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

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

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CERTIFICATE

This is to certify that the thesis entitled **'EFFECT OF PHOSPHORUS AND BORON ON THE GROWTH AND YIELD OF MUNGBEAN'** 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 **SAMI ULLAH**, Reg. no. **12-05095** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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

Abstract

The research work was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka during the Rabi season of November, 2019 to March, 2020 to study the effects of phosphorus (P) and boron (B) on the growth and yield of mungbean. Two factor experiments with Randomized Complete Block Design (RCBD) was followed with 9 treatments ($P_0B_{0,}$ $P_1B_{0,}$ $P_0B_{1,}$ $P_0B_{2,}$ $P_2B_{0,}$ $P_1B_{1,}$ $P_1B_{2,}$ P_2B_1 and P_2B_2 where P_0: 0 kg P ha^{-1}, P_1: 25 kg P ha^{-1}, P_2: 50 kg P ha^{-1}, B_0: 0 kg B ha^{-1}, B_1: 1.5 kg B ha^{-1} and B_2: 3 kg B ha^{-1}) and replicated thrice. All of the growth and yield parameters of mungbean was significantly affected and increased with increasing levels of P and B. The tallest plant (66.63 cm), maximum number of leaves $plant^{-1}$ (13.87), number of branches $plant^{-1}$ (2.53), number of pods $plant^{-1}$ (9.21), pod length (13.67 cm) , number of seeds pod^{-1} (12.80) were found in P_2B_2 treatment combination and all the results were statistically similar with P_1B_1 treatment. the interaction effect of P_2B_2 treatment results the hiegest weight of l000-seed (41.02 g), the highest seed yield (1.26 t ha^{-1}) and the maximum stover yield (2.33 t ha^{-1}) those were statistically similar with P_1B_1 treatment. The results of this research work indicated that the plants performed better in P_2B_2 treatment over the control treatment (P_0B_0) and it was also observed that statistically similar results were found in P_1B_1 treatment and cost effective as well. So, It can be therefore, concluded from the above study that the treatment P_1B_1 (P@25 kg ha^{-1} and B @ 1.5 kg ha^{-1}) was found to the most suitable treatment combination for the higher yield of mungbean in shallow Red Brown Terrace Soils of Bangladesh.

TABLE OF CONTENT

TABLE OF CONTENT

TABLE OF CONTENT

TABLE OF CONTENT

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The mungbean, *Vigna radiata* (L.) Wilczek has been grown in India since ancient times. It is also referred to as green gram, golden gram and chop Soybean. Mungbeans are grown widely for use as a human food (as dry beans or fresh sprouts), but can be used as a green manure crop and as forage for livestock. It is native to the Indian subcontinent and mainly cultivated in India, China, Thailand, Philippines, Indonesia, Myanmar, Bangladesh, Laos and Cambodia but also in hot and dry regions of Europe and the United States.

In Bangladesh, daily consumption of pulses is only 14.30 g capita^{-1} day^{-1} (BBS, 2018), while the World Health Organization (WHO) suggested 45g capita^{-1} day^{-1} for a balanced diet. Due to shortage of production 291 thousand metric tons pulses was imported in Bangladesh in 2006-07 fiscal years (BBS, 2010). Though total pulse production in Bangladesh is 231 thousand metric tons (BBS, 2011), but to provide the above mentioned requirement of 45g capita^{-l} day^{-1} , the production has to be increased even more than three folds. Mungbean has good digestibility and flavor. It contains 24-25% protein, 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.

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^{0}C (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).

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 t ha^{-1} (Ramakrishna *et al.,* 2000).

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 BARI mung -6, BARI mung -5.

Phosphorous deficiency has been aggravated in Bangladesh soils due to increase in cropping intensity. P has lost due to leaching loss, and absorbed at different layer of soil. According to Tandon (1995),as the concentration of available P in the soil solution is normally insufficient to support the plant growth, continual replacement of soluble P from inorganic and organic sources is necessary to meet the P requirements of crop (Tisdale *et al*., 2010). Additional application of P is Increase nodule formation which increases nitrogen fixation and finally productivity of mungbean. It plays an important role in virtually all major metabolic processes in plant including photosynthesis, energy transfer, signal transduction, macromolecular biosynthesis and respiration. P, the master key element is known to be involved in a plethora of functions in the plant growth and metabolism. The cellular machinery is difficult to be imagined without phosphorus being involved in its metabolic continuity and even perpetuation. Such key functions include cell division and development, photosynthesis, breakdown of sugars, energy transfer, nutrient transfer within the plant and expression. The P is present at levels of 400-1200 mg kg^{-1} of soil (Begon *et al*., 1990). Its deficiency is the most important single factor, which is responsible for poor yield of mungbean in all types of soil. It is a indispensable constituent of nucleic acid, ADP and ATP. Nitrogen and phosphorus alone or in combination play a remarkable role in increasing yield and improving the quality of mungbean. P plays a vital role in the formation and translocation of carbohydrates, root development, crop maturation and resistance to disease pathogens. Thus, increase the mungbean yield and improves its quality (Arya and Kalara, 1988). P is needed in relatively large amounts by legumes for growth and nitrogen fixation and has been reported to promote leaf area, biomass, yield, nodule number, nodule mass, etc., in a number of legumes (Pacovsky, *et al.,* 1986). P deficiency can limit nodulation by legumes and P fertilizer application can overcome the deficiency (Carsky *et al.,* 2001). Large amount of P applied as fertilizer enters into the immobile pools through precipitation reaction with highly reactive aluminium (Al^{+}) and iron (Fe^{3+}) in acidic and calcium (Ca^{2+}) in calcareous or normal soils (Gyaneshwar *et al.,* 2002 and Hao *et al.,* 2002). Efficiency of P fertilizer throughout the world is around 10-25 percent. In addition to major nutrients use of micronutrient is also important and required for higher productivity of pulses. Among the micronutrients, boron deficiency in plant is second after zinc and about 33 percent of soil samples tested was found deficient in boron. Primary role concerned with Ca metabolism, keeps Ca in soluble form within the cell and act as a regulator of K/Ca ratio, constituent of cell membrane and essential for cell division. It is also primarily needed to maintain the growth of apical growing point.

Among the various factors responsible for maximizing the yield of mungbean, P levels and frequency of B levels is most important. It is essential that mungbean should not suffer due to inadequate mineral especially P. Since chemical fertilizers are scare and costly. It is necessary to use them economically in combination with P and B, as mungbean shows high response to high phosphorus levels and frequency of B levels.

Therefore, keeping the above facts in view, the present investigation on effects of differen P levels and frequency of boron levels on growth and yield of mungbean during the Rabi season of 2019, with the following objectives:

Objectives:

1. To evaluate the response of mungbean to Phosphorus and Boron
2. To investigate the interaction effects of P and B on the growth and yield of mungbean
3. To find out the optimum doses of phosphorus and boron for maximizing the yield of mungbean

CHAPTER II

REVIEW OF LITERATURE

Nutrient deficiency in soil is the key factor for poor productivity of mungbean. The extent and magnitude of nutrient deficiency has aggravated in the recent past due to intensive agriculture and indiscriminate use of plant nutrients (Anonymous, 2009). Although many research works on mungbean have been performed extensively in several countries in the world, 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. A very few studies related to yield and development of mungbean have been carried out in our country as well as many other countries of the world, which is not adequate and conclusive. In this chapter, an attempt has been made to review the available information at home and abroad regarding the effect of P and B on the yield of mungbean and other legumes.

2.1 EFFECTS OF PHOSPHORUS ON GROWTH AND YIELD OF MUNGBEAN

Tickoo *et al.* (2006) carried out an experiment on mungbean with the cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30.0 m spacing and was supplied with 36-46 kg 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-^{1}) respectively compared to cv. Pusa 105. Nitrogen and P 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 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.

