EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF MAIZE

A Thesis

By

MD. MONIRUZZAMAN
Student No. 1705017

MASTER OF SCIENCE
IN
CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200, BANGLADESH

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Department of Crop Physiology and Ecology
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DECEMBER, 2018

DEDICATED

TO

MY BELOVED PARENTS

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EFFECT OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF MAIZE

ABSTRACT

A field experiment was carried out at the research field of Crop Physiology and Ecology department, Hajee Mohammad Danesh Science and Technology University, Dinajpur during April to July 2018 to evaluate the performance of maize (BARI hybrid Bhutta-7) as influenced by different levels of nitrogen and sulphur. The experiment comprised of two factors; such as factor A: Three nitrogen levels, N_0: 0 kg N/ha (control), N_1: 100 kg N/ha, N_2: 150 kg N/ha and factor B: four levels of sulphur like, S_0: 0 kg S/ha, S_1: 15 kg S/ha, 25 kg S/ha and S_3: 35 S/ha. The experiment was set up in a randomized complete block design with three replications. Both nitrogen and sulphur significantly affected growth, yield and yield contributing characters of maize. In case of nitrogen, the tallest plant, highest leaf area, branch number per plant, maximum days to tasseling, silking and maturity were observed in N_2 (150 kg N/ha) but leaf number and plant dry weight was highest in N_1 (100 kg N/ha) and the result was minimum for all above parameters in N_0 (0 kg N/ha). In case of sulphur, the tallest plant, highest leaf area, leaf number, branch number per plant, plant dry weight, maximum days to tasseling, silking and maturity were observed in S_2 (25 kg S/ha) and the result was tolerant for all above parameters in S_0 (0 kg S/ha). In interaction, the tallest plant, highest leaf area, branch number per plant, maximum days to tasseling, silking and maturity were observed in N_2S_2 interaction but leaf number and plant dry weight was highest in N_1S_2 interaction whereas the result was lowest for all above parameters in N_0S_0 interaction. In case of yield and yield contributing characters like cob length, number of cob per plant, number of grains/cob, 1000-grain weight, grain yield and stover yield had significant variation due to different nitrogen and sulphur levels. In different nitrogen levels, the best performance was observed in N_1 (100 kg N/ha) whereas, the lowest performance was observed in N_0 (0 kg N/ha). In different sulphur levels, best performance observed in S_2 (25 kg S/ha) and the lowest performance was observed in S_0 (0 kg S/ha). Therefore in interaction, highest cob length, number of cob per plant, number of grains/cob, 1000-grain weight, grain yield and stover yield were found in N_1S_2 interaction and the result was opposite for all above parameters in N_0S_0 interaction. Based on the above findings it can be concluded that an application of 100 kg N ha^{-1} with 25 kg of S ha^{-1} is the best combination of nitrogen and sulphur for obtaining higher yield attributes and yield of hybrid maize.

CONTENTS

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important grain crops in the world. It has a good potential as a cereal crop side by side with rice and wheat in Bangladesh. It covers about 2.834 hectares of land producing 46,000 tons of grains annually (BBS, 2008). As food, it can be consumed directly as green cob, roasted cob or popped grain. Its grain can be used for human consumption in various ways, such as corn meal, fried grain and flour. It has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil, and 1.5% minerals. Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 gm grains (Chowdhurv and Islam, 1993).

Despite its importance, the average yield of maize in the country is not satisfactory, It is rather low compared with leading maize growing country of the world. Among them mismanagement of plant nutrition is considered to be the major one. Hence there is a need to improve this major component of the production technology for getting higher maize production of better quality.

Balanced nutrition is an essential component of nutrient management and plays a significant role in increasing crop production and its quality. For the major processes of plant development and yield formation the presence of nutrients like N, P, K, S and Mg etc. in balanced form is essential (Mahmood, 1994; Randhawa and Arora, 200). Nitrogen is the motor of plant growth and makes up 1 to 4 percent of dry matter of the plants (Anonymous, 2000). Nitrogen is a component of protein and nucleic acids and when N is sub-optimal, growth is reduced (Haque *et al*., 2001). Nitrogen being constituent of the building blocks of protein, chlorophyll and almost all plant structures (Verma *et al.,* 2012) involved in many physiological and biochemical processes and hence improving maize growth. Nitrogen not only stimulates root growth and crop development but also has a synergistic effect on other nutrients as well (Smil, 2001).

Sulfur is also an essential nutrient for plant growth and development as it is a part of major metabolic compounds such as amino acids (methionine and cysteine), glutathione, proteins, and sulpho-lipids. The demand and plant requirement for sulfur and metabolism in maize plants are closely related to N supply (Reuveny *et al*., 1980) and S status (Duke and Reisenauer, 1986) of the plant. Sulfur deficiency in the soil adversely affect uptake of nitrate and natural process of nitrate reductase (Prosser *et al.,* 2001) and result in steady-state nitrate accumulation in maize (Gilbert *et al*., 1997). Rasheed *et al.* (2003) reported that N applied to maize crop along with the S, resulted significantly in higher yield and yield components than NPK alone and also than NPK with Mg application. Combined application of sulfur and nitrogen to maize, not only increase nitrogen use efficiency but also sulfur use efficiency (Fismes *et al.,* 2000). It is therefore, essential to know the best level of both N and S for getting a higher maize yield, so that maximum benefits could be achieved.

Therefore, the present study was designed to find out the following objectives-

1. To evaluate the effect of nitrogen on the growth and yield of maize.
2. To assess growth and yield responses of maize to different levels of sulphur.
3. To investigate the interaction effect of nitrogen and sulphur levels on the performance of maize.

CHAPTER II

REVIEW OF LITERATURE

A good number of research works have been carried out on various aspects of management practices for higher productivity of maize. Still intensive research on improving its yield and quality is in progress. A brief review relating morpho-physiological, yield attributes and yield of maize as influenced by different nitrogen and sulphur levels are reviewed in this chapter.

Effect of nitrogen and sulphur on the growth, yield and yield components of maize

An experiment was conducted by Daoudi and Singh (2017) to find out the effect levels of nitrogen and sulphur on growth and yield of hybrid maize (*Zea mays* L.). The experiment was laid out in RBD having 12 treatments replicated thrice and it consisted of 3 levels of nitrogen *viz.* 100kgN, 120kg N and 140kg N and 4 levels of sulphur *viz.* Control, 15kg S ha^{-1}, 30kg S ha^{-1} and 45kg S ha^{-1}. The experimental findings record that the maximum plant height (198.67cm), maximum plant dry weight (178.09g), LAI (5.16), length of cobs with and without husk (27.67cm and 20.83cm), respectively. Grain rows cob^{-1} (16.07) and grains row-1 (30.15), 1000 grain weight (238.67g) and grain yield (9717kg ha^{-1}) were recorded in treatment T11 (140 kg N ha^{-1}+ 30 kg S ha^{-1}) followed by treatment T7 (120kgN ha1+ 30 kg S ha^{-1}) and it was concluded that nitrogen and sulphur significantly influenced the growth parameters and yield of hybrid maize and higher level of sulphur *i.e.* 45 $kgha^{-1}$ increased the cost of cultivation and also had antagonistic effect on yield attributes of maize.

Rasheed *et al.* (2004) laid out an experiment to evaluate the effect of nitrogen and sulfur on growth, yield and quality of double cross hybrid (DCH) maize (Cargil-707). Application of fertilizers at the rate of 150 + 30 and 150 + 20 kg of nitrogen and sulfur per hectare respectively greatly increased dry weight per plant (DWP), plant grains number per ear (GNE) and grain weight per ear (GWE) over other treatments. Similarly, the highest grain yield of 8.59 tons per hectare was recorded from the plot fertilized at the rate of 150 kg N and 30 kg S per hectare, while maximum grain oil content (GOC) and grain protein contents (GPC) were recorded from plot fertilized at the rate of 150 + 30 and 150 + 20 kg N and S per hectare respectively.

An experiment was laid out to evaluate the effect of nitrogen and sulphur on growth, yield and quality of hybrid maize (cargill-707). Application of fertilizer at 150±30 and 150+20 kg N and S per hectare, respectively greatly increased dry weight per plant, No. of grains per cob and grain weight per cob over other treatments, Similarly, highest grain yield of 8.59 tons per hectare was recorded from plot fertilized at 150 kg N and 30 kg S per hectare. While maximum grain oil and crude protein contents were recorded from plot fertilized at 150+30 and 150 20 kg N and S per hectare, respectively (Hussain *et al.,* 1999).

