EFFECT OF MANURING AND SPLIT APPLICATION OF NITROGEN ON GRAIN YIELD AND QUALITY OF MAIZE

BY

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This is to certify that the thesis entitled "Effect of manuring and split application of nitrogen on grain yield and quality of maize" submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka – 1207, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY**, embodies the results of piece of a bonafide research work carried out by **Khondaker Yeasen Mohammad Shoukat**, Registration No. 26192/00486 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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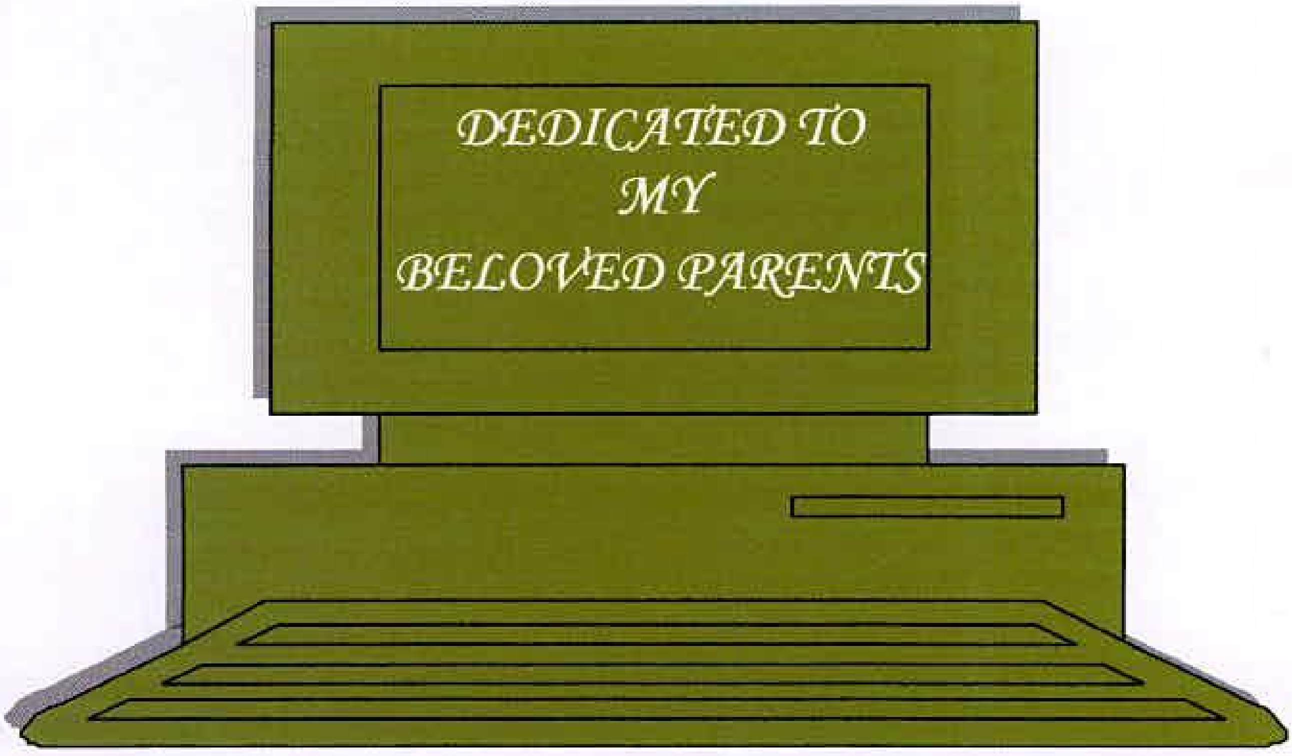
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ABSTRACT

An experiment was conducted at the agronomy field laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagor, Dhaka, during the period from March to June 2006 to study the effect of manuring and split application of nitrogen on grain yield and quality of maize cv. Barnali. There were four manurial doses, namely, M_1 – Inorganic Fertilizer (IF) only, M_2 – IF + cow-dung 5 t ha^{-1}, M_3 – IF + cow-dung 10 t ha^{-1} and M_4 – IF + cow-dung 15 t ha^{-1} and two split applications of nitrogen, viz. SP_1–2 splits and SP_2-3 splits. Manuring was placed in main plot and split application of nitrogen in subplot each measuring 5m X 3m in a split plot design used with three replications. Four nutrients were applied which were N, P_2O_5, K_2O and S at the rate of 115 -72 - 60 - 22.32 kg ha^{-1} and three nutrients were supplied in the form of Urea, TSP, MP and Gypsum respectively. In SP_1 basal dose of urea was applied at final land preparation, and 1st split at 25 and 2nd split at 45 days of sowing. In SP_2 basal dose urea was applied at final land preparation, and 3 splits respectively at 25, 45 and 65 days of sowing. Inorganic fertilizers + cow-dung 15 t ha^{-1} (M_4 treatment) gave the best response for all the parameters, whereas inorganic fertilizer (IF) only (M_1 treatment) gave the poorest response. Grain and stalk yields ranged respectively from 5.43 to 9.02 t ha^{-1} and from 6.76 to 12.16 t ha^{-1} due to different manuring treatments. The highest grain yield was obtained from M_4 treatment, identically followed by M_3 treatment. Grain protein content 10.6 was from M_1 treatment and 13.16 from M_4 treatment, the latter being identically followed by M_3 and M_2 treatments. Grain N and protein contents were nearly 2 times higher than those in stalk. Three split applications of N gave higher grain yield and tended to increase nutrient content of grain and stalk over 2 split applications of nitrogen. Results of the present study showed that application of cow-dung at the rate of 10 and 15 t ha^{-1} together with recommended dose of inorganic fertilizers improved grain yield and quality over inorganic fertilizers alone and 3 split applications of nitrogen increased grain yield and tended to improve grain quality of maize over 2 split applications of nitrogen.

Chapter 1

Introduction

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CHAPTER 1

INTRODUCTION

Maize (*Zea mays*) is one of the most efficient crop plants which can give high biological yield as well as grain yield relatively in short period of time due to its unique photosynthetic mechanism (Hatch and Slack, 1966). Maize is a multi purpose crop; every part of the plant and its products are used in one form or the other. Grain can be used for human consumption in various ways, such as corn meal, fried grain and corn flour. The green parts of the plant can be fed to livestock. Maize also is used for various industrial purpose. It has been used in the manufacture of oil, syrup, sugar, corn, flakes, bran, starch, whisky and cigarette wrappers from young husks. Maize starch is used in food, chemical, textile, paper and plastic industries. The by-product of the oil extraction is cake which is valued in livestock feed. Maize has starch rich endosperm and fat rich embryo and nutritionally it can be compared with rice and wheat.

Moderate temperature of 24° c to 30° c and about 800 mm of well distributed rainfall are conducive to good growth of maize (Thakur, 1980). The agro climatic condition of Bangladesh is favorable for its cultivation around the year (Islam and Kaul, 1986). Pest disease infestation is less in maize than in other cereals. In Bangladesh, the area under maize cultivation was 50 thousand hectares and total production was 27 thousand metric tons during 2002 – 03 (BBS, 2004). The crop has been included in the crop diversification and intensive cropping programmes of Bangladesh (Kaul and Rahaman, 1983).

Despite its importance, the average yield of maize in the country is not satisfactory. It is rather low compared with leading maize growing countries of the world. The national average yield is only 1.06 tons per hectare, whereas, the newly released varieties have the potential to produce more than 9 tons per hectare (BBS, 2003). Maize may offer a partial solution to the chronic food shortage of Bangladesh if its present yield level and total production can be raised. Maize can contribute significantly in this respect because of its higher productivity per unit area than wheat or rice. The problem of low grain yield of maize in the country may be attributed, among other reasons, the declining productivity of high to medium high lands under continuous cropping. This problem may be overcome by judicious application of inorganic and organic fertilizers.

In Bangladesh the demand of maize is increased for its comprehensive use in poultry feeds as well as in bakery as raw materials. The present demand of maize in Bangladesh is needed in poultry farms. But only 27 thousand mt of maize is currently produced in Bangladesh (BBS, 2004) with the cultivation of modern and hybrid varieties. But still the maize production remain far below the requirement of the country. It is because of low yield under low cost technologies and improper management in the farmers field. Maize is generally cultivated in the country following the patterns; maize – T. Aman – potato/Rabi crops or B. Aus/jute – fallow – maize. Both the cropping patterns are rice based and in rice based cropping system, nutrient mining is occurring due to non-addition or non-recycling of organic matter. So the low yield performance of maize in Bangladesh may be overcome by judicious integration of organic and inorganic fertilizer with the cultivation of modern hybrid varieties of maize.

Organic matter and micro – nutrient deficiencies are major constraints in many of our soil which may decrease maize yield and quality. Practically no soil can sustain high crop yields for an indefinite period from its own nutrient reserves. The importance of soil organic matter in soil fertility and crop productivity is well recognized. Organic matter deficiency is one of the limiting factor for high yields. The deficiency of soil organic matter can affect soil structure, water holding capacity and nutrient status of the soil. Organic manures are known to improve physical, chemical and biological properties of the soil. Because of their low nutrient content and slow action nature, however, organic manures alone may not be able to meet the nutrient requirements of crops and, therefore, fertilizer have to be applied.

Application of organic manures in combination with fertilizer helps both in the nutrition of the crop and in the maintenance of soil fertility. When added to soil, some of the plant nutrients in inorganic form have low efficiency compared with the effect of the same nutrients applied along with organic manures (Bhriguranshi, 1988). Integrated fertilizer management increases grain yield and quality over single application of fertilizer, particularly nitrogen (Talashilker and Vimal, 1986). Moreover, the use of organic manures may reduce the amount of chemical fertilizers to be applied for successful crop production. Organic manure are known to improve physical, chemical and biological properties of the soil and also to enhance the microbial activity.

Nitrogen nutrition is a major consideration for increasing grain yield and quality of maize. But nitrogen is mobile compared to other essential elements and as such it is subjected to be loss through various means. So for its efficient use it should be applied in split dose at different phase of plant growth and development (Singh, 1985). To augment the maize production and as such to help sustain the poultry industry with the generation of employment scope for millions of people in Bangladesh it is prime need to find out a suitable fertilizer management system for increased maize production. To serve this purpose, split application of 3 levels of nitrogen along with 3 levels of organic manures and a carotene rich maize variety Barnali have been selected to conduct an experiment to fulfill the following objectives:

1. To determine the optimum level of nitrogen and organic manure at integrated application on grain yield and quality of maize.

2. To find out the optimum number of split application of nitrogen in grain yield and quality of maize.

3. To determine the interaction effect of nitrogen and organic manure on maize for its grain yield and quality.

Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURE

2.1 Effect of manuring on grain yield

Maize responds differently to different manuring conditions for grain yield. Some of the studies are reported below.

Shaoming *et al.* (2004) reported that the nitrogen uptake and biomass of intercropped maize increased by 57.53 and 47.02% respectively compared to sole maize cropping. On the other hand, the nitrogen uptake and biomass of intercropped soybean decreased by 1.21 and 14.56% respectively compared to sole soybean cropping.

Maia and Cantarutti (2004) reported that the continuous use of organic fertilizers increased maize productivity, whereas chemical fertilizer application showed less expressive effects. They also observed that the continuous use of the organic fertilizers provided an increase in total N reserve and availability of N, while the chemical fertilizer application had little influence on these characteristics.

Ogboghodo *et. al.* (2004) reported that amended with poultry manure, statistical analysis showed that the highest rate of crude oil application (75 ml) and the 150 kg ha^{-1} rate of poultry manure application affected maize growth, dry matter yield and soil properties significantly. For example at 75 ml crude oil application, plant height increased from 20 to 149 cm and dry matter yield increased from 27 to 58 g as level of manure applied increased from 0 to 150 kg ha^{-1}.

Mahua and Banerjee (2003) studied the effects of different N fertilizer levels (50, 100 and 150 kg ha^{-1}) and plant population density (40, 65 and 90x103 plants ha^{-1}) on the yield of popcorn cultivars 'V.L. Amber popcorn' and 'Ambel popcorn'. Data were recorded for shelling percentage, test weight, grain yield, stover yield and harvest index. All parameters increased with increasing N levels and decreasing population density, with 'V.L. Amber popcorn' recording higher values recorded compared to the other cultivar.

Nyamangara *et al*. (2003) conducted an experiment to see the effects of N fertilizer (0, 60, 120 kg N ha^{-1}) and aerobically composted cattle manure (0, 12.5 mg ha^{-1} or 37.5 mg ha^{-1} applied only in the first year), singly or in combination, on yield and N uptake in maize cv. They observed that the combined application of manure and N fertilizer resulted in greater net N recovery in all growing seasons (up to 120 kg N ha^{-1}) compared with the separate applications of both N sources. The interaction between manure and N fertilizer enhanced N recovery. Aerobically composted cattle manure from smallholder farming areas of Zimbabwe was a poor source of N for maize growth in the short-term, even at high application rates. Combined application of manure with judicious use of N fertilizer can be positively exploited by smallholder farmers in Zimbabwe and other countries of sub-Saharan Africa.

Merzlaya *et al.* (1995) conducted an experiment in which five fertilizer systems were applied to a maize crop including 3 application rates of biohumas (5, 10 and 20 t ha^{-1} of cattle manure composted by earthworms), a control (without fertilizers) and the application of NPK fertilizers (60:60:120). They observed that the application of 10 t ha^{-1} of biohumas was most effective and increased maize yield by 30%.

Li *et al.* (1995) reported that N, P and organic fertilizer contributed markedly to yield but the contribution of K was small. The quadratic production function for N, P and organic fertilizer showed interaction between N and organic fertilizer. In a field experiment, combinations of winter wheat straw and 5 t liquid DAM fertilizer [urea, ammonium nitrate, 30% N ha^{-1}], and 50 t cattle manure ha^{-1} and pig and pig slurry (to supply 120 kg N ha^{-1}) were applied. All treatments plus ammonium sulphate and liquid DAM fertilizer were also applied. No P, K, Mg or lime were applied during the experimental period. Ammonium sulphate increased yield by 7.6% compared to the control with no fertilizer (Balik *et al.* 1995). Application of organic manures to plants irrigated with sodium fluoride gave higher yields than plants receiving ground water or sodium fluoride alone (Joyakumar *et. al.* 1994).

