EFFECTS OF NITROGEN AND BORON ON GROWTH AND YIELD OF KHOI BHUTTA

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JUNE, 2018

EFFECTS OF NITROGEN AND BORON ON GROWTH AND YIELD OF KHOI BHUTTA

A Thesis
By

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Submitted to the Department of Agricultural Chemistry
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (M.S.)
IN
AGRICULTURAL CHEMISTRY

SEMESTER: JANUARY - JUNE, 2018

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECTS OF NITROGEN AND BORON ON GROWTH AND YIELD OF KHOI BHUTTA''** submitted to the Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGRICULTURAL CHEMISTRY**, embodies the results of a piece of *bona fide* research work carried out by **MST. RUKSANA BEGUM EVA**, Registration No. **12-04939**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

I further certify that any help or sources of information received during the course of this investigation has duly been acknowledged**.**

Dated: June, 2018

Dhaka, Bangladesh

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ACKNOWLEDGEMENTS

*The author first wants to articulate her enormous wisdom of kindness to the Almighty "**ALLAH**" for His never ending blessing, protection, regulation, perception and assent to successfully complete of research and prepare thesis.*

*The author would like to express her deepest sense of gratitude to her research supervisor, **Professor Dr. Rokeya Begum,** Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 for her scholastic guidance, innovative suggestion, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of this manuscript.*

*The author also grateful to her respected Co-Supervisor **Associate Professor Dr. Md. Sirajul Islam Khan,** Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 for his constant encouragement, cordial suggestions, constructive criticisms and valuable advice during the research period and preparing the thesis.*

*The author expresses her sincere respect and sense of gratitude to Chairman **Associate Professor Dr. Md. Sirajul Islam Khan,** Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 for his valuable suggestions and cooperation during the study period.*

The author would like to express her deepest respect and boundless gratitude to the honorable teachers of the Department of Agricultural Chemistry for their valuable teaching, sympathetic co-operation, direct and direct advice, suggestions and inspirations during the whole study period.

The author would like to express her cordial thanks to the departmental and field staffs for their active help during the experimental period.

The author expresses her sincere appreciation to her parents, brother, sister and relatives for their inspiration, help and encouragement throughout the study period.

June, 2018 ***The Author***

SAU, Dhaka

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ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the Boro season of the year 2017-18 to evaluate the effects of nitrogen and boron on growth and yield of Khoi Bhutta. The two factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Factor A: Four different levels of nitrogen [N_0 = Control (0 kg N ha^{-1}), N_1 = 60 kg N ha^{-1}, N_2 = 100 kg N ha^{-1}, N_3 = 140 kg N ha^{-1}] and Factor B: Four different levels of boron [B_0 = Control (0 kg B ha^{-1}), B_1 = 0.8 kg B ha^{-1}, B_2 = 1.2 kg B ha^{-1}, B_3 = 1.6 kg B ha^{-1}]. Significant variation was observed on growth and yield of Khoi Bhuttadue to application of different doses of nitrogen and boron. In case of nitrogen, the highest plant height at different days after sowing (76.8 cm, 121.8 cm and 166.8 cm respectively), number of leaves/plant at different days after sowing (14.25, 16.25 and 18.25 respectively), number of grain rows/cob (14.92), number of grains/row (41.25), number of grains/cob (542.10), 1000-grain weight (141.20 g), grain yield (3.78 t ha^{-1}), stover yield (4.56 t ha^{-1}), biological yield (5.66 t ha^{-1}), harvest index (45.32%), N in grain (1.65%), N in straw (1.48%), N in root (0.95%), B in grain (0.52%), B in straw (0.47%) and B in root (0.45%) were recorded from N_3 and lowest from N_0. In case of boron, the highest plant height at different days after sowing (67.95 cm, 112.9 cm and 157.9 cm respectively), number of leaves/plant at different days after sowing (10.58, 12.58 and 14.58 respectively), number of grain rows/cob (12.58), number of grains/row (38.33), number of grains/cob (480.50), 1000-grain weight (129.80 g), grain yield (3.33 t ha^{-1}), stover yield (4.17 t ha^{-1}), biological yield (7.51 t ha^{-1}), harvest index (44.47%), N in grain (1.14%), N in straw (0.84%), N in root (0.34%), B in grain (0.58%), B in straw (0.42%) and B in root (0.37%) were recorded from B_3 and lowest from B_0. In interaction, the highest plant height at different days after sowing (79.60 cm, 124.60 cm and 169.60 cm respectively), number of leaves/plant at different days after sowing (16.00, 18.00 and 20.00 respectively), number of grain rows/cob (16.67), number of grains/row (43.33), number of grains/cob (559), 1000-grain weight (43.70 g), grain yield (3.92 t ha^{-1}), stover yield (4.66 t ha^{-1}), biological yield (8.58 t ha^{-1}), harvest index (45.69%), N in grain (1.78%), N in straw (1.54%), N in root (0.98%), B in grain (0.69%), B in straw (0.57%) and B in root (0.48%) were recorded from N_3B_3 and lowest from N_0B_0. Therefore, the application of 140 kg N ha^{-1} with 1.6 kg B ha^{-1} was suitable for better growth and yield of Khoi Bhutta.

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LIST OF ABBREVIATIONS

%	Percent
@	At the rate of
^0C	Degree Celsius
AEZ	Agro-Ecological Zone
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
RCBD	Randomized Complete Block Design
CV%	Percentage of Coefficient of Variance
DAS	Days After Sowing
e.g.	As for example
et al.	and others
g	Gram
ha	Hectare
i.e.	that is
kg	Kilogram
kg ha^{-1}	kg per hectare
LSD	Least Significant Difference
m	Meter
SAU	Sher-e-Bangla Agricultural University
t ha^{-1}	Ton per hectare

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) belongs to the Poaceae family is one of the most important cereal crops in the world both as food for human and feed for animals. It is the most efficient crops which can give high biological yield as well as grain yield in a relatively short period of time due to its unique photosynthetic mechanism of C_4 pathway. It has very high yield potential, there is no other cereal on the earth which has so immense potentiality and that is why it is called “Queen of Cereals” (Ferdaushi, 2011).

Maize (*Zea mays* L.) is a cereal crop gradually assuming increasing importance in Bangladesh due to its high yield potentiality and versatile use. It is considered as third cereal crop in Bangladesh after rice and wheat. Maize also ranks third in terms of production among the world major cereal crops, following closely behind wheat and rice. More than 70 countries have each over one million hectares of maize making it the world’s most widely distributed crop. The nutritional composition of maize is higher than the other cereal crops. There are two types of white maize named dent maize and flint maize. They are largely associated with certain types of food products and dishes (Ahmed, 1994).

Maize is one of the most important cereal crops of the world. In Bangladesh, the cultivation of maize has been gaining popularity in recent years because of its high productivity and diversified use. In Bangladesh, it covers about 3.5 lac hectares of land producing 23 lac metric tons grains. Maize crop has been included as a major enterprise in the crop diversification and intensive cropping programs. Maize is a major cereal crop for both livestock feed and human nutrition, worldwide. With its high content of carbohydrates, fats, proteins, some important vitamins and minerals. So, maize can contribute in food and nutritional security program in Bangladesh because of its higher productivity and nutritional value (Baral, 2016).

The agro-climatic condition of Bangladesh is favorable for its cultivation round the year. As a food it can be consumed directly as a green cobs, roasted cobs or popped grain, flour, sattu and its stalk can be used as cattle feed. As a commercial crop, maize is used for manufacturing starch, corn flakes, alcohol etc (Thakur, 1980).

Maize oil is used as the best quality edible oil. Green parts of the plant and grains are used as the feed of livestock and poultry. Stover and dry leaves are used as good fuel. The important industrial use of maize includes in the manufacture of starch and other products such as glucose, high fructose sugar, maize oil, alcohols, baby foods and breakfast cereals (Kaul, 1985).

Among the various factors of production, the nutrient management has been recognized as the most significant factor limiting the yield levels in maize. The productivity of crop decreased in recent years because of decline in soil fertility status. Farmers are facing difficulty in maintaining soil fertility because of shortage of production and availability of Nitrogen. Ensuring balanced quantity of nutrients in a given soil for good plant growth is the greatest challenge of the day as yield potentials vary among soils. For maintaining sustained crop production, balanced manuring is essential to build up soil health (Sharif *et al.,* 2004).

The low productivity of maize is attributed to many factors like decline of soil fertility, poor agronomic practices, and limited use of input, insufficient technology generation, poor seed quality, disease, insect, pest and weeds. Supply of nutrients at an appropriate amount is always imperative for better growth and development of a crop. However, yield and quality parameters are greatly affected by inadequate availability of plant nutrients. Low yield of fodder maize is due to many constraints but NPK fertilizer application is one of the major factors (Witt *et al.*, 2008).

Khoi Bhutta was developed by the scientists of BARI (Bangladesh Agricultural Research Institute) and was officially released by National Seed Board of Bangladesh in 1986. Plant height is medium (165-180 cm) and ear height is 70-80 cm. Kernels are small size, 1000 grain weight 140-150 g, kernels are yellow flint type. Upper portion of leaf is smaller than lower portion, high popping quality (95%). Intermediate maturing. Planting time starts from mid-November to mid-December. Ripening time require in rabi season is 125-130 days and 90-100 days in kharif season. The yield in rabi season is 3.5-4 t/ha and 2.5-3.5 t/ha in kharif season.

Growth of maize is affected by the availability of nutrient: both macro and micro nutrients are left contribution in the growth and yield of maize production. Nitrogen (N) is an important macronutrient and boron (B) is an important micro nutrient. Nitrogen content differed in plants and also in different parts of the individual plant. The amount of nitrogen is generally much higher in leaves than in stems, leaf sheaths and roots, and it changes with plant age. More than a minimum level of nitrogen supply is necessary for vegetative parts to contribute to the formation of seed protein (Venekamp *et al*., 1987).

Nitrogen is the motor of plant growth and makes up 1 to 4 percent of dry matter of the plants (Anon., 2000). Nitrogen is a component of protein and nucleic acids and when N is sub-optimal, growth is reduced (Haque *et al*., 2001). Nitrogen application had pronounced effect in increasing vegetative growth of crop plants (Khan *et al.,* 1999).

Boron (B) is vital component to plant health, due to its role in forming and strengthening cell walls. Low boron levels lead to poor growth of fast growing tissues and plant development. Boron is an essential micronutrient required for growth and development of plants (Marschner, 1995). Boron deficiency or toxicity is a widespread and agriculturally important micronutrient disorder affecting the productivity of cultivated crops in many parts of the world (Shorrocks, 1997 and Nable *et al*., 1997).

Considering the above facts, the present study was under taken with the following objectives:

- To evaluate the effect of nitrogen on growth, yield and yield contributing characters of Khoi Bhutta
- To evaluate the effect of boron on growth, yield and yield contributing characters of Khoi Bhutta and
- To investigate the suitable combination of nitrogen and boron for higher productivity of Khoi Bhutta.

CHAPTER II

REVIEW OF LITERATURE

Maize is one of the common and most important cereal crops of Bangladesh and as well as many countries of the world. For increasing the growth and yield of maize, abundant studies were conducted in the country and abroad. But a very few studies related to growth, and yield of maize due to nitrogen and boron application have been carried out in our country as well as many other countries of the world. On the other way, the research work so far done in Bangladesh and is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the effect of nitrogen and boron on growth and yield of maize have been reviewed in this chapter.

2.1 Effect of nitrogen in maize

Sezer and Yanbeyi (1997); Kececi *et al*. (1987) stated that nitrogen plays a vital role in nutritional and physiological status of plants, promotes changes in mineral composition of plant, and is the most important element for plant growth and development. The optimal amounts of plant nutrients in the soils cannot be utilized efficiently if nitrogen is deficient in plants. Nitrogen deficiency or excess can result in reduced maize yields. Maize nitrogen requirement can be as high as 150-200 kg N per hectare. However, the amount of optimum nitrogen fertilizer varies with cultivars and ecological conditions.

Shagholi *et al*. (2013) reported that increased intake of nitrogen improves biological yield of corn and average dry matter yield at the rate of 1.345, 1.431 and 1.499 kg per square meter respectively.

Ayub *et al.* (2002) reported that application of nitrogen to maize increase the nutritive value by increasing crude protein and by reducing ash fiber contents.

Nannetti *et al*. (1990) reported that higher rates of nitrogen application reduced the number of effective nodules, increased the risk of lodging and encouraged diseases. It can also depress the growth of legumes (Liebman, 1989).

Das (2004) reported that application of N enhanced the vegetative growth of crop plants and resulted in more number of leaves at higher nitrogen levels.

Safdar (1997) reported that application of nitrogen increased the number of leaves of maize plants.

Ahmed (1998) reported that nitrogen fertilizer greatly effect on vegetative growth, maize yield as well as grain quality. Nitrogen application had pronounced effect in increasing vegetative growth of crop plants (Khan *et al.,* 1999).

Bamuaafa (2012) reported that application of 120 kg/fed gave significant increases in number of leaves/plant, plant height and ear leaf area/plant.

Namakka *et al.* (2012) reported that nitrogen application increased growth analysis such as crop growth rate and leaf area index.

Akram (2014) found that photosynthetic pigments in maize plants was improved by nitrogen application, however, chlorophyll a/b ratio was decreased.

Ibrahim and Kandil (2007) observed that the chemical constituents of corn grains as carbohydrate and oil concentrations are significant increase by nitrogen application; also enhanced the amino acid formation and proline content (Ali *et al.,* 1999).

