EFFECT OF DIFFERENT COMBINATIONS OF PHOSPHORUS AND BORON ON GROWTH AND YIELD OF A SELECTED BARI MUNG-6

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This is to certify that the thesis entitled, Effect of different combinations of phosphorus and boron on growth and yield of a selected BARI Mung-6. Submitted to the DEPARTMENT OF SOIL SCIENCE, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in SOIL SCIENCE embodies the result of a piece of bonafide research work carried out by MD. AZIM MIA, Registration No. 09-03286 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 been duly acknowledged by him.

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Effect of different combinations of phosphorus and boron on growth and yield of a selected BARI Mung-6

ABSTRACT

The study was carried out at Sher-e-Bangla Agricultural University, Dhaka during the period from April to June of 2015 to find out the effect of different combinations of phosphorus and boron on growth and yield of a selected BARI Mung-6. The treatments of the experiment were laid out with Randomized Complete Block Design (RCBD) with three replications. There were two factors *viz*. phosphorus and boron. Four phosphorus levels *viz*. (i) P_0 = (Control), (ii) P_1 = 20 kgha^{-1}, (iii) P_2 = 30 kg ha^{-1} and (iv) P_3 = 40 kg ha^{-1} and four levels boron *viz.* (i) B_0 = (Control), (ii) B_1 = 1 kg ha^{-1}, (iii) B_2 = 1.5kg ha^{-1} and (iv) B_3 = 2kg ha^{-1} were considered. The experimental findings revealed that the longest plant (83.71 cm), maximum number of leaves plant^{-1} (23.27), maximum number of branches plant^{-1} (5.86), highest pod length (10.28 cm), highest number of pods plant^{-1} (35.47), highest number of seeds pod^{-1} (11.6), highest 1000 seed weight (38.72 g), highest grain yield (1.81 t ha^{-1}), highest stover yield (2.86 t ha^{-1}), highest biological yield (4.67 t ha^{-1}) and the highest harvest index (38.80) were recorded from P_2B_1. The highest protein content (14.78%) was recorded from $P_2B_2$and also from P_2B_1 (14.71%). In conclusion, P_2B_1(30 kg P ha^{-1}and 1 kg B ha^{-1}) may give the maximum return in respects of yield and quality for the betterment of pulses producers and eaters in Bangladesh.

LIST OF CONTENTS

LIST OF CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

%	=	Percent
^0C	=	Degree Centigrade
BARC	=	Bangladesh Agricultural Research Council
BARI	=	Bangladesh Agricultural Research Institute
BCR	=	Benefit Cost Ratio
cm	=	Centimeter
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
g	=	gram (s)
Kg ha^{-1}	=	Kilogram per hectare
Kg	=	Kilogram
LSD	=	Least Significant Difference
m	=	Meter
MP	=	Muriate of Potash
P^H	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
t ha^{-1}	=	tone per hectare
TSP	=	Triple Super phosphate
WHO	=	World Health Organization

CHAPTER 1

INTRODUCTION

Bangladesh grows various types of pulse crops namely grasspea, lentil, mungbean, blackgram, chickpea, and cowpea which are important pulse crops because they are the cheap source of easily dietary protein.Mungbean (*Vignaradiata* 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. 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. It 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).

Due to shortage of production, 291 thousands metric ton pulses was imported in Bangladesh in 2006-07 fiscal years (BBS, 2010). 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 yieldof 2 to 41 ton 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 green plants are used as animal feed and the residues as manure. Hence, on the nutritional point of view, mungbean is perhaps the best of all other pulses (Khan, 1981 and Kaul, 1982). As a whole, mungbean could be considered as an inevitable component of sustainable agriculture. In Bangladesh, BARI mung-6 is a yield potential pulse crop which innovated by Bangladesh Agricultural Research Institute (BARI). It is well fit growing capacity in all crop rotations in Bangladesh (BARI, 1998). BARI Mung- 6 is well known that short duration and drought tolerant crops.

Mungbean has been gaining its popularity as an important pulse crop in the High Ganges River Floodplain Soil due to its short duration and lucrative return. The High Ganges River Floodplain Soil is characterized by low fertility with medium to low level of P and B content (BARC, 2005). Farmers in this region grow mungbean either with nitrogen only or without any fertilizer.

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 Chhibbam, 1992).

Phosphorous (P) fertilization is the major mineral nutrient yield determinant in legume crops. Applied phosphorous significantly influence the yield performance of pulse crop.(Nasreen*et al*., 2006). Phosphorous deficiency reduces the total vegetative growth, secondary branches, leaf development and finally yields of mungbean (Smith, 1980). Interestingly, application of phosphorus fertilizer is significant for growers for their farming production. Because phosphorus can play a vital role for enrich mungbean mineral composition. It is known that P can promote nodule formation which fixing atmospheric N_2 in root, even it also help to promote early root formation and the formation of lateral, fibrous and healthy roots (Solaiman and Habibullah, 1990; Awomi*et al*., 2012).

On the other hand, micronutrients like boron alsohave the significant effect to achieve the potential yield ofmungbean. Intensification of cropping system withadoption of high yielding varieties has resulted in themining of nutrients from soils leading to nutrientsdeficiency. As a result farmers are not achieved theirtargeted production. The balanced fertilization may resultin increasing productivity of the crop (Afzal*et al*., 2004).Since no systematic attempt has been made so far withregard to P and B fertilization of Mungbean in the High Ganges River Floodplain Soils, the present study was,therefore, carried out to find out the effect of levels ofapplied P and B on the performance of summer mungbean. Considering the above facts, the present investigation has been undertakento study the following objectives:

1. To study the most promising combination of phosphorous and boron for attaining the maximum yield and yield contributing characters and quality also.

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_2O_5 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 P_2O_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^{-1} in a field experiment conducted in New Delhi. India during the kharif season in 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 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^{-1} 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^{-1}) 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^{-1}, which was at a with 60 kg P ha^{-1}. and both were significantly superior to 30 kg P ha^{-1}. Likewise, 60 kg P ha^{-1} 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^{-1} 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^{-1}) 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^{-1} 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^{-1}. 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^{-1}. Single super phosphate at 60 kg ha^{-1} 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^{-1}). Maximum plant height (31.2 cm), dry matter/plant (36.1 g) and number of pods/plant (l 7.4) was obtained with 60 kg DAP 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, number of pods/ plant, 1000-grain weight and grain yield. The highest yield of 1022 kg ha^{-1} was obtained at the phosphorus level of 100 kg ha^{-1} 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}.

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 134. SML 357 and SML 668) to P application (0. 20. 40 and 60 kg P_2O_5 ha^{-1}) 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 134, thus lowering the harvest index significantly compared to SML 668 and SML 357. Phosphorus application showed a non-significant effect on number of branches $plant^{-1}$, number of seeds pod^{-1}, 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^{-1}) compared to lower levels (0 and 20 kg ha^{-1}). 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 P_2O_5 ha^{-1}.