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

Ahmad (2005) conducted a field study in Pakistan, during the 2002 kharif season, to investigate the effect of different N fertilizer application rates and seed sizes on plant height and crop stand in maize cv. Kissan-92. Four seed sizes i.e. small, medium, large (having a diameter of 0.5, 0.6-0.7 and 0.8-1.0 cm, respectively) and composite (not graded) and 4 N levels (0, 60, 120 and 180 kg/ha) were tested. Maximum plant height, number of plants per m-2 and low percent mortality was recorded with 120 kg N/ha. Larger seeds resulted in maximum emergence per m^2, plant height, number of plants per m2 and low percent mortality.

To study the effect of nitrogen (N) and sulfur (S) on maize hybrids an field experiments were laid out. Nitrogen (0, 250, 300, 350 kg ha^{-1}) and Sulfur (0, 20, 40, 60 kg ha^{-1}) in main plots, whereas maize hybrids (R-3305, R-2210, R-2207) in subplots, were replicated thrice in randomized complete block design with split plot arrangement. Maximum biological yield, grain yield and harvest index were recorded with 350 kg N ha^{-1}. Among studied maize hybrids, R-2210 achieved more biological yield, grain yield and harvest index than R-3305 and R-2207. Maximum net income and benefit cost ratio (BCR) were recorded in plots with 350 kg N and 40 kg S ha^{-1} for R-2210. Nitrogen and sulfur content in soil and tissue were substantially increased with application of both the nutrients. However, sulfur content in plant tissue did not vary with increasing N from 250 to 350 kg ha^{-1}, but was considerably improved with respect to control. It is concluded that R-2210 produced maximum yield, BCR value and N content in tissue with 350 kg N ha^{-1}, however S content in soil and in tissue was more with 40 kg S ha^{-1}. Hence, it is recommended that 350 kg N ha^{-1} and R-2210 should be used for optimum grain yield and economic benefits (Qahar and Ahmad 2016).

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

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

Ali *et al*. (2013) showed that Nitrogen and Sulphur application, significantly affected the phonological, growth and yield parameters of maize except, number of cobs per plant and 1000- grain weight. Application of fertilizers at the rate of 175 + 25 and 175 + 35 kg of nitrogen and sulfur per hectare, respectively greatly increased the number of days to tasseling & silking, leaf area at tasseling, cob length, number of grains per row except number of cobs per plant and 1000- grain weight over other treatments. However, maximum harvest index (32.65 %) was recorded from the plot fertilized at the rate of 175 kg N and 15 kg S per hectare, respectively.

Ferguson (2004) studied with an earlier research in Nebraska evaluating variable rate nitrogen (N) application to irrigated maize found no significant benefit to variable N compared to uniform N, using a fixed expected yield and site-specific 7 implementation of the current University of Nebraska N recommendation algorithm. Research was initiated in 2002 to review the accuracy of the current N recommendation algorithm for maize, among other nutrient recommendations, and explore the potential for developing N recommendation algorithms specific to agroecological regions in Nebraska. Final, detailed analysis will not be conducted until the study is completed in 2004. Studies in 2002 and 2003 have produced grain yields typically in the range of 14-16 Mg ha-1. Preliminary results suggest that the current N recommendation algorithm generates the most profitable fertilizer N rate much of the time, and there is little evidence so far for the need to develop agroecological zone-specific equations. There is some limited evidence for the need for tillage-specific recommendations. This study thus far suggests that accurately characterizing spatial yield potential within a field, and thus spatial N demand, may be more important than developing region-specific N recommendation algorithms.

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

Agba and Ogar (2005) conducted two field experiments to determine the efficacy of Nitrogen fertilizer on the growth and yield of improved maize variety in the teaching and research farm department of Agronomy Obubra, Cross River University of Technology, Nigeria, during the 2003/2004 cropping seasons. The experiment comprised seven rates of urea (46% N) fertilizer at 0, 50, 90, 130, 170, 210 and 250 kg/ha with three replications. Urea application significantly increased plant height, 8 number of leaves and ear weight, ear length and ear diameter per plant. The use of 210 kg N/ha produced the best maize grain yield of 2.43 and 2.96 tonnes/hectare in 2003 and 2004, respectively.

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

Hassan (2002) conducted two field experiments in Nasser's Faculty of Agricultural Sciences in Yemen during two consecutive growing seasons of 1992/93 and 1993/94, to study the effect of organic manure or mineral nitrogen source on the growth and yield of maize (*cv*. Knega36). The experiment of organic manure contained 4 treatments: control, poultry manure, sheep manure and cattle manure, while the inorganic fertilizer experiment contained 3 treatments: control, $CO(NH2)_2$ and $(NH4)_2$ SO4. Each experiment was performed in a complete randomized block design with 3 replicates. Results showed that the plant height was lower compared with untreated control, poultry and cattle manures in 1992/93 growing season. Similar results were obtained with sheep manure treatment compared with control in 1993/94 growing season. The effect of sheep manure on plant yield, weight of 1000 seeds and fedd an yield was lowest for both seasons. Significantly positive results were obtained in the second experiment with the use of (NH4)2 SO4 on the effect on plant length, ear height, number of ears/plant, plant dry weight, plant yield and feddan yield compared to urea treatment in both seasons.

Duan *et al*. (2007) conducted a field experiment in order to elucidate the effects of nitrogen on the growth and development in summer maize (Zea mays), the photosynthetic characteristics regulated by nitrogen application rates in summer maize was studied. The results indicated that the photosynthetic rate (Pn), cholorophyll content (Chl), soluble protein content (Pro), Hill reaction activity, Ca2+-ATPase activity, Mg2+-ATPase activity and PEPCase activity in lower leaf, ear leaf and upper leaf of summer maize cultivar (Ludan 50) all increased, with the increase of nitrogen application amount. While the growth progressed, the Pn and Pro in all tested leaves gradually decreased. The dynamic changes of Chl in leaves showed different patterns, with little changes at different assaying points in the lower leaf and a single peak curve in the ear leaf and upper leaf. There were different patterns on traits of Hill reaction activity, Ca^{2+}ATPase activity and Mg^{2+} ATPase 13 activity, such as the pattern of gradual decrease, single peak curve and double peaks curve. The changes of PEPCase activities in the tested leaves all showed a curve with one peak while the growth progressed. With the increase of nitrogen application amount, leaf source capacity, biomass and yield all increased.

The results indicated that all photosynthetic characteristics, including Pn, and its related physiological and biochemical parameters could be improved based on application of suitable nitrogen amount. The Ca^{2+}ATPase activity is one of the important factors that can affect the function of photoreaction system in maize. In the experiment, Pn was affected little by PEPCase and largely regulated by function of photosystem and dark reaction system in the photosynthetic organ during the early and mid-growth stage. Meanwhile, it is suggested that leaf source capacity could be used as a criteria to evaluate the productivity of single plant in maize.

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

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Research field of the department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University (HSTU) Dinajpur, during the period of April to July 2018. Details of the methodology of the experiment followed during the research period are presented in this chapter.

3.1. Location

The experiment was conducted in the research field of Crop Physiology and Ecology department, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The experimental site is situated under the Dinajpur Sadar Upazila and located at 25º39′ N latitude and 88º41” E longitude with an elevation of 37.58 meter above the sea level.

3.2. Characteristics of soil and climate

The soil was collected from 15cm depth of the research field of CPE department. The soil was non-calcareous red brown terrace with loamy texture belonging to the AEZ (Old Himalain Piedmont plain). The collected soil was well pulverized and dried in the sun and Decomposed cowdung was mixed with the soil. The soil is sandy loam under the Order Inceptisol. The experimental site is situated in the sub-tropical region characterized by heavy rainfall during the months from May to September and scantly rainfall in the rest of the year.

3.3. Treatment of the experiment

The experiment considered of two factors. Details of the treatments are presented below:

Factor A: Three levels of nitrogen-

N_0 = 0kg /ha

N_1 = 100 kg/ha

N_2 = 150 kg/ha

Factor B: Four levels of sulphur-

S_0 = 0 kg/ha

S_1 = 15 kg/ha

S_2 = 25 kg/ha

S_3 = 35 kg/ha

3.4. Layout of the experiment

The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatments in each plot of each block. There were 36 unit plots altogether in the experiment. The size of the plot was 3 m × 2 m. The distance between two blocks and two plots was 50 cm each.

