GROWTH AND YIELD OF MUNGBEAN (BARI Mung 5) (*Vigna radiata*) IN RESPONSE OF NITROGEN AND BORON

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CERTIFICATE

This is to certify that the thesis entitled, **Growth And Yield Of Mungbean (Bari Mung 5)** ***(Vigna Radiata)*** **In Response Of Nitrogen And Boron** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN SOIL SCIENCE,** embodies the result of a piece of *bonafide* research work carried out by***H. M. Niaz Morshed*****,** Registration No.***08-02863***under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated- June, 2015
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GROWTH AND YIELD OF MUNGBEAN (BARI Mung 5) (*Vigna radiata*) IN RESPONSE OF NITROGEN AND BORON

ABSTRACT

The experiment was conducted at the research field, SAU, Dhaka, in the Robi season during the period from March 2014 to June 2014 to study the effect of nitrogewn and boron on growth and yield of mungbaen. The experiment consists of four levels of nitrogen viz. control, 25 kg N ha^{-1}, 35 kg N ha^{-1} and45 kg N ha^{-1} and three levels of boron viz. control, 1 kg B ha^{-1} and2 kg B ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of different levels of nitrogen, the highest number of pods per plant(24.89), length of pod (9.68 cm), number of seeds per pod (14.67), 1000 grains weight (44.50), grain yield (1.68 t ha^{-1}) and harvest index (56.42 %) were found from N_2. For different levels of boron, the highest number of pods per plant(22.08), length of pod (10.18 cm), number of seeds per pod (15.47), 1000 grains weight (44.26), grain yield (1.63 t ha^{-1}) and harvest index (55.71 %) were found from B_1. Amongthe interaction effect, the number of pods per plant(26.33), length of pod (11.53 cm), number of seeds per pod (17.80), 1000 grains weight (49.70), grain yield (2.0 t ha^{-1}) and harvest index (68.97 %) were observed from N_2B_1.In this study it was found that N_2B_1 always gave better result over yield and growth parameter of mungbean. So this combination of nitrogen and boron is suggested for better result on mungbean cultivation.

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@	:	At the Rate of
Abstr.	:	Abstract
AEZ	:	Agro-ecological Zone
Agric.	:	Agriculture
AVRDC	:	Asian Vegetables Research and Development
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ration
cv.	:	Cultivar
DAS	:	Days After Sowing
et al.	:	et alii (and others)
FAO	:	Food and Agriculture Organization of the United Nations
FW	:	Fresh weight
FYM	:	Farm Yard Manure
Hort.	:	Horticulture
i.e.	:	That is
J.	:	Journal
LSD	:	Least Significant Difference
NS	:	Non-significant
RCBD	:	Randomized Complete Block Design
Sci.	:	Science
Soc.	:	Society
UK	:	United Kingdom
UNDP	:	United Nations Development Program
Viz.	:	Namely

CHAPTER I

INTRODUCTION

Pulse crops belong to grain legume. Bangladesh grows various types pulse crops. Among them lentil, cowpea, blackgram, mung bean, field pea and grass pea are important. Pulses constitute the main source of protein for the people, particularly the poor sections of Bangladesh. These are also the best source of protein for domestic animals. Besides, the crops have the capability to enrich soils through nitrogen fixation. Pulse protein is rich in lysine that is deficient in rice. According to FAO (2013) recommendation, a minimum intake of pulse by a human should be 80 gm/day, whereas it is 7.92 g in Bangladesh (BBS, 2011). This is because of fact that national production of the pulses is not adequate to meet our national demand. Both the acreage and production of the pulses are decreasing in Bangladesh day by day due to the inception of wheat and born rice in our cropping system with irrigation facilities. In Bangladesh, total production of pulses is only 0.65 million ton against 2.7 million tons requirement. This means the shortage is almost 80% of the total requirement (Rahman and Ali, 2007). This is mostly due to low yield (MoA, 2013). At present, the area under pulse crop is 0.406 million hectare with a production of 0.322 million tons (BBS, 2013). Where mung bean is cultivated in the area of 0.108 million ha with production of 0.03 million tons (BBS, 2014).

Mung bean [*Vigna radiata* L. Wilczek] is one of the most important pulse crops in Bangladesh. This commonly grown pulse crop belongs to the family Fabaceae. Its edible grain is characterized by good digestibility, flavor, high protein content and absence of any flatulence effects (Ahmad *et al.*, 2008). It holds the 3rd in protein content and 4th in both acreage and production in Bangladesh (BBS, 2012). The agro-ecological condition of Bangladesh is favorable for growing this crop. Mung bean grain contains 51% carbohydrate, 26% protein. 10% moisture. 4% mineral and 3% vitamins (Khan, 1981a; Kaul, 1982). On the nutritional point of view, mung bean is one of the best among pulses (Khan, 1981b). It is widely used as "Dal" in the country like other pulses.

In Bangladesh, although mung bean ranks 4th in acreage and production but ranks 1st in market price. Mung bean covers an area of 22,267 hectare and production was about 17000 metric tons. The average production of mung bean in the country is about 763 kg ha^{-1} (BBS, 2014). About 3 t ha^{-1} of seed yield have been reported in a trial in Taiwan (Lawn, 1978). But in Bangladesh the average yield is very low. The average yield of mung bean is 0.69 t ha^{-1} (BBS, 2014). The yield difference indicates the wide scope for increasing yield of mung bean.

Bangladesh is a developing country. Where population is increasing and land is decreasing is day by day, so we have to produce more food in our limited land. To meet up the increased demand of food, farmers are growing more cereal crops. So, at present the cultivation of pulse has gone to marginal land because farmers do not want to use their fertile land in pulse cultivation. Another cause of decreasing pulse cultivation is its low yield. But the agroclimatic conditions of Bangladesh favor mung bean production almost throughout the year. The farmers of Bangladesh generally produce mung bean by one ploughing and hardly use any fertilizer and irrigation due to its lower productivity and also to their poor socio-economi condition and lack of proper knowledge. There is an ample scope for increasing the yield of mung bean with improved management practices.

Pulses although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers becomes helpful in increasing the yield (Patel *et al.*, 1984). Nitrogen is the most useful for pulse crops because it is the components of protein. Nitrogen plays a vital role as a constituent of protein, nucleic acid and chlorophyll. It is also the most different element to manage in a fertilization system such an adequate, but not excessive amount of nitrogen is available during the entire growing season (Anon, 1972). An adequate supply of nitrogen is essential for vegetative growth and desirable yield (Yoshizawa *et al.*, 1981). On the other hand, excessive application of nitrogen is not only uneconomical, but it can prolong the growing period and delay crop maturity. Excessive nitrogen application causes physiological disorder (Obreza and Vavrina, 1993).

Micronutrient (B, Zn, Mo, Mg etc.) is very important micro fertilizer for increasing the yield of mung bean cultivation. Boron is very important in cell division and in pod as well as seed formation and in relation to water uptake. The chlorosis and browning of young leaves, killed growing points, distorted blossom development, lesions in pit and roots was the deficiency symptoms of some boron sensitive crops. The critical level of boron with reference to crops in general was reported to range from 0.3 to 0.8 ppm depending on soil types (Shorrocks, 1984). Zinc is involved in auxin formation, activation of dehydragenase enzymes and stabilization of ribosomal fractions (Aghatise and Tayo, 1994).

Therefore, the nitrogen and boron might have the positive effects on low temperature stress tolerance on mung bean under late sowing condition in Kharif-II season. Keeping these facts in mind the study were undertaken to achieve the following objectives:

- To study the effect of nitrogen on growth and yield of mung bean.
- To evaluate the response of boron on growth and yield of mung bean.
- To observe the interaction effects of N and B on growth and yield of mung bean.

CHAPTER II

REVIEW OF LITERATURE

Mung bean is one of the important pulse crops in Bangladesh as well as many countries of the world. The crop has conventional less concentration by the researcher on various aspects because normally it grows with less care and management practices. For that a very few studies related to yield and development of mung bean have been carried out in our country as well as many other countries of the world. So, the research as far done in Bangladesh is not adequate and conclusive. In this chapter, an attempt has been made to review the available information in home and abroad regarding the effect of nitrogen and boron on the yield of mung bean and other legumes.

2.1 Effect of nitrogen on growth and yield of Mung bean

A study was conducted by Nigamananda (2007) in Uttar Pradesh, India during 2005-2006 to evaluate the effect of N application time as basal and as DAP (Diammonium phosphate) or urea spray and plant growth regulator (NAA at 40 ppm) on the yield and yield components of mung bean cv, K-851. The recommended rate of N:P:K (20:50:20 kg ha^{-1}) as basal was used as a control. Treatments included: ½ basal N + foliar N as urea or DAP at 25 or 35 days after sowing (DAS); ½ basal N + ¼ at 25 DAP + ¼ at 35 DAS as urea or DAP; and ½ basal N + ½ foliar spraying as urea or DAP + 40 ppm NAA. Results showed that 2% foliar spray as DAP and NAA, applied at 35 DAS, resulted in the highest values for number of pods/plant (38.3), seeds/pod, test weight flower number, fertility, fertility coefficient and grain yield (9.66 q ha^{-1}).

Tickoo *et al.* (2006) carried out an experiment on mung bean cultivars Pusa 105 and Pusa Vishal of which seeds were sown at 22.5 and 30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1} in a field experiment conducted in Delhi, India during the Kharif season of 2000. Cultivar Pusa Vishal recorded higher boilogical and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. Difference in the values of the parameters examined. NP rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both crops.

