EFFECT OF PHOSPHORUS AND BORON FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF PHOSPHORUS AND BORON FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN SOIL SCIENCE,** embodies the result of a piece of *bona fide* research work carried out by **MD. ZANNATUL HASAN,** Registration No. **08-02848** 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 of during the course of this investigation has duly been acknowledged.

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DEDICATED TO
MY
BELOVED PARENTS

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ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka during the period from September, 2013 to December, 2013 to study the effectiveness of phosphorus and boron alone and in combination on the growth and yield of BARI Mung 5 *(Vignaradiata)*. The experiment included three levels of phosphorus viz., 0, 20 and 40 kg P ha^{-1} and three levels of boron viz., 0, 0.75, and 1.5 kg B ha^{-1}. The experiment was laid out in a Randomized Complete Block Design with three replications. Phosphorus showed significant influence on yield and yield attributes of mungbean. Application of phosphorus @ 40 kg ha^{-1} produced the highest plant height, number of branches $plant^{-1}$, pod $plant^{-1}$, pod length, seeds pod^{-1}, 1000-seed weight, grain yield and stover yield. In all cases the lowest values were found with the control treatment. Application of boron @ 1.5 kg ha^{-1} gave the highest plant height, number of branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, pod length, 1000-seed weight, grain yield, and stover yield. In all cases the lowest values are found in the control treatment. Combined application of phosphorus @ 40 kg and boron @ 1.5 kg ha^{-1}resulted the highest plant height, number of branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, pod length, 1000-seed weight, seed yield (1.79 t/ha), and stover yield(2.96 ton/ha). Phosphorus and boron alon or in combined application showed significant effect on yield and yield attributes of mungbean. The addition of P and B not only increased the yield but also protect the soil from total exhaustion of nutrients.

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Chapter I
INTRODUCTION

Mungbean (*Vigna radiata L.*), also known as green gram or golden gram is one of the most important pulses in Bangladesh. It belongs to the family Leguminosae. It is native to the Indian subcontinent and mainly cultivated in India, China, Thailand, Philippines, Indonesia, Mayanmar, Bangladesh, Laos and Cambodia but also in hot and dry regions of Europe and the United States. It is used as a foodstuff in both savory and sweet dishes.

Pulse is a popular crop in the daily diet of the people of Bangladesh. Pulses have been considered as "poor men's meat" since pulses contains more protein than meat and also more economical, they are the best source of protein for the underprivileged people. It is taken mostly in the form of soup which is commonly known as "dal". Generally, there is no complete dish without "dal" in Bangladesh. Green pulse seeds also can be consumed as fried peas or can be used in curry.

In Bangladesh, daily consumption of pulses is only 14.30g capita^{-1} (BBS, 2010), while The World Health Organization (WHO) suggested 45g capita^{-1} day^{-1} for a balanced diet. Due to shortage of production 291 thousands metric ton pulses was imported in Bangladesh in 2006-07 fiscal year (BBS, 2010). Though total pulse production in Bangladesh is 231 thousand metric ton (BBS, 2011), but to provide the abovementioned requirement of 45g capita^{-1} day^{-1}, the production has to be increased even more than three folds.

Mungbean has good digestibility and flavor. It contains 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and phosphorus are 132 and 367 mg per 100 grams of seed, respectively (Frauque *et al.,* 2000). Hence, on the nutritional point of view, mungbean is perhaps the best of all other pulses (Khan, 1981 and Kaul, 1982), contains almost triple amount of protein as compared to rice. It can also minimize the scarcity of fodder because the whole plant or its by product can be used as good animal feed. Cultivation of pulses also can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through nitrogen fixation. As a whole, mungbean could be considered as an inevitable component of sustainable agriculture.

The major cropping pattern in Bangladesh consists of two major crops of rice (i.e. boro rice-fellow-aman rice). In Bangladesh, more than 75% of the total cropping area is occupied by rice where pulse crop covers only 2.8% of the total cropping area (BBS, 2005). Mungbean is one of the important pulse crops of Bangladesh. It grows well in all over Bangladesh. The majority portion is being produced in southern part of the country. Among the pulse crops the largest area is covered by lentil (40.17%) and mungbean is grown in only 6.34% area (BBS, 2005). The cultivation of mungbean in Bangladesh is tends to increase and it covers 54, 57 and 68 thousand acres respectively in the 2008-09, 2009-10 and 2010-11 fiscal years (BBS, 2011). At present the average yield of mungbean grain in our country is about 279 kg $acre^{-1}$ (BBS, 2010). So mungbean can be a good solution for the increasing need of plant protein.

Among the pulse crops, mungbean has a special importance in intensive crop production system of the country for its short growing period (Ahmed *et al.*, 1978). In Bangladesh it can be grown in late winter and summer season. Summer mungbean can tolerate high temperature exceeding 40^0C and grown well in the temperature range of 30-35^0C (Singh and Yadav, 1978). This crop is reported to be drought tolerant and can also be cultivated in areas of low rainfall, but also grows well in the areas with 750-900 mm rainfall (Kay, 1979). So, cultivation of mungbean in the summer season could be an effective effort to increase pulse production in Bangladesh.

It is recognized that pulses offer the most practical means of solving protein malnutrition in Bangladesh but there is an acute shortage of grain legumes in relation to its requirements, because the yield of legumes in farmer's field is usually less than 1 t ha^{-1} against the potential yield of 2 to 41 ha^{-1} (Ramakrishna *et al.,* 2000). Low yields of grain legumes, including mungbean make the crop less competitive with cereals and high value crops. Therefore, to meet the situation it is necessary to boost up the production through varietal development and proper management practices as well as summer mungbean cultivation. The possibilities of growing mungbean in summer are being experimented and some successes have already been made in Bangladesh. Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) developed 17 mungbean varieties with yield potentials in recent years. Very recently, with the introduction of some high yielding varieties like BARIMUNG -6, BARIMUNG -5 increasing attention is being paid to the cultivation of this crop in order to mitigate the alarmingly protein shortage in the diet of our people.

Mungbean is highly responsive to fertilizers and manures. It has a marked response to nitrogen, phosphorus and potassium. These nutrients play a key role in plant physiological process. A balanced supply of essential nutrients is indispensable for optimum plant growth. Continuous use of large amount of N, P and K are expected to influence not only the availability of other nutrients to plants because of possible interaction between them but also the buildup of some of the nutrients creating imbalances in soils and plants leading to decrease fertilizer use efficiency (Nayyar and Chhibbam1992).

Phosphorus plays a remarkable role in plant physiological processes. It is an essential constituent of majority of enzymes which are of great importance in the transformation of energy in carbohydrate metabolism in different types of plants and is closely related in cell division and grain development. Phosphorus is a key constituent of ATP and it plays a significant role in the energy transformation in plants and also in various physiological processes (Sivasankar *et al.* 1982). It is also essential for energy storage and release in living cells. Phosphorus shortage restricted the plant growth and remains immature (Hossain, 1990). Experimental findings of Arya and Kalra (1988) revealed that application of phosphorus had no effect on the growth of mungbean, while number of grains per pod, weight of 1000-seeds were found to be increased with increasing level of phosphorus from zero to 50 kg P ha^{-1}. Phosphorus deficiency causes yield reduction by limiting plant growth (Poehlman, 1991). It influences nutrient uptake by promoting root growth and nodulation (Singh *et al.*, 1999). Phosphorus enhances the uptake of nitrogen in the crop which increase protein content of mungbean (Soni and Gupta, 1999). Phosphorus is essential constituents, nucleoprotein, phospholipids, many enzymes and other plant substances.

Boron is an essential mineral micronutrient for all vascular plants like mungbean. It plays vital roles in the physiological processes of plants such as cell maturation, cell elongation and cell division, sugar transport, hormone development, carbohydrate, proten and nucleic acid metabolisms, cytokinins synthesis. Functions of B are interrelated with those of N,P,K and Ca in plants. In legumes(mungbean) the deficiency symptoms of boron are chlorosis and browning of young leaves. Burning of the tips of leaves and restricted root growth are the B toxicity symptoms in most crops (Kaul, 1982).

Considering the above facts, the present investigation has been undertaken to study the following objectives

Objectives:

- To evaluate the response of mungbean to phosphorus and boron.
- To find out the optimum doses of posphorus and boron for maximizing the yield of mungbean.
- To study the interactive influence of posphorus and boron on the growth and yield of mungbean.

Chapter 2
Review of literature

Chapter II
REVIEW OF LITERATURE

A huge number of research works on mungbean have been performed extensively in several countries especially in the South East Asian countries for its improvement of yield and quality. In Bangladesh, little attention has so far been given for the improvement of mungbean variety or its cultural management. Currently Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have started extensive research work on varietal development and improvement of this crop. Findings of various experiments related to the present study in home and abroad have been reviewed and discussed in this chapter.

2.1. Effect of phosphorus on growth, yield and yield contributing characters of mungbean

Nigamananda and Elamathi (2007) conducted an experiment during 2005-06 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 greengram. Results showed that 2% foliar spray as DAP and NAA, applied at 35 DAS resulted in the highest values for number of pods plant^{-1} (38.3), seeds pod^{-1}, test weight, flower number, fertility coefficient, grain yield (9.66 q ha^{-1}).

