT

An experiment was conducted during April to July 2010 at the Agronomy field laboratory of Sher-e-Bangla Agricultural University, Dhaka to evaluate the performance of maize as influenced by different levels of nitrogen under different spacings. The experiment comprised two different factors; (1) four levels of nitrogen application viz. N_1 (180 kg N/ha), N_2 (220 kg N/ha), N_3 (260 kg N/ha) and N_4 (275 kg N/ha) and (2) three different plant spacings viz. S_1 (60 cm × 25 cm), S_2 (75 cm × 25 cm) and S_3 (90 cm × 25 cm). The experiment was set up in randomized complete block design (factorial) with three replications. Results revealed that both nitrogen and plant spacing significantly affected growth, yield and yield contributing characters of maize. The highest nitrogen level N_4 (275 kg N/ha) recorded the highest value of all growth parameters at all data recording days whereas the lowest nitrogen level N_1 (180 kg N/ha) recorded the lowest values of all the growth parameters. In respect of yield contributing characters and yield, results revealed a different scenario where nitrogen level N_2 (220 kg N/ha) obtained the highest values of cob length, number of grains/cob, weight of grains/cob, 1000- grain weight, grain yield and harvest index and the corresponding lowest values were obtained from the lowest nitrogen level N_1 (180kg N/ha). The highest spacing S_3 (90 cm × 25 cm) though produced the shortest maize plant but it produced the highest number of leaves/plant, leaf area and dry weight/plant and all corresponding lowest values were recorded from the lowest spacing S_1 (60 cm× 25 cm). The medium spacing S_2 (75 cm × 25 cm) compared to S_4 produced lower values in growth parameters but it recorded the highest values in yield contributing characters and grain yield and the lowest values of yield contributing characters and grain yield were recorded from the lowest spacing S_1 (60 cm × 25 cm) but the highest stover yield was recorded from S_1 and the lowest from S_3 spacing. The N_2 (220 kg N/ha) in combination with S_2 (75 cm × 25 cm) performed the best and obtained the highest cob length (23.40 cm), number of grains/cob (515.76) weigh of grains/cob (146.10 g), 1000- grain weight (269.30 g) which contributed to obtain the highest grain yield (4.79 t/ha) and harvest index (38.71%). The corresponding lowest values were obtained from $N_1 \times S_1$ but the highest stover yield (6.19 t/ha) and lowest stover yield were obtained from $N_4 \times S_1$ and $N_1 \times S_3$, respectively.

LIST OF TABLES

LIST OF APPENDICES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEZ	: Agro Ecological Zone
Agri.	: Agriculture
SAU	: Sher-e-Bangla Agricultural University
BAU	: Bangladesh Agriculture University
BARI	: Bangladesh Agriculture Research Institute
BINA	: Bangladesh Institute of Nuclear Agriculture
BBS	: Bangladesh Bureau of Statistics
DAS	: Days After Sowing
FAO	: Food and Agricultural Organization
UNDP	: United Nations Development programme
AIS	: Agriculture Information System

CHAPTER 1

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important grain crops in the world. It has a good potential as a cereal crop side by side with 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. It has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil, and 1.5% minerals. Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 gm grains (Chowdhurv and Islam, 1993).

In Bangladesh, the cultivation of maize has been gaining popularity in 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 46,000 tons of grains annually (BBS, 2008). Maize crop has been included as a major enterprise in the crop diversification and intensive cropping programs (Kaul, 1983). It is one of the most efficient crop which can give high biological yield as well as grain yield in a relatively short period of time due to its unique photosynthetic mechanism.

There is a little scope for increasing cultivable area in the world. Therefore, farmers in developing countries have shown keen interest in intercropping practices to increase crop production vertically to meet their requirements for food, fibre and fodder from the existing area (Bandyopadhyay, 1984).

It has been found that this crop can very well be fitted in cropping pattern under partially irrigated high land conditions (BARI, 1982). However, it competes with broadcast aus in *KHARIF* season and other upland crops in *RABI* season.

Yield is a function of inter-plant and intra-plant competition. Nitrogen is the key element in increasing productivity. The response of applied fertilizer depends on the inherent potential of the varieties to absorb and utilize them for the production of dry matter. Application of N fertilizer have significant effect on grain yield and quality of maize (Bangarwa, 1997). Thus this study was conducted on the issue of N management and spacing would enrich the knowledge on development of management tools for high yield per unit area of this crop.

Objectives

i. To assess growth and yield response of maize to different levels of nitrogen.
ii. To assess growth and yield response of maize to different levels of spacing
iii. To assess growth and yield response of maize to interaction effect of nitrogen and spacing.

CHAPTER 2

REVIEW OF LITERATURE

In recent years, many scientists are engaged to change the pattern of growth and development of plants for long time to achieve higher yield benefit. It is evident that nitrogen application become helpful to increase the yield but in case of maintaining proper spacing the yield is reached to the best (Patro and Sahoo, 1994). Furthermore, literature revealed that nitrogen and spacing interface each other to increase grain yield of maize. Available literatures have been reviewed in this regard and presented below.

2.1 Effect of nitrogen

Farmers in the humid tropics of Asia and other regions tend to destroy crop stover or leave the material on the surface for decomposition, although organic matter is a vital component in maintaining productivity of the farming systems. Hence a field study in Sri Lanka evaluated the impact of the time and method of application of two common crop stovers on the N nutrition and yields of a rainfed maize crop, grown in a minor season. The use of a stover from a grain provided greater contents of N to maize than maize stover. Application of the stover before planting and its incorporation into the soil proved to be the most beneficial in terms of greater N uptake by the crop, N availability in soils, and increased maize yields (Sangakkara and Nissanka, 2003).

Delgado (2009) evaluated an experiment for determination of the amounts and patterns of N uptake and dry matter (DM) production by maize, *Zea mays*, are important to establish optimum N rates and application ages. We evaluated the pattern of N uptake and DM production of maize (hybrid PB-8) grown under 0, 30, 60, 90, 120, and 180 kg N ha^{-1}, applied as urea, at variable initial amounts of mineral

N (NO3-N, and NH4-N) in a Fluventic Haplustoll soil of Aragua State, Venezuela. Contrary to what has been observed for nitrogen, relative DM production was not affected by soil N availability. The maximum relative N uptake in the 0 and 120 kg N ha-1 treatments was observed at 90 and 60 days after sowing, while it was at 75 days in the other treatments. Generally, rates of DM production and N uptakes increased with increments in N availability: the highest rates of DM and N accumulation (424 and 8.7 kg ha-1 day-1, respectively) were observed at the 180 kg N ha-1 treatment. The total DM at 90 days was significantly correlated with total N taken up (r=0.97), and with the ratio amount of DM: unit of N taken up at 30 days (-0.92). There was a limit in the ratio at 30 days (18 kg DM: kg N uptake; ~5.6% N in tissue of the whole plant) under which there was no increment in total DM at 90 days.

Jin (2004) conducted an experiment with a high-starch maize variety (ZD21) grown in a field experiment with a common variety (SM25) as the control. Urea was applied at 0, 150, 195 and 240 kg N/ha. As compared with SM25, ZD21 had greater maximum N uptake rate, which occurred at an earlier date, and higher total N uptake at maturity, though its grain yield was lower. The nitrogen in its grain largely originated from the nitrogen absorbed by the roots rather than from the transfer of N from the vegetative organs. It had higher total starch and amylopectin and lower amylose/amylopectin ratio than SM25. It had higher total crude proteins, albumin, globin and glutelins and lower prolamins. Its total fatty acids were relatively low. however, the content of unsaturated fatty acids were fairly high. In both varieties, the responses of amylopectin, prolamins, palmitic acid, oleic acid and linoleic acid to N application were similar to those of the contents of starch, crude protein and fatty acids, and increased with N rate if N application was not excessive. Nitrogen application had no significant effect on the contents of amylose, albumin, globin and glutelins and of stearic acid, arachidic acid and linolenic acid.

Ghulam (2005) conducted field study in Pakistan, during the 1997 and 1998 summer seasons, to assess the effects of irrigation and N rates on maize cv. Golden yield. Results revealed that the different yield parameters, i.e. cobs per plant, grains per cob and mean grain weight were influenced significantly by different irrigation schedules and N rates. Generally, the grain yield increased with increasing irrigation or N levels. Maximum grain yield (>7.0 t/ha) was recorded with I3 (-8 bars) irrigation schedule and N3 rate of 200 kg/ha.

Ahmad (2005) conducted a field study in Pakistan, during the 2002 kharif season, to investigate the effect of different N fertilizer application rates and seed sizes on plant height and crop stand in maize cv. Kissan-92. Four seed sizes i.e. small, medium, large (having a diameter of 0.5, 0.6-0.7 and 0.8-1.0 cm, respectively) and composite (not graded) and 4 N levels (0, 60, 120 and 180 kg/ha) were tested. Maximum plant height, number of plants per m^{-2} and low percent mortality was recorded with 120 kg N/ha. Larger seeds resulted in maximum emergence per m^2, plant height, number of plants per m^2 and low percent mortality.

Niu (2005) conducted a field test with a fodder maize variety Baimaya was conducted in 2002 in Xuanhua, Hebei, China, to investigate the effects of different amounts of N fertilizer applied as a top dressing (0 as control, 34.5, 69.0, 103.5, 138.0, 172.5 and 207.0 kg N/ha) on crop yield and quality. The top dressing of N fertilizer significantly enhanced the yield of fodder maize and the contents of crude protein, true protein and amino acids in stalks. The highest fresh (45 089.9 kg/ha) and dry yields (9 378.7 kg/ha) were noted at 138.0 kg N/ha. The highest contents of crude protein (7.84%), true protein (1.97%) and amino acids (0.28%) in stalks were also noted at 138.0 kg N/ha. Therefore, the optimum amount of N fertilizer applied as a top dressing in the northwest arid land in Hebei province is 138.0 kg N/ha.

Siddiqui *et al*. (2006) conducted a field experiment at Students Farm, Sindh Agriculture University, Tandojam, Pakistan to observe the emergence of maize and nitrogen use efficiency of the crop under different fertility regimes (0-0, 90-00, 90-60, 90-90, 90-120, 150-00, 150-60, 150-90 and 150-120 N-P kg ha-1) applied in the plots ploughed through tillage practices with cultivator, chisel and desi plows. Better emergence was obtained with 90-90 NP kg ha^{-1}. The seedling emergence decreased at higher rates of N and P. The interaction of tillage x fertilizer revealed that fertilizer at the rate of 90-150 kg ha^{-1} and tillage practices with cultivator exhibited higher seedling emergence, while the plots ploughed with chisel plough and desi plough recorded decreased emergence. However, chisel ploughing recorded higher fertilizer nitrogen use efficiency than the plots ploughed by cultivator or desi plough. Nitrogen use efficiency at high levels of nitrogen applications was low than in the low rates of N incorporation. It was concluded that tillage practices should be performed with cultivator and 90 kg N ha-1 is suitable for good seedling emergence and crop yield of maize.

Tank (2006) conducted a field experiment in Anand, Gujarat, India during the rabi seasons of 2001-02 to determine the effects of Azospirillum lipoferum inoculation of maize seeds, alone or in combination with N application (0, 60, 120 and 180 kg/ha) at one-third + one-third + one-third, one-half + one-fourth + one-fourth or one-fourth + one-half + one-fourth proportions on the growth and yield of the crop. Inoculation with A. lipoferum, application of 180 kg N/ha applied and N application at one-fourth + one-half + one-fourth proportions gave the highest values for plant height at harvest, number of grains per cob, 1000-grain weight, protein content, grain yield, stover yield, net returns and benefit:cost ratio.

Ferguson (2004) studied with an earlier research in Nebraska evaluating variable rate nitrogen (N) application to irrigated maize found no significant benefit to variable N compared to uniform N, using a fixed expected yield and site-specific implementation of the current University of Nebraska N recommendation algorithm. Research was initiated in 2002 to review the accuracy of the current N recommendation algorithm for maize, among other nutrient recommendations, and explore the potential for developing N recommendation algorithms specific to agroecological regions in Nebraska. Final, detailed analysis will not be conducted until the study is completed in 2004. Studies in 2002 and 2003 have produced grain yields typically in the range of 14-16 Mg ha-1. Preliminary results suggest that the current N recommendation algorithm generates the most profitable fertilizer N rate much of the time, and there is little evidence so far for the need to develop agroecological zone-specific equations. There is some limited evidence for the need for tillage-specific recommendations. This study thus far suggests that accurately characterizing spatial yield potential within a field, and thus spatial N demand, may be more important than developing region-specific N recommendation algorithms.

Gomma and El-Douby (2010) conducted field experiments in Egypt, during 1999 and 2000 to study the effects of N levels (0, 80, 100 and 120 kg/feddan), alone and in combination with farmyard manure (0 and 20 t/feddan), under different tillage systems (no-tillage, chisel ploughing alone and mouldboard ploughing + chisel ploughing) on maize growth and yield. Data were recorded for plant height, leaf area, ear length, number of rows per ear, number of kernels per row, 100-kernel weight, ear weight, weight of grains per ear, shelling percentage, grain yield per feddan, cost of cultivation and production, and net returns. The results are presented.

Agba and Ogar (2005) conducted two field experiments to determine the efficacy of Nitrogen fertilizer on the growth and yield of improved maize variety in the teaching and research farm department of Agronomy Obubra, Cross River University of Technology, Nigeria, during the 2003/2004 cropping seasons. The experiment comprised seven rates of urea (46% N) fertilizer at 0, 50, 90, 130, 170, 210 and 250 kg/ha with three replications. Urea application significantly increased plant height, number of leaves and ear weight, ear length and ear diameter per plant. The use of 210 kg N/ha produced the best maize grain yield of 2.43 and 2.96 tonnes/hectare in 2003 and 2004, respectively.

Oktem (2008)conducted field experiments in Sanliurfa, Turkey, during 2003 and 2004, to study the effects of different nitrogen (N) fertilizer application rates (120, 160, 200, 240, 280, 320 and 360 kg/ha) on fresh ear yield and kernel protein content of sweet corn (*Zea mays* var. saccharata). N levels were significant for fresh ear yield and protein content of kernels. Increasing N applications increased the fresh ear yield and protein content of kernels. The N use efficiency increased up to 240 kg/ha rate (60.7 and 56.8%), but later decreased in both years. When the regression analysis, economic considerations, climate and environment pollution were evaluated together, optimum N rate was 280 kg/ha along with the soil N content for sweet corn cv. Jubilee grown in a semi-arid region.