3.5. Land preparation

The experimental field was first opened on April 03, 2018 with the help of a power tiller and prepared by three successive ploughing and cross-ploughing. Each ploughing was followed by laddering to have a desirable fine tilth. The visible larger clods were hammered to break into small pieces. All kinds of weeds and residues of previous crop were removed from the field. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.6. Seed

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

3.7. Fertilizers

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

3.8. Sowing of seeds

Sowing was done on 05 April 2018 in rows maintaining plant spacing as per treatment. Seeds were sown continuously in rows. After sowing, the seeds were covered with soil and slightly pressed by hand.

3.9. Thinning and weeding

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

3.10. Weeding

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

3.11. Irrigation

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

3.12. Crop sampling and data collection

Ten sample plants were randomly selected in each plot and marked with tag for recording plant characters.

3.13. Data collection

Five plants were selected randomly from each plot to record the following data.

i. Plant height

ii. Leaves plant^{-1}

iii. Leaf area

iv. Branch plant^{-1}

v. Dry weight plant^{-1}

vi. Days to tasseling

vii. Day to silking

viii. Day to maturity

ix. Cob length

x. Cob plant^{-1}

xi. Grains cob^{-1}

xii. 1000-grain weight

xiii. Grain yield

xiv. Stover yield

3.14. Procedure of recording data

3.14.1. Plant height

Height of 5 plants at 20, 40, 60 and 80 days after sowing were measured from ground level (stem base) to the tip of the plant. Mean plant height was calculated and expressed in cm.

3.14.2. Leaves plant^{-1}

Number of leaves of 5 randomly selected plants at 20, 40, 60 and 80 days after sowing were counted and recorded. Average value of 5 plants was recorded as number of leaves/plant.

3.14.3. Leaf area

Leaf area at 30, 60 days after sowing and at harvest was measured from leaf length and leaf breadth from 5 selected plants and then averaged as leaf area/plant in cm^2. Actual leaf area was calculated by multiplying leaf length × leaf breath × 0.75.

3.14.4. Branch plant^{-1}

Number of branches per plant was counted and the data were recorded from randomly selected 5 plants at harvest and mean value was counted and recorded.

3.14.5. Days required tasseling, silking and maturity

The number of days required from sowing to tasseling, silking and maturity was recorded from each plot.

3.14.6. Dry weight plant^{-1}

Randomly selected 5 plants at 30, 60 days after sowing and at harvest from each plot were oven dried and weighed. The average value was recorded in g plant^{-1}.

3.14.7. Cob length

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

3.14.8. Weight of 1000-seeds

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

3.14.9. Grain yield

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

3.14.10. Stover yield

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

3.14.11. Data Analysis

The data were analyzed by partitioning the total variance with the help of computer by using MSTAT program. The treatment means were compared using Tukey′s test at $P \leq 1\%$ level.

CHAPTER IV

RESULT AND DISCUSSION

The influence of nitrogen and sulphur on the growth and yield of maize presented in several tables and figures and discussed in this chapter.

4.1. Plant height

Plant height at 20, 40, 60 and 80 days after sowing was significantly influenced by different nitrogen levels (Fig.1). In every time, the tallest plant height was found in N_2 (150 kg N/ha) and the shortest plant height was found in N_0 (0 kg N/ha). In all cases, plant height was increased with the advancement of time and also with the increment of nitrogen levels. These results were expected since nitrogen stimulates cell division and extension in turn increases number and length of internodes resulting in taller plants. The results also agreed with Tank (2006) and Ahmad (2005).

Plant height at 20, 60, 60 and 80 days after sowing was significantly influenced by different sulphur levels (Fig. 2). In all cases, plant height was increased with the advancement of time d. In in most cases, tallest plant height was found in S_2 (25 kg S/ha) and the shortest plant height was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced the height of plant significantly at 20, 60, 60 and 80 days after sowing (Table 1). In general the height of plant increased with the advanced of time after sowing. At 20 days after sowing, the tallest plant (56.00 cm) was observed in N_2S_2 interaction which was statistically similar

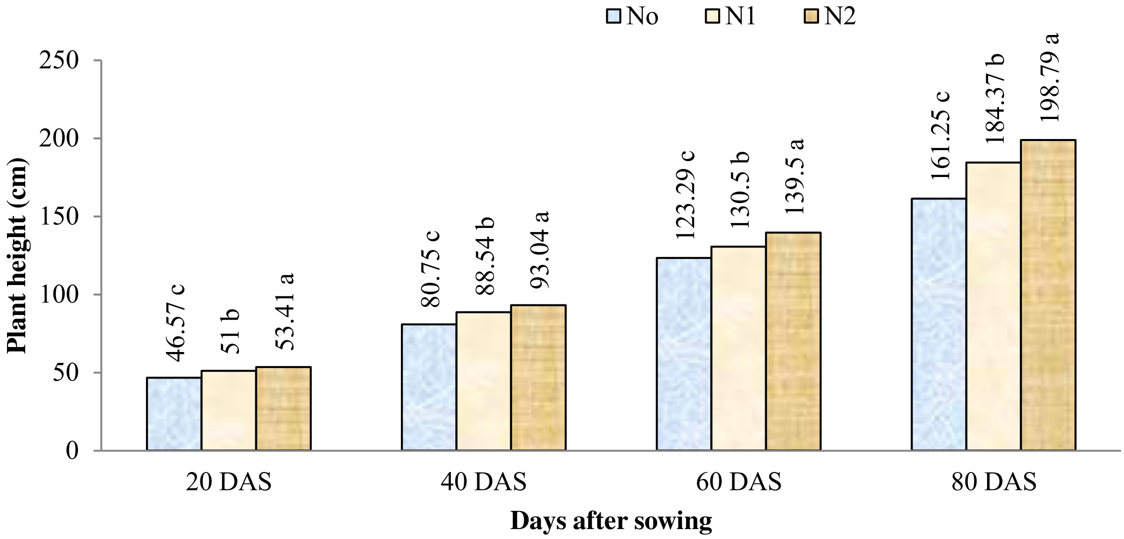

Fig. 1. Plant height at different days after sowing as influenced by different nitrogen levels

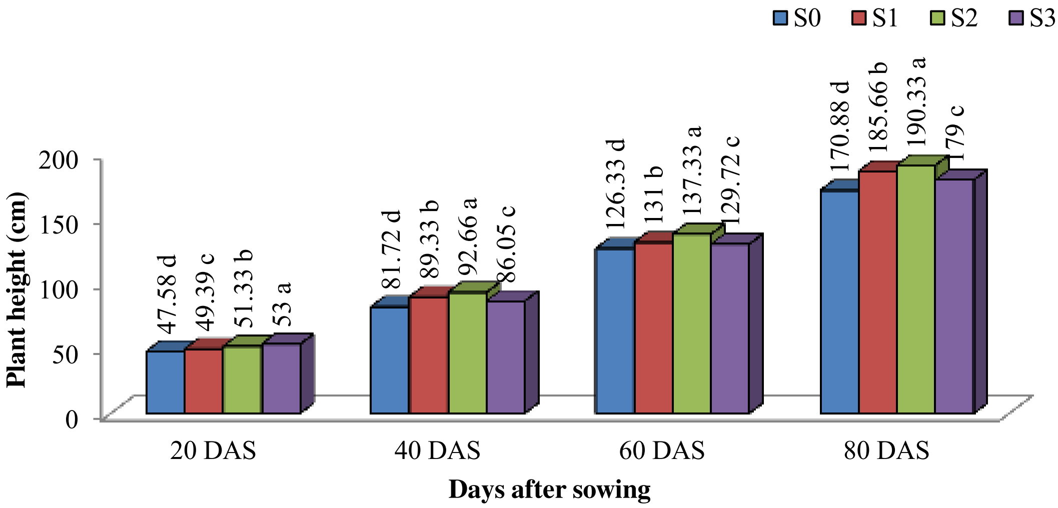

Fig. 2. Plant height at different days after sowing as influenced by different sulphur levels

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at P ≤ 5% level of probability.

N_0 = 0kg /ha　　S_0 = 0 kg/ha
N_1 = 100 kg/ha　　S_1 = 15 kg/ha
N_2 = 150 kg/ha　　S_2 = 25 kg/ha
　　S_3 = 35 kg/ha

Table 1. Performance on plant height of maize as influenced by interaction of nitrogen and sulphur

Interaction		Plant height (cm)			
		20 DAS	40 DAS	60 DAS	80 DAS
N_0	S_0	44.10 f	75.00 i	119.00 h	150.00 j
	S_1	45.18 f	83.00 g	124.00 f	164.00 h
	S_2	47.00 e	85.00 f	129.00 e	171.00 g
	S_3	50.00 d	80.00 h	121.16 g	160.00 i
N_1	S_0	48.00 e	83.16 g	125.00 f	170.50 g
	S_1	50.00 d	90.00 d	129.00 e	192.00 e
	S_2	51.00 d	93.00 c	138.00 c	195.00 d
	S_3	55.00 ab	88.00 e	130.00 e	180.00 f
N_2	S_0	50.66 d	87.00 e	135.00 d	192.16 e
	S_1	53.00 c	95.00 b	140.00 b	201.00 b
	S_2	56.00 a	100.00 a	145.00 a	205.00 a
	S_3	54.00 bc	90.16 d	138.00 c	197.00 c
Level of significance		*	**	*	**
CV (%)		8.35	10.21	9.25	5.36

In a column, values followed by similar letter(s) did not differ significantly by Tukey'stest at $P \leq 5\%$.