Malik *et al.* (2006) conducted a field experiment in Faisalabad, Pakistan in 2000 and 2001 to evaluate the interactive effects of irrigation and P 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. P application at 40 kg P 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 greengram can be successfully grown with P at 40 kg P ha^{-1}.

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 P 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. P application resulted in significant increase in N and P content and their uptake.

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 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.

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 greengram cv. AAU-34. The highest number of branches plant-1 (3.23) was obtained with 30 kg MRP + 30 kg SSP ha^{-1}. Single super phosphate at 60 kg/ha gave the highest number of clusters plant-1 (4.36). Pod length (7.34 cm), seeds pod-1 (10.5). 1000 seed weight (34.9 g) and seed yield (1.51 t ha^{-1}). Maximum plant height (31.2 cm), dry matter plant-1 (36.1 g) and number of pods plant-1 (l 7.4) was obtained with 60 kg DAP ha^{-1} .

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.

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 P 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 ha^{-1}.

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^{-1}. The increase in phosphorus levels decreased the days to flowering and increased the branches plant^{-1}, number of pods plant^{-1}, 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^{-1} yield in the control. However, the most economical phosphorus level was 40 kg ha^{-1} , because it produced a grain yield statistically comparable to 100 kg P ha^{-1}.

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25, and 50 kg N ha^{-1}) and phosphorus (0, 50, 75 and 100 kg P 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 (1.1ton 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. P level of 35 kg ha^{-1} produced the maximum grain yield.

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 ha^{-1}). 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.

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}, P kg 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}).

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 mungbean 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.

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.

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.

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).

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.

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 seeds per weight and grain yields were also increased significantly by application of phosphorus along with nitrogen.

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 nonsignificant. Increasing potassium levels significantly increased potassium uptake. Available K in soil after K harvest of crop increased with increasing levels of K.

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 $P_2O_5ha^{-1}$.

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).

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.

2.2 EFFECTS OF BORON ON THE GROWTH AND YIELD OF MUNGBEAN

El-Yazied and Mady (2012) study the effect of separate and combined foliar applications of B (0, 25 and 50 ppm) and yeast extracts (0, 2.5 and 5 ml/L) on growth, yield and some biochemical constituents. The results revealed that, foliar application with boron and yeast extract either individually or in a mixture, significantly stimulate many growth aspects as number of leaves per plant, dry weights of both stems and leaves per plant, total leaf area and absolute growth rate as compared with the control treatment. In addition, foliar spraying with boron at 50 ppm and yeast extract at 5 ml L^{-1} increased photosynthetic pigments, NPK, B, total sugars, total free amino acids and crude protein content in leaves at 70 and 85 days after sowing. Moreover, boron and yeast extract treatments not only increased auxins and cytokinins but also decreased abscissic acid at 75 days after sowing during second season. All treatments not only increased number of formed flowers, setted pods per plant, green pod and dry seed yields, as well as satisfactory effect upon shedding percentage, i.e. reduced it. Hence, it could be recommended that foliar spraying with boron at 50 ppm and yeast extract at 57 ml L^{-1} can be used to increase the final green pods and seed yield as well as seed quality of broad bean plants.

Arora *et al.* (2012) examined the optimum concentration of boron needed to mitigate the harmful effect of salinity at early establishment of seedlings including seed germination. The decrease was reverted with specific optimal concentration of B (3X10-3 Mm) and based on maximum germination percentage.

However, Patil *et al.* (2012) studied the individual and combined effects of boron and salinity on soybean seed germination. The result revealed that the treatments of both NaCl and boron (5 ppm) delayed the germination .However higher concentration (50 and 100 ppm) of boron was found to be enhanced germination percentage over control by 10%. The combination of boron with NaCl specially 5 and 100 ppm Boron with 100 Mm NaCl) effectively mitigate the adverse effects of

NaCl on germination of soybean seeds. In addition to it 50 mM NaCl concentration was found to be reduced the delayed effects of 5 ppm boron on germination.

Singh *et al*. (2012) reported Influence of boron on yield attributes of soybean. There were 25 treatment combinations consisting of five rates of B (0, 0.5, 1.0, 2.0 and 4.0 kg B ha^{-1}). The results of the experiments revealed that application of 2.0 kg ha^{-1} recorded better yield attributes (branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1} and 100 seed weight and higher yield than the other treatments. Seidel and Basso (2012) also evaluated the effects of boron applied to leaf spraying at different stages of soybean, on yield components and productivity of soybean. Results showed that application of B did not influence soybean yield in any application stage and the yield components (pod number $plant^{-1}$, grain number pod^{-1}, grain weight) did not differ significantly with application to leaf spraying of B, probably due to their adequate content in soil and water availability during the growing season.

Devi *et al.* (2012) evaluate the effects of foliar application of borax @ 0.1% solution on cabbage [Bassica oleracea (L.) var. capitata]. The growth in terms of plant height, leaf numbers, leaf length and fresh biomass production was affected by the boron levels. The foliar spray was done twice at 25 and 50 days after transplanting showed significant increase in plant height, number of leaves, shoot fresh weight, dry weight, root fresh weight and dry weight and yield. The head diameter was increased with application of borax.

Chaturvedi *et al.* (2012) reported that soybean yield attributed viz., pods/plant, seeds/pod and hundred seed weight were increased significantly by the addition of boron and FYM at the fertility levels of 50% and 100% NPK. However, Devi *et al.* (2012) study the effect of boron fertilization on yield of soybean at five levels of boron (0, 0.5, 1.0, 1.5 and 2.0 kg boron ha^{-1}). The study revealed that number of branches per plant; pods per plant and 100 seed weight were increased with the application of boron as compare to control. The overall result revealed that application of 1.5 kg B ha^{-1} were found to be the optimum levels of boron for obtaining maximum yield attributes.

Saxena and Nainwal (2010) evaluate the response of boron nutrition on yield attributes in kharif seasons of 2007 and 2008 with five levels of boron (0, 0.5, 1.0, 1.5 and 2.0 kg B/ha). The effect of different doses of boron application on seed yield was significant. On mean performance basis, the application of 2.0 kg B per ha gave maximum yield.

Crak *et al.* (2006) examined the effect of soil and foliar application of boron (66.14% B2O3) at different rates (0, 0.5, 1, 1.5 and 2 kg ha^{-1}) on plant height, first pod height, pod $plant^{-1}$, boron content of seed, germination rate, 1000-seed weight of soybean during 2002-03. They reported that increasing boron rates applied either as soil or foliar improved yield (40%), first pod height (17%), boron content of seed (42%), germination rate (11%) and 1000-seed weight (5%) of soybean. For maximum yield, 1.09 kg ha^{-1} rate of boron was recommended).

Rajni and Meitei (2004) determine the effect of foliar spraying of B (0.5 and 1.0 ppm) and Zn (0.01 and 0.10 ppm) and their combinations with a control. They found that combined application of B (1.0 ppm) and Zn(0.10 ppm) after 20 and 40 days of sowing of the seeds was found to be beneficial for growth in terms of plant height, leaf number, branch number and shoot weight, earliness, yield in terms of number, length, fresh weight, dry weight and percent dry matter of pod and number of seeds per pod.