Mohamed *et al.* (2000); Shirazi *et al.* (2011) and El-Mekser *et al.* (2015) reported that nitrogen application improved maize yield.

Sangoi *et al*. (2007) reported that splitting N at different growth stages could also be beneficial in increasing the grain yield of maize hybrids.

Mungai *et al*. (1999) found that N splitting into two fractions produced significantly higher yields than conventional maize cultivation in the tested area (no top-dressing).

Cheema *et al.* (2010) stated that nitrogen is a component of protoplasm, proteins, nucleic acids, chlorophyll and plays a vital role in vegetative and reproductive phases of crop growth. Higher nitrogen levels are reported to increase plant height, stem thickness, leaf area, leaf area index, dry matter accumulation; net assimilates ratio and yield per hectares.

Hassan *et al.* (2010) and Iqbal *et al.* (2006) reported that fodder maize cultivar Akbar received high nitrogen through fertigation produced maximum stem diameter, leaf area index, green fodder yield and total dry matter.

Reddy and Bhanumurty (2010) reported that applying 240 kg N ha^{-1} gave significantly higher green fodder yield, dry matter yield and crude protein.

Almodares *et al.* (2009) reported that fodder maize biomass and crude protein increased with increase in N content.

Karasu *et al.* (2009) found that high forage and dry matter yield of maize cultivars LG 2687, PR34N43 and H 2547 were obtained by the application of 300 kg ha^{-1} N.

Ayub *et al.* (2007) reported that higher nitrogen application significantly increased plant height, leaf area $plant^{-1}$, leaf number, stem diameter, green fodder yield, dry matter, crude protein, crude fiber and total ash percent.

Thakur *et al.* (1997) and Diallo *et al.* (1996) stated that higher N applications increase the cell division, cell elongation, nucleus formation as well as green foliage. It also encourages the shoot growth. Therefore, higher doses of nitrogen increased the chlorophyll content which increased the rate of photosynthesis and extension of stem resulting increased plant height.

Lemaire and Gastal (1997) demonstrated that, under appropriate levels of other nutrients in the soil, nitrogen provides the greatest increment to maize yield.

Ferreira *et al.* (2001) concluded that nitrogen fertilization improved grain quality increasing protein and mineral nutrients content, intervening positively in the number of ears per plant, weight of ears, as the mass of a thousand seeds increased according to the nitrogen doses. Another important factor for the determination of nitrogen fertilization in maize is the difference in N use and assimilation among hybrids (Nunes *et al*., 2013).

D'Andrea *et al*. (2008) reported that nitrogen plays a pivotal role in several physiological processes in maize plants. It is of fundamental importance to establishing the plant's photosynthetic capacity. Nitrogen is important for kernel initiation, contributes in determining maize sink capacity and helps to maintain functional kernels throughout grain filling. It also influences the number of developed kernels and final kernel size. However, nitrogen effects on kernel number per plant could be related primarily to traits responsible for plant biomass production (i.e. leaf area, light capture, and radiation use efficiency) rather than to the partitioning of biomass and N to the ear.

Andrade *et al*. (2002) found that nitrogen deficiency promotes a reduction in maize crop growth rate and subsequently reduces grain yield. Its deficiency in maize is often visually apparent through reductions in leaf area, leaf chlorophyll status, especially as leaves age and vegetative biomass. Such phenomenon decrease plant light interception, photo assimilate production, and final grain yield (Echarte *et al*., 2008).

Hughes (2006) stated that nitrogen deficiency in maize could also be indicated by yellowing of mature leaves starting at the leaf tips and then extending along the mid-ribs, stunted plants, delayed flowering and short and poorly filled ears.

Hammad *et al*. (2011) reported that low nitrogen supply decreases grain yield by reducing grain number and individual grain weight. The potential weight of individual grains is determined by two main factors: the number of endosperm cells which are formed within the first 2-3 weeks after pollination (i.e. during the lag phase of kernel development) and assimilate availability during grain filling (Paponov and Engels, 2005).

Gungula *et al*. (2005) reported that increase in N supply within limits has been associated with increase in leaf area, leaf weight and chlorophyll content, all of which determine the photosynthetic activity of the leaf and ultimately dry matter production and allocation to the various organs of plants. This shows that adequate N supply can be used to delay leaf senescence in maize thereby maintaining the leaves green and functional for a longer period. Photosynthetic rate, leaf surface area and size of the sink all increase with increase in nitrogen levels. Increase in leaf area and photosynthetic capacity with increased N levels is attributed to the effects of N on cell and tissue growth.

Ciampitti and Vyn (2011) observed that availability of sufficient nitrogen to maize extends the periods of post-silking dry matter and N accumulation and this phenomenon has been associated with higher grain yields. However, increased N availability promotes greater yield responses with high yielding than with low yielding maize varieties.

Hageman and Below (1984) stated that nitrogen plays a pivotal role in several physiological processes inside the plant. It is fundamental to establish the plants photosynthetic capacity; it prolongs the effective leaf area duration, delaying senescence (Earl and Tollenaar, 1997); it is important for ear and kernel initiation, contributing to define maize sink capacity (Tollenaar *et al*., 1994).

Huber *et al*. (1994) and Jones *et al*. (1996) reported that nitrogen helps to maintain functional kernels throughout grain filling, influencing the number of developed kernels and kernel final size.

McCullough *et al*. (1994b) found the effect of N availability on important maize agronomic traits has been examined by a number of workers. Nitrogen limiting conditions produce several restrictions to plant development, delaying silking (Russel, 1991), decreasing pre-anthesis crop growth rate (McCullough *et al*., 1994a), dwindling leaf area index at flowering and accelerating leaf senescence rates throughout the life cycle (Wolfe *et al*., 1988).

Delgado (2009) evaluated an experiment for determination of the amounts and patterns of N uptake and dry matter (DM) production by maize (*Zea mays* L.*)* are important to establish optimum N rates and application ages. He evaluated the pattern of N uptake and DM production of maize (hybrid PB-8) grown under 0, 30, 60, 90, 120, and 180 kg N ha^{-1}, applied as urea, at variable initial amounts of mineral N (NO_3-N, and NH_4-N) in a Fluventic Haplustoll soil of Aragua State, Venezuela. Contrary to what has been observed for nitrogen, relative DM production was not affected by soil N availability. The maximum relative N uptake in the 0 and 120 kg N ha^{-1} treatments was observed at 90 and 60 days after sowing, while it was at 75 days in the other treatments. Generally, rates of DM production and N uptakes increased with increments in N availability: the highest rates of DM and N accumulation (424 and 8.7 kg ha^{-1}/day, respectively) were observed at the 180 kg N ha^{-1} treatment. The total DM at 90 days was significantly correlated with total N taken up (r=0.97), and with the ratio amount of DM: unit of N taken up at 30 days (-0.92). There was a limit in the ratio at 30 days (18 kg DM: kg N uptake; ~5.6% N in tissue of the whole plant) under which there was no increment in total DM at 90 days.

Sangakkara and Nissanka (2003) conducted a field study in Sri Lanka to evaluate the impact of the time and method of application of two common crop stovers on the N nutrition and yields of a rain fed maize crop, grown in a minor season. The use of a stover from a grain provided greater contents of N to maize than maize stover. Application of the stover before planting and its incorporation into the soil proved to be the most beneficial in terms of greater N uptake by the crop, N availability in soils, and increased maize yields.

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

Ghulam (2005) conducted field study in Pakistan, during the 1997 and 1998 summer seasons, to assess the effects of irrigation and N rates on maize cv. Golden yield. Results revealed that the different yield parameters, i.e. cobs per plant, grains per cob and mean grain weight were influenced significantly by different irrigation schedules and N rates. Generally, the grain yield increased with increasing irrigation or N levels. Maximum grain yield (>7.0 t/ha) was recorded with I3 (-8 bars) irrigation schedule and N_3 rate of 200 kg/ha.

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

Niu (2005) conducted a field test with a fodder maize variety Baimaya 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 (9378.7 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 deshi ploughs. 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 × 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 deshi plough recorded decreased emergence. However, chisel ploughing recorded higher fertilizer nitrogen use efficiency than the plots ploughed by cultivator or deshi 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.

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

Oktem (2008) conducted a field experiment 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.

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

2.2 Effect of boron in maize

Miwa and Fujiwara (2008) reported that boron is essential for plant growth as a micronutrient. Boron has an important role in accumulation of carbohydrates, lignification, photosynthesis, cell wall structure, vegetative growth, cell wall synthesis and retention of flowers and fruits. It is also responsible for indole and phenol acetic acid metabolism, membrane transportation and its insufficiency leads to brownish spots in plant tissues (photosynthesis retardation and speculations), stunting of the newly emerged plants.

Wrobel *et al*. (2006) reported that boron is able to alleviate the drought effects and its use as micronutrient enhance the parameters of the major yield components, thus escalating yield level and enriching the chemical symphony of crops.

Shagoli *et al*. (2013) reported that application of boron at the rate of 1.259 to 1.383 and 1.406 B kg per square meter produce a positive and significant result on dry matter production.

Muhammad *et al*. (2012) observed that application of boron at the rate of 0.30kg ha^{-1} significantly increased plant height, leaf area, stem diameter, cob weight, and number of grains per cob, protein and oil content of maize.

Salem *et al*. (2016) studying the effect of colemenite ore as boron fertilizer on maize and reported that, height of plant, stem width/grith, green and dry leaves per plant, ear head length and grain yield per pot were significantly affected with the application of 3 kg B.

Aden and Sevin (2006) suggested that the addition of 7.7 kg ha^{-1} of boron to elevate the deficiency levels of soil B. They conclude by saying that the application of the suggested boron in soil increase levels of N, Ca, Mg, P, K and Mn in shoot and leaves tissues of maize, but decrease Fe, Zn and Cu content.

Palta and Karadavut (2011) reported that the application of 3.0 kg B ha^{-1} produce a better growth when compared to control.

Muhammad *et al*. (2015) reported that application of graded boron to maize increase all the agronomic growth parameters of maize. The increase was achieved with the application of 8 kg boron (granubor).

Gurpreet and Kelly (2015) in their trial observed that foliar application of Boron on corn resulted in higher yield and ear leaf tissue in addition to decreasing severity of gray leaf spot; however, it increases the severity of northern leaf blight.

Tombo *et al*. (2008) stated that plant height was positively and significantly affected by boron applications.

Tahir *et al*. (2009) reported that the addition of boron to maize increased 1000-grain weight significantly.

Rahim *et al*. (2004) and Ahmad *et al*. (2000) reported that boron application increased the grain yield significantly in maize as compared with no application.

Ziaeyan and Rajaie (2009) described increased biological yield in maize by foliar application of boron.

Dwivedi *et al*. (2002) mentioned that protein contents of maize grains were highly increased with boron application.

Gupta (1993) stated that boron is relatively immobile in a corn plant and its availability is essential at all growth stages, particularly during fruit and seed development.

Boron deficiency in corn was first observed during the 1960s in the United States and B applications showed more than a 10% increase in yield on coarse textured soils. In corn, B deficiency caused barren ears and blank stalks at concentrations below 0.05 ppm which resulted in lower yields (Shorrocks and Blaza, 1973).

Woodruff *et al.* (1987) reported that B interacted with N, K and lime while B fertilization at 2.24 kg ha^{-1} was necessary for preventing a reduction in corn yields when higher K fertilizer rates were applied in South Carolina.

Jahiruddin *et al*. (2001) found that in B deficient soils, a B application increased plant B concentration which helped to improve the quality of corn fodder for animals without causing any significant increase in dry matter yield.

Borges *et al*. (2009) reported that minimum amounts of B accumulated in corn during initial growth stages and maximum accumulation was observed after 100 days of seedling emergence in two corn hybrids in Brazil while the total amount of B required to produce one ton of corn was 0.9 g.

Günes and Alpaslan, (2000) found that B decreased P uptake and dry weight of corn genotypes, while a Ca application antagonized shoot B concentrations of four corn hybrids (Kanwal *et al*., 2008).

Aref (2011) reported that boron applied with high Zn levels resulted in higher NPK concentrations in corn grains.

Palta and Karadavut (2011) found that a pre-plant soil application of B, at 3 kg ha^{-1}, had a greater effect on corn growth and average dry matter accumulation, but had lower yields compare to the non-treated control.

Bingham and Garber (1970) found in a greenhouse experiment, corn plants showed injury to soil solution B concentrations of 20 mg B L^{-1}.

Hassegawa *et al*. (2008) reported that B application of 0.5 kg ha^{-1} along with a combination of nitrogen (100 kg ha^{-1}) and Zn (0 and 1.0 kg ha^{-1}) resulted in reduced fungal mycotoxin production, which were responsible for rotting of corn ears.

Loomis and Durst (1992) found that boron deficiency reduced pollen germination rate and retardation of pollen tube growth. Boron deficiency also caused morphological abnormalities, including swelling at the tip of the pollen tube.

Walden (1993) reported that rates of germination of maize pollen grains were above 90% when was treated for 30 minute by 0.01% boric acid and continued pollen tubes 16 h after germination.

Aydyn *et al*. (2003) indicated that boron plays a vital role in pollination, viability of pollen grains, and development of plant tissue, promote germination pollen grains, and promotes tube growth, water relations and sugar translocation.

Walden (1993); Ray (1999); Echarte *et al*. (2006) and Sittichai *et al*. (2010) reported that B foliar increase no. of grains/ear and grain yield.