A field experiment was conducted by Raman and Venkataramana (2006) during February to May 2002 in Annamalainagar, Tamil Nadu, India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of mung bean. There were 10 foliar spray treatments, consisting of water spray, 2% diamonium phosphate (DAP) at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA, DAP + NAA, DAP + Penshibao, DAP + NAA + Penshibao was significantly superior to other treatments in increasing the values of N, P and K uptakes, yield attributes and yield. The highest grain yield of 1529 kg ha^{-1} was recorded with this treatment.

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg ha^{-1}) on the growth and yield of mung bean cv. AEM 96 in Tandojam, Pakistan, during the spring season of 2004. The different NPK levels significantly affected the crop parameters. The 10-30-30 kg NPK $ha^{-1}$was the best treatment, recording plant height of 56.25, germination of 90.50%, satisfactory plant population of 162.00, prolonged days taken to maturity of 55.50, long pods of 5.02 cm, seed weight per plant of 10.53 g, seed index of 3.52 g and the highest seed yield of 1205.2 kg ha^{-1}. There was no significant change in the crop parameters beyond this level.

Nadeem *et al.* (2004) studied the response of mung bean cv. NM – 98 to seed inoculation and different levels of fertilizer (0-0, 15-30, 30-60 and 45-90 kg N-P_2O_5 ha^{-1}) under field conditions. Application of fertilizer significantly increased the yield and the maximum seed yield was obtained when 30 kg N $ha^{-1}$was applied along with 60 kg P_2O_5 ha^{-1}.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mung bean cv. NM-98 in 2001. They observed that number of flowers per plant was found to be significantly higher by 25 kg N ha^{-1}. Number of seeds per pod was significantly affected by varying levels of nitrogen and phosphorus. Growth and yield components were significantly affected by nitrogen and phosphorus. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 P kg ha^{-1}resulted with maximum seed yield (1112.96 kg ha^{-1}).

Rajender *et al.* (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mung bean genotypes MH 85-111 and T44 Grain yield increased with increasing N retes up to 20 kg ha^{-1}. Further increase in N did not affect yield.

The effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) on mung bean cultivars MH 85-111 and T44 were determined in a field experiment conducted by Rajender *et al.* (2002) in Hisar, Haryana, India during the summer of 1999-2000. The number of branches, number of pods per plant, number of seeds per pod, 100-seed weight and straw yield increased with increasing P rates, whereas grain yield increased with increasing rates of up to 40 kg P ha^{-1}only.

Mahboob and Asghar (2002) studied effect of seed inoculation at different nitrogen levels on mung bean at the agronomic research station, Farooqabad in Pakistan. They revealed that various yield components like 1000 grain weight were affected significantly with 50-50-0 NPK kg ha^{-1}. Again they revealed that seed inoculation + 50-50-0 NPK kg ha^{-1}exibited superior performance in respect of seed yield (955 kg ha^{-1}).

Srinivas *et al.* (2002) conducted an experiment on the performance of mung bean at 0, 25 and 60 kg N ha^{-1} and 0, 25, 50 kg P ha^{-1} were tested. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg ha^{-1}followed by a decrease with further increase in N. They also observed that 1000-seed weight increased with increasing rates of N up to 40 kg ha^{-1}along with increasing rates of P.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. Mung bean was grown using farmers practices (no fertilizer) or using a combinations of fertilizer application (30 kg N + 35 kg P_2O_5 ha^{-1}). Seed yield was 0.40 ton $ha^{-1}$with farmer's practices, while the highest yield was obtained by the fertilizer application (0.77 ton ha^{-1}).

Karle and Pawar (1998) examined the effect of varying levels of N and P fertilizers on summer mung bean. They reported higher seed yield in mung bean with the application of 15 kg N $ha^{-1}$and 40 kg P_2O_5 ha^{-1}.

Patel *et al.* (1992) conducted a field trial to evaluate the response of mung bean to sulphur fertilization under different levels of nitrogen and phosphorus. Mung bean cv. Gujrarat-2 and K-851 were given 10 kg N + 20 kg P ha^{-1}, 20 kg N + 40 kg P $ha^{-1}$and and 0, 10, 20 or 30 kg S ha^{-1}as gypsum. Seed yield was 1.2 and 1.24 t ha^{-1}in Gujrarat 2 K 851 respectively 20 kg N + 40 kg P ha^{-1}.

Tank *et al.* (1992) observed when mung bean was fertilized with 20 kg N ha^{-1}along with to level of 40 kg P_2O_5 ha^{-1}increased seed yield significantly over the unfertilized control. They also reported that mung bean fertilizer with 20 kg N ha^{-1} along with 75 kg P_2O_5 ha^{-1}significantly increased the number of pods per plant.

A field experiments was conducted by Sarkar and Banik (1991) to study the effect of N and P on yield of mung bean. Results showed that application of N along with P significantly increased the seed yield of mung bean. The maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5 ha^{-1}.

A field experiment was conducted by Sarker and Banik (1991) to study the effect of N and P on yield of mung bean. Results showed that application of N along with P significantly increased the seed yield of mung bean. The maximum seed yield was obtained with the combination of 20 kg N and 60 kg P2O5 ha^{-1}.

Suhartatik (1991) in a study observed that increased application of NPK fertilizers significantly increased the plant height of mung bean.

Bali *et al.* (1991) conducted a field trail on mung bean in Kharif seasons on silty clay loam soil. Thay revealed that 1000 seed weight increased with 40 kg N $ha^{-1}$and 60 kg P_2O_5 ha^{-1}.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1}along with 50 kg P ha^{-1}increased mung bean yield.

Results from field experiments conducted by Mahadkar and Saraf (1988) during summer season of mung bean showed that the application of N with P and K at 20:25 kg ha^{-1}gave higher seed yield.

Results of an experiment, conducted by Sardana and Verma (1987) in Delhi, India, revealed that application of nitrogen, phosphorus and potassium fertilizers in combination resulted in significant increase in plant height of mung bean. They also stated that the application of nitrogen, phosphorus and potassium fertilizers in combination resulted in the significant increase in seed yield of mung bean. They also stated that application of nitrogen, phosphorus and potassium fertilizers combined resulted in significant increases in 1000 seed weight of mung bean.

Patel and Parmer (1986) conducted an experiment on the response of green of mung bean to varying levels of nitrogen and phsophorus. They observed that increasing N application to rainfed mung bean (cv. Gujrat-1) from 0 to 50 kg N ha^{-1}increased the number of pods per plant.

In trails, on clay soils during the summer season Patel *et al.* (1984) observed the effect of N levels (0, 10, 20 and 30 kg N ha^{-1}) and that of the P (0, 10, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}) on the growth and seed yield of mung bean. In that experiment, it was found that application of 30 kg N ha^{-1}along with 40 kg P_2O_5 ha^{-1}significantly increased the number of pods per plant. They observed that application of 40 kg P_2O_5 ha^{-1}along with 20 kg N ha^{-1}significantly increased the 1000-seed weight of mung bean.

An experiment was conducted by Trung and Yoshida (1983) using 0-100 ppm N as treatment in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. They found that seed yield of mung bean increased with the increase in N up to 50 ppm.

2.2 Effect of boron on growth and yield of Mung bean

Biswas *et al.* (2010) conducted a two-year field experiment during kharif season of 2005 and 2006 at the Pulse and Oilseeds Research Sub-station, Beldabga, Murshidabad, West Bengal, India to study the effect of boron spray and seed inoculation on nodulation, growth and seed yield ofmung bean. The results revealed that two rounds of foliar spray of 0.05% B solution at 25 and 40 days after sowing (DAS) increased seed yield by 9.02% (1236.50 kg ha^{-1}) over water spray (1164.50 kg ha^{-1}). Combined inoculation of seed with Rhizobium + Azotobacter + PSB (1629.00 kg ha^{-1}) and Rhizobium + PSB rermarkbly increased the seed yield due to better nodulation along with improvement in growth and yield. The effect of interaction between foliar spray and inoculation on seed yield was found significant.

Srivastava *et al.* (2005) observed that in absence of applied B, there was no yield as no pods were formed, in comparison to a yield of 300 kg ha^{-1} in the full nutrient treatment. There was yellowing of younger leaves and typical 'little leaf' symptoms when B was omitted. A critical concentration range of 15-20 ppm B was found for the shoot tips of mung bean.

Ali *et al.* (2002) reported that yield losses of varying magnitude in mung bean, e.g., 22-50% due to Zinc (Zn), up to 100% due to boron (B) and 16-30% due to sulphur (S). Genotypic differences in response to application of Fe, B and Zn have also been found among mung bean genotypes.

Bharti *et al.* (2002) carried out a field experiment in Bihar, India during the winter of 1997-98 to observe the effect of B (0, 1.5 and 2.5 kg ha-1) application on the yie;ld and nutrition of mung bean (cv. BG256). They reported that the mean seed yield and seed and stover Zn and B content increased, whereas stover yield decreased with the increasing B and Zn rate.

Abdo (2001) conducted two field experiments at Giza Exparimental Station, ARC, Egypt, during the 1998 and 1999 seasons to study the effect of foliar spray with micronutrients (Zn, Mn or B) on morphological, physiological and anatomical parameters of two mung bean (*Vigna radiata*) cultivars V-2010 (Giza-1) and VC-1000. Zn (0.2 or 0.4 g/l), Mn (1.5 or 2.0 g/l), B (3.0 or 5.0 g/l) and a mixture of Zn, Mn and B (0.2, 1.5 and 3.0 g/l, respectively) in addition to distilled water as control were sprayed once at 35 DAS. The results showed that foliar spray with the adopted conc. of Zn, Mn or B alone or in a mixture, increased significantly most of the growth parameters over the control in both seasons. Application of Zn (0.2 g/l) along followed by a mixture of micronutrients results in better morphological and physiological parameters. It wsa observed that mung bean cv. VC-1000 surpassed cv. V-2010 in all parameters under investigation in both seasons. The effect of spraying with low level of Zn, Mn, B and their mixture on the inmternal structure of the vegetative growth of mung bean cv. VC-1000 was investigated.