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^{-1}11 and K 851 to different P levels (0, 20, 40 and 60 kg P_2O_5 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^{-1}. 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^{-1} increased the number of pods/plant grain yield and grains per pod over the control and P at 20 kg ha^{-1}. 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}).

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 $plant^{-1}$ 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 nonsignificant. 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 t 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 plant^{-1} 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 di-ammonium 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 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 P_2O_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 Kalra (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 rnung 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 $P_2O_5ha^{-1}$ 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 B on yield and quality of mungbean

Plants require B for nodule formation in legumes (Tisdale *et al.* 1999). Kanzaria and Patel (1985) found that B application increased nodule weight of groundnut. Saxena and Mehrotra (1985) reported that application of 11.2 kg borax ha^{-1} gave maximum yield of groundnut, whereas at a lower dose of 5.6 kg ha^{-1} was found optimal. Rerkasem *et al.* (1987) stated that application of 20 kg borax ha^{-1} increased seed yield in black gram (*Vigna mungo)* while 10 kg borax ha^{-1} increased DM yield, the number of nodules $plant^{-1}$, the number of pods $plant^{-1}$ and the number of seeds pod^{-1} in green gram (*Vigna radiata).* Howeler *et al.* (1987) observed that yield of bean was nearly doubled with the application of 1 kg B ha^{-1}. Sakai *et al.* (1988) reported on a coarse textural soil that application of 2 and 2.5 kg B ha^{-1} increased grain yield of black gram and chickpea by 63% and 38%, respectively.

Kulkami *et al.* (1989) reported that B application increased nodule weight, nodule number and dry weight of groundnut. Buzetti *et al.* (1990) observed that when soybean cv. porana was treated with 0, 0.2, 0.4, 0.6 or 0.8 pg g^{-1} B pot^{-1}, soybean DM and seed yield pot^{-1} increased up to approx. 0.3 pgg^{-1} B and decreased at higher B rates.

Dwivedi, *et al.* (1990) conducted experiment in sandy loam acid Alfisol with different cropping sequence to study the direct and residual effect of B. The stated that B at 1.0 kg ha ^{1} increased yields at all the cropping sequence an increasing B rates increased B contents in plants and seeds.

Sakai *et al.* (1990) carried out field trials at 7 sites in North Bihar. They observe that seed yield of chickpea increased from 1.4 t ha^{-1} with no B to 1.79 t ha^{-1} with 3 kg B ha^{-1}. The yield response to B application was greater on low B soils.

Roy *et al.* (1992) observed that soil application of 20 kg borax ha^{-1} increased seed yield of lentil, while soil application of 3 kg Na-molybdate ha^{-1} gave only small (about 14%) increases.

Posypanov *et al.* (1994) observed that the applying of 1 kg B ha^{-1} to peas and soybeans and treating seeds with the equivalent of 50 g ammonium molybdalc ha^{-1} increased nodule weight atmospheric N fixation and seed yield.

Islam *el al.* (1995) carried out a field experiment on grey floodplain soils at Bogra, Bangladesh. They reported that they yield of chickpea obtained was 14% higher from 2 kg B.

Singh *et al.* (1994) noted that green 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.

Talashikar and Chavan (1996) observed that pod production of groundnut was enhanced significantly with the addition of B by 44%.

Srivastava *et al.* (1996) conducted an experiment in a field in B deficient soil, chickpeas cv. Kalika were given complete fertilizer or the complete fertilizer minus each of the trace elements. It was observed in the experiment that flower abortion was the highest and no seed was produced in the treatment given no B.

Srivastava *et al.* (1997) conducted a diagnostic nutrient trial with chickpea in three different places in Nepal. Boron deficiency was established as the dominant nutritional problem causing flower and pod abortion. No pods or grains were formed in the absence of applied B. Application of 0.5 kg B ha^{-1} was found to optimally correct the syndrome.

Panwar *et al.* (1998) conducted a pot experiment with non calcareous soil in India and found that chickpeas seed yield was reduced by 4.4% and 61% after application of 0.8 and 0.2 mg B kg^{-1} soil, respectively. Straw yield was less affected by high level of B, but dry matter was increased by 0.2% foliar application of B. Several field trials have been conducted by the OFRD scientists of BARI, Joydevpur to see the response of legume crop to B fertilizer. They got good response of crop on B application (BARI, 1998).

Abhijit *et al.* (1999) reported that boron in the form of borax @ 5 kg ha^{-1} increased significantly the growth and yield of yellow sarson.

Sakai *et al.* (1999) conducted a field experiment in calcareous soil to evaluate the direct and residual effects of different levels of B (0, 4, 16, 32 and 64 kg borax ha^{-1}) and FYM (0, 2.5 and 5 t ha^{-1}) alone or in combinations on maize-lentil cropping system. Increasing levels of B up to 16 kg borax ha^{-1} significantly increased and higher level decreased the yield of first corp. B uptake by corps increased due to available B in post-harvest soil.

Srivastava *et al.* (1999) observed that the average grain yield of chickpea and other legume crops was 0.1 t ha^{-1} where B was not applied while the yield was 1.4 t ha^{-1} when 0.5 kg ha^{-1} B was applied.

Verma *et al.* (1999) observed that in a pot experiment with mungbean cv. PDM-54 B was applied by seed treatment, soil application (basally or at flowering) or foliar spraying. Boron increased yield and growth parameters, with the best results in terms of seed yield plant^{-1} given when the equivalent of 5 kg borax ha^{-1} was applied at flowering.

Eguchi (2000) conducted a pot experiment on soybean using B deficient alluvial soil and found that the leaves remained green during the harvesting stage in the B deficient plot. Delay of maturity and decrease yield to 67% than B treated plot.

Hermantarajan *et al.* (2000) carried out a foliar treatment of B at different rates and observed that application of 50 μg g^{-1} B significantly influenced plant height, root length, total dry matter production, and seed yield of soybean than 100 μg g^{-1} B.

Kumar *et al.* (2002) observed that mungbean was grown in solution culture to study the effect of B deficiency on leaf expansion and intercellular airspaces. Different B concentrations were supplied just after initiation of the second trifoliate leaf because this is the first leaf whose growth depends on the exogenous B supply. The proportion of the spongy mesophyll region comprising airspaces in B-deficient leaves was less than 50% of that observed in leaves of plants supplied with sufficient B. An experiment was conducted in sandy loan calcareous soil in Uttar Pradesh, India during 1995-96 to study the effect of B application on yield of pea (cv. Rachma) and black gram (cv. Pv-19). Application of B upto 4 kg borax ha^{-1} significantly increased the grain yield of black gram and pea (Singh, R. *et al.* 2002).