2.3 INTERACTION EFFECTS OF BORON AND PHOSPHORUS ON GROWTH AND YIELD OF MUNGBEAN

A field experiment was conducted by Hamza *et al.* (2015) at the Agronomy Field Laboratory, Bangladesh Agricultural University to examine the growth and yield response of mungbean as influenced by P and B application. There were sixteen treatment combinations comprising four levels of phosphorus (0, 20, 40 and 60 kg ha^{-1}) and boron (0, 1.0, 1.5 and 2.0 kg ha^{-1}) and one control. Interaction effect of phosphorus and boron was significant in respect of plant height. However, the tallest plant (86.03 cm) was found from the plant treated with 60 kg P ha^{-1} × 1.0 kg B ha^{-1} followed by 60 kg P ha^{-1} × 1.5 kg B ha^{-1}, 40 kg P ha^{-1} × 1.5 kg B ha^{-1}, 60 kg P ha^{-1}× 2.0 kg B ha^{-1} while the shortest plant (60.91 cm) was obtained from control plot. This might be due to the lack of phosphorus and boron in soil which reduced the cell division, carbohydrate and protein synthesis and also lowers the normal activities of the cambium tissue. They also found that the interaction effect of phosphorus and boron on seed yield was highly significant. The highest seed yield (1.25 t ha^{-1}) was observed when the fertilizer combination was 40 kg P ha^{-1} × 1.5 kg B ha^{-1}. The lowest seed yield (0.95 t ha^{-1}) was obtained from control plot.

Ram *et al.* (2017) conducted a field experiment on greengram. The treatment combination was T1 = N1 (20:40:20 NPK), T2 = N1 (20:40:20 NPK) +20 DAS (0.2% foliar spray of borax) T3 = N1 (20:40:20 NPK)+35DAS (0.2% foliar spray of borax) T4 N1 (20:40:20 NPK)+20 and 35 DAS (0.2% foliar spray of borax) T5 = N2 (20:50:20 NPK) T6 = N2 (20:50:20 NPK)+20 DAS (0.2% foliar spray of borax) T7 = N2 (20:50:20 NPK)+35 DAS (0.2% foliar spray of borax) T8 N2 (20:50:20 NPK) +20 and 35 DAS (0.2% foliar spray of borax) T9 = N3 (20:60:20 NPK) T10 = N3 (20:60:20NPK) + 20DAS (0.2% foliar spray of borax) T11 = N3 (20:60:20NPK) + 35 DAS(0.2% foliar spray of borax) T12 = N3 (20:60:20NPK) + 20 and 35 DAS (0.2% foliar spray of borax). They observed that there was a steady increase in the plant height from 15 to 60 DAS. At 45, 60 DAS significant influence was observed in plant height due to different treatments; while at 15 and 30 DAS the effects of the treatments were non significant. At 45 DAS, there was significant difference between the treatments and maximum plant height (47.46 cm), number of pods (42.46 plant^{-1}) and grain yield (1.62 t ha^{-1}) was observed by the application of T11 i.e., N3 (20:60:20 NPK) +(0.2% foliar spray of borax).

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 along with statistical analysis.

3.1 Soil description of experimented area

The Research work was done to study the effects of phosphorus and boron fertilization on growth, yield and yield contributing characters of mungbean at Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during Rabi Season 2019-2020. The experimental location situated at $23^{0}77$ N and $90^{0}33$ E longitude with an elevation of 1 meter from sea level.

3.2 Description of soil

Soil of the experimented field belongs to the Tejgaon series under the Agro ecological Zone, AEZ-28 (Madhupur Tract). In this series soil types are in general is shallow deep Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was oven-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical parameters. The morphological characteristics of the experimental field and initial physical and chemical characteristics of the soil are presented in Table 3.1, 3.2 and 3.3 respectively.

Table 3.1 Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University
AEZ No. and name	AEZ-28, Madhupur Tract
General soil type	Shallow Red Brown Terrace Soil
Soil series	Tejgaon
Topography	Fairly leveled
Depth of inundation	Above flood level
Drainage condition	Well drained
Land type	Medium high land

Table 3.2 Physical characteristics of the initial soil of the experimental field

%Sand(2-0.02 mm)	33.13
%Silt(0.02-0.002 mm)	32.77
%Clay(<0.002 mm)	34.10
Textural Class	Clay Loam
Particle density	2.45 g cc^{-1}

Table 3.3 Chemical characteristics of the initial soil of the experimental field

pH	**6.18**
Organic Matter(%)	1.18
Organic Carbon (%)	0.71
Total N(%)	0.063
Available P (ppm)	16
Exchangeable K (ppm)	12.15
Available S (ppm)	10.85

3.3 Climate

The experimental area has sub-tropical climate characterized by medium temperature, medium rainfall during November, 2019 to March, 2020 and scanty rainfall during rest of the year. The annual precipitation of the site is 2052 mm and potential evapotranspiration is 1286 mm, the average maximum temperature is 26-32^{0}C, average minimum temperature is 12.4^{0}C and the average mean temperature is 28.12^{0}C (BBS, 2019).

3.4 Description of mungbean variety

BARI Mung-6, a high yielding variety of mungbean was released by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur in 2003. It is photo insensitive, short lifespan, 55 to 58 days require to mature and bold seeded crop. The special characteristic of this variety is it is almost synchronized maturity. It was developed from the NM-92 line introduced by AVRDC in 1992. Its yield potentiality is about 1.5 to 1.7 t ha^{-1}. This variety is resistant to yellow mosaic virus diseases, insects and pest attack (BARI, 2008).

3.5 Preparation of the field

The selected plot for the experimental plot was opened by power tiller driven rotovator on the 26 November, 2019. Afterwards several times the land was ploughed and cross-ploughed 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 (Fig 1).

3.6 Treatments

Fertilizer treatment consisted of 3 levels of P (0, 25 and 50 kg P ha^{-1}) and B (0, 1.5 and 3 kg B ha^{-1}) designed as RCBD. The following treatments will be comprised for the experiment.

Rate of Phosphorus:

P_0: 0 kg P ha^{-1}

P_1: 25 kg P ha^{-1}

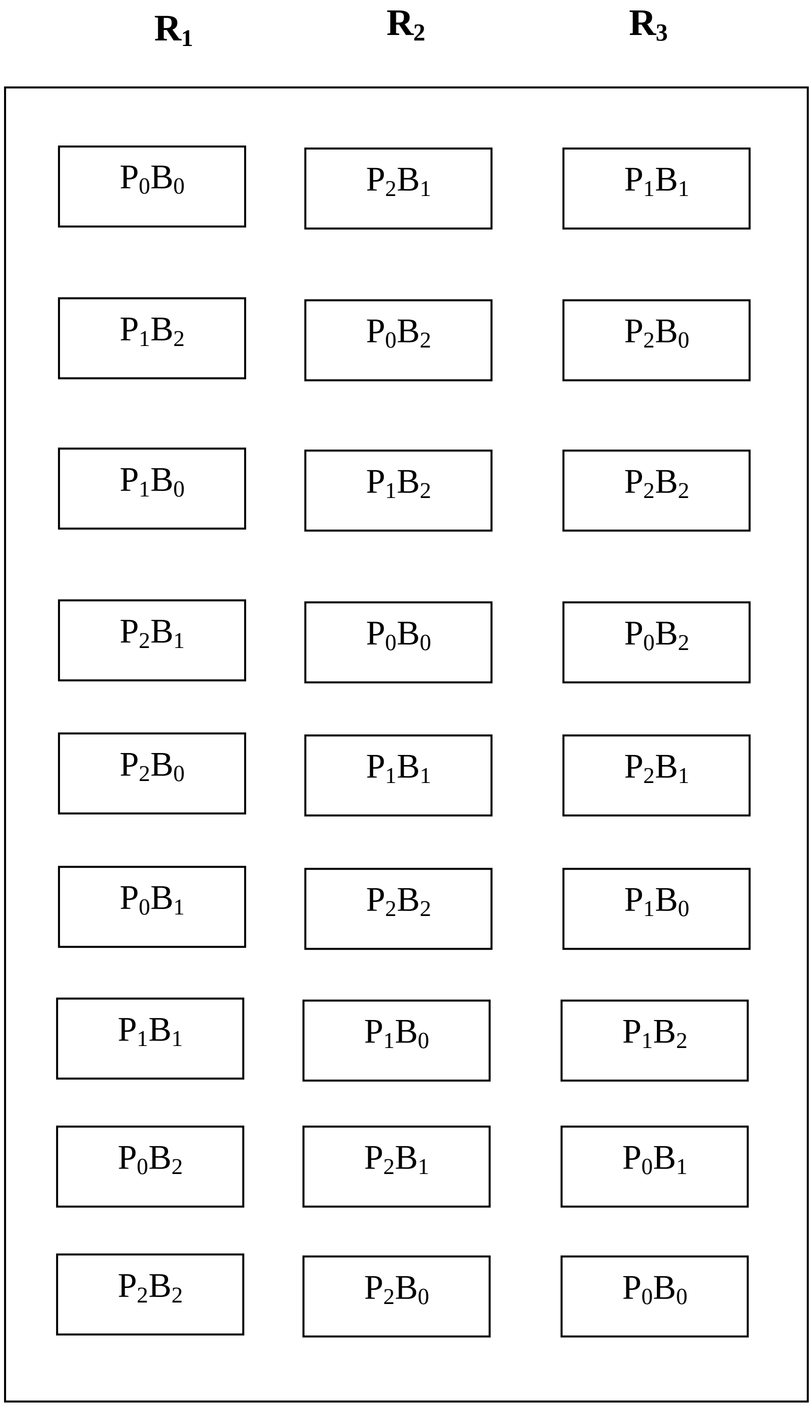
P_2: 50 kg P ha^{-1}

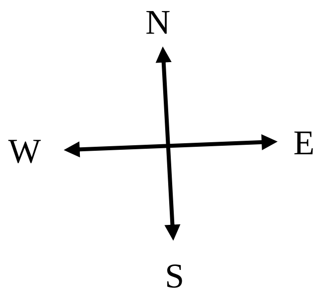
Rate of Boron:

B_0: 0 kg B ha^{-1}

B_1: 1.5 kg B ha^{-1}

B_2: 3 kg B ha^{-1}





Each Plot Area: 3 m x 1.5 m = 4.5 m^2

Plot to Plot Distance: 1 m

Plot distance from border: 0.50 m

Length of field: 10 m

Breadth of field: 12 m

Figure 1: Layout of experimental plot

3.7 Application of fertilizers:

Recommended doses of N, K and Zn (40 kg N from Urea, 20 kg K ha^{-1} from MoP, 2 kg Zn ha^{-1} from ZnSO4, respectively) were applied. The required amounts of TSP (as per treatment), Boric acid (as per treatment) and half of the recommended dose of urea fertilizer were applied as basal dose during final land preparation. The remaining half of urea was top dressed after 22 days of germination.

3.8 Seed sowing

Seeds of BARI Mung-6 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Seeds were sown in the main field on the 27^{th} November, 2019 having line to line distance of 30 cm and plant to plant distance of 10 cm.

3.9 Weeding and thinning

Weeds of different types were controlled manually and removed from the field. The weeding and thinning were done after 25 days after sowing, on December 23, 2019. Care was taken to maintain constant plant population (100-110 plants) per plot.

3.10 Pest Management

To rescue the plant from the infested Cutworm at the seedling stage application of Dursban-25EC @ 2.5ml Litr-^{1} was done twice on December 12 and 27, 2019. Special care was taken to protect the crop from birds especially after sowing and germination stages.

3.11 Harvesting

The crop was harvested at maturity on 2nd March, 2020. The harvested crop of each individual plot was bundled separately. Grain and straw yields were recorded plot wise and the yields were expressed in ton ha^{-1}.

3.12 Collection of sample

Samples were collected from different places of each plot. 10 plants from each plot were selected as samples.

3.13 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.14 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.15 Collection of data

Ten (10) plants from each plot were selected at 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:

Plant height (cm)

Number of leaves plant^{-1}

Number of primary branches plant^{-1}

Number of pods plant^{-1}

Pod length plant^{-1} (cm)

Number of seeds pod^{-1}

1000 - seeds weight (g)

Grain yield (t ha^{-1})

Stover yield (t ha^{-1})

Biological yield

3.15.1 Plant height

The plant height was measured from the ground level to the top of the plant. 10 plants were selected randomly from each plot at harvesting stage. Plant height was measured and averaged.

3.15.2 Number of leaves plant^{-1}

Numbers of leaves were counted at harvesting stage. 10 plants were selected randomly from each plot and number of leaves were counted and averaged.

3.15.3 Number of primary branches plant^{-1}

10 plants were selected randomly from each plot at harvesting stage. Number of primary branches were counted and averaged.

3.15.4 Number of pods plant^{-1}

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

3.15.5 Length of pods plant^{-1}

10 plants were selected randomly from each plot. 10 pods were selected from each plant. Pod length were measured and averaged.

3.15.6 Number of seeds pod $^{-1}$

It was done after harvesting. 10 plants were selected randomly from each plot. At first, number of seeds plant^{-1} were counted and averaged. Then it was multiplied with number of pods plant^{-1} and averaged.

3.15.7 1000 seeds weight

Hundred seeds of mungbean were counted randomly and then weighed plot wise. Then calculated the weight of 1000 seeds.

3.15.8 Seed yield

Seeds obtained from 1m^2 area from the center of each unit plot was dried, weighed carefully and then converted into t ha-^{1}.

3.15.9 Stover yield

Stover remained after collection of seed (1m^2 of each individual plot) was dried, weighed carefully and the yield was expressed in t ha^{-1}.

3.15.10 Biological yield (t ha^{-1})

The summation of seed yield and above ground Stover yield was the biological yield.

Biological yield = Seed yield + Stover
yield.

3.16 Chemical analysis of the soil samples

The soil samples were collected before sowing of seeds were digested with conc. HNO_3 and $HClO_4$ mixture for the determination of N, P, K and S.

a) Phosphorous

Phosphorous in the digest was determined by ascorbic acid blue color method (Murphy and Riley, 1962) with the help of a Spectrophotometer (LKB Novaspec, 4049)..

b) Sulphur

Sulphur content in the digest was determined by turbid metric method as described by Hunt (1980) using a Spectrophotometer (LKB Novaspec, 4049)

c) Nitrogen

Plant samples were digested with 30% H_2O_2, cone. H_2SO_4 and a catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Selenium powder in the ratio 100: 10: 1, respectively) for the determination of total nitrogen by Micro-Kjeldal method. Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01N H_2SO_4 (Jackson. 1973).

d) Soil pH

Soil pH was determined by pH meter.