Jovanovic (1994) reported that maize yield was affected by duration of application and used quantity of liquid manure. Liquid manure used during springs increased the average yield by 1.72 t ha^{-1} in comparison with that used during summer, i.e. by 0.78 t ha^{-1}, in comparison with that used during autumn. The most favorable quantity of liquid manure is 100 cu. m/ha. The quantity of 50 cu. m ha^{-1} is not sufficient for high maize yield, and the quantity of 150 cu. mha^{-1} is not statistically justified. The effects of 1.5 – 6.0 t pig slurry/m of furrow, 1.5 t slurry + NPK fertilizer + 20 kg $ZnSo_4$ or 200 kg $(NH_4)_2So_4$ ha^{-1} or a control treatment (no fertilizer) on yield of maize were investigated. Mean yields for 3 years showed that best yields were obtained with 3.1 (3.8 t ha^{-1}) and 4.51 (4.9 t ha^{-1}) of slurry.

Ailineal *et al.* (1994a) reported that maize and wheat grown alone or in maize/wheat, peas/wheat/maize, peas/wheat/maize/sunflower + grass rotations were given no fertilizers or 100 kg N + 100 kg P_2O_5, 70 kg P_2O_5 or 40 kg P_2O_5 + 20 t FYM/ha. Over the period of rotation maize grain yield increased by 18 – 22%. In a field trial rice and maize grown in rotation were given inorganic fertilizers, organic compost, or a combination of the two. Crop yields over 6 cropping seasons were higher with inorganic fertilizers (180 kg N + 100 kg P_2O_5 + 100 kg K_2O/ha for maize) than with compost (40 t/ha applied to maize) or the compost/NPK mixture (Juang. 1993).

Jovanovic *et al.* (1993) reported that lime and liquid manure application gave higher maize yield than solid manure application. Lower amounts of mineral nutrients (N 100, P_2O_5 60, K_2O 40 kg ha^{-1}) in interaction with lime and liquid manure was statistically more justified than higher amounts of mineral nutrients (N 150, P_2O_5 90, K_2O 60 kg ha^{-1}). The higher yield was obtained by solid manure application (40 t ha^{-1}) in interaction with higher amount of mineral nutrients.

Khanday *et al.* (1993) conducted a field experiment in kharif season, maize cv. early composite was given 18 in which N (40, 80 or 120 kg ha^{-1}), FYM (farmyard manure 0, 10 or 20 t ha^{-1}) and Zn (0, 20 kg $ZnSo_4$ ha^{-1}). Single application of N (up to 80 kg ha^{-1}), Zn and FYM increased grain yields. There was no Zn × N interaction for grain yield. Number of grain/cob increased with increased FYM, and FYM + up to 120 kg N. In another study, maize cv. Roberta was supplied with 43.2 or 86.4 t ha^{-1} of composted municipal waste, 60 t ha^{-1} manure or no organic manure with or without 40 kg Kcl ha^{-1}. In the study it was observed that grain yield was not affected by the manure, and the application of N, P, and K increased grain yields by 70.4% (Pardini *et al.* 1993). Field experiments were conducted by Samling *et al.* (1992), in which maize was given combinations of N (0, 25, 50 or 75 kg ha^{-1} as calcium nitrate), P (0. 11, 22 or 33 kg ha^{-1} as triple super phosphate) and 5 t ha^{-1} FYM. Grain yields increased by application of P + FYM, N only and N + P + FYM.

Sharma *et al.* (1993) found that maize receiving 0, 50, 100, 150 or 200 kg N ha^{-1} produced grain yields of 1.99, 2.99, 3.46, 3.15, 3.28 and 3.89 t/ha, respectively. Supplying maize with 0, 3.33, 6.66 or 13.32 t ha^{-1} bioslurry (decomposed cattle manure) gave grain yields of 2.25, 3.20, 3.17 and 3.20 t ha^{-1}. Fertilizers and periodical manuring (6.7 t ha^{-1} annually) increased the productivity by 4.2 – 4.3 t ha^{-1} grain equivalent (Lvoilov and Malova, 1993).

In another study by Hung *et al.* (1992), pig manure either alone or with chemical fertilizer increased 1000 grain weight and grain yields. Maize gave the best response to 20 t ha^{-1} pig manure + chemical fertilizers.

Popescu *et al.* (1992) conducted an study in which cv. Pllol was supplied with 0 – 100 kg N ha^{-1} as ammonia nitrate + 0 – 100 kg P_2O_5 ha^{-1} + 0 – 60 t FYM ha^{-1}. Grain yields ranged from 3.33 t ha^{-1} with no N, P or FYM to 6.80 t ha^{-1} with 100 kg N + 100 kg P_2O_5 + 40 t FYM, respectively. The effects of FYM, crop residues and fertilizer on yields of maize were studied and it was found that maximum grain yield was 11.4 t ha^{-1} (Sarkadi. 1993).

Maize in a P vulgaris/wheat/maize/wheat/sunflower rotation gave grain yield increase of 48 – 72% with an increase in N rate compared with increase of 14 – 29% with P only, in a wheat/maize rotation 50 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 40 – 60 t FYM ha^{-1} (every 4 year) gave mean maize grain yields of 6.19 – 6.58 t ha^{-1} and at higher NP rates grain yields increased by 10% (Ailineal *et al.*, 1994b). The effects of 0, 30 or 60 kg P_2O_5 and 0 or 10 t FYM/ha on a wheat/maize cropping sequence revealed that FYM application increased grain yield (Negi *et al.* (1992a).

Negi *et al.* (1992b) reported that application of FYM increased maize grain yields by 5.0 – 6.2%. A field trail conducted by Khanday and Thakur (1991) in which maize was given 40, 80 or 120 kg N ha^{-1}, 0, 10 or 20 t FYM ha^{-1} and 0 or 25 kg $ZnSo_4$ ha^{-1}. Grain yield was found to increase up to 80 kg N, 20 kg FYM and 25 kg Zn ha^{-1}. In another study, use of compost to fertilizer maize resulted in highly significant yield increase, similar to those obtained with chemical fertilizers (Vijiala *et al.* 1991). A field trail on maize cv. Moldavaskii 257 was conducted and the crop was given no fertilizers, 0 –180 kg N ha^{-1} + 90 kg P_2O_5 ha^{-1} + 150 kg K_2O ha^{-1} or 40 or 80 t peat ha^{-1} + compost ha^{-1}, alone or each with NPK rate. Average grain yields were 4.15 t ha^{-1} with no fertilizers, 4.52 t ha^{-1} with PK alone, 5.97 – 6.63 t ha^{-1} with mineral NPK alone, 5.69 – 6.09 t ha^{-1} with compost alone, 6.20 – 6.47 t ha^{-1} with compost + PK and 6.65 – 6.80 t ha^{-1} with compost + NPK (Barsukov. 1991). The effects of nitrification inhibitors in conjunction with manure application were inconsistent and did not increase grain yield. Supplemental inorganic N application increased grain yield when volatile N loss occurring from manure (Sawyer *et al.* 1991).

Raelea *et al.* (1991) reported the effects on soil productivity of subsurface drainage and tillage with application of manures and fertilizers were studied. On clayey soils maize yields were increased by deep loosening and addition of 50 t humus, 120 kg N and 80 kg P_2O_5 ha^{-1}.

Konzen *et al.* (1990) reported that 46% higher yield was obtained from 1.5 t than full NPK fertilizer. NPK fertilizer + 1.5 t of slurry gave equivalent results 4.5 t of slurry alone.

2.2 Effect of nitrogen fertilizer on grain yield

Mohamed (2004) reported that Planting maize at 24 000 plants/fed significantly increased all studied characters, except for plant and ear heights, number of rows per ear and shelling percentage. The highest yield (24.38 ard fed^{-1}) was recorded in this treatment, while the lowest was at 30 000 plants fed^{-1}. Increasing N level up to

120 kg fed^{-1} increased the grain yield of maize and its components. The highest grain yield (32.09 $ardfed^{-1}$) increased up to 135.09% of unfertilized maize by adding 120 kg N/fed. Ear diameter, ear length, number of kernels per row, 100-kernel weight, grain yield per plant and per feddan (1 feddan = 0.42 ha) were significantly affected by the 1st order interaction (plant density x N level). Also, the grain yield per plant and per feddan were affected by (hybrid x N level), whereas the 1st order interaction of hybrid x plant density and the 2nd interaction order hybrid, plant density and N level did not significantly affect all the characters. The results generally showed that growing S.C. 10 at 24 000 plants fed^{-1} and adding 120 kg N fed^{-1} produced high grain yield. The results indicate positive and highly significant correlation coefficients between grain yield per plant and its components, except for number of rows per ear. Maize grain yield significantly responded to N application and that response was quadratic. It gave the highest value for coefficient of determination, and the lowest value of standard error compared with linear response under the 3 population densities. The optimum N rate ranged from 103 to 111 kg N/fed. Grain yield at the optimum level ranged from 26 to 31 ard fed^{-1} and the monetary return ranged from 2686 to 3286 <pounds>E/fed.

Ma. *et al*. (2004) reported that three N application methods were tested on two maize hybrids, Pioneer 3893 and Pioneer 38P06 Bt. At planting, 60 kg N ha^{-1} as ammonium nitrate was applied to all treatments. In addition, 6.5 kg N ha^{-1} and 13.5 kg N ha^{-1} as 15N-labeled urea were applied to either foliage (Treatment I) or soil (Treatment II) at V6 and V12 stages, respectively. In Treatment III, 20 kg N ha^{-1} as 15N-labeled urea was injected into space between ear and husks at silking. The results showed that compared with soil N application neither foliar spray nor injection through ear affected grain yield or Stover dry matter. The NUE values ranged from 12 to 76% for N fertilizer applied at V6 and V12 stages, or at silking for all treatments. There was no interaction of hybrid x N application methods on any variables measured with the only exception that for soil N application, grain NUE in Pioneer 38P06 Bt was significant higher than in Pioneer 3893. The difference in total N and NUE of grain and Stover between soil N application and foliar N spray was inconsistent. However, NUE was substantially higher for N injection through the ear than for foliar or soil application without differential responses between the two hybrids. Nitrogen injection through the ear at silking might have altered N redistribution within the plant and improved NUE. Hence, it can potentially enhance grain protein content. Foliar N spray is not advocated for maize production in Ontario.

Rambo *et al*. (2004) observed that the major plant parameters that can be used as indicators of plant N level for effective management of N side-dress application in maize to enhance the N use efficiency and decrease the environmental impact of N.

Sofi *et a*l. (2004) studied the effects of N (0, 120 and 160 kg ha^{-1}) and K (0, 40 and 80 kg ha^{-1}) on maize (Ganga Safed-2) performance and soil fertility. The highest grain (5.95 t ha^{-1}) and stover (13.10 t ha^{-1}) yields, and N (97 kg ha^{-1}), P (24 kg ha^{-1}) and K (108 kg ha^{-1}) uptake were recorded for plants supplied with 160 kg N + 80 kg K ha^{-1}. Soil available N, P and K significantly increased with N and K application. Soil P^{H} electrical conductivity and organic C content were not significantly affected by N and K.

Nazakat & Nawaz *et al*. (2004) reported that the effects of the combined application of N and P at 0:0, 60:40, 120:50, 180:60 and 240:70 kg/ha on the growth and yield of maize (cv. Golden) on loam soil were studied in Bahawalpur, Pakistan, during 1999. N as urea was applied during sowing (50%), together with P as triple super phosphate (100%), and rest N (50%) before the tasselling stage. Plant height was greatest (197.7 cm) with 240 kg N + 70 kg P ha^{-1}The application of 180 kg N + 60 kg P ha^{-1} , esulted in the greatest cob length (15.33 cm), number of grains per cob (487.7), and grain yield (2467 kg h). The greatest 1000-grain weight (300.7 g) was obtained with 120 kg N + 50 kg P ha^{-1}. Plant height, 1000-grain weight and cob length were significantly correlated with grain yield.

Vladeva (2003) found that maize plants were supplied with different N rates under non-irrigated conditions in a field experiment conducted for 2 years. Leaf N content was highest during the 5 to 6 leaf and 9 to 10 leaf stages of the crop. Application of 12 kg N/day in combination with P and K resulted in a 460 kg grain yield/day.

Mar *et al* . (2003) found that nitrogen fertilization is an important factor for the increment of the out-of-season maize grains yield (sown after soybean harvest, in the autumn-winter season) in the States of Parana, Sao Paulo, Mato Grosso do Sul, Mato Grosso and Goias. An experimental trial was set up aiming at the evaluation of grain yielding potential and other agronomic characters of the out-of-season maize cultivars AG-3010, as a result of five N doses (30, 60, 90, 120 and 150 kg.ha^{-1}) and four ways of N application (E1=all N applied at sowing; E2, E3, and E4=1/3 of the total N applied at the sowing and 2/3 when the plants had four, eight, and ten expanded leaves, respectively). The best results for all evaluated characters were achieved with 120 kg.N ha^{-1} fertilization, at the stage of four to eight expanded leaves, with 1/3 of N applied at the sowing. Also, up to 60 N kg ha^{-1} N, there was no need of fractioning the total N doses.

Shirazi *et al.* (2000) carried out a field experiment at Trishal in Mymensingh district during 27 December to 8 may 1998 to study the effect of irrigation and nitrogen levels on the yield and yield contributing character of maize (cv. Barnali). Application of four nitrogen levels 00. 50, 100, and 120 kg/ha. Application of 120 kg N/ha significantly increased grain yield from 3.o3 to

3.95 t/ha and 100-grain weight from 22.80 to 25.06g compared with other nitrogen treatments. The highest yield was found with the application of 100 kg N/ha which was 225% higher over the control.

Pandey *et al.* (2000) conducted a filed experiment to study the effect of dose and time of nitrogen application on yield and yield attributes of baby corn (*Zea mays* L.). it was reported that increased nitrogen doses favorably affected the higher yield attributes and yield. Application of 120 kg N/ha gave significantly higher yield (1573 kg/ha) compared with 60 and 90 kg N/ha respectively.

Thakur *et al.* (1998) carried out a field experiment during rainy season of 1993 and 1994 to study the effect of nitrogen and spacing on baby corn (*Zea mays* L.) at Bajaura revealed that baby corn yield increased significantly with increasing application up to 150 kg N/ha, but the cobs with husk and green fodder yields recorded significant increase up to 200 kg N/ha.

Jovin (1996) reported that the agronomic traits of standard and two groups of modified maize hybrids in relation to nitrogen ratio (100 & 200 kg/ha) and crop densities (44, 600; 54, 900 and 64, 900 plant ha^{-1}) were to determine the justification of the sister line utilization in the maize hybrid development. Higher ratio of mineral nitrogen did mot significantly affect yield and other traits. The crop density increase up to G3 significantly increased the following traits under irrigation: yield, plant height and ear height, but the effect on lodging was not significant. Yield, plant height, ear height and lodging under conditions without irrigation were significantly higher in G2 than G1. significantly higher yield, plant height ear height were higher in the version M under conditions without irrigation. Medium late maturity hybrids were more yielding than medium early maturity hybrids under condition of both irrigation and non-irrigation.