2.3 Effect of P and B on yield and quality of mungbean

Singh and Singh (1990) conducted an experiment on a sandy loam soil and found that the application of B and P significantly influenced the green pod yield of bean. Maximum pod yield of 11 t ha^{-1} was recorded at 28 kg P ha^{-1} along with 1 kg B ha^{-1}.

Mondal and Roy (1991) conducted an experiment in acidic soil and found that dry matter yield increased with lime and/or P. B + lime and B + P but not with lime alone. Lime. P and B alone and in different combination increased uptake of B and P.

Mandal and Sinha (1997) had undertaken a field experiment in 1995 at Coochbehar, West Bengal. India, green gram *(Vigna radiala) cv*. B-105 was grown on the same plots after mustard receiving 0, 20, 40 or 60 kg P_2O_5 and 0, 10 or 30 kg borax ha^{-1}. Green gram seed yield was the highest (1.52 t ha^{-1}) in plots previously given 40 kg P_2O_5 + 10 kg borax ha^{-1}. However, this residual treatment combination was statistically significant with 40 kg P_2O_5 + 20 kg borax ha^{-1}.

CHAPTER III

MATERIALS AND METHODS

This chapter included the details of the experimental materials and methods followed by the study.

3.1 Experimental site

The experiment was carried out at the Sher-e-Bangla Agricultural University (Farm, Dhaka. The experimental site is situated at 23^{o}77' North Latitude and 90^{o}30' East Longitude. The elevation of the experimental site is 8.0 m above the sea level. The area belongs to the Agro-ecological Zone (AEZ- 28): Madhupur Tract.

3.2 Soil

The experiment was conducted on silty clay loam soil of the Order Inceptions. The soil of SAU farm is high land having irrigation facilities. The morphological, physical and chemical characteristics of the experimental soil are presented in Appendix 2.

3.3 Climate

The climate of the experimental site is sub-tropical, wet and humid. Heavy rainfall occurs in the monsoon (mid-April to mid-August) and scanty during rest of the year.

3.4 Crop: Mungbean

BARI Mung-6 was used in the study. The salient characteristics of this variety are presented below:

3.4.1BARI mung-6

BARI released BARI Mung-6 in 2003. Plant height of this variety ranges from 40 to 45 cm and seeds are deep green in color. One thousand seed weight is about 51-

52 g. The variety requires 55 to 60 days to mature, and average yield is 1,500 kg ha^{-1}. It is also resistant to Cercospora leaf spot and tolerant to yellow mosaic virus (BARI, 2014).

3.5Treatments and experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot was measured 3 m × 2 m. Variety-1 (BARI Mung-6)

3.6Treatments of experiment

Two factors experiment was considered for the experiment

Factor A: 4 phosphorus levels

P_0 = (Control)
P_1 = 20 kg P ha^{-1}(i.e. 100 kg TSP ha^{-1})
P_2 = 30 P kg ha^{-1} (i.e. 150 kg TSP ha^{-1})
P_3 = 40 P kgha^{-1} (i.e. 200 kg TSP ha^{-1})

Factor B: 4 boron levels

B_0 = (Control)

B_1 = 1 kg ha^{-1}(i.e. 5.88 kg Boric acid ha^{-1})

B_2 = 1.5 kg ha^{-1} (i.e. 8.82 kg Boric acid ha^{-1})

B_3 = 2 kg ha^{-1} (i.e. 11.76 kg Boric acid ha^{-1})

3.7Treatment Combination of experiment

P_0B_0, P_0B_1, P_0B_2, P_1B_3, P_1B_0,P_1B_1, P_1B_2, P_2B_3, P_2B_0, P_2B_1, P_2B_2,P_3B_3,P_3B_0, P_3B_1,P_3B_2,P_3 B_3.

3.8Land preparation

The experimental lands were opened with a power tiller and subsequently ploughed twice followed by laddering. Weed stubble and crop residues were removed. 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.

3.9Fertilizer application

Organic fertilizercowdungwas applied along with Urea, TSP, MP, Gypsum and Zinc sulphateand Boric acid were applied for the cultivation of test variety. The following recommended doses of manure and fertilizers were used (BARI, 2014):

Cowdung	=	5 t ha^{-1}
Urea	=	40-50 kg ha^{-1}
TSP	=	80-85 kg ha^{-1}
MoP	=	30-35 kg ha^{-1}
Gypsum	=	30 kg ha^{-1}
$ZnSO_4$	=	2.0 kg ha^{-1}
Boric acid	=	1.5 kg ha^{-1}

In case of TSP and boric acid, for the experiment, it were applied as per treatment

3.10 Sowing

Mungbean was sown on 27 February 2015. Healthy seeds of mungbean @ 35 kg ha^{-1} were sown by hand as uniformly as possible in furrows. Seeds were sown in the afternoon and immediately covered with soil to avoid sunlight. Line to line distance was 30 cm.

3.11 Intercultural operation

Weeding was done at 12 and 35 days after sowing. Thinning was done on the same date of 1st weeding to maintain optimum plant density. Plant to plant distance was maintained at 10 cm. A light irrigation was given after sowing for germination of seed. Pest did not infest the BARI mung-6 crop at the early stage. The insecticide Sumithion 57 EC was sprayed @ 0.02% at the time of pod formation to control pod borer. No disease was observed in the experimental field.

3.12Harvesting and sampling

The crops were harvested at a time due to synchronous maturity of pods. At first 50% of early matured pods were harvested by hand picking at 55 days after sowing. Finally 4 days after first harvesting all plants were harvested plot-wise by uprooting and were bundled separately, tagged and brought to the threshing floor of the SAU farm. All of the harvested pods were kept separately in properly tagged gunny bags. Ten plants were randomly selected prior to maturity from each plot for data recording.

3.13Threshing, drying, cleaning and weighing

The crop bundles were sun dried for two days on threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks. The collected seeds were dried in sun to lower the moisture content to 12% level. The dried and cleaned seed and stover were weighed plot-wise.

3.14 Data collection of growth and yield parameters

3.14.1 Plant height

The plant height was measured from base of the plant to the tip of the main shoot for ten randomly tagged plants with the help of scale at 30 DAS and harvest. The average of ten plants was computed and expressed as the plant height in centimeters.

3.14.2 Number of leaves per plant

The numbers of green trifoliate leaves present on each plant were counted manually from the ten tagged plants at 30 DAS and harvest. The mean number of leaves per plant was calculated and expressed in number per plant.

3.14.3 Number of branches per plant

The total number of branches originating from the main stem was counted at 30 DAS and harvest from ten earlier tagged plants. Average was worked out and expressed as number of branches per plant.