Martens and Westermann (1991) stated that maize has been previously considered to have a relatively low boron (B) requirement as compared to other cereals. However, based on field responses to B application, its deficiency has been reported in maize across five continents (Bell and Dell, 2008; Shorrocks, 1997; Shorrocks and Blaza, 1973). For example, maize yield increase of 10% were reported in Rhodesia (now Zimbabwe), up to 26% in India (Shorrocks and Blaza, 1973), more than 10% in Switzerland (Mozafar, 1987) and by 9% in China (Li and Liang, 1997). Deficiency of B in field grown maize was first observed in the 1960s in the United States (Shorrocks and Blaza, 1973), and yield increase of more than 10% were observed in response to B application (Woodruff *et al*., 1987).

Akhter and Mahmud (2009) reported that the yield of maize grain increased significantly due to added boron up to 2.0 kg B ha^{-1} and yield components like plant height, ear height and straw yield were influenced significantly due to application of boron.

Singh *et al*. (1990) found that Rabi maize gave the optimum yield at 1.5 kg ha^{-1} B application and Kharif maize produced the best yield at 2.0-2.5 kg B ha^{-1} rate.

Soomro *et al*. (2011) reported that foliar application of B at earlier, middle and later growth stages along with recommended dose of NPK resulted in higher maize food and fodder yield. Boron also involves in stimulation of root and shoots development, tassel and silk formation, movement of sugars from leaves to ears, pollen germination, pollen tube growth and seed formation, better water use efficiency and drought tolerance.

Vaughan (1977) reported that in B-deficient maize, poor grain-setting can result in barren cobs, and this was attributed to the silks being non-receptive.

Wang *et al*. (2015) reported that B application enhances biomass accumulation of plant and promotes radial cell division and hence improved stem girth over control.

CHAPTER III

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, intercultural operations, data collection and statistical analysis. The details of experimental materials and methods are described below:

3.1 Experimental period

The experiment was conducted during the period from November, 2017 to April, 2018 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The present piece of research work was conducted in the experimental plot of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 23º41' N latitude and 90º22' E longitude at an altitude of 8.6 meter above the sea level.

3.2.2 Agro-ecological region

The experimental site belongs to the agro-ecological zone of “Madhupur Tract”, AEZ-28. This was a region of complex relief and soils developed over the Madhupur clay, where floodplain sediments buried the dissected edges of the Madhupur Tract leaving small hillocks of red soils as “islands” surrounded by floodplain. The experimental site was shown in the map of AEZ of Bangladesh in Appendix I and the morphological characteristics of the experimental field was shown in Appendix II.

3.2.3 Soil

Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood levels. The selected plot was medium high land. The details were presented in Appendix III.

3.2.4 Climate

Experimental site was located in the sub-tropical monsoon climatic zone, set aparted by winter during the months from November, 10 to April, 10 (Rabi season). Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for potato growing in Bangladesh.

3.3 Details of the experiment

3.3.1 Experimental treatments

The experiment consisted of two factors such as nitrogen (N) and boron (B) fertilizers. The treatments were as follows:

Factor A: Four different levels of nitrogen

N_0: Control (0 kg N ha^{-1})

N_1: 60 kg N ha^{-1}

N_2: 100 kg N ha^{-1}

N_3: 140 kg N ha^{-1}

Factor B: Four different levels of phosphorus

B_0: Control (0 kg B ha^{-1})

B_1: 0.8 kg B ha^{-1}

B_2: 1.2 kg B ha^{-1}

B_3: 1.6 kg B ha^{-1}

Treatment combinations = 4 × 4 = 16

Replications = 3

3.3.2 Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications thus comprised 48 plots. The layout of the experiment was prepared for distributing the combination of nitrogen and boron. The details of the layout was presented in Appendix IV.

3.4 Planting material

Khoi Bhutta was developed by the scientists of BARI (Bangladesh Agricultural Research Institute) and was officially released by National Seed Board of Bangladesh in 1986. Plant height is medium (165-180 cm) and ear height is 70-80 cm. Kernels are small size, 1000 grain weight 140-150 g, kernels are yellow flint type. Upper portion of leaf is smaller than lower portion, high popping quality (95%). Intermediate maturing. Planting time starts from mid-November to mid-December. Ripening time require in rabi season is 125-130 days and 90-100 days in kharif season. The yield in rabi season is 3.5-4 t/ha and 2.5-3.5 t/ha in kharif season.

3.5 Crop management

3.5.1 Collection of seed

The planting material was collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur-1701, Dhaka.

3.5.2 Land preparation

The plot selected for the experiment was opened in the first week of November 2017 with a power tiller, and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil for planting of maize seeds. The experimental plot was partitioned into the unit plots in accordance with the experimental design. Recommended doses of well-rotten cow-dung manure and chemical fertilizers were mixed with the soil of each unit plot. The size of experimental plot was 25 m × 9 m and size of each unit plot was 2.5 m × 1.2 m.

3.5.3 Source application

The crop was fertilized as per recommendation of BARI. The experimental plot was fertilized with following dose of muriate of potash (MoP), TSP, gypsum and zinc sulphate. Full doses of muriate of potash, TSP, gypsum, zinc sulphate and one-third of the urea were applied at the time of final land preparation. The remaining urea was applied in two equal splits on 40 and 75 days after sowing. Cow dung was applied 10 days before final land preparation.

Fertilizers	Dose (kg ha^{-1})
Cow dung	4000-6000
MoP	96-144
TSP	168-216
Gypsum	144-168
Zinc Sulphate	10-15

Source: BARI, 2015

3.5.4 Sowing of seed

The maize seeds were planted in lines each having a line to line distance of 60 cm and plant to plant distance of 20 cm having 2 seeds $hole^{-1}$ under direct sowing in the well prepared plot on 4th December, 2017.

3.5.5 Intercultural operations

3.5.5.1 Weeding and mulching

Weeding and mulching were done to keep the plots free from weeds, easy aeration of soil and to conserve soil moisture, which ultimately ensured better growth and development. The weeds were uprooted carefully after complete emergence of maize seedlings as and whenever necessary. Breaking the crust of the soil, when needed was done through mulching.

3.5.5.2 Thinning and gap filling

The excess plants were thinned out from all of the plots at 35 and 60 days after sowing (DAS) for maintaining optimum population of the experimental plots.

3.5.5.3 Irrigation

First irrigation was given on 20 days after sowing. Second irrigation was given on 40 days after sowing. Third irrigation was given on 70 days after sowing and fourth irrigation was given on 90 days after sowing.

3.5.5.4 Plant protection measures

After 30 days of planting, first spray of Darsban was done against the pest such as cut worm. Ripcord was applied to control leaf feeder caterpillar during entire vegetative periods at times.

3.5.5.5 Harvesting, threshing and cleaning

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

3.5.5.6 Drying and weighing

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

3.5.5.7 Recording of data

The following data were collected during the experimentation.

i. Plant height

ii. Number of leaves/plant

iii. Number of grain rows/cob

iv. Number of grains/row

v. Number of grains/cob
vi. 1000-grain weight
vii. Grain yield
viii. Stover yield
ix. Biological yield
x. Harvest index
xi. Nitrogen content in grain, shoot and root
xii. Boron content in grain shoot and root

3.5.5.8 Data recording procedure

A brief outline of the data recording procedure followed during the study period is given below:

i. Plant height

The height of plant was recorded in centimeter (cm) at the time of 40 DAS, 80 DAS and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

ii. Number of leaves/plant

Leaf number was count from the top to bottom of the plant at the time of 40 DAS, 80 DAS and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

iii. Number of grain rows/cob

The number of rows of five cobs was counted at each of the five randomly selected plants in each plot and averaged.

iv. Number of grains/row

The number of grains of five cobs was counted at each of the five randomly selected plants in each plot and averaged.

v. Number of grains/cob

Grain numbers of 5 randomly selected cobs/plot were counted for total grains from the base to tip of the ear and finally averaged.

vi. 1000-grain weight

A composite sample was taken from the yield of 5 plants. One hundred (100) grains (g) were randomly collected, sun dried, weighed by an electronic balance and then multiplied by 10.

vii. Grain yield

Weighted cleaned and well dried grains collected from each plot were taken and converted into hectare and were expressed converted to t/ha.

viii. Stover yield

After separation of seeds from plant, the straw and shell harvested was sun dried and the weight was recorded and then converted into t/ha.

ix. Biological yield

Grain yield and stover yield were all together regarded as biological yield. Biological yield was calculated with the following formula:

Biological yield (t/ha) = Grain yield (t/ha) + Stover yield (t/ha)

x. Harvest index

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

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain yield+Stover yield)}} \times 100$$

xi. Nitrogen content in grain, shoot and root

Determination of nitrogen

The Macro Kjeldahl method was used to determine the total Nitrogen in root, shoot and grain of plant samples. Three steps were followed in this method. These are as follows:-

A. **Digestion**: In this step the organic nitrogen was converted to ammonium sulphate by sulphuric acid and digestion accelerators (Catalyst Mixture) at a temperature of 360^0-440º C.

$$N + H_2SO_4 = (NH_4)_2SO_4$$

B. **Distillation**: In this step, the solution was made alkaline from the distillation of ammonia. The distilled ammonia was received in boric acid solution.

$$(NH_4)_2SO_4 + NaOH = Na_2SO_4 + NH_3 + H_2O$$

$$2NH_3 + H_3BO_3 = (NH_4)_3BO_3$$

C. **Titration**: To determine the amount of NH_3, ammonium borate was titrated with standard sulfuric acid.

$$(NH_4)_3BO_3 + H_2SO_4 = (NH_4)_2SO_4 + H_3BO_3$$

Reagents: 4% Boric Acid solution, Mixed indicator (Bromocresol green and Methyl red), 40% Sodium Hydroxide solution, Standard Sulphuric Acid solution 0.05 N and 0.05 N Na_2CO_3 solution.

Procedure: About 1.0 g of oven dried sample was weighed and then taken into a 250 ml Kjeldahl flask. Then 5 g catalysts mixer (K_2SO_4:$CuSO_4.5H_2O$: Se=100:1:1) was added in to flask. Then about 25 ml concentrated H_2SO_4 was also added to the flask. The flask was heated until the solution become clear and then allowed to cool and then about 120 ml of distilled water was added and 5-6 glass bead into the flask. After digestion, 40% NaOH 125 ml was added to the conical flask and attached quickly to the distillation set. Then the flask was heated continuously. In the meantime, 25 ml of 4% boric acid solution and 2-4 drops of mixed indicator was taken in a 500 ml receiver conical flask. After distillation, about 150 ml distillate was collected into receiver conical flask. The distillate was then titrated with standard H_2SO_4 taken from a burette until the green color completely turns to pink color at the end point. The same procedure was followed for a blank sample. The result was calculated using the following formula-

$$\%N = (T-B) \times N \times 1.4/S$$

Where, T= Titration value for sample (ml), B= Titration value for blank (ml), N= Normality of H_2SO_4 (N), S= Weight of the sample (g), 1.4= conversion factor

xii. Boron content in grain, shoot and root

Determination of boron (Azomethine H method)

Azomethine H forms colored complex with H_3BO_3 in aqueous media. Over a concentration range of 0.5 to 10 µg B/ml the complex is stable at pH 5.1. Maximum absorbance occur at 420 nm with little or no interference from a wide variety of salts. The technique is rapid, reliable and more convenient to use than traditional procedures (Berger and Truog, 2002).

Apparatus

(1) Spectrophotometer

(2) Poly-propylene tubes 10 ml capacity

Reagents

(1) Distilled water

(2) Buffer solution: 250 g ammonium acetate (NH_4OAc) and 15 g ethylene di-amine tetra acetic acid (EDTA disodium salt) were dissolved in 400 ml distilled water. About 125 ml glacial acetic acid was added and mixed together.

(3) Azomethine H reagent: 0.45 g azomethine H was dissolved in 100 ml of 1% ascorbic acid solution.

(4) Calcium hydroxide suspension: 0.4 g calcium hydroxide was added to 100 ml distilled water.

(5) 0.1N HCl: 8.3 ml concentrated HCl was added to 900 ml distilled water, mixed and cooled to room temperature. The volume was made up to 1000 ml with distilled water.

(6) Calcium chloride 0.01M: 1.11 g anhydrous $CaCl_2$ was dissolved in 900 ml distilled water and the volume was made up to 1000 ml.

(7) Boron standard solution: 0.114 g Boric acid (H_3BO_3) was dissolved in distilled water and the volume was adjusted to 1000 ml. Each ml contained 20 µg B. About 10, 20, 30, 40 and 50 ml of the stock solution were diluted to 100 ml with distilled water to have solution with B concentration of 2, 4, 6, 8 and 10 µg of B/ml respectively. Include a distilled water sample for the 0 µg of B/ml standard solution.

Preparation of plant extract

0.5 g plant sample was taken in porcelain/platinum dishes. Calcium hydroxide about 0.5 g was added. The sample was ignited in the muffle furnace at 550^0C for 4 hours to obtain white grey ash. Dishes were cooled and moistened the ash carefully with distilled water and then 5 ml 0.1N HCl was added. The content was transferred into 25 ml volumetric flask to mix and the volume was made up to 25 ml with distilled water. For analysis of B, 1 ml aliquot was taken and proceeded for the standard curve.

Procedure

1 ml aliquot of blank and diluted B standards were taken into a 10 ml polypropylene tube, 2 ml buffer solution was added and mixed together. About 2 ml of azomethine H reagent was added, mixed and after 30 minutes the absorbance was recorded at 420 nm on spectrophotometer. With the help of absorbance readings of standard solutions

of different concentration of B the standard curve was drawn and a factor for concentration of B for 1 absorbance was calculated which was utilized to calculate B in plant sample.