Nedic *et al.* (1995) observed that a partial foliar application of nitrogen combined with the application to the soil has no positive effects on maize yield in comparison to the conventional soil application. Better result were obtained by the application of weal than by the application of urea. The best results for our growing conditions were acquired with the fertilizing variant of 40 kg N ha^{-1} in autumn with addition of 90 kg N ha^{-1} in spring at pre – planting. However, special attention should be paid to the variant with a total of 40 kg N ha^{-1}. The differences in grain yield and maize yield components over years, depending on fertilizing, are the result of very different amount and distribution of precipitation.

Labois (1989) conducted a field trail with maize hybrids grown continuously or in rotation with soybeans to see the effect of different forms and rates of N fertilizer, applied with or without N – serve nitrification inhibit9or were investigated, comme4rcial hybrid P 3377 and experimental line XC 754 were promising under the conditions of trail. When N and N – serve were applied early, N applied late, N – serve decreased yield and increased lodging under continuous maize cropping.

Thanik *et al.* (1988) found that maize hybrid Ganga Safed – 2 gave grain yields of 4.71, 5.23 and 5.34 t ha^{-1} with 60, 120 and 180 kg N ha^{-1} respectively, 4.35, 5.33 and 5.72 t ha^{-1} until 0, 30 and 60 kg P_2O_5 ha^{-1} respectively and 4.87 and 5.32 t with 0 and 60 kg K_2O ha^{-1} respectively. The N × P interaction was significant. Application of 180 kg N + 60 kg P_2O_5 ha^{-1} gave the highest yield of 6.21 t followed by 5.92 t ha^{-1} with 120 kg N + 30 kg P_2O_5 ha^{-1}.

Nimje and Seth (1988) conducted a field trail with maize grown with 0 – 120 kg N ha^{-1} in the winter seasons of 1982 – 84. It was observed in the trail that of N increasing rates increased the number of ears $plant^{-1}$, ear size, grain yields and 1000 – grain weight. The optimum N rates were 103.4 kg ha^{-1} in 1982 – 83 and 106.8 kg in 1983 – 84; the yields were 6.84 and 5.6 t ha^{-1} respectively.

Ubravic *et al.* (1988) reported that maize was grown at 3 – sites in 1984 – 85 with 90 kg P_2O_5, 70 kg K_2O and 120 kg N ha^{-1} with the N supplied as calcium ammonium nitrate, urea or ammonium nitrate. Mean yields were 7.84 t/ha without fertilizer, 8.48 t ha^{-1} with PK, 9.06 t ha^{-1} with PK + ammonium nitrate, 8.65 t ha^{-1} with PK + urea and 8.87 t ha^{-1} with PK + ammonium nitrate. Yield response to different forms of N were not significant.

Polito (1988) conducted a field trail in central and E. low in 1982 – 84, average maize yields ranged from 6.49 to 11.2 t ha^{-1}. Yields were not increased by higher N – rate with lowest rates ranging from 67 – 168 kg ha^{-1}.

Ali *et al.* (1986) carried out a field trail in 1983 – 84, maize cv. Sultan was given no fertilizers, 75 kg N + 75 kg P + 75 kg K or 150 kg N + 150 kg P + 75 kg K ha^{-1}. Grain yield increased with increasing NPK rate. Highest grain yield in 1983 and 1984 were 4.37 and 2.77 t ha^{-1} respectively with the application of 150 kg N + 150 kg P + 75 kg K.

Milam and Hickingbottom (1986) reported that in field trials at Winnsboro, Louisiana in 1986 application of 168 – 336 kg N ha^{-1} had no significant effect on yield, percentage of broken stalks or plant height maize cv. Pioneer 3165. Ring Aroused (1609) and Stauffer (7759) had average grain yields of 1591.02, 1076.12 and 776.44 kg N ha^{-1} respectively.

Hardas, Karagianne & Hrestou (1985) studied the effect of applying combination of 0 – 200 kg N and 0 – 120 kg P to maize and of 0 0160 kg N and 0 – 120 kg P ha^{-1} to wheat plus NPK fertilizer was studied in 2 – years rotations between 1981 and 1984. Yields of crops increased in response to N in all years and in response to N and Pin the 4[th] year. The optimum application rates appeared to be 180 kg N ha^{-1} for maize and at least 160 kg N ha^{-1} for wheat.

Sokolov and Ekhtibarov (1985) conducted a field trail in 1982 – 84 with maize given PK 120 kg N applied by drilling to 12 – 15 cm depth or broadcasting followed cultivation gave average grain yields of 9.79 and 8.34 t/ha and grain protein contents of 11.4 and 9.4% respectively compared with 5.40 t/ha and 6.5% respectively with PK alone.

Okajima *et al.* (1983) conducted a field trail on brown lowland soils in Hokkaido in 1978, maize was grown with 150 kg each of P_2O_5 ha^{-1} and 0 –200 kg N ha^{-1} as ammonium sulphate. DM yield and N content of maize increased with increasing N rate. Grain yield increased from 0.91 t ha^{-1} with no N to 10.09 t with 200 kg N ha^{-1}.

2.3 Effect of split application of nitrogen on grain yield

Split application of nitrogen has been reported to have significant effect on grain yield and yield contributing characters of maize by many workers.

Srivastava and Singh (1997) reported that in trails with maize under rain fed condition in Rajasthan, 60 kg N ha^{-1} applied in 2 equal split dressing at the knee height stage and at the pre-tasselling stage increased grain yields from 1.20 – 1.26 t ha^{-1}. N applied in 2 split dressing at other stages gave lower yield increases. Grain yields increased with increase in N and P rates. The grain yield of 3.5 t ha^{-1} was obtained from 120 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} (Singh and Dubey 1991).

Hammissa *et al.* (1997) reported that time of N application had no significant effect on maize yields at Germmiza or sids, but at Mallawi treatments in which part of the N was applied after tasselling gave inferior yields. N content and total N uptake by grain, cobs and stalk increased as the rate of applied N increased.

Shanti *et al.* (1996) carried out a field experiment at Rajendranagar, Hyderbad, in rainy season (Kharif) 1993 to study the performance of newly released maize (*Zea mays*) hybrid DHM 107 in comparison with the control composite 'Varum' at different levels of nitrogen. The levels of nitrogen were 0, 40, 80, 120 and 160 kg ha^{-1} and genotypes were hybrid DHM 107 and varum. Nitrogen was applied as per the treatments in 3 equal splits, i.e. basal, at knee high stage (24 days after sowing) and pre tasselling (44 days after sowing). Application 160 kg N ha^{-1} gave highest grain yield, but it was statistically at par with that of 120 kg N ha^{-1} and significantly superior to other N levels. (Like wise, the grain number was significantly high under could be accosted for increase cob sized.) The higher tests weights was associated with the crop under 120 and 160 kg N ha^{-1} compared with other levels. Application of adequate N not only increased the yield but also improved the quality of grain as evident from the higher protein content in grain under 120 and 160 kg N ha^{-1}.

Sharma and Thakur (1995) carried out a field trail in Kharif (monsoon) in 1987 – 89 at Bajaura Himachal Pradesh and maize cv. Early composite was given 45, 67.5 or 90 kg N ha^{-1} in 3 equal split application at sowing, knee – high and pre – tasselling stage (recommended times of application) or in 2 or 3 split applications at 2 – 3 weeks after sowing, knee – high and pre – tasselling stages. Average grain yield increased with rate of N application and was highest when applied in the recommended 3 split applications.

Grain yield was increased (maximum 4.83 t ha^{-1}) by increasing the rates of applied N (Gupta and Gautam, 1994). Yields of maize cv. ND60 and ZD2 increased with application of N alone or with N plus the lower rate of P (Cao *et al.* (1995).

Rajan *et al.* (1992) conduced a field experiment in which maize cv. Co1 was given 0, 30, 60 or 90kg N ha^{-1}. Maize yield was significantly increased by 60 kg N ha^{-1}. Grain yield increased with increased rate of N application and was lower in Novjot (2.82 t ha^{-1}) than the other 3 cultivars EH 40084, prabhat, and ganga5 (3.31 – 3.55 t ha^{-1}) (Paradhan and Sharma 1993).

Mondardo *et al.* (1991) observed the effects of 75 kg N ha^{-1}, 0 or 60 kg P ha^{-1} and 0 or 70 kg K ha^{-1} on yields of maize crops grown on land where tobacco residues had been incorporated. N increased mean yield from 2.5 to 3.4 t ha^{-1} in 1984 and from 1.5 to 3 t ha^{-1} in 1985. N did not significantly increase yield in 1986. In all years N applied as ammonium nitrate at sowing and as urea after emergence gave best results. In a field experiment by Haque (1979), maize cv. W. yellow 1 was given PK + 200 kg N ha^{-1} as urea in 1, 2 or 3 split applications in the seedbed or at 25 – 30 or 50 days after sowing. Highest grain yields of 2.27 t ha^{-1} were given by N in the seedbed + 67% at 25 days after sowing, compared with yields of 1.57 and 2.53 t ha^{-1} with the urea applied in the seed bed as urea and S – coated urea, respectively. Highest grain yield in the early season (6.48 t ha^{-1}) was given when urea was applied 50% at 30 days and 50% at 50 days after sowing. Leaf N content increased with increasing number of urea applications.

Maidal and Fishbeck (1990) reported that the best utilization of N fertilizer and yields were obtained from a split dressing of 120 kg N ha^{-1} with 50% applied in rows at sowing and 50% broadcast at 20 cm height. Maize cv. Giza2, D. C. 202, TC4141 and pioneerr3147 were given 0, 15 or 30% of a 90 or 120 kg N/feddan (1 feddan = 0.42 ha) application at sowing, and the remainder in 2 equal applications at 21 and 35 days after sowing. Grain yields were 2.25 and 2.98 t/feddan with 90 and 120 kg N/ha, respectively, and 3.21, 2.70 and 2.35 t/feddan with 0, 15 and 30% of N application, respectively, at sowing (Ahmed, 1989a). Mean maize yields were unaffected by N rate or FYM application, they were 8.73, 9.86 and 9.85 t ha^{-1} with 0, 125 or 250 kg N ha^{-1}, respectively. Two split applications of 62.5 kg N ha^{-1} and applications in mid July gave significantly higher yields (10.0 and 9.92 t ha^{-1}, respectively) than no N (8.59 t ha^{-1}) or 125 kg N ha^{-1} applied in mid – June (9.41 t ha^{-1}). (Conti *et al.* 1990).

Ahmed (1989b) observed that grain yields of maize cv. Giza2, D. C. 202 and T. C. 4141 (white) and pioneer 3147 (yellow) given 90 kg N/feddan were 2.93, 2.81, 1.89 and 2.47 t/feddan, respectively. Corresponding yields with 120 kg N/feddan were 3.51, 3.43, 2.19 and 2.80 t/feddan. One thousand grain weight ranged from 288.0 g in pioneer 3147 at 90 kg N/feddan to 404.2 g in T. C. 4141 at 120 kg N/feddan. Experiments with maize and other cereals proved that best result in grain production was obtained with two applications of N fertilizer. Two applications to maize in some cases lowered yield (Castillon. 1990).

Brar and Khehra (1977) reported that split application of N significantly increased yield compared with a single application at sowing, and yield increased with increasing number of applications. Yield increases were due to an increase in number of ears/unit area and higher grain weight/ear. Three split dressing of N are recommended on sandy loam soils.

Kukula and Macheel (1976) observed that yields were higher with 160 kg N ha^{-1} applied in 2 equal split dressing – one before sowing and other at the 7 leaf stage than with same rate of N applied before sowing.

2.4 Effect of manuring and split application of nitrogen on grain quality

Grain protein content of maize is a desirable quality which depends on manuring, soil temperature, split application of nitrogen, variety, fertilizer management, water management and other agronomic practices. There is a notable effect of manuring and split application of nitrogen on protein content and other qualities of maize grains.

Huang-Shaowen *et al.* (2004) studied the effect of different rates of N fertilizer on grain yield and contents of protein, amino acid and fatty acid of high-oil maize cv. Jiyou-1 was studied. The increase in grain yield ranged from 10.5 to 22.9%. The optimum N fertilizer rates based on benefit and yield was 180.3 kg N ha^{-1}. There was a significant increase in the contents of grain protein, prolamine (zein) and glutelin. N increased grain protein content by 7.1-13.3% with an average of 10.6%, prolamine (zein) content by 22.1-39.1% with an average of 29.9%, and glutelin content by 25.0-40.7% with an average of 35.0%. N at 175 kg/ha produced the highest grain protein content, while 125 kg N ha^{-1} produced the best protein quality (highest glutelin to zein ratio at 0.45, and lowest relative content of zein in grain protein at 32.7%). The increase in total amino acid content ranged from 11.9 to 20.3% with an average of 17.3% and total essential amino acid content from 12.4 to 20.4% with an average of 17.1%. The highest total amino acid content (11.5%) and the highest total essential amino acid content (4.2%) were observed in seeds supplemented with 175 kg N ha^{-1}. Proper N application significantly increased the contents of fatty acid, total unsaturated fatty acid, linoleic acid, and oleic acid. Compared to the treatment without N application, N at 175-225 kg ha^{-1} increased the contents of grain fatty acid, total unsaturated fatty acid, linoleic acid and oleic acid by 7.0-7.5%, 7.4-8.3%, 7.0-8.5% and 8.1-8.4%, respectively. However, the over-application of N decreased the contents of grain fatty acid, total unsaturated fatty acid, linoleic and oleic acid.

Babnik *et al.* (2002) found that grain yield and concentration of crude protein (CP) in grain increased linearly with N application. Grain yield increased by 25 kg dry matter (DM) ha^{-1} and CP concentration by 0.13 g kg^{-1} DM per each additional kg of N.

Lianget *et al.* (1996) studied the effect of fertilizer rates on maize grain yield and grain N content ratio. Grain yield and grain N concentrations generally followed a exponential relation ship with increasing N rates. The critical grain N concentration, defined as that associated with the highest grain yield, was achieved with 285 kg N/ha for all years except in 1989 when it occurred with 170 kg N/ha. It is concluded that the relationship between the critical grain N concentration and grain yield could serve as a diagnostic tool for N applications.