3.14.4Number of pods per plant

The total number of pods from ten randomly selected plants was counted manually from each treatment. Average was worked out and recorded as number of pods per plant.

3.14.5 Number of seeds pod^{-1} and seed yield plant^{-1}(g)

Ten pods were selected at random from the total number of pods harvested from tagged ten plants. The seeds from each pod were separated, counted and average was worked out and expressed as number of seeds pod^{-1}.The yield of seeds from ten randomly selected plants were counted from each treatment. Average was calculated and recorded as seed yield plant^{-1}(g).

3.14.6Weight of thousand seed

One hundred seeds were counted from the seed sample of each plot separately and then their weight was recorded by the help of an electrical balance. These values were multiplied by ten to determine the weight of thousand seed.

3.14.7 Stover Seed yield

The seed yield obtained from the net plot area of each treatment was added with the yield obtained for ten tagged and harvested plants. The seeds were cleaned and dried in shade for five days. After size grading seed weight per plant was recorded in gram. The seed yield per hectare was computed and expressed in kg per hectare.

3.14.8 Biological yield

Biological yield was determined by the following formula

Biological yield = Grain yield + Stover yield

3.14.9 Harvest index

Harvest index was calculated by the following formula

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 10$$

3.14.10 Protein content of seed

Protein content was measured by the laboratory test from collected seed sample and was expressed in percent.

3.15 Statistical analysis

The collected data on different growth and yield parameters and protein content of mungbean were statistically analyzed. The means for all treatments were calculated and the analyses of variances for all the characters were performed by ‘F’ variance test using MSTAT-C computer package program. The significance of difference between pair of means was performed by the Duncan’s Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

CHPATER IV

RESULTS AND DISCUSSION

The study was conducted to determine the effect of phosphorus (P) and boron (B) on the growth and yield of BARI Mung-6.The experimental findings of different yield contributing characterswere recorded to find out the optimum levels of phosphorus and boron on BARI Mung-6. 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 phosphoruson plant height

Plant height of BARI Mung-6 varied significantly due to the application of different level of phosphorus (Fig.1and Appendix 3). Result showed that the longest plant (60.66, 77.89 and 81.05 cm at 30 and 45 DAS and at harvest, respectively)was recorded under P_1 = 20 kgha^{-1}treated plot followed by P_2 = 30 kg ha^{-1}while the shortest plant (51.03, 72.76 and 76.36 cm at 30 and 45 DAS and at harvest, respectively) was achieved from P_0 = No phosphors (Control followed by P_3 = 40 kg ha^{-1}.Patel and Patel (1991) reported 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. 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}.

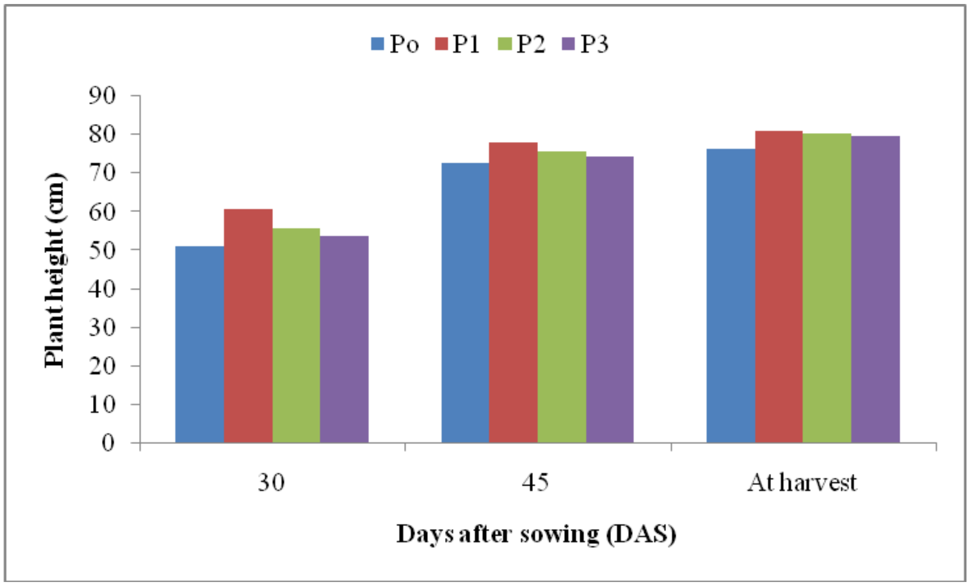

Fig. 1. Response of phosphorus on plant height of BARI Mung-6
P_0 = (Control), P_1 = 20 kg ha^{-1}, P_2 = 30 kg ha^{-1}, P_3 = 40 kg ha^{-1}

4.1.2 Effect of boron on plant height

Application of boron showed statistically significant variation in terms of plant height of BARI Mung-6 (Fig. 2 and Appendix 3). The findings showed that the longest plant (59.65, 75.64 and 80.82 cm at 30 and 45 DAS and at harvest, respectively) was found in B_1 = 1 kg ha^{-1} followed by B_2 = 1.5 $kgha^{-1}$where the lowest plant height (52.15, 72.90 and 78.34 cm at 30 and 45 DAS and at harvest, respectively) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.Eguchi (2000) reported that a pot experiment on soybean using B deficient alluvial soil and found that the leaves remained green during the harvesting stage in the B deficient plot. Delay of maturity and decrease yield to 67% than B treated plot. Hermantarajan*et al.* (2000) carried out a foliar treatment of B at different rates and observed that application of 50 μgg^{-1} B significantly influenced plant height, root length, total dry matter production, and seed yield of soybean than 100 μgg^{-1}B.

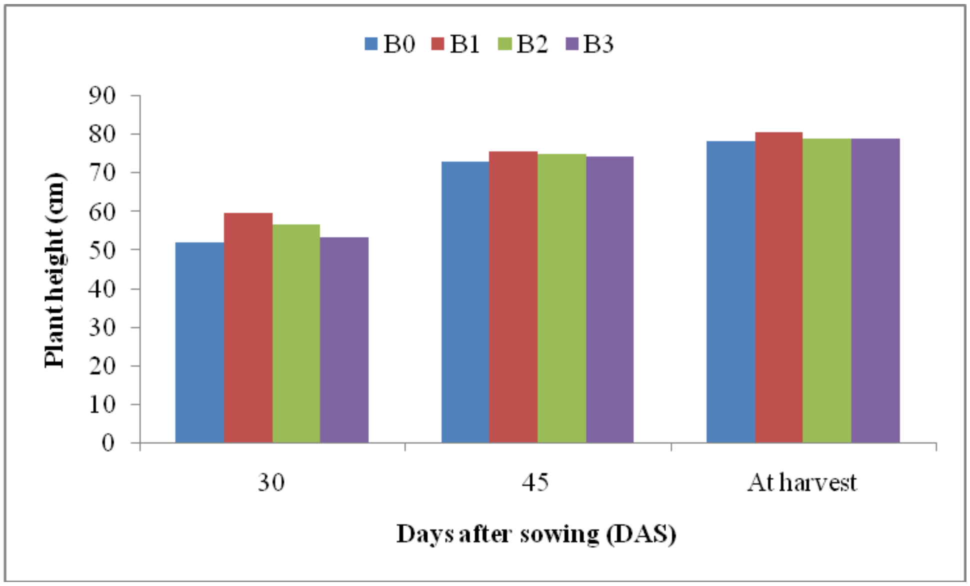

Fig. 2. Response of boron on plant height of BARI Mung-6
B_0 = (Control), B_1 = 1 kg ha^{-1}, B_2 = 1.5 kg ha^{-1}, B_3 = 2 kg ha^{-1}