The effect of N and S fertilizers on grain quality of 2 maize hybrids (Luyu16 and Nongda108) with different responses to S fertilizer was investigated. Application of N and S fertilizers increased the contents of protein, amino acid, soluble sugar, crude fat, oil as well as N, P, K, S and microelements (Fe, Cu, Zn, Mn, Mg, Ca and Na). The starch content was increased with N but decreased with S treatment. However, both treatments improved the amylopectin percentage in starch. S fertilizer improved the grain quality of maize very significantly when N was increased (Xie, R.Z. 2003).

Farghly (2001) conducted two field experiments at the Shandaweel Agricultural Research Station in Egypt during the 1998 and 1999 summer seasons in a split-plot design with four replications. The effects of the preceding winter crops (faba bean, sugarbeet and wheat) were investigated in the main plots, while the effect of different N rates were determined in the subplots. The N rates were 90, 105 and 120 kg N/fed for maize, and 45, 60 and 75 kg N/fed for sunflower. Highly significant differences due to the preceding winter crops were obtained in terms of plant growth characters and yield of maize and sunflower. The values were maximum after faba bean and minimum after wheat. The seed yield/fed of maize and sunflower grown after faba bean was 15.2 and 17.72%, respectively, higher than those grown after wheat. All the growth characters of maize and sunflower were increased by increasing N levels up to 120 kg N/fed for maize and 75 kg N/fed for sunflower. The increments in grain yield of maize as affected by adding 120 kg N/fed over 105 and 90 g N/fed were 7.2 and 14.5%, respectively. The seed yield of sunflower fertilized with 75 kg N/fed was 6.3 and 13.3%, respectively, higher than the yields obtained with 60 and 45 kg N/fed. The yields of maize and sunflower grown after faba bean and fertilized with 90 kg N/fed for maize and 45 kg N/fed for sunflower were similar to the yields obtained after wheat and fertilized with 120 kg N/fed for maize and 75 kg N/fed for sunflower.

Hassan (2002) conducted two field experiments in Nasser's Faculty of Agricultural Sciences in Yemen during two consecutive growing seasons of 1992/93 and 1993/94, to study the effect of organic manure or mineral nitrogen source on the growth and yield of maize (cv. Knega36). The experiment of organic manure contained 4 treatments: control, poultry manure, sheep manure and cattle manure, while the inorganic fertilizer experiment contained 3 treatments: control, $CO(NH_2)_2$ and $(NH_4)_2$ SO_4. Each experiment was performed in a complete randomized block design with 3 replicates. Results showed that the plant height was lower compared with untreated control, poultry and cattle manures in 1992/93 growing season. Similar results were obtained with sheep manure treatment compared with control in 1993/94 growing season. The effect of sheep manure on plant yield, weight of 1000 seeds and feddan yield was lowest for both seasons. Significantly positive results were obtained in the second experiment with the use of $(NH_4)_2$ SO_4 on the effect on plant length, ear height, number of ears/plant, plant dry weight, plant yield and feddan yield compared to urea treatment in both seasons.

Chun and Chen (2005) studied with an NC-II design experiment, 4 inbred maize lines were crossed with 3 inbred maize lines to form 12 cross combinations. The parent lines and their F1 offspring were grown in sand culture in a greenhouse and supplied with $Ca(NO_3)_2$. Under high N, all the root traits studied, with the exception of axial root length, showed a non-additive inheritance. Under low N stress, the root traits, with the exception of number of axial roots, showed an additive inheritance. At both N levels, root dry weight, total root length and lateral root length showed considerably high SCA. As compared with the high N treatment, the GCA of various root traits declined while the SCA of root dry weight, total root length and lateral root length increased in low N stress treatment.

Chun and Chen (2005) conducted a field experiment with four maize hybrids, 2 nitrogen (N)-efficient and 2 N-inefficient, were grown to investigate the relationship between root growth and N uptake as well as yield formation under 2 N levels (with or without N supply). The N-efficient hybrids (NE1 and ND108) took up more N than the N-inefficient hybrids. The difference in N uptake was mainly attributed to N accumulation in the plants after silking. NE1 and ND108 had greater root dry weight at both N levels. Under low N, 209 x 115, an N-inefficient hybrid, had similar root weight to ND108 despite its lowest N accumulation and yield. A close relationship was observed between post-silking root size and N uptake during the entire growth period. In the N-efficient hybrids, efficient N uptake before silking helps the build-up of a big root system, which, in turn, leads to a big N uptake after silking. As a result, N export from the leaves was reduced and a longer photosynthetic activity was maintained. It is concluded that root size is the dominant factor determining N accumulation, though the role of N uptake rate is not to be neglected.

Girma (2005) conducted a field experiment during the rainy season of 2003 to study the effects of nitrogen rates (0, 10, 20 and 30 kg/ha) and moisture conservation practices (flat bed, ridge furrow, flat bed + mulching and ridge furrow + mulching) on the soil, soil water, yield and yield components of maize (Zea mays) grown in a rift valley in central Ethiopia. Grain yield was affected by nitrogen fertilizer levels but 1000-grain weight, total biomass, straw yield, soil temperature, soil moisture content, and infiltration rate were not affected by the nitrogen rates. Significant effects in harvest index and water use efficiency of nitrogen rates were observed only at Dera and Melkassa, respectively. Moisture conservation practices improved grain and straw yields, harvest index, and total biomass compared to the use of flat beds due to the availability of moisture. Bulk density, infiltration rate, water use efficiency, and soil moisture content were also affected by moisture conservation practices. Mulching reduced soil temperature prior to maize maturity.

The soil water storage was 600 mm in the 0-200 cm soil profile of fallowing plots in the summer of 364 mm precipitation (including 82 mm of irrigation). It was 204 mm more than that before sowing, and 39 mm more than that of maize planting plots. As far as the moisture distribution in the soil profile over the whole growing season was concerned, it was found that the water from rain and irrigation was able to move down to the 260 cm depth under fallowing, and it only moved down to the layer at 180 cm depth under planting. When planting maize, nitrate N residue in the 0-200 cm soil was 78 kg/ha, being 89 kg/ha less than that under fallowing. Moreover, nitrate N in soil of the maize planting plots mainly remained in layers above 60 cm depth, and that in fallowing soil was leached down to 220 cm depth. Wang (2006).

Maize grain yield is closely associated with kernel number at maturity, and kernel number is affected by apical kernel abortion mainly occurring at early kernel filling stage. Improving apical kernel development and reducing apical kernel abortion can contribute to increment of kernels per ear. The objectives of this work were to evaluate the effect of nitrogen supply on early kernel development and grain yield in maize. In field condition, early development of apical kernel in summer maize hybrid Zhengdan 958 and its grain yield under different nitrogen supplies (0, 120, 180 and 240 kg/ha) and the activities of enzymes related to kernel development such as acid sucrose invertase (AI), neutral sucrose invertase (NI), sucrose synthase (SS), ADPGase and starch synthase were determined. The results showed that suitable nitrogen supply obviously increased the activities of enzymes above and promoted apical kernel development. At 5-20 days after pollination (DAP), higher activities of AI, NI, SS, ADPGase and starch synthase in apical kernel were obtained under nitrogen supply of 180 kg/ha, indicating the sucrose utilization and starch synthesis were improved. The fresh weight, size, dry weight, the contents of soluble sugar, nitrogen and starch in apical kernel in 5-20 DAP were higher under nitrogen supply of 180 kg/ha than under other nitrogen rates. With increasing supply of nitrogen ranging from 0 to 180 kg/ha, the kernel development were promoted and the kernel abortion were reduced which resulted in more kernels per ear and higher yield. Nitrogen deficiency or excessiveness affected apical kernel development, which resulted in higher kernel abortion and lower grain yield. (Shen *et al*. 2006).

Duan *et al*. (2007) conducted a field experiment in order to elucidate the effects of nitrogen on the growth and development in summer maize (Zea mays), the photosynthetic characteristics regulated by nitrogen application rates in summer maize was studied. The results indicated that the photosynthetic rate (Pn), cholorophyll content (Chl), soluble protein content (Pro), Hill reaction activity, Ca2+-ATPase activity, Mg2+-ATPase activity and PEPCase activity in lower leaf, ear leaf and upper leaf of summer maize cultivar (Ludan 50) all increased, with the increase of nitrogen application amount. While the growth progressed, the Pn and Pro in all tested leaves gradually decreased. The dynamic changes of Chl in leaves showed different patterns, with little changes at different assaying points in the lower leaf and a single peak curve in the ear leaf and upper leaf. There were different patterns on traits of Hill reaction activity, Ca2+-ATPase activity and Mg2+-ATPase activity, such as the pattern of gradual decrease, single peak curve and double peaks curve. The changes of PEPCase activities in the tested leaves all showed a curve with one peak while the growth progressed. With the increase of nitrogen application amount, leaf source capacity, biomass and yield all increased. The results indicated that all photosynthetic characteristics, including Pn, and its related physiological and biochemical parameters could be improved based on application of suitable nitrogen amount. The Ca2+-ATPase activity is one of the important factors that can affect the function of photoreaction system in maize. In the experiment, Pn was affected little by PEPCase and largely regulated by function of photosystem and dark reaction system in the photosynthetic organ during the early and mid-growth stage. Meanwhile, it is suggested that leaf source capacity could be used as a criteria to evaluate the productivity of single plant in maize.

Maize cultivars with improved grain yields under nitrogen (N) stress are desirable for sub-Saharan African maize growing environments. This study assesses N uptake, N utilization, and the genotype x environment (G x E) interaction of 16 tropical maize (Zea mays L.) hybrids differing in grain yield under low-N conditions. Hybrids were evaluated under low-N, medium-N, and high-N at Harare, Zimbabwe, in 2003 and 2004 and at Kiboko, Kenya, in 2003. At maturity, N accumulation in the aboveground biomass ranged from 47 to 278 kg N ha-1 in various experiments. Grain yields ranged from 1.5 to 4.3 Mg ha^{-1} and 10.6 to 14.9 Mg ha^{-1} for the same experiments, respectively. Significant G x E interactions were observed which became more pronounced as the difference in N stress intensity between two environments increased. High grain yield under low-N was consistently associated with higher postanthesis N uptake, increased grain production per unit N accumulated, and an improved N harvest index. Additive main effect and multiplicative interaction analysis identified hybrids with specific adaptation to either low-N or high-N environments. Several hybrids produced high yields under both low-N and high-N conditions. More detailed studies with these hybrids are required to examine the underlying physiological mechanisms contributing to the N-use efficiency. (Worku and Banziger, 2007).

Chaudhari *et al*. (2006) studied in Pune, Maharashtra, India, during the kharif of 1999. that the effects of farmyard manure (FYM), biological N fixer (BNF), urea, vermicompost and compost on the performance of maize (Deccan Double Hybrid-103) Treatment with 120 kg N ha^{-1} to maize, 1/4 of which was applied though different organic manures and 3/4 was applied through urea + BNF, significantly increased leaf area, dry matter production, and grain and dry fodder yields than the application of 40 and 80 kg N ha^{-1}, 1/4 of which was applied through different organic sources and 3/4 was applied through urea + BNF. N at 120 kg ha^{-1} applied through organic sources (1/4) and urea + BNF (3/4) was recommended for maize.

2.2 Effect of spacing

Chandankar *et al*. (2005) conducted a field experiment during the monsoon season of 2003 in Maharashtra, India to evaluate the effects of farmyard manure (FYM at 0 and 5 t/ha), N:P:K rates (90:45:22.5, 120:60:30 and 150:75:37.5 kg/ha), and plant density (83 333 and 111 111 plants/ha) on maize yield and economics. FYM increased plant height. The highest NPK rate showed 34.1% higher grain yield over the lowest rate. Low plant density produced taller plants, with broader and heavier ears.

Alvarez (2006) conducted a field experiment in Minas Gerais, Brazil during 2001-02. The effects of row spacing (0.7 and 0.9 m) and plant density (55 000 and 75 000 plants/ha) on the performance of maize hybrids AG1052, AG9010 and DKB440 were determined. Dry matter and grain yield increased with increasing sowing density and decreasing row spacing. The hybrid AG1051 recorded the highest dry matter yield and ear height regardless of row spacing and experimental year, whereas the hybrids AG9010 and DKB440 recorded the highest grain yield regardless of planting density and experimental year.

Sener (2004) conducted a two-year study at Mustafa Kemal University, Agricultural Faculty, Research Farm, Turkey to determine the optimum intra-row spacing for maize hybrids commercially grown in Eastern Mediterranean Region during 2000 and 2001 growing seasons. Maize hybrids react differently to various plant density and intra-row spacing. Main plots were maize hybrids of Dracma, Pioneer 3223, Pioneer 3335, Dekalb 711 and Dekalb 626. Split-plots were intra-row spacing of 10.0, 12.5, 15.0, 17.5 and 20.0 cm. Split-plot size was 2.8 by 5.0 m with four rows per plot. The effects of intra-row spacings on the grain yield and some agronomic characteristics were statistically significant. Hybrid × intra-row spacing interaction effects were significant only at ear length and grain yield. The highest grain yields were obtained from Pioneer 3223 and Dracma at 15.0 cm intra-row spacing (11 718 and 11 180 kg ha-1, respectively).

Jiotode (2002) conducted a field experiment with Maize cv. AMC-1 (Akola maize Composite-1) was tested for its growth responses and water use influenced by irrigation levels at 40, 60 or 80 mm CPE and irrigation as per the critical growth stages of the crop, and three row spacings of 30, 45 and 60 cm during the rabi seasons of 1996-97 in Akola, Maharashtra, India. Irrigation at 40 mm CPE recorded the highest values in terms of all the growth parameters as well as consumptive use, potential evapotranspiration, soil moisture depletion, absolute water use rate and relative water use rate. However, water use efficiency was highest in the case of irrigation as per the critical growth stages of the crop and at 60-cm row spacing. A row spacing of 60 cm recorded the highest number of leaves, leaf area, and dry matter per plant. Plant height and leaf area index were highest at the 30-cm row spacing.