3.6 Statistical Analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using MSTAT-C computer package program. The significant differences among the treatment means were compared by Least Significant Different (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

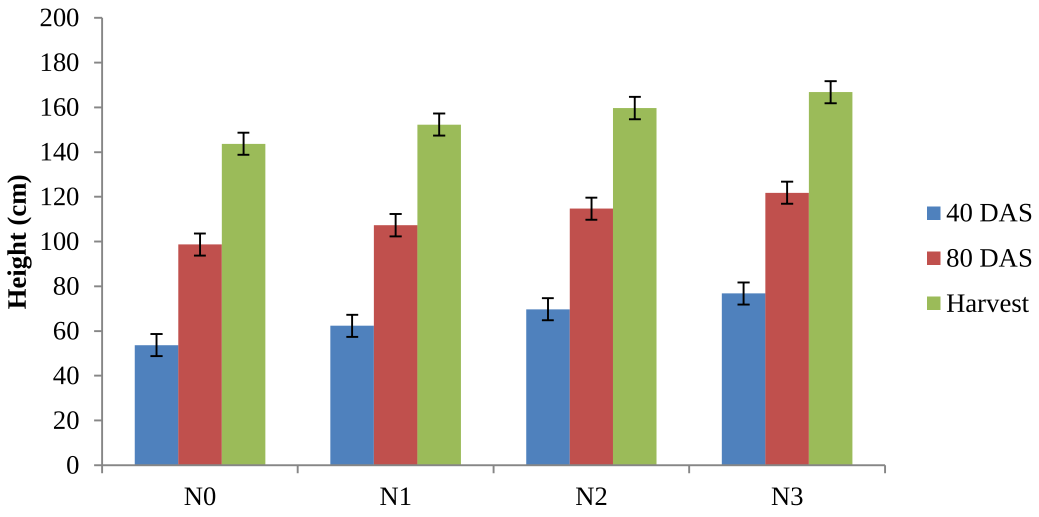
RESULTS AND DISCUSSION

The results obtained from the study have been presented, discussed and compared in this chapter through table(s), figure(s) and appendice(s). The results are interpreting under the following headings.

4.1 Plant height

Effect of nitrogen

The plant height (cm) of Khoi Bhutta was significantly influenced by different doses of nitrogen at 40, 80 DAS and at harvest (Figure 1 and Appendix V). The results revealed that at 40, 80 DAS and at harvest, the treatment N_0 produced the shortest plant (53.70 cm, 98.7 cm and 143.7 cm respectively) and the treatment N_3 produced the tallest plant (76.8 cm, 121.8 cm and 166.8 cm respectively). Similar results were reported by Ayub *et al.* (2007) who reported that higher nitrogen application significantly increased plant height, leaf area plant^{-1} and leaf number of maize.

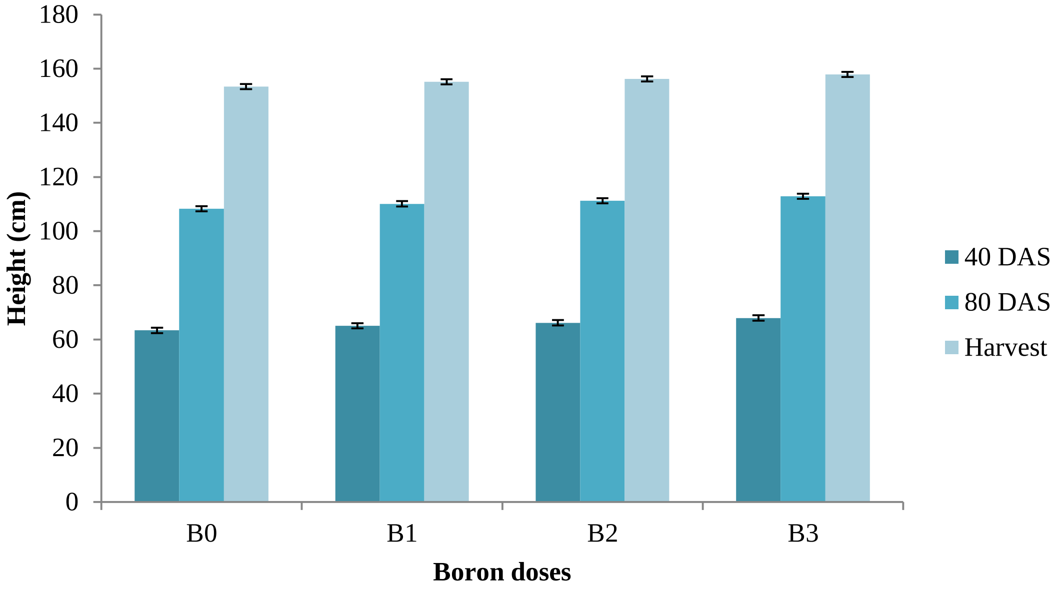


N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

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

Effect of boron

The plant height (cm) of Khoi Bhutta was significantly influenced by different doses of boron at 40, 80 DAS and at harvest (Figure 2 and Appendix VI). The results revealed that at 40, 80 DAS and at harvest, the treatment B_0 produced the shortest plant (63.35 cm, 108.3 cm and 153.4 cm respectively) and the treatment B_3 produced the tallest plant (67.95 cm, 112.9 cm and 157.9 cm respectively). Similar results were reported by Tombo *et al*. (2008) who stated that plant height was positively and significantly affected by boron applications.



B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

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

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on plant height at 40, 80 DAS and at harvest (Table 1). At 40, 80 DAS and at harvest, the lowest plant height (51.40 cm, 96.40 cm and 141.40 cm respectively) was observed from the N_0B_0 treatment and the highest plant height (79.60 cm, 124.60 cm and 169.60 cm respectively) was observed from N_3B_3 treatment.

Table 1: Interaction effect of nitrogen and boron on plant height and number of leaves/plant at different days after sowing

Treatments		Plant height (cm)			Number of leaves/plant		
		40 DAS	80 DAS	Harvest	40 DAS	80 DAS	Harvest
N_0	B_0	51.40 n	96.40 n	141.40 m	3.67 j	5.67 j	7.67 l
	B_1	53.20 lm	98.20 lm	143.20 l	4.00 ij	6.00 ij	8.00 kl
	B_2	54.40 m	99.40 klm	144.40 kl	4.33 ij	6.33 ij	8.33 kl
	B_3	55.80 kl	100.80 kl	145.80 kl	5.33 hi	7.33 hi	9.33 jk
N_1	B_0	60.30 ijk	105.30 ijk	150.30 jk	6.00 gh	8.00 gh	10.00 ij
	B_1	61.70 hij	106.70 ij	151.60 ij	6.67 gh	8.67 gh	10.67 ij
	B_2	62.90 hi	107.90 hi	152.90 ij	7.33 fg	9.33 fg	11.33 hi
	B_3	64.50 h	109.50 gh	154.50 hi	8.33 f	10.33 f	12.33 gh
N_2	B_0	67.60 fg	112.60 g	157.60 h	10.00 e	12.00 e	13.67 fg
	B_1	69.10 efg	114.10 fg	159.10 g	10.67 e	12.67 e	14.67 ef
	B_2	70.20 ef	115.20 ef	160.20 fg	11.33 de	13.33 de	15.33 de
	B_3	71.90 de	116.90 de	161.90 ef	12.67 cd	14.67 cd	16.67 cd
N_3	B_0	74.10 cde	119.10 cd	164.10 de	13.00 bc	15.00 bc	17.00 bc
	B_1	76.30 cd	121.30 c	166.30 cd	13.67 bc	15.67 bc	17.67 bc
	B_2	77.20 bc	122.20 bc	167.20 bc	14.33 b	16.33 b	18.33 b
	B_3	79.60 a	124.60 a	169.60 a	16.00 a	18.00 a	20.00 a
$LSD_{(0.05)}$		0.7364	0.8032	0.9299	1.401	1.401	1.340
CV (%)		7.67	8.43	8.36	9.12	7.49	6.09
Significant level		*	*	*	*	*	*

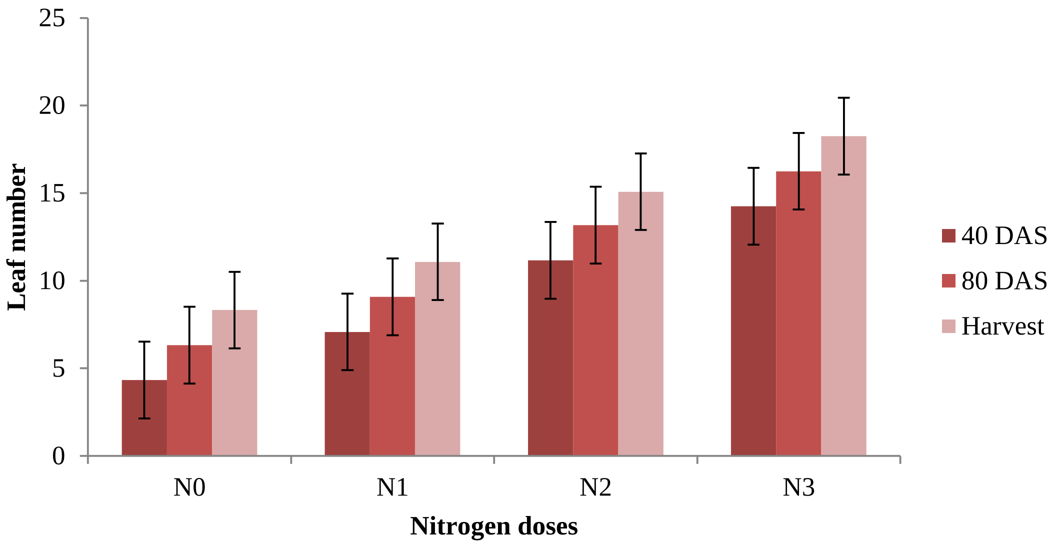
* - Significant at 5% level

N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}; B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

4.2 Number of leaves/plant

Effect of nitrogen

The number of leaves/plant of Khoi Bhutta was significantly influenced by different doses of nitrogen at 40, 80 DAS and at harvest (Figure 3 and Appendix V). The results revealed that at 40, 80 DAS and at harvest, the treatment N_0 produced the lowest number of leaves (4.33, 6.33 and 8.33 respectively) and the treatment N_3 produced the highest number of leaves (14.25, 16.25 and 18.25 respectively). This result are in conformity with Ayub *et al.* (2007) who reported that higher nitrogen application significantly increased plant height, leaf area plant^{-1} and leaf number of maize.

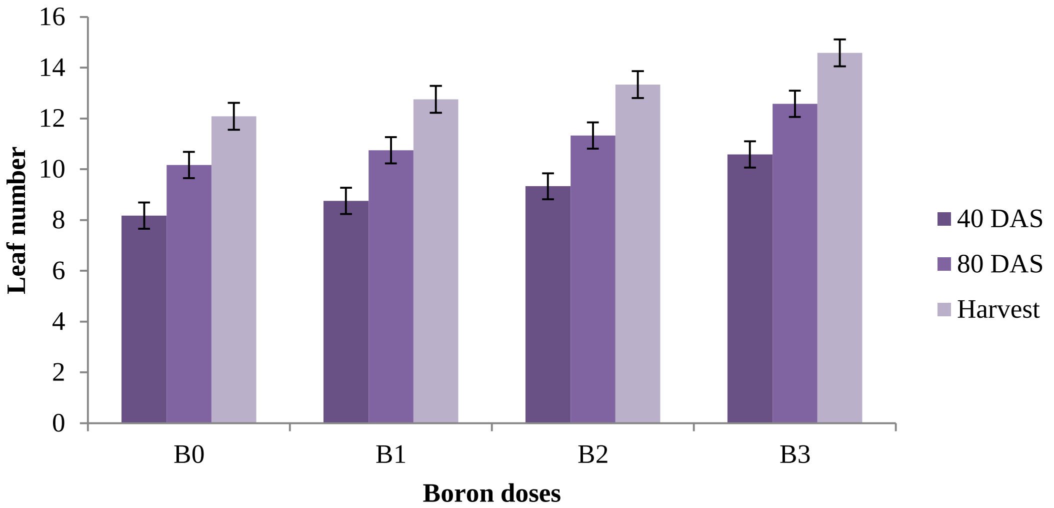


N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Figure 3. Effect of nitrogen on number of leaves/plant at different days after sowing

Effect of boron

The number of leaves/plant of Khoi Bhutta was significantly influenced by different doses of boron at 40, 80 DAS and at harvest (Figure 4 and Appendix VI). The results revealed that at 40, 80 DAS and at harvest, the treatment B_0 produced the lowest number of leaves (8.17, 10.17 and 12.08 respectively) and the treatment B_3 produced the highest number of leaves (10.58, 12.58 and 14.58 respectively). This result are in conformity with Muhammad *et al.* (2015) who reported that application of graded boron to maize increase all the agronomic growth parameters of maize.



B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Figure 4. Effect of boron on number of leaves/plant at different days after sowing

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on number of leaves/plant at 40, 80 DAS and at harvest (Table 1). At 40, 80 DAS and at harvest, the lowest number of leaves (3.67, 5.67 and 7.67 respectively) was observed from the N_0B_0 treatment and the highest number of leaves (16.00, 18.00 and 20.00 respectively) was observed from N_3B_3 treatment.