Rizk and Adbo (2001) carried out two field experiments at Giza Exparimental Station, ARC, Egypt, during the 1998 and 1999 seasons to investigate the response of mung bean (*Vigna radiata*) to treatment with some micronutrients. Two cultivars of mung bean (V-2010 and VC-1000) were used inthis investigation. Zn (0.2 or 0.4g/l), Mn (1.5 or 2.0 g/l), B (3.0 or 5.0 g/l) and a mixture of Zn, Mn and B (0.2, 1.5 and 3.0 g/l, respectively), in addition to distilled water as control were sprayed once at 35 DAS. The obtained results could be summarized in the following: Generally, cultivar VC-100 surpassed cultivar V-1000 in yield and its components as well as in the chemical composition of seeds with exception in 1000-seed weight and phosphorus percentage in seeds. All treatments increased significant yield and its components especially Zn (0.2 g/l) which showed a highly significant increase in all characters under investigation compared to the control. All adopted treatments increased significantly protein percentage in seeds of the two mung bean cultivars in both seasons. Among all treatments of micronutrients, B gave the highest percentage of crude protein. Seeds mung bean cv. VC-1000 exceeded those in both seasons.

Vrema and Mishra (1999) carried out a pot experiment with mung beancv. PDM 54; boron was applied by seed treatment, soil application or foliar spraying. Boron increased yield and growth parameters with the best results in terms of seed yield plant^{-1} when the equivalent of 5 kg boron ha^{-1} was applied at flowering.

Wang *et al.* (1999) reported that there is limited risk of B toxicity due to the of boron fertilizer at up to 4 to 8 times recommended rates in mung bean-rice cropping rotations in southeast china. The low risk of B toxicity can be attributed to relatively high B removal in harvested seed, grain and stubble, the redistribution of fertilizer B by leaching in the 0 to 60 cm layer and to boron sorption.

Verma*et al.* (1988) in a pot experiment with mung bean cv. PDM 54, boron was applied by seed treatment, soil application or foliar spraying. Boron increased yield and growth parameters with the best results in terms in terms of seed yield/plant given when the equivalent of 5 kg borax ha^{-1} was applied at flowering.

Chowdhury and Narayanan (1992) observed that the tallest plant height of mung bean(64.9 cm) was found in plant receiving inoculums alone with Zn and B (both 1 kg ha^{-1}) as compared to all other treatments. They also reported that plant height increased 123% higher in plants receiving inoculums along with Zn (1 kg ha^{-1}) and B (1 kg ha^{-1}) over control.

Mandal *et al.* (1998) noted that most of alluvial acidic soils in North Bengal, India may response to the application of B fertilizer thus increasing the yield of pulse crops in the area.

Rahman and Alam (1998) observed that application of B (1.5 kg ha^{-1}) produced significant 10.17% higher branches $plant^{-1}$ over control in mung bean.

Bonilla *et al.* (1997) suggested that B is an oligatory requirement for normal determinate nodule development and functioning in case of bean. Boron deficiency in pea caused a decrease in the number of nodules and an alteration of indeterminate nodule development. Moreover, B plays an important role in mediating cell surface interactions that lead to endocytosis of rhizobia by hoist cells and hence to the cporrect establishment of the symbiosis between pea and rhizobium (Bolanos *et al.*, 1994) .

Talashikar and Chavan (1996) reported a significant increase of pod yield and haulm of ground due to application of boron of mung bean cultivation.

Saha *et al.* (1996) conducted a filed experiment in pre-khraif seasons of 1993-94 at Pundibari, India, Yellow season was given 0, 2.5or 5.0 kg borax and 0, 1 or 2 kg $ZnSO_4$ ha^{-1} applied as soil, 66% soil + 33% foliar or foliar applications and the residual effects were studied on summer mung bean. In both years mung bean seed yield was highest with a combination of 5 kg borax + 2 kg $ZnSO_4$. Soil application gave higher yields than foliar or soil + foliar application.

Srivastava*et al.* (1996) conducted a field experiment in Nepal with mung bean in Boron deficient soil and observed the highest flower abortion and no seed production in the treatment with any B addition.

Zaman *et al.* (1996a) conducted an experiment on mung bean and observed that application of B (2.0 kg ha^{-1}) produced 23.37% higher 1000 seed weight over control.

Zaman *et al.* (1996b) conducted an experiment on mung bean and observed that the application of Zn (1 kg ha^{-1}) with B (2 kg ha^{-1}) produced maximum plant height (35.03 cm) compared to control (21.53 cm). They also reported that the application of Zn (1 kg ha^{-1}) either alone or in combination with B (1 or 2 kg ha^{-1}) appreciable in creased root length of mung bean over the control. They also reported that plant received 1 kg Mo ha^{-1} with 2 kg ha^{-1} produced 50.31 and 40.21% higher root length of mung bean over control.

Zaman *et al.* (1996c) observed that application of B (2 kg ha^{-1}) significant increased 23.57% higher plant height of mung bean over control. They also observed that application of B (2 kg ha^{-1}) produced 23.18% and 20.49% higher root length over control in 1989 and 1990, respectively.

Bolanos *et al.* (1994) suggested that B is required for normal development and function of nodules in case of pea. In the absence of B, the number, size and weight of nodules decreased and nodules development changed leading to an inhibition of nitrogenase activity.

Mahajan *et al.* (1994) found that soil application of B (0.5 kg ha^{-1}) increased pod yield and harvest index significantly of mung bean.

Wu *et al.* (1994) observed that plant dry weights of different organs in soybean were positively correlated with B concentration.

Gupta and Gupta (1993) reported that in the a pot experiment in soil containing 0.4 mg kg^{-1} available B, mung bean or mung beans were grown following application of 0-6 mg B kg^{-1} soil and also reported that mung bean was more susceptible to boron than mung bean. Boron conc. In both crops was lower in the seeds than in the straw and was increased at higher B rates.

Islam and Sarkar (1993) found higher number of seed $pod^{-1}$of mung beandue to application of B @ 1.5 kg ha^{-1} above and below which seed set was hampered.

Bell *et al.* (1990) observed that leaf elongation was inhibited by interruption of the B supply 5 days late the appearance of B deficiency symptoms in the roots as observed in mung bean (*Vigna radiata*).

Buzetti *et al.* (1990) observed that plant boron concentration increased or decreased with increasing or decreasing rate of applied zinc of soybean.

Dwivedi *et al.* (1990) observed that under acute B stress flowering and grain formation of pulse, oil and cereal crops were drastically reduced.

Marschner (1990) reported that the deficiency symptoms of some boron sensitive crops like legumes, Brassica, beets, celery, gmung beans and fruit trees showed chllorosis and browning of young leaves, killed growing points, distorted blossom development, lesions in pit and roots and plants, burning of the tips of the leaves and restricted root growth are the boron toxicity symptoms in most crops.

Sakaland Sinha(1990) carried out field trails at 7 sites inNorth Bihar, India. They observed the seed yield of mung bean increased from 1.4 t/ha with no B to 1.76 t/ha with 3 kg B/ha. The yield response to B application was grater on low B soils. It was conclude the on soils <0.35 ppm B, 3 kg B/ha was optimum and on soils >0.35 ppm B, 2kg B/ha was optimum.

Yang *et al.* (1989) reported that combined application of N, K, Zn and B increased seed yield in mung beanseed. Application of B along with N, K and Zn promoted CO_2 assimilation, nitrate reduced activity in leaves and dry matter accumulation. Seed glucosinolate and erucic acid content varies among cultivars and generally decreased with increasing K, Zn and B while seed oil content increased.

Sakal *et al.* (1988) reported that on a coarse textured highly calcareous soil, application of 2.0 and 2.5 kg B ha^{-1}increased grain yields of mung bean and mung bean by 63 and 38%, respectively.

Schon and Blevins (1987) obtained increased mung bean yields with increasing levels of B from 0 to 2.5 kg ha^{-1}. Similar results were also observed by Rerkasem *et al.* (1987) in mung beanand mung bean.

Rerkasem *et al.* (1987) observed that 10 kg borax ha^{-1} increased the number of nodes $plant^{-1}$ in mung bean.

Salins *et al.* (1985) reported that B application increased the weight of aerial parts and roots of mung bean.

Dutta *et al.* (1984) stated that application of B (1 kg ha^{-1}) in mung bean increased leaf area ratio, leaf area index, crop growth rate, number of branches $plant^{-1}$, no. of pod $plant^{-1}$, weight of seed pod^{-1} and a decrease in chlorophyll content and net assimilation rate but the relative growth rate, total dry matter and seed yield and some of other growth attributes were unaffected.

Oliveria and Kato (1983) observed that foliar N, P and K contents of bean were unaffected by B and Zn fertilization.

Agarwala *et al.* (1981) found that direct effects of B are reflected by the close relationship between B supply and pollen production capacity of the anthers as well as the viability of the pollen grains of mung bean.

Franco and Munns (1981) reported that seed yield shoot weight in bean due to B application.

Chakavarty *et al.* (1979) stated that boron concentration in legume crops increased significantly with increasing level of applied boron.

Gerath *et al.* (1975) reported an increasing in yield of mung bean through application of boron fertilizer and recommeneded an application of 1 to 2 kg B ha^{-1} for increased yield.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the period from March 2014 to June 2014 to study the effect of nitrogen and boron mangement on growth and yield of mung bean**.** The details of the materials and methods have been presented below:

3.1. Description of the experimental site

3.1.1. Location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University,Dhaka. The location of the site is 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level (Anon, 1989). Location of the experimental site presented in Appendix I.