2.3 Interaction effect of nitrogen and plant spacing

The alteration of spatial distribution of plants is an option to increase the grain yield. For high-yielding materials more information about the influence of N application is needed. Thus, the influence of row spacing, population density and N rate on the leaf N concentration, estimated concentration of chlorophyll, number of grains per ear, mass of thousand grains, grain yield, and protein content were evaluated. A study was carried out in Jaboticabal, Sao Paulo, Brazil, in 2000/01. The treatments comprised 2 row spacings (0.60 and 0.80 m), 3 population densities (40 000, 60 000 and 80 000 plants ha-1) and 4 N rates (0, 50, 100, and 150 kg N ha^{-1}). Increased N rates in top-dressing led to an increase in the leaf N and estimated chlorophyll concentration, number of grains per ear, mass of thousand grains, grain yield and protein content of grains. Higher grain yield was achieved with increasing top-dressed N rates in combination with a 0.80 m row spacing and a plant density of 80 000 plants ha^{-1}. (Amaral , 2009).

Oktem and Oktem (2008) conducted a field experiment in southeastern Turkey during 1998-99. The effects of N and intra-row spacing on the ear characteristics of sweetcorn cv. Merit were determined. The treatments comprised application of N at 150, 200, 250, 300 and 350 kg/ha and intra-row spacings/plant densities of 140 mm=102 040 plants/ha, 180 mm=79 370 plants/ha, 220 mm=64 930 plants/ha, 260 mm=54 940 plants/ha and 300 mm=47 620 plants/ha. Increasing nitrogen applications increased ear length, ear diameter, kernel number per ear and single fresh ear weight. At a wider plant spacing, the values for all yield characteristics were high.

Muhammad *et al.* (2003). conducted a field experimentin Faisalabad, Pakistan, during the autumn season of 1997 and 1998 to study the growth of hybrid maize under different planting techniques and nutrient levels. The planting methods consisted of 70 cm spaced single rows, 105 cm spaced double-row strips and 70 cm spaced ridges. The nutrient levels were 250 kg N, 250 kg N + 150 kg P, 250 kg N + 150 kg P + 100 kg K, 250 kg N + 150 kg P + 100 kg K + 15 kg S, 250 kg N + 150 kg P + 100 kg K + 15 kg Mg and 250 kg N + 150 kg P + 100 kg K + 15 kg S + 15 kg Mg ha^{-}1. Among the planting techniques, sowing on ridges resulted in the highest leaf area index (LAI, 5.22), dry matter (DM, 1478.62 g m^{-2}), crop growth rate (CGR, 31.12 g m^{-2} day^{-1}) and net assimilation rate (NAR, 8.09 g m^{-2} day^{-1}). The application of 15 kg S along with N and P at 250 and 150 kg ha^{-}1, respectively, resulted in higher LAI, DM, CGR and NAR than NP alone. The application of S and/or Mg with NPK at 250^{-}150-100 kg ha^{-1} gave higher LAI, DM, CGR or NAR than NPK alone; however, the differences were not statistically significant.

Ma *et al*. (2003) conducted field experiments to evaluate maize response to row spacing and N fertility over a 4-year period (1997-2000) on loam or clay loam soils at Ottawa, Ontario, Canada. Row spacings of 0.51, 0.76 and 0.76 m paired row, alone or in combination with hybrid, were tested in the subplot whereas combination of fertilizer N by population density (1997 and 1998) or N alone was assigned to the main plot. In 1997 and 1998, combinations of N by density consisted of 0, 60, 120, 180 and 240 kg ha-1 at 89 000 plants ha-1, and 60 and 180 kg N ha^{-1} at 69 000 plants ha-1 using a single hybrid, Pioneer 3893. In 1999 and 2000, N levels of 0, 80 and 180 kg ha-1 were the main plots and 6 combinations of hybrids (Pioneer 3893 and Pioneer 38P06 Bt) by row spacing were grown in the subplots at 69 000 plants ha^{-1}. Row spacing and fertilizer levels showed no significant interaction for any parameter at any developmental stage. In both 1997 and 1998, row spacing had no significant effect on yield (yield differed by 5% among row spacing treatments) or harvest index (varied from 0.45 to 0.53). For Pioneer 38P06 Bt in 1999, grain yield of the 0.51 m row spacing with the 80 kg N ha^{-1} was 14.6% higher than the conventional 0.76 m row spacing. In 2000, the substantially lower (11%) yield of the 0.76 m paired row spacing than the other row spacing treatments was more likely the result of an exceptionally cool and wet season. In 1997 and 1998, plant density showed no effect on shoot or root dry matter (DM). The lower density (69 000 plants ha^{-1}), however, showed a higher root-to-shoot ratio than the higher density. Shoot DM, root DM and root-to-shoot ratio did not differ between the 60 and 180 kg N ha^{-1} treatments. While higher N levels increased above- and below-ground crop N contents, row spacing showed no consistent effects on maize plants at the early stages.

Balwinder and Walia (2003) conducted a field experiment in Ludhiana, Punjab, India during the kharif season of 2000-01. The effects of N (125, 150 ad 175 kg/ha), plant density (75 000 and 90 000 kg/ha) and atrazine (0.75 or 1 kg/ha) application on the ability of maize to compete with weeds were determined. Weed dry matter accumulation was not significantly affected by the N rates, although it was lower with the application of 0.75 kg atrazine/ha + straw mulching 30 days after sowing and during harvesting in 2001. Plant population of 90 000/ha resulted in lower dry matter accumulation of the weeds. Leaf area index, cob length and grain yield of the crop increased with increasing rates of N. Atrazine at 0.75 kg/ha + mulching resulted in the highest values of the parameters measured except for grain yield in 2000 which was highest with the application of 1 kg atrazine/ha. Plant population of 90 000/ha resulted in higher leaf area index but lower grain yield compared to a plant population of 75 000.

Ogbaji (2003) conducted field experiments during the 1997 and 1998 cropping seasons to study the effect of 3 levels of N fertilizer (0, 45 and 90 kgN/ha) and 3 levels of intra-row spacing (30, 40 and 50 cm) on the growth and yield of a local white maize cultivar in Makurdi, Nigeria. The growth parameters measured were the number of leaves per plant, plant height and grain yield. N fertilizer application and spacing influenced maize growth at various weeks after planting. At 10 weeks after planting (10 WAP) in 1997, a combination of 90 kg N/ha and intra-row spacing of 50 cm gave a significantly higher mean number of leaves per plant (17.63) and plant height (270.21 cm) than the control. At the same period in 1998, similar results were obtained (25.01 and 289.45 cm, respectively). Significant differences in grain yield also existed between different N levels and spacing regimes. Higher mean grain yields of 1734.87 kg/ha and 2041.23 kg/ha were obtained in 1997 and 1998, respectively, in the treatment combination of 90 kg N/ha and intra-row spacing of 50 cm. It is recommended that farmers in the Makurdi environment adopt the application of 90 kg N/ha and an intra-row spacing of 50 cm when using the local white maize cultivar, which is very popular in the study area.

El-Sheikh (2010) conducted two field experiments in Moshtohor, Egypt, during 2009 and 2010 to investigate the performance of 3 maize hybrids, i.e. Single cross 10 (S.C. 10), Double cross Taba (D.C. Taba) and Three-way cross 310 (T.W.C. 310), and one open pollinated cultivar, namely Giza-2, under 3 population densities, i.e. 18 000 (D_1), 24 000 (D_2) and 30 000 (D_3) plants/fed, and 3 N levels, i.e. 0 (N1), 60 (N2) and 120 kg/fed (N2), regarding growth, grain yield and its components, as well as N use efficiency (NUE). The soil was clay of pH 8.01, 2.2% organic matter content and 38 micro g/g NO_3--N. D_1 showed the highest values for ear leaf area, grain yield and yield components, whereas D_2 gave the highest values for plant height, ear height and number of dry leaves per plant. For D.C. Taba and T.W.C. 310, NUE increased with increasing plant density; but for S.C. 10 the reverse was true. Differences between D_1

and D_2 were noticed in grain yield/fed and some traits not statistically significant. N_3 increased plant growth, grain yield and yield components more than N_2. A higher NUE was observed under D_1 and N_3, but under D_3 the reverse was true; under D_2 both rates were similar. The 3 hybrids produced the highest values of NUE at N_2. The difference between N_2 Na N_3 in some traits was insignificant. S.C. 10 gave the highest number of leaves per plant (green and total), ear leaf area, yield components and grain yield/fed, whereas Giza 2 gave the lowest. The 3 hybrids showed higher efficiency in assimilating N compared with Giza 2 at N_2 and N_3. Ear leaf area, grain yield and some of the yield components were significantly increased under D1 and D_2 and supply of N_3 or with S.C. 10. S.C. 10 supplied with N_3 at D1 is recommended for maize production and NUE.

Zhao and Yang (2006) conducted a field trial with maize cv. Yayu No. 8 in the Teaching Farm of Sichuan Agricultural University in China. A split plot design was involved, with the factor A in main plot (planting density) at 3 levels (67500, 97500 and 127 500 plants/ha) and the factor B in sub-plot (N rate) at 5 levels (0, 112.5, 225.0, 337.5 and 452 kg/ha). The effects were investigated of different planting densities and different N application rates on the dynamic changes of dry and fresh matter yields and on the kernel yield. When the planting density and the N rate were 97500 plants/ha and 337.5 kg/ha, respectively (optimum levels), the fresh matter yield, dry matter yield and dry ear yield reached 71032, 22820 and 11548 kg/ha, respectively. The results of regression model prediction of planting density and N rate with biomass indicated that the highest theoretical yield of fresh matter (70799 kg/ha) was obtained at 106 800 plants/ha and 273.48 kg N/ha. The highest theoretical yield of dry matter (22936 kg/ha) was obtained at 111 300 plants/ha and 280.52 kg N/ha. Effects of planting density and N rate on the biomass and ear yield of Yayu No. 8 all reached an extremely significant level.

Pena (2006) evaluated the effect of planting date, nitrogen rates and plant density on the forage yield and quality of two early maize hybrids, at Pabellon, Aguascalientes, Mexico. Management practices in maize (Zea mays) are important considerations for obtaining high yield production and good forage quality. The maize hybrids 'Halcon' and 'H-322E' were evaluated at two planting dates (6 May and 17 June 2003), three plant densities (60 000, 80 000 and 100 000 plants/ha) and two nitrogen rates (180 and 240 kg ha-). At 1/3 milk line stage, we measured the total dry matter (TDM), neutral detergent fibre (NDF), acid detergent fibre (ADF), and in vitro digestibility (IVD), and milk production per tonne of dry matter (MT) and milk per hectare (MHA) were estimated. At the later planting date, TDM, NDF and ADF were 2.4 t ha^{-1}, 25 g kg^{-1} and 24 g kg^{-1}, respectively, and significantly higher than those obtained at the earlier planting date; however, DIV, MT and MPH were similar at both planting dates. Nitrogen rate had no effect on forage yield and quality. As plant density increased from 60 000 to 100 000 plants/ha, TDM increased 4.5 t ha^{-1} and MHA 1.9 t ha^{-1}, whereas IVD decreased 1.6%. H-322E yielded 2.4 t ha^{-1} more TDM than 'Halcon'; however, 'Halcon' had higher forage quality with higher DIV and MT, and lower NDF and ADF contents. The MHA of both hybrids was similar with a mean of 14.4 t ha^{-1} Thus, with any of the two hybrids and any of the two planting dates, at a population density of 100 000 plants/ha and fertilized with 180 kg ha^{-1} of nitrogen, it would produce high yield of milk per hectare at the Aguascalientes Valley.

Badr and Othman (2006) conducted two field experiments in Gharbia Governorate, Egypt, in 2003 and 2004 to investigate the effects of 3 planting densities (16 000, 20 000 and 24 000 plants/feddan), 3 organic manure (OM) and biofertilizer Microbin (B) treatments (0, OM and B), and 4 N levels (0, 60, 80 and 100 kg/feddan) on the growth, yield and yield components of maize, as well as soil fertility status at harvest. Plant and ear heights were increased significantly by increasing plant density in both seasons, whereas area of topmost ear leaf was decreased significantly by increasing plant density in both seasons. Number of grains per row and 100-grain weight decreased significantly due to increasing plant density in the 2 seasons. Grain yield was increased significantly in the first season, while the differences were not significant in the second season as the plant density increased. All the growth characters were increased significantly by adding OM or treating the seeds with the B. Grain yield and its components followed the same trend. The increasing N level significantly increased the growth, yield and yield components. The increases in grain yield were 80.41, 122.62 and 156.08% with N levels of 60, 80 and 100 kg/feddan compared with the control in the first season and 32.43, 49.19 and 56.77% in the second season, respectively. Grain yield was affected significantly due to the interaction of plant densities and N levels in 2003. In 2003 and 2004, OM and B interacted with N to alter the grain yield. The treatments of 24 000 plants/feddan+B+60 kg N/feddan resulted in the highest value of N use efficiency (NUE). The highest value of grain N uptake was due to the combination of 16 000 plants/feddan+B+100 kg N/feddan. The combination of 16 000 plants/feddan+B+100 kg N/feddan proved the best in terms of soil fertility. NUE increased as plant density increased. Addition of organic fertilizer or treating the seeds with B seemed to increase NUE. Increasing N level resulted in reduced NUE values. Increasing the plant density slightly decreased the grain N uptake, while addition of organic fertilizer or treating the seeds with B enhanced this character. The grain N uptake gradually increased due to increasing N up to 100 kg/feddan.

The values of residual soil N decreased as plant density increased, while an opposite trend was observed under addition of organic fertilizer or treating the seeds with B. Increasing N level resulted in gradual increases in this character.

From the above discussed review of literature , it may be concluded that nitrogen and plant spacing is very much promising for higher maize yield. Nitrogen and plant spacing is very much crucial factor for growing maize.

CHAPTER 3

MATERIALS AND METHODS

The experiment was undertaken in April 10 to July 2010in the Agronomy field laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to determine 'Performance of maize as influenced by different levels of nitrogen and spacings'.

3.1 Experimental site

The present experiment was conducted in the Agronomy farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.2 m from sea level.

3.2 Climate

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). The present experiment was conducted in kharij season. Hot temperature and medium to heavy rainfall moist weather is the main feature of the kharif season. The monthly total rainfall, average sunshine hour, temperature during the study period (April to July) collected from the Bangladesh Meteorological Department, Agargoan, Dhaka are presented in Appendix I.

3.3 Characteristics of Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. It had shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix II.

3.4 Materials

3.4.1 Seed

A hybrid variety of maize named ‘BARI hybrid bhutta-7’ developed by Bangladesh Agricultural Research Institute (BARI); Joydebpur, Gazipur was used in the experiment as a plant material.