Malik *et al.* (2006) conducted a field experiment in Faisalabad, Pakistan in 2000 and 2001 to evaluate the interactive effects of irrigation and phosphorus on green gram *(Vigna radiata,* cv. NM-54). Five phosphorus doses (0, 20, 40, 60 and 80 kg *P* ha^{-1}) were arranged in a split plot design with four replications. Phosphorus application at 40 kg P_2O5 ha^{-1} affected the crop positively, while below and above this rate resulted in no significant effects. Interactive effects of two irrigations and 40 kg P_2O_5 ha^{-1} were the most effective. The rest of the combinations remained statistically non-significant to each other. It may be concluded that green gram can be successfully grown with phosphorus at 40 kg $P2O_5$ ha^{-1}.

Tickoo *et al.* (2006) carried out an experiment on mungbean and cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30.0 m spacing and was supplied with 36-46 and 58-46 kg of N/P/ha in a field experiment conducted in New Delhi. India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t/ha) respectively compared to cv. Pusa 105. Nitrogen and phosphorus 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 the cultivars.

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 greengram *(V. radiata)*. There were 10 foliar spray treatments, consisting of water spray. 2% diammonium phosphate (DAP) at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA, DAP + NAA, DAP + Penshibao, DAP + Zn chelate, DAP + Penshibao + NAA, and DAP + NAA + Zn chelate. Crop nutrient uptake, yield and its attributes (number of pods/plant and number of seeds/pod) of greengram augmented significantly due to foliar nutrition. The foliar application of 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 was recorded with this treatment.

Bhat *et al.* (2005) conducted a study during the summer of 2004 in Uttar Pradesh, India to examine the effects of phosphorus levels on greengram. Four phosphorus rates (0. 30, 60 and 90 kg/ha) were used. All the phosphorus rates increased the seed yield significantly over the control. The highest seed yield was observed with 90 kg P/ha, which was at a with 60 kg P/ha. and both were significantly superior to 30 kg P/ha. Likewise, 60 kg P/ha significantly improved the yield attributes except test weight compared to control. For the phosphorus rates, the stover yield followed the trend observed in seed yield.

A field experiment was conducted by Vikrant (2005) on a sandy loam soil in Hisar, Haryana India during khatif 2000-01 and 2001-02 to study the effects of P (0. 20. 40 and 60 kg P^2O^5 ha^{-1}) applications to green gram cv. Asha. Application of 60 kg P, being at par with 40 kg P, was significantly superior to 0 and 20 kg P/ha in respect of grain, stover and protein yields of green gram.

Manpreet *et al.* (2005) conducted a field experiment to assess the response of different mungbean genotypes in terms of nutrient uptake and quality to incremental levels of phosphorus application. Genotypes showed significant differences for straw and grain N content and grain P content while straw P content, N and P uptake differed non-significantly. Phosphorus application resulted in significant increase in N and P content and their uptake.

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) on the growth and yield of mungbean 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 was the best treatment, recording plant height of 56.3. germination of 90.5%. satisfactory plant population of 162.0. prolonged days taken to maturity of 55.5. long pods of 5.02 crn, seed weight of 10.5 g, seed index of 3.5 g and the highest seed yield of 1205.2 kg/ha. There was no significant change in the crop parameters beyond this level.

A field experiment was conducted by Edwin *et al.* (2005) during 1995 and 1996 pre-kharif seasons in Imphal. Manipur, India to study the effect of sources

(Single superphosphate (SSP), diammonium phosphate (DAP). Mussoorie rock phosphate (MRP). phosphate solubilizing organism (PSO) and farmyard manure) and levels (10, 15, 30 and 60 kg P_2O_5 ha^{-1}) of P on the growth and yield of green gram cv. AAU-34. The highest number of branches/plant (3.23) was obtained with 30 kg MRP + 30 kg SSP/ha. Single super phosphate at 60 kg/ha gave the highest number of clusters/plant (4.36). Pod length (7.34 cm), seeds/pod (10.5). 1000-seed weight (34.9 g) and seed yield (15.1 q/ha). Maximum plant height (31.2 cm), dry matter/plant (36.1 g) and number of pods/plant (1 7.4) was obtained with 60 kg DAP/ha.

Khan *et al.* (2004) conducted a study to determine the effect of different levels of phosphorus on the yield components of mungbean cv. NM-98 in D.I. Khan. Pakistan in 2000. Treatments comprised: 0, 20, 40, 60, 80, and 100 kg P/ha. The increase in phosphorus levels decreased the days to flowering and increased the branches/plant, number of pods/ plant, 1000-grain weight and grain yield. The highest yield of 1022 kg/ha was obtained at the phosphorus level of 100 kg/ha compared to a 774-kg/ha yield in the control. However, the most economical phosphorus level was 40 kg/ha, because it produced a grain yield statistically comparable to 100 kg P/ha.

A field experiment was conducted by Manpreet *et al.* (2004) in Ludhiana. Punjab. India during summer 2000 to investigate the response of mungbean genotypes (SML 1 34. SML 357 and SML 668) to P application (0. 20. 40 and 60 kg P_2O_5/ha) under irrigated conditions. Yield attributes such as number of branches/plant and pods/plant were significantly higher in SML 357 and SML 134. whereas pod length and 100-seed weight were higher in SML 668. which accounted for higher grain yield in this cultivar compared to SML 134 but was at par with SML 357. The straw yield showed the reverse trend with significantly higher value for SML 1 34, thus lowering the harvest index significantly compared to SML 668 and SML 357. Phosphorus application showed a non-significant effect on number of branches/plant, number of seeds/pod, pod length and 100-seed weight. However, the increase in P level showed significant increase in the number of pods per plant, which accounted for significantly higher grain and straw yields at higher levels (40 and 60 kg/ha) compared to lower levels (0 and 20 kg/ha). Harvest index remained unaffected with P application. The economic optimum P level for all the 3 summer mungbean genotypes was found to be 46. 1 kg P_2O_5/ha.

Nadeem *et al.* (2004) studied the response of mungbean 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}.

Asif *et al* (2003) conducted a field trial to find out the influence of phosphorus fertilizer on growth and yield of mungbean in India. They found that various levels of phosphorus significantly affected the number of leaves $plant^{-1}$, number of pods $plant^{-1}$, plant height, number of grain pod^{-1} and 1000 grain weight. Phosphorus level of 35 kg ha^{-1} produced the maximum grain yield.

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 mungbean cv. NM-98 in 2001. They observed that number of flowers/plant was found to be significantly higher by 25 kg N ha^{-1}. Number of seeds/pod was significantly affected by varying levels of 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 kg P ha^{-1} resulted with maximum seed yield (1.1 ton ha^{-1}).

Satish *et al.* (2003) conducted an experiment in Haryana, India in 1999 and 2000 to investigate the response of mungbean cultivars Asha, MH 97-2, MH

85-111 and K 851 to different P levels (0, 20, 40 and 60 kg P_2O_5/ha). Results revealed that the highest dry matter content in the leaves, stems and pods was obtained in Asha and MH 97-2. The total above-ground dry matter as well as the dry matter accumulation in leaves, stems and pods increased with increasing P level up to 60 kg P/ha. MH 97-2 and Asha produced significantly more number of pods and branches/plant compared to MH 85-111 and K 851. Phosphorus at 40 and 60 kg/ha increased the number of pods/plant grain yield and grains per pod over the control and P at 20 kg/ha. The number of branches plant^{-1} increased with increasing P rates.

Rajender *et al.* (2002) 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 niungbean genotypes MH 85-111 and T44. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect yield. The number of branches, number of pods plant^{-1}, numbers of seeds pod^{-1}. 1000-seed weight and straw yield increased with increasing rates P. whereas grain yield increased with increasing rates up to 40 kg P ha^{-1} only

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on mungbean at the Agronomic Research Station, Farooqabad in Pakistan. They revealed that various yield components like 1000-grain weight was affected significantly with 50-50-0 N kg ha^{-1}, Pkg ha^{-1}, K kg ha^{-1} application. Again they revealed that seed inoculation with 50-50-0 N kg ha^{-1}, kg ha^{-1}, K kg ha^{-1} exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

Nita *et al.* (2002) carried out a field experiment on mungbean and showed that seed yield, protein content and net production value increased with increasing rates of K and S. Similarly, the status of N and P in soil decreased with increasing rates of K and S.

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at different levels of nitrogen and phosphorus. Different rates of N (0, 25 and 60 kg ha^{-1}) and P (0, 25, 50 and 60 kg ha^{-1}) were tested. They observed that the number of pods/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 was increased with increasing rates of N up to 40 kg ha^{-1} along with increasing rates of P which was then followed by a decrease with further increase in N.

Yadav and Rathore (2002) carried out a field trial to find out the effect of phosphorus and iron fertilizer on yield, protein content and nutrient uptake in mungbean on loamy sandy soil in India. The results indicated that the seed and stover yield increased with the increasing phosphorus levels but significantly increased up to 60 kg P_2O_5 ha^{-1}. These results were confirmative to earlier reports of Singh *et al.* (1993).

Umar *et al.* (2001) observed that plant height and numbers of branches per plant were significantly increased by phosphorus application. Number of pods per plant, number of seeds per pod, 1000-seed weight and grain yields were also increased significantly by application of phosphorus along with nitrogen.

Teotia *et al.* (2001) conducted a greenhouse experiment to study the effect of P and S interaction on yield and nutrient composition of mungbean cv. *Pant Moong-2* and revealed that P and S applied individually or in combination increased the N and K content of the grain and straw and the yield of the plant.