3.1.2. Soil

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). 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 level. The selected plot was medium high land. The details were presented in Appendix II and Appendix III.

3.1.3. Climate

The geographical location of the experimental site was under the subtropical climate, characterized by 3 distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix IV.

3.2. Test crop and its characteristics

Seeds of BARI Mung-5 was collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. After multilocation trials BARI released this variety for general cultivation with a popular name BARI Mung-5 in the year 2002. The plant attains a height of 35-40 cm, the leaves look light green and its life duration is about 75-80 days. Seeds are larger than local variety and light brown yellow in color. Seed contains 20-25 % protein. 1000 seeds weight is 35-40 g. Under proper management practices it may give 2.0-2.5 t ha^{-1} grain yield.

3.3. Experimental details

3.3.1. Treatments

The experiment comprised as two factors

Factor A: 4 nitrogen levels

N_0 = 0 kg N ha^{-1}
N_1 = 25 kg N ha^{-1}
N_2 = 35 kg N ha^{-1}
N_3 = 45 kg N ha^{-1}

Factor B: 3 boron levels

B_0 = 0 kg B ha^{-1}
B_1 = 1 kg B ha^{-1}
B_2 = 2 kg B ha^{-1}

Total 12 treatment combinations were as follows: N_0B_0, N_0B_1, N_0B_2, N_1B_0, N_1B_1, N_1B_2, N_2B_0, N_2B_1, N_2B_2, N_3B_0, N_3B_1 and N_3B_2.

Every treatment received N, P and K as basal doses. The rates and sources of nutrients used in the study are given below:

Name of the Element	Rate (kg ha^{-1})	Source of the Fertilizer
N	0, 25, 35, 45	Urea
P	100	Triple Super Phosphate(TSP)
K	58	Muriate of Potash (MoP)
Zn	2.0	Gypsum
B	0.0, 1.0, 2.0	Boric acid

3.3.2. Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of doses of micronutrient and sowing time. The 12 treatment combinations of the experiment were assigned at random into 8 plots of each replication. The size of each unit plot 2.5 × 2.5 m. The spacing between blocks and plots were 0.5 m and 0.25 m.

3.4. Growing of crops

3.4.1. Raising seedlings

3.4.1.1. Seed collection

The seeds of the test crop i.e., BARI Mung5 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur**.**

3.4.1.2. Seed sprouting

Healthy seeds were selected by specific gravity method.

3.4.2. Preparation of the main field

The plot selected for the experiment was opened in the first week of March, 2014 with a power tiller, and was exposed to the sun for a week, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.4.3. Fertilizers and manure application

The fertilizer P, K and Zn were applied at 100, 58 and 2 kg ha^{-1} in the form of TSP, MP and gypsum, respectively during final land preparation as basal dose. Nitrogen and boron were applied respectively from urea and boric acid as per treatment during final land preparation.

3.4.4. Intercultural Operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the mungbean.

3.4.4.1. Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains.

3.4.4.2. Weeding

Several weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after sowing (DAS), 2^{nd} and 3^{rd} weeding was done at 35 and 50 DAS, respectively.

3.4.4.3. Plant protection

The plots were infested by caterpillar, which was successfully controlled by applying Basudin 10 G at the rate of 16.8 kg ha^{-1}. There was no disease infestation on the crop.

3.5. Harvesting, threshing and cleaning

The crop was harvested at full maturity on 15 May, 2014 to 30 May, 2014 and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of mungbean seed. Fresh weight of grain and stover were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The stover was sun dried and the yields of grain and stover $plot^{-1}$ were recorded and converted to t/ha.

Operations	Working Dates
First ploughing of the field	March 05, 2014
Second ploughing of the field	March 15, 2014
Final ploughing of the field	March 24, 2014
Application of fertilizers (Urea-1st split, TSP, MP, Gypsun, Boric Acid)	March 24, 2014
Seed sowing	March 26, 2014

Intercultural Operations	Working Dates
First weeding	April 07, 2014
Second weeding	April 19, 2014
Third weeding	April 30, 2014
Insecticides application	April 10, 2014 to May 05, 2014
Harvesting and threshing	15 May, 2014 to 30 May, 2014

3.6 Collection and Recording of data

Ten plants were selected randomly from each unit plot prior to harvest for recording data on crop parameters and the yield of grain and straw were taken plot wise. The following parameters were recorded at harvest:

- Plant height (cm)
- Number of leaves plant^{-1}
- Number of branches plant^{-1}
- Dry matter (%) plant^{-1}
- Number of pods plant^{-1}
- Pod length plant^{-1} (cm)
- Number of seeds pod^{-1}
- Weight of 1000 grains (g)
- Grain yield (t ha^{-1})
- Straw yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

3.6.1. Plant height

The height of plant was recorded in centimeter (cm) at the harvesting time. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the leaves.

3.6.2. Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted at the harvesting time. Leaves number plant^{-1} were recorded by counting all leaves from each plant of each plot and mean was calculated.

3.6.3. Number of branches plant^{-1}

The branches were counted from the 10 randomly selected plant at harvest time and mean value was determined.

3.6.4. Dry matter content (%)

Dry weight plant^{-1} were measured at an interval of 10 days starting from at harvest time. First the fresh weight was taken. Then the samples of stem were dried in oven at 72^{0}C for 72 hours. From which the dry matter percentage of above ground harvest was calculated with the following formula (Elfinesh *et al.,* 2011)-

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.6.5. Number of pods plant^{-1}

Number of total pods of ten plants from each plot was noted and the mean number was expressed per plant basis.

3.6.6. Pod length plant^{-1}

Length of total pod of ten plants from each plot was noted and the mean number was expressed per pod basis.

3.6.7. Number of seeds pod^{-1}

Number of total seeds from ten randomly selected pods of ten plants from each plot was noted and the mean number was expressed per pod basis.

3.6.8. Weight of 1000 seeds

One thousand cleaned and dried seeds were counted randomly form each sample and weight by using a digital electric balance and the weight was expressed in gram.

3.6.9. Grain yield

The plants of the central 1.0 m^2 from the plot were harvested for taking grain yield. The grains were threshed from the plants, cleaned, dried and then weighed. The yield of grain in kg $plot^{-1}$ was adjusted at 12% moisture content of grain and then it was converted to t ha^{-1}.

3.6.10. Stover yield

The stover of the harvested crop in each plot was sun dried to a constant weight. Then the stovers were weighted and thus the stover yield $plot^{-1}$ was determined. The yield of stover in kg $plot^{-1}$ was converted to t ha^{-1}.

3.6.11. Biological yield

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

Biological yield = Grain yield + Stover yield.

3.6.12. Harvest index (%)

Harvest index was calculated from the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

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

3.7. Collection of Samples

3.7.1. Soil sample

The initial soil samples were collected randomly from different spots of the field selected for the experiment at 0-15 cm depth before the land preparation and mixed thoroughly to make a composite sample for analysis. Post harvest soil samples were collected from each plot at 0-15 cm depth in July 1, 2014. The samples were air-dried, grounded and sieved through a 2 mm sieve and preserved for analysis.

3.8. Soil sample analysis

The initial and postharvest soil sample were analyzed for both physical and chemical properties in the laboratory of Soil Resource Development Institute (SRDI), Farmgate, Dhaka.

The properties studied included soil texture, pH, organic matter, total N, available P, exchangeable K and available S. The properties studied included soil pH, particle density, and organic matter, total N, available P, exchangeable K, available S and available Zn. The soil was analyzed by the following standard methods:

3.8.1. Particle Size Analysis

Particle size analysis of soil sample was done by hydrometer method. The textural class ascertained using USDA textural triangle.

3.8.2. Soil pH

Soil pH was determined by glass electrode pH meter in soil-water suspension having soil: water ratio of 1:2.5 as outlined by Jackson (1962).

3.8.3. Organic Carbon

Organic carbon of the soil was determined by wet oxidation method described by Walkley and Black (1934). To obtain organic matter content, the amount of organic carbon was multiplied by the van Bemmelen factor of 1.73. The result was expressed in percentage.

3.8.4. Organic Matters

The Organic Matter content was determined by multiplying the percent organic carbon with Van Bemmelen factor 1.73.

3.8.5. Total nitrogen

Total nitrogen of soil samples was estimated by Micro-kjeldahl Method where soils were digested with 30% H_2O_2 concentrated H_2SO_4 and catalyst mixture ($K_2SO_{4:}$ $CuSO_{4,}$ 5 H_2O: Selenium powder in the ratio of 100:10:1, respectively). Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01 NH_2SO_4.

3.8.6. Available phosphorous

Available phosphorous was extracted from the soil by shaking with 0.5 $MNaCO_3$ solution of pH 8.5. The phosphorous in the extract was then determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 nm wave length by spectrophotometer and available P was calculated with the help of a standard curve.

3.8.7. Exchangeable potassium

Exchangeable potassium in the soil sample was extracted with 1N neutral ammonium acetate (NH_4OAc) and the potassium content was determined by flame photometer (Black. 1965).

3.9. Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Different (LSD) at 5% level of proability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of nitrogen and boron on growth and yield of mungbean. The results obtained from the study have been presented, discussed and compared in this chapter through tables, figures and appendices. The analyses of variance of data in respect of all the parameters have been shown in Appendix V-VIII. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings.