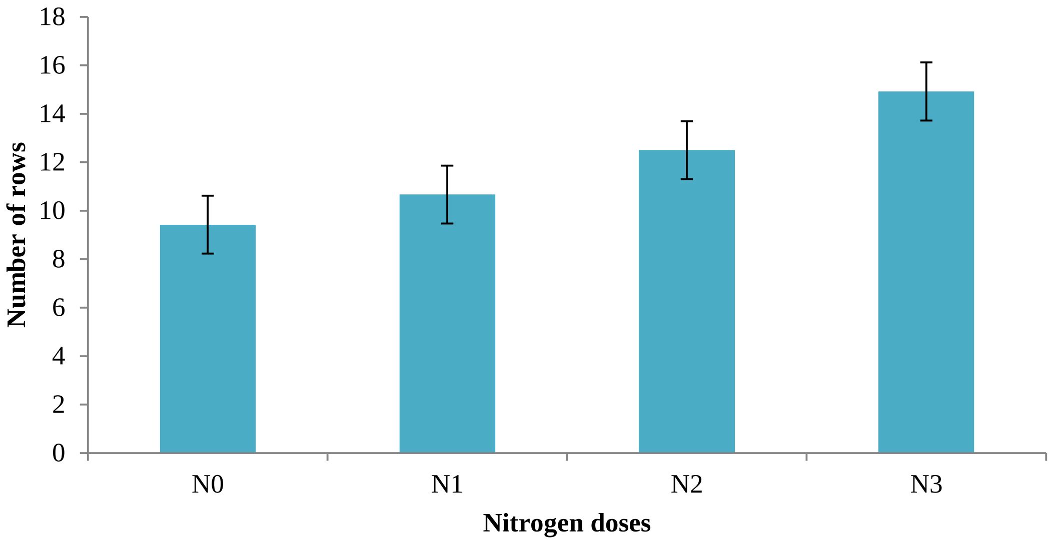
4.3 Number of grain rows/cob

Effect of nitrogen

The number of grain rows/cob of Khoi Bhutta was significantly influenced by different doses of nitrogen (Figure 5 and Appendix VII). The results revealed that, the treatment N_0 produced the lowest number of grain rows/cob (9.42) and the treatment N_3 produced the highest number of grain rows/cob (14.92).

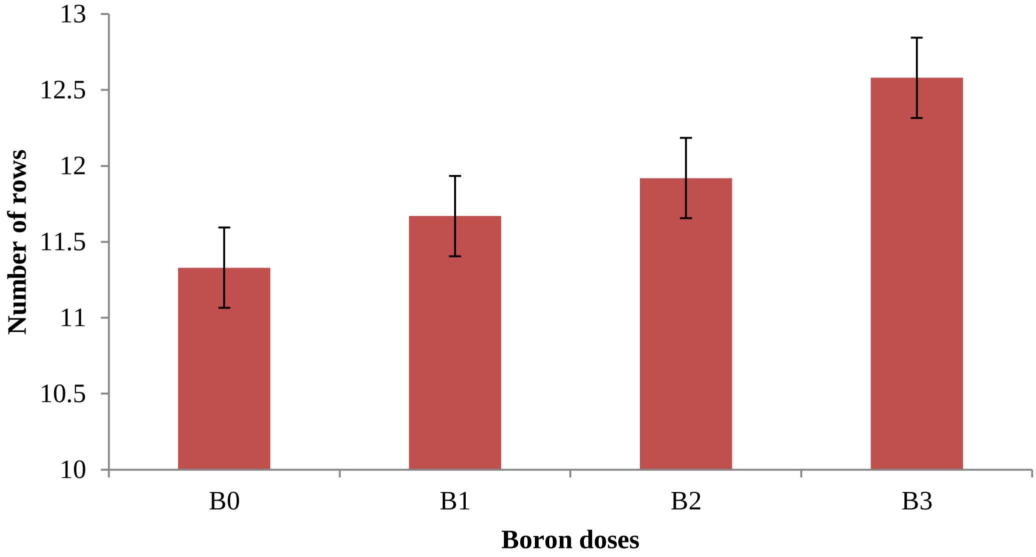
Effect of boron

The number of grain rows/cob of Khoi Bhutta was significantly influenced by different doses of boron (Figure 6 and Appendix VIII). The results revealed that, the treatment B_0 produced the lowest number of grain rows/cob (11.33) which was statistically similar with B_1 (11.67) and B_2 (11.92); whereas, the treatment B_3 produced the highest number of grain rows/cob (12.58) which was statistically similar with B_2 (11.92).



N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Figure 5. Effect of nitrogen on number of grain rows/cob



B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Figure 6. Effect of nitrogen on number of grain rows/cob

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on number of grain rows/cob (Table 2). The lowest number of grain rows/cob (9.00) was observed from the N_0B_0 treatment which was statistically similar with N_0B_1 (9.33), N_0B_2 (9.67), N_0B_3 (9.67) and N_1B_0 (10.33); whereas, the highest number of grain rows/cob (16.67) was observed from N_3B_3 treatment.

Table 2: Interaction effect of nitrogen and boron on number of grain rows/cob, number of grains/row, number of grains/cob and 1000-grain weight

Treatments		Rows/cob	Grains/row	Grains/cob	1000-grain wt. (g)
N_0	B_0	9.00 j	31.33 l	325.70 j	109.60 j
	B_1	9.33 ij	32.33 kl	341.00 hi	113.60 i
	B_2	9.67 ij	33.00 jkl	360.00 hi	114.70 hi
	B_3	9.67 ij	34.00 ijk	382.70 h	115.60 h
N_1	B_0	10.33 hij	34.67 h-k	416.30 hg	119.30 g
	B_1	10.67 g-j	35.33 g-j	434.30 g	122.40 fg
	B_2	10.67 g-j	35.67 ghi	436.00 fg	123.20 f
	B_3	11.00 f-i	36.67 fgh	464.70 f	124.90 f
N_2	B_0	12.00 e-h	37.33 efg	483.70 ef	129.60 e
	B_1	12.33 d-g	37.67 d-g	487.00 e	132.40 cd
	B_2	12.67 c-f	38.33 c-f	505.30 de	133.30 cd
	B_3	13.00 b-e	39.67 b-e	515.70 d	134.80 cd
N_3	B_0	14.00 bcd	40.00 bcd	526.70 cd	138.90 c
	B_1	14.33 bc	40.47 abc	538.00 bcd	141.60 bc
	B_2	14.67 b	41.33 ab	544.70 bc	141.50 bc
	B_3	16.67 a	43.00 a	559.00 a	143.70 a
$LSD_{(0.05)}$		1.780	2.581	6.995	0.1055
CV (%)		8.99	4.19	6.92	6.05
Significant level		*	*	*	*

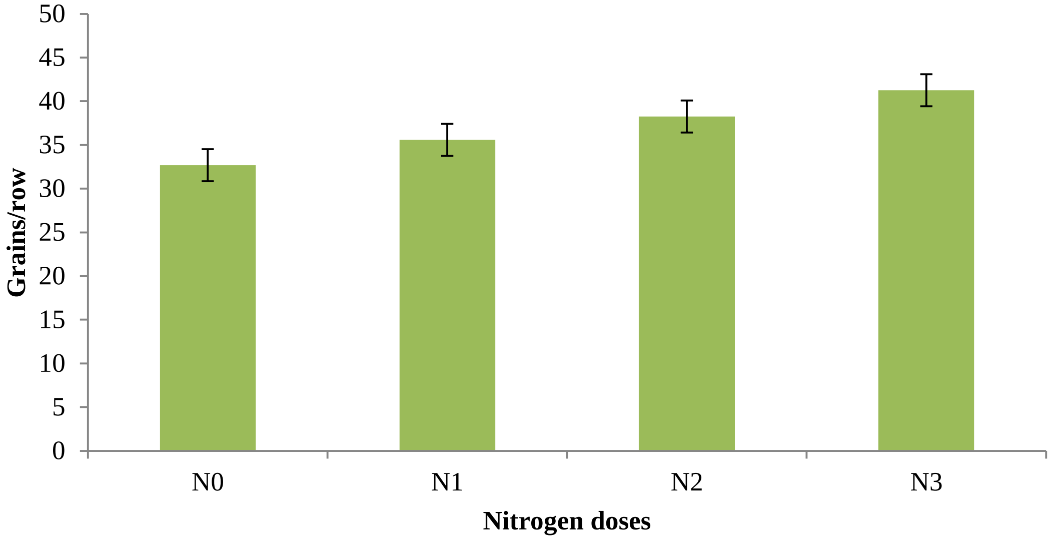
* - Significant at 5% level

N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}; B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

4.4 Number of grains/row

Effect of nitrogen

The number of grains/row of Khoi Bhutta was significantly influenced by different doses of nitrogen (Figure 7 and Appendix VII). The results revealed that, the treatment N_0 produced the lowest number of grains/row (32.67) and the treatment N_3 produced the highest number of grains/row (41.25).

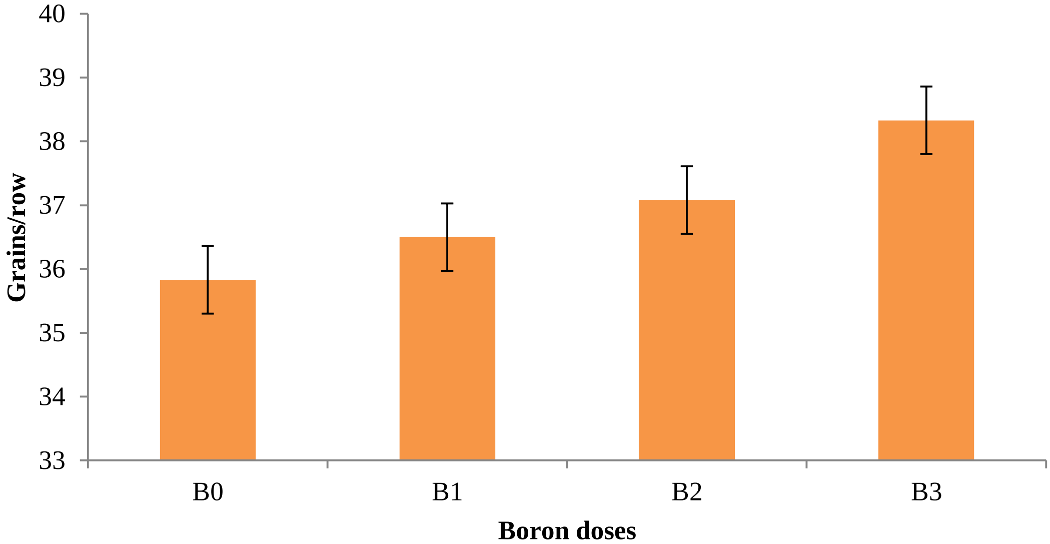


N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Figure 7. Effect of nitrogen on number of grains/row

Effect of boron

The number of grains/row of Khoi Bhutta was significantly influenced by different doses of boron (Figure 8 and Appendix VIII). The results revealed that, the treatment B_0 produced the lowest number of grains/row (35.83) which was statistically similar with B_1 (36.50) and B_2 (37.08); whereas, the treatment B_3 produced the highest number of grains/row (38.33) which was statistically similar with B_2 (37.08).



B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Figure 8. Effect of nitrogen on number of grains/row

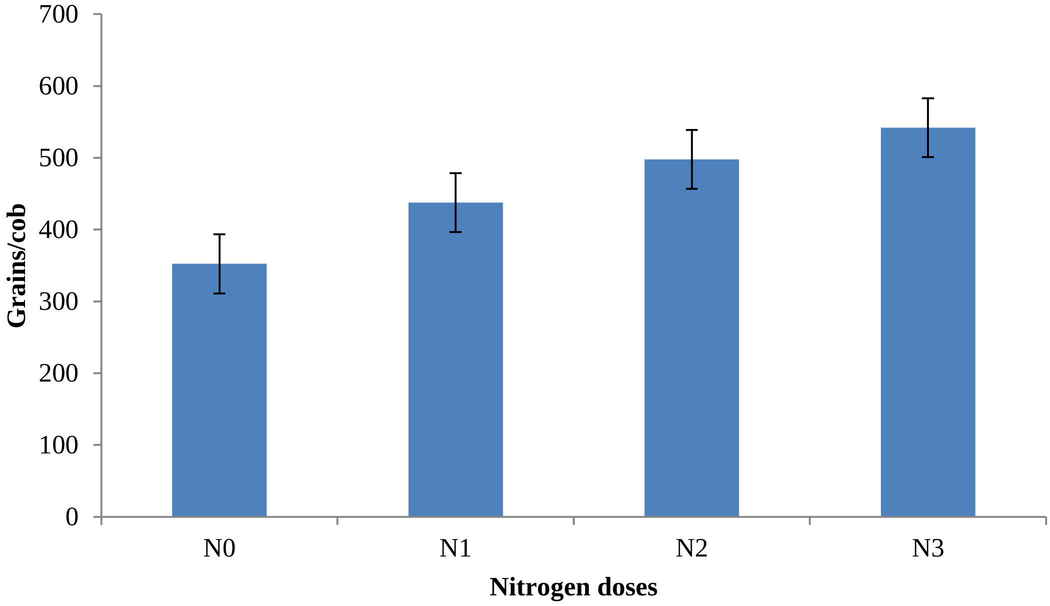
Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on number of grains/row (Table 2). The lowest number of grains/row (31.33) was observed from the N_0B_0 treatment which was statistically similar with N_0B_1 (32.33) and N_0B_2 (33.00); whereas, the highest number of grains/row (43.33) was observed from N_3B_3 treatment.