4.1. 3Combinedeffect of phosphorus and boron on the plant height

Significant variation was found on plant height of BARI Mung-6 by thecombined effect of phosphorus and boron (Table 1 and Appendix 3). Result revealed that the longest plant (76.75, 77.53 and 83.71 cm at 30 and 45 DAS and at harvest, respectively) was recorded from P_2B_1 which was statistically same with P_1B_2 and followed by $P_1B_3$where theshortest plant (50.92, 72.20 and 75.25 cm at 30 and 45 DAS and at harvest, respectively) was achieved by P_0B_0 followed by P_0B_2, P_0B_3, P_1B_0, P_2B_0 and P_3B_0.

Table 1.Response of phosphorus and boron on plant height of BARI Mung-6

Treatments	**Plant height (cm)**		
	30 DAS	**45 DAS**	**At harvest**
P_0B_0	**50.92 i**	**72.20 f**	**75.25 d**
P_0B_1	**51.70 gh**	**73.34 ef**	**78.63 c**
P_0B_2	**51.00 hi**	**72.61 f**	**75.37 d**
P_0B_3	**50.51 i**	**72.66 f**	**76.18 d**
P_1B_0	**52.28 fg**	**72.85 f**	**78.77 c**
P_1B_1	**56.44 c**	**75.83 bc**	**80.73 bc**
P_1B_2	**76.61 a**	**77.15 a**	**83.27 a**
P_1B_3	**75.30 b**	**75.17 b**	**81.42 b**
P_2B_0	**52.78 f**	**73.56 ef**	**79.81 bc**
P_2B_1	**76.75 a**	**77.53 a**	**83.71 a**
P_2B_2	**57.35 c**	**76.95 ab**	**81.53 b**
P_2B_3	**53.16 ef**	**74.42 de**	**80.51 bc**
P_3B_0	**52.62 fg**	**72.75 f**	**79.53 bc**
P_3B_1	**54.72 d**	**75.85 bc**	**80.23 bc**
P_3B_2	**54.09 de**	**74.97 cd**	**80.18 bc**
P_3B_3	**53.28 ef**	**73.45 ef**	**78.43 c**
$LSD_{0.05}$	**0.9608**	**1.209**	**2.173**
CV (%)	**9.37**	**8.42**	**10.59**

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

P_0 = (Control) **B_0 = (Control)**
P_1 = 20 kgha^{-1} **B_1 = 1 kg ha^{-1}**
P_2 = 30 kg ha^{-1} **B_2 = 1.5 kg ha^{-1}**
P_3 = 40 kg ha^{-1} **B_3 = 2kg ha^{-1}**

4.2Number of leaves plant^{-1}

4.2.1 Effect of phosphorus on number of leaves plant^{-1}

Number of leaves plant^{-1}of BARIMung-6 differed significantly due to theapplication of different level of phosphorus(Fig. 3 and Appendix 4). Result revealed that the maximum number of leavesplant^{-1}(11.76, 14.93 and 22.97 at 30 45 DAS and at harvest, respectively) was recorded from P_1 = 20 kg ha^{-1}followed by P_2 = 30 kg ha^{-1}and P_3 = 40 kg ha^{-1}, while the minimum number of leaves plant^{-1}(10.27, 12.78 and 19.44 at 30 and 45 DASand at harvest, respectively)was recorded in P_0 = No phosphors (Control).Probably,phosphorus ensured the availability of other essential nutrients as a resultmaximum growth was occurred and the ultimate results is the maximumnumber of leaves per plant. Bhat*et al*. (2005) observed 60 kg Pha^{-1} significantlyimproved the yield attributes compared to the control.

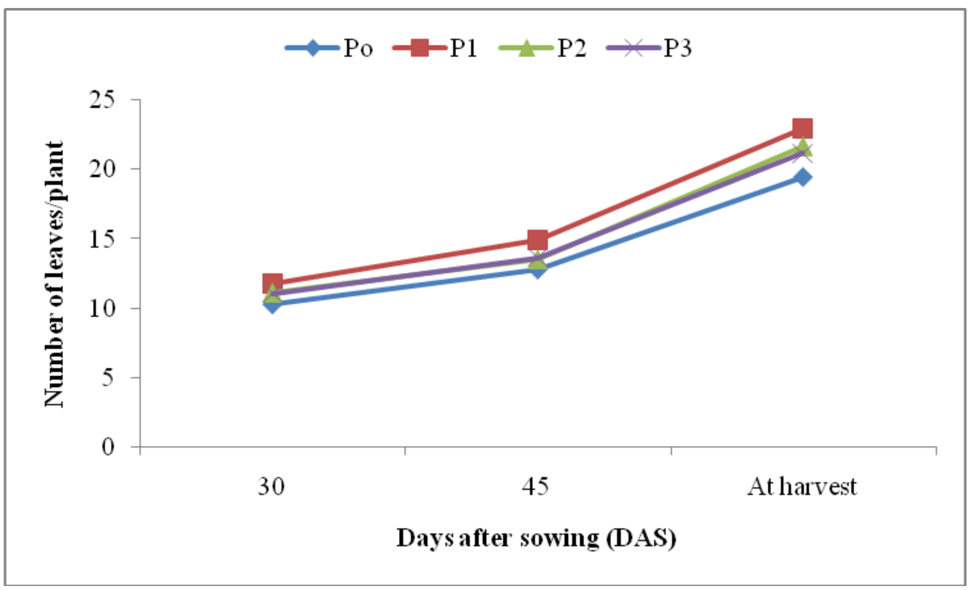

Fig. 3. Response of phosphorus on number of leaves per plant of BARI Mung-6

P_0 = (Control), P_1 = 20 kg ha^{-1}, P_2 = 30 kg ha^{-1}, P_3 = 40 kg ha^{-1}

4.2.2 Effect of boron on number of leaves plant^{-1}

Application of boron showed statistically significant variation in terms of number of leaves plant^{-1}of BARI Mung-6 (Fig.4 and Appendix 4). The findings showed that the maximum number of leaves plant^{-1}(11.65, 14.17 and 22.05 at 30 and 45 DAS and at harvest, respectively) was found in B_1 = 1 kg ha^{-1} followed by B_2 = 1.5 kg ha^{-1}where the minimum number of number of leaves plant^{-1} (10.61, 14.01and 20.36at 30 and 45 DAS and at harvest, respectively) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.