Two field experiments were conducted in Kalubia Governorate. Egypt, in 1999 and 2000 summer seasons by El-Metwally and Ahmed (2001) to investigate the effects of P levels (0, 15. 30 and 45 kg ha^{-1}) on the growth, yield and yield components as well as chemical composition of mungbean cv. Kawmy-1. Growth, yield and yield components of mungbean were markedly improved with the addition of 45 kg P ha^{-1}. Addition of 45 kg P ha^{-1} markedly increased total carbohydrates and protein percentages compared with other treatments. Application of 45 kg P ha^{-1} markedly increased the number of pods $plant^{-1}$. Addition of 30 kg P ha^{-1} was the recommended treatments to obtain the best results for growth, yield and yield components as well as chemical composition of mungbean.

Prasad *et al.* (2000) conducted a pot experiment to study the effect of potassium on yield K-uptake by summer mungbean (cv. T-44) and showed that the grain yield increased potassium application but result was statistically non-significant. Increasing potassium levels significantly increased potassium uptake. Available K in soil after K harvest of crop increased with increasing levels of K.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat. Assam. India. Mungbean 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 farmers practices, while the highest yield was obtained by the fertilizer application (0.77 ton ha^{-1}).

Mastan *et al.* (1999) stated that the number of pods $plants^{-1}$ of summer mungbean cv. LOG 127 increased with increasing P rates.

Mitra *et al.* (1999) reported that mungbean grown in acid soils of Tripura, The maximum number of pods/plants were recorded with application of 50 kg P_2O_5 ha^{-1}.

Raundal *et al.* (1999) also reported that application of phosphorus 60 kg ha^{-1} to mungbean grown in *Kharif* season significantly increase the dry matter yield.

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

Singh and Ahlawat (1998) reported that application of phosphorus to mungbean cv. PS 16 increased the number of branches $plant^{-1}$ up to 12.9 kg ha^{-1} when grown in a sandy loam soil, low in organic carbon and N, and medium in P and K and with a pH of 7.8.

Ramamoorthy and Raj (1997) obtained 517 kg ha^{-1} seed yield of rainfed green gram without applied phosphorus and the highest (1044kg) with 25kg P_2O_5 ha^{-1}.

Sharma and Singh (1997) carried out a field experiment during 1989 and 1990 to study the effect of various levels of phosphorus (0, 25, 50 and 75 kg ha^{-1}) on the growth and yield of mungbean. Results of their study revealed that application of phosphorus at 30 kg ha^{-1} enhanced the plant height significantly.

Thakur *et al.* (1996) conducted an experiment with greengram *(Vigna radiata)* grown in kharif [monsoon] 1995 at Akola, Maharashtra, India which was given 0. 25. 50 or 75 kg P_2O_5 ha^{-1} as single superphosphate or diammonium phosphate. Seed and straw yields were not significantly affected by P source, and seed yield averaged 0.91, 1.00, 1.24 and 1.13 ha^{-1} at the 4 P rates, respectively. Phosphorus uptake was also highest with 50.

Shukla and Dixit (1996) conducted a field trial to study the response of mungbean to different levels of phosphorus. They also reported that application of phosphorus up to 50 kg P_2O_5 ha^{-1} significantly increased the vigour of the plants resulted in more dry matter production.

Bayan and Saharia (1996) carried out an experiment to study the effect of phosphorus on mungbean during the *kharif* seasons of 1994-95 in Bishanath Chariali Assam, India. The results indicated that plant height was unaffected by phosphorus application.

Rajkhowa *et al.* (1992) reported that application of phosphorus at 0- 60 kg P_2O_5 ha^{-1} increased seed yield of mungbean. However, the increase was significant up to 20 kg P_2O_5 ha^{-1} application.

Satter and Ahmed (1992) reported that phosphorus application up to 60 kg $P2O_5$ ha^{-1} on mungbean progressively and significantly increased nodulation, shoot length and weight, grain yield and total protein content.

Singh and Chaudhary (1992) conducted a field experiment with green gram and observed that phosphorus had beneficial effect on branches per plant, yield attributes and yield. Application of 30 kg P_2O_5 ha^{-1} recorded significantly higher values of these attributes than the control.

Sarkar and Banik (1991) conducted a field experiment and stated that increase in P_2O_5 up to 60 kg ha^{-1} progressively increased the number of nodules/plants of mungbean.

Solaiman *et al,* (1991) found that higher dose of phosphorus decrease the grain and other parameters. Phosphorus application at the rate of 60 kg P_2O_5 ha^{-1} significantly increased nodule number, dry weight of plant tops and mungbean yield

Patel and Patel (1991) observed that plant height of mungbean showed superiority at 60 kg P_2O_5 ha^{-1} followed by 40 kg P_2O_5 ha^{-1} application rate, growth on the soil which was sandy in texture, low in total N (0.04%), higher in available Phosphorus (77.33kg ha^{-1}) and rich in available potassium

(388.15 kg ha^{-1}) with the pH 7.5. Thus plant height was found to be increased with increasing levels of phosphorus from 0 to 60 kg ha^{-1}.

Reddy *et al.* (1990) set up an experiment with three cultivars of mungbean in 1987, applying 0 or 50 kg P_2O_5 ha^{-1} as a basal dressing or 50 kg P_2O_5 ha^{-1} in two equal split dressing at the sowing and flowering stages. They found that application of phosphorus increased the dry matter accumulation in mungbean.

Thakuria and Saharia (1990) observed that phosphorus levels significantly influenced the grain yield of green gram. The highest plant height, pods $plant^{-1}$ and the grain yield were recorded with 20kg P_2O_5 ha^{-1}, which was of equal value with 40 and 60 kg P_2O_5 ha^{-1}.

Kalita (1989) conducted an experiment with applying 30 kg P_2O_5 ha^{-1} to mungbean and observed that application of phosphorus increased the number of pods $plants^{-1}$. In another trial, Reddy *et al.* (1990) found similar result.

Arya and Karla (1988) found that application of phosphorus had no effect on the growth of summer mung, while number of grains per pod, weight of 1000-seeds and grain yield were found to be increased with increasing level of phosphorus from zero to 50 kg P_2O_5 ha^{-1}. Phosphorus content was also found to be affected by application of phosphorus.

Ahmed *et al.* (1986) carried out an experiment with various levels of phosphorus on the growth and yield of mungbean. They noted that phosphorus application up to 60 kg ha^{-1} progressively and significantly enhanced the plant height. They also stated that phosphorus application significantly increased plant height, number of pods per plant, grain and straw yields and protein content of mungbean.

Samiullah *et al.* (1986) conducted a field experiment on summer mung to study the effect of four levels of phosphorus (0, 30, 45, 60 P_2O_5 ha^{-1}). They noted that 60 kg P_2O_5 ha^{-1} proved optimum for yield parameters such as length, 1000 seed weight, pod number, seed number and seed yield.

Patel *et al.* (1984) studied the effect of 0, 20, 40, 60 and 80 kg P_2O_5 ha^{-1} on growth and seed yield of summer mungbean. They reported that 40 kg P_2O_5 ha^{-1} significantly increased the seed yield, number of pods per plant and 1000-seed weight.

Rajput and Verma (1982) found the beneficial effect of phosphorus on grain yield, number of pods per plant and seeds per pod of mungbean. The highest response was recorded with 50 kg P_2O_5 ha^{-1} in most of the characters.

Anwar *et al.* (1981) reported beneficial effect of P application on greengram in respect to number of pods $plant^{-1}$, number of seed $plant^{-1}$, weight of 1000 seeds at low doses of P but higher doses of P showed depressing effect. The maximum grain yield of 1446.6 kg ha^{-1} was recorded at 60kg P_2O_5 ha^{-1} compared to only 886.6 kg ha^{-1} in control.

Sharma and Yadav (1976) conducted field experiment using 4 doses of phosphorus (0, 40, 80 and 120 kg P_2O_5 ha^{-1}).They reported that phosphorus application had a significant effect on grain yield of gram. They observed that yield increased up to a dose of 50 kg P_2O_5 ha^{-1}, but declined slightly when the doses were further increased. Straw yield was not significantly affected by phosphorus levels.

2.2. Effect of boron on growth, yield and yield contributing characters of mungbean

Srivastava *et al.* (2005) obserbed that in absenceee of applied boron, there was no yield as no pods were formed, in comparison to na yield of 300 kg ha^{-1} in the full nutrient treatment. There was yellowing of younger leaves and typical 'little leaf' symptoms when boron was omitted.

Bharti *et al.* (2002) carried out a field experiment in Bihar, India during the winter of 1997-98 to observe the effects of B (0, 1.5 and 2.5 $kgha^{-1}$) application on the yield and nutrition of chickpea (cv. BG256). They reported that the mean seed yield, and seed and stover N and B content increased, whereas stover yield decreased with the increasing B rate.

Verma and Mishra (1999) carried out a pot experiment 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 of seed yield $plant^{-1}$ when the equivalent of 5 kg borax $ha-^{I}$ was applied at flowering.

Wang *et al.* (1999) reported that there is limited risk of B toxicity due to the use of borax fertilizer at up to 4 to 8 times recommended rates in rape-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.

Mondal *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. Number, size and weight of nodules decreased and nodule development changed leading to an inhibition of nitrogenase activity.

Gupta *et al.* (1993) reported that in a pot experiment in soil containing 0.4 mg kg^{-1} available B, chickpeas or lentils were grown following application of 0-6 mg B kg^{-1} soil and also reported that lentil was more susceptible to boron than chickpea. Boron concentration in both crops was lower in the seeds than in the straw, and was increased at higher B rates.