Hummam (1995) conducted a field trail in Egypt in 1991 – 92 to assess the effect of 15 – 105 kg N/feddan with or without nitrapyrin (at a rate of 0.5% N in fertilizer) as a nitrification inhibitor on growth and yield of maize cv. Ganga2 sown in clay on 20 and 26 June in 1991 and 1992 respectively. Increasing N levels up to 105 kg generally increased growth, yield, yield components (ear length and diameter, no. of kernels/row, ear and kernel weights and shelling percentage) and protein content of maize. The addition of nitrapyrin gave the highest levels of growth and yield, gave yields increased by 12% and 10.3 in 1991 and 1992 respectively compared with fertilizer alone. Plant height, kernel weight, shelling percentage, grain yield/feddan and grain protein content were affected by the interaction between nitrogen levels and nitrapyrin grain yield increased to a maximum of 3025 and 2676 kg/feddan (in 1991 and 1992 respectively) with 105 kg N in the absence of nitrapyrin, but to a near maximum of 3243 and 2800 kg with 90kg N + nitrapyrin. It is concluded that the use of nitrapyrin as an inhibitor permits a saving of 40 kg N/feddan (1 feddan = 0.42 hectare) for reducing nitrogen losses.

Silva *et al*. (1993) studied the effect of N application rates (0, 60 and 120 kg ha^{-1}) on the protein content of maize cv. Centralmex grains and found significant effect of N levels. Application of 120 kg N resulted in greater maize grain protein content (9.6%) than when no N was applied (8.3%). There was no significant difference between the use of 0 and 60 kg N (9.3% protein). Grain protein concentration was 8.4% higher than that of unfertilized plants. Both protein concentration and N content were not different among the N applications (Feng *et al*., 1993). NP application resulted in improved seed and grain quality, particularly protein content (Carmet *et al*., 1990). A calcareous meadow soil given PK, applying 60, 90, 120 or 150 kg N ha^{-1} gave average grain yield of 2.25, 2.48. 2.93 and 2.81 t ha^{-1}, respectively compared with 1.92 t ha^{-1} without N applied, and N increased grain protein contents (Bataev and Magomedov, 1991).

Oikeh *et al*. (1988) reported that 5 maize cultivars were evaluated for grain quality parameters on soil supplemented with 0, 30, 60 and 120 kg N ha^{-1} at Zaria, Northern Nigeria. Increasing N levels increased grain yield, kernel weight and grain protein quadratically for all the cultivars. Hybrid 8644 – 27 had the highest grain yield (5.3 t ha^{-1}) and weight (26.62 mg) respectively. Average grain protein yield per unit area was significantly different among cultivars in both years (1993 – 1994).

Giardini *et al*. (1988) reported that maize (cv. G77, XL 342 and 72A) was given 0, 60, 120, 180 or 240 kg N ha^{-1} annually to continous with or without incorporation of whole or chopped maize stalks. N application increased average grain yields by 30% in 1966 – 71 (cv. G77), by 96% in 1972 – 80 (cv. XL 342) and by 66% in 1981 – 86 (cv. 72A). Optimum N rates were 70, 186 and 163 kg N ha^{-1} in 1966 – 71, 1972 – 80 and 1981 – 86, respectively. Increasing N rate also increased grain protein content and harvest index.

Bonquet *et al.* (1987) conducted an experiment in 1987 at St. Joseph, maize hybrid RA 1604 was given 49.28, 99.68, 200.48 or 249.04 kg N/ha. Increasing N rate increased grain yields from 2724 to 3813.6 kg ha^{-1}. Increasing N rate increased number of ears/ha, 100 – grain wt. , number of grains per ear and grain protein contents increased with increasing N rate.

Albinet (1986) reported that maize cv. HC208 was given 0 –259 kg N + 0 – 250 kg P_2O_5 ha^{-1}. With N alone, grain CP (crude protein) initially increased with an increase in N rate up to 128 – 192 kg N ha^{-1}. Added N significantly increased leaf levels of N, P, K, S, Mn and Zn and levels of CP in grain. Maize yields and grain protein content increased with increasing N application (Decau 1978). Maize cv. HD208 was given 0 –160 kg N ha^{-1} 0 – 128 Kg P_2O_5 and 0 – 96 Kg K_2O ha^{-1}. Grain CP content increased with an increase in N rate but optimum yield was obtained with 128 kg N ha^{-1}, and with >96 kg P_2O_5 ha^{-1} there was a decline in CP yield. There was a positive interaction between N and P_2O_5 in increasing CP content and yield. Application of 64 – 160 kg N + 64 kg P_2O_5 + 64 kg K_2O ha^{-1} gave the most positive interactions to increase CP content and yield (Albinet 1978). In Canada, maize cv. Funk4023 was given 0 or 180 kg N ha^{-1} as ammonium nitrate, urea or calcium ammonium nitrate. Between 20 and 30 days after pollination (DAP), protein concentration in maize grains declined sharply, thereafter only slightly, irrespective of the treatment. At most stages protein concentration was raised significantly by N application without clear differences between N fertilizer sources. At 20 DAP grains of N fertilized plants contained 25.5 mg g^{-1} more protein than those without N-application (Zhang *et al.*,1994).

Getmanets *et al.* (1981) reported that increasing N rates from 0 to 60, 120 or 180 kg ha^{-1} applied with 90 kg P_2O_5 ha^{-1} to 2 irrigated maize hybrids grown on chernozem soil increased the 4 – year average grain yields from 6.06 to 7.76, 8.51 and 9.02 t ha^{-1}, respectively and increased grain protein content. Maize protein content was increased with higher N rates in the NPK fertilizer and N increase4d mostly the Zein factor of protein. The factional and amino acid composition of the protein was increased by applying Zn (Getmanets and Klyavzo, 1981). The protein quality of some improved hybrids would be only slightly changed by late application of N, whereas their protein quantity would be increased considerably (Zink 1979).

Karastan and Babushkin (1981) reported that application of 60 t + FYM + 60 kg N + 60 kg P_2O_5 + 60 kg K_2O or 120 kg N + 60 kg P_2O_5 + 90 kg K_2O ha^{-1} increased average grain yields from 4.74 to 6.63 t ha^{-1} and increased grain N, protein and P contents. The liquid manure is the most efficient in plant nutrition as compared with semi – liquid and litter manures. The quantity of protein increased under the effect of fertilizers (Lyatsyaga and Tarazevich 1994). Maize cv. Ganga5 given 0, 5, 7.5 or 10 t slurry ha^{-1}, respectively, compared with 1.78, 1.96 and 2.20 t ha^{-1} from treatments given 0, 50 or 100 kg mineral N ha^{-1}. Grain CP content increased with an increase in slurry and N rates (Pawar *et al.*, 1991). Maize yield was increased by 12% by FYM and 1.2% by fertiliz3ers. All the ways of increasing soil fertility showed significant effects on increasing protein, starch, fat and amino acids in the crop seed (Wang *et al.*, 1994).

Anonymous (1977) reported that grain yield and CP content increased with increasing N rate but grain size and number of ears/plant were not affected. The response of maize cv. Hybrid 19 to 30, 45, 60, 75 or 90 kg N/feddan was investigated. N application increased the total and protein N contents of the grain. The method of N application had no significant effect on the soluble and protein N content of the grain. However, there was some increase in protein N in the split dressing treatment (Moursi and Saleh, 1980).

From the reviews presented in this chapter, it is evident that appropriate manuring and split application of nitrogen are important for good yield and improved quality, particular protein content of maize. However the effect of both the factors may vary from place to place for different edaphic and biotic factors.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

An experiment was conducted at the Agronomy field of Sher-e- Bangla Agricultural University, Dhaka, during the period from March to June 2006 to study the effect of manuring and split application of nitrogen on grain yield and quality of maize cv. Barnali.

3.1 Experimental treatments

The experiment included four fertilization treatments and two split application of nitrogen. The treatments were as follows:

Manurial doses – 4

M_1 = inorganic fertilizer (IF) only
M_2 = IF + cowdung 5 t ha^{-1}
M_3 = IF + cowdung 10 t ha^{-1}
M_4 = IF + cowdung 15 t ha^{-1}

Split application of nitrogen – 2

Sp_1 = 2 split application
Sp_2 = 3 split application

In IF, inorganic fertilizers were applied as per BARC (1989) recommendations. The doses of fertilizer and method of application have been described in section 3.6 (fertilizer application) of this chapter.

3.2 Design of the experiment

The experiment was laidout in a split – plot design with three replications assigning fertilization treatments to main plots and split application of nitrogen to subplots at random. The space between blocks, main plots and subplots were 1m, 1m and 0.5m in each case respectively. The size of unit plot was 5m × 3m. The total number of unit plots were 24.

3.3 Procurement of seed

Seeds of maize variety Barnali were procured from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Barnali is a high yielding variety, resistant to most insects and diseases and possesses other characteristics of modern maize variety.

3.4 Land preparation

The experimental field was opened on 16, March 2006. individual plots were prepared by repeated spading until the soil achieved a good tilth and ready for sowing. Weeds and stubble were removed and the plots were leveled.

3.5 Lay out of the experiment

The experiment was laid out on 21, March 2006 according to the experimental design. The field was divided into 3 blocks to represent 3 replications. Each block was divided into 4 main plots to accommodate the manurial treatments and each main plots into 2 subplots, to accommodate the split applications of nitrogen treatments.

3.6 Fertilizer application

The land was fertilized as per treatment specifications. Nitrogen, phosphorus, potassium, and sulphur were applied through urea (46% N), triple superphosphate (TSP, 48% P_2O_5), muriate of potash (MP, 60% K_2O), and gypsum (18.6% S), respectively.

Rates of different nutrient eliments were as follows:

N – 115 kg ha^{-1}
P_2O_5 – 72 kg ha^{-1}
K_2O – 60 kg ha^{-1}
Sulphur – 22.32 kg ha^{-1}

In Sp_1 and SP_2, urea was applied in 2 and 3 equal splits, respectively. The whole quantity of TSP, MP, gypsum and first dose of urea were applied as basal dose during final land preparation. In 2 split application of N, the rest of urea was applied in two equal installments at after 25 and 45 days after sowing DAS. In 3 split application of N, the rest of urea was applied in three equal splits at 25, 45 and 65 DAS.

Rates of organic fertilizer were cow-dung at 0, 5, 10 and 15 t ha^{-1}. Cow-dung was incorporated with the soil during final land preparation.

3.7 Sowing of seed

Seeds were sown on 22, March 2006 by hand drilling at a depth of 4 – 6 cm in 75 cm apart furrows. There were 4 rows per plot. Within a row, hills were spaced 25 cm apart and three seeds were sown per hill. A seed rate of 30 kg ha^{-1} was used as per recommendation by BARI (1993).

3.8 Weeding and thinning

Weeding was done three times, first at 25 DAS, second at 45 DAS and third at 70 DAS. Thinning was done at 25 DAS. One healthy plant was retained and the other plants were removed.

3.9 Irrigation

The plot was irrigated one time during the growing period of crop. Irrigation was applied at 42 DAS.

3.10 Insects and disease control

There was no major incidence of insects or diseases. So, no pest control measures were adopted in the experiment. The experimental crop was grown with proper care and management.

3.11 Harvesting and processing

The experimental crop was harvested plot-wise at maturity on 27 June 2006. Ten plants were randomly selected from each plot at harvesting for collection of data on plant characters and yield components. The harvested crop of each plot was bundled separately, tagged and taken to the threshing floor. These were dried in bright sunshine, threshed and the grains were cleaned properly. Grain and straw were thoroughly dried before their weights were recorded.

3.12 Collection of experimental data

Data on the following plant characters and yield components were collected from the sample plants of each plot:

1. Plant height (cm)
2.Number of cobs/plant
3.Cob length (cm)
4.Circumference of cob (cm)
5.Number of grains/plant
6.1000 – grain weight (g)
7.Grain weight/plant (g)
8.Stalk weight/plant (g)

Grain and stalk yields per plot were recorded properly and converted to tons per hectare. Grain samples were oven dried overnight, ground in a grinding machine and approximately 10 g for grain and stalk were preserved separately in polythene bags for chemical analysis in the Soil Resources Development Institute (SRDI), Dhaka.

3.13 Collection of data on quality attributes

The grain and stalk samples were analyzed for the determination of nitrogen, phosphorus, potassium and protein contents. The procedure for chemical analysis were as follows:

a) Nitrogen

Nitrogen contents of the grain and stalk were determined by micro – kjeldahl method after digestion with conc. H_2SO_4 , digestion tablet ($CUSO_4$ + Selenium mixture) and then distillation with 40% NaOH solution. The ammonia distilled over was absorbed in H_3BO_3 indicator solution and titrated with 0.01N H_2SO_4. The results were expressed in percentage.

b) Phosphorus

The phosphorus in the digest was determined by developing the yellow colour by adding ammonium molybdate, ammonium vanadate (Barton/s solution) and measuring the colour with the help of a spectrophotometer at 440 mu (Chapman, 1961). The results were expressed in percentage.

c) Potassium

potassium content in maize grain and stalk were determined with the help of flame photometer after digesting the samples with conc. HNO_3. The results were expressed in percentage.

d) Protein

Protein contents in grain and stalk of maize were determined by multiplying the nitrogen contents of grain and stalk, respectively, by 5.85. The results were expressed in percentage.

3.14 Statistical analysis

The collected data were analyzed statistically using the "Analysis of variance" technique and mean differences among the treatments were adjudged by Duncun's Multiple Range Test (DMRT) and Least Significant Difference (LSD) test where necessary.

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The present study was undertaken to find out the effect of manuring and split application of nitrogen on yield, yield components and quality of maize. To measure the yield and yield components of maize, the characters studied were plant height, number of cobs per plant, cob length, circumference of cob, number of grains per plant, 1000 grain weight and to measure the quality of maize, the parameters studied were N content (%), P content (%), K content (%) and protein content (%) in both grain and stalk of maize.

Results of the present study have been presented and discussed in this chapter. The summary of analysis of variance of various plant characters/parameters studied have been presented in the appendices 3 through 6. Manuring effects on various plant characters/parameters under study have been shown in Table 1. The effect of split application of N and the interaction effect of manuring and split application of N on the studied parameters have been presented in Table 2 and Figs 1 through 4. Manuring and split application of N and their interaction effect on the parameters studied to measure yield and yield components have been presented in Table (3 through 5) and Figs. 5 through 10 and the parameters studied to measure the quality of maize have been shown in Tables 6 and 7 and figs. 11 through 14.

4.1 Effect of manuring on various plant characters

Results on summary of analysis of variance of various plant characters indicated that manuring exhibited significant influence on all plant characters of maize under study except cob circumference at 1% level of probability whereas plant height and cob length were affected at 5% level of probability (Appendix 3).