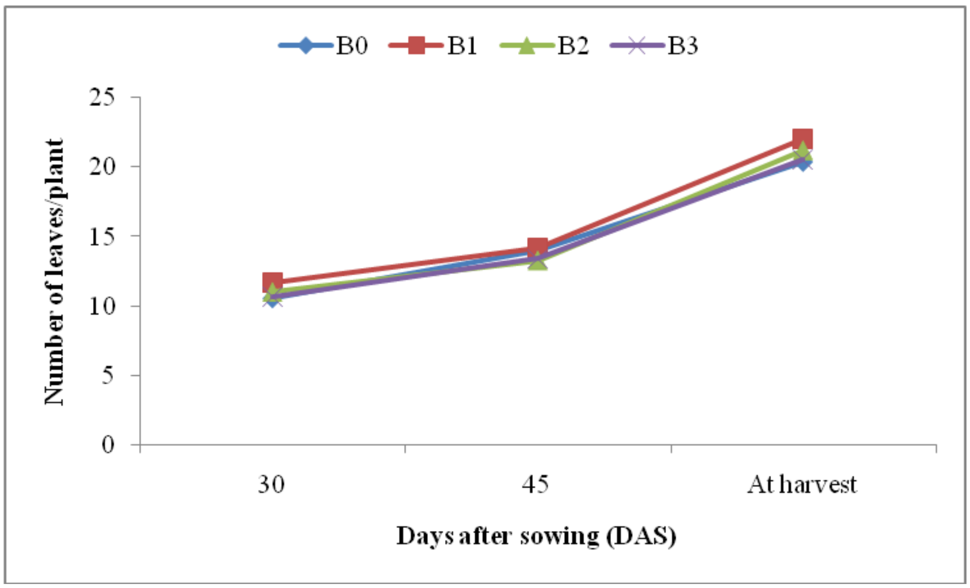

Fig. 4. Response of boron on number of leaves per plant of BARI Mung-6

B_0 = (Control), B_1 = 1 kg ha^{-1}, B_2 = 1.5 kg ha^{-1}, B_3 = 2 kg ha^{-1}

4.2.3 Combined effect of phosphorus and boronon number of leaves plant^{-1}

Combined effect of phosphorus and boron showed statisticallysignificant variation for number of leaves plant^{-1}(Table 2 and Appendix 4). Result revealed that the maximum number of leaves plant^{-1}(12.85, 15.38 and 23.27 at 30 and 45 DAS and at harvest, respectively) was recorded from P_2B_1 which was statistically similar with $P_2B_2$and followed by $P_1B_1$where the minimum number of leaves plant^{-1}(9.23, 11.02 and 18.44 at 30 and 45 DASand at harvest, respectively) was achieved by P_0B_0followed by P_0B_2, P_0B_3, P_1B_0, P_2B_0 and P_3B_0.

Table 2. Response of phosphorus and boron on number of leaves per plant of BARI Mung-6

Treatments	**Number of leaves plant^{-1}**		
	30 DAS	**45 DAS**	**At harvest**
P_0B_0	**9.23 g**	**11.02 f**	**18.44 k**
P_0B_1	**10.95 d**	**13.28 e**	**20.90 e-g**
P_0B_2	**10.68 de**	**13.25 e**	**19.47 ij**
P_0B_3	**10.20 f**	**12.60 f**	**18.97 jk**
P_1B_0	**11.70 b**	**14.17 bc**	**21.68 c-e**
P_1B_1	**11.80 ab**	**14.48 b**	**22.95 bc**
P_1B_2	**11.22 c**	**13.88 cd**	**21.33 d-f**
P_1B_3	**11.93 ab**	**13.18 e**	**22.64 a-c**
P_2B_0	**9.97 f**	**11.84 d**	**19.90 h-j**
P_2B_1	**12.85 a**	**15.38 a**	**23.27 a**
P_2B_2	**12.02 ab**	**14.87 ab**	**22.86 ab**
P_2B_3	**10.42 ef**	**13.93 cd**	**20.55 f-h**
P_3B_0	**11.53 bc**	**14.07 b-d**	**21.43 d-f**
P_3B_1	**11.60 bc**	**13.55 de**	**21.80 c-e**
P_3B_2	**11.13 cd**	**13.05 ef**	**21.22 d-f**
P_3B_3	**10.08 f**	**13.93 b-d**	**20.21 g-i**
$LSD_{0.05}$	**0.444**	**0.498**	**0.901**
CV (%)	**8.44**	**7.97**	**10.89**

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

P_0 = (Control) **B_0 = (Control)**

P_1 = 20 kg ha^{-1} **B_1 = 1 kg ha^{-1}**

P_2 = 30 kg ha^{-1} **B_2 = 1.5 kg ha^{-1}**

P_3 = 40 kg ha^{-1} B_3 = 2 kg ha^{-1}

4.3.Number of branches plant^{-1}

4.3.1 Effect of phosphorus on number of branches plant^{-1}

Number of branchesplant $^{-1}$ of BARI Mung-6 differed significantly due to the application of different level of phosphorus (Fig.5and Appendix 5). The findings showed that the maximum number of branches plant^{-1}(2.96, 4.71 and 5.95 at 30 45 DAS and at harvest, respectively) was recorded from P_2= 30 kg ha^{-1}which was statistically same with P_1 = 20 kg ha^{-1}while the minimum number of branches plant^{-1}(2.22, 3.03 and 4.36 at 30 and 45 DASand at harvest, respectively) was recorded from P_0 = No phosphors (Control) followed by P_3 = 40 kg ha^{-1}.Umar *et al*. (2001) stated that plant height and numbers of branches per plant were significantly increased by phosphorus application in soybean. 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.