N_0 = 0kg /ha S_0 = 0 kg/ha
N_1 = 100 kg/ha S_1 = 15 kg/ha
N_2 = 150 kg/ha S_2 = 25 kg/ha
S_3 = 35 kg/ha

with N_1S_3 followed by N_2S_3, N_2S_1, N_1S_2, N_1S_1, N_0S_3 and shortest plant height (44.10 cm) were observed in N_0S_0 interaction which was statistically similar with N_0S_1 followed by N_0S_2 and N_1S_0 interaction. At 40 days after sowing, the tallest plant (100.00 cm) was observed in N_2S_2 interaction which was followed by N_2S_1, N_1S_2, N_2S_3, N_1S_1, N_1S_3, N_2S_0 and shortest plant height (75.00 cm) was observed in N_0S_0 interaction which was followed by N_0S_3, N_0S_1 and N_1S_0 interaction. At 60 days after sowing, the tallest plant (145.00 cm) was observed in N_2S_2 interaction which was followed by N_2S_1, N_2S_3, N_1S_2, N_2S_0, and shortest plant height (119.00 cm) was observed in N_0S_0 interaction which was followed by N_0S_3, N_1S_3 which was statistically similar with N_1S_1, N_0S_2 followed by N_1S_0 interaction. At 80 days after sowing, the tallest plant (205.00 cm) was observed in N_2S_2 interaction which was followed by N_2S_1, N_2S_3, N_1S_2, N_1S_2, N_1S_3 and shortest plant height (150.00 cm) was observed in N_0S_0 interaction which was followed by N_0S_3, $N_1S_1$and N_1S_0 interaction.

4.2. Leaf number

Leaf number at 20, 40, 60 and 80 days after sowing was significantly influenced by different nitrogen levels (Fig.3). In every time, the highest leaf number was found in N_1 (100 kg N/ha) and the lowest leaf number was found in N_0 (0 kg N/ha). In all cases, leaf number was increased with the advancement of time. Another finding by Agba and Ogar (2005) was in conformity with the present study.

Leaf number at 20, 60, 60 and 80 days after sowing was significantly influenced by different sulphur levels (Fig. 4). In all cases, leaf number was increased with

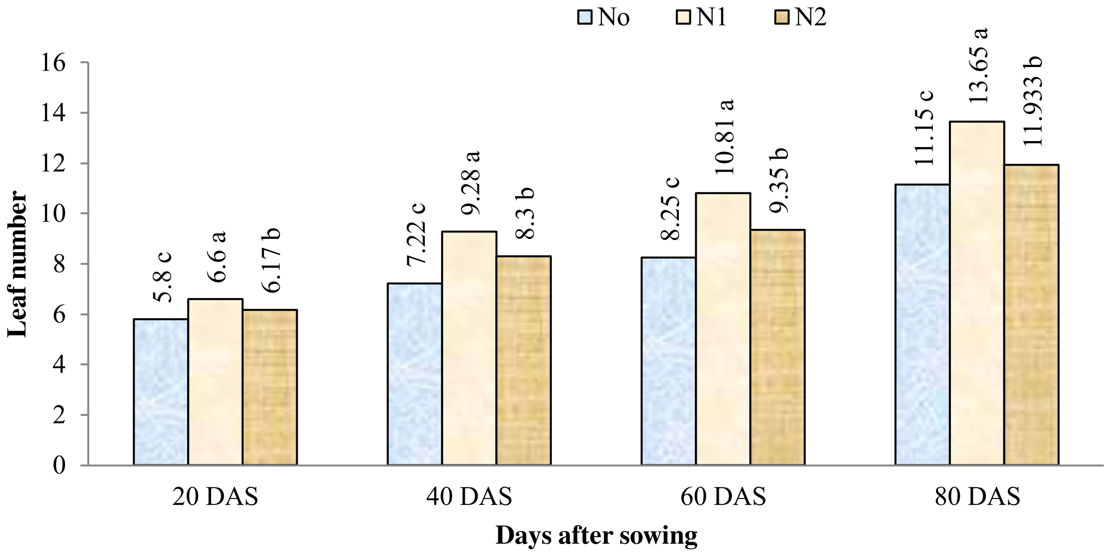

Fig. 3. Number of leaves at different days after sowing as influenced by different nitrogen levels

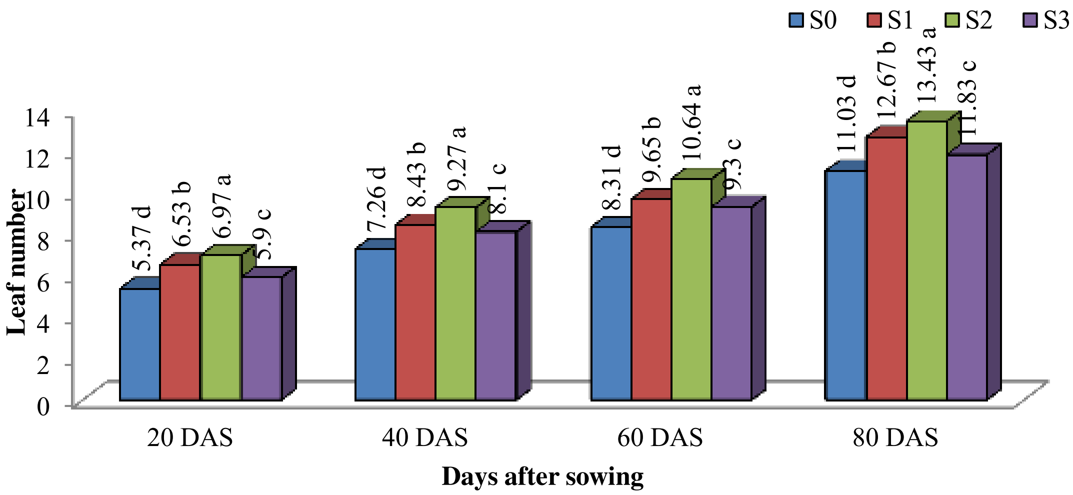

Fig. 4. Number of leaves at different days after sowing as influenced by different sulphur levels

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_0 = 0kg /ha	S_0 = 0 kg/ha
N_1 = 100 kg/ha	S_1 = 15 kg/ha
N_2 = 150 kg/ha	S_2 = 25 kg/ha
	S_3 = 35 kg/ha

Table 2. Performance on number of leaves of maize as influenced by interaction of nitrogen and sulphur

Interaction		Leaf number			
		20 DAS	40 DAS	60 DAS	80 DAS
N_0	S_0	5.10 i	5.96 h	7.13 h	10.30 g
	S_1	6.00 f	7.20 fg	8.50 g	11.50 e
	S_2	6.33 d	8.63 d	9.10 f	12.10 d
	S_3	5.80 g	7.10 g	8.30 g	10.70 f
N_1	S_0	5.73 g	8.53 d	9.50 e	12.00 d
	S_1	7.10 b	9.50 b	11.16 b	14.30 b
	S_2	7.50 a	10.10 a	12.10 a	15.10 a
	S_3	6.10 e	9.00 c	10.50 d	13.20 c
N_2	S_0	5.30 h	7.30 f	8.30 g	10.80 f
	S_1	6.50 c	8.60 d	9.30 ef	12.23 d
	S_2	7.10 a	9.10 c	10.73 c	13.10 c
	S_3	5.80 g	8.20 e	9.10 f	11.60 e
Level of significance		*	**	*	*
CV (%)		8.38	9.12	8.56	7.45

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq 5\%$.