It revealed from the Table 1 that out of 4 levels of manure the level of M_4 (Inorganic fertilizer + cowdung 15 t ha^{-1}) showed significantly the highest influence on the three parameters viz. plant height, number of cobs per plant and cob length. Plant height for different treatments ranged from 225.67 cm to 235.83 cm of which the highest one (235.83 cm) was recorded from M_4 (IF + cow-dung 15 t ha^{-1}) treatment, which was similar to 230.17 cm obtained from M_3 (IF + cow-dung 10 t ha^{-1}) but higher than 226.67 cm and 225.67 cm obtained from M_2 (IF + cow-dung 5 t ha^{-1}) and M_1 (IF + cowdung 0 t ha^{-1}) respectively, while the later three values of heights (M_1, M_2 and M_3) were similar to each other. These results indicated that organic manure particularly cow-dung at 15 t ha^{-1} increased plant height significantly. Similar results were also reported by Malhotra and Khehra (1986), Prosad *et al.* (1985). Jovin (1996), Mar *et al.* (2003) and Nazarat and Nawaz. *et al*. (2004).

Table 1 : Effect of manuring on various plant characters of maize

Fertilization	Plant height (cm)	Number of Cobs/plant	Cob length (cm)	Circum. of cob (cm)
M_1	225.67	1.03	19.99	13.26
M_2	226.67	1.08	20.86	12.96
M_3	230.17	1.23	20.56	12.79
M_4	235.83	1.32	22.00	12.89
LSD (0.05)	7.759	0.1743	1.282	---
CV	1.67%	14.17%	3.45%	4.31%

M_1 = Inorganic fertilizer (IF) only, M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1} , M_4 = IF + cow-dung 15 t ha^{-1}

The results showed that application of cow-dung up to 15 t ha^{-1} increased cob length significantly. Of course there was progressive increase of cob length with each increase of cow-dung dose which was supported by Nazakat and Nawaz *et al.* (2004).

In respect of number of cobs $plant^{-1}$, the highest number (1.32) which was obtained from M_4 was statistically similar to 1.23 obtained from M_3 but it was statistically different from 1.03 and 1.08 obtained from M_1 and M_2 respectively. From the results it was observed that there was progressive increment in number of cob $plant^{-1}$ with the increase of cowdung dose. This agreed with the findings of Nimije and Seth (1988) and Nyamangara *et al.* (2003).

In cob length as revealed from the Table-1 M_4 produced statistically the longest cob (22 cm) which was similar to 20.86 cm obtained from M_2 but was significantly different from 19. 99cm and 20.56 cm, the cob lengths obtained from M_1 and M_3 respectively. The results showed that application of cowdung up to 15 t ha^{-1} increased cob length significantly. Of course there was progressive increase of cob length with increase of cow-dung which was supported by Nazakat and Nawaz *et al.* (2004).

In circumference of cob, numerically 13.26 cm obtained from M_1 was the highest, which was followed by 12.96 cm 12.69 cm and 12.79 cm obtained respectively from M_2, M_4 and M_3.

4.2 Effect of split application of nitrogen (N) on various plant characters of Maize

Split application of nitrogen had profound effect on various plant characters studied as was revealed from Appendix-3 and table-2. SP_2 i.e. 3 split application of nitrogen recorded higher values than SP_1 i.e. 2 split application in all the characters. Higher values were as such 232.17cm. 1.23, 21.05 cm and 13.32 cm obtained respectively in the characters of plant height, number of cobs plant^{-1}, cob length and circumference of cob where the corresponding significantly lower values obtained in SP_1 were 227.00 cm, 1.07, 20.66 cm and 12.63 cm respectively.

Compared to SP_1 nitrogen loss might be less in SP_2 which resulted in more protein and carbohydrate accumulation in the plant parts. As a result there were higher records of values in SP_2 for different plant characters under study. Similar views were shown by Albinet (1978), Decau (1978) and Albinet (1986).

Table 2. Effect of split application of nitrogen on various plant characters of maize

Treatment	Plant height (cm)	Number of cobs/plant	Cob length (cm)	Circum. of cob (cm)
SP_1	227.00	1.07	20.66	12.63
SP_2	232.17	1.23	21.05	13.32
LSD (0.05)	1.568	0.077	0.293	0.228

SP_1 = 2 split application of nitrogen, SP_2 = 3 split application of nitrogen

4.3. Effect of interaction of manuring and split application of N on various plant characters of maize

Interaction effect of manuring and split application of N could not show any significant effect on any one of the studied characters of Maize. Plant height as revealed from the Fig. 1 ranged from 224.33 cm to 239 cm, the highest value (numerically) was followed by 235.33 cm, 232.67 cm, 229 cm, 226 cm, 225.33 cm, 225 cm and 224.33 cm being found respectively from the interaction M_4SP_2, M_3SP_2, M_4SP_1, M_2SP_2, M_3SP_1 and M_2SP_1 respectively.

Number of cobs plant^{-1} varied from 0.9 to 1.5 in which the highest one was observed from the highest level of interaction M_4SP_2 and the lowest one from the lowest level of interaction M_1SP_1 (Fig. 2).

In the cob length numerically the highest length (22.65) was observed from treatment M_4SP_2 and the lowest length (19.76 cm) was observed from the treatment M_1SP_2 (Fig. 3).

Variation in circumference of cob (Fig. 4) was very little. It ranged from 12.04 cm to 13.74 cm where the highest one was observed from M_4SP_2 but the lowest one was observed from M_4SP_1.

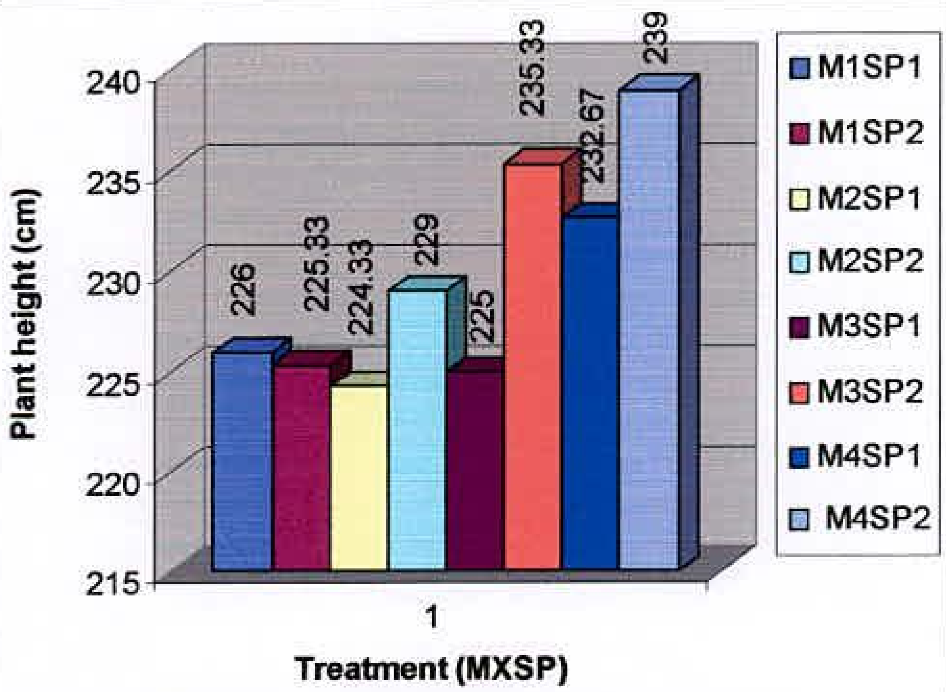


Fig. 1.Effect of interaction of manuring and split application of nitrogen on plant height of maize (LSD = 0.05NS)

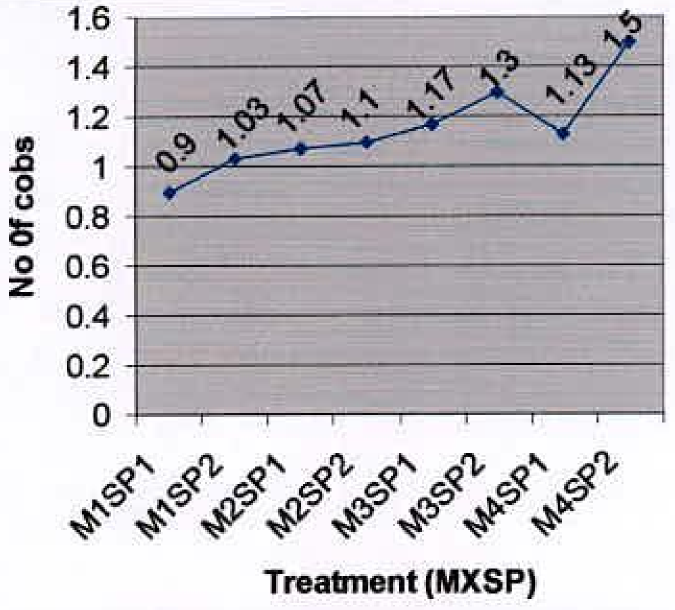


Fig. 2.Effect of interaction of manuring and split application of nitrogen on number of cobs/plant of maize (LSD = 0.05NS)

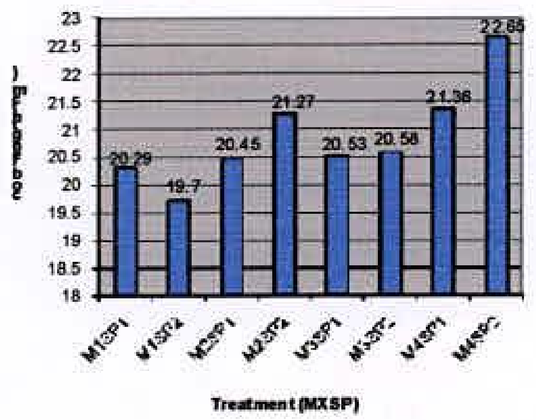


Fig.3.Effect of interaction of manuringand split application of nitrogenon cob length of maize (LSD= 0.05NS)

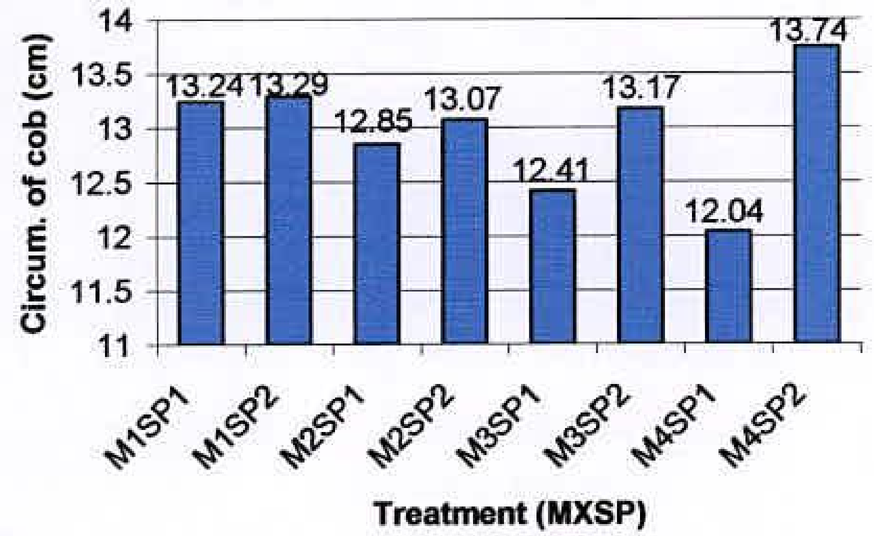


Fig 4.Effect of interaction of manuring and split application of nitrogen on circum. of cob of maize (LSD = 0.05NS)

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1}

M_4 = IF + cow-dung 15 t ha^{-1}

SP_1 = 2 split application of nitrogen

SP_2 = 3 split application of nitrogen

4.4 Effect of manuring on yield and yield components of maize

Summary of analysis of variance Table (Appendix 4) revealed that with each increment of per hectare manurial dose (cow-dung) there was significant variation in the grain and stalk yield as well as in the yield components viz no of grains $plant^{-1}$, 1000 grain weight, grain weight $plant^{-1}$ at 1% level of probability. M_4 treatment revealed significantly the highest value in all the above parameters. Eeach successive increment of per hectare manurial dose caused significant variation in the no of grains $plani^{-1}$ M_4 treatment as revealed from Table. 3 produced the highest (515.00) number of grain $plant^{-1}$ which was followed by 491.00, 470.67 and 457.50 obtained from the successive treatments viz M_3, M_2

and M_1 respectively . This increment of grain number $plant^{-1}$ was happened due to the effect of additional manure in each treatment. The combined effect of N and manure caused addition of N on plant which resulted in the increment of number of grains $plant^{-1}$. The result was in agreement with the findings of Khanday *et al.* , (1993). Similar findings were reported by Khanday and Thakur (1991), Konzen *et al.* (1990) and Liang, S. C. *et al.* (1996).

Table 3 : Effect of manuring on yield and yield components of maize

Fertilization	Number of grain/plant	1000-grain wt (g)	Grain wt/plant (g)	Stalk wt/plant (g)	Grain yield (t/ha)	Stalk yield (t/ha)
M_1	457.50	280.21	123.83	247.83	5.43	9.02
M_2	470.67	288.50	135.17	267.17	5.69	10.40
M_3	491.50	293.85	133.50	265.50	5.83	11.22
M_4	515.00	334.60	144.33	278.33	6.76	12.16
LSD(0.05)	11.71	15.26	5.973	5.733	0.3338	1.40
CV (%)	1.781	1.60	4.06	1.41	2.72	5.72

M_1 = Inorganic fertilizer (IF) only, M_2 = IF + cow-dung 5 t ha^{-1}
M_3 = IF + cow-dung 10 t ha^{-1} . M_4 = IF + cow-dung 15 t ha^{-1}

The highest 1000 grain weight 334.6g obtained from M_4 treatment was significantly different from 293.85g, 288.5g and 280.21g obtained from M_3, M_2 and M_1 treatments respectively but later three 1000 grain weights were similar to one another.

The highest grain weight plant^{-1} (144.33g) which was observed in M_4 (Table. 3) was significantly higher than 135.17g, 133.50g and 123.83g observed respectively from the treatments M_2, M_3 and M_1, the last one being significantly the lowest, while M_2 and M_3 treatments were similar to each other. These results indicated that application of cow-dung at the rate of 10 and 15 t ha^{-1} increased 1000 grain weight. Similar results were reported by Hung *et al.* (1992).

Similar findings were also observed in stalk weight plant^{-1} (Table 3). The highest stalk weight plant^{-1} (278.33 g) was observed in M_4 which was significantly different from the stalk weight of 265.5g, 267.17g and 247.83g obtained respectively from M_3, M_2 and M_1 treatments the last one being the lowest and statistically being different from those of M_3 and M_2 while the later two were similar to each other.