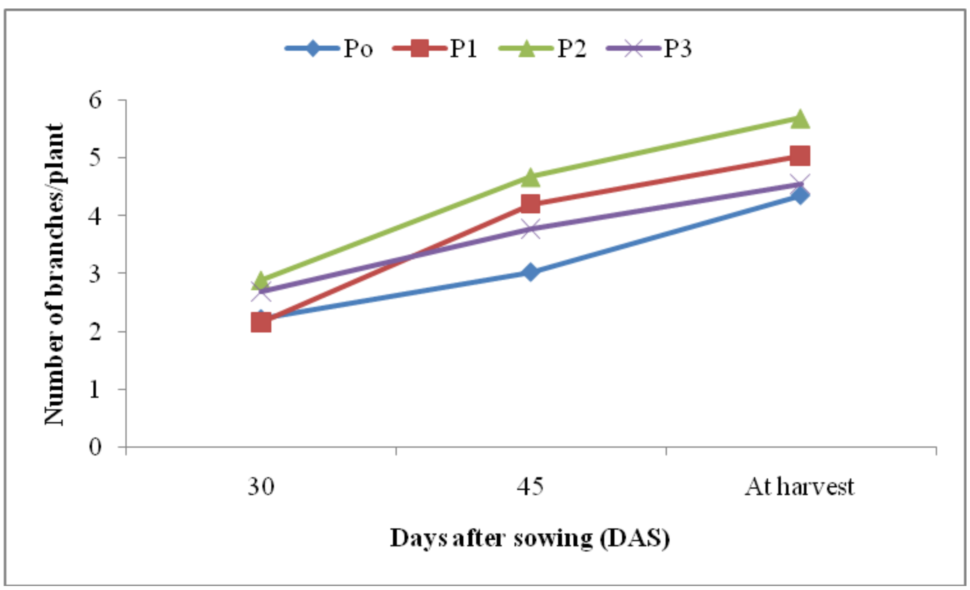

Fig. 5. Response of phosphorus on number of branches plant^{-1} of BARI Mung-6

P_0 = (Control), P_1 = 20 kg ha^{-1}, P_2 = 30 kg ha^{-1}, P_3 = 40 kg ha^{-1}

4.3.2 Effect of boron on number of branches plant^{-1}

Application of boron showed statistically significant variation in terms of number of branches plant^{-1}of BARI Mung-6 (Fig.6 and Appendix 5). Result revealed that the maximum number of branches plant^{-1}(2.95, 4.10 and 5.02 at 30 and 45 DAS and at harvest, respectively) was found in B_1 = 1 kg ha^{-1} followed by B_2 = 1.5 kg ha^{-1}where the minimum number of branches plant^{-1}(2.37, 3.30 and 4.65 at 30 and 45 DAS and at harvest, respectively) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.

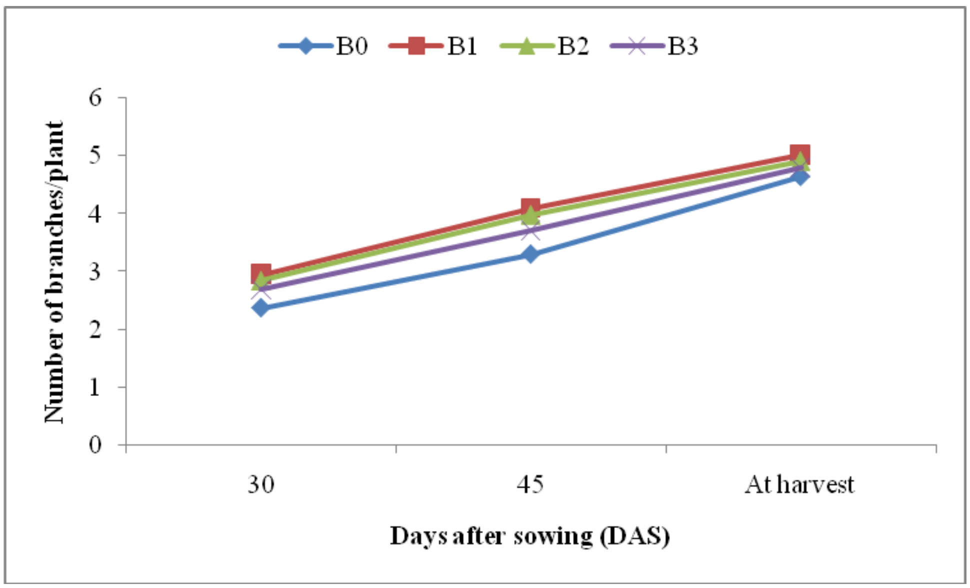

Fig. 6. Response of boron on number of branches plant^{-1} of BARI Mung-6

B_0 = (Control), B_1 = 1 kg ha^{-1}, B_2 = 1.5 kg ha^{-1}, B_3 = 2 kg ha^{-1}

4.3.3 Combined effect of phosphorus and boron on number of branches plant^{-1}

Combined effect of phosphorus and boron influenced in significantly variation for number of branches plant^{-1}(Table 3 and Appendix 5). Result showed that the maximum number of branches plant^{-1}(3.78, 4.95 and 5.86 at 30 and 45 DAS and at harvest, respectively) was recorded from P_2B_1 which was statistically identical with P_2B_2 and followed by P_1B_3, $P_1B_2$and $P_1B_1$where the minimum number of branches plant^{-1}(2.10, 2.85 and 4.18 at 30 and 45 DASand at harvest, respectively) was achieved by P_0B_0 followed by P_0B_3, P_0B_2, P_0B_1 and P_1B_0.

Table 3. Response of phosphorus and boron on number of branches plant^{-1} of BARI Mung-6

Treatments	Number of branches plant^{-1}		
	30 DAS	**45 DAS**	**At harvest**
P_0B_0	2.10 k	2.85 l	4.18 f
P_0B_1	2.33 i	3.21 jk	4.50 d-f
P_0B_2	2.26 jk	3.12 k	4.43 d-f
P_0B_3	2.20 jk	2.96 l	4.35 ef
P_1B_0	2.46 g-i	3.45 hi	4.61 de
P_1B_1	3.15 bc	4.35 bc	5.18 ab
P_1B_2	3.05 cd	4.21 cd	5.11 a-c
P_1B_3	3.20 bc	4.45 b	5.25 ab
P_2B_0	2.55 gh	3.56 gh	4.73 c-e
P_2B_1	3.78 a	4.95 a	5.86 a
P_2B_2	3.28 a	4.64 a	5.30 a
P_2B_3	2.75 f	3.78 f	4.61 de
P_3B_0	2.38 h-j	3.35 ij	5.10 a-c
P_3B_1	2.95 de	4.11 de	5.05 a-c
P_3B_2	2.81 ef	3.98 e	4.83 b-d
P_3B_3	2.63 fg	3.70 fg	5.05 a-c
$LSD_{0.05}$	0.175	0.149	0.369
CV (%)	8.56	11.29	10.35

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

P_0 = (Control) B_0 = (Control)
P_1 = 20 kg ha^{-1} B_1 = 1 kg ha^{-1}

P_2 = 30 kg ha^{-} B_2 = 1.5 kg ha^{-1}

P_3 = 40 kg ha^{-1} **B_3 = 2 kg ha^{-1}**

4.4Pod length

4.4.1 Effect of phosphoruson pod length

Pod length (cm) of BARIMung-6 differed significantly due to the application of different level of phosphorus (Table 4and Appendix 6). Result revealed that the highest pod length(8.47 cm) was recorded from P_2= 30 kg ha^{-1}which was statistically identical with P_1 = 20 kg ha^{-1}while the lowest pod length (6.41) was recorded from P_0 = No phosphors (Control) followed by P_3 = 40 kg ha^{-1}.