3.4.2 Fertilizers

The recommended dose of TSP and MoP was 120 and 100 kg/ha, respectively. But under the present experiment Urea (as nitrogen) was applied as per treatment. One-half of urea and total amount of all other fertilizers of each plot were applied and incorporated into soil. Rest of the urea was top dressed after 30 days of sowing (DAS).

3.5 Methods

3.5.1 Treatments

Two factors were used as combination for 12 treatments. Four levels of nitrogen and three levels of plant spacing were used for the combination of twelve (12) treatments of the present experiment.

Factor A: Levels of nitrogen

Treatments : 4

(i) N_1 = 180 kg N/ha
(ii) N_2 = 220 kg N/ha
(iii) N_3 = 260 kg N/ha
(iv) N_4 = 275 kg N/ha

Factor B: Plant spacing

Treatments : 3

(i) S_1 = 60 cm × 25 cm
(ii) S_2 = 75 cm × 25 cm
(iii) S_3 = 90 cm × 25 cm

3.5.2 Land preparation

The experimental plot was irrigated to remove its hard dryness before ploughing. Then it was first opened with tractor drawn disc plough after having ‘joe’ condition. Ploughed soil was then brought into desirable tilth by 4 operations of ploughing, harrowing and laddering. Stubble and weeds were removed. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers were incorporated thoroughly.

3.5.3 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. The number of total plot was 12 × 3 = 36. The unit plot size was 3.4 m × 2.75 m. The replications were separated from one another by 1m. The distance between plots was 0.5 m.

3.5.4 Sowing of seeds

Sowing was done on 10 April 2010 in rows maintaining plant spacing as per treatment. Seeds were sown continuously in rows. After sowing, the seeds were covered with soil and slightly pressed by hand.

3.5.5 Thinning and weeding

The optimum plant population was maintained by thinning excess plant. Seeds were germinated 6 days after sowing (DAS). First and second thinning was done at 15 and 30 DAS, respectively to maintain plant to plant distance properly.

3.5.6 Weeding

Weeding was done twice; first weeding was done at 20 DAS and second weeding was done at 45 DAS.

3.5.7 Irrigation

Three irrigations were given as plants required. First irrigation was given immediately after topdressing and second and third irrigations were applied at 45 and 65 DAS. After irrigation when the plots were in joe condition, spading was done uniformly and carefully to conserve the soil moisture.

3.6 Crop sampling and data collection

Ten sample plants were randomly selected in each plot and marked with tag for recording plant characters. Data on plant height, number of leaves/plnt, dry weight, 1000- seed weight, yield etc. were recorded at different growth duration.

3.7 Harvesting and threshing

Crops were harvested when 90% of the cob became golden in color. The matured crop was harvested and the harvested crops were carried to the threshing floor. The crop was sun dried by spreading on the threshing floor. Seeds were then separated from the plants.

3.8 Drying and weighing

Seeds and stovers thus collected were dried in the sun for a couple of days. Dried seeds and stovers of each plot was weighed and subsequently converted into kg/ha weight.

3.9 Data collection

At harvesting, 5 plants were selected randomly from each plot to record the following data.

i. Plant height (cm)
ii. Number of leaves/plant
iii. Leaf area
iv. Dry weight/plant
v. Cob length
vi. Number of grains/cob
vii. Weight of grains/cob
viii. 1000-grain weight (g)
ix. Grain yield (kg ha^{-1})
x. Stover yield (kg ha^{-1})
xi. Harvest index (%)

3.10 Procedure of recording data

3.10.1 Plant height (cm)

Height of 5 plants were measured from ground level (stem base) to the tip of the plant. Mean plant height was calculated and expressed in cm.

3.10.2 Number of leaves/plant

Number of leaves of 5 randomly selected plants were counted and recorded. Average value of 5 plants was recorded as number of leaves/plant.

3.10.3 Leaf area

Leaf area was measured from leaf length and leaf breadth from 5 selected plants and then averaged as leaf area/plant in cm^2.

3.10.4 Dry weight plant^{-1}

Randomly selected 5 plants from each plot were oven dried and weighed. The average value were recorded in g plant^{-1}.

3.10.5 Cob length

Total number of cobs were collected from 5 randomly selected plants and length was taken with measuring tape and then averaged to express in cm.

3.10.6 Weight of 1000-seeds

A composite sample was taken from the yield of 5 plants. The 1000-seeds of each plot were counted and weighed with a digital electric balance. The 1000-seed weight was recorded in gram.

3.10.7 Grain yield (t/ha)

After threshing, cleaning and drying, total grain from harvested area (6 $m^{2)}$ were recorded and was converted to t/ha.

3.10.8 Stover yield (t/ha)

After separation of seeds from plant, the straw and shell harvested (6 m^2 area) was sun dried and the weight was recorded and then converted into t/ha.

3.10.9 Harvest index (%)

Harvest index was calculated by dividing the economic (seed) yield from the net plot by the total biological yield (seed + stover) from the same area and multiplying by 100.

$$\text{Harvest index (\%)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100.$$

3.11 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference between the results of nitrogen and plant spacing on growth, yield and yield contributing characters of maize. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

The experimental results regarding the Performance of maize as influenced by different level of nitrogen under different spacing on the growth, yield and yield components of maize have been presented and discussed in this chapter. The effects of nitrogen and plant spacing and their interaction on growth, yield and yield contributing characters have been shown below.

4.1 Growth parameters

4.1.1 Plant height

4.1.1.1 Effect of nitrogen

Plant height is an important growth parameters considering it's productivity performance. Under the present study, plant height was significantly influenced by different nitrogen level of application at different days after sowing (DAS) (Fig 1 and Appendix III). Results showed that the N_4 (275 kg/ha) was evident for highest plant height at all growth stages. The tallest plant at 30, 60 DAS and at harvest were 83.10, 152.10 and 207.20 cm respectively obtained with N_4 (275 kg/ha). The competition in accordance with plant height among the nitrogen treatments the smallest plant was demonstrated with N_1 (180 kg/ha) and the lowest plant height at 15, 30, 45 DAS and at harvest were 77.99, 144.90 and 195.50 cm respectively. The results obtained from N_2 (220 kg/ha) and N_3 (260 kg/ha) showed intermediate results compared to highest and lowest results. Similar findings were observed by Tank (2006) and Ahmad K. (2005).

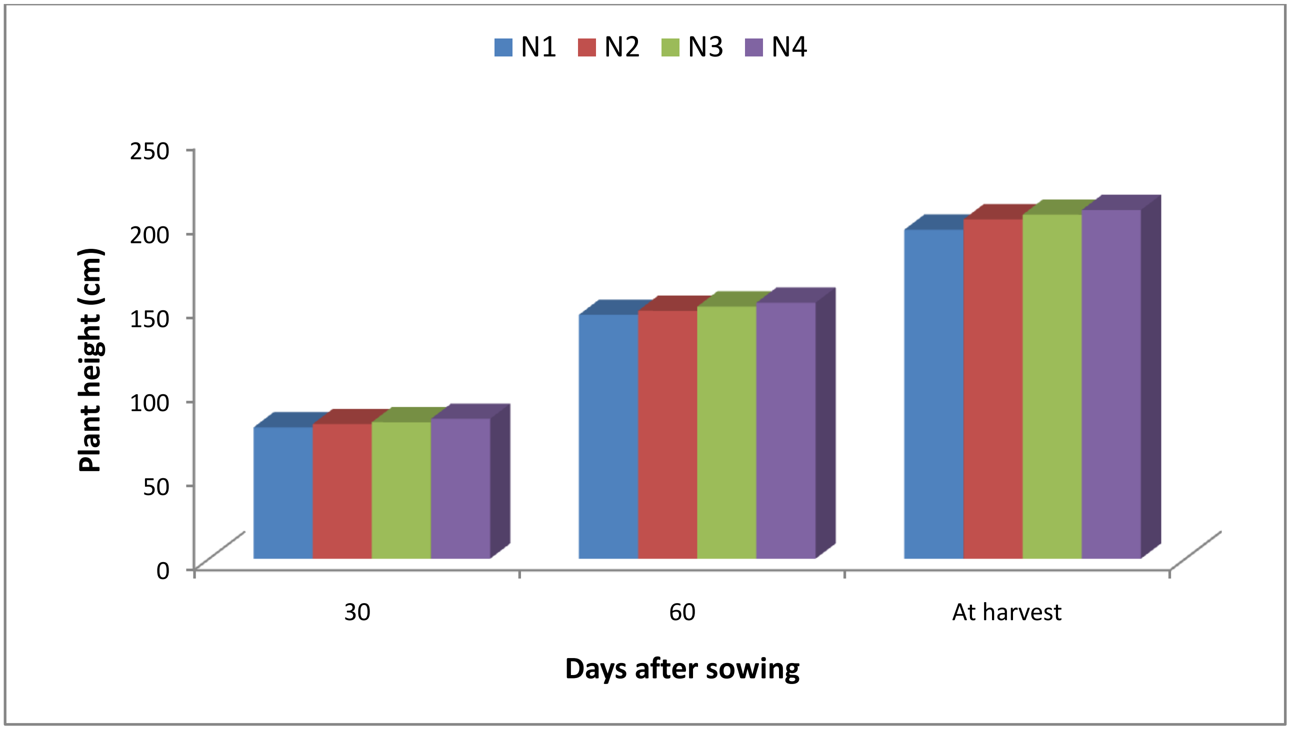

Fig 1: Performance of plant height of maize as influenced by different levels of Nitrogen (SE at 30, 60 and at harvest = 0.0101, 0.0252 and 0.0346 , respectively).

N_1 = 180 kg N/ha
N_2 = 220 kg N/ha
N_3 = 260 kg N/ha
N_4 = 275 kg N/ha

4.1.1.2 Effect of spacing

Considerable variation was occurred for plant height among the spacing treatments under the present study (Fig 2 and Appendix III). Data represent in Table 1 showed the highest plant spacing was evident for lower plant height where lower plant spacing showed higher plant height. The highest plant height at 30, 60 DAS and at harvest were 87.76, 156.80 and 215.70 cm respectively with S_1 (60 cm × 25 cm) where the lowest were 73.78, 140.00 and 187.70 cm respectively with S_3 (90 cm × 25 cm). The spacing treatment, S_2 (75 cm × 25 cm) showed intermediate results at all growth stages. Similar result was also achieved by Chandankar *et al.* (2005).

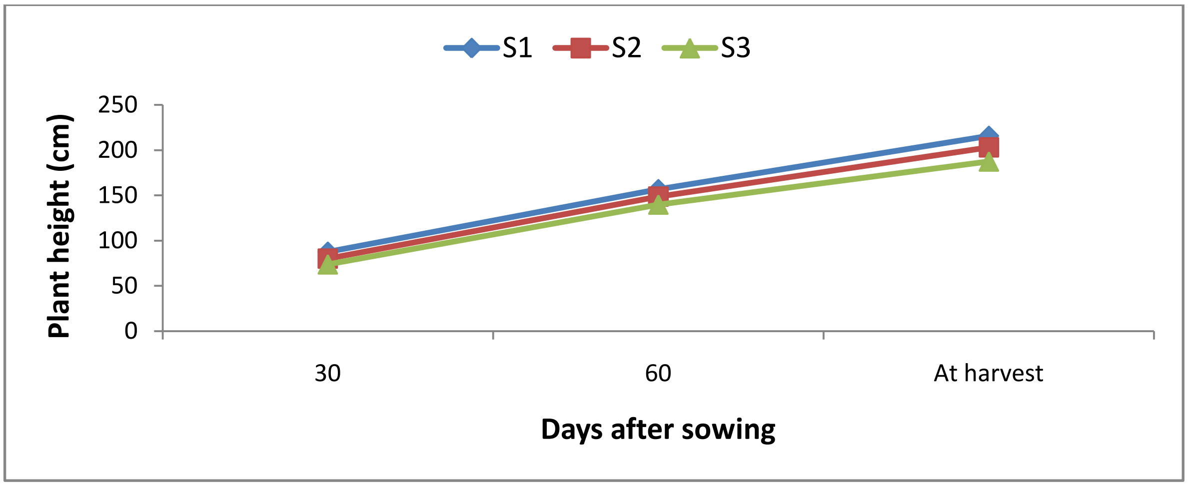

Fig 2: Performance of plant height of maize as influenced by different spacings
(SE at 30, 60 and at harvest 0.0094, 0.0241 and 0.0334, respectively.)

S_1 = 60 cm × 25 cm

S_2 = 75 cm × 25 cm

S_3 = 90 cm × 25 cm

4.1.1.3 Interaction effect of nitrogen and spacing

Plant height was significantly influenced by the combination of different levels of nitrogen and spacing at different growth stages of maize (Table 1). Nitrogen at the rate of 275 kg/ha (N_4) along with S_1 (60 cm × 25 cm) gave the tallest plant; 90.36, 160.30 and 220.20 cm at 30, 60 DAS and at harvest respectively which was statistically similar with N_3S_1 (217.30 cm) at harvest. The treatment combination N_1S_3 gave the lowest plant height at 30, 60 DAS and at harvest (72.04, 135.40 and 175.20 cm respectively). The result finding under the present study was in conformity with Ogbaji (2003).

Table 1: Performance on plant height of maize as influenced by interaction of Nitrogen and spacing

Interaction (N × S)	Plant height (cm)		
	30 DAS	60 DAS	At harvest
$N_1 \times S_1$	85.54 c	154.20 bc	211.20 c
$N_1 \times S_2$	76.39 g	145.30 fg	200.20 f
$N_1 \times S_3$	72.04 i	135.40 j	175.20 i
$N_2 \times S_1$	87.01 bc	155.60 b	214.20 b
$N_2 \times S_2$	79.24 f	147.90 ef	202.30 ef
$N_2 \times S_3$	73.64 hi	138.50 i	188.20 h
$N_3 \times S_1$	88.11 b	157.20 b	217.30 a
$N_3 \times S_2$	80.98 e	150.20 de	203.60 de
$N_3 \times S_3$	74.14 h	142.00 h	192.30 g
$N_4 \times S_1$	90.36 a	160.30 a	220.20 a
$N_4 \times S_2$	83.67 d	151.60 cd	206.20 d
$N_4 \times S_3$	75.29 gh	144.40 gh	195.20 g
SE	0.0188	0.0482	0.0668
CV(%)	8.54	7.68	8.87

Figures in a coloumn having the same letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT.