Grain yield of 6.76 t ha^{-1} obtained from M_4 treatment as revealed from Table 3 was the highest and was significantly different from the yield 5.83 tha^{-1}, 5.69 t ha^{-1} and 5.43 t ha^{-1} respectively obtained from M_3, M_2 and M_1 treatments while 5.43 t ha^{-1} the lowest grain yield obtained form M_1 which was statistically lower than 5.83 t ha^{-1} obtained from M_3 but was identical to M_2 while the later was identical to M_3 . In this study the highest grain yield came from M_4 (IF + cow-dung 15 t ha^{-1}) which was the result of superior performance of all yield components due to the treatment. These results indicated that application of organic manure in the form of cow-dung at the rate of 15 tha^{-1} in addition to recommended dose of inorganic fertilizers increased grain yield over inorganic fertilizers alone. Similar results were observed by Nimije and Seth (1986), Li *et al.* (1995), Balik *et al.* (1995), Merzlaya *et.al.* (1995), Jung T. C. (1993), Jakela W. E. (1992), Smaling *et al.* (1992) and Karastan, D. I. and Babushkin, Y. V. (1981).

In stalk yield of maize (Table. 3) M_4 produced the highest yield of 12.16 t ha^{-1} which was similar l with 11.22 t ha^{-1} obtained from M_3, while the later was at per with 10.40 t ha^{-1} of M_2 but was significantly higher than 9.02 t ha^{-1} of M_1 treatment. The highest and lowest stalk yield from M_4 and M_1 treatments were the result of superior and inferior performance of plant height and stalk weight per plant from these two treatments. These results showed that application of organic manure increased stalk yield over control. This finding is in support of Lyastsyaga, and Tarazevich. (1994).

4.5 Effect of split application of nitrogen on yield and yield components of maize

Yield and yield components of maize were found to be significantly influenced by split application of nitrogen (Table 4). Significantly higher values obtained from SP_2 for yield and yield components were 6.14 t ha^{-1}, 11.1 t ha^{-1}, 494.75g, 308.21g, 141.17g, and 274.00g wheres the corresponding lower values in SP_1 were 5.71 t ha^{-1}, 10.33 t ha^{-1}, 472.58g, 290.38g, 127.25g and 255.42g obtained for grain yield, stalk yield, numbers of grains $plant^{-1}$, 1000- grain weight, grain weight per plant and stalk weight per plant, respectively. As nitrogen accumulation was more in different plant parts due to its 3 times application, so there was cumulative effect in producing higher yield in SP_2 both in grain and stalk. Similar effect was found by Nandal and Agrawal (1988). Maidal and Fishbeck (1990) reported that 50% of 120 kg N ha^{-1} applied in rows at sowing and 50% broadcast at 20 cm height gave significantly higher yields 10 t ha^{-1} than applied without split (8.59 t ha^{-1}).

Table 4 . Effect of split application of nitrogen on yield and its components of maize

Nitrogen application	Number of grain/plant	1000-grain wt (g)	Grain wt/plant (g)	Stalk wt/plant (g)	Grain yield (t/ha)	Stalk yield (t/ha)
SP_1	472.58	290.38	127.25	255.42	5.71	10.30
SP_2	494.75	308.21	141.17	274.00	6.14	11.10
LSD (0.05)	3.5188	1.948	2.225	1.527	0.18	0.249

SP_1 = 2 split application of nitrogen, SP_2 = 3 split application of nitrogen

4.6 Effect of split application of nitrogen on N, P, K and protein contents of grain and stalk

Like yield and yield components and plant characters of maize, SP_2 also showed remarkably higher values for quality of crop except P content(%) both in grain and stalk (Table 5). N, K and protein contents were increased by 1.18%, 0.11%, and 1.09% , respectively in grain and 0.8%,0.27% and 0.47% in stalk while P content was decreased by 0.01% in grain and increased by 0.02% in stalk. This result was in conformity with those represented by Sing and Dubey (1994), Badiyala and Verma (1991), Gupta and Gautom (!994), Paradher and Sharma (1993) and Liang *et al.* (1996). Shanti *et al.* (1996) carried out a field experiment in Maize applying N at 3 split-basal, knee high and pre-tasseling and observed that split application not only increased yield but also improved quality of grain as evident from the higher protein content. Similar results were also observed by Silva *et al.* (1993), Carmet *et al.* (1990), Bataev and mogomedov (1991).

Brar and Khehra (1997) reported that split application of N significantly increased yield compared to a single application at sowing and yield increased with increasing amount of application, 3 split application are recommended on sandy loam soil.

Sharma and Thakar (1995) carried out a field trail on maize cultivation applying N in 3 equal split at sowing, knee high and pre-tasselling stage (recommended time of application) and found average grain yield increased with the increase of nitrogen and was the highest when applied in 3 recommended split applications.

Table 5. Effect of split application on N, P, K and protein contents of grain and stalk of maize.

Nitrogen application	N content (%)		P content (%)		K content (%)		Protein content(%)	
	Grain	Stalk	Grain	Stalk	Grain	Stalk	Grain	Stalk
SP_1	1.88	0.84	0.15	0.12	0.5	2.18	10.98	4.91
SP_2	2.06	0.92	0.14	0.14	0.61	2.45	12.07	5.38
LSD(0.005)	0.022	0.063	0.060	0.638	0.012	0.046	0.252	0.341

SP_1 = 2 split application of nitrogen, SP_2 = 3 split application of nitrogen

4.7 Effect of interaction of manuring and split application of nitrogen on yield and yield components of maize

Interaction effect of manuring and split application of nitrogen caused variation in 1000 grain at 1% level of probability but grain yield ha^{-1} and stalk weight $plant^{-1}$ at 5% level of probability. The interaction could not keep significant influence on other yield components of maize (Appendix-4).

In the number of grains plant^{-1} (Fig.5) the interaction effect was insignificant. Numerically the highest number of grains plant^{-1} was recorded in M_4SP_2 as 530, which was followed by 500, 483, 480.67 468.33 and 460.67 obtained, respectively from the treatments M_4SP_1 and M_3SP_2 M_3SP_1 M_1SP_2 M_2SP_2 and 446.67 and the lowest one was obtained in M_1SP_1 (Fig. 5).

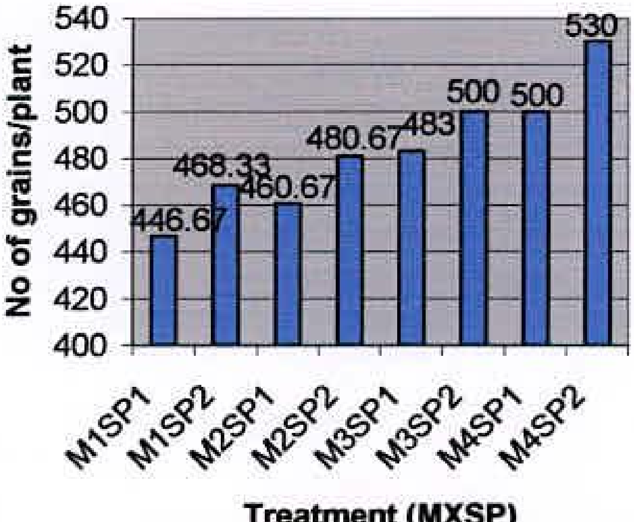


Fig. 5. Effect of interaction of manuring and split application of nitrogen on number of grain/plant of maize (LSD = 0.05NS)

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1}

M_4 = IF + cow-dung 15 t ha^{-1}

SP_1 = 2 split application of nitrogen

SP_2 = 3 split application of nitrogen

Interaction effect caused significant variation in 1000 grain weight (Fig 6). The interaction between 15 ton cow-dung ha^{-1} and 3 split application of nitrogen

(M_4SP_2) produced 357.7 g of 1000 grain weight which was significantly different from all the other 1000 grain weights found in the rest different interaction treatments. Next highest 1000 grain weight (311.5g) found from the treatment M_4SP_1 was similar with 1000 grain weight of 298.70 and 296.00 got from the treatments M_3SP_2 and M_2SP_2 while the later (296g) was at par with 289g, 281.00g, 280.43g and 280.00g, obtained respectively from M_3SP_1, M_2SP_1 M_1SP_2 and M_1SP_1 (the interaction giving the lowest 1000 grain weight). The result indicated that 3 split application of nitrogen caused efficient use of nitrogen and as such the combined effect of highest amount of cow-dung (M_4) and nitrogen might have caused more production of protein and carbohydrate in the grain. This was further evidenced from the lowest 1000 grain weight 280g where 1000 grain weight was obtained from the interaction of 0 level cow-dung and 2 split application of nitrogen.

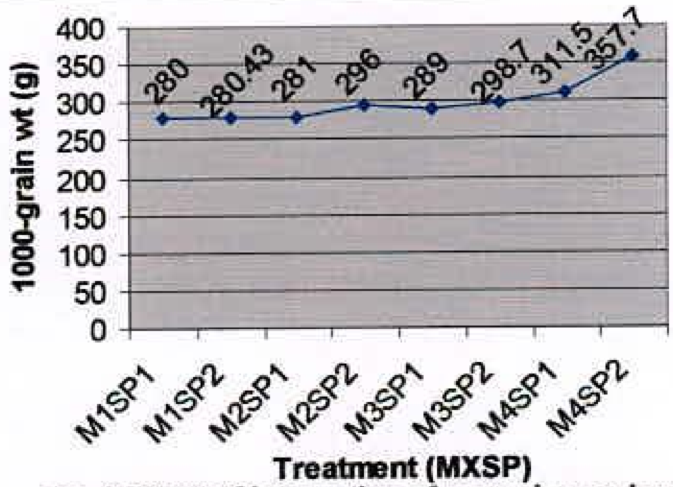


Fig. 6.Effect of interaction of manuring and split application of nitrogen on 1000 grain wt/plant of maize

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1}

M_4 = IF + cow-dung 15 t ha^{-1}

SP_1 = 2 split application of nitrogen

SP_2 = 3 split application of nitrogen

Grain weight plant^{-1} was not varied significantly due to the interaction effect of manuring and split application of nitrogen (Fig. 7). The interaction of cow-dung at 15 t ha^{-1} and 3 split application of nitrogen gave numerically the highest (156g) grain weight plant^{-1} , which was followed by 143.3g, 140g, 132.67g, 127g, 125.33g and 122.33g obtained respectively from the treatments M_2SP_2, M_3SP_2, M_4SP_1, M_3SP_1 and M_2SP_1, M_1SP_2 and M_1SP_1, last one being the lowest. The highest level of cow-dung and 3 split application of nitrogen though increased 37% grain weight plant^{-1} from the control treatment but it was not statistically significant (Fig. 7).

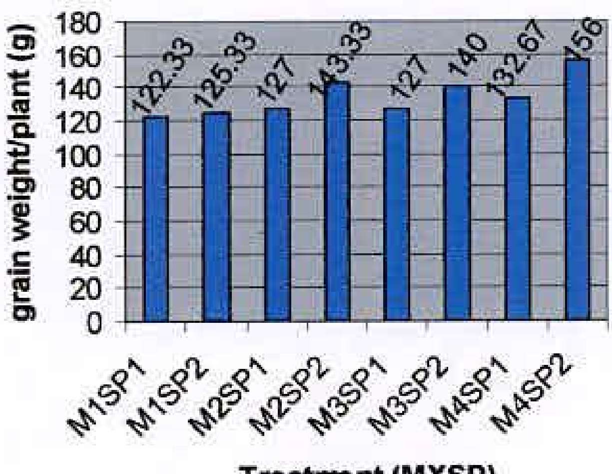


Fig. 7.Effect of interaction of manuring and split application of nitrogen on grain wt/plant of maize (LSD = 0.05NS)

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1}

M_4 = IF + cow-dung 15 t ha^{-1}

SP_1 = 2 split application of nitrogen

SP_2 = 3 split application of nitrogen

Significant variation in grain yield was observed with the interaction effect of manuring and split application of nitrogen (Fig. 8). Like the parameter 1000 grain weight plant^{-1}, the combination of highest level of manuring and 3 split application of nitrogen produced the highest grain yield (7.19 t ha^{-1}) which was significantly different from the other values of grain yield obtained from the other different interaction treatments. The highest level of cow-dung interacting with 2 split application of nitrogen gave the second highest grain yield (6.33 t ha^{-1}) which was statistically lower than 7.19 t ha^{-1} but was significantly different from the other values of grain yield ha^{-1} obtained from the different interaction treatments. The 3rd level of cow-dung i.e. 10.0 t ha^{-1} along with 3 split application of nitrogen recorded the 3rd highest grain yield (6.00 t ha^{-1}) which was at par with 5.83 t ha^{-1} obtained from M_2SP_2 but it was statistically higher than 5.66 t ha^{-1} and 5.55 t ha^{-1} obtained from M_3SP_1 and M_2SP_2 while 5.31 t ha^{-1} obtained from M_1SP_1 was the lowest yield which was similar with 5.55 t ha^{-1} but statistically lower than all other values of grain yield.

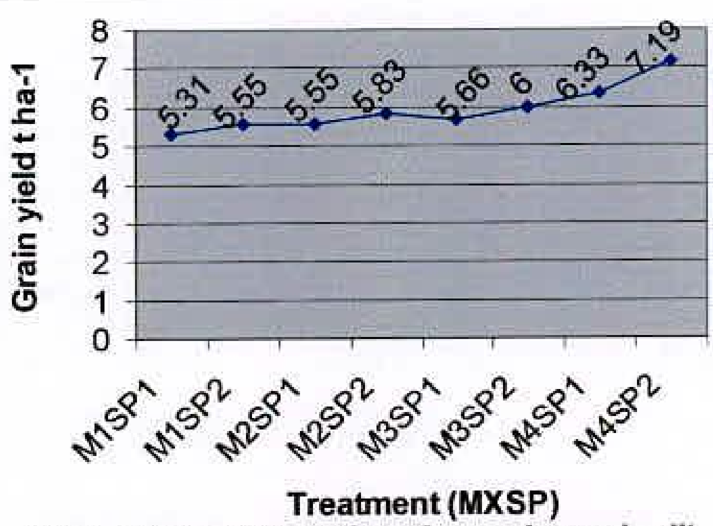


Fig.8. Effect of interaction of manuring and split application of nitrogen on grain yield of maize LSD (0.05)=0.3036*

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1} SP_1 = 2 split application of nitrogen

M_3 = IF + cow-dung 10 t ha^{-1} SP_2 = 3 split application of nitrogen

M_4 = IF + cow-dung 15 t ha^{-1}

4.8 Effect of interaction of manuring and split application of nitrogen on stalk weight plant^{-1}

Variation in interaction of cow dung rate and split application of nitrogen showed significant effect on stalk weight plant^{-1} (Appendix-4). Cow-dung at the rate of 15tha^{-1} along with three split application of nitrogen (M_4SP_2) showed the highest stalk weight plant^{-1} (288.33 g) which was statistically similar to 281.33g recorded from interaction of cow-dung 5t ha^{-1} and two split application of nitrogen (M_2SP_2). But it was significantly higher than the values of stalk weight plant^{-1} obtained from the rest different interaction treatments. The rest values range from 271.67g to 241g. Stalk weight plant^{-1} (271.67g) obtained respectively from the treatment M_3SP_2 was statistically similar to 268.33g found from M_4SP_2 which values was statistically higher than 259.33g, 254.67g and 253g obtained respectively from the treatments M_3SP_1, M_1SP_2 and M_2SP_1 and the value of stalk weight plant^{-1}(241g) was significantly the lowest being obtained from the interaction of 0 t cowdung ha^{-1} + 2 split application of nitrogen (M_1SP_1).