4.1 Plant height

It was evident from Table1 and Appendix V that the height of plant was significantly influenced by nitrogen. Plant height increased with advancing growing period irrespective of nitrogen, the mungbean height increased rapidly at the early stages of growth and rate of progression in height was slow at the later stages except control treatment. 35 kg N ha^{-1} (N_2) treatment showed the longest height (56.00 cm) which was statistically similar with 25 kg N ha^{-1} (51.32 cm) and 45 kg N ha^{-1} (51.17 cm) whereas, the shortest plant (48.66 cm) was recorded from control i.e., no nitrogen (N_0) treatment. Plant height of a crop depends on the plant vigor, cultural practices, growing environment and agronomic management. In the present experiment since mungbean was grown in the same environment and were given same cultural practices except nitrogen. So, the variation of plant height might be due to the effect different level of nitrogen.

Significant variation of plant height was found due to boron in all the studied durations (Appendix V and Table 2). The tallest plant (54.96 cm) was obtained from 1 kg B ha^{-1} (B_1) treatment which was statistically similar (51.52 cm) with

2 kg B ha^{-1} (B_2) treatment whereas, the shortest plant (48.88 cm) was obtained from the 0 kg B ha^{-1}i.e., control (B_0) treatment.

Significant interaction effects of nitrogen and boron on plant height was observed at harvesting time (Appendix V and Table 3). Plant height increased with advancing growing period irrespective of nitrogen and boron fertilization. The tallest plant (60.78 cm) was obtained from N_2B_1(35 kg N $ha^{-1}$and 1 kg B ha^{-1}) treatment, which was statistically similar with N_3B_1 (55.40 cm) and N_1B_2 (55.00 cm). On the other hand, the shortest plant (43.20 cm) was obtained from N_0B_0(control) treatment.

4.2 Number of leaves plant^{-1}

The effect of nitrogen on number of leaves plant^{-1} was significant. Results revealed that, the number of leaves plant^{-1} of mungbean increased gradually with increased the nitrogen fertilizer upto 35 kg N ha^{-1}(N_2) at harvesting time (Appendix V and Table 1). The maximum leaves number plant^{-1} (7.66) was observed from 35 kg N ha^{-1}(N_2) treatment and the minimum number (6.25) was observed from 0 kg N ha^{-1}(N_0) treatment. The present study referred that 35 kg N ha^{-1}produced maximum number of leaves.

The number of leaves plant^{-1} was significantly influenced by different boron application levels at harvesting time (Appendix V and Table 2). The number of leaves plant^{-1} gradually increased with the advancement of plant age up to 1 kg B ha^{-1} and thereafter more/less remain static with advancing growing period, irrespective of different boron fertilizer. The maximum leaves number plant^{-1} (7.17) was observed from the 1 kg B ha^{-1}(B_1) treatment which was statistically similar B_2(7.12)whereas, the minimum number (6.64) was observed from the control (B_0) treatment.

There was significant variation among the interaction of nitrogen and boron on the total numbers of leaves plant^{-1}at harvesting time (Appendix V and Table 3).The highest number of leaves plant^{-1} (8.67) was recorded with the combination of 35 kg N $ha^{-1}$and 1 kg B ha^{-1}(N_2B_1) treatment whereas, the minimum (4.89) was recorded from the control (N_0B_0) treatment. Present study revealed that 35 kg N $ha^{-1}$and 1 kg B ha^{-1} produced maximum number of leaves.

4.3 Number of branches per plant

The number of branches $plant^{-1}$ was significantly varied among the nitrogen fertilizer(Appendix V and Table 1). Number of branches $plant^{-1}$ increasing with increasing the rate of nitrogen continued up to N_2 level. The maximum (2.22) number of branches $plant^{-1}$ was counted from 35kg N ha^{-1} and the minimum number (0.56) was counted from control (N_0) treatment. The study referred that 35kg N ha^{-1} produced maximum number of branches plant $^{-1}$.

Different level of boron application significantly affected the number of branches $plant^{-1}$ of mungbean (Appendix V and Table 2). The maximum number of branches $plant^{-1}$ (1.75) was recorded from 1 kg B ha^{-1} (B_1) treatment and the minimum numberof branches $plant^{-1}$ (1.00) was counted from control (B_0) treatment. Present study showed that 1 kg B ha^{-1} produced maximum number of branches $plant^{-1}$.

Interaction effect of nitrogen and boron significantly influenced numberof branches plant $^{-1}$ (Appendix V and Table 3). The highest numberof branches $plant^{-1}$ (3.00) was recorded from the combination of 35kg N ha^{-1} and 1 kg B ha^{-1} (N_2B_1) treatment while, the minimum number (0.33) of branches $plant^{-1}$ was recorded from the combination of no nitrogen and boron (N_0B_0) treatment.

4.4Dry matter content (%)

Dry matter content (%) was significantly influenced by nitrogen fertilizer at harvesting time (Appendix V and Table 1). 35kg N ha^{-1} produced higher dry matter (39.76 %) whereas, the lowest (31.23 %) was recorded from control treatment.This might be due to the affect of fertilization management.

Dry matter content varied significantly with different levels of boron at harvesting time (Appendix V and Table 2).The maximum dry matter (39.72 %) was produced from 1 kg B ha^{-1} (B_2)treatment while, the minimum (30.50 %) was found from 0kg B ha^{-1} (B_0) treatment. Present study showed that dry weight of mungbean was significantly increased with increasing boron concentration up to 1 kg B ha^{-1} thereafter declined.

Interaction effect of nitrogen and boron fertilizer on dry matter at harvesting time were significant (Appendix V and Table 3). It was observed that the maximum (45.87 %) was obtained from the combination of35kg N ha^{-1}and 1 kg B ha^{-1}(N_2B_1) treatment whereas, the minimum (25.53 %) was recorded from the N_0B_0 (control) treatment.

Table 1. Effect of nitrogen on growth parameter of mungbean

Treatment	Plant height (cm)	Number of leaves per plant	Number of branches per plant	Dry matter content (%)
N_0	48.66 b	6.25 d	0.56 c	31.23 d
N_1	51.32 ab	6.63 c	1.22 b	33.04 c
N_2	56.00 a	7.66 a	2.22 a	39.76 a
N_3	51.17 ab	7.38 b	1.33 b	35.21 b
$LSD_{(0.05)}$	5.85	0.25	0.43	1.57
CV (%)	6.67	6.35	4.37	11.15

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Table 2. Effect of boron on growth parameter of mungbean

Treatment	Plant height (cm)	Number of leaves per plant	Number of branches per plant	Dry matter content (%)
B_0	48.88 b	6.64 b	1.00 c	30.50 c
B_1	54.96 a	7.17 a	1.75 a	39.72 a
B_2	51.52 ab	7.12 a	1.41 b	34.22 b
$LSD_{(0.05)}$	5.07	0.21	0.26	1.69
CV (%)	6.67	6.35	4.37	11.15

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Table 3. Interaction effect of nitrogen and boron on growth parameter of mungbean

Treatments	Plant height (cm)	Number of leaves per plant	Number of branches per plant	Dry matter content (%)
N_0B_0	43.20 d	4.89 f	0.33 d	25.53 h
N_0B_1	49.00 cd	7.34 b	0.67 c	30.07 g
N_0B_2	51.87 b-d	6.85 c	0.67 c	34.87 d
N_1B_0	48.43 cd	7.49 b	1.00 c	31.53 f
N_1B_1	50.00 b-d	6.29 de	1.67 b	35.43 d
N_1B_2	55.00 ab	6.04 e	1.00 c	37.07 c
N_2B_0	54.10 bc	7.69 b	1.67 b	40.50 b
N_2B_1	60.73 a	8.67 a	3.00 a	45.87 a
N_2B_2	49.77 b-d	7.56 b	2.00 b	32.73 e
N_3B_0	49.97 cd	6.49 d	1.00 c	32.00 f
N_3B_1	55.40 ab	7.46 b	1.67 b	38.53 c
N_3B_2	50.97 b-d	6.97 c	2.00 b	33.60 de
$LSD_{(0.05)}$	5.08	0.34	0.34	1.57
CV (%)	6.67	6.35	4.37	11.15

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Note: N_0 = 0 kg N ha^{-1}, N_1 = 25 kg N ha^{-1}, N_2 = 35 kg N ha^{-1}, N_3 = 45 kg N ha^{-1}andNote: B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1},B_2 = 2 kg B ha^{-1}

4.5 Number of pod plant^{-1}

Number of pods plant^{-1} of mungbean differed significantly due to nitrogen fertilizer (Appendix VI and Table 4). The height number of pod plant^{-1} (24.89) was recorded from 35kg N ha^{-1} (N_2) treatment whereas, the lowest (16.56) was found 0kg N ha^{-1} (N_0)treatment.

Statistically significant differences were found for number of pod plant^{-1} of mungbean due to boron fertilizer (Appendix VII and Table 5). The highest number of pod plant^{-1} (22.08) was recorded from1 kg B ha^{-1}(B_1) treatment. On the other hand, the lowestnumber of pod plant^{-1} (18.83) was observed from control(B_0) treatment.

Interaction effectnitrogen and boron fertilizershowed significant variation in number of pod plant^{-1} (Appendix VII and Table 6). The highest number of pod plant^{-1} (26.33) was recorded from the combination of 35kg N ha^{-1}and1 kg B ha^{-1}(N_2B_1) treatmentwhereas, the lowest (14.00) was observed from thecombination of 0kg N ha^{-1}and 0kg B ha^{-1}(N_0B_0) treatment.

4.6Length of pod

Length of pod of mungbean differed significantly due to nitrogen fertilizer (Appendix VI and Table 4). The maximum length pod (9.68 cm) was recorded from N_2 treatment and the minimum (7.09 cm) was found inN_0 treatment.

Statistically significant differences were found for length of pod of mungbean due to boron fertilizer (Appendix VI and Table 5). The maximum length of pod (10.18 cm) was recorded from B_1 treatment whereas, the minimum (6.38 cm) was observed from B_0 treatment.