N_1 = 180 kg N/ha
N_2 = 220 kg N/ha
N_3 = 260 kg N/ha
N_4 = 275 kg N/ha

S_1 = 60 cm × 25 cm
S_2 = 75 cm × 25 cm
S_3 = 90 cm × 25 cm

4.1.2 Leaves/plant

4.1.2.1 Effect of nitrogen

Under the present study, number of leaves/plant was significantly influenced by different nitrogen level of application at different days after sowing (DAS) (Figure 3 and Appendix IV). Results showed that the N_4 (275 kg/ha) was evident for highest number of leaves/plant at all growth stages. The highest number of leaves/plant at 30, 60 DAS and at harvest were 6.74, 12.32 and 17.03 respectively obtained with N_4 (275 kg/ha). The lowest number of leaves/plant viewed with N_1 (180 kg/ha) and that were 5.70, 11.07 and 15.88 at 15, 30, 45 DAS and at harvest respectively. The results obtained from N_2 (220 kg/ha) and N_3 (260 kg/ha) showed intermediate results compared to highest and lowest results. Another finding by Agba and Ogar (2005) was in conformity with the present study.

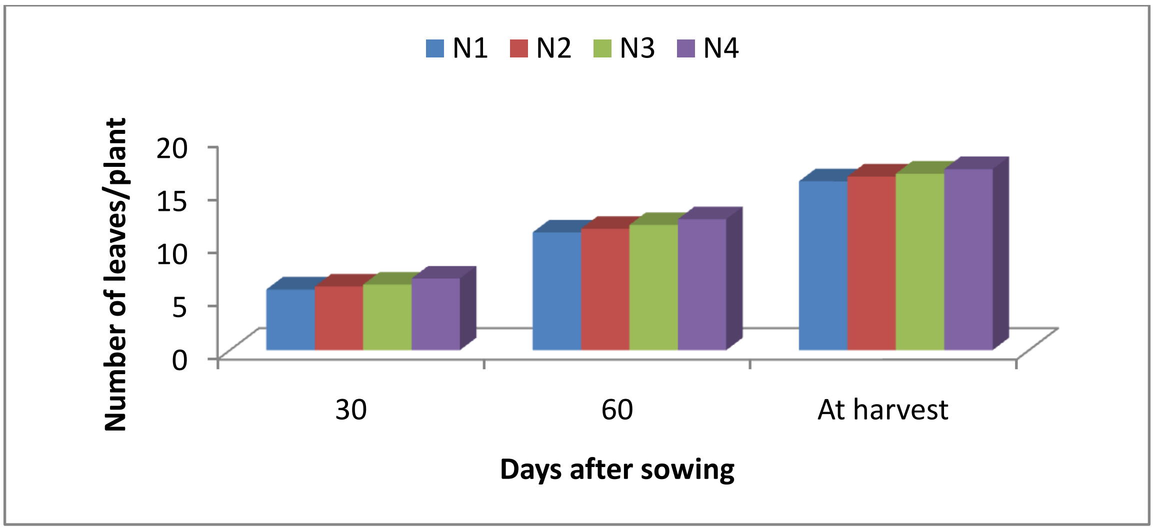

Fig 3: Performance of leaves/plant of maize as influenced by different levels of nitrogen (SE at 30, 60 and at harvest is 0.0174, 0.0247 and 0.0174 , respectively.)

N_1 = 180 kg N/ha
N_2 = 220 kg N/ha
N_3 = 260 kg N/ha
N_4 = 275 kg N/ha

4.1.2.2 Effect of spacing

Significant variation was observed in terms of number of leaves/plant among the spacing treatments under the present study (Fig 4 and Appendix IV). The higher number of leaves/plant was achieved with higher plant spacing where lower plant spacing showed lower number of leaves/plant. The highest number of leaves/plant at 30, 60 DAS and at harvest were 7.32, 13.30 and 17.79 respectively with S_3 (90 cm × 25 cm) where the lowest were 4.94, 9.66 and 14.91 respectively was with S_1 (60 cm × 25 cm). The spacing treatment, S_2 (75 cm × 25 cm) showed intermediate results at all growth stages. The result finding under the present study was in conformity with Jiotode (2002).

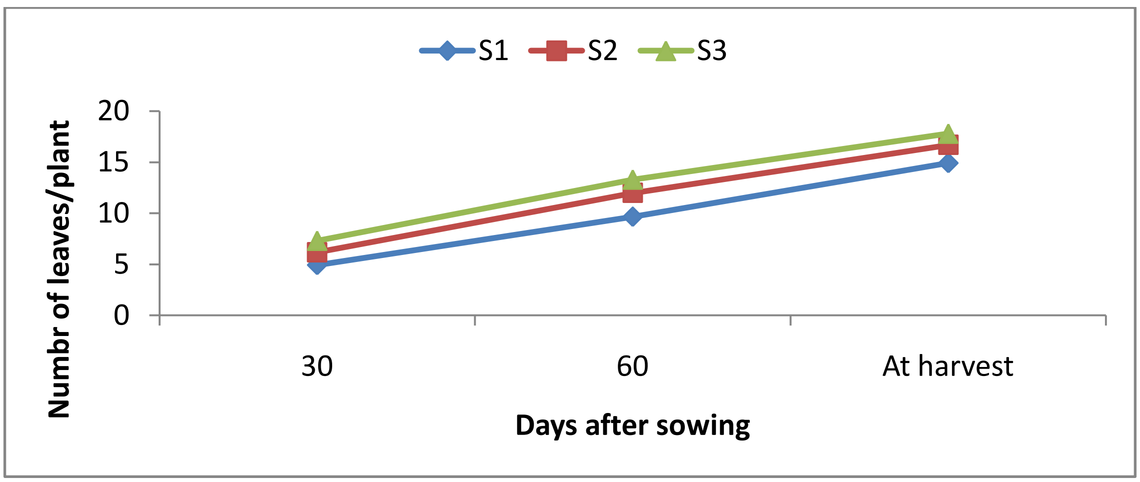

Fig 4: Performance of leaves/plant of maize as influenced by different plant spacings
(SE at 30, 45 and at harvest is 0.061, 0.0241 and 0.0163, respectively.)

S_1 = 60 cm × 25 cm

S_2 = 75 cm × 25 cm

S_3 = 90 cm × 25 cm

4.1.2.3 Interaction effect of nitrogen and spacing

Number of leaves/plant was also significantly influenced by the combination of different levels of nitrogen and spacing at different growth stages of maize (Table 2 and Appendix IV). Nitrogen at the rate of 275 kg/ha (N_4) along with S_3 (90 cm × 25 cm); N_4S_3 gave the highest number of leaves/plant; 8.14, 14.14 and 18.66 at 30, 60 DAS and at harvest respectively. The treatment combination N_1S_1 gave the lowest number of leaves/plant at 30, 60 DAS and at harvest (4.34, 9.04, and 14.41 respectively). The result finding under the present study was conformity with Ogbaji (2003).

Table 2: Performance on leaves/plant of maize as influenced by interaction of nitrogen and spacing

Treatment	Leaves/plant		
	30 DAS	60 DAS	At harvest
$N_1 \times S_1$	4.34 h	9.04 g	14.41 h
$N_1 \times S_2$	5.85 e	11.29 e	16.11 e
$N_1 \times S_3$	6.91 bc	12.89 bc	17.11 d
$N_2 \times S_1$	4.89 g	9.32 g	14.80 g
$N_2 \times S_2$	6.01 de	11.94 d	16.71 d
$N_2 \times S_3$	7.04 b	13.00 b	17.49 c
$N_3 \times S_1$	5.16 fg	10.01 f	15.00 g
$N_3 \times S_2$	6.14 d	12.14 d	16.91 d
$N_3 \times S_3$	7.19 b	13.19 b	17.91 b
$N_4 \times S_1$	5.39 f	10.26 f	15.44 f
$N_4 \times S_2$	6.69 c	12.56 c	17.00 d
$N_4 \times S_3$	8.14 a	14.14 a	18.66 a
SE	0.032	0.0482	0.0326
CV(%)	5.28	7.34	6.88

Figures in a coloumn having the same letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT.

N_1 = 180 kg N/ha
N_2 = 220 kg N/ha
N_3 = 260 kg N/ha
N_4 = 275 kg N/ha

S_1 = 60 cm × 25 cm
S_2 = 75 cm × 25 cm
S_3 = 90 cm × 25 cm

4.1.3 Leaf area/plant

4.1.3.1 Effect of nitrogen

Leaf area/plant was significantly influenced by different nitrogen level of application at different days after sowing (DAS) (Table 3 and Appendix V). Results showed that N_4 (275 kg/ha) was evident for highest leaf area/plant at all growth stages. The highest leaf area/plant at 30, 60 DAS and at harvest were 233.20, 583.90 and 688.20 cm^2 respectively which was obtained with N_4 (275 kg/ha). The lowest leaf area/plant viewed with N_1 (180 kg/ha) and that were 223.40, 564.70 and 660.10 cm^2 at 15, 30, 45 DAS and at harvest respectively. The results obtained from N_2 (220 kg/ha) and N_3 (260 kg/ha) showed intermediate results compared to highest and lowest results.

4.1.3.2 Effect of spacing

Significant variation was observed in case of leaf area/plant among the spacing treatments under the present study (Table 3 and Appendix V). Data represent in Table 3 showed that higher leaf area/plant was achieved with higher plant spacing where lower plant spacing showed lower leaf area/plant. The highest leaf area/plant at 30, 60 DAS and at harvest were 243.50, 597.80 and 709.20 cm^2 respectively with S_3 (90 cm × 25 cm) where the lowest were 211.50, 551.10 and 637.40 cm^2 respectively which was with S_1 (60 cm × 25 cm). The spacing treatment, S_2 (75 cm × 25 cm) showed intermediate results at all growth stages. The result finding under the present study was in conformity with Jiotode (2002).

4.1.3.3 Interaction effect of nitrogen and spacing

Leaf area/plant was significantly influenced by the combined effect of nitrogen and spacing at different growth stages of maize (Table 3 and Appendix V). The treatment combination, N_4S_3 gave the highest leaf area/plant; 248.40, 608.00 and 720.20 cm^2 at 30, 60 DAS and at harvest respectively which was significantly different from all other treatments. The treatment combination N_1S_1 gave the lowest leaf area/plant at 30, 60 DAS and at harvest (208.40, 540.00 and 618.50 cm^2 respectively).

Table 3: Performance of leaf area of maize as influenced by interaction of nitrogen and spacing

Treatment	Leaf area/plant (cm^2)		
	30 DAS	60 DAS	At harvest
Effect of nitrogen			
N_1	223.40 d	564.7 d	660.10 d
N_2	227.2 0 c	572.1 c	668.60 c
N_3	229.40 b	577.8 b	680.20 b
N_4	233.20 a	583.9 a	688.20 a
SE	0.0158	0.0338	0.045
Effect of spacing			
S_1	211.50 c	551.1 c	637.40 c
S_2	229.80 b	574.9 b	676.20 b
S_3	243.50 a	597.8 a	709.20 a
SE	0.014	0.032	0.041
Interaction effect of nitrogen and spacing			
$N_1 \times S_1$	208.40 h	540.00 l	618.50 k
$N_1 \times S_2$	222.40 f	565.30 h	661.60 g
$N_1 \times S_3$	239.20 c	588.70 d	700.30 c
$N_2 \times S_1$	210.10 h	549.80 k	632.10 j
$N_2 \times S_2$	229.10 e	572.10 g	669.40 f
$N_2 \times S_3$	242.40 bc	594.40 c	704.20 c
$N_3 \times S_1$	211.60 h	554.30 j	645.40 i
$N_3 \times S_2$	232.5 de	578.90 f	682.80 e
$N_3 \times S_3$	244.10 b	600.20 b	712.30 b
$N_4 \times S_1$	216.20 g	560.30 i	653.60 h
$N_4 \times S_2$	235.10 d	583.40 e	690.90 d
$N_4 \times S_3$	248.40 a	608.00 a	720.20 a
SE	0.0286	0.064	0.082
CV(%)	8.62	7.48	9.34

Figures in a coloumn having the same letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT.

N_1 = 180 kg N/ha
N_2 = 220 kg N/ha
N_3 = 260 kg N/ha
N_4 = 275 kg N/ha

S_1 = 60 cm × 25 cm
S_2 = 75 cm × 25 cm
S_3 = 90 cm × 25 cm

4.1.4 Dry weight/plant

4.1.3.1 Effect of nitrogen

Significant influence was measured for dry weight/plant with different nitrogen level at different days after sowing (DAS) (Figure 5 and Appendix VI). Results revealed that N_4 (275 kg/ha) produced the highest dry weight/plant at all growth stages. The highest dry weight/plant at 30, 60 DAS and at harvest were 43.81, 238.70 and 282.90 g respectively which was statistically identical with N_2 (220 kg/ha) at harvest. The lowest dry weight/plant was achieved from N_1 (180 kg/ha) and that were 38.47, 225.80 and 369.30 g at 15, 30, 45 DAS and at harvest respectively. The results obtained from N_2 (220 kg/ha) and N_3 (260 kg/ha) showed intermediate results compared to highest and lowest results. Another finding by Shen *et al*. (2006) conforms the above findings.

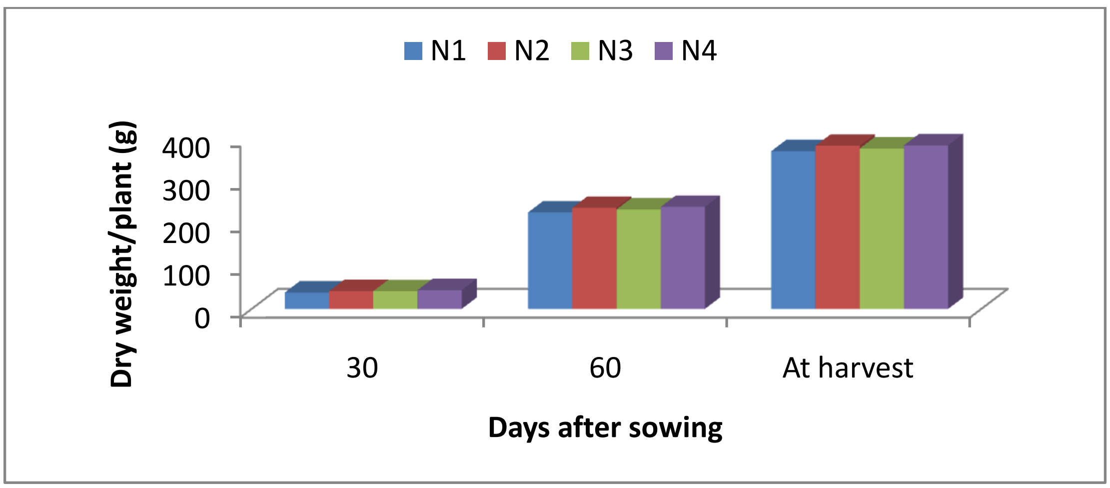

Fig 5: Performance on dry weight/plant of maize as influenced by different levels of nitrogen (SE at 30, 45 and at harvest 0.0326, .0422 and 0.0252, respectively).