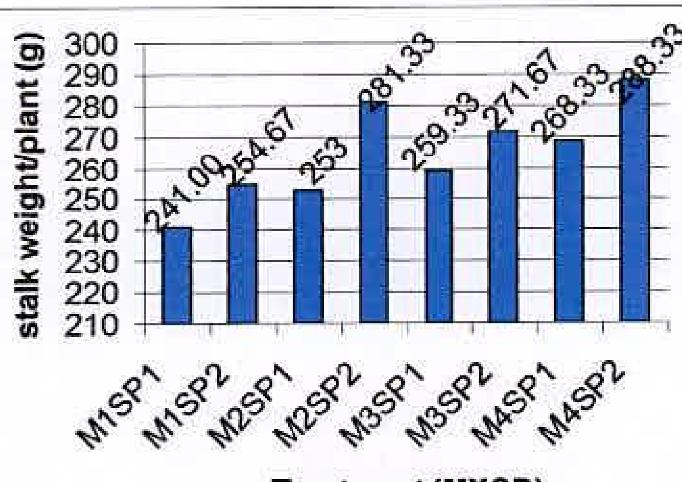


Fig. 9.Effect of interaction of manuring and split application of nitrogen on stalk wt/plant of maize LSD (0.05)=7.046*

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cowdung 5 t ha^{-1} — SP_1 = 2 split application of nitrogen

M_3 = IF + cowdung 10 t ha^{-1} — SP_2 = 3 split application of nitrogen

M_4 = IF + cowdung 15 t ha^{-1}

4.9 Effect of interaction of manuring and split application of nitrogen on stalk yield ha^{-1}

Interaction effect could not keep any significant influence on per hectare stalk yield though there was significant effect on stalk weight $plant^{-1}$(Fig. 9). The reason might be explained in this way that in stalk weight $plant^{-1}$, the area was very small and here difference between two treatments was expressed in gram i.e. a small quantity but in stalk yield ha^{-1} the area was very large and the difference between two treatments was expressed in ton which was a large quantity, so in the former area the variation was brought into notice but in the later case variation could not be brought into notice statistically. Numerically the highest stalk yield (12.64 t ha^{-1}) was observed in M_4SP_2 and the lowest (8.79 t ha^{-1}) was observed in M_1SP_1.

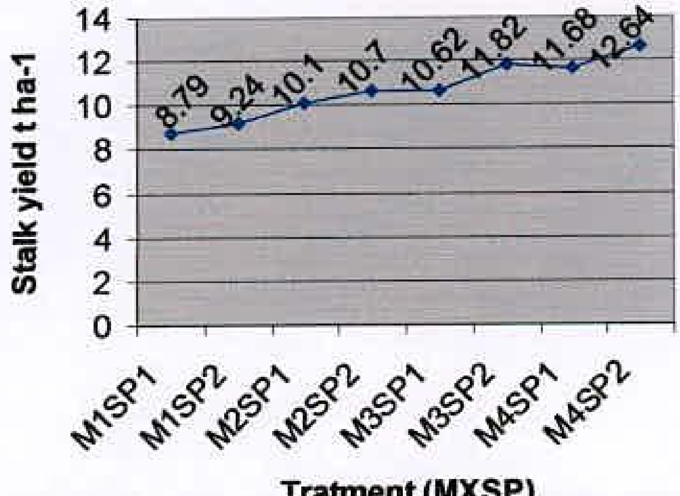


Fig. 10.Effect of interaction of manuring and split application of nitrogen on stalk yield of maize
LSD(0.05)NS

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1}

M_4 = IF + cow-dung 15 t ha^{-1}

SP_1 = 2 split application of nitrogen

SP_2 = 3 split application of nitrogen

4.10 Effect of manuring on N,P,K and protein content in grain and stalk of maize

Variation in manurial dose exerted significant difference at 1% level of probability in different nutrient content viz N, P, K and protein content both in grain and stalk of maize (Appendix- 5 and 6). Nitrogen content with M_4 (IF + 15 t cow-dung ha^{-1}) treatment was 2.25% which was significantly higher than those nitrogen content in grain of maize received from low level of manure than M_4 (Table 6). The second highest nitrogen content (1.94%) in grain of maize observed with M_2 (IF + 5 t cowdung ha^{-1}) was statistically similar to 1.88% N and 1.81% N obtained respectively from M_3 (IF + 10 t cowdung ha^{-1}) and M_1 (IF + 0 t cowdung ha^{-1}).

Table 6.Effect of manuring on N, P, K and protein contents of grain and stalk of maize.

Nitrogen application	N content (%)		P content (%)		K content (%)	
	Grain	Stalk	Grain	Stalk	Grain	Stalk
M_1	1.81	0.84	0.14	0.12	0.44	2.17
M_2	1.94	0.87	0.13	0.12	0.51	2.26
M_3	1.88	0.90	0.16	0.14	0.53	2.35
M_4	2.25	0.91	0.14	0.14	0.73	2.46
LSD(0.05)	0.174	0.018	0.018	0.018	0.581	0.129
CV (%)	5.37	1.64	11.27	10.05	6.71	4.88

M_1 = Inorganic fertilizer (IF) only , M_2 = IF + cow-dung 5 t ha^{-1}
M_3 = IF + cow-dung 10 t ha^{-1} , M_4 = IF + cow-dung 15 t ha^{-1}

In stalk of maize as revealed from the Table-6, M_4 (IF + 15 t cowdung ha^{-1}) gave similar response with that of M_3 (IF + 10 t cowdung ha^{-1}) where the nitrogen contents were respectively 0.91% and 0.90%. Nitrogen content 0.87% recorded with M_2 (IF + 5 t cowdung ha^{-1}) was statistically higher than 0.84% nitrogen content found in M_1 (IF + 0 t cowdung ha^{-1}). Bonquet *et al.* (1787) observed the similar findings in maize with increasing N rate.

From the above results it revealed that grain N content was higher in all manuring doses than those in stalk and it increased 115% to 147% in grain than in stalk. Further in both grain and stalk nitrogen content increased with the increase of manurial doses and in both the cases it was significantly lowest at M_1(IF + 0 t cowdung ha^{-1}) and was significantly highest at M_4 (IF + 15 t cowdung haa^{-1}).

This findings was in agreement with Sofi *et al.* (2004) and Okajima *et al.* (1983). Maia and Centarulli (2004) reported that continuous use of organic fertilizers provided an increase in total N reserve and availability of N while the chemical fertilizer had little influence on this character.

P content in maize grain became the highest (0.16%) with M_3 (IF + 10 t cowdung ha^{-1}) which was identical with 0.14% P obtained from both M_4 (IF + 15 t cow-dung ha^{-1}) and M_1 (IF + 0 t cowdung ha^{-1}) While M_2 (IF + 5 t cowdung ha^{-1}) gave significantly the lowest P content (0.13%) in grain. No significant variation observed among M_1, M_2 and M_4.

More or less similar content of P were found in grain and stalk. P content in stalk ranged from 0.12% to 0.14% where the former percent was obtained by both M_1 and M_2 treatment and the later was obtained from both M_4 and M_3.

Highest K content (0.73%) observed in M_4 was statistically superior to all other values of K content in grain obtained respectively in M_3, M_2 and M_1 treatments. Of course M_3 treatment gave 2^{nd} highest K% (0.53) in grain which was similar with 0.51% found from M_2 treatment. M_1 treatment obtained the lowest K% (0.44) in grain which was significantly lower than 0.51%.

In stalk, M_4 and M_3 gained similar K% viz 2.46 and 2.35 while the later was again statistically identical to the value of K content (2.26%) (Table 6). The lowest value of K 2.17 on M_1 was identical to 2.26% but was significantly lower than other values of K% in stalk. It revealed from the treatment effect that K% in stalk was almost 4 times higher that of grain and in both grain and stalk, K% increased proportionally with the increase of manure rate.

Protein content was reverse of K content as revealed from the Fig. 11 and Fig. 12. It was higher in grain than in stalk and it was almost double in grain than in stalk. It was observed from the Fig. 11 that grain protein% like N and K was highest (13.16%) in M_4 treatment while was significantly higher than those values obtained in M_3, M_2 and M_1 treatment. The respective values of protein content against the treatments were 10.99%, 11.36%, and 10.6% which were statistically identical to one another. Sokolov and Ekhtibarov (1985) conducted a field trail in maize with recommended dose of P + k and with 120 kg N ha^{-1} and obtained 11.4% protein in place of 6.5% protein with PK alone.

In stalk M_4 and M_3 treatments showed similar response in protein content obtaining respectively 5.31% and 5.26% which were similar to each other but each of them was significantly higher than those values found in M_2 and M_1 treatments while K% obtained in M_2 (5.06) and M_1 (4.93) were identical to each other. Other results indicated that the use of cow-dung at the rate of 10 to 15tha^{-1} in addition to recommended dose of inorganic fertilizer significantly increased the concentration of protein in grain and also in stalk. Huang-Shaowen et al. (2004) studied the effect of different rates of N fertilizer on grain yield and contents of protein and some acids and observed that N at the rate of 125 kg ha^{-1} produced highest quantity of best quality protein. Similar findings was also reported earlier by Oikeh *et al.* (1988), Zhang *et al.* (1994).

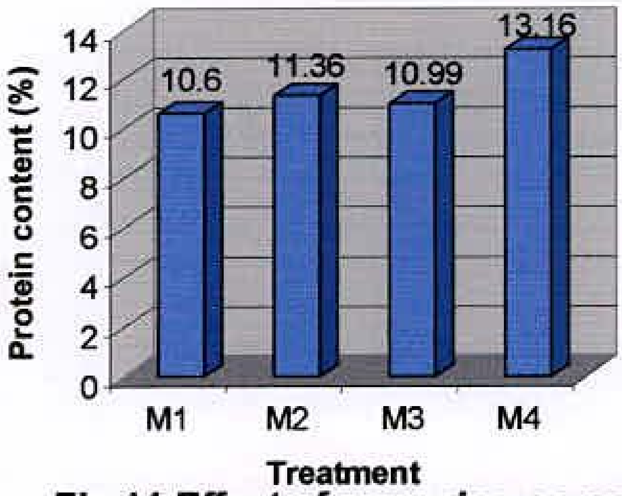
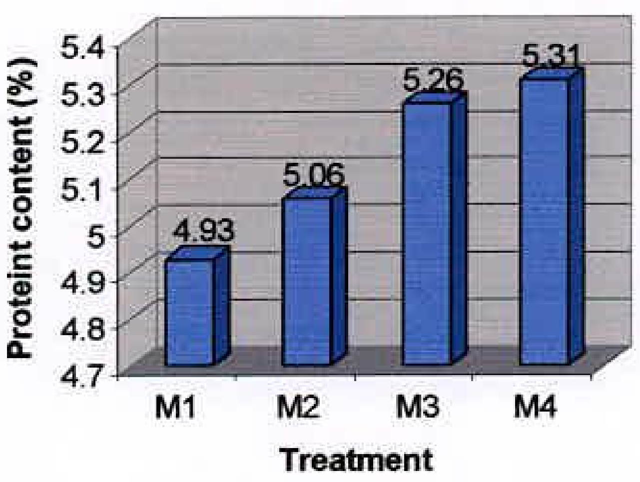


Fig.11.Effect of manuring on protein content of grain in maize LSD(0.05)=1.006**



Fig,12.Effect of manuringon protein content in stalk of maize LSD(0.05)=0.1537**

M_1 = Inorganic fertilizer (IF) only , M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1} , M_4 = IF + cow-dung 15 t ha^{-1}

4.11 Combined effect of manuring and split application of nitrogen on N, P, K and protein contents of grain and stalk of maize

Interaction of manuring and split application of nitrogen could not keep any significant effect on nitrogen and protein content of maize but it kept significant effect on P and K content of maize in grain only but not in stalk as revealed from (Appendix 5&6) and Table 7.

Table 7. Effect of interaction of manuring and split application of nitrogen on N, P, K and protein contents of grain and stalk of maize.

Interaction (MXSP)	N content(%)		P content(%)		K content(%)	
	Grain	Stalk	Grain	Stalk	Grain	Stalk
M_1SP_1	1.74	0.81	0.15	0.11	0.40	2.13
M_1SP_2	1.88	0.88	0.13	0.13	0.47	2.23
M_2SP_1	1.85	0.82	0.12	0.11	0.49	2.14
M_2SP_2	2.04	0.91	0.14	0.13	0.52	2.38
M_3SP_1	1.82	0.85	0.18	0.13	0.42	2.21
M_3SP_2	1.93	0.95	0.14	0.15	0.64	2.50
M_4SP_1	2.10	0.88	0.14	0.13	0.67	2.23
M_4SP_2	2.40	0.94	0.15	0.15	0.79	2.70
LSD(0.05)	---	---	0.0188	---	0.05954	---
CV (%)	5.37	1.64	11.27	10.05	6.71	4.88

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1}

M_4 = IF + cow-dung 15 t ha^{-1}

SP_1 = 2 split application of nitrogen

SP_2 = 3 split application of nitrogen

Manuring had significant effect on N content of maize in grain and in stalk but in combination with split application of nitrogen it could not keep significant effect on N content of both maize grain and stalk. It was because split application of nitrogen might not have contributed in the increase of nitrogen in maize rather it might have helped in the uptake of more phosphorus and potassium in maize grain. So it kept significant effect on P and K content of maize grain.