3.17 Statistical analysis

The data obtained from the experiment were analyzed statistically to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the differences among pairs of treatments was estimated by the least significant difference (LSD) test at *5%* and 1% level of probability and DMRT was calculated in statistix 10.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted at Sher-e-Bangla Agricultural University farm to determine the effects of P and B on growth, yield and yield contributing characters of mungbean. Data on different yield contributing characters and yield were recorded to find out the optimum levels of phosphorus and boron fertilization on mungbean. The results have been presented and discussed and possible interpretations have been given under the following headings:

4.1 Plant height

4.1.1 Effect of Phosphorus on the plant height of mungbean

Different phosphorus levels showed significant variation on plant height of mungbean (Table 4.1). Significant variation was observed on the plant height of mungbean when the field was fertilized with 3 levels of P dose (eg. 0, 25, 50 kg P ha^{-1}). Among the different doses of phosphorus, P_2 showed the highest plant height (82.18 cm) at harvesting period. On the other hand, the lowest plant height (58.61 cm) was observed in the P_0 treatment where phosphorus was not applied. This might be due to the lack of phosphorus in soil which reduced the cell division, carbohydrate and protein synthesis and also lowers the normal activities of the cambium tissue

4.1.2 Effect of Boron on the plant height of mungbean

A significant variation was observed on mungbean in respect of plant height when boron fertilizers in different doses were applied (Table 4.2). Among the different fertilizer doses, B_2 showed the highest plant height (61.60 cm), which was statistically similar with B_1 treatment. On the contrary, the lowest plant height (56.28 cm) was observed in the treatment where no boron fertilizer was applied. The crop of the control plot suffered from B deficiency

4.1.3 Interaction effects of Phosphorus and Boron on the plant height of mungbean

Combined application of different doses of phosphrus and boron fertilizers had significant effect on the plant height of mungbean (Table 4.3). The lowest plant height (55.11 cm) was observed in the treatment combination of P_0B_0. On the other hand, the highest plant height (66.63 cm) was recorded with P_2B_2 treatment which was statistically similar with P_2B_1 (61.78 cm), P_1B_1 (60.63 cm), P_1B_2 (58.55 cm), P_2B_0 (57.68 cm) and P_1B_0 (57.41 cm) treatments. The plant height was increased with the increasing dose of P and B fertilizers. This might be due to higher availability of P and B and their uptake that progressively enhanced the vegetative growth of the plant.

4.2 Number of leaves plant^{-1}

4.2.1 Effect of Phosphorus on the number of leaves plant^{-1} of mungbean

In Table 4.1, maximum number of leaves plant^{-1} (13.76 cm) was observed in P_2 treatment which was statistically similar with P_1 (13.26 cm) treatment. The lowest number of leaves plant^{-1} (8.87 cm) was recorded in the P_0 (control) treatment. From Table 4.1 it is shown that increased dose of P application results increased number of leaves plant^{-1}.

4.2.2 Effect of Boron on the number of leaves plant^{-1} of mungbean

A significant variation was observed due to the application of different level of boron (table 4.2). The maximum number of leaves per plant (11.87) was recorded in B_2 which was statistically similar with B_1 (11.73) treatments. It was also observed that the minimum number of leaves per plant (9.42) was recorded where no boron (B_0) was applied.

4.2.3 Interaction effects of Phosphorus and Boron on the number of leaves plant^{-1} of mungbean

The combined application of different doses of phosphorus and boron fertilizers on the number of leaves plant $^{-1}$ of mungbean results significant variation (Table 4.3). The highest number of leaves plant^{-1} (13.87) was recorded with the treatment combination of P_2B_2 which was statistically similar with P_2B_1 (13.47), P_1B_1 (12.13) and P_1B_2 (11.90) treatment. The lowest number of leaves plant^{-1} (7.84) was observed in control (P_0B_0). It was also observed (Table 4.3) that the increasing dose of P and B combination treatment results increasing the number of leaves plant^{-1} of mungbean.

4.3 Number of branch plant^{-1}

4.3.1 Effect of Phosphorus on the number of branch plant^{-1} of mungbean

Application of different doses of phoshporus fertilizer showed significant variations in respect of number of branches plant^{-1} (Table 4.1). Among the different doses of P, P_2 showed the highest number of branches plant^{-1} (2.36) which was statistically similar (1.69) with P_1 treatment.

4.3.2 Effect of Boron on the number of branch plant^{-1} of mungbean

A Significant variation was observed in the number of branches plant^{-1} of mungbean when three levels of boron (0,1.5 and 3 kg B ha^{-1}) were applied (Table 4.2). The highest number of branches plant^{-1}(2.09) was recorded in B_2 treatment which was statistically similar with B_1 treatment.

4.3.3 Interaction Effects of Phosphorus and Boron on the number of branch plant^{-1} of mungbean

The combined effect in a view of combined application of different doses of phosphorus and boron fertilizers on the number of branches plant^{-1} of mungbean was significant which was recorded in table 4.3. The maximum number of branches plant^{-1} (2.53) was recorded with the treatment combination of P_2B_2. Which was statistically similar with P_2B_1 (2.51), P_1B_1 (2.27), P_1B_2 (2.01) and P_2B_0 (2.00) treatment. On the other hand, the lowest number of branches plant^{-1}(1.27) was found in P_0B_0 treatment (control treatment). High level of P in the soil helps the uptake of other nutrients, which ultimately produces healthy plant with the maximum productive branches of the crop. Lack of P results in low rate of plant growth and plant branching.

Table 4.1: Effect of Phosphorus on the plant height, number of leaves plant^{-1} and number of branch plant^{-1} of mungbean

Treatment	Plant height (cm.)	Number of leaves plant^{-1}	Number of branch plant^{-1}
P_0	58.61^{c}	8.87^{b}	1.20^{b}
P_1	73.08^{b}	13.76^{a}	1.69^{a}
P_2	82.18^{a}	13.76^{a}	2.36^{a}
$LSD_{0.05}$	5.89	0.70	0.67
CV(%)	19.70	24.52	22.70

Table 4.2: Effect of Boron on the plant height, number of leaves plant^{-1} and number of branch plant^{-1} of mungbean

Treatment	Plant height (cm.)	Number of leaves plant^{-1}	Number of branch plant^{-1}
B_0	56.28^{b}	9.42^{b}	1.24^{b}
B_1	58.86^{a}	11.73^{a}	2.07^{a}
B_2	61.60^{a}	11.87^{a}	2.29^{a}
$LSD_{0.05}$	4.99	0.79	0.93
CV(%)	19.70	24.52	22.70

Table 4.3: Effect of Phosphorus and Boron on the plant height, number of leaves plant^{-1} and number of branch plant^{-1} of mungbean

Treatment	Plant height (cm.)	Number of leaves plant^{-1}	Number of branch plant^{-1}
P_0B_0	55.11^{b}	7.84^{d}	1.27^{d}
P_0B_1	56.05^{b}	9.20^{cd}	1.45^{cd}
P_0B_2	56.39^{b}	9.87^{c}	1.60^{b-d}
P_1B_0	57.41^{ab}	10.20^{bc}	1.93^{bc}
P_1B_1	58.55^{ab}	11.90^{ab}	2.01^{ab}
P_1B_2	60.63^{ab}	12.13^{ab}	2.27^{a}
P_2B_0	57.68^{ab}	10.33^{bc}	2.00^{a-c}
P_2B_1	61.78^{ab}	13.47^{a}	2.51^{a}
P_2B_2	66.63^{a}	13.87^{a}	2.53^{a}
$LSD_{0.05}$	9.61	1.97	0.55
CV(%)	19.70	24.52	22.70

4.4 Number of pods plant^{-1}

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

A significant variation in respect of number pods plant^{-1} (Table 4.4) was observed due to different doses of phosphorus fertilizer application. From Table 4.4, it is observed that P_2 showed the highest number of pods plant^{-1} (9.14) which was statistically similar (8.52) with P_1 treatment. On the contrary, the lowest number of pods plant^{-1} (7.96) was observed with P_0 (control).

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

A significant variation was observed due to different doses of boron fertilizer application in respect of pods plant^{-1} of mungbean (Table 4.5). The highest number of pods plant^{-1} (8.71) was recorded in B_2 which was statistically similar (8.44) with B_1 treatment. The lowest number of pods plant^{-1} (7.98) was recorded in the B_0 treatment where no boron was applied. This result might be due to B helps in flower and pollen grain formation.