4.5 Number of grains/cob

Effect of nitrogen

The number of grains/cob of Khoi Bhutta was significantly influenced by different doses of nitrogen (Figure 9 and Appendix VII). The results revealed that, the treatment N_0 produced the lowest number of grains/cob (352.30) and the treatment N_3 produced the highest number of grains/cob (542.10). Similar result was reported by Dawadi and Sah (2012) who reported that the number of cobs plant^{-1}, grains row^{-1} and grains cob^{-1} increased with increasing nitrogen level.



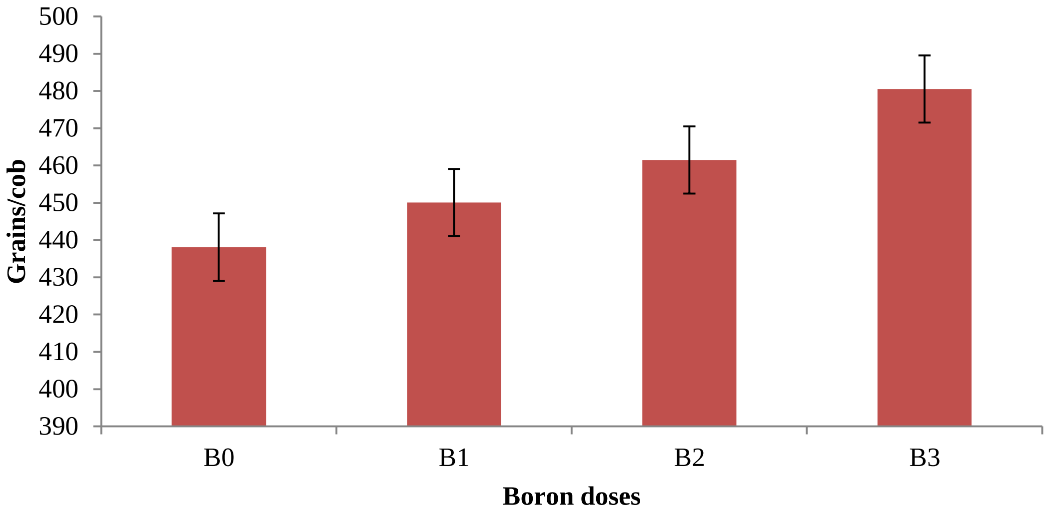
N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Figure 9. Effect of nitrogen on number of grains/cob

Effect of boron

The number of grains/cob of Khoi Bhutta was significantly influenced by different doses of boron (Figure 10 and Appendix VIII). The results revealed that, the treatment B_0 produced the lowest number of grains/cob (438.10) and the treatment B_3 produced the highest number of grains/cob (480.5). This result is in conformity with

Muhammad *et al*. (2012) who observed that application of boron significantly increased stem diameter, cob weight, and number of grains per cob, protein and oil content of maize.



B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Figure 10. Effect of nitrogen on number of grains/cob

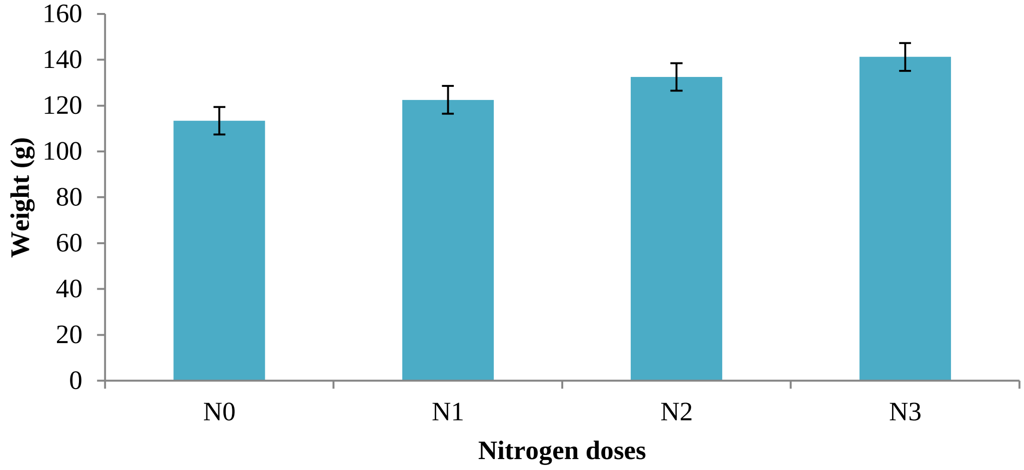
Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on number of grains/cob (Table 2). The lowest number of grains/cob (325.70) was observed from the N_0B_0 treatment and the highest number of grains/cob (559.00) was observed from N_3B_3 treatment.

4.6 1000-grain weight

Effect of nitrogen

The 1000-grain weight of Khoi Bhutta was significantly influenced by different doses of nitrogen (Figure 11 and Appendix VII). The results revealed that, the treatment N_0 produced the lowest 1000-grain weight (113.40 g) and the treatment N_3 produced the highest 1000-grain weight (141.20 g). Similar results were reported by Niazuddin *et al*. (2002); Dawadi and Sah (2012) who observed increased in thousand grain weight with increase in nitrogen levels.

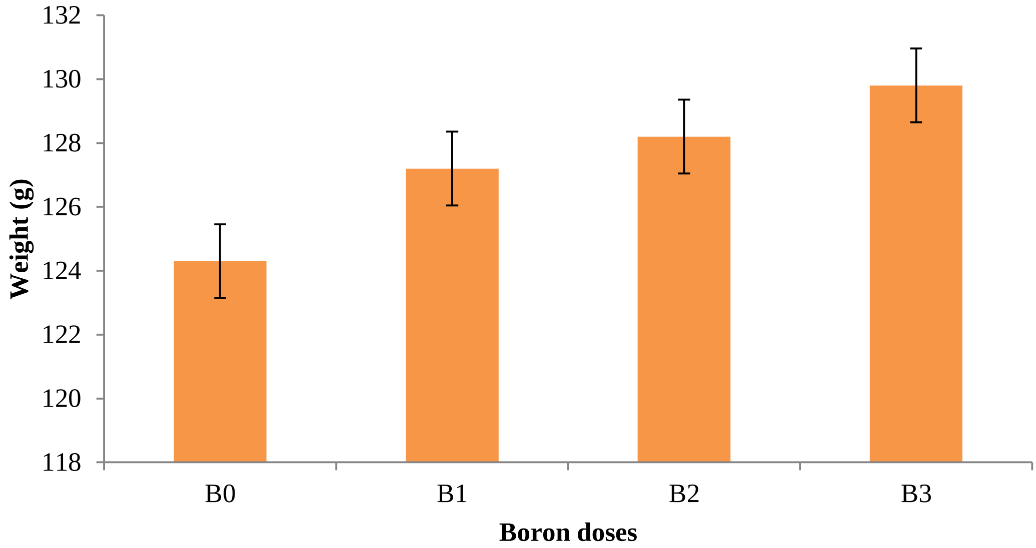


N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Figure 11. Effect of nitrogen on 1000-grain weight

Effect of boron

The 1000-grain weight of Khoi Bhutta was significantly influenced by different doses of boron (Figure 12 and Appendix VIII). The results revealed that, the treatment B_0 produced the lowest 1000-grain weight (124.30 g) and the treatment B_3 produced the highest 1000-grain weight (129.80 g). Similar findings were reported by Tahir *et al.* (2009) who reported that the addition of boron to maize increased 1000-grain weight significantly.



B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Figure 12. Effect of nitrogen on 1000-grain weight

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on 1000-grain weight (g) (Table 2). The lowest 1000-grain weight (109.60 g) was observed from the N_0B_0 treatment and the highest 1000-grain weight (143.70 g) was observed from N_3B_3 treatment.

4.7 Grain yield

Effect of nitrogen

The grain yield (t ha^{-1}) of Khoi Bhutta was significantly influenced by different doses of nitrogen (Table 3). The results revealed that, the treatment N_0 produced the lowest grain yield (2.43 t ha^{-1}) and the treatment N_3 produced the highest grain yield (3.78 t ha^{-1}). This result is in conformity with Lemaire and Gastal (1997) who demonstrated that under appropriate levels of other nutrients in the soil, nitrogen provides the greatest increment to maize yield.

Table 3: Effect of nitrogen on grain yield, stover yield, biological yield and harvest index

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_0	2.43 d	3.23 d	5.66 d	42.93 d
N_1	3.02 c	3.87 c	6.89 c	43.88 c
N_2	3.42 b	4.27 b	7.69 b	44.47 b
N_3	3.78 a	4.56 a	8.34 a	45.32 a
LSD $_{(0.05)}$	0.03729	0.03729	0.08744	0.2042
CV (%)	7.25	6.24	5.45	6.56
Significant level	*	*	*	*

* - Significant at 5% level

N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Effect of boron

The grain yield (t ha^{-1}) of Khoi Bhutta was significantly influenced by different doses of boron (Table 4). The results revealed that, the treatment B_0 produced the lowest grain yield (2.99 t ha^{-1}) and the treatment B_3 produced the highest grain yield (3.33 t ha^{-1}). Similar results were reported by Rahim *et al*. (2004) and Ahmad *et al*. (2000)

who reported that boron application increased the grain yield significantly in maize as compared with no application.

Table 4: Effect of boron on grain yield, stover yield, biological yield and harvest index

Treatments	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
B_0	2.99 c	3.84 c	6.83 c	43.78 c
B_1	3.13 b	3.98 b	7.11 b	44.02 b
B_2	3.21 b	4.06 b	7.27 b	44.15 b
B_3	3.34 a	4.17 a	7.51 a	44.47 a
$LSD_{(0.05)}$	0.03729	0.03729	0.08744	0.2042
CV (%)	7.25	6.24	5.45	6.56
Significant level	*	*	*	*

* - Significant at 5% level

B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on grain yield ($t\ ha^{-1}$) (Table 5). The lowest grain yield (2.21 $t\ ha^{-1}$) was observed from the N_0B_0 treatment which was statistically similar with N_0B_1 (2.34 $t\ ha^{-1}$) and N_0B_2 (2.51 $t\ ha^{-1}$); whereas, the highest grain yield (3.92 $t\ ha^{-1}$) was observed from N_3B_3 treatment.

4.8 Stover yield

Effect of nitrogen

The stover yield ($t\ ha^{-1}$) of Khoi Bhutta was significantly influenced by different doses of nitrogen (Table 3). The results revealed that, the treatment N_0 produced the lowest stover yield (3.23 $t\ ha^{-1}$) and the treatment N_3 produced the highest stover yield (4.56 $t\ ha^{-1}$). This result is in conformity with Ullah *et al*. (2007); Dahmardeh (2011); Dawadi and Sah (2012) who reported that grain and stover yield increased with increase in nitrogen levels.

Table 5: Interaction effect of nitrogen and boron on grain yield, stover yield, biological yield and harvest index

Treatments		Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_0	B_0	2.21 h	2.98 g	5.19 i	42.58 k
	B_1	2.34 gh	3.14 fg	5.48 gh	42.70 j
	B_2	2.51 gh	3.34 fg	5.85 gh	42.91 j
	B_3	2.63 g	3.46 ef	6.09 g	43.19 i
N_1	B_0	2.80 efg	3.64 def	6.44 fg	43.47 hi
	B_1	2.98 ef	3.83 de	6.81 f	43.76 gh
	B_2	3.09 ef	3.95 d	7.04 ef	43.89 gh
	B_3	3.21 def	4.06 cd	7.27 ef	44.15 fg
N_2	B_0	3.29 de	4.15 cd	7.44 e	44.22 ef
	B_1	3.39 cde	4.24 c	7.63 de	44.43 ef
	B_2	3.44 cd	4.27 c	7.71 d	44.62 e
	B_3	3.55 cd	4.40 bc	7.95 cd	44.65 de
N_3	B_0	3.66 c	4.47 bc	8.13 c	45.02 cd
	B_1	3.74 c	4.52 bc	8.26 bc	45.28 bc
	B_2	3.82 b	4.58 b	8.40 b	45.48 b
	B_3	3.92 a	4.66 a	8.58 a	45.69 a
$LSD_{(0.05)}$		0.07457	0.07457	0.1749	0.4085
CV (%)		7.25	6.24	5.45	6.56
Significant level		*	*	*	*

* - Significant at 5% level

N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}; B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Effect of boron

The stover yield (t ha^{-1}) of Khoi Bhutta was significantly influenced by different doses of boron (Table 4). The results revealed that, the treatment B_0 produced the lowest stover yield (3.84 t ha^{-1}) and the treatment B_3 produced the highest stover yield (4.17 t ha^{-1}).

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on stover yield (t ha^{-1}) (Table 5). The lowest stover yield (2.98 t ha^{-1}) was observed from the N_0B_0 treatment which was statistically similar with N_0B_1 (3.14 t ha^{-1}) and N_0B_2 (3.34 t ha^{-1}); whereas, the highest stover yield (4.66 t ha^{-1}) was observed from N_3B_3 treatment.

4.9 Biological yield

Effect of nitrogen

The biological yield (t ha^{-1}) of Khoi Bhutta was significantly influenced by different doses of nitrogen (Table 3). The results revealed that, the treatment N_0 produced the lowest biological yield (5.66 t ha^{-1}) and the treatment N_3 produced the highest biological yield (8.34 t ha^{-1}).

Effect of boron

The biological yield (t ha^{-1}) of Khoi Bhutta was significantly influenced by different doses of boron (Table 4). The results revealed that, the treatment B_0 produced the lowest biological yield (6.83 t ha^{-1}) and the treatment B_3 produced the highest biological yield (7.51 t ha^{-1}). Similar findings were described by Ziaeyan and Rajaie (2009) who described increased biological yield in maize by foliar application of boron.