N content in maize under the interaction effect of manuring and split application of nitrogen varied from 1.74% to 2.4.0% where lowest value showed with the treatment M_1SP_1 and highest one showed with M_4SP_2 (Table-7). So it was evident from the result that increased level of manuring in interaction with nitrogen splitties helped in the increase of N content in grain. This finding was in agreement with Feng *et al.* (1993), and Getmanets, *et al.* (1981).

N content in stalk of maize under the influence of interaction ranged from 0.81% to 0.95% of which the lowest one was recorded against the treatment M_1SP_1 and the highest one was recorded against the treatment M_3SP_2. this finding was in support of Giardini. I. , (1986).

P content in maize grain varied significantly under the influence of interaction (Table. 7) and the variables ranged from 0.12% to 0.18% where the highest value which was observed with the treatment M_3SP_1 was significantly different from other values found with other treatments and the lowest value was obtained in maize grain with M_2SP_1. The second highest P content (0.15%) was found with both the highest level of treatment M_4SP_2 and the lowest level of treatment M_1SP_1. So the effect of these interaction was beyond explanation. The 2nd highest value (0.15%) of K found to be 0.14% which was identical with 0.13% obtained from M_4SP_1, M_2SP_2, M_3SP_2 and M_1SP_2 which were identical to one another lowest values and also identical with the lowest value of P concentration in grain obtained under the influence of interaction (M_2SP_1).

In stalk of maize P content as revealed from the Table.7 was almost similar with all the treatment and it ranged from 0.11% to 0.15%.

K content in grain of maize showed the similar response under the interaction influence of the treatment as was observed under individual treatment effect of manuring and split application of nitrogen. The interaction between highest level of individual treatments M_4SP_2 gave the highest concentration of K (0.79%) in maize grain. which was significantly different from other values of K concentration in grain. The second highest K content in maize grain was 0.67% found with M_4SP_1 that at a with 0.64% found from M_3SP_2. K content found with M_2SP_2 0.52% was the 4th highest and it was at a with 0.49% and 0.47% K found with M_2SP_1 and M_1SP_2 while the later value was statistically higher than 0.40% the lowest K concentration obtained from M_1SP_1.

K content on stalk of maize was almost 5 times higher than that in grain but the interaction effect could not cause significant variation in K uptake by the stalk of maize. K content in stalk varied from 2.13% to 2.70% the highest being found with M_4SP_2 and the lowest with M_1SP_1.

Karastan and Babushkin (1981) reported that application of FYM along with mineral nutrients increased grain yield and increased protein and P contents. The quantity of protein increased with an increase in slurry and N rates (Pawar *et al.* 1991). Wang *et al.* (1994) also reported that Maize yield was increased 12% by FYM and 1.2% by fertilizers. All the ways of increasing soil fertility showed significant effects on increased protein, starch, fat and amino acids in crop seeds.

Protein content both in grain and stalk of maize was not significantly varied with interaction influence. Nitrogen is a constituent of protein. As nitrogen uptake in both grain and stalk was not significantly influenced by the interaction effect, so protein content was not also significantly Influenced by the interaction effect.

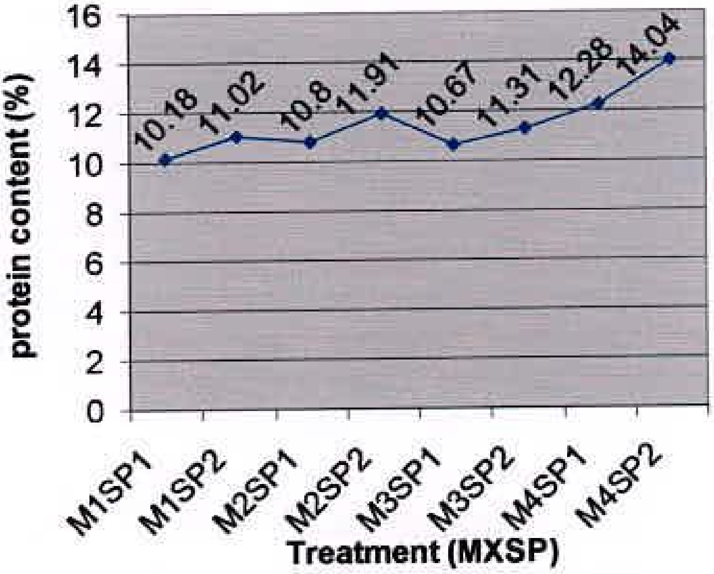


Fig.13. Effect of interaction of manuring and split application of nitrogen on protein content in grain of maize LSD(0.05)NS

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1}

M_4 = IF + cow-dung 15 t ha^{-1}

SP_1 = 2 split application of nitrogen

SP_2 = 3 split application of nitrogen

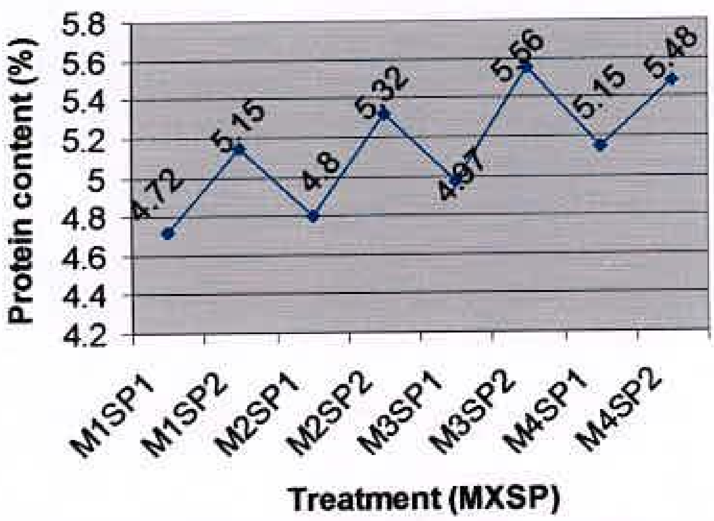


Fig.14.Effect of interaction of manuring and split application of nitrogen on protein content in stalk of maize. LSD(0.05)NS

M_1 = Inorganic fertilizer (IF) only

M_2 = IF + cow-dung 5 t ha^{-1}

M_3 = IF + cow-dung 10 t ha^{-1}

M_4 = IF + cow-dung 15 t ha^{-1}

SP_1 = 2 split application of nitrogen

SP_2 = 3 split application of nitrogen

With all interaction treatment, protein content in grain was almost double than that in stalk. Protein content in grain ranged from 10.18% to 14.04%, the highest being observed with the treatment M_4SP_2 and the lowest being with M_1SP_1 14.01% was further followed by 12.28%, 11.91%, 11.31%, 11.02% 10.80% 10.67% and 10.18% being found with the treatments M_4SP_1, M_2SP_2, M_3Sp_2, M_1SP_2, M_2SP_1, M_3SP_1 and M_2SP_1. respectively. Protein content in stalk varied from 5.48% to 4.72%, the interaction influence in the uptake of protein was more or less similar to that of grain. The highest was showed by the treatment M_4SP_2 and the lowest by M_1SP_1.

Chapter 5
Summary and conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy field laboratory of Sher- e – Bangla Agricultural University, Dhaka, during the period from March to June 2006 to study the effect of manuring and split application of nitrogen on grain yield and quality of maize, CV. Barnali. The study included four manurial doses, viz. Inorganic fertilizers (IF) only (M_1) and no manure , IF + cowdung 5 t ha^{-1} (M_2) , IF + cowdung 10 tha^{-1} (M_3) and IF + cowdung 15 tha^{-1} (M_4)and two split applications of nitrogen, namely, two split application (SP_1), and three split application(SP_2). Fertilizer treatments were placed in main plots and split application of nitrogen in sub plots each measuring 5m X 3m in a split plot design with three replications. Inorganic fertilizers were applied as per were Urea – 250 kg ha^{-1}, TSP 150 kg ha^{-1}, MP 100 kg ha^{-1}, and Gypsum 120 kg ha^{-1}. The full dose of TSP, MP Gypsum and first dose of urea ($\frac{1}{2}$ of 250 kg) were applied as basal dose during at final land preparation. In 2 split application of N, the rest of urea (125 kg) was applied in two equal splits at 25 and 45 days of sowing. In 3 split application of N, the rest of urea (125 kg) was applied in three equal split at 25, 45 and 65 days of sowing. Seeds were sown on March 22, 2006 with a spacing of 75cm X 25cm. The crop was harvested on June 27, 2006.

Observations were made in respect of plant height, number of cobs $plant^{-1}$, cob length, circumference of cob, number of grains $plant^{-1}$, 1000 – grain weight , stalk weight $plant^{-1}$, grain yield ha^{-1}, stalk yield ha^{-1}, N, P, K, and protein content in maize grain and stalk.

Results showed that the effect of fertilization was significant on yield and all the characters studied, except number of cobs $plant^{-1}$ and grain weight per plant. In general M_4 treatment supplying inorganic fertilizers + cow-dung 15 t ha^{-1} gave the best response, whereas M_1 treatment i. e. inorganic fertilizers only gave the poorest response. Grain and stalk yields ranged from 5.43 to 6.76 t ha^{-1} and from 9.02 to 12.16 t ha^{-1} respectively. Highest grain yield was obtained from M_4 treatment which was identically followed by M_3 treatment (5.83 t ha^{-1}). This implied that application of cow-dung at the rate of 10 and 15 t ha^{-1} in addition to recommended doses of inorganic fertilizers increased grain yield over inorganic fertilizers alone.

Effect of manuring was significant on grain N and protein content. Grain N and protein contents were nearly three times higher than those in stalk, and it was reverse for K content. Grain protein content ranged from 10.6% from M_1 treatment to 13.16% from M_4 treatments, the latter being identically followed by M_3 (10.99%) and M_2 (11.36%) treatments.

Effect of split application of nitrogen was significant on grain weight plant^{-1}, number of grains plant ha^{-1}, and grain yield. Grain yield was higher from SP_2 treatment (6.71 t ha^{-1}) than from SP_1 treatment (6.39 t ha^{-1}) indicating that 3 split applications of N was superior to 2 split applications of N for grain yield.

Effect of split application of N was significant on grain P content. Three split applications of N (SP_2) increased grain P content and tended to increase nutrient of grain and stalk including protein content over two split applications of N.

Interaction effect of manuring and split application of nitrogen was significant on plant height only, the height being highest from M_4SP_1 and lowest from M_1SP_1 interactions.

Result of the present study showed that application of cow-dung at the rate of 10 and 15 t ha^{-1} together with recommended inorganic fertilizers improved grain yield and quality over inorganic fertilizers alone, and 3 split applications of nitrogen increased grain yield and tended to improve grain quality of maize over 2 split applications of nitrogen.

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Appendices

APPENDICES

Appendix 1. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0 – 15 cm depth)

Mechanical composition:

Particle size constitution

Sand	:	40%
Silt	:	40%
Clay	:	20%
Texture	:	Loamy

Chemical composition:

Soil characters	Value
Organic matter	1.44%
Potassium	0.15 meq/100 g soil
Calcium	3.60 meq/100 g soil
Magnisium	1.00 meq/100 g soil
Total nitrogen	0.072
Phophorus	22.08 μg/g soil
Sulpher	25.98 μg/g soil
Boron	0.48 μg/g soil
Copper	3.54 μg/g soil
Iron	262.6 μg/g soil
Manganese	164 μg/g soil
Zinc	3.32 μg/g soil

Appendix 2. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from December 2005 to May 2006

Year	Month	Average Air temprature (◦c)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2006	March	33.20	21.80	22.00	46.13
	April	33.74	23.96	23.81	61.27
	May	33.66	24.11	24.95	64.40
	June	33.54	24.86	24.87	65.12

Appendix 3. Summary of analysis of variance of various plant characters of maize

Source of variation	D.F.	Mean Square Values			
		P. height (cm)	No of cob/plant	Cob length (cm)	Circum.of cob (cm)
Replication	2	48.167^{NS}	0.035^{NS}	2.161^{NS}	0.951^{NS}
Manuring (M)	3	126.500*	0.146**	4.300*	0.2500
Error1	6	17.83	0.009	0.487	0.812
Split application (N)	1	160.167*	0.167*	0.920^{NS}	0.815*
MXN	3	31.167^{NS}	0.030	1.033^{NS}	0.837^{NS}
Error 2	8	14.667	0.030	0.516	0.313

* = Significant at 5% level of probability.

** = Significant at 1% level of probability.

NS = Not Significant.

Appendix 4 Summary of analysis of variance of yield and its component of maize

Source of variation	D. F.	Mean Square Values					
		No of grain/plant	1000 grain wt (g)	Grain wt/plant (g)	Stalk wt/plant (g)	Grain yield (t/ha)	Stalk yield (t/ha)
Replication	2	124.292^{NS}	62.125	130.792**	0.792	0.001	1.078^{NS}
Manuring (M)	3	3793.667**	3513.462**	423.153**	954.153**	2.010**	10.660**
Error1	6	40.625	72.239	10.409	9.736	0.033**	0.631
Split application (N)	1	2948.167**	1907.810**	1162.092**	2072.042**	1.105*	3.856*
MXN	3	46.500	590.414**	107.264^{NS}	80.153*	0.122*	0.175
Error 2	8	74.292	22.876	29.708	19.00	0.26	0.374

* = Significant at 5% level of probability.

** = Significant at 1% level of probability.

NS = Not Significant.

Appendix 5.Summary of analysis of variance of N P K and protein contents of grain in maize

Source of variation	D.F.	Mean Square Values			
		N %	P%	K%	Protein %
Replication	2	0.006	0.000[NS]	0.007*	0.202
Manuring (M)	3	.225**	0.001*	0.096**	7.712**
Error1	6	0.009	0.000	0.001	0.300
Split application (N)	1	0.207**	0.000	0.072**	7.091**
MXN	3	0.010	0.001*	0.009*	0.353
Error 2	8	0.011	0.000	0.001	0.384

* = Significant at 5% level of probability.

** = Significant at 1% level of probability.NS = Not Significant.

Appendix 6. Summary of analysis of variance of N P K and protein contents of stalk in maize

Source of variation	D.F.	Mean Square Values			
		N %	P%	K%	Protein %
Replication	2	0.000	0.000	0.021[NS]	0.005
Manuring (M)	3	0.006**	0.001*	0.093**	0.190**
Error1	6	0.000	0.000	0.005	0.007
Split application (N)	1	0.038**	0.002**	0.454**	1.314**
MXN	3	0.001[NS]	0.000	0.034[NS]	0.019[NS]
Error 2	8	0.000	0.000	0.013	0.007

* = Significant at 5% level of probability.

** = Significant at 1% level of probability. NS = Not Significant.