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

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

Dwivedi *et al.* (1990) reported that B uptake $plant^{-1}$ showed highly significant positive correlation with yield of lentil, soybean, greengram and was a reliable index for predicting crop response to B.

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

Sakal *et al.* (1990) carried out field trails at 7 sites in North Bihar, India. They observed the seed yield of chickpea increased from 1.4t with no B to 1.79 t/ha with 3kg B/ha. The yield response to B application was grater on low B soils. It was concluded that on soils <0.35 ppm, 3 kg B/ha was optimum and on soils >0.35 ppm B, 2kg B ha^{-1} was optimum. Boron concentration in all crops increased significantly with increasing level of applied boron. It is also reported that increased level of boron application in mustard increased tissue B content (Yadav and Manchanda 1982; Dutta *et al.*, 1984 and Yang *et al.*, *1989).*

Kulkamy *et al.* (1989) reported that the boron application increased nodule weight, nodule number and dry weight of groundnut.

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

Sakal *et al.* (1988) reported that on a coarse textured highly calcareous soil, application of 2.0 and 2.5 kg B/ha increased grain yields of blackgram and chickpea by 63 and 38%, respectively.

Dear and Lipsett (1987) found that reproductive growth is more sensitive to B deficiency than vegetative growth.

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

Vinay-Singh and Singh (1984) observed that the toxicity symptoms of boron in lentil plants started appearing first in the 8 ppm level. Most important symptoms were the yellowing of the leaflets of lower leaf followed by browning and scorching.

Dugger (1983) and Lewis, (1980) reported that the function of boron is primarily extra cellular and related to lignifications and xylem differentiation, membrane stabilization and altered enzyme reactions. Plants absorb B principally in the form of H_3B0_3 and to a smaller extent as $B_4o_7^{2-}$, H_2B0^{3-} and $HB0_3^{2-}$ The element plays a vital role in the physiological processes of plants such as cell nutrition, cell elongation and cell division, carbohydrate, protein and nucleic acid metabolism, cytokinins synthesis, auxins and phenol metabolism.

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

Howoler *et al.* (1978) observed that yield of beans was nearly doubled with the application of 1 kg B ha^{-1}.

Gupta (1979) stated that some plant species have a low B requirement and may also be sensitive to elevated B level even only slightly above those needed for normal growth. Therefore, toxic effects of B are likely to arise due to excessive use of B fertilizers.

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

Erikson (1979) reported that boron has both direct and indirect effects on fertilization. Indirect effects are related to the increase in amount and change in sugar composition of the nectare, whereby the flowers of species that rely on pollinating insects become more attractive to insects.

Gupta (1979) reported that boron is a micronutrient requiring for plant growth relatively to a smaller amount. The total B content of soils lies between 20 and

200 ppm with the available (hot water soluble) B fraction ranging from 0.4 to 0.5 ppm.

Gerath *et at.* (1975) reported an increase in yield of winter rape through application of boron fertilizer and recommended an application of 1 to 2 kg B ha^{-1} for increased yield.

Jakson and Chapman (1975) observed that boron stimulates germination, particularly pollen tube growth. Boron is also essential for sugar translocation, thus affecting carbon and nitrogen metabolism of plants.

2.3. Interaction effect of phosphorus and boron on mungbean

Mishpra *et al.* (2001) conducted an experiment on the effect of nutrient management and plant growth regulators on the yield and economics of chickpea in Madhya Pradesh, India during the *rabi* season of 1998-99. Boron and phosphorus treatments gave the height net returns. Seed and stover yields were higher in boron and phosphorus treatments.

Singh and Singh. (1994) noted that greengram pod yield of French bean increased with increase in P application and with up to 1 kg B ha^{-1} Application of more than 1 kg B caused a toxic effect.

Roy *et al.* (1992) observed that combined application of 60 kg p_2o_5 ha^{-1} and 20 kg borax ha^{-1} in soil increased seed yield of lentil.

Singh and Singh (1990) find out in a field trial on a sandy loam acid Alfisol of pH 5.4 and 0.50 ppm hot water soluble B, the application of Band P significantly influenced the green pod yields of French bean. Maximum pod yield of 11 t ha^{-1} was recorded at 28 kg P ha^{-1} applied in combination with 1 kg B ha^{-1} showing thereby a synergistic relationship between P and B.

Wani *et al.* (1988) observed that B-enriched superphosphate was more effective than single superphosphate. The application of B-enriched superphosphate or single superphosphate at 100 kg p_2o_5 ha^{-1} gave pod yields of 1.92 and 1.76 t ha^{-1}, protein contents of28.81and 27.88% and oil contents of 48.67 and 46.25% , respectively compared with 1.42 t/ha, 25.32% and 45.37 %, respectively found in Band P control treatment.

Patel and Golakia (1986) noted that the results of a pot experiment with medium black calcareous clay soil growing groundnut as a test crop showed a positive effect of P and B uptake. This could be attributed to the favorable effect of boron, which alters the permeability of plasmalemma; at the root surface in such way that P absorption increases.

Singh and Singh (1983) carried out an experiment on lentil with an alluvial sandy soil of pH 8.5 and 0.43 ppm hot water extractable B, increasing levels of applied B from 0 to 8.0 ppm increased the P content in 6 weeks old lentil shoots from 0.70 to 1.50 % and boron concentration from 56.7 to 413.3 ppm. The dry matter yield decreased from 2.70 to 1.66 g pori. Similarly, the application of 0 to 6 ppm B in a non-calcareous sierozem sandy soil of pH 8.2 and 0.43 ppm hot water soluble B under screenhouse condition increased the P content in 6 week old chickpea shoots from 0.75 to 1.60 %.

Pandey and Singh (1981) reported that seed yields of greengram grown with NPK on a sandy loam calcareous soil (pH 8.3) were increased by applying 10 kg borax ha^{-1}.

Chapter 3

Materials and Methods

Chapter III
MATERIALS AND METHODS

This chapter includes a brief description of the experimental site, experimental period, climatic condition, crop or planting materials, land preparation, experimental design and layout, crop growing procedure, treatments, intercultural operations, data collection, preparation and chemical analysis of soil and plant samples along with statistical analysis.

3.1 Location

The field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka- 1207 during the period from 25th September, 2013 to December, 2013 .

3.2 Soil

The soil of the experimental field belongs to the Tejgaon series under the Agro ecological Zone, Madhupur Tract (AEZ- 28) and the General Soil.

Table 1. Salient features of the experimental field

Morphological Features	Characteristics
Location	Sher-e-Bangla Agricultural University Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of inundation	Above flood level
Drainage condition	Well drained
Land type	High land

Table 2. Initial physical and chemical properties of experimental soil analyzed at Soil Resources Development Institute (SRDI), 2012, Farmgate, Dhaka.

Characteristics	Value
Partical size analysis	
% Sand	33
%Silt	41
% Clay	26
Textural	**Silty-clay**
pH	5.7
Organic matter (%)	1.09
Total N (%)	0.05
Available P (ppm)	21.54
Exchangeable K (me/100 g soil)	0.15

3.3 Climate

The experimental area has sub-tropical climate characterized by high temperature, heavy rainfall during May to September and scanty rainfall during rest of the year. The annual precipitation of the site is 2052 mm and potential evapotranspiration is 1286mm, the average maximum temperature is 20.5^{0}C, average minimum temperature is 14.14^{0}C and the average mean temperature is 18.12^{0}C (BBS, 2013).

3.4 Seeds and variety

BARI Mung-5, a high yielding variety of mungbean was released by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur in 1997. It is photo insensitive, short lifespan 55 to 60 days and bold seeded crop. The special characteristic of this variety is its synchronized maturity. It was developed from the NM-92 line introduced by AVRDC in 1992. Its yield potentiality is about 1.5 to1.7 ton ha^{-1}. This variety is resistant to yellow mosaic virus diseases, insects and pest attack (BARI, 2008).

3.5 Design and layout of experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations. Fertilizer treatment consisted of 3 levels of P (0, 20, and 40 kg P ha^{-1} designated as P_0, P_1, and P_2, respectively) and 3 levels of B (0, 0.75, and 1.5 kg B ha^{-1} designated as B_0, B_1, and B_2, respectively). There were nine (9) treatment combinations, where all the treatments were applied on the allotted plot which was 3.5 m x 1.75 m maintaining 0.5 m gap between each plot.

3.6 Treatments and treatment combinations of experiment

Doses of P and B (kg/ha)

Phosphorus

1. P_0 = No phosphorus (control)
2. P_1 = 20 kg
3. P_2 = 40 kg

Boron

1. B_0 = No boron (control)
2. B_1 = 0.75 kg
3. B_2 = 1.5 kg

Doses of P and B (g/plot)

Phosphorus

1. P_0 = No phosphorus (control)
2. P_1 = 12.25 g
3. P_2 = 24.5 g

Boron

1. B_0 = No boron (control)
2. B_1 = 2.705 g
3. B_2 = 5.41 g

Treatment Combinations

1. P_0B_0 = Control (without P and B)
2. P_0B_1 = 0 g P/plot+2.705 g B/plot
3. P_0B_2= 0 g P/plot+5.41 g B/plot
4. P_1B_0 = 12.25 g P/plot+0 g B/plot
5. P_1B_1 = 12.25 g P/plot+ 2.705 g B/plot
6. P_1B_2= 12.25 g P/plot+5.41 g B/plot
7. P_2B_0 = 24.5 g P/plot+0 g B/plot
8. P_2B_1 = 24.5 g P/plot+2.705 g B/plot
9. P_2B_2= 24.5 g P/plot+5.41 g B/plot

3.7 Land preparation

The plot selected for the experiment was opened by power tiller driven rotovator; afterwards the land was ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. Finally, the land was leveled and the experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in the following section

3.8 Fertilizers application

The sources of N, P_2O_5, K_2O were urea, triple superphosphate (TSP), muriate of potash (MOP), were applied as 24, 40 and 48 kg/ha, respectively. Half amount of urea was applied during the final land preparation and rest of the urea was applied as top dressing at 25 DAS. The entire amounts of TSP, MOP were applied during the final land preparation respectively. Well rotten cow dung (10 t/ha) was also applied during final land preparation. The fertilizers were then mixed well with the soil by spading and individual unit plots were leveled.