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on biological yield (t ha^{-1}) (Table 5). The lowest biological yield (5.19 t ha^{-1}) was observed from the N_0B_0 treatment and the highest biological yield (8.58 t ha^{-1}) was observed from N_3B_3 treatment.

4.10 Harvest index

Effect of nitrogen

The harvest index (%) of Khoi Bhutta was significantly influenced by different doses of nitrogen (Table 3). The results revealed that, the treatment N_0 produced the lowest harvest index (42.93%) and the treatment N_3 produced the highest harvest index (45.32%). Similar findings were reported by Sahar *et al.* (2005) who stated that grain and stalk yield were significantly influenced by the increased rate of nitrogen thus increased the harvest index.

Effect of boron

The harvest index (%) of Khoi Bhutta was significantly influenced by different doses of boron (Table 4). The results revealed that, the treatment B_0 produced the lowest harvest index (43.78%) and the treatment B_3 produced the highest harvest index (44.47%).

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron showed significant variation of Khoi Bhutta on harvest index (%) (Table 5). The lowest harvest index (42.58%) was observed from the N_0B_0 treatment and the highest harvest index (45.69%) was observed from N_3B_3 treatment.

4.11 Chemical composition

4.11.1 Nitrogen (N) content in grain

Effect of nitrogen

Nitrogen (N) content in grain of Khoi Bhutta showed statistically significant difference due to different doses of nitrogen (Table 6). The highest N content (1.65%) was observed in grain from the treatment N_3 and the lowest amount of N (0.85%) found in grain from treatment N_0. Khatik and Dikshit (2001) reported that the increasing application pf nitrogen in soil resulted in increasing N contents in grain, straw and root of maize.

Effect of boron

Nitrogen (N) content in grain of Khoi Bhutta showed statistically significant difference due to different doses of boron (Table 7). The highest N content (1.14%) was observed in grain from the treatment B_3 and the lowest amount of N (0.34%) found in grain from treatment B_0.

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron had significant influence on nitrogen (N) content in grain of Khoi Bhutta (Table 8). The highest N (1.78%) in grain was observed from the treatment N_3B_3 and the lowest N (0.87%) in grain was observed from N_0B_0 which was statistically similar with N_0B_1 (0.90%) and N_0B_2 (0.93%).

Table 6: Effect of different doses of nitrogen on N and B content in grain, straw and root

Treatments	Grain		Straw		Root	
	% N	% B	% N	% B	% N	% B
N_0	0.85 d	0.13 d	0.43 d	0.09 d	0.35 d	0.18 d
N_1	1.07 c	0.25 c	0.73 c	0.22 c	0.54 c	0.27 c
N_2	1.37 b	0.41 b	1.12 b	0.36 b	0.78 b	0.38 b
N_3	1.65 a	0.52 a	1.48 a	0.47 a	0.95 a	0.45 a
LSD $_{(0.05)}$	0.03300	0.03300	0.04042	0.02334	0.03300	0.02334
CV (%)	3.32	7.23	6.73	5.23	7.72	5.81
Significant level	*	*	*	*	*	*

* - Significant at 5% level

N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Table 7: Effect of different doses of boron on N and B content in grain, straw and root

Treatments	Grain		Straw		Root	
	% N	% B	% N	% B	% N	% B
B_0	0.34 d	0.36 d	0.06 d	0.19 c	0.04 d	0.11 d
B_1	0.58 c	0.44 c	0.28 c	0.27 b	0.14 c	0.21 c
B_2	0.87 b	0.51 b	0.58 b	0.34 b	0.25 b	0.29 b
B_3	1.14 a	0.58 a	0.84 a	0.42 a	0.34 a	0.37 a
LSD $_{(0.05)}$	0.03300	0.03690	0.04042	0.02609	0.03300	0.02609
CV (%)	3.32	7.23	6.73	5.23	7.72	5.81
Significant level	*	*	*	*	*	*

* - Significant at 5% level

B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Table 8: Interaction effect of different doses of nitrogen and boron on N and B content in grain, straw and root

Treatments		Grain		Straw		Root	
		% N	% B	% N	% B	% N	% B
N_0	B_0	0.87 h	0.15 g	0.16 h	0.11 h	0.11 h	0.13 f
	B_1	0.90 h	0.18 g	0.23 g	0.15 g	0.16 h	0.17 f
	B_2	0.93 h	0.20 f	0.28 g	0.18 fg	0.22 g	0.20 e
	B_3	0.98 g	0.23 f	0.35 g	0.20 f	0.28 g	0.21 e
N_1	B_0	1.05 g	0.24 f	0.61 f	0.21 f	0.35 f	0.22 e
	B_1	1.13 f	0.27 e	0.68 ef	0.25 e	0.41 f	0.23 e
	B_2	1.19 f	0.31 e	0.73 e	0.28 e	0.46 ef	0.26 de
	B_3	1.22 ef	0.35 e	0.79 e	0.31 d	0.53 e	0.28 de
N_2	B_0	1.27 ef	0.39 de	1.01 d	0.34 d	0.61 d	0.31 d
	B_1	1.30 e	0.42 d	1.08 d	0.37 d	0.67 d	0.33 cd
	B_2	1.36 de	0.45 d	1.13 c	0.41 c	0.73 c	0.36 c
	B_3	1.44 d	0.51 c	1.19 c	0.44 c	0.79 c	0.37 c
N_3	B_0	1.51 cd	0.53 c	1.36 bc	0.45 c	0.85 bc	0.39 c
	B_1	1.59 c	0.57 c	1.43 b	0.50 b	0.89 b	0.42 b
	B_2	1.69 b	0.62 b	1.48 ab	0.53 ab	0.92 b	0.44 b
	B_3	1.78 a	0.69 a	1.54 a	0.57 a	0.98 a	0.48 a
LSD $_{(0.05)}$		0.07380	0.03092	0.05218	0.02677	0.05355	0.05218
CV (%)		3.32	7.23	6.73	5.23	7.72	5.81
Significant level		*	*	*	*	*	*

* - Significant at 5% level

N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}; B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

4.11.2 Nitrogen (N) content in straw

Effect of nitrogen

Nitrogen (N) content in straw of Khoi Bhutta showed statistically significant difference due to different doses of nitrogen (Table 6). The highest N content (1.48%) was observed in straw from the treatment N_3 and the lowest amount of N (0.43%) found in straw for the treatment N_0.

Effect of boron

Nitrogen (N) content in straw of Khoi Bhutta showed statistically significant difference due to different doses of boron (Table 7). The highest N content (0.84%) was observed in straw from the treatment B_3 and the lowest amount of N (0.06%) found in straw from the treatment B_0.

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron had significant influence on nitrogen (N) content in straw of Khoi Bhutta (Table 8). The highest N (1.54%) in straw was observed from the treatment N_3B_3 which was statistically similar with N_3B_2 (1.48%) and the lowest N (0.16%) in straw was observed from N_0B_0.

4.11.3 Nitrogen (N) content in root

Effect of nitrogen

Nitrogen (N) content in root of Khoi Bhutta showed statistically significant difference due to different doses of nitrogen (Table 6). The highest N content (0.95%) was observed in root from the treatment N_3 and the lowest amount of N (0.35%) found in root for the treatment N_0.

Effect of boron

Nitrogen (N) content in root of Khoi Bhutta showed statistically significant difference due to different doses of boron (Table 7). The highest N content (0.34%) was observed in root from the treatment B_3 and the lowest amount of N (0.04%) found in root from the treatment B_0.

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron had significant influence on nitrogen (N) content in root of Khoi Bhutta (Table 8). The highest N (0.98%) in root was observed from the treatment N_3B_3 and the lowest N (0.11%) in root was observed from N_0B_0 which was statistically similar with N_0B_1 (0.16%).

4.12.1 Boron (B) content in grain

Effect of nitrogen

Boron (B) content in grain of Khoi Bhutta showed statistically significant difference due to different doses of nitrogen (Table 6). The highest B content (0.52%) was observed in grain from the treatment N_3 and the lowest amount of B (0.13%) found in grain from treatment N_0.

Effect of boron

Boron (B) content in grain of Khoi Bhutta showed statistically significant difference due to different doses of boron (Table 7). The highest B content (0.58%) was observed in grain from the treatment B_3 and the lowest amount of B (0.36%) found in grain from treatment B_0.

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron had significant influence on boron (B) content in grain of Khoi Bhutta (Table 8). The highest B (0.69%) in grain was observed from the treatment N_3B_3 and the lowest B (0.15%) in grain was observed from N_0B_0 which was statistically similar with N_0B_1 (0.18%).

4.12.2 Boron (N) content in straw

Effect of nitrogen

Boron (B) content in straw of Khoi Bhutta showed statistically significant difference due to different doses of nitrogen (Table 6). The highest B content (0.47%) was observed in straw from the treatment N_3 and the lowest amount of B (0.09%) found in straw for the treatment N_0.

Effect of boron

Boron (B) content in straw of Khoi Bhutta showed statistically significant difference due to different doses of boron (Table 7). The highest B content (0.42%) was observed in straw from the treatment B_3 and the lowest amount of B (0.19%) found in straw from the treatment B_0.

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron had significant influence on Boron (B) content in straw of Khoi Bhutta (Table 8). The highest B (0.57%) in straw was observed from the treatment N_3B_3 which was statistically similar with N_3B_2 (0.53%) and the lowest B (0.11%) in straw was observed from N_0B_0.

4.12.3 Boron (N) content in root

Effect of nitrogen

Boron (B) content in root of Khoi Bhutta showed statistically significant difference due to different doses of nitrogen (Table 6). The highest B content (0.45%) was observed in root from the treatment N_3 and the lowest amount of B (0.18%) found in root for the treatment N_0.

Effect of boron

Boron (B) content in root of Khoi Bhutta showed statistically significant difference due to different doses of boron (Table 7). The highest B content (0.37%) was observed in root from the treatment B_3 and the lowest amount of B (0.11%) found in straw from the treatment B_0.

Interaction effect of nitrogen and boron

Interaction of different doses of nitrogen and boron had significant influence on Boron (B) content in root of Khoi Bhutta (Table 8). The highest B (0.48%) in root was observed from the treatment N_3B_3 and the lowest B (0.13%) in root was observed from N_0B_0 which was statistically similar with N_0B_1 (0.17%).

CHAPTER V

SUMMARY AND CONCLUSION

Different growth and yield parameters varied significantly due to difference in the doses of nitrogen and boron. Different doses of nitrogen had significant effect on growth and yield of Khoi Bhutta. At 40, 80 DAS and at harvest, treatment N_0 produced the shortest plant (53.70 cm, 98.7 cm and 143.7 cm respectively) and treatment N_3 produced the tallest plant (76.8 cm, 121.8 cm and 166.8 cm respectively). At 40, 80 DAS and at harvest, treatment N_0 produced the lowest number of leaves (4.33, 6.33 and 8.33 respectively) and treatment N_3 produced the highest number of leaves (14.25, 16.25 and 18.25 respectively). Among the treatments, treatment N_0 produced the lowest number of rows/cob (9.42) and treatment N_3 produced the highest number of rows/cob (14.92). The treatment N_0 produced the lowest number of grains/row (32.67) and treatment N_3 produced the highest number of grains/row (41.25). The treatment N_0 produced the lowest number of grains/cob (352.30) and treatment N_3 produced the highest number of grains/cob (542.10). The treatment N_0 produced the lowest 1000-grain weight (113.40 g) and treatment N_3 produced the highest 1000-grain weight (141.20 g). The minimum grain yield (2.43 t ha^{-1}) was recorded from the treatment N_0 and the maximum (3.78 t ha^{-1}) was recorded from N_3. The lowest stover yield (3.23 t ha^{-1}) was found from N_0 and the highest (4.56 t ha^{-1}) from N_3. The treatment N_0 produced the lowest biological yield (5.66 t ha^{-1}) and treatment N_3 produced the highest biological yield (8.34 t ha^{-1}). The treatment N_0 produced the lowest harvest index (42.93%) and treatment N_3 produced the highest harvest index (45.32%).

The lowest N (0.85%) in grain was recorded from N_0 and the highest (1.65%) from N_3. The lowest N (0.43%) in straw was recorded from N_0 and the highest (1.48%) from N_3. The lowest N (0.35%) in root was recorded from N_0 and the highest (0.95%) from N_3.

Different doses of boron had significant effect on growth and yield of Khoi Bhutta. At 40, 80 DAS and at harvest, treatment B_0 produced the shortest plant (63.35 cm, 108.3 cm and 153.4 cm respectively) and treatment B_3 produced the tallest plant (67.95 cm, 112.9 cm and 157.9 cm respectively). 40, 80 DAS and at harvest, the treatment B_0 produced the lowest number of leaves (8.17, 10.17 and 12.08 respectively) and the treatment B_3

produced the highest number of leaves (10.58, 12.58 and 14.58 respectively). Among the treatments, treatment B_0 produced the lowest number of rows/cob (11.33) and the treatment B_3 produced the highest number of rows/cob (12.58). The treatment B_0 produced the lowest number of grains/row (35.83) and the treatment B_3 produced the highest number of grains/row (38.33). The treatment B_0 produced the lowest number of grains/cob (438.10) and the treatment B_3 produced the highest number of grains/cob (480.5). The treatment B_0 produced the lowest 1000-grain weight (124.30 g) and the treatment B_3 produced the highest 1000-grain weight (129.80 g). The minimum grain yield (2.99 t ha^{-1}) was recorded from the treatment B_0 and the maximum (3.34 t ha^{-1}) was recorded from B_3. The lowest stover yield (3.84 t ha^{-1}) was found from B_0 and the highest (4.17 t ha^{-1}) from B_3. The treatment B_0 produced the lowest biological yield (6.83 t ha^{-1}) and treatment B_3 produced the highest biological yield (7.51 t ha^{-1}). The treatment B_0 produced the lowest harvest index (43.78%) and treatment B_3 produced the highest harvest index (44.47%).