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

The combined application of different doses of phosphorus and boron results significant variations 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 4.6). The highest number of pods plant^{-1} (9.21) was recorded with the treatment combination of P_2B_2 which was statistically similar with P_2B_1 (9.19) and P_1B_2 (9.01) treatment. On the other hand, the lowest number of pods plant^{-1} (8.05) was found in P_0B_0 treatment.

4.5 Number of seeds pod^{-1}

4.5.1 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 4.4). The maximum number of seeds pod^{-1} (12.33) was recorded in P_2 treatment which was statistically similar (11.53) with P_1 treatment. The lowest number of seeds pod^{-1} (10.89) was recorded in the P_0 (control) treatment. It might be due to insufficiency of P nutrient which ultimately lowered the nutrient uptake and hampers the growth and development of mungbean.

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

Different doses of nitrogen fertilizers showed significant variations in respect of seed pod^{-1} (Table 4.5). Among the different doses of fertilizer, B_2 showed the highest number of seeds pod^{-1} (12.56) which was statistically similar (11.89) with B_1 treatment. On the other hand, the lowest number of seeds pod^{-1} (10.71) was observed with B_0 where no B fertilizer was applied.

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

A significant variation was observed in respect of the combined effect of different doses of phosphorus and boron fertilizer on number of seeds pod^{-1} of mungbean (Table 4.6). The highest number of seeds pod^{-1} (12.80) was recorded with the treatment combination of P_2B_2 which was statistically similar with P_2B_1(12.47), P_1B_2 (12.34) and P_1B_1 (12.21) treatment. On the other hand, the lowest number of seeds pod^{-1} (10.84) was found in P_0B_0 treatment (control).

4.6 Weight of 1000 seeds

4.6.1 Effect of phosphorus on weight of 1000 seeds (g) of mungbean

A significant variation was observed in respect of weight of 1000 seeds by the application of different levels of phosphorus (Table 4.4). Among the different doses of P fertilizers, P_2 showed the highest weight of 1000 seeds (37.48 g) and it was significant from other treatments. On the contrary, the lowest weight of 1000 seeds (34.81 g) was observed with P_0 (control) where no phosphorus fertilizer was applied.

4.6.2 Effect of boron on the weight of 1000 seeds (g) of mungbean

Different doses of boron fertilizers showed no significant variations in respect of the weight of 1000-seed (Table 4.5). The highest weight of 1000 seeds (36.85 g) was recorded in B_2. The lowest weight of 1000-seed (35.16 g) was recorded in the B_0 treatment where no boron was applied. As B affects cell division, carbohydrate metabolism, sugar and starch formation, which help to increase in size and weight of seed.

4.6.3 Interaction effects of phosphorus and boron on weight of 1000-seed (g) of mungbean

A significant variation was observed on the weight of 1000 seeds of mungbean when different doses of phosphorus and boron were applied (Table 4.6). The highest weight of 1000 seeds (41.02 g) was recorded in P_2B_2, which was statistically similar (39.60 g) with P_2B_1 treatment. The lowest weight of 1000-seed (33.53 g) was recorded in the P_0B_0 treatment where no P and B were applied.

4.7 Pod length

4.7.1 Effect of phosphorus on pod length of mungbean

Application of phosphorus fertilizers at different doses showed significant variation on the pod length of mungbean (Table 4.4). Among the different P fertilizer doses, P_2 showed the highest pod length (11.78 cm) which was statistically similar (10.67 cm) with P_1 treatment. The lowest pod length (9.28 cm) was recorded in the P_0 (control) treatment where no P was applied.

4.7.2 Effect of boron pod length of mungbean

The pod length as affected by different doses of boron showed significant variation (Table 4.5). Among the different doses of B the highest pod length (11.22 cm) was observed in B_2 treatment which was statistically similar (10.54 cm) with B_1 treatment. This may be due to B is essential in cell division which increases pod length. The lowest pod length (9.79 cm) was recorded in the B_0 treatment where no B was applied.

4.7.3 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 4.6). The highest pod length (13.67 cm) was recorded in the treatment combination of P_2B_2 which was statistically similar with P_2B_1 (12.67 cm), P_1B_2 (12.24 cm) and P_1B_1 (12.01cm) treatment combinations. On the other hand, the lowest pod length (9.27 cm) was found in P_0B_0 treatment (control).

Table 4.4: Effect of phosphorus on the number of pods plant^{-1}, number of seeds pod^{-1} , weight of 1000 seeds and length of pod of mungbean

Treatment	Number of Pods Plant^{-1}	Number of Seeds Pod^{-1}	Weight of 1000 seeds (g)	Length of Pod (cm)
P_0	7.96^{b}	10.89^{b}	34.81^{c}	9.28^{b}
P_1	8.52^{a}	11.53^{ab}	36.56^{b}	10.67^{a}
P_2	9.14^{a}	12.33^{a}	37.48^{a}	11.78^{a}
$LSD_{0.05}$	0.84	1.01	1.45	1.27
CV(%)	18.67	16.97	22.92	14.34

Table 4.5: Effect of boron on the number of pods plant^{-1}, number of seeds pod^{-1}, weight of 1000 seeds and length of pod of mungbean

Treatment	Number of Pods Plant^{-1}	Number of Seeds Pod^{-1}	Weight of 1000 seeds (g)	Length of Pod (cm)
B_0	7.98^{b}	10.71^{b}	35.16^{NS}	9.79^{b}
B_1	8.44^{ab}	11.89^{a}	36.11^{NS}	10.54^{a}
B_2	8.71^{a}	12.56^{a}	36.85^{NS}	11.22^{a}
$LSD_{0.05}$	0.53	0.69	2.45	0.71
CV(%)	18.67	16.97	22.92	14.34

Table 4.6: Interaction effects of phosphorus and boron on the number of pods plant^{-1}, number of seeds pod^{-1}, weight of 1000 seeds and length of pod of mungbean

Treatment	Number of Pods Plant^{-1}	Number of Seeds Pod^{-1}	Weight of 1000 seeds (g)	Length of Pod (cm)
P_0B_0	8.05^{f}	10.84^{d}	33.53^{d}	9.27^{c}
P_0B_1	8.64^{e}	11.47^{cd}	33.80^{d}	9.67^{c}
P_0B_2	8.65^{de}	11.89^{bc}	34.24^{cd}	10.67^{bc}
P_1B_0	8.75^{c-e}	12.07^{bc}	34.47^{cd}	11.02^{bc}
P_1B_1	8.86^{bc}	12.21^{ab}	36.27^{b}	12.01^{ab}
P_1B_2	9.01^{ab}	12.34^{ab}	36.70^{b}	12.24^{ab}
P_2B_0	8.83^{b-d}	12.12^{b}	34.73^{cd}	11.60^{b}
P_2B_1	9.19^{a}	12.47^{ab}	39.60^{a}	12.67^{ab}
P_2B_2	9.21^{a}	12.80^{a}	41.02^{a}	13.67^{a}
$LSD_{0.05}$	0.20	0.63	1.51	2.01
CV(%)	18.67	16.97	22.92	14.34

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

4.8.1 Effect of phoshporus on the seed yield of mungbean

Application of different doses of phosphorus fertilizer showed significant variations in respect of seed yield (Table 4.7). Among the different doses of P showed the highest seed yield (1.06 t ha^{-1}) which was statistically similar (0.99 t ha^{-1}) with P_1 treatments. On the other hand, the lowest seed yield (0.83 t ha^{-1}) was observed with P_0, where no phosphorus fertilizer was applied. It might be due to increase levels of P improve seed formation whereas P deficiency develops unhealthy seeds and results lower grain yield.