3.9 Seed collection and sowing

Seeds of BARI Mung-5 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Seeds were sown in the main field on the 25th September, 2013 having line to line distance of 30 cm and plant to plant distance of 10 cm.

3.10 Cultural and management practices

Various intercultural operations such as thinning of plants, weeding and spraying of insecticides were accomplished whenever required to keep the plants healthy and the field weed free. At the very early growth stage (after 15 days of emergence of seedlings) the plants were attacked by Cutworm, which was removed by applying Malathion. Special care was taken to protect the crop from birds especially after sowing and germination stages. The field was irrigated twice- one at 15 days and the other one at 30 days after sowing.

3.11 Harvesting

The crop was harvested at maturity on 3rd December, 2013. The harvested crop of each plot was bundled separately. Grain and straw yields were recorded plot wise and the yields were expressed in t ha^{-1}.

3.12 Collection of experimental data

Ten (10) plants from each plot were selected as random and were tagged for the data collection. Data were collected at harvesting stage. The sample plants were cut down to ground level prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

1. Plant height (cm)
2. Number of primary branch plant^{-1}
3. Number of pod plant^{-1}
4. Pod length (cm)
5. Number of seeds pod^{-1}
6. Weight of 1000 seeds (g)
7. Grain yield (t /ha)
8. Stover yield (t/ ha)

3.12.1 Plant height

The plant height was measured from the ground level to the top. Height of 10 plants randomly from each plot were measured. It was done at the ripening stage of the crop.

3.12.2 No. of branches plant^{-1}

Branches were counted at the ripening stage. Branches of 10 plants randomly from each plot were counted and averaged.

3.12.3 No. of pods plant^{-1}

Pods were counted at the ripening stage. Pods of 10 plants randomly from each plot were counted and averaged.

3.12.4 No. of seeds pod^{-1}

It was done after harvesting. At first, number of seeds pod" was counted. Seeds of 10 pods randomly from each plot were counted and averaged.

3.12.5 Pod length

Length of 10 pods from each plot were measured randomly and averaged after harvesting.

3.12.6 Thousand seed weight

Thousand seed of mungbean were counted randomly and then weighed plot wise.

3.12.7 Grain yield

Grains obtained from 1 m2 area from the center of each unit plot was dried, weighed carefully and then converted into t ha^{-1}

3.12.8 Stover yield

Stover obtained from each individual plot was dried, weighed carefully and the yield expressed in t ha^{-1}.

3.13 Soil pH

The pH of the soil was determined with the help of a glass electrode pH meter using soil: water ratio of 1: 2.5 (Jackson, 1962).

3.14 Statistical Analysis

The collected data were statistically analyzed by using the ANOV A technique. The test of significance of all parameters was done. The Duncan's Multiple Range Test (DMRT) with Least Significant Difference value was determined with appropriate levels of significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984). The statistical package MSTATC was used for this purpose.

Chapter 4
Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

The study was conducted to determine the effect of phosphorus (P) and boron (B) on the growth and yield of mungbean. Data on different yield contributing characters and yield were recorded to find out the optimum levels of phosphorus and boron on mungbean. The results on different parameters are presented in this chapter.

4.1 Plant height

4.1.1 Effect of phosphorus on the plant height of mungbean

The effects of phosphorus on the plant height of mungbean are presented in Table 3. Significant variation was observed on the plant height of mungbean when the field was fertilized with different doses of phosphorus. Among the different doses of phosphorus, P_2 (40 kg P ha^{-1}) showed the highest plant height (55.75 cm) which was significantly different from the fertilizer dose of P_1 (20 kg p ha^{-1}). On the other hand, the lowest plant height (48.44cm) was observed in the Po treatment where phosphorus was not applied. It was observed that plant height increased gradually with the increment of phosphorus doses. This might be due to higher availability of N P S K and their uptake that progressively enhanced the vegetative growth of the plant. This result is similar with the findings of some other researchers, e.g. Sharma and Singh (1997) found significant increase in plant height of greengram due to the application of 40 kg P ha^{-1}.

Table 3. Effect of phosphorus on the growth parameters of mungbean

treatments	plant height(cm)	no. of branches plant^{-1}	no. of pods plant^{-1}	no. of seeds pod^{-1}
P_0	48.44 b	9.24 c	11.81 c	7.93 c
P_1	51.10 b	11.68 b	14.72 b	9.91 b
P_2	55.75 a	14.42 a	16.70 a	11.23 a
LSD	**4.484**	**0.6336**	**1.033**	**0.6704**
CV (%)	**8.67**	**5.38**	**7.17**	**6.93**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per LSD (0.05).

4.1.2 Effect of boron on the plant height of mungbean

Mungbean showed significant variation in respect of plant height when boron fertilizer in different doses were applied (Table 4). Among the different fertilizer doses, B_2 (1.5 kg B ha^{-1}) showed the highest plant height (53.67cm), which was not significantly different from the plant height fertilizer dose of B_1 (0.75 kg B ha^{-1}). On the contrary, the lowest plant height (49.62cm) was observed in the treatment where no boron fertilizer was applied which was also significantly identical with B_2 treatment.

Table 4. Effect of boron on the growth parameters of mungbean

Treatments	Plant height(cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}
B_0	49.62 a	10.06 c	12.90 b	8.79 b
B_1	51.99 a	12.23 b	14.84 a	9.83 a
B_2	53.67 a	13.06 a	15.49 a	10.44 a
LSD	**4.484**	**0.6336**	**1.033**	**0.6704**
CV (%)	**8.67**	**5.38**	**7.17**	**6.93**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per LSD (0.05).

4.1.3 Interaction effect of phosphorus and boron on the plant height of Mungbean

Combined application of different doses of phosphorus and boron fertilizers had significant effect on the plant height of mungbean (Table 5). The lowest plant height (47.82 cm) was observed in the treatment combination of P_0B_0 (No phosphorus and No boron). On the other hand, the highest plant height (59.69 cm) was recorded with P_2B_2 (40 kg P ha^{-1} + 1.5 kg B ha^{-1}) treatment.

Table 5. Interaction effect of phosphorus and boron on the growth and yield contributing parameters of mungbean

Treatments	Plant height(cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}
P_0B_0	47.82 c	8.03 e	11.11 f	7.13 f
P_0B_1	48.36 bc	9.66 d	12.10 ef	8.21 ef
P_0B_2	49.13 bc	10.03 d	12.21 ef	8.45 de
P_1B_0	49.45 bc	10.09 d	13.43 de	9.38 cd
P_1B_1	51.66 bc	12.26 c	15.09 cd	10.03 c
P_1B_2	52.18 abc	12.69 c	15.65 bc	10.32 bc
P_2B_0	51.58 bc	12.05 c	14.16 cd	9.89 c
P_2B_1	55.97 ab	14.77 b	17.32 ab	11.25 b
P_2B_2	59.69 a	16.44 a	18.61 a	12.56 a
LSD	7.766	1.097	1.789	1.161
CV (%)	8.67	5.38	7.17	6.93

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per LSD (0.05).

4.2 No. of branches plant^{-1}

4.2.1 Effect of phosphorus on the No. of branches plant^{-1} of mungbean

Significant variation was observed in the number of branches plant^{-1} of mungbean when different doses of phosphorus were applied (Table 3). The highest number of branches plant^{-1} (14.42) was recorded in P_2 (40 kg P ha^{-1})

which was statistically different from two other treatments. The lowest number of branches plant^{-1} (9.24) was recorded in the P_0 treatment where no phosphorus was applied. Singh *et al.* (1999) also found similar results with increasing rate of P and they noted that the number of branches plant^{-1} generally increased with the application of Phosphorus.

4.2.2 Effect of boron on No. of branches plant^{-1} of mungbean

Different doses of boron fertilizer showed significant variations in respect of number of branches plant^{-1} (Table 4). Among the different doses of boron, B_2 (1.5 kg B ha^{-1}) showed the highest number of branches plant^{-1} (13.06) which was statistically different from all other treatments. On the contrary, the lowest number of branches plant^{-1} (10.06) was observed with B_0 treatment where no boron fertilizer was applied. Dutta *et al.* (1984) also found similar results with the application of 1 kg B ha^{-1}

4.2.3 Interaction effect of phosphorus and boron on the No. of branches plant^{-1} of mungbean

The combined effect of different doses of P and B fertilizers on the number of branches plant^{-1} of mungbean was significant (Table 5). The highest number of branches plant^{-1} (16.44) was recorded with the treatment combination of P_2B_2 (40 kg P ha^{-1} + 1.5 kg B ha^{-1}). On the other hand, the lowest number of branches plant^{-1} (8.03) was found in P_0B_0 treatment (control treatment).