Interaction effectofnitrogen and boronapplication showed significant variation in length ofpod (Appendix VI and Table 6). The maximum length of pod (11.53 cm) was recorded from thecombination of 35kg N ha^{-1} and1 kg B ha^{-1} (N_2B_1)treatment whereas, the minimum (5.20 cm) was observed from thecombination of 0kg N ha^{-1} and0kg B ha^{-1} (N_0B_0)treatment.

4.7 Number of seeds pod^{-1}

Number of seeds pod^{-1} of mungbean differed significantly due to different levels of nitrogen(Appendix VI and Table 5). The height number of seeds pod^{-1} (14.67) was recorded from N_2 treatment. In comparatively,The lowest number of seeds pod^{-1} (01.67) was found N_0treatment.

Statistically significant differences were found for number of seeds pod^{-1} of mungbean due to different level of boron (Appendix VI and Table 4). The maximum number of seeds pod^{-1} (15.47) was recorded from B_1 treatmentand the minimum (9.83) was observed from B_0treatment.

The number of seeds pod^{-1} was significantly influenced by the interaction ofnitrogen and boron (Appendix VI and Table 6). The maximum number of seeds pod^{-1} (17.80) was recorded from the combination of N_2B_1 treatmentwhereas, the minimum (8.50) was observed from the combination ofN_0B_0treatment.

Table 4. Effect of nitrogen on yield contributing characters of mungbean

Treatment	No. of pods per plant	Length of pod (cm)	No. of seeds per pod	1000 seeds weight (g)
N_0	16.56 c	7.09 c	10.67 d	37.14 d
N_1	21.00 b	8.42 b	12.67 c	40.92 b
N_2	24.89 a	9.68 a	14.67 a	44.50 a
N_3	19.56 b	8.21 b	12.73 b	40.07 c
$LSD_{(0.05)}$	1.97	0.41	0.05	2.11
CV (%)	5.70	2.90	0.23	4.26

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Note: N_0 = 0 kg N ha^{-1}, N_1 = 25 kg N ha^{-1}, N_2 = 35 kg N ha^{-1} and N_3 = 45 kg N ha^{-1}

Table 5. Effect of boron on yield contributing characters of mungbean

Treatment	No. of pods per plant	Length of pod (cm)	No. of seeds per pod	1000 seeds weight (g)
B_0	18.83 c	6.38 c	9.83 c	37.72 c
B_1	22.48 a	10.18 a	15.47 a	44.26 a
B_2	20.58 b	8.47 b	12.75 b	40.00 b
$LSD_{(0.05)}$	1.71	0.35	0.04	2.14
CV (%)	5.70	2.90	0.23	4.26

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Note: B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1} andB_2 = 2 kg B ha^{-1}

Table 6. Interaction effect of nitrogen and boron on yield contributing characters of mungbean

Treatments	No. of pods per plant	Length of pod (cm)	No. of seeds per pod	1000 seeds weight (g)
N_0B_0	14.00 i	5.20 i	8.50 l	33.50 f
N_0B_1	19.67 ef	6.39 h	9.60 k	37.70 de
N_0B_2	25.00 ab	7.80 f	11.20 h	41.00 c
N_1B_0	15.67 h	6.20 h	10.00 j	37.67 de
N_1B_1	18.00 fg	8.87 d	13.20 e	40.10 cd
N_1B_2	21.67 cd	10.21 b	15.50 b	44.70 b
N_2B_0	22.33 cd	10.10 bc	15.40 c	42.53 bc
N_2B_1	26.33 a	11.53 a	17.80 a	49.70 a
N_2B_2	16.67 gh	7.20 g	10.30 i	36.83 e
N_3B_0	21.67 cd	8.65 de	12.90 f	40.35 cd
N_3B_1	23.33 bc	9.70 c	15.00 d	42.80 bc
N_3B_2	20.67 de	8.34 e	12.80 g	40.02 cd
$LSD_{(0.05)}$	1.97	0.41	0.05	2.93
CV (%)	5.70	2.90	0.23	4.26

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Note: N_0 = 0 kg N ha^{-1}, N_1 = 25 kg N ha^{-1}, N_2 = 35 kg N ha^{-1}, N_3 = 45 kg N ha^{-1}andNote: B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1},B_2 = 2 kg B ha^{-1}

4.8 1000 grain weight

1000 grains weight of mungbean differed significantly due to different levels of nitrogen (Appendix VI and Table 4). The highest 1000 grains weight (44.50 g) was recorded from the 35kg N ha^{-1} (N_2) treatment whereas, the lowest (37.14 g) was found in the 0kg N ha^{-1} (N_0) treatment.

Statistically significant differences were found for 1000 grains weight of mungbean due to different levels of boron application (Appendix VI and Table 5). The maximum 1000 grains weight(44.26 g) was recorded from the 1 kg Bha^{-1} (B_1) treatment whereas, the minimum 1000 grains weight (37.72 g) was observed from the 0kg B ha^{-1} (B_0) treatment.

Interaction effectofnitrogen and boron applicationshowed significant variation in 1000 grains weight of mungbean (Appendix VI and Table 6). The highest

1000 grains weight (49.70 g) was recorded from the combination of 35kg N ha^{-1} and 1 kg B ha^{-1} (N_2B_1) treatment. On the other hand, the lowest (34.50 g) grain weight was recorded from the combination of control (N_0B_0) treatment.

4.9 Grain yield

Grain yield of mungbean varied significantly due to nitrogen application (Appendix VII and Table 8). The highest grain yield (1.68 t ha^{-1}) was recorded from the 35kg N ha^{-1} treatmentwhereas, the lowest (1.11 t ha^{-1}) was found in the 0kg N ha^{-1} treatment.

Grain yield varied significantlydue toboron application (Appendix VII and Table 7). The highest grain yield (1.63 t ha^{-1}) was recorded from the 1 kg B ha^{-1} treatment whereas, the lowest (1.10 t ha^{-1}) was found in the 0kg B ha^{-1} treatment.

Statistically significant differences in grain yield of mungbean were recorded for the interaction of nitrogen and boron (Appendix VII and Table 9). The maximum grain yield (2.00 t ha^{-1}) was recorded from the combination of35kg N ha^{-1}with1 kg B ha^{-1}whereas, the minimum (0.93 t ha^{-1}) was found in the combination of0kg N ha^{-1} with 0kg B ha^{-1} treatment.

4.10 Stover yield

Stover yield of mungbean were significantly influenced by nitrogen fertilizer (Appendix VII and Table 7). The maximum stover yield (2.13 t ha^{-1}) was recorded from the N_0 treatment whereas, the minimum (1.30 ha^{-1}) was found in theN_2treatment.

Stover yield of mungbean were significantly influenced by boron fertilizer (Appendix VII and Table 8). The maximum stover yield (2.03 t ha^{-1}) was recorded from theB_0 treatment whereas, the minimum (1.31 t ha^{-1}) was found in theB_1treatment.

The interaction effect of nitrogen and boron fertilizer on stover yield of mungbean was significant (Appendix VII and Table 9). The height stover yield (2.40 t ha^{-1}) was recordved from the combination ofN_0B_0 treatment which was statistically identical N_2B_2 (2.29 t ha^{-1}).On the other hand, the lowest stover yield (0.90 t ha^{-1}) was found in the combination ofN_2B_1 treatment.

4.11 Biological yield

Different levels of nitrogen fertilizer application was significant in producing biological yield (Appendix VII and Table 7). The highest biological yield (3.24 t ha^{-1}) was observed from N_0 treatment.On the other hand, the lowestbiological yield (2.98 t ha^{-1}) was found in N_2treatment.

Different levels of boron fertilizer applicationwas significantly in producing biological yield (Appendix VII and Table 8). The maximum biological yield (3.13 t ha^{-1}) was observed from B_0 treatment which was statistically similar (3.12 t ha^{-1}) to B_1treatment whereas, the minimum (2.93 t ha^{-1}) was found in B_1 treatment.

Interaction effect of different levels of nitrogen and boron fertilizer applicationwas showed significant variation in biological yield (Appendix VII and Table 9). The maximum biological yield (3.39 t ha^{-1}) was recorded from the combination of N_2B_2 treatment which was statistically similar (3.23 t ha^{-1}) to N_0B_0 treatment whereas, the lowest (2.88 t ha^{-1}) was observed from the combination ofN_2B_0 treatment which was statistically identical (2.90 t ha^{-1}) to $N_2B_1$and similar (3.06, 2.99, 3.01, 2.95, 3.00, 3.05 and 3.06 t ha^{-1}, respectively) toN_0B_1, N_0B_2, N_1B_1, N_1B_1, N_3B_0, N_3B_1 and N_3B_2.

Table 7. Effect of nitrogen on yieldsand yield contributing characters of mungbean

Treatment	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
N_0	1.11 c	2.13 a	3.24 a	34.64 c
N_1	1.30 b	1.70 b	3.00 b	43.59 b
N_2	1.68 a	1.30 c	2.98 c	56.42 a
N_3	1.38 b	1.64 b	3.02 b	46.35 b
$LSD_{(0.05)}$	0.10	0.26	0.22	5.69
CV (%)	4.54	9.12	4.24	7.34

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Note: N_0 = 0 kg N ha^{-1}, N_1 = 25 kg N ha^{-1}, N_2 = 35 kg N ha^{-1} and N_3 = 45 kg N ha^{-1}

Table 8. Effect of boron on yieldsand yield contributing characters of mungbean

Treatment	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
B_0	1.10 c	2.03 a	3.13 a	35.39 c
B_1	1.63 a	1.75 b	2.93 b	55.71 a
B_2	1.38 b	1.31 c	3.12 ab	44.65 b
$LSD_{(0.05)}$	0.09	0.22	0.19	4.92
CV (%)	4.54	9.12	4.24	7.43

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Note: B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1} andB_2 = 2 kg B ha^{-1}

4.12 Harvest Index

A significant difference was found in harvest index due to nitrogen (Appendix VII and Table 7). The maximum harvest index (56.42 %) was recorded from 35kg N ha^{-1} (N_2) treatment whereas, the minimum (34.64 %) was found from control (N_0) treatment.