N_1	=	180 kg N/ha	S_1	=	60 cm × 25 cm
N_2	=	220 kg N/ha	S_2	=	75 cm × 25 cm
N_3	=	260 kg N/ha	S_3	=	90 cm × 25 cm
N_4	=	275 kg N/ha			

4.1.3.2 Effect of spacing

Different plant spacing of maize significantly affected dry weight/plant (Fig 6 and Appendix VI). Data showed that higher dry weight/plant was achieved with higher plant spacing where lower plant spacing showed lower dry weight/plant. It was observed tah the highest dry weight/plant at 30, 60 DAS and at harvest were 46.62, 244.80 and 394.10 g respectively with S_3 (90 cm × 25 cm) where the lowest were 36.06, 218.60 and 357.40 respectively was with S_1 (60 cm × 25 cm). The spacing treatment, S_2 (75 cm × 25 cm) showed intermediate results at all growth stages. The result finding under the present study was in conformity with Jiotode (2002).

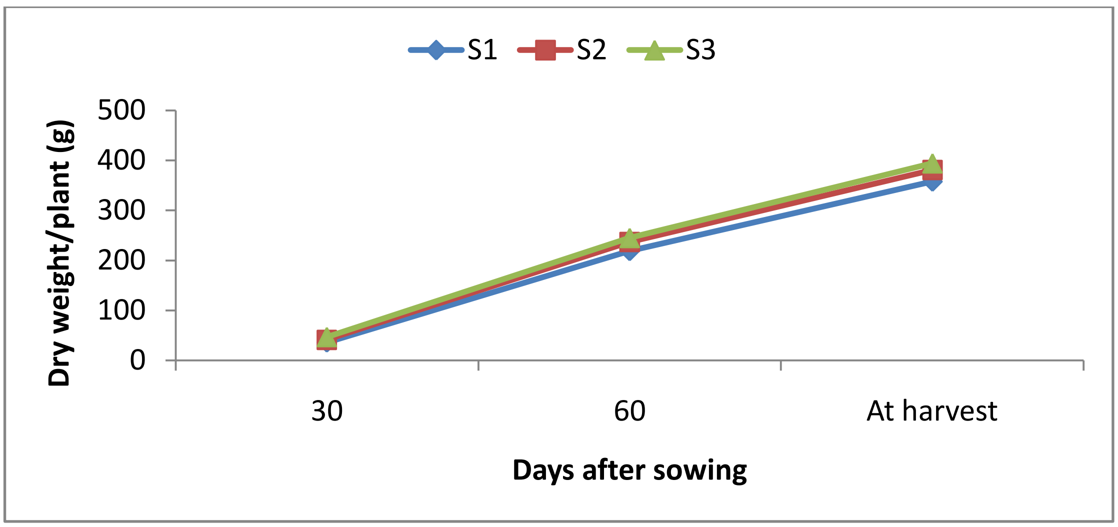

Fig 6: Performance of dry weight/plant of maize as influenced by different plant Spacings (SE at 30, 45 and at harvest 0.0312, 0.0403 and 0.0202 respectively).

S_1 = 60 cm × 25 cm
S_2 = 75 cm × 25 cm
S_3 = 90 cm × 25 cm

4.1.1.3 Interaction effect of nitrogen and spacing

Interaction of nitrogen and spacing also affected dry weight/plant significantly at different growth stages of maize (Table 4 and Appendix VI). It was observed that the treatment combination, N_4S_3 gave the highest dry weight/plant; 52.54, 254.20 and 404.10 g at 30, 60 DAS and at harvest respectively which was significantly different from all other treatments. The treatment combination N_1S_1 gave the lowest dry weight/plant at 30, 60 DAS and at harvest (34.18, 208.70 and 349.90 g respectively). The result finding under the present study was in conformity with Zhao, Y. and Yang, W. Y. (2006)

Table 4: Performance of dry weight/plant of maize as influenced by different levels of nitrogen under different spacing

Treatment	Dry weight/plant (g)		
	30 DAS	60 DAS	At harvest
Interaction effect of nitrogen and spacing			
$N_1 \times S_1$	34.18 i	208.70 j	349.90 k
$N_1 \times S_2$	38.94 fg	230.10 g	372.50 g
$N_1 \times S_3$	42.30 de	238.50 de	385.70 e
$N_2 \times S_1$	35.32 hi	218.10 i	355.10 j
$N_2 \times S_2$	45.11 c	250.40 b	400.20 b
$N_2 \times S_3$	44.29 cd	241.30 d	390.50 d
$N_3 \times S_1$	37.03 gh	221.10 i	359.20 i
$N_3 \times S_2$	40.15 ef	232.20 fg	371.50 g
$N_3 \times S_3$	47.36 b	245.20 c	396.10 c
$N_4 \times S_1$	37.71 g	226.40 h	365.50 h
$N_4 \times S_2$	41.19 e	235.50 ef	379.10 f
$N_4 \times S_3$	52.54 a	254.20 a	404.10 a
SE	0.0624	0.081	0.040
CV(%)	9.28	9.46	10.18

Figures in a coloumn having the same letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT.

N_1 = 180 kg N/ha
N_2 = 220 kg N/ha
N_3 = 260 kg N/ha
N_4 = 275 kg N/ha

S_1 = 60 cm × 25 cm
S_2 = 75 cm × 25 cm
S_3 = 90 cm × 25 cm

4.2 Yield contributing parameters

4.2.1 Cob length

4.2.1.1 Effect of nitrogen

Cob length of maize was significantly affected by different levels of nitrogen application (Table 5 and Appendix VII). It was observed that the longest cob (21.77 cm) was found with N_2 (220 kg/ha) where the shortest (17.18 cm) was obtained with N_1 (180 kg/ha). The other nitrogen treatments; N_3 (260 kg/ha) and N_4 (275 kg/ha) showed significantly different results compared to highest and lowest value of cob length. The results obtained by Balwinder and Walia (2003) was similar with the present findings.

4.2.1.2 Effect of spacing

Different spacing had significant effect on cob length of maize (Table 5 and Appendix VII). Results represented in Table 5 indicated that the longest cob (21.49 cm) was attained with S_2 (75 cm × 25 cm) where the shortest (19.20 cm) was with S_1 (60 cm × 25 cm). The another treatment, S_3 (90 cm × 25 cm) showed significantly different results in respect of highest and lowest value of cob length.

4.2.1.3 Interaction effect of nitrogen and spacing

Interaction effect of nitrogen and spacing significantly influenced the cob length of maize (Table 5 and Appendix VII). Results in table 5 showed that the longest cob (23.40 cm) was achieved with the combined effect of N_2S_2 which was closely followed by N_3S_2. On the other hand the shortest cob length (16.11 cm) was observed by N_1S_1. The results obtained from all other treatments were significantly different from highest and lowest value of cob length.

4.2.2 Grains/cob

4.2.2.1 Effect of nitrogen

Number of grains/cob of maize was significantly affected by different levels of nitrogen application (Table 5 and Appendix VII). It was observed that the highest number of grains/cob (469.90) was found with N_2 (220 kg/ha) which was not significantly different from N_3 (260 kg/ha). But the lowest number of grains/cob (399.10) was obtained with N_1 (180 kg/ha). The other nitrogen treatments; N_4 (275 kg/ha) showed significantly different results compared to the highest and the lowest value of grains/cob. Similar findings was observed by Tank (2006) and Ghulam, A. (2005).

4.2.2.2 Effect of spacing

Different spacing had significant effect on grains/cob of maize (Table 5 and Appendix VII). Results represented in Table 5 indicated that the highest grains/cob (473.00) was attained with S_2 (75 cm × 25 cm) where the lowest (426.90) was with S_1 (60 cm × 25 cm). The another treatment, S_3 (90 cm × 25 cm) showed significantly different results in respect of the highest and the lowest value of grains/cob.

4.2.2.3 Interaction effect of nitrogen and spacing

Interaction effect of nitrogen and spacing significantly influenced the grains/cob of maize (Table 5 and Appendix VII). Results in table 5 showed that the highest number of grains/cob (515.70) was achieved with the combined effect of N_2S_2 where the lowest number of grain/cob (388.30) was observed by N_1S_1. The results obtained from all other treatments were significantly different from the highest and the lowest value of grains/cob.

4.2.3 Weight of grains/cob

4.2.3.1 Effect of nitrogen

Weight of grains/cob of maize was significantly affected by different levels of nitrogen application (Table 5 and Appendix VII). It was observed that the highest weight of grains/cob (120.90 g) was found with N_2 (220 kg/ha) which was not significantly different from N_3 (260 kg/ha). But the lowest weight of grains/cob (85.49 g) was obtained with N_1 (180 kg/ha). The other nitrogen treatments; N_4 (275 kg/ha) showed significantly different results compared to the highest and the lowest value of grains/cob weight.

4.2.3.2 Effect of spacing

Different spacing had significant effect on weight of grains/cob of maize (Table 5 and Appendix VII). Results represented in Table 5 indicated that the highest weight of grains/cob (123.00 g) was attained with S_2 (75 cm × 25 cm) where the lowest (98.88 g) was with S_1 (60 cm × 25 cm). The another treatment, S_3 (90 cm × 25 cm) showed significantly different results in respect of highest and lowest value of grains/cob weight.

4.2.3.3 Interaction effect of nitrogen and spacing

Interaction effect of nitrogen and spacing significantly influenced the weight of grains/cob of maize (Table 5 and Appendix VII). Results in table 5 showed that the highest weight of grains/cob (146.10 g) was achieved with the combined effect of N_2S_2 where the lowest weight of grain/cob (80.89 g) was observed by N_1S_1. The results obtained from all other treatments were significantly different from highest and lowest value of grains/cob weight.

4.2.4 Weight of 1000 grains

4.2.4.1 Effect of nitrogen

1000 grain weight of maize was significantly affected by different levels of nitrogen application (Table 5 and Appendix VII). It was observed that the highest 1000 grain weight (246.40 g) was found with N_2 (220 kg/ha) where the lowest (204.80 g) was obtained with N_1 (180 kg/ha). The other nitrogen treatments; N_3 (260 kg/ha) and N_4 (275 kg/ha) showed significantly different results compared to highest and lowest value of 1000 grain weight. Similar findings was observed by Tank (2006).

4.2.4.2 Effect of spacing

Different spacing had significant effect on 1000 grain weight of maize (Table 5 and Appendix VII). Results represented in Table 5 indicated that the highest 1000 seed weight (247.30 g) was attained with S_2 (75 cm × 25 cm) where the lowest (221.70 g) was with S_1 (60 cm × 25 cm). The another treatment, S_3 (90 cm × 25 cm) showed significantly different results in respect of highest and lowest 1000 seed weight.

4.2.4.3 Interaction effect of nitrogen and spacing

Interaction effect of nitrogen and spacing significantly influenced the 1000 grain weight of maize (Table 5 and Appendix VII). Results in table 5 showed that the highest 1000 grain weight (269.30 g) was achieved with the combined effect of N_2S_2 where the lowest 1000 grain weight (200.30 g) was observed by N_1S_1. The results obtained from all other treatments were significantly different from highest and lowest value of 1000 grain weight. The result finding under the present study was conformity with Amaral Filho, (2009).

Table 5: Performance of yield contributing characters of maize as influenced by different levels of nitrogen and spacing

Treatment	Cob length (cm)	Grains/cob	Weight of grains/cob (g)	1000- grain weight (g)
Effect of nitrogen				
N_1	17.18 d	399.10 c	85.49 c	204.80 d
N_2	21.77 a	469.90 a	120.90 a	246.40 a
N_3	21.48 b	469.10 a	120.20 a	244.10 b
N_4	20.84 c	449.60 b	110.00 b	235.30 c
SE	0.014	0.003	0.013	0.022
Effect of spacing				
S_1	19.20 c	426.90 c	98.88 c	221.70 c
S_2	21.49 a	473.00 a	123.0 a	247.30 a
S_3	20.26 b	440.80 b	105.60 b	229.00 b
SE	0.013	0.002	0.011	0.021
Interaction effect of nitrogen and spacing				
$N_1 \times S_1$	16.11 h	388.30 l	80.89 k	200.30 l
$N_1 \times S_2$	17.31 g	398.30 k	85.39 j	204.30 k
$N_1 \times S_3$	18.11 g	410.70 j	90.19 i	209.70 j
$N_2 \times S_1$	19.19 f	431.00 h	100.10 g	222.70 h
$N_2 \times S_2$	23.40 a	515.70 a	146.10 a	269.30 a
$N_2 \times S_3$	21.86 cd	460.70 e	114.50 d	240.30 e
$N_3 \times S_1$	20.41 e	439.70 g	105.10 f	229.30 g
$N_3 \times S_2$	22.85 ab	498.70 b	134.40 b	261.30 b
$N_3 \times S_3$	22.06 bc	471.30 d	123.10 c	248.70 d
$N_4 \times S_1$	21.11 de	448.70 f	109.40 e	234.30 f
$N_4 \times S_2$	22.41 bc	479.30 c	126.30 c	254.30 c
$N_4 \times S_3$	19.00 f	420.70 i	94.37 h	217.30 i
SE	0.027	0.004	0.023	0.042
CV(%)	7.59	8.18	6.37	10.42

Figures in a coloumn having the same letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT.