4.3 Number of pods plant^{-1}

4.3.1 Effect of phosphorus on the number of pods plant^{-1} of mungbean

Significant variation was observed in number of pods plant^{-1} of mungbean when different doses of phosphorus were applied (Table 3). The highest number of pods plant^{-1} (16.70) was recorded in P_2 (40 kg P ha^{-1}) which was statistically different from other treatment. The lowest number of pods plant^{-1} (11.81) was recorded in the P_0 treatment where no phosphorus was applied. Mastan *et al.* (1999), Kalita (1989) and Reddy *et al.* (1990) also found similar results.

4.3.2 Effect of boron on the number of pods plant^{-1} of mungbean

Different doses of boron fertilizers showed significant variations in respect of number of pods plant^{-1} (Table 4). Among the different doses of fertilizers, B_2 (1.5 kg B ha^{-1}) showed the highest number of pods plant^{-1} (15.49) which was statistically identical with B_1(14.84). On the contrary, the lowest number of pods plant^{-1} (12.90) was observed with B_0 treatment. Dutta *et al.* (1984) also found similar results with the application of 1 kg B ha^{-1}.

4.3.3 Interaction effect of phosphorus and boron on the number of pods Plant^{-1} of mungbean

The combined effect of different doses of P and B fertilizers on number of pods plant^{-1} of mungbean was significant (Table 5). The highest number of pods plant^{-1} (18.61) was recorded with the treatment combination of P_2B_2 (40 kg P ha^{-1} + 1.5 kg B ha^{-1}) which was statistically different from the rest of the treatments. On the other hand, the lowest number of pods plant^{-1} (11.11) was found in P_0B_0 treatment.

4.4 Number of seeds pod^{-1}

4.4.1 Effect of phosphorus on the number of seeds pod^{-1} of mungbean

Significant variation was observed in number of seeds pod^{-1} of mungbean when different doses of phosphorus were applied (Table 3). The highest number of seeds pod^{-1} (11.23) was recorded in P_2 (40 kg P ha^{-1}). The lowest number of seeds pod^{-1} (7.93) was recorded in the P_0 treatment where no phosphorus was applied.

4.4.2 Effect of boron on the number of seeds pod^{-1} of mungbean

Different doses of boron fertilizers showed significant variations in respect of number of seeds pod^{-1} (Table 4). Among the different doses of fertilizer, B_2 showed the highest number of seeds pod^{-1} (10.44) which was statistically similar with the B_1 (0.75 kg B ha^{-1}) treatment. On the contrary, the lowest number of seeds pod^{-1} (8.79) was observed with B_0, where no boron fertilizer was applied.

4.4.3 Interaction effect of phosphorus and boron on the number of seeds pod^{-1} of mungbean

The combined effect of different doses of P and B fertilizer on number of seeds pod^{-1} of mungbean was significant (Table 5). The highest number of seeds pod^{-1} (12.56) was recorded with the treatment combination of P_2B_2 (40 kg P ha-^{1} + 1.5 kg B ha^{-1}). On the other hand, the lowest number of seeds pod^{-1} (7.13) was found in P_0B_0 treatment (control).

4.4.4 Effect of phosphorus on yield contributing characters at different doses

As depicted in the Figure 1, it revealed that higher number of pods plant^{-1} (16.70) and seeds pod^{-1} (11.23) as well as yield (1.46 t/ha) of mungbean were found higher in the treatment P_2 (40 kg/ha) which was significantly higher over P_1 (20 kg/ha) treatment and the minimum number of pods plant^{-1} (11.81) and seeds pod^{-1} (7.93) as well as yield (0.69 t/ha) of mungbean were found in P_0 (control) treatment. That is the best treatment (P_2) increased pods/plant, seeds/pod and yield significantly by the application of phosphorus at 40 kg per hacter over control.

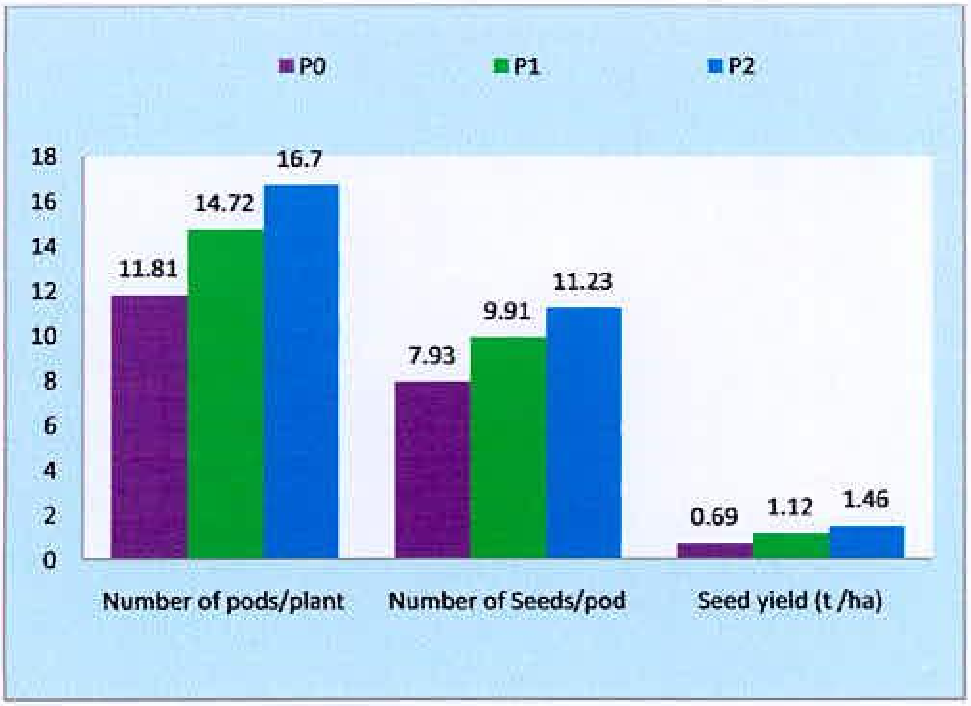

Figure 1 : Effect of different phosphorus level on the number of pods plant^{-1} & seeds pod^{-1} and yield of mungbean

4.5 Pod length (cm)

4.5.1 Effect of phosphorus on pod length of mungbean

The pod length as affected by different doses of phosphorus showed statistically significant variation (Table 6). Among the different doses of P the highest pod length (8.58 cm) was observed in P_2 (40 kg P ha^{-1}) which was statistically different from other treatment. The lowest pod length (6.34 cm) was recorded in the P_0 treatment where no P was applied.

4.5.2 Effect of boron on pod length of mungbean

Application of B fertilizer at different doses showed significant variation on the pod length of mungbean (Table 7). Among the different B fertilizer doses, B_2 (1.5 kg B ha^{-1}) showed the highest pod length (8.27 cm), which was statistically similar with B_1 (0.75 kg B ha^{-1}) treatment. The lowest pod length

(6.72 cm) was recorded in the B_0 treatment where no B was applied.

4.5.3 Interaction effect of phosphorus and boron on pod length of mungbean

Combined effect of different doses of P and B fertilizers on pod length showed a statistically significant variation (Table 8). The highest pod length (9.63 cm) was recorded in the treatment combination of P_2B_2 (40 kg P ha^{-1}+ 1.5 kg B ha^{-1}) which was statistically identical with the treatment combinations of P_2B_1 (40 kg P ha^{-1}+ 0.75 kg B ha^{-1}) and P_1B_2 (20 kg P ha^{-1}+ 1.5 kg B ha^{-1}) treatment. On the other hand, the lowest pod length (6.04 cm) was found in P_0B_0 treatment.

4.6 Weight of 1000 seed (g)

4.6.1 Effect of phosphorus on weight of 1000-seed of mungbean

A significant variation was observed on the weight of 1000 seed of mungbean when different doses of P were applied (Table 6). The highest weight of 1000 seed (49.53 g) was recorded in P_2 (40 kg P ha^{-1}), which was statistically similar with P_1 (20 kg P ha^{-1}) treatment. The lowest weight of 1000 seed (43.64 g) was recorded in the P_0 treatment where no P was applied.

Table 6. Effect of phosphorus on yield and yield contributing characters of mungbean

Treatments	Pod length (cm)	1000-seed wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
P_0	6.34 c	33.94 b	0.69 c	1.06 c
P_1	7.83 b	35.64 a	1.12 b	1.84 b
P_2	8.58 a	38.45 a	1.46 a	2.35 a
LSD	**0.7165**	**3.84**	**0.08361**	**0.1999**
CV (%)	**9.45**	**6.10**	**7.71**	**11.41**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per LSD (0.05).

4.6.2 Effect of boron on weight of 1000 seed of mungbean

Different doses of B fertilizers showed significant variations in respect of the weight of 1000 seed (Table 7). Among the different doses of B fertilizers, B_2 (1.5 kg B ha^{-1}) showed the highest weight of 1000 seed (48.34 g) and it was identical with B_1 (0.75 kg B ha^{-1}) treatment. On the contrary, the lowest weight of 1000 seed (45.04 g) was observed with B_0 where no B fertilizer was applied.

4.6.3 Interaction effect of phosphorus and boron on weight of 1000 seed of mungbean

The combined effect of different doses of P and B fertilizers on the weight of 1000 seed of mungbean was significant (Table 8). The highest weight of 1000 seed (51.54 g) was recorded with the treatment combination of P_2B_2 which was statistically similar with P_2B_1 (50.02 g), P_2B_0 (47.03 g), P_1B_2 (48.23 g), P_1B_1 (47.87 g), and P_1B_0 (46.76 g) treatments. On the other hand, the lowest weight of 1000 seed (41.32 g) was found in P_0B_0 treatment (control).