N_0 = 0kg /ha　　S_0 = 0 kg/ha
N_1 = 100 kg/ha　　S_1 = 15 kg/ha
N_2 = 150 kg/ha　　S_2 = 25 kg/ha
S_3 = 35 kg/ha

the advancement of time. In most cases, highest leaf number was found in S_2 (25 kg S/ha) and the lowest leaf number was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced leaf number of plant significantly at 20, 60, 60 and 80 days after sowing (Table 2). In general the number of leaves increased with the advanced of time after sowing. At 20 days after sowing, the highest leaf number (7.50) was observed in N_1S_2 interaction which was statistically similar with N_2S_2 followed by N_1S_1, N_2S_1, N_0S_2, N_1S_3, N_0S_1 interaction and lowest leaf number (5.10) were observed in N_0S_0 followed by N_2S_0, N_1S_0 which was statistically similar with N_0S_3 interaction. At 40 days after sowing, the highest leaf number (10.10) was observed in N_1S_2 interaction which was followed by N_1S_1, N_1S_2, N_3S_3 which was statistically similar with N_1S_3 followed by N_0S_2 which was statistically similar with N_2S_1, N_1S_0 and lowest leaf number (5.96) was observed in N_0S_0 interaction which was followed by N_0S_3, N_0S_1 and N_2S_0 interaction. At 60 days after sowing, the highest leaf number (12.10) was observed in N_1S_2 interaction which was followed by N_1S_1, N_2S_2, N_1S_3, N_2S_0, N_2S_1 interaction and lowest leaf number (7.13) was observed in N_0S_0 interaction which was followed by N_0S_3 which was statistically similar with N_0S_1 interaction. At 80 days after sowing, the highest leaf number (15.10) was observed in N_1S_2 interaction which was followed by N_1S_1, N_1S_3, N_2S_1 which was statistically similar with N_0S_2, N_1S_0 and lowest leaf number (10.30) was observed in N_0S_0 interaction which was followed by N_0S_3, and N_2S_0 interaction.

4.3. Leaf area

Leaf area at 30, 60 days after sowing and harvest was significantly influenced by different nitrogen levels (Fig.5). In every time, the highest leaf area was found in N_2 (150 kg N/ha) and the lowest leaf area was found in N_0 (0 kg N/ha). In all cases, leaf area was increased with the advancement of time.

Leaf area at 30, 60 days after sowing and harvest was significantly influenced by different sulphur levels (Fig. 6). In all cases, leaf area was increased with the advancement of time. In all time, highest leaf area was found in S_2 (25 kg S/ha) and the lowest leaf area was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced leaf area significantly at 30 days after sowing and harvest but not at 60 DAS (Table 3). In general the area of leaves increased with the advanced of time after sowing. At 30 days after sowing, the highest leaf area (245.00 cm^2) was observed in N_2S_2 interaction followed by N_2S_1, N_2S_3, N_0S_2, N_1S_1 interaction and lowest leaf area (208.00 cm^2) was observed in N_0S_0 followed by N_1S_0, $N_1S_0$1which was statistically similar with N_1S_3 and N_2S_0 interaction. At 60 days after sowing, the highest leaf area (620 cm^2) was observed in N_2S_2 interaction and lowest leaf area (540 cm^2) was observed in N_0S_0 interaction. At harvest, the highest leaf area (720.00 cm^2) was observed in N_2S_2 interaction which was followed by N_1S_1, N_1S_2, N_2S_1, N_2S_3, N_1S_1 interaction and lowest leaf area (618.00 cm^2) were observed in N_0S_0 interaction which was followed by N_0S_1, N_0S_3 and N_0S_2.

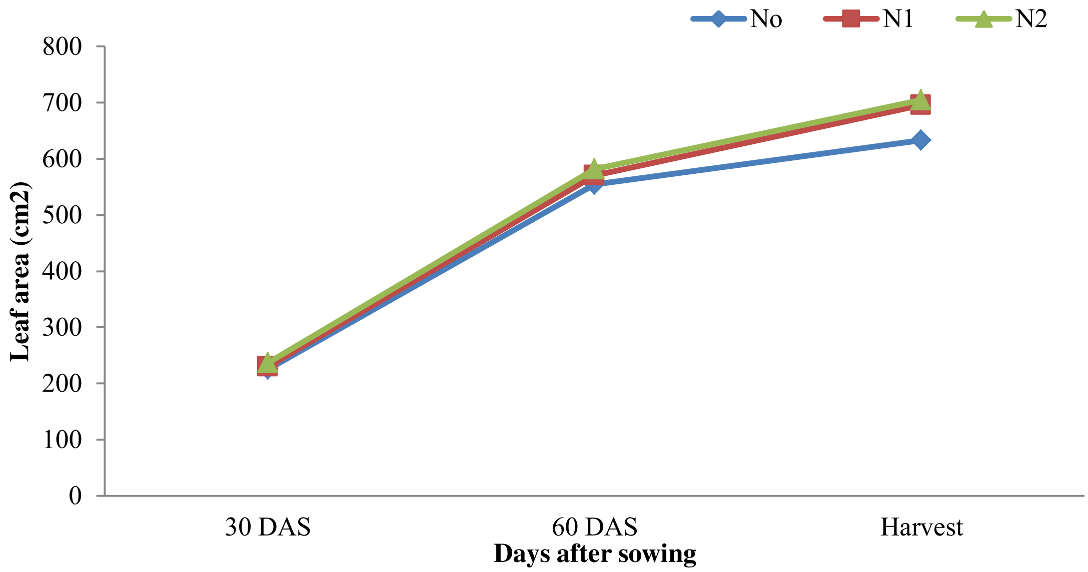

Fig. 5. Leaf area at different days after sowing as influenced by different nitrogen levels

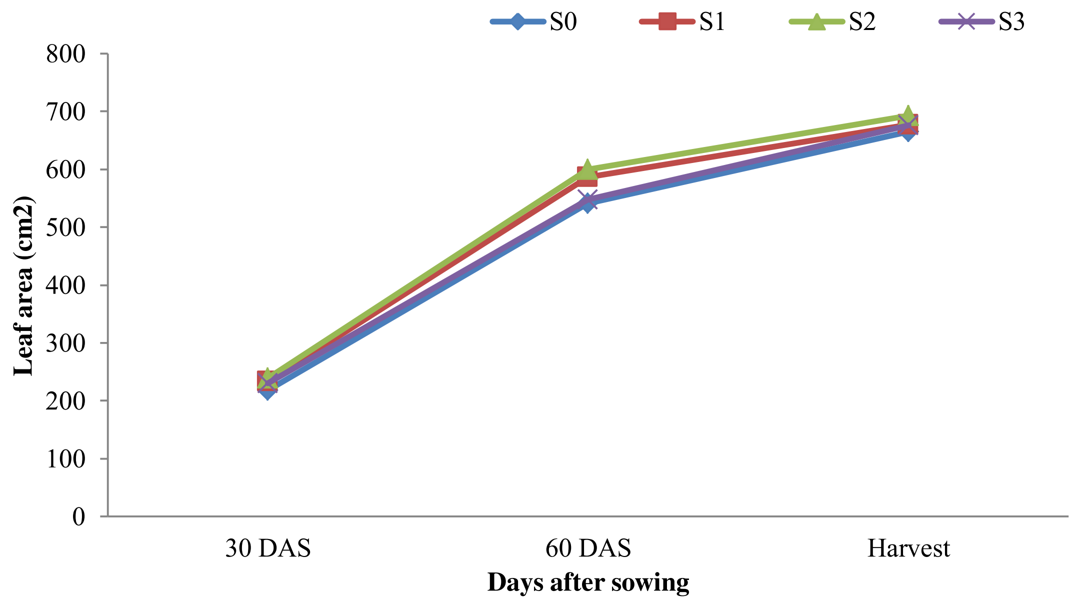

Fig. 6. Leaf area at different days after sowing as influenced by different sulphur levels

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_0 = 0kg /ha	S_0 = 0 kg/ha
N_1 = 100 kg/ha	S_1 = 15 kg/ha
N_2 = 150 kg/ha	S_2 = 25 kg/ha
	S_3 = 35 kg/ha

Table 3. Performance on leaf area of maize as influenced by interaction of Nitrogen and Sulphur

Interaction		Leaf area (cm^2)		
		30 DAS	60 DAS	At harvest
N_0	S_0	208.00 h	540	618.00 j
	S_1	230.00 e	558	627.00 i
	S_2	235.00 c	570	650.00 g
	S_3	226.00 f	548	635.00 h
N_1	S_0	216.00 g	585	685.00 f
	S_1	232.00 d	600	698.00 d
	S_2	239.00 b	608	710.00 b
	S_3	230.00 e	490	690.00 e
N_2	S_0	230.00 e	500	691.00 e
	S_1	238.00 b	603	708.00 b
	S_2	245.00 a	620	720.00 a
	S_3	235.33 c	605	702.00 c
Level of significance		*	NS	*
CV (%)		7.98	10.38	7.22

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq 5\%$.