A significant difference was found in harvest index due to boron (Appendix VII and Table 8). The maximum harvest index (55.71 %) was recorded from1 kg B ha^{-1} (B_1) treatment whereas, the minimum (35.39 %) was found incontrol(B_0) treatment.

The interaction effect of nitrogen and boron fertilizer application was significant on harvest index of mungbean (Appendix VII and Table 9). The height harvest index (68.97 %) was recorded from the combination of 35kg N ha^{-1} with 1 kg B ha^{-1} (N_2B_1) treatmentwhereas, the lowest (27.93 %) were found in thecombination of 0kg N ha^{-1} with 0kg B ha^{-1} i.e., control (N_0B_0) treatment which, was statistically similar (32.49 %) to thecombination of 35kg N ha^{-1} and 2 kg B ha^{-1} (N_2B_2) treatment. Present study reveled that 35kg N ha^{-1} and 1 kg B ha^{-1} produced best harvest index (%).

Table 9. Interaction effect of nitrogen and boron on yields and yield contributing characters of mungbean

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_0B_0	0.93 f	2.40 a	3.23 ab	27.93 e
N_0B_1	1.06 e	2.00 b	3.06 cd	34.64 d
N_0B_2	1.29 d	1.70 c	2.99 cd	43.11 c
N_1B_0	1.12 e	2.00 b	3.12 bc	35.87 d
N_1B_1	1.31 d	1.70 c	3.01 cd	43.50 c
N_1B_2	1.55 c	1.40 d	2.95 cd	52.81 b
N_2B_0	1.65 bc	1.23 d	2.88 d	57.57 b
N_2B_1	2.00 a	0.90 e	2.90 d	68.97 a
N_2B_2	1.10 e	2.29 a	3.39 a	32.49 de
N_3B_0	1.30 d	1.70 c	3.00 cd	43.33 c
N_3B_1	1.74 b	1.30 d	3.05 cd	57.18 b
N_3B_2	1.37 d	1.69 c	3.06 cd	45.60 c
$LSD_{(0.05)}$	0.1071	0.2623	0.2204	5.690
CV (%)	4.54	9.12	4.24	7.43

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Note: N_0 = 0 kg N ha^{-1}, N_1 = 25 kg N ha^{-1}, N_2 = 35 kg N ha^{-1}, N_3 = 45 kg N ha^{-1}andNote: B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1},B_2 = 2 kg B ha^{-1}

4.13Nutrient status of post-harvest soil of mungbean as affected by nitrogen and boron

4.13.1 Soil pH

Combined application of nitrogen and boron has not significant effect on pH of post-harvest soil(Table 10). The highest pH (5.65) was recorded in treatment N_2B_1 receiving 35 kg N and 1 kg B ha^{-1} and the lowest pH value (5.20) in N_0B_0 treatment.

4.13.2 Organic matter content of soil (%)

Combined application of nitrogen and boron has significant effect on organic matter of post-harvest soil (Table 10). The highest OM (1.25 %) was recorded in treatment N_2B_1where35 kg N and 1 kg B ha^{-1}were applied and the lowest OM value (0.83 %) in N_0B_0 treatment

4.13.3 Total nitrogen content of soil (%)

Total nitrogen content of post-harvest soil was significantly influenced by combined application of nitrogen and boron (Table 10). The highest N content (0.19 %) of soil was observed in case of N_2B_1 treatment with 35 kg N and 1 kg B ha^{-1}. In contrast, the lowest N content (0.11%) was obtained in the N_0B_0 treatment where no N and B fertilizer were applied.

4.13.4 Phosphorus content of soil (ppm)

Phosphorus Content of post-harvest soil was significantly influenced by combined application of nitrogen and boron (Table 10). Among the different treatments, N_2B_1 treatment showed the highest P content (24.13 ppm) in post-harvest soil. On the other hand, the lowest P content (14.15 ppm) was observed in N_0B_0 treatment with no N and B fertilization.

4.13.5 Potassium content of soil (meq 100gm $soil^{-1}$)

The combined effect of nitrogen and boron has significant effect on potassium content of post-harvest soil (Table 10). However the highest K content (0.25

meq 100 gm soil^{-1}) was recorded in N_2B_1 treatment that receiving 35 kg N and 1 kg B ha^{-1} and the lowest potassium content of post harvested soil (0.10 meq 100 gm soil^{-1}) was recorded in N_0B_0 treatment (control).

Table 10. Interaction effect of nitrogen and boron on the pH, organic matter, total N, available P and K in the soil after harvest of mungbean

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Available K (meq 100 g soil^{-1})
N_0B_0	5.20	0.83 g	0.11 f	14.15 g	0.10
N_0B_1	5.42	0.88 f	0.13 ef	16.00 f	0.15
N_0B_2	5.40	0.94 e	0.16 c	18.15 d	0.16
N_1B_0	5.55	0.89 f	0.15 cd	17.21 e	0.14
N_1B_1	5.45	0.90 f	0.14 de	19.41 c	0.18
N_1B_2	5.47	1.24 c	0.14 de	17.79 e	0.19
N_2B_0	5.57	1.28 b	0.16 c	19.32 c	0.20
N_2B_1	5.65	1.25 a	0.19 a	24.13 a	0.21
N_2B_2	5.40	1.07 d	0.17 b	21.01 b	0.25
N_3B_0	5.39	1.10 d	0.15 cd	17.00 e	0.19
N_3B_1	5.57	1.18 b	0.15 cd	21.23 b	0.22
N_3B_2	5.43	1.08 b	0.16 c	18.47	0.17
$LSD_{(0.05)}$	NS	0.03	0.01	1.00	NS
CV (%)	3.26	4.37	4.36	5.29	2.03

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Note: N_0 = 0 kg N ha^{-1}, N_1 = 25 kg N ha^{-1}, N_2 = 35 kg N ha^{-1}, N_3 = 45 kg N ha^{-1}andNote: B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1},B_2 = 2 kg B ha^{-1}

In this study it was found that N_2B_1 always gave better result over yield and growth parameter of mungbean. So this combination of nitrogenandboron is suggested for better result on mungbean cultivation.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the research field, Sher –e- Bangla Agricultural University, Dhaka, in the Robi season during the period from March 2014 to June 2014 to study the effect of nitrogen and boron on growth and yield of mung bean.The experiment consists of four levels of nitrogen viz. control, 25 kg N ha^{-1}, 35 kg N ha^{-1} and45 kg N ha^{-1} and three levels of boron viz. control, 1 kg B ha^{-1} and2 kg B ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

The maximum number of branches plant^{-1} (2.00), length of pod (9.08 cm), number of pod plant^{-1} (14.17), number of seeds pod^{-1}(10.33) and 1000 grain weight (40.04 g) was counted from 17 kg Zn ha^{-1}. The highest grain yield (1.78 t ha^{-1}), straw yield (3.10 t ha^{-1}), biological yield (4.05 t ha^{-1}) and harvest index (51.42 %) was observed from the 35 kg N ha^{-1} (N_1) treatment.

The maximum number of branches plant^{-1} (1.33), length pod (9.42 cm), number of pod plant^{-1} (14.74), number of seeds pod^{-1} (10.06) and 1000 grain weight (39.06 g) was recorded from 24 August (S_1) treatment. The highest grain yield (1.55 t ha^{-1}) and harvest index (47.19 %) was found from 1 kg B ha^{-1} (B_1) treatment.

The highest exudation rate (2352 mg hr^{-1}) and RWC (93.33 %) was obtained from the combination of 17 kg Zn ha^{-1} and 24 August treatment. The maximum number of branches plant^{-1} (3.00), length of pod (10.60 cm), number of pod plant^{-1} (17.67), number of seeds pod^{-1} (11.67) and 1000 grain weight (42.83 g) was found from the combination of F_4S_1 treatment. The maximum grain yield (2.03 t ha^{-1}) and harvest index (62.89 %) was observed from the combination of 35 kg N ha^{-1} with 1 kg B ha^{-1} (N_2B_1) treatment.

Based on the experimental results, it may be concluded that-

i) The effect of nitrogen and boron had positive effect on morphological and growth characters, yield and yield attributes in mungbean.

ii) Application of 35 kg N ha^{-1} with 2 kg B ha^{-1} combination seemed to be more suitable for getting higher yield in mungbean.

Recommendations

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study may be conducted in different agro-ecological zones (AEZ) and seasons of Bangladesh for exploitation of regional adaptability and other performances;
2. Some higher levels of nitrogen and boron may be included in future program for more confirmation of the results.