Table 7. Effect of boron on yield and yield contributing characters of mungbean

Treatments	Pod length (cm)	1000-seed wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
B_0	6.72 b	31.25 b	0.88 c	1.33 c
B_1	7.75 a	34.21 ab	1.11 b	1.86 b
B_2	8.27 a	39.76 a	1.29 a	2.06 a
LSD	0.7165	2.859	0.08361	0.1999
CV (%)	9.45	6.10	7.71	11.41

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per LSD (0.05).

4.7 Grain yield of mungbean (t/ha)

4.7.1 Effect of phosphorus on the grain yield of mungbean

Significant variation was observed on the grain yield of mungbean when different doses of P were applied (Table 6). The highest grain yield of mungbean (1.46 t ha^{-1}) was recorded in P_2 (40 kg P ha^{-1}) which was statistically different from other treatments. The lowest grain yield of mungbean (0.69 t ha^{-1}) was recorded in the P_0 treatment where no P was applied. These fmdings are similar with the fmdings of Satter and Ahmed (1992).

4.7.2 Effect of B on the grain yield of mungbean

Different doses of B fertilizers showed insignificant effect of grain yield of mungbean (Table 7). Among the different doses of B fertilizers, B_2 (1.5 kg B ha^{-1}) showed the highest grain yield of mungbean (1.29 t ha^{-1}). B fertilizer dose of B_1 (0.75 kg ha^{-1}) showed 1.11 t ha^{-1}. On the contrary, the lowest grain yield of mungbean (0.88 t ha^{-1}) was observed with B_0 where no B fertilizer was applied.

Table 8. Interaction effects of phosphorus and boron on yield and yieldcontributing characters of mungbean

Treatments	Pod length (cm)	1000-seed wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
P_0B_0	6.04 d	31.05 d	0.61 f	0.99 f
P_0B_1	6.23 d	33.56 cd	0.69 ef	1.06 ef
P_0B_2	6.76 d	34.75 bcd	0.77 e	1.12 ef
P_1B_0	7.03 cd	35.87 abc	0.98 d	1.34 de
P_1B_1	8.02 bc	36.52 abc	1.08 d	2.07 c
P_1B_2	8.43 ab	37.52 abc	1.31 c	2.11 bc
P_2B_0	7.09 cd	38.87 abc	1.05 d	1.67 d
P_2B_1	9.01 ab	40.58 ab	1.55 b	2.44 b
P_2B_2	9.63 a	41.27 a	1.79 a	2.96 a
LSD	**1.241**	**4.952**	**0.1448**	**0.3462**
CV (%)	**9.45**	**6.10**	**7.71**	**11.41**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per LSD (0.05).

4.7.3 Interaction effect of P and B fertilizers on grain yield of mungbean

The combined effect of different doses of P and B fertilizers on the grain yield of mungbean was significant (Table 8). The highest grain yield of mungbean (1.79 t ha^{-1}) was recorded with the treatment combination of P_2B_2 which was statistically different from all other treatments. On the other hand, the lowest grain yield of mungbean (0.613 t ha^{-1}) was found in P_0B_0 treatment (No P and No B).

4.7.4 Effect of boron on yield contributing characters at different doses

As depicted in the Figure 2, it was revealed that maximum number of pods $plant^{-1}$ (15.49) and seeds pod^{-1} (10.44) as well as yield (1.29 t/ha) of mungbean were found in the treatment B_2 (1.5 kg/ha) which was significantly higher over B_1 (0.75 kg/ha) treatment and the minimum number of pods $plant^{-1}$ (12.90) and seeds pod^{-1} (8.79) as well as yield (0.88 t/ha) of mungbean were found in B_0 (control) treatment. That is the best treatment (B_2) increased maximum number of pods $plant^{-1}$ and seeds pod^{-1} as well as yield over control.

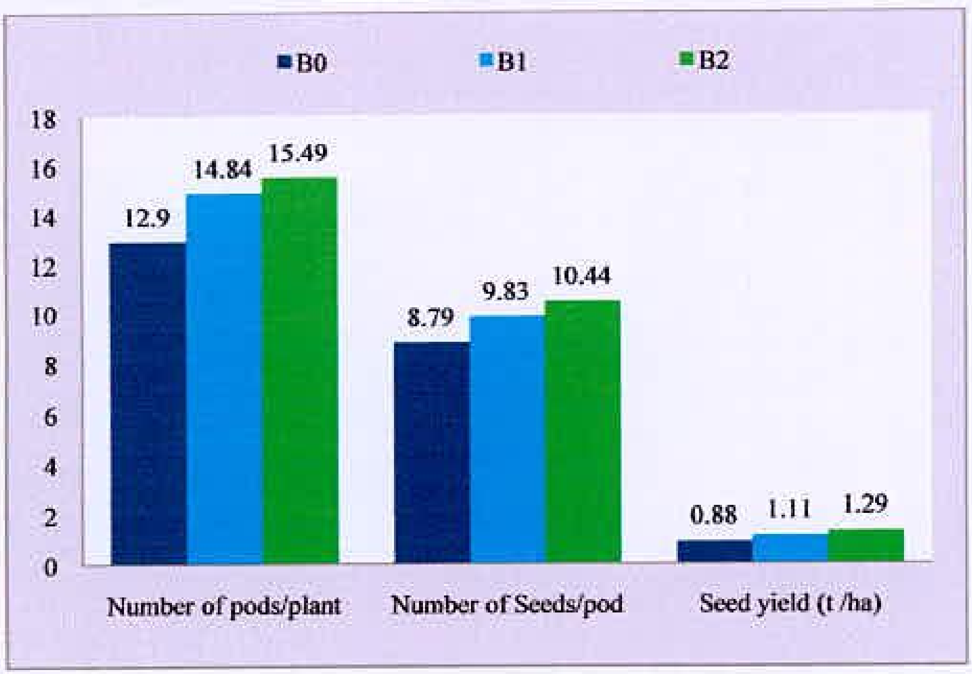

Figure 2 : Effect of different Boron level on the number of pods $plant^{-1}$ & seeds pod^{-1} and yield of mungbean

4.7.5 Relationship between number of seeds pod^{-1} and yield of mungbean (t/ha)

Correlation study was done to establish the relationship between the number of seeds pod^{-1} and yield of mungbean. From the study it revealed that highly significant correlation (R^2 = 0.998) was observed between the parameters (Figure 3). It was evident from the Figure 3 that the equation y = 0.545x + 8.231 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.998) showed that, fitted regression line had a significant regression co-efficient. From these relations it can be concluded that yield of mungbean was strongly (R^2 = 0.985) correlated with the number of seeds pod^{-1}, i.e., the yield of mungbean increased with the increase of number of seeds pod^{-1}.

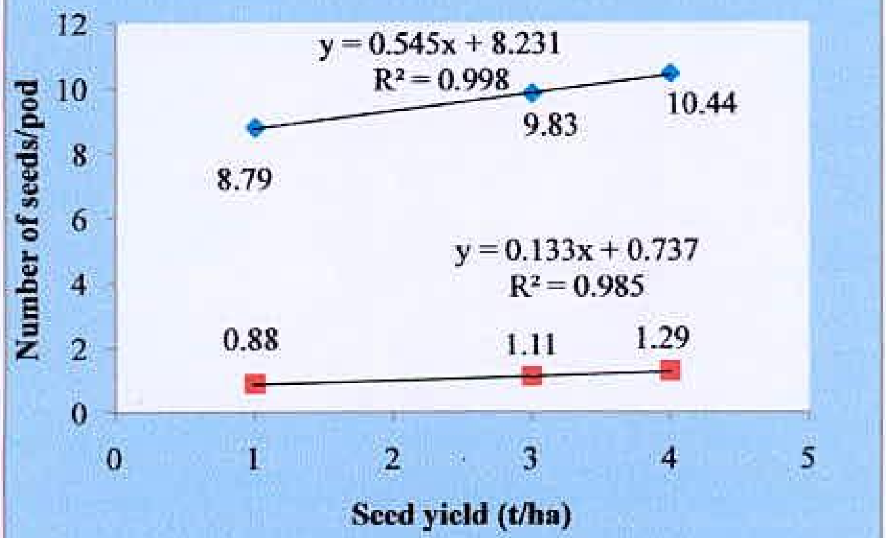

Figure 3: Linear relationship between number of seeds pod^{-1} and seed yield(t ha^{-1})

4.8 Stover yield of mungbean (t ha^{-1})

4.8.1 Effect of P on the stover yield of mungbean

Significant variation was observed on the stover yield of mungbean when different doses of P were applied (Table 6). The highest stover yield of mungbean (2.35 t ha^{-1}) was recorded in P_2 (40 kg P ha^{-1}), which was statistically different from other treatments. The lowest stover yield (1.06 t ha^{-1}) was recorded in the P_0 treatment where no P was applied.

4.8.2 Effect of B on the stover yield of mungbean

Different doses of B fertilizers showed significant variations in respect of stover yield of mungbean (Table 7). Among the different doses of B fertilizers, B_2 (0.75 kg B ha-1) showed the highest stover yield (2.06 t ha^{-1}), which was statistically different from other treatments. On the contrary, the lowest stover yield (1.33 t ha^{-1}) was observed with B_0 treatment.