N_0 = 0kg /ha S_0 = 0 kg/ha
N_1 = 100 kg/ha S_1 = 15 kg/ha
N_2 = 150 kg/ha S_2 = 25 kg/ha
S_3 = 35 kg/ha

4.4. Dry weight plant^{-1}

Dry weight per plant at 30, 60 days after sowing and at harvest was significantly influenced by different nitrogen levels (Fig. 7). In every time, the highest dry weight was found in N_1 (100 kg N/ha) and the lowest dry weight was found in N_0 (0 kg N/ha). In all cases, dry weight per plant was increased with the advancement of time. Another finding by Shen *et al*. (2006) conforms the above findings.

Dry weight per plant at 30, 60 days after sowing and at harvest was significantly influenced by different sulphur levels (Fig. 8). In all cases, dry weight was increased with the advancement of time. In most cases, highest dry weight was found in S_2 (25 kg S/ha) and the lowest dry weight per plant was found in S_0 (0 kg S/ha). Greater dry weight per plant with sulfur application was also reported by Kochar *et al*. (1990), Mahmood (1994) and Grobler *et al*. (1999).

The interaction of different nitrogen and sulphur levels influenced dry weight per plant significantly at 30, 60 days after sowing and at harvest (Table 4). In general the dry weight increased with the advanced of time after sowing. At 30 days after sowing, the highest dry weight (47.00 gm) was observed in N_1S_2 interaction followed by N_1S_1, N_1S_3, N_1S_0 which was statistically similar with N_2S_1 and N_2S_3 interaction and lowest dry weight per plant (34.00 gm) was observed in N_0S_0 followed by N_0S_3 which was statistically similar with N_0S_3 and N_0S_1 interaction. At 60 days after sowing, the highest dry weight per plant (250.00 gm) was observed in N_1S_2 interaction followed by N_1S_1, N_2S_2, N_2S_1 and N_0S_2 interaction

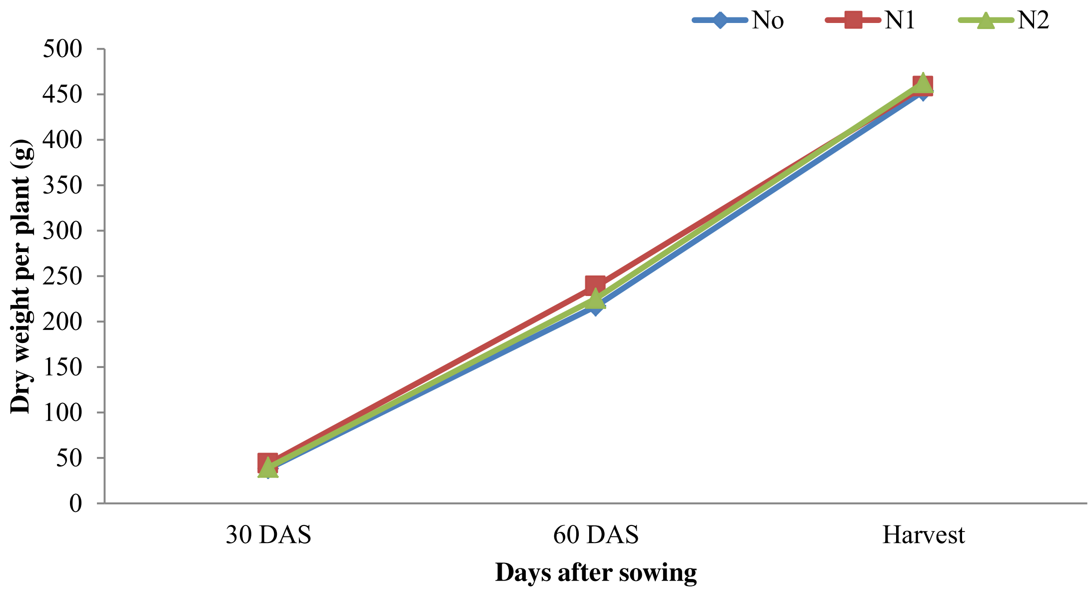

Fig. 7. Dry weight per plant at different days after sowing as influenced by different nitrogen levels

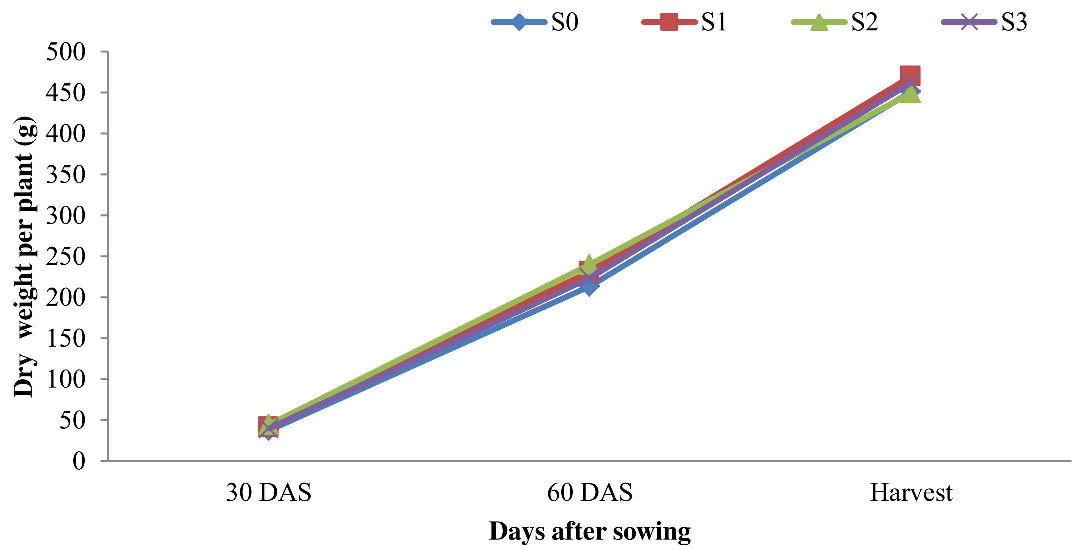

Fig. 8. Dry weight per plant at different days after sowing as influenced by different sulphur levels

At specific days after sowing, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability.

N_0 = 0kg /ha S_0 = 0 kg/ha
N_1 = 100 kg/ha S_1 = 15 kg/ha
N_2 = 150 kg/ha S_2 = 25 kg/ha
S_3 = 35 kg/ha

Table 4. Dry weight per plant as influenced by interaction of nitrogen and Sulphur

Interaction		Dry weight per plant (gm)		
		30 DAS	60 DAS	At harvest
N_0	S_0	34.00 g	200.66 l	435.00 h
	S_1	38.00 ef	221.00 h	459.00 e
	S_2	42.23 c	230.00 f	467.00 c
	S_3	37.00 f	215.00 j	452.00 g
N_1	S_0	40.00 d	229.00 g	462.00 d
	S_1	45.00 b	241.00 b	490.66 a
	S_2	47.00 a	250.00 a	485.00 ab
	S_3	43.10 c	235.00 d	480.00 b
N_2	S_0	37.00 f	211.00 k	455.00 f
	S_1	40.00 d	231.33 e	460.00 e
	S_2	43.00 c	238.66 c	480.00 b
	S_3	39.00 de	220.00 i	454.00 f
Level of significance		*	**	*
CV (%)		10.11	7.25	9.34

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq 5\%$.

N_0 = 0kg /ha S_0 = 0 kg/ha
N_1 = 100 kg/ha S_1 = 15 kg/ha
N_2 = 150 kg/ha S_2 = 25 kg/ha
S_3 = 35 kg/ha

and lowest dry weight per plant (200.66 gm) was observed in N_0S_0 interaction followed by N_2S_0 and N_0S_3 interaction. At harvest, the highest dry weight per plant (490.66 gm) was observed in N_1S_1 interaction which was statistically similar with N_1S_2, N_1S_3, N_2S_2 followed by N_0S_2, N_1S_0 interaction and lowest dry weight per plant (435.00 gm) were observed in N_0S_0 interaction which was followed by N_0S_3, N_0S_1 and N_2S_1 interaction.

4.5. Days to tasseling

Days to tasseling was significantly influenced by different nitrogen levels (Table 5). The maximum days to tasseling was found in N_2 (150 kg N/ha) and the minimum days to tasseling was found in N_0 (0 kg N/ha).