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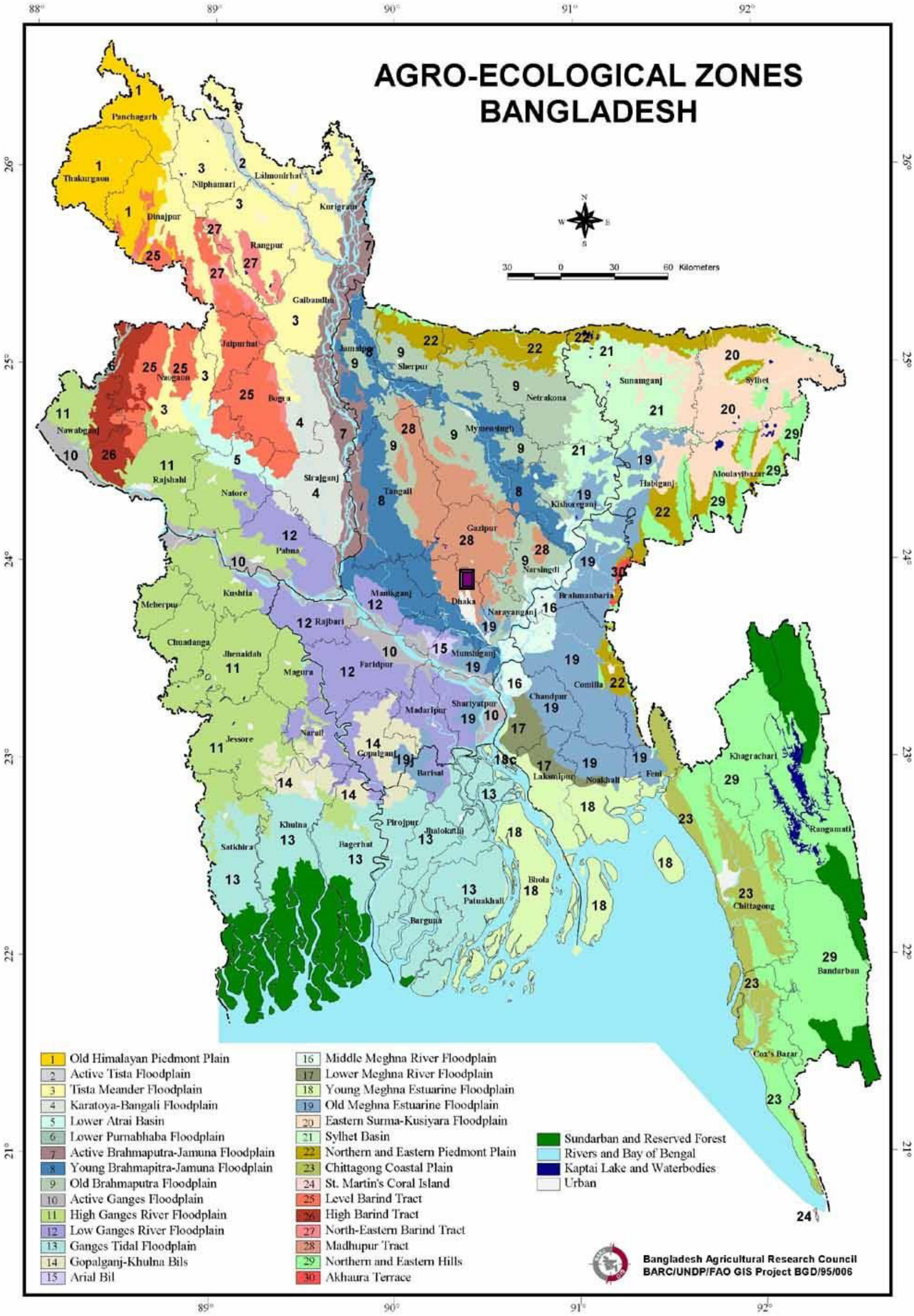
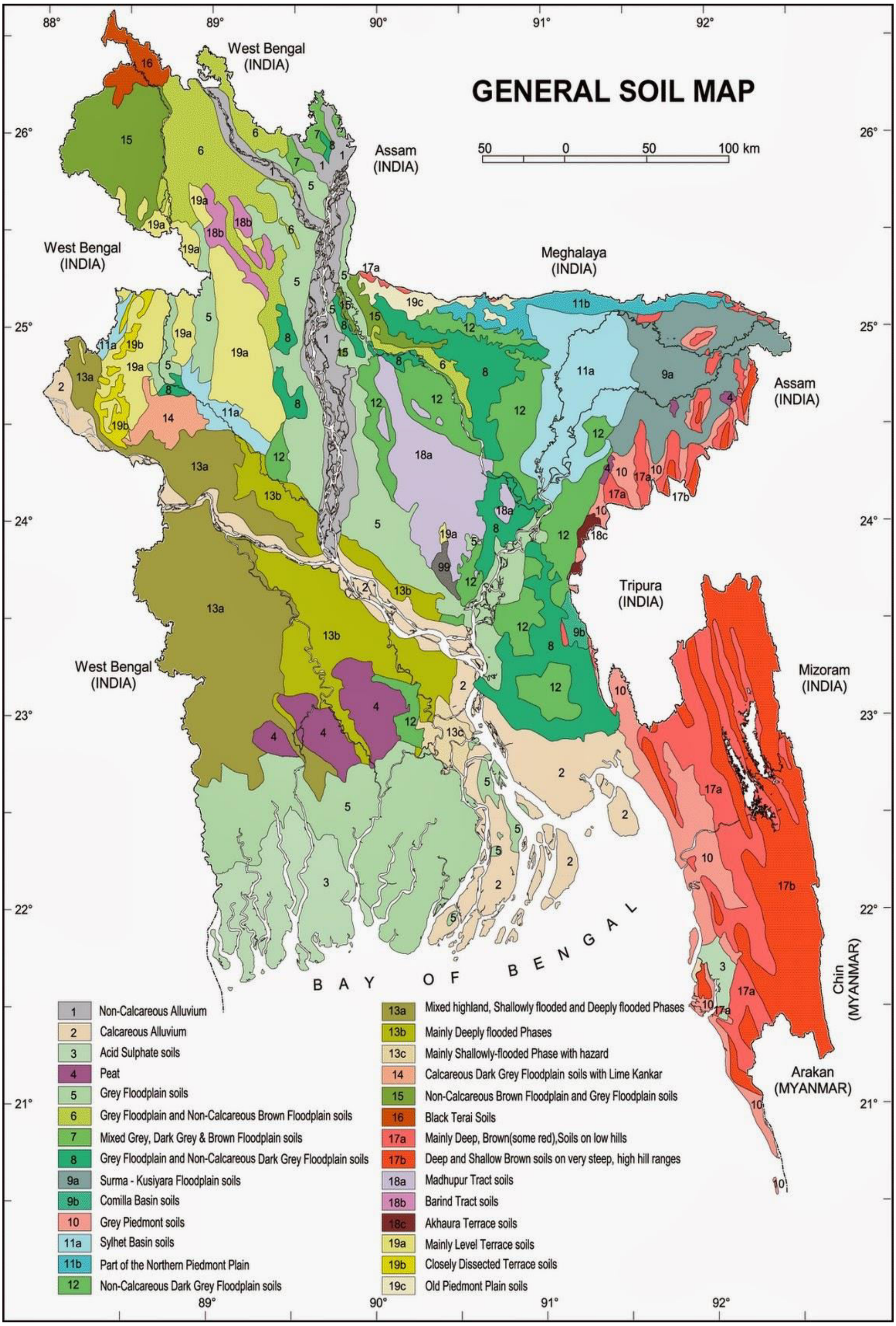
APPENDICES

Appendix I: Map showing the experimental sites under study



The experimental site under study

Appendix II: Map showing the general soil sites under study



Appendix III: Characteristics ofsoil of experimental site is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Boro–Aman–Boro

B. Physical and chemical properties of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
Ph	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20.00
Exchangeable K (mel 1.00 g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2014

Appendix IV. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from March 2014 to June 2014

Month	Average air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)	Total Sunshine per day (hrs)
	Maximum	Minimum	Mean			
March, 2014	36.0	23.6	29.8	81	319	4.0
April,2014	34.8	24.4	29.6	81	279	4.4
May, 2014	34.8	18.0	26.4	77	227	5.8
June, 2014	29.7	20.1	24.9	65	258	6.4

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan. Dhaka – 1212

Appendix V: Error mean square values for growth parameter of mung bean

Source of variation	Degrees of freedom	Plant height	Number of leaves per plant	Number of branches per plant	Dry matter content
Replication	2	0.009	0.068	0.058	29.538
A	3	0.393*	1.378**	0.638*	22.871*
B	2	0.439**	1.209*	0.937*	23.371*
A × B	6	0.038*	0.012*	0.037*	1.388**
Error	22	0.004	0.024	0.017	11.292

*Significant at 5% level of probability

** Significant at 1% level of probability

Appendix VI: Error mean square values for number of pods plant^{-1}, pod length, number of seeds pod^{-1} and 1000 grain weight of mung bean

Source of variation	Degrees of freedom	Number of pods plant^{-1}	Pod length	Number of seeds pod^{-1}	1000 grains weight
Replication	2	4.000	0.096	0.001	0.186
A	3	31.750*	43.002**	95.807**	132.281**
B	2	107.889*	10.131**	24.101*	82.548*
A × B	6	7.306**	0.024*	0.697**	3.323*
Error	22	1.364	0.059	0.001	3.000

*Significant at 5% level of probability

** Significant at 1% level of probability

Appendix VII: Error mean square values for grain yield, stover yield, biological yield and harvest index of mung bean

Source of variation	Degrees of freedom	Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	0.009	0.068	0.058	29.538
A	3	0.833*	1.577**	0.147*	1242.871*
B	2	0.494**	1.040*	0.134*	723.641*
A × B	6	0.017*	0.018*	0.017*	18.225**
Error	22	0.004	0.024	0.017	11.292

*Significant at 5% level of probability
** Significant at 1% level of probability

Appendix VIII: Error mean square values for post-harvest soil of mungbean

Source of variation	Degrees of freedom	pH	OM	N	P	K
Replication	2	0.001	0.096	0.001	0.003	0.186
A × B	6	0.306**	0.024*	0.697**	0.476*	0.323*
Error	22	1.364	0.059	0.001	0.005	0.001

*Significant at 5% level of probability
** Significant at 1% level of probability