4.8.3 Interaction effect of P and B on stover yield of mungbean

The combined effect of different doses of P and B fertilizers on the stover yield was significant (Table 8). The highest stover yield (2.96 t ha^{-1}) was recorded with the treatment combination of P_2B_2 (40 kg P ha^{-1} + 1.5 kg B ha^{-1}). On the other hand, the lowest stover yield (0.99 t ha^{-1}) was found in P_0B_0 treatment (No P and No B).

Chapter 5
Summary and conclusion

Chapter V

SUMMARY AND CONCLUSION

An experiment was conducted at the Sher-e-Bangla Agricultural University Farm Dhaka 1207 (Tejgaon series under AEZ No.28) during the kharif season of March, 2014 to May, 2014 to study the "Influence of phosphorus and boron on the growth and yield of mungbean". Two factor experiment with randomized complete block design was followed with 9 treatments having unit plot size of 3m x 2m (6m2) and replicated thrice. Two factors were phosphorus and boron. The treatments were P_0B_0 control (No phosphorus + No boron), P_0B_1 (No phosphorus + 0.75 kg B ha^{-1}), P_0B_2 (No phosphorus + 1.5 kg B ha^{-1}), P_1B_0 (20 kg P ha^{-1} + No boron), P_1B_1 (20 kg P ha^{-1} + 0.75 kg B ha^{-1}), P_1B_2 (20 kg P ha^{-1} + 1.5 kg B ha^{-1}), P_2B_0 (40 kg P ha^{-1} + No boron), P_2B_1 (40 kg P ha^{-1} + 0.75 kg B ha^{-1}), P_2B_2 (40 kg P ha^{-1} + 1.5 kg B ha^{-1}). The required amounts of P (from TSP) and B (from boric acid) were applied at a time as per treatment combination after field layout of the experiment and were mixed properly through hand spading.

The data were collected plot wise for plant height (cm), number of primary branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, pod length (cm), weight of l000-seed (g), grain yield (t ha^{-1}) and stover yield (t ha^{-1}) . All the data were statistically analyzed following LSD and the mean comparison was made by DMRT. The results of the experiment are stated below.

Plant height was significantly affected by different levels of P and B. Plant height increased with increasing levels of P and B individually. The individual application of P @ 40 kg ha^{-1} (P_2) produced the tallest plant (55.7 cm), whereas application of B @ 1.5 kg ha^{-1} (B_2) produced the tallest plant of 53.67cm height. The tallest plant (59.69 cm) was found in P_2B_2 treatment, which was higher over other treatments.

The individual application of P and B showed positive effect on the number of branches per plant, number of pods per plant, number of seeds per pod, weight of 1000 seed, grain yield and stover yield. All the plant characters increased with increasing levels of P and B up to higher level except 1000 seed weight. Like all other plant characters, grain yield was influenced significantly due to application of P. Grain yield increased with increasing levels of P up to certain level.

The highest grain yield (1.46 t ha^{-1}) was found in plants receiving P @ 40 kg ha^{-1} and the lowest was recorded in Po treatment. Individual application of boron also showed significant effect in grain yield. Application B @ 1.5 kg ha^{-1} (B_2) produced the highest grain yield (1.29 t ha^{-1}). The combined application of P and B had positive effect on grain yield of mungbean. The highest grain yield of mungbean was recorded in P_2B_2 (1.79 t ha^{-1}) treatment which was statistically different with each other. The lowest yield was recorded in P_0B_0 treatment. Combined application of P @ 40 kg ha^{-1} and B @ 1.5 kg ha^{-1} produced higher grain yield compared to control treatment significantly.

Considering all the parameters studied the following conclusion may be drawn:-

- Significantly higher growth and yield performance of mungbean was observed by the P_2B_2 treatment i.e., by the combined application of phosphorus and boron fertilizers @ 40 kg P $ha-^{1}$ and 1.5 kg B ha^{-1}.

Based on the results of the present study, the following recommendation may be drawn:-

- The combined application of Phosphorus and boron fertilizers @ 40 kg P ha^{-1} and 1.5 kg B ha^{-1} may be recommended in Tejgaon series under AEZ No.28 to get higher growth and yield of mungbean and also to maintain soil fertility and productivity compared to their individual applications.

However, to reach a specific conclusion and recommendation, more research work on mungbean fertilization should be done in different Agro-ecological zones of Bangladesh.

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Chapter VI
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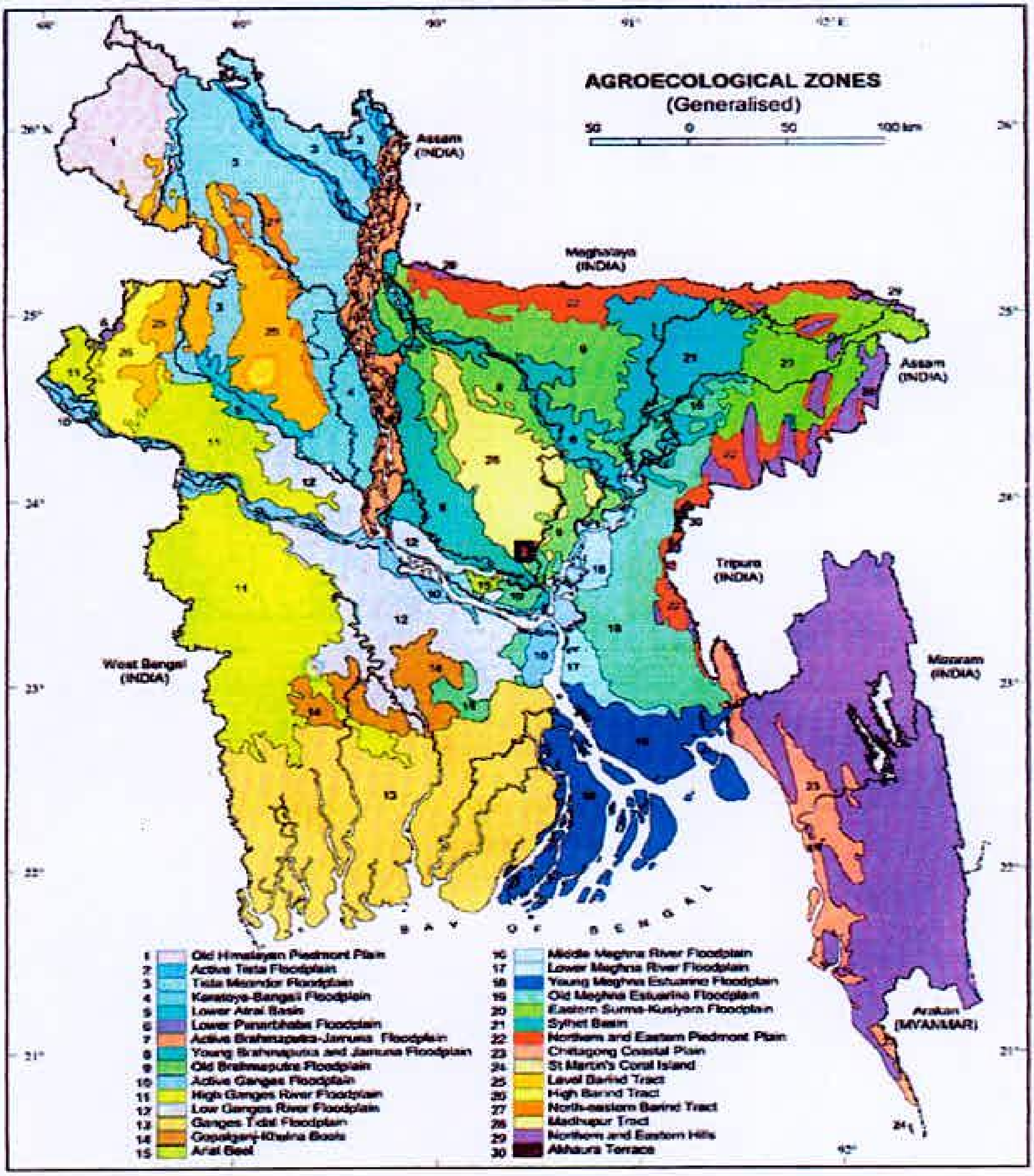
Appendices

Chapter VII

APPENDIX

Appendix 1. Map showing the experimental site under study



Appendix 2. Monthly meteorological information during the period from September to December, 2013

Month	Air temperature (^0C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
September, 2013	23	16	45	61
October, 2013	25	18	55	137
November, 2013	23	15	72	245
Decemver, 2013	22	17	79	315

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

Appendix 3: Commonly used symbols and abbreviations

Abbreviations	**Full word**
%	Percent
@	At the rate
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BD	Bangladesh
BINA	Bangladesh Institute of Nuclear Agriculture
CEC	Cation Exchange Capacity

cm	Centi-meter
CV%	Percentage of coefficient of variation
df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
EC	Emulsifiable concentration
et al	and others
etc	Etcetera
FAO	Food and Agricultural Organization
g	Gram
h	Hours
J.	Journal
kg ha^{-1}	Kilograms per hector
t ha^{-1}	Ton per hector
kg	kilogram
m	Meter
m^2	square meter
MOA	Ministry of Agriculture
MSE	Mean square of the error
No.	Number
ppm	parts per million
RCBD	randomized complete block design
Rep.	replication
Res.	research
SAU	Sher-e-Bangla Agricultural University
Sc.	Science
SE	Standard Error
Univ.	University
var.	Variety