The lowest B (0.36%) in grain was recorded from B_0 and the highest (0.58%) from B_3. The lowest B (0.19%) in straw was recorded from B_0 and the highest (0.42%) from B_3. The lowest B (0.11%) in root was recorded from B_0 and the highest (0.37%) from B_3.

At 30, 50, 70 and 90 DAT the highest plant height (31.77 cm, 50.77 cm, 70.80 cm and 90.23 cm respectively) were observed from the As_0T_2 treatment and the lowest (18.37 cm, 31.37 cm, 43.27 cm and 54.40 cm respectively) were observed from As_3T_1 treatment. At 40, 80 DAS and at harvest, the lowest plant height (51.40 cm, 96.40 cm and 141.40 cm respectively) was observed from the N_0B_0 treatment and the highest plant height (79.60 cm, 124.60 cm and 169.60 cm respectively) was observed from N_3B_3 treatment. At 40, 80 DAS and at harvest, the lowest number of leaves (3.67, 5.67 and 7.67 respectively) was observed from the N_0B_0 treatment and the highest number of leaves (16.00, 18.00 and 20.00 respectively) was observed from N_3B_3 treatment. The lowest number of grain rows/cob (9.00) was observed from the N_0B_0 treatment and the highest number of grain rows/cob (16.67) was observed from N_3B_3 treatment. The lowest number of grains/row (31.33) was observed from the N_0B_0 treatment and highest number of grains/row (43.33) was observed from N_3B_3 treatment. The lowest number of grains/cob (325.70) was observed from the N_0B_0 treatment and the highest number of grains/cob

(559.00) was observed from N_3B_3 treatment. The lowest 1000-grain weight (109.60 g) was observed from the N_0B_0 treatment and the highest 1000-grain weight (143.70 g) was observed from N_3B_3 treatment. The lowest grain yield (2.21 t ha^{-1}) was observed from the N_0B_0 treatment and the highest grain yield (3.92 t ha^{-1}) was observed from N_3B_3 treatment. The lowest stover yield (2.98 t ha^{-1}) was observed from the N_0B_0 treatment and the highest stover yield (4.66 t ha^{-1}) was observed from N_3B_3 treatment. The lowest biological yield (5.19 t ha^{-1}) was observed from the N_0B_0 treatment and the highest biological yield (8.58 t ha^{-1}) was observed from N_3B_3 treatment. The lowest harvest index (42.58%) was observed from the N_0B_0 treatment and the highest harvest index (45.69%) was observed from N_3B_3 treatment.

The lowest N (0.87%) in grain was recorded from N_0B_0 and the highest (1.78%) from N_3B_3. The lowest N (0.16%) in straw was recorded from N_0B_0 and the highest (1.54%) from N_3B_3. The lowest N (0.11%) in root was recorded from N_0B_0 and the highest (0.98%) from N_3B_3.

The lowest B (0.15%) in grain was recorded from N_0B_0 and the highest (0.69%) from N_3B_3. The lowest B (0.11%) in straw was recorded from N_0B_0 and the highest (0.57%) from N_3B_3. The lowest B (0.13%) in root was recorded from N_0B_0 and the highest (0.48%) from N_3B_3.

From the above results it can be concluded that,

- The application of nitrogen and phosphorus had positive effect on the growth, yield and quality of Khoi Bhutta.
- Application of 140 kg N ha^{-1} with 1.6 kg B ha^{-1} produced better result for the parameters studied**.**

From the above conclusions, the following recommendations can be made:

- ✓ Effect of different doses of nitrogen and boron may be studied for growing Khoi Bhutta.
- ✓ Such studies should be carried out to different agro-ecological zones (AEZs) of the country.

CHAPTER VI

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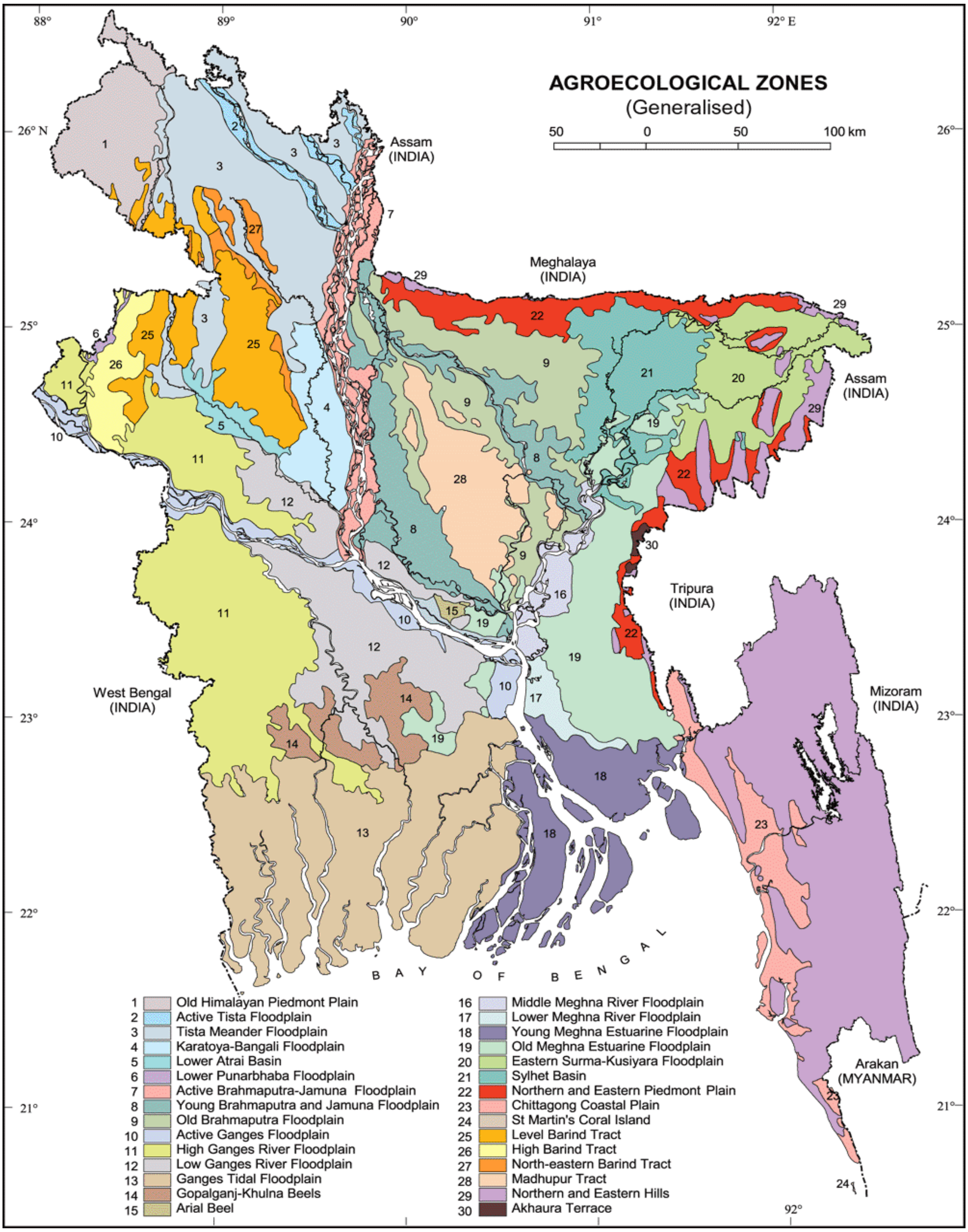
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Morphological characteristics of the experimental field

Morphology	Characteristics
Location	SAU Farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ- 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(SAU Farm, Dhaka)

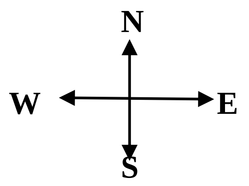
Appendix III. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions: % Sand (2.0-0.02 mm) % Silt (0.02-0.002 mm) % Clay (<0.002 mm)	 22.26 56.72 20.75
Textural class	Silt Loam
pH (1: 2.5 soil- water)	5.9
Organic Matter (%)	1.09
Total N (%)	0.028
Available K (ppm)	15.625
Available P (ppm)	7.988
Available S (ppm)	2.066

(SAU Farm, Dhaka)

Appendix IV. Layout of the experimental field

R_1	R_2	R_3
N_0B_0	N_1B_2	N_2B_3
N_0B_1	N_1B_3	N_2B_2
N_0B_2	N_1B_0	N_2B_1
N_0B_3	N_1B_1	N_2B_1
N_1B_0	N_2B_3	N_3B_2
N_1B_1	N_2B_2	N_3B_3
N_1B_2	N_2B_1	N_3B_0
N_1B_3	N_2B_0	N_3B_1
N_2B_0	N_3B_2	N_0B_3
N_2B_1	N_3B_3	N_0B_0
N_2B_2	N_3B_1	N_0B_2
N_2B_3	N_3B_0	N_0B_1
N_3B_0	N_0B_3	N_1B_2
N_3B_1	N_0B_1	N_1B_0
N_3B_2	N_0B_2	N_1B_1
N_2B_3	N_1B_0	N_1B_2



Plot length = 25 m

Plot width = 9 m

Plot area = 25 × 9 = 225 m^2

Unit plot length = 2.5 m

Unit plot breadth = 1.2 m

Unit plot area = 2.5 × 1.2 = 3 m^2

N_0 = Control (0 kg N ha^{-1})

N_1 = 60 kg N ha^{-1}

N_2 = 100 kg N ha^{-1}

N_3 = 140 kg N ha^{-1}

B_0 = Control (0 kg B ha^{-1})

B_1 = 0.8 kg B ha^{-1}

B_2 = 1.2 kg B ha^{-1}

B_3 = 1.6 kg B ha^{-1}

Appendix V. Effect of nitrogen on plant height and number of leaves hill^{-1} at different days after sowing

Treatments	Plant height (cm)			Number of leaves hill^{-1}		
	40 DAS	80 DAS	Harvest	40 DAS	80 DAS	Harvest
N_0	53.70 d	98.70 d	143.70 d	4.33 d	6.33 d	8.33 d
N_1	62.35 c	107.30 c	152.30 c	7.08 c	9.08 c	11.08 c
N_2	69.70 b	114.70 b	159.70 b	11.17 b	13.17 b	15.08 b
N_3	76.80 a	121.80 a	166.80 a	14.25 a	16.25 a	18.25 a
LSD $_{(0.05)}$	0.3682	0.4016	0.4650	0.7006	0.7006	0.6701
CV (%)	7.67	8.43	8.36	9.12	7.49	6.09
Significant level	*	*	*	*	*	*

* - Significant at 5% level

N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Appendix VI. Effect of boron on plant height and number of leaves hill^{-1} at different days after sowing

Treatments	Plant height (cm)			Number of leaves hill^{-1}		
	40 DAS	80 DAS	Harvest	40 DAS	80 DAS	Harvest
B_0	63.35 d	108.30 d	153.40 d	8.17 d	10.17 d	12.08 d
B_1	65.07 c	110.10 c	155.10 c	8.75 c	10.75 c	12.75 c
B_2	66.18 b	111.20 b	156.20 b	9.33 b	11.33 b	13.33 b
B_3	67.95 a	112.90 a	157.90 a	10.58 a	12.58 a	14.58 a
LSD $_{(0.05)}$	0.3682	0.4016	0.4650	0.7006	0.7006	0.6701
CV (%)	7.67	8.43	8.36	9.12	7.49	6.09
Significant level	*	*	*	*	*	*

* - Significant at 5% level

B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}

Appendix VII. Effect of nitrogen on number of grain rows/cob, number of grains/row, number of grains/cob and 1000-grain weight

Treatments	Number of grain rows/cob	Number of grains/rows	Number of grains/cob	1000-grain weight (g)
N_0	9.42 d	32.67 d	352.30 d	113.40 d
N_1	10.67 c	35.58 c	437.80 c	122.50 c
N_2	12.50 b	38.25 b	497.90 b	132.50 b
N_3	14.92 a	41.25 a	542.10 a	141.2 a
LSD $_{(0.05)}$	0.8902	1.291	3.497	0.05273
CV (%)	8.99	4.19	6.92	6.05
Significant level	*	*	*	*

* - Significant at 5% level

N_0 = 0 kg, N_1 = 60 kg, N_2 = 100 kg, N_3 = 140 kg ha^{-1}

Appendix VIII. Effect of boron on number of grain rows/cob, number of grains/row, number of grains/cob and 1000-grain weight

Treatments	Number of grain rows/cob	Number of grains/rows	Number of grains/cob	1000-grain weight (g)
B_0	11.33 b	35.83 b	438.10 d	124.30 d
B_1	11.67 b	36.50 b	450.10 c	127.20 c
B_2	11.92 ab	37.08 ab	461.50 b	128.20 b
B_3	12.58 a	38.33 a	480.50 a	129.80 a
LSD $_{(0.05)}$	0.8902	1.291	3.497	0.05273
CV (%)	8.99	4.19	6.92	6.05
Significant level	*	*	*	*

* - Significant at 5% level

B_0 = 0 kg, B_1 = 0.8 kg, B_2 = 1.2 kg, B_3 = 1.6 kg ha^{-1}