N_1 = 180 kg N/ha
N_2 = 220 kg N/ha
N_3 = 260 kg N/ha
N_4 = 275 kg N/ha

S_1 = 60 cm × 25 cm
S_2 = 75 cm × 25 cm
S_3 = 90 cm × 25 cm

4.2.5 Grain yield (t/ha)

4.2.3.1 Effect of nitrogen

Grain yield of maize was significantly affected by different levels of nitrogen application (Table 6 and Appendix VIII). It was observed that the highest grain yield (4.46 t/ha) was found with N_2 (220 kg/ha) which was not significantly different from N_3 (260 kg/ha). But the lowest grain yield (3.86 t/ha) was obtained with N_1 (180 kg/ha). The other nitrogen treatments; N_4 (275 kg/ha) showed significant difference results compared to highest and lowest value of grain yield (t/ha). Similar findings were observed by Tank (2006).

4.2.3.2 Effect of spacing

Different spacings had significant effect on grain yield of maize (Table 6 and Appendix VIII). Results represented in Table 6 indicated that the highest grain yield (4.49 t/ha) was obtained with S_2 (75 cm × 25 cm) where the lowest (4.11 t/ha) was with S_1 (60 cm × 25 cm). Another treatment, S_3 (90 cm × 25 cm) showed significantly different results in respect of highest and lowest value of grain yield . Similar results were also found by Sener (2004).

4.2.3.3 Interaction effect of nitrogen and spacing

Interaction effect of nitrogen and spacing significantly influenced the grain yield of maize (Table 6 and Appendix VIII). Results in table 6 showed that the highest grain yield (4.79 t/ha) was recorded from the combined effect of $N_2 \times S_2$ where the lowest grain yield (3.79 t/ha) was observed by $N_1 \times S_1$. The combined effect of N_3S_2, N_4S_2, N_3S_3, N_2S_3 also showed higher grain yield but significantly different from N_2S_2. The results obtained from all other treatments showed intermediate results compared to the highest and the lowest value of grain yield . These results are in conformity with Amaral Filho (2009).

4.2.6 Stover yield

4.2.5.1 Effect of nitrogen

Stover yield/ha of maize was significantly affected by different levels of nitrogen application (Table 6 and Appendix VIII). It was observed that the highest stover yield (5.96 t/ha) was found with N_4 (275 kg/ha) which was significantly different from all other nitrogen treatments. But the lowest stover yield (5.78 t/ha) was obtained with N_1 (180 kg/ha) which was not significantly different from N_2 (220 kg/ha). The other nitrogen treatments; N_3 (260 kg/ha) showed significantly different results compared to highest and lowest value of stover yield (t/ha). Similar findings were observed by Tank (2006).

4.2.5.2 Effect of spacing

Different spacing had significant effect on stover yield (t/ha) of maize (Table 6 and Appendix VIII). Results represented in Table 6 indicated that the highest stover yield (6.10 t/ha) was attained with S_1 (60 cm × 25 cm) where the lowest (5.65 t/ha) was with S_3 (90 cm × 25 cm). The another treatment, S_2 (75 cm × 25 cm) showed significantly different results in respect of highest and lowest value of stover yield (t/ha). The result obtained by Girma (2005) was similar with the present findings.

4.2.5.3 Interaction effect of nitrogen and spacing

Interaction effect of nitrogen and spacing significantly influenced the stover yield (t/ha) of maize (Table 6 and Appendix VIII). Results in table 6 showed that the highest stover yield (6.19 t/ha) was recorded from the combined effect of N_4S_1 which was closely followed by N_3S_1. On the other hand the lowest stover yield (5.56 t/ha) was observed by N_1S_3 which was closely followed by N_2S_3. The results obtained from all other treatments showed significantly different result compared to highest and lowest value of stover yield (t/ha).

4.2.7 Harvest index

4.2.7.1 Effect of nitrogen

Harvest index of maize was significantly affected by different levels of nitrogen application (Table 6 and Appendix VIII). It was observed that the highest harvest index (43.22%) was found with N_2 (220 kg/ha) which was not significantly different from N_3 (260 kg/ha). But the lowest harvest index (40.03%) was obtained with N_1 (180 kg/ha). The other nitrogen treatments; N_4 (275 kg/ha) showed significantly different results compared to highest and lowest value of harvest index.

4.2.7.2 Effect of spacing

Different spacing had significant effect on harvest index (t/ha) of maize (Table 6 and Appendix VIII). Results represented in Table 6 indicated that the highest harvest index (43.29%) was attained with S_2 (75 cm × 25 cm) where the lowest (40.23%) was with S_1 (60 cm × 25 cm). The another treatment, S_3 (90 cm × 25 cm) showed significantly different results in respect of highest and lowest value of harvest index.

4.2.7.3 Interaction effect of nitrogen and spacing

Interaction effect of nitrogen and spacing significantly influenced the harvest index of maize (Table 6 and Appendix VIII). Results in table 6 showed that the highest harvest index (45.21%) was recorded from the combined effect of N_2S_2 where the lowest harvest index (38.71%) was observed by N_1S_1. The combined effect of N_3S_2, N_3S_3, N_2S_3, N_4S_2 also showed higher harvest index value but significantly different from N_2S_2 and N_1S_1. The results obtained from all other treatments showed intermediate result compared to highest and lowest value of harvest index.

Table 6: Yield performance of maize as influenced by different levels of nitrogen and spacing

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Effect of nitrogen			
N_1	3.86 c	5.781 c	40.03 c
N_2	4.46 a	5.828 c	43.22 a
N_3	4.45 a	5.906 b	43.08 a
N_4	4.32 b	5.960 a	42.02 b
SE	0.032	0.015	0.022
Effect of spacing			
S_1	4.11 c	6.10 a	40.23 c
S_2	4.49 a	5.86 b	43.29 a
S_3	4.23 b	5.65 c	42.73 b
SE	0.034	0.014	0.021
Interaction effect of nitrogen and spacing			
$N_1 \times S_1$	3.79 j	5.99 cd	38.71 j
$N_1 \times S_2$	3.86 j	5.79 efg	39.99 i
$N_1 \times S_3$	3.94 i	5.56 i	41.39 e
$N_2 \times S_1$	4.14 g	6.06 bc	40.46 h
$N_2 \times S_2$	4.79 a	5.81 ef	45.21 a
$N_2 \times S_3$	4.41 e	5.61 hi	43.99 c
$N_3 \times S_1$	4.21 g	6.14 ab	40.74 g
$N_3 \times S_2$	4.69 b	5.89 de	44.29 b
$N_3 \times S_3$	4.50 d	5.69 gh	44.21 b
$N_4 \times S_1$	4.31 f	6.19 a	41.01 f
$N_4 \times S_2$	4.60 c	5.94 d	43.69 d
$N_4 \times S_3$	4.05 h	5.74 fg	41.35 e
SE	0.068	0.029	0.042
CV(%)	8.39	8.09	9.16

Figures in a coloumn having the same letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT.

N_1 = 180 kg N/ha
N_2 = 220 kg N/ha
N_3 = 260 kg N/ha
N_4 = 275 kg N/ha

S_1 = 60 cm × 25 cm
S_2 = 75 cm × 25 cm
S_3 = 90 cm × 25 cm

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the performance of maize as influenced by different levels of nitrogen under different spacings. The experiment comprised two different factors; (1) four levels of nitrogen application viz. N_1 (180 kg N/ha), N_2 (220 kg N/ha), N_3 (260 kg N/ha) and N_4 (275 kg N/ha) and (2) three different plant spacings viz. S_1 (60 cm × 25 cm), S_2 (75 cm × 25 cm) and S_3 (90 cm × 25 cm).

The experiment was set up in randomized complete block Design (factorial) with three replications. There were 12 treatment combinations. The experimental plot was fertilized as per treatment with nitrogen and phosphorus fertilizer. Data on different growth and yield parameters were recorded and analyzed statistically.

Data were collected on plant height (cm), number of leaves/plant, leaf area/plant, dry weight/plant (g), cob length, number of grains/cob, weight of grains/cob, 1000- grain weight (g), grain yield (t/ha), stover yield (t/ha), and harvest index (%).

Considerable effect was observed on growth, yield and yield contributing characters of maize with different levels of nitrogen application. The growth parameters; plant height (cm), number of leaves/plant, leaf area/plant and dry weight/plant (g) were highest with higher nitrogen doses of N_4 (275 kg N/ha). The highest plant height (83.10, 152.10 and 207.20 cm at 30, 60 DAS and at harvest , respectively), number of leaves/plant (6.74, 12.32 and 17.03 at 30, 60 DAS and at harvest respectively), leaf area/plant (233.20, 583.90 and 688.20 cm^2 at 30, 60 DAS and at harvest respectively) and dry weight/plant (43.81, 238.70 and 282.90 g at 30, 60 DAS and at harvest respectively) were with N_4 (275 kg N/ha). But the lowest plant height (77.99, 144.90 and 195.50 cm respectively at 30, 60 DAS and at harvest respectively), number of leaves/plant (5.70, 11.07 and 15.88 at 30, 60 DAS and at harvest, respectively), leaf area/plant (223.40, 564.70 and 660.10 cm^2

at 30, 60 DAS and at harvest respectively) and dry weight/plant (38.47, 225.80 and 369.30 g at 30, 60 DAS and at harvest respectively) were with N_1 (180 kg N/ha).

Yield and yield contributing parameters was also affected significantly by different levels of nitrogen application. It was evident that the highest cob length (21.77 cm), number of grains/cob (469.90), weight of grains/cob (120.90 g), 1000-grain weight (246.40 g), grain yield (4.464 t/ha), and harvest index (43.22%) were achieved by N_2 (220 kg N/ha). But the lowest cob length (17.18 cm), number of grains/cob (399.10), weight of grains/cob (85.49 g), 1000-grain weight (204.80 g), grain yield (3.864 t/ha), and harvest index (40.03%) were achieved by N_1 (180 kg N/ha). But in terms of stover yield (t/ha), the highest result (5.96 t/ha) was obtained with N_4 (275 kg N/ha) where the lowest (5.781 t/ha) was with N_1 (180 kg N/ha).

Results under the present study showed that growth, yield and yield contributing characters of maize were significantly influenced by different plant spacings. The lowest plant spacing, S_1 (60 cm × 25 cm) showed the highest plant height (87.76, 156.80 and 215.70 cm at 30 and 60 DAS, at harvest, respectively) where the higher plant spacing S_3 (90 cm × 25 cm) showed the lowest plant height (73.78, 140.00 and 187.70 cm at 15, 30, 45 DAT and at harvest respectively). But in terms of other growth parameters; the highest number of leaves/plant (7.32, 13.30 and 17.79 at 30 and 60 DAS and at harvest, respectively), leaf area/plant (243.50, 597.80 and 709.20 cm^2 at 15, 30, 45 DAT and at harvest, respectively), dry weight/plant (43.81, 238.70 and 282.90 g at 15, 30, 45 DAT and at harvest, respectively) were obtained from S_3 (90 cm × 25 cm) where the lowest number of leaves/plant (4.94, 9.66 and 14.91 at 30 and 60 DAS and at harvest, respectively), leaf area/plant (211.50, 551.10 and 637.40 cm^2 at 15, 30, 45 DAT and at harvest respectively), dry weight/plant (38.47, 225.80 and 369.30 g 30 and at 60 DAS and at harvest, respectively) were obtained from S_1 (60 cm × 25 cm).

In case of yield and yield contributing parameters; the highest cob length (21.49 cm), number of grains/cob (473.00), weight of grains/cob (123.00 g), 1000-grain weight

(247.30 g), grain yield (4.49 t/ha), and harvest index (43.29%) were achieved by S_2 (75 cm × 25 cm) where the lowest cob length (19.20 cm), number of grains/cob (426.90), weight of grains/cob (98.88 g), 1000 grain weight (221.70 g), grain yield (4.11 t/ha), and harvest index (40.23%) were achieved by S_1 (60 cm × 25 cm), but the highest stover yield (6.10 t/ha) was obtained from S_1 (60 cm × 25 cm) where the lowest (5.65 t/ha) was from S_3 (90 cm × 25 cm).

The growth, yield and yield contributing parameters of maize were also significantly affected by different levels of nitrogen application along with different plant spacing. The highest plant height (90.36, 160.30 and 220.20 cm at 30, 60 DAS and at harvest respectively) was with N_4S_1 where the lowest (72.04, 135.40 and 175.20 cm at 30, 60 DAS and at harvest respectively) was by N_1S_3. But the number of leaves/plant (8.14, 14.14 and 18.66 at 30, 60 DAS and at harvest respectively), leaf area/plant (248.40, 608.00 and 720.20 cm^2 at 30, 60 DAS and at harvest respectively) and dry weight/plant (52.54, 254.20 and 404.10 g at 30, 60 DAS and at harvest respectively) were with N_4S_3. But the lowest number of leaves/plant (3.34, 9.04, and 14.41 at 30, 60 DAS and at harvest respectively), leaf area/plant (208.40, 540.00 and 618.50 cm^2 at 30, 60 DAS and at harvest respectively) and dry weight/plant (34.18, 208.70 and 349.90 g at 30, 60 DAS and at harvest respectively) were with N_1S_1.

Yield and yield contributing parameters were affected significantly by different treatment combinations. It was evident that the highest cob length (23.40 cm), number of grains/cob (515.70), weight of grains/cob (146.10 g), 1000-grain weight (269.30 g), grain yield (4.793 t/ha), and harvest index (45.21 %) were achieved by $N_{2\times}S_2$. But the lowest cob length (16.11 cm), number of grains/cob (388.30), weight of grains/cob (80.89 g), 1000-grain weight (200.30 g), grain yield (3.793 t/ha), and harvest index (38.71%) were achieved by $N_{1\times}S_1$. But in terms of stover yield (t/ha), the highest result (6.19 t/ha) was obtained with $N_{4\times}S_1$ where the lowest (5.56 t/ha) was with $N_{1\times}S_3$.

It may be concluded from the results that nitrogen and plant spacing is very much promising for higher maize yield. The best nitrogen dose was 220 kg/ha and plant spacing was 75 cm × 25 cm under the present study. The combination of N_2S_2 (220 kg N/ha with 75 cm × 25 cm plant spacing) performed best in producing the highest yield compared to other treatments comprised with other nitrogen doses and plant spacing under the present study. On the other hand interactions of nitrogen at 220 kg ha^{-1} and plant spacing of 75 cm × 25 cm showed its superiority in producing the highest grain of maize.

The present research work was carried out at the Sher-e-Bangla Agricultural University and in one season only. Further trial of this work in different locations of the country is needed to justify the present findings and arrive at a definite conclusion.