4.8.2 Effect of boron on seed yield of mungbean

Significant variation was observed in the number of seed yield of mungbean when different doses of boron were applied (Table 4.8). The highest seed yield (1.15 t ha^{-1}) was recorded in B_2 treatment which was statistically similar (0.92) with B_1 treatment. B helps the stigma to become receptive and sticky which increase pollination. As a result fruit setting increases and so as number of seeds per pod.

4.8.3 Interaction effects of phosphorus and boron on the seed yield of mungbean

The interaction effect in respect of combined application of different doses of phosphorus and boron fertilizers on the seed yield of mungbean was significant which was recorded in Table 4.9. The highest seed yield (1.26 t ha^{-1}) was recorded with the treatment combination of P_2B_2which was statistically similar (1.20, 1.13, 1.08, 0.93 t ha^{-1} respectively) with P_2B_1, P_1B_2, P_1B_1 and P_2B_0 treatment. Heigher doses of P might be minimal the effect of B deficiency because both P and B features on grain filling and pollen development. On the other hand, the lowest seed yield (0.60 t ha^{-1}) was found in P_0B_0 treatment (control treatment).

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

4.9.1 Effect of phoshporus on the stover yield of mungbean

Different doses of phosphorus fertilizers showed significant variations in respect of stover yield of mungbean (Table 4.7). Among the different doses of P fertilizers, P_2 Showed the highest stover yield (1.91 t ha^{-1}), which was statistically similar (1.80 t ha^{-1}) with P_1 treatment. On the contrary, the lowest stover yield (1.61 t ha^{-1}) was observed with P_0 (control) treatment.

4.9.2 Effect of boron on the stover yield of mungbean

Significant variation was observed on the stover yield of mungbean when different doses of boron were applied (Table 4.8). The highest stover yield of mungbean (2.14 t ha^{-1}) was recorded in B_2, which was significant from other treatment. The lowest stover yield (1.40 t ha^{-1}) was recorded in the B_0 treatment where no boron was applied.

4.9.3 Interaction effects of phosphorus and boron on stover yield of mungbean

The combined effect of different doses of phosphorus and boron fertilizers on the Stover yield was significant (Table 4.9). The highest Stover yield (2.33 t ha^{-1}) was recorded with the treatment combination of P_2B_2 treatment which was statistically similar (2.20, 2.17 and 2.07 t ha^{-1} respectively) with P_2B_1, P_1B_2 and P_1B_1 treatment. treatment. On the other hand, the lowest Stover yield (1.17 t ha^{-1}) was found in P_0B_0 (control) treatment.

4.10 Biological yield (t ha^{-1}) of mungbean

4.10.1 Effect of phosphorus on the biological yield of mungbean

Application of different doses of phoshporus fertilizer showed significant variations in respect of biological yield (Table 4.7). Among the different doses of phosphorus, P_2 showed the highest biological yield (2.96 t ha^{-1}) which was statistically similar with (2.79 t ha^{-1}) P_1 treatments. On the other hand, the lowest biological yield (2.44 t ha^{-1}) was observed with N_0, where no phoshporus fertilizer was applied.

4.10.2 Effect of boron on the biological yield of mungbean

Different doses of boron fertilizers showed significant variations in respect of biological yield of mungbean (Table 4.8). Among the different doses of boron fertilizers, B_2 Showed the highest biological yield (3.30 t ha^{-1}), which was statistically similar (2.70 t ha^{-1}) with B_1 treatment. On the contrary, the lowest biological yield (2.15 t ha^{-1}) was observed with B_0 (control) treatment.

4.10.3 Interaction effects of phosphorus and boron on the biological yield of mungbean

The interaction effect in respect of combined application of different doses of phosphorus and boron fertilizers on the biological yield of mungbean was significant which was recorded in Table 4.9. The highest biological yield (3.53 t ha^{-1}) was recorded with the treatment combination of P_2B_2. Which was statistically similar (3.41, 3.30, 3.15 and 2.63 t ha^{-1} respectively) with P_2B_1, P_1B_2, P_1B_1 and P_2B_0 treatment. On the other hand, the lowest biological yield (1.77 t ha^{-1}) was found in P_0B_0 treatment (control treatment).

Table 4.7: Effect of Phosphorus on the seed yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield (t ha^{-1}) of mungbean.

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})
P_0	0.83^{b}	1.61^{b}	2.44^{b}
P_1	0.99^{ab}	1.80^{a}	2.79^{ab}
P_2	1.06^{a}	1.91^{a}	2.96^{a}
$LSD_{0.05}$	0.19	0.11	0.41
CV(%)	26.84	28.77	28.04

Table 4.8: Effect of Boron on the seed yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield (t ha^{-1}) of mungbean.

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})
B_0	0.76^{b}	1.40^{c}	2.15^{b}
B_1	0.92^{ab}	1.78^{b}	2.70^{ab}
B_2	1.15^{a}	2.14^{a}	3.30^{a}
$LSD_{0.05}$	0.29	0.27	0.67
CV(%)	26.84	28.77	28.04

Table 4.9: Interaction effects of Phosphorus and Boron on the seed yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield (t ha^{-1}) of mungbean.

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})
P_0B_0	0.60^{d}	1.17^{e}	1.77^{e}
P_0B_1	0.73^{cd}	1.33^{de}	2.07^{de}
P_0B_2	0.77^{cd}	1.50^{c-e}	2.27^{c-e}
P_1B_0	0.80^{cd}	1.50 $^{c-e}$	2.30^{b-e}
P_1B_1	1.08^{a-c}	2.07 $^{a-c}$	3.15^{a-c}
P_1B_2	1.13^{ab}	2.17 ^{ab}	3.30^{ab}
P_2B_0	0.93^{a-d}	1.70 $^{b-e}$	2.63 $^{a-e}$
P_2B_1	1.20^{ab}	2.20 ^{ab}	3.41^{a}
P_2B_2	1.26^{a}	2.33^{a}	3.53^{a}
$LSD_{0.05}$	0.36	0.58	0.97
CV(%)	26.84	28.77	28.04

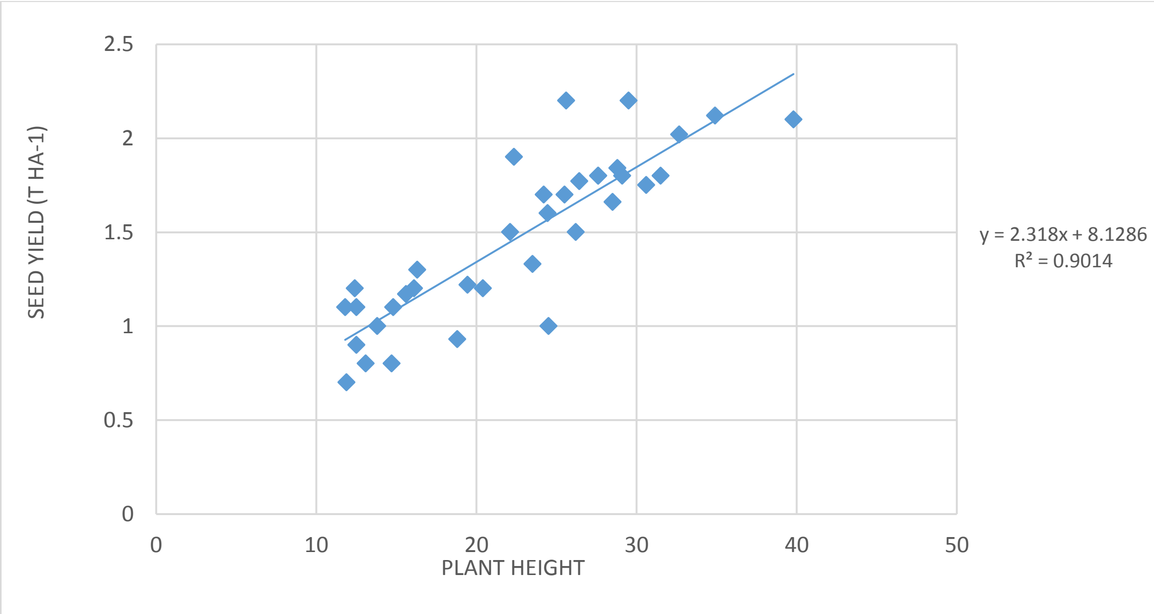


Figure2: Linear relationship between plant height and seed yield of mungbean

Correlation study was done to establish the relationship between the plant height and yield of mungbean. From the study it revealed that highly significant correlation (R^2 = 0. .9014) was observed between the parameters (Figure 2). It was evident from the Figure 2 that the equation y = 2.318x + 8.1286 gave a good fit to the data, and the co-efficient of determination (R^2 = 0. 9014) 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 = 0.9014) correlated with the plant height, i.e., the yield of mungbean increased with the increase of plant height.