Days to tasseling was significantly influenced by different sulphur levels (Table 5). The maximum days to tasseling was found in S_2 (25 kg S/ha) and the minimum days to tasseling was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced days to tasseling significantly (Table 5). The maximum days to tesseling (57.00) was observed in N_2S_2 interaction followed by N_2S_3 which was statistically similar with N_2S_1, N_1S_2 followed by N_1S_1 and N_1S_3 interaction and minimum days to tasseling (49.00) was observed in N_0S_0 followed by N_2S_0 which was statistically similar with N_0S_1, N_0S_3 and N_1S_0 interaction. The results are in accordance with the finding of Nawaz (1989) and Khaliq *et al.* (2008).

Table 5. Effect of nitrogen and sulphur on days to tasseling, days to silking and days to physiological maturity

Treatment		Days to tasseling	Days to silking	Days to maturity
Nitrogen levels				
N_0		50.75 c	58.00 b	106.91 c
N_1		53.00 b	61.25 a	111.25b
N_2		54.50 a	61.41 a	116.12 a
Level of significance		**	**	**
Sulphur levels				
S_0		50.00 c	56.00 d	106.55 d
S_1		53.33 b	61.88 b	113.11 b
S_2		55.00 a	63.00 a	116.50 a
S_3		52.66 b	60.00 c	109.55 c
Level of significance		**	**	**
Interaction				
N_0	S_0	49.00 e	54.00 f	100.00 i
	S_1	51.00 d	59.00 d	110.33 f
	S_2	53.00 c	60.00 cd	113.00 d
	S_3	50.00 de	59.00 d	104.33 h
N_1	S_0	50.00 de	57.00 e	108.00 g
	S_1	54.00 bc	63.00 b	112.00 de
	S_2	55.00 b	65.00 a	116.00 bc
	S_3	53.00 c	60.00 cd	109.00 g
N_2	S_0	51.00 d	57.00 e	111.66 e
	S_1	55.00 b	63.66 ab	117.00 b
	S_2	57.00 a	64.00 ab	120.50 a
	S_3	55.00 b	61.00 c	115.33 c
Level of significance		*	*	**
CV (%)		3.39	4.47	7.66

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq 5\%$.

N_0 = 0kg /ha	S_0 = 0 kg/ha
N_1 = 100 kg/ha	S_1 = 15 kg/ha
N_2 = 150 kg/ha	S_2 = 25 kg/ha
	S_3 = 35 kg/ha

4.6. Days to silking

Days to silking was significantly influenced by different nitrogen levels (Table.5). The maximum days to silking was found in N_2 (150 kg N/ha) and the minimum days to silking was found in N_0 (0 kg N/ha).

Days to silking was significantly influenced by different sulphur levels (Table 5). The maximum days to silking was found in S_2 (25 kg S/ha) and the minimum days to silking was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced days to silking significantly (Table 5). The maximum days to silking (65.00) was observed in N_1S_2 which was statistically similar with N_2S_2, N_2S_1 interaction followed by N_1S_1, N_2S_3, N_0S_1 and N_0S_3 interaction and minimum days to silking (54.00) was observed in N_0S_0 followed by N_1S_0 which was statistically similar with N_2S_0, interaction. The delay in silking of the crop rose with higher dose of nitrogen and sulphur might be due to more vegetative growth of plants. These results are in line with the finding of Nawaz (1989) and Khaliq *et al.* (2008) who reported that application of nitrogen delayed the silking of maize crop.

4.7. Days to maturity

Days to maturity was significantly influenced by different nitrogen levels (Table 5). The maximum days to maturity was found in N_2 (150 kg N/ha) and the minimum days to maturity was found in N_0 (0 kg N/ha).

Days to maturity was significantly influenced by different sulphur levels (Table 5). The maximum days to maturity was found in S_2 (25 kg S/ha) and the minimum days to maturity was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced days to maturity significantly (Table 5). The maximum days to maturity (120.5) was observed in N_2S_2 which was followed by N_2S_1, N_1S_2, N_2S_3, N_0S_2 and N_1S_1 interaction and minimum days to maturity (100) was observed in N_0S_0 followed by N_0S_3 and N_0S interaction.

4.8. Cob length

Cob length was significantly influenced by different nitrogen levels (Table 6). The highest cob length was found in N_1 (100 kg N/ha) and the shortest cob length was found in N_0 (0 kg N/ha). The results obtained by Balwinder and Walia (2003) was similar with the present findings.

Cob length was significantly influenced by different sulphur levels (Table 6). The highest cob length was found in S_2 (25 kg S/ha) and the shortest cob length was found in S_0 (0 kg S/ha).

Cob length was not significantly influenced by the interaction of different nitrogen and sulphur levels (Table 6). The highest cob length (17.5 cm) was observed in interaction N_1S_2 and shortest cob length (14.00 cm) was observed in N_0S_0 interaction. These results are in accordance with the findings of Mahmood (1994).

Table 6. Effect of nitrogen and sulphur on cob length, number of cob per plant, number of grains per cob

Treatment		Cob length (cm)	Number of cobs $plant^{-1}$	Number of grains cob^{-1}
Nitrogen levels				
N_0		15.17 c	0.99 c	415.00 c
N_1		17.37 a	1.06 a	489.91 a
N_2		16.25 b	1.03 b	435.50 b
Level of significance		**	**	**
Sulphur levels				
S_0		15.00 d	0.97 c	428.33 d
S_1		16.60 b	1.03 b	448.33 b
S_2		17.53 a	1.06 a	468.66 a
S_3		15.93 c	1.04 b	441.88 c
Level of significance		**	**	**
Interaction				
N_0	S_0	14.00	0.87 d	390.00 j
	S_1	15.50	1.03 c	420.00 h
	S_2	16.10	1.03 c	435.00 f
	S_3	15.10	1.03 c	415.00 i
N_1	S_0	16.00	1.03 c	475.00 d
	S_1	17.50	1.05 b	490.00 b
	S_2	19.00	1.11 a	511.00 a
	S_3	17.00	1.06 b	483.66 c
N_2	S_0	15.00	1.03 c	420.00 h
	S_1	16.80	1.03 c	435.00 f
	S_2	17.50	1.06 b	460.00 e
	S_3	15.70	1.03 c	427.00 g
Level of significance		NS	**	**
CV (%)		4.39	3.92	5.20

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq 5\%$.

N_0 = 0kg /ha S_0 = 0 kg/ha
N_1 = 100 kg/ha S_1 = 15 kg/ha
N_2 = 150 kg/ha S_2 = 25 kg/ha
S_3 = 35 kg/ha

4.9. Cob plant^{-1}

Number of cobs per plant was significantly influenced by different nitrogen levels (Table 6). The highest number of cob per plant was found in N_1 (100 kg N/ha) and the lowest number of cobs per plant was found in N_0 (0 kg N/ha).

Number of cob per plant was significantly influenced by different sulphur levels (Table 6). The highest number of cobs per plant was found in S_2 (25 kg S/ha) and the lowest number of cob per plant was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced number of cob per plant significantly (Table 6). The highest number of cobs per plant (1.11) was observed in N_1S_2 which was followed by N_1S_3, N_1S_1 interaction and lowest number of cobs per plant (0.87) was observed in N_0S_0 followed by N_0S_1 which was statistically similar with N_0S_2, N_0S_3, N_1S_0, N_2S_0, N_2S_1 and N_2S_3 interaction. These results are in accordance with the findings of Mahmood (1994).

4.10. Grains cob^{-1}

Number of grains per cob was significantly influenced by different nitrogen levels (Table 6). The highest number of grains per cob was found in N_1 (100 kg N/ha) and the lowest number of grains per cob was found in N_0 (0 kg N/ha). Similar findings were observed by Tank (2006) and Ghulam (2005).

Number of grains per cob was also significantly influenced by different sulphur levels (Table 6). The highest number of grains per cob was found in S_2 (22 kg S/ha) and the lowest number of grains per cob was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced number of grains per cob significantly (Table 6). The highest number of grains per cob (511.00) was observed in N_1S_2 which was followed by N_1S_1, N_1S_3, N_1S_1, N_2S_2 interaction and lowest number of grains per cob (390.00) was observed in N_0S_0 followed by N_0S_3, N_0S_1, N_2S_3, and N_2S_1 interaction.

4.11. Thousand grain weight

Nitrogen levels was significantly influenced thousand grains weight (Table 7). The highest thousand grains weight was found in N_1 (100 kg N/ha) and the lowest thousand grain weight was found in N_0 (0 kg N/ha).