REFERENCES

Agba, O. A. and Ogar, E. A. (2005). Efficacy of nitrogen on the growth and yield of maize (Zea mays L.) in Obubra, Cross River State. Calabar, Nigeria: Department of Animal Sciences and Fisheries, Cross River University of Technology. *Agric. Forestry Social Sci*. **3**(1): 35-40.

Ahmad,K.(2005). Effect of nitrogen and seed size on maize crop, Stand and plant height. *Agric and Social Sci*. **1**(4): 380-381.

Alvarez, C. G. D. (2006). Evaluation of agronomic characteristics and production of forage and grains of maize in different densities of sowing and row spacings. *Ciencia Agrotecnologia*. **30**(3): 402-408.

Amaral Filho, J. P. R. (2009). Row spacing, population density and nitrogen fertilization in maize.Vicosa, Brazil: Sociedade Brasileira de Ciencia do Solo. Revista *Brasileira Ciencia Solo*. **29**(3): 467-473.

Anonymous. 1989. Annual Report. 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Badr, M. M. A. and Othman, S. A. (2006). Effect of plant density, organic manure, bio and mineral nitrogen fertilizers on maize growth and yield and soil fertility. Moshtohor, Egypt: Faculty of Agriculture, Zagazig University. *Annals of Agri Sci*. Moshtohor. **44**(1): 75-88.

Balwinder, K. and Walia, U.S. (2003). Effect of nitrogen and plant population levels on competition of maize (Zea mays L.) with weeds. *Indian Weed Sci*. **35(**1/2): 53-56.

Bandopadhyay, S. K. (1984). Nitrogen and water relations in grain sorghum legume intercropping systems. Ph.D. Dissertation. IARI, New Delhi, India.

Bangarwa, R. (1997). The production of grains and stocks by maize as affected by intercropping with legumes. *Philipp. Agric.* **9**(2): 36 **-** 46.

BBS. (2008). Monthly Statistical Bulletin. Statistics Division. Ministry of Planning. Government of the Peoples Republic of Bangladesh. Dhaka. p. 57.

BARI (Bangladesh Agricultural Research Institute). (1982). Annual Report, Joydebpur, Gazipur.

Chandankar, M. M., Ghanbahadur, M. R. and Shinde,V. S. (2005). Yield and economics of maize as influenced by FYM, N.P.K. and plant density. *Annals of Plant Physiology*.**19**(2): 172**-**174.

Chaudhari, P. M., Patil, H. E. and Hankare, R. H. (2006). Effect of integrated nitrogen management in maize (Zea mays L) on pattern of leaf area and dry matter production. Muzaffarnagar, India: Hind Agri-Horticultural Society. *Int. Plant Sci*. Muzaffarnagar. **1**(1): 17-21.

Chowdhury, M. K. and Islam, M. I. (1993). Utilization efficiency of applied N as related to yield advantages in maize/lentil intercropping. *Field Crops Res*. **30**(1-2): 441-518.

Chun, L. and Chen, F. J. (2005). Analysis of the combining ability of the response of root morphology to low nitrogen stress in maize seedlings. Beijing, China: Editorial Department of Plant Nutrition and Fertilizer Science. *Plant. Nutr. Fert. Sci.* **11**(6): 750-756.

Chun, L. and Chen, F. (2005). Root growth, nitrogen uptake and yield formation in maize hybrids differing in N-use efficiency. Beijing, China: Editorial Department of Plant Nutrition and Fertilizer Science. *Plant Nutra. Ferti. Sci.* **11**(5): 615-619.

Delgado, R. (2009). Evaluation of maize growth and nitrogen uptake at various levels of nitrogen availability in a Mollisol of Venezuela. *Agronomia Trop. Maracay*. **52**(1): 5-22.

Duan, W. W., Zhao, H. M. and Li., Y. M. (2007). Responses of photosynthesis characteristics to nitrogen application rates in summer maize (Zea mays L.). Beijing, China: Science Press. *Acta Agronomica Sinica*. **33**(6): 949-954. URL: http://www.chinacrops.org

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. 1979. Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh. Dept. Soil Survey, Govt. People’s Republic of Bangladesh.p. 118.

El-Sheikh, F. T. (2010). Effect of plant population densities on nitrogen use efficiency of some maize varieties. *Annals Agric. Sci*. Moshtohor. 36(1): 143-162.

FAO.(1988). Food and Agricultural Organization of the United Nations, Soil Survey Project of Bangladesh. Soil Resources Tech. Rep. pp. 101-159.

Farghly, B. S. (2001). Effect of the preceding winter crop and nitrogen fertilization on yield and yield components of maize and sunflower. *Egyptian Agricul. Res.* **79**(4): 1423-1437.

Ferguson, R. (2004). Developing recommendations for site-specific nitrogen management of irrigated maize. Proceedings the International Conference on Precision Agriculture and Other Precision Resources Management, Hyatt-Regency, Minneapolis, MN, USA, 25-28-July, pp. 1814-1824.

Ghulam, A. (2005). Effect of irrigation schedules and nitrogen rates on yield and yield components of maize. *Agric. Social Sci*. **1**(4): 335-338 .

Girma,W. (2005). Nitrogen fertilization and moisture conservation practices on maize (Zea mays L.) grown under dryland conditions of Ethiopia. Bangkok, Thailand: Kasetsart University. *Kasetsart Nat. Sci.* **39**(1): 1-11.

Gomez, K.A. and Gomez. A.A. (1984). Statistical Procedure for Agricultural Research (2nd edn.) Int. Rice Res. Inst., A Willey Inter Science Pub., pp. 28-192.

Gomma, M. R. and El-Douby, K. A. (2010). Maize grain yield as influenced by nitrogen levels with and without organic manure under different tillage systems. Moshtohor, Egypt: Faculty of Agriculture, Zagazig University. *Annals Agric. Sci*., Moshtohor. **40**(2): 723-739 .

Hassan, A. A. G. (2002). Effect of organic manure or mineral nitrogen source on the growth and yield of maize. *Univ. Aden J. Natu. Appl. Sci*. **6**(3): 513-522.

Islam, M. A. and Kaul, A. (1986). N and carbon effect on the growth and yield performance of maize. *J. Agron. Crop Sci.* **161**(1):1116.

Jin. J. Y. (2004). Effects of nitrogen (N) rate on nitrogen uptake, yield and quality of high-starch and common maize genotypes. *Plant Nutrit. Fert. Sci*. **10**(6): 568-573.

Jiotode, D. J. (2002). Growth parameters and water use studies of maize as influenced by irrigation levels and row spacings. *Crop Res. Hisar*. **24**(2): 292-295.

Kaul, A. (1982). Maize in Bangladesh. BARC (Bangladesh Agricultural Research Council), Farmgate, Dhaka. p.27.

Ma, B. L., Dwyer, L. M. and Costa, C. (2003). Row spacing and fertilizer nitrogen effects on plant growth and grain yield of maize. *Canadian J. Plant Sci*. **83**(2): 241-247.

Muhammad, R., Abid, H. and Tariq, M. (2003). Growth analysis of hybrid maize as influenced by planting techniques and nutrient management. *Int. Agric. Biol*. **5**(2): 169-171.

Niu, R. (2005). Effects of nitrogen top-dressing on yield and quality of green maize in northwest arid land in Hebei province. *Maize Sci*. **13**(2): 116-118.

Ogbaji, M. I. (2003). Effects of nitrogen rates and intra-row spacing on local maize (Zea mays L.) in Southern Guinea Savannah zone of Nigeria. Sust. *Agric. Environ*. **5**(1): 147-152.

Oktem, A. (2008). Effect of nitrogen on fresh ear yield and kernel protein content of sweet corn (Zea mays saccharata) under upper Mesopotamia region of Turkey. *Indian J. Agric. Sci*. **78**(1): 50-52.

Oktem, A. G. and Oktem, A. (2008). Effect of nitrogen and intra row spaces on sweet corn (Zea mays saccharata Sturt) ear characteristics. *Asian J.Plant Sci*. **4**(4): 361-364.

Patra, H. and Sahoo, P.N. (1994). Response of plant genotypes to nitrogen and plant spacing. *Indian J. Agron. Res*. **7**(2): 191-192.

Pena. R. A. (2006). Forage yield and quality of early maize hybrids in response to planting date, nitrogen and plant density.Chapingo, Mexico: Sociedad Mexicana de Fitogenetica. *Revista Fitotecnia Mexicana*. **29**(3): 207-213.

Sangakkara, U. R. and Nissanka, S. P. (2003). Nitrogen uptake and yields of rainfed maize (Zea mays L.) as affected by time and method of crop stover application in the humid tropics. *Maydica*. **48**(3): 191-196.

Sener, O. (2004). The effects of intra-row spacings on the grain yield and some agronomic characteristics of maize (Zea mays L.) hybrids. *Asian J. Plant Sci*. **3**(4): 429-432.

Shen. L., Wei. Y. and Lan. L. W. (2006). Effect of nitrogen supply on early kernel development and yield in summer maize (Zea mays L.). Beijing, China: Science Press. *Acta Agronomica Sinica.* **32**(11): 174-175. URL: http://www.chinacrops.org

Siddiqui, M. H., Oad, F. C. and Jamro, G. H. (2006). Emergence and nitrogen use efficiency of maize under different tillage operations and fertility levels. *Asian J. Plant Sci*. **5**(3): 508-510.

Tank, D. A. (2006). Nitrogen management in rabi maize (Zea mays L.). *Crop Res. Hisar*. **31**(2): 323-324. URL: www.cropresearch.org

UNDP. (1988). Land resources appraisal of Bangladesh for Agricultural Development. Report. 2. Agro-ecological Regions of Bangladesh. United Nations Dev. Prog. and Food and Agric. Organization. pp. 212-221.

Wang, X. (2006). Influence of planting maize and fallowing on soil moisture and mineral nitrogen. Beijing, China: Editorial Department of Scientia Agricultura Sinica. *Scientia Agricultura Sinica*. **39**(6): 1179-1185. URL: http://www.ChinaAgriSci.com

Worku, M. and Banziger, M. (2007). Nitrogen uptake and utilization in contrasting nitrogen efficient tropical maize hybrids. Madison, USA: Crop Science Society of America. *Crop Sci*. **47**(2): 519-528. URL: http://crop.scijournals.org/

Xie, R. (2003). Influence of nitrogen and sulfur interaction on grain quality of maize. *Scientia Agricultura Sinica*. **36**(3): 263-268.

Zhao, Y. and Yang W. Y. (2006). Effects of planting density and nitrogen applied rate on yield of dual purpose maize for grain and silage. Jilin, China: Editorial Committee of the Journal of Maize Science. *Journal of Maize Sci.* **14**(2): 119-123.

APPENDICES

Appendix I. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from March 2010 to August 2010

Month	***RH (%)***	***Air temperature (^oC)***			***Rainfall (mm)***
		Max.	***Min.***	***Mean***	
April	61.40	33.74	23.81	28.77	185
May	64.27	32.5	24.95	28.72	180
June	66.24	28.28	25.34	26.81	184
July	81	31.4	25.8	28.6	542

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II: Characteristics of experimental soil was analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental soil

Morphological features	***Characteristics***
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	***Value***
Partical size analysis	
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty-clay
Ph	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III: Performance on plant height of maize as influenced by different level of nitrogen and spacing

Source of variation	Degrees of Freedom	Plant height		
		Mean square value		
		30 DAS	60 DAS	At harvest
Replication	2	0.000	0.001	0.004
Factor A	3	41.088	6.085	2.001
Factor B	2	58.911	8.416	4.677
AB	6	2.371	2.319	6.942
Error	22	0.439	0.854	1.126
CV%		8.54	7.68	8.87

Appendix IV: Performance of leaves/plant of maize as influenced by different level of nitrogen and spacing

Source of variation	Degrees of Freedom	Leaves per plant		
		Mean square value		
		30 DAS	60 DAS	At harvest
Replication	2	0.002	0.001	0.012
Factor A	3	1.727*	2.554*	2.115*
Factor B	2	6.976*	4.901*	25.232*
AB	6	0.105**	2.126*	4.118*
Error	22	0.085	0.144	1.426
CV%		5.28	7.34	6.88

** Significant at $p \leq 0.01$
* Significant at $p \leq 0.05$

Appendix V: Performance on leaf area of maize as influenced by different level of nitrogen and spacing

Source of variation	Degrees of Freedom	Leaf area/plant		
		Mean square value		
		30 DAS	60 DAS	At harvest
Replication	2	0.006	0.013	0.012
Factor A	3	12.415*	6.187*	7.860*
Factor B	2	26.803*	16.684*	14.832*
AB	6	8.018*	3.580*	3.595*
Error	22	3.246	3.446	4.336
CV%		8.62	7.48	9.34

** Significant at $p \leq 0.01$
* Significant at $p \leq 0.05$

Appendix VI: Performance on dry weight/plant of maize as influenced by interaction of nitrogen and spacing.

Source of variation	Degrees of Freedom	Dry weight/plant Mean square value		
		30 DAS	60 DAS	At harvest
Replication	2	0.253	0.004	0.012
Factor A	3	14.254*	2.168*	35.689*
Factor B	2	13.647*	21.266*	41.680*
AB	6	2.826**	13.389*	24.622*
Error	22	0.249	4.144	6.844
CV%		9.28	9.46	10.18

** Significant at $p \leq 0.01$
* Significant at $p \leq 0.05$

Appendix VII: Performance on yield contributing characters of maize as influenced by different level of nitrogen and spacing

Source of variation	Degrees of Freedom	Mean square value			
		Cob length (cm)	Grain/cob	Weight of grains/cob (g)	1000 grain weight (g)
Replication	2	0.014	3.083	1.000	1.022
Factor A	3	40.855*	27.954*	18.111*	10.968*
Factor B	2	15.779*	67.083*	42.333*	18.881*
AB	6	4.809**	18.898*	68.667*	24.222*
Error	22	1.006	4.962	6.636	4.193
CV%		7.59	8.18	6.37	10.42

** Significant at $p \leq 0.01$
* Significant at $p \leq 0.05$

Appendix VIII: Yield performance of maize as influenced by different level of nitrogen and spacing

Source of variation	Degrees of Freedom	Mean square value		
		Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Replication	2	1.149	0.004	0.002
Factor A	3	14.057*	4.707*	19.504*
Factor B	2	26.595*	8.441*	31.947*
AB	6	42.000*	3.103*	3.460**
Error	22	5.348	2.014	3.062
CV%		8.39	8.09	9.16

** Significant at $p \leq 0.01$
* Significant at $p \leq 0.05$