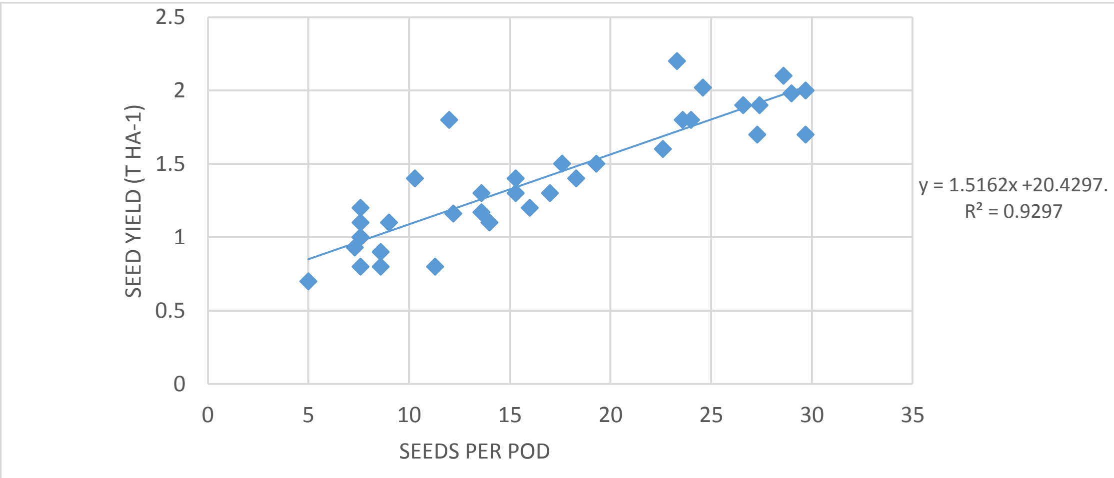


Figure 3: Linear relationship between seeds per pod and seed yield of mungbean

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 =0.9297) was observed between the parameters (Figure 3). It was evident from the Figure 2 that the equation y = 1.5162x + 20.4297. gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9297) 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 = 0.9297) correlated with the number of seeds pod^{-1}, i.e., the yield of mungbean increased with the increase of number of seeds pod^{-}

CHAPTER V

SUMMERY AND CONCLUSION

The research work was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka (Tejgaon soil series under AEZ No. 28) during the Rabi season of November, 2019 to March, 2020 to study the growth and yield of mungbean (BARI Mung-6) as influenced by different levels of phosphorus and boron. Two factor experiments with Randomized Complete Block Design (RCBD) was followed with 9 treatments (P_0B_0, P_1B_0, P_0B_1, P_0B_2, P_2B_0, P_1B_1, P_1B_2, P_2B_1 and P_2B_2 where P_0: 0 kg P ha^{-1}, P_1: 25 kg P ha^{-1}, P_2: 50 kg P ha^{-1}, B_0: 0 kg B ha^{-1}, B_1: 1.5 kg B ha^{-1} and B_2: 3 kg B ha^{-1}) having unit plot size of 3m x 1.5m (4.5m^2) and replicated thrice. The data were collected plot wise for plant height (cm), number of leaves $plant^{-1}$, number of branches $plant^{-1}$, number of pods $plant^{-1}$, pod length (cm), number of seeds pod^{-1}, weight of l000 seed (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield. All the data were statistically analyzed following LSD and the mean comparison was made by LSD. Plant height was significantly affected by different levels of P and B. Plant height increased with increasing levels of P and B.

The individual statistical results of P_2 treatment produced the tallest plant (82.18 cm), whereas B_2 treatment produced the tallest plant of 61.60 cm. The tallest plant (66.63 cm) was found in P_2B_2 treatment combination, which was higher over other treatments. The application of P and B showed positive effect on the number of leaves $plant^{-1}$, number of branches $plant^{-1}$, number of pods $plant^{-1}$, pod length (cm), number of seeds pod^{-1}, weight of l000-seed (g), seed yield (t ha^{-1}) and Stover yield (t ha^{-1}). All the plant characters increased with increasing levels of P and B up to higher level. The maximum value of number of leaves $plant^{-1}$ (13.76 at P_2, 11.87 at B_2 and 13.87 at P_2B_2 respectively), number of branches $plant^{-1}$ (2.36 P_2, 2.29 B_2 and 2.53 P_2B_2 respectively), number of pods $plant^{-1}$ (9.14 P_2, 8.71 B_2 and 9.21 P_2B_2 respectively), pod length (11.78 P_2, 11.22 B_2 and 13.67 cm P_2B_2 respectively) , number of seeds pod^{-1} (12.33 P_2, 12.56 B_2 and 12.80 P_2B_2 respectively), and weight of l000-seed (37.48 P_2, 36.85 B_2 and 41.02 g P_2B_2 respectively). Most of the results of above parameters were statistically similar with P_1B_1 treatment.

Like all other plant characters, grain yield was influenced significantly due to application of P and B. Seed yield increased with increasing levels of P up to certain level. The highest seed yield (1.06 t ha^{-1}) was found in plants receiving P @ 50 kg ha^{-1} and the lowest was recorded in untreated control treatment. Individual statistical results of B also showed significant effect on seed yield. Application B @ 3 kg ha^{-1} (B_2) produced the highest seed yield (1.15 t ha^{-1}). The interaction results of P and B had positive effect on seed yield of mungbean. The highest seed yield of mungbean was recorded in P_2B_2 (1.26 t ha^{-1}) which was statistically similar with P_1B_1 treatment.

The stover yield (t ha^{-1}), and biological yield (t ha^{-1}) of mungbean had also influenced by the application of phosphorus and boron fertilizers and had positive relationships with the increased doses of P and B. The maximum value of stover yield were 1.91 t ha^{-1}, 2.14 t ha^{-1} and 2.33 t ha^{-1} in respect of individual application of P and B and combined treatment of P and B. All of the statistical data of yield parameters had shown statistically similar result with P_1B_1 treatment. It was also observed that the lowest value of all parameters of yield contributing characters of mungbean found in control (P_0B_0) treatment.

The results of this research work indicated that the plants performed better in respect of seed yield in P_2B_2 treatment over the control treatment (P_0B_0). It was also observed that the statistically similar results were found at P_1B_1 treatment which was optimum doses of P and B treatment and cost effective as well. So, It can be therefore, concluded from the above study that the treatment of P_1B_1 (application of P @ 25 kg ha^{-1} application of B @ 1.5 kg ha^{-1}) was found to the most suitable treatment combination for the higher yield of mungbean in shallow Red Brown Terrace Soils of Bangladesh.

CHAPTER VI

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