Thousand grains weight was significantly influenced by different sulphur levels (Table 7). The highest thousand grains weight was found in S_2 (25 kg S/ha) and the lowest Thousand grain weight was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels influenced thousand grains weight significantly (Table 7). The highest thousand grain weight (290.00 gm) was observed in N_1S_2 which was followed by N_1S_1, N_1S_3, N_2S_2, N_2S_1 interaction and lowest thousand grains weight (255.00 gm) was observed in N_0S_0 followed by N_0S_3, N_0S_1, N_2S_0, N_0S_0, and N_0S_2 interaction. These results are in line with the findings of Khaliq *et al.* (2009).

Table 7. Effect of nitrogen and sulphur on thousand grain weight, yield and stover yield

Treatment		Thousand grain weight (gm)	Yield (ton /ha)	Stover yield (t/ha)
Nitrogen levels				
N_0		260.33 c	3.83 c	5.65 c
N_1		281.25 a	4.57 a	6.01 a
N_2		271.33 b	4.27 b	5.86 b
Level of significance		**	**	
Sulphur levels				
S_0		263.66 d	3.95 d	5.78 c
S_1		272.33 b	4.32 b	5.90 b
S_2		279.00 a	4.47 a	5.96 a
S_3		268.88 c	4.15 c	5.82 c
Level of significance		**	**	**
Interaction				
N_0	S_0	255.00 k	3.50 j	5.56
	S_1	261.00 i	3.95 h	5.74
	S_2	267.00 g	4.10 g	5.89
	S_3	258.33 j	3.70 i	5.79
N_1	S_0	270.00 e	4.25 e	5.94
	S_1	285.00 b	4.71 b	5.99
	S_2	290.00 a	4.85 a	6.09
	S_3	280.00 c	4.50 c	5.99
N_2	S_0	266.00 h	4.10 g	5.61
	S_1	271.00 d	4.31 d	5.81
	S_2	280.00 c	4.48 c	6.06
	S_3	268.33 f	4.19 f	5.69
Level of significance		**	**	*
CV (%)		5.21	6.74	6,35

In a column, values followed by similar letter(s) did not differ significantly by Tukey's test at $P \leq 5\%$.

N_0 = 0kg /ha S_0 = 0 kg/ha
N_1 = 100 kg/ha S_1 = 15 kg/ha
N_2 = 150 kg/ha S_2 = 25 kg/ha
S_3 = 35 kg/ha

4.12. Yield

Nitrogen levels was significantly influenced yield per hectare of maize (Table 7). The highest yield was found in N_2 (100 kg N/ha) and the lowest yield was found in N_0 (0 kg N/ha). Similar findings were observed by Tank (2006).

Yield of maize per hectare was significantly influenced by different sulphur levels (Table 6). The highest yield was found in S_2 (25 kg S/ha) and the lowest yield was found in S_0 (0 kg S/ha). It was also observed that sulphur had significant influence on grain yield at 30 kg ha^{-1}than 45 kg ha^{-1} as it shows antagonistic effect thus reduced grain yield. These findings corroborate with the results of (Shiraji *et al.,* 2000 and Pandey *et al.,* 2000).

The interaction of different nitrogen and sulphur levels influenced yield significantly (Table 7). The highest yield (4.85 ton/ha) was observed in N_1S_2 which was followed by N_1S_1, N_1S_3, N_2S_2, N_2S_1, N_1S_0, and N_2S_3 interaction and lowest yield (3.50 ton/ha) was observed in N_0S_0 followed by N_0S_3, and N_0S_1 interaction.

4.13. Stover yield

Nitrogen levels was significantly influenced stover yield per hectare of maize (Table 7). The highest stover yield was found in N_2 (100 kg N/ha) and the lowest stover yield was found in N_0 (0 kg N/ha). Similar findings were observed by Tank (2006).

Stover yield of maize was significantly influenced by different sulphur levels (Table 6). The highest stover yield was found in S_2 (25 kg S/ha) and the lowest stover yield was found in S_0 (0 kg S/ha).

The interaction of different nitrogen and sulphur levels was not significantly influenced stover yield (Table 7). The highest yield (6.09 ton/ha) was observed in N_1S_2 interaction and N_2S_3 interaction and lowest stover yield (5.56 ton/ha) was observed in N_0S_0 interaction.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at research field and laboratory in the Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period from April to July 2018 to evaluate the effect of different Nitrogen and Sulphur levels on the growth and yield of maize. The experiment was laid out in a Randomized Complete Block Design with three replications. Each block then divided into twelve unit plot of 3 m x 1 m sizes. The distance between sub plots and plot to plot was 0.5 m. The experiment comprised of two sets of factors such as A: Three nitrogen levels, N_0: o kg N/ha (control), N_1: 100 kg N/ha, N_2: 150 kg N/ha and B: four levels of sulphur like, S_0: 0 kg S/ha, S_1: 15 kg S/ha, 25 kg S/ha and S_3: 35 S/ha. Observations were made on height of plant, number of leaves per plant, leaf area, number branches per plant, dry weight per plant, days to tasseling, day to silking, day to maturity, cob length, number of cob per plant, number of grains/cob, 1000-grain weight , grain yield and stover yield.

There was a significant variation in all the parameters due to different nitrogen and sulphur levels. In case of nitrogen, the tallest plant, highest leaf area, branch number per plant, maximum days to tasseling, silking and maturity were observed in N_2 (150 kg N/ha) but leaf number and plant dry weight was highest in N_1 (100 kg N/ha) and the result was opposite for all above parameters in N_0 (0 kg N/ha).

In case of sulphur, the tallest plant, highest leaf area, leaf number, branch number per plant, plant dry weight, maximum days to tasseling, silking and maturity were observed in S_2 (25 kg S ha^{-1}) and the result was opposite for all above parameters in S_0 (0 kg S ha^{-1}).

In interaction, the tallest plant, highest leaf area, branch number per plant, maximum days to tasseling, silking and maturity were observed in N_2S_2 interaction but leaf number and plant dry weight was highest in N_1S_2 interaction whereas the result was opposite for all above parameters in N_0S_0 interaction.

In case of yield and yield contributing characters like cob length, number of cob per plant, number of grains/cob, 1000-grain weight, grain yield and stover yield had significant variation due to different nitrogen and sulphur levels. In different nitrogen levels, best performance observed in N_1 (100 kg N ha^{-1}) whereas lowest performance was observed in N_0 (0 kg N ha^{-1}). In different sulphur levels, best performance observed in S_2 (25 kg S ha^{-1}) and lowest performance was observed in S_0 (0 kg S ha^{-1}). Therefore, in interaction, highest cob length, number of cob per plant, number of grains/cob, 1000-grain weight, grain yield and stover yield were found in N_1S_2 interaction and the result was opposite for all above parameters in N_0S_0 interaction

Based on the above findings it can be concluded that an application of 100 kg N ha^{-1} with 25 kg of S ha^{-1} is the best combination of nitrogen and sulphur for obtaining higher yield attributes and yield of hybrid maize and can be recommended to the farmers of Dinajpur region for sustaining productivity of maize.

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APPENDICES

Appendix I. Characteristics of soil of the experimental site

General characters	Description	
Location	Crop Physiology and Ecology, HSTU, Dinajpur	
AEZ	Old Himalayan Piedmont Plain (AEZ-1)	
General Soil type	Non-Calcareous Brown Floodplain Soil	
Parent material	Piedmont alluvium	
Soil series	Ranishankail	
Drainage	Moderately well drained	
Flood level	Above flood level	
Topography	High land	
Physical characteristics	**Value**	
Bulk density (g cm-3)	0.86-1.07	
Particle size (%)		
Sand (2-0.02mm)	60.0	
Silt (0.02-0.002mm)	27.0	
Clay (< 0.002mm)	13.0	
Textural class	Sandy loam	
Chemical characteristics	**Content**	**Interpretation**
pH	5.40-5.50	Moderately acidic
Organic carbon (%)	0.69	Low
Organic matter (%)	1.19	Low
CEC (meq/100g soil)	5.60	Low
Total N (%)	0.07	Very low
Available P (ppm)	16.75	Medium
Exchangeable K (meq/100g soil)	0.17	Medium low

Source: Analysis of initial soil samples was done in SRDI, Dinajpur, Bangladesh

Appendix II: Weather data for growing season of mungbean, April to July, 2018

Month	Relative humidity (%)	Temperature		Total rainfall (mm)
		Minimum (^oC)	Maximum (^oC)	
April	79.00	21.60	34.30	4.00
May	78.23	23.34	32.29	17.93
June	80.13	26.17	33.59	14.80
July	84.13	25.17	32.09	13.80

Source: Wheat Research Centre, Dinajpur.