4.4.2 Effect of boronon pod length

Application of boron showed statistically significant variation in terms of pod length (cm) of BARIMung-6(Table 4 and Appendix 6). Result revealed that the highest of pod length (8.52 cm) was found in B_1 = 1 kg ha^{-1} followed by B_2 = 1.5 kg ha^{-1} where the lowestpod length (6.83 cm) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.

4.4.3 Combined effect of phosphorus and boronon pod length

Combined effect of phosphorus and boron showed statistically significant variation for pod length (cm) of BARIMung-6(Table 4 and Appendix6).The findings revealed that the highest pod length (10.28 cm) was recorded from P_2B_1followed by $P_1B_3$where the minimum number of pod length (cm) of BARIMung-6(6.16 cm) was achieved by P_0B_0 followed by P_0B_3, P_0B_2, P_0B_1 and P_1B_0.

4.5Number of pods plant^{-1}

4.5.1 Effect of phosphoruson number of pods plant^{-1}

Number of pods plant^{-1}of BARIMung-6 differed significantly due to the application of different level of phosphorus (Table 4 and Appendix 6).Result revealed that the highest number of pods plant^{-1} (28.91) was recorded from P_2= 30 kg ha^{-1}which was statistically identical with P_1 = 20 kg ha^{-1}while the lowest number of pods plant^{-1} (16.84) was recorded from P_0 = No phosphors (Control) followed byP_3 = 40 kg ha^{-1}.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.

4.5.2 Effect of boronon number of pods plant^{-1}

The studied findings revealed that significantly variation was found in terms of number of pods plant^{-1} of BARIMung-6 was recorded for the application of boron(Table 4 and Appendix 6).The findings revealed that the highest number of pods plant^{-1} (24.5) was found in B_1 = 1 kg ha^{-1} followed by B_2 = 1.5 kg ha^{-1} where the lowest number of pods plant^{-1} (18.9) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.Howeler*et al.*(1987) stated that application of 20 kg borax ha^{-1} increased seed yield in black gram (*VignamungoL.)*while 10 kg borax ha^{-1} increased dry matter yield and number of pods plant^{-1} in green gram (*Vignaradiata).*

4.5.3 Combined effect of phosphorus and boronon number of pods plant^{-1}

Combined effect of phosphorus and boron showed statistically significant variation number of pods plant^{-1} ofBARIMung-6(Table 4 and Appendix 6). Result revealed that the highest number of pods plant^{-1} (35.47) was recorded from P_2B_1 followed by $P_2B_3$where the minimum number of pods plant^{-1} of BARIMung-6 (15.40) was achieved by P_0B_0 followed by P_0B_0, P_0B_3, P_0B_2, P_0B_1 and P_3B_0.

4.6Number of seeds pod^{-1}

4.6.1 Effect of phosphoruson number of seeds pod^{-1}

Number of seeds pod^{-1}of BARI Mung-6 differed significantly due to the application of different level of phosphorus (Table 4 and Appendix 6).

The findings revealed that the highest number of seeds pod^{-1}(10.53) was recorded from P_2= 30 kg ha^{-1}which was statistically identical with P_1 = 20 kg ha^{-1}while the lowest number of seeds pod^{-1}(8.47) was recorded from P_0 = No phosphors (Control) followed by P_3 = 40 kg ha^{-1}.

4.6.2 Effect of boron on number of seeds pod^{-1}

Application of boron showed statistically significant variation in terms of number of seeds pod^{-1}of BARIMung-6 (Table 4 and Appendix 6). The findings revealed that the highest number of seeds pod^{-1}(10.6) was found in B_1 = 1 kg ha^{-1} followed by B_2 = 1.5 kg ha^{-1} where the lowest number of seeds pod^{-1}(9.22) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.Srivastava*et al.* (1997) stated that a diagnostic nutrient trial with chickpea in three different places in Nepal. Boron deficiency was established as the dominant nutritional problem causing flower and pod abortion. No pods or grains were formed in the absence of applied B. Application of 0.5 kg B ha^{-1} was found to optimally correct the syndrome.

4.6.3 Combined effect of phosphorus and boron on number of seeds pod^{-1}

Combined effect of phosphorus and boron showed statistically significant variation number of seeds pod^{-1}of BARIMung-6(Table 4 and Appendix 6). Result revealed that the highest number of seeds pod^{-1}(11.6) was recorded from P_2B_1 followed by P_2B_2, P_1B3, P_1B_1 and $P_1B_2$where the minimum number of seeds pod^{-1}of BARIMung-6 (8.62) was achieved by P_0B_0 followed by P_0B_3, P_0B_2, P_0B_1 and P_3B_0.

4.7 1000-seed weight

4.7.1 Effect of phosphorus on 1000 seed weight

Weight of 1000 seeds (g) of BARI Mung-6 differed significantly due to the application of different level of phosphorus (Table 5 and appendix 6).

The highest weight of 1000 seeds (37.53 g) was recorded from P_2 = 30 kg ha^{-1}which was statistically identical with P_1 = 20 kg ha^{-1} while the lowest weight of 1000 seeds (33.68 g) was recorded from P_0 = No phosphors (Control) followed by P_3 = 40 kg ha^{-1}. Samiullah*et al*. (1986) reported that 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.

4.7.2 Effect of boron on 1000 seed weight

Application of boron showed statistically significant variation in terms of weight of 1000 seeds of BARI Mung-6 (Table 5 and Appendix 6). Result revealed that the highest weight of 1000 seeds (37.23 g) was found in B_1 = 1 kg ha^{-1} which was statistically identical with B_2 = 1.5 kg ha^{-1} where the lowest weight of 1000 seeds (34.83 g) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.

4.7.3 Combined effect of phosphorus and boron on 1000 seed weight

The findings showed for combined effect of phosphorus and boron on weight of 1000 seeds of BARI Mung-6 (Table 5 and Appendix 6). Result revealed that the highest weight of 1000 seeds (38.72 g) was recorded from P_2B_1 followed which was statistically similar with P_2B_2, P_1B_3 and P_1B_1 where the minimum weight of 1000 seeds of BARI Mung-6 (32.63 g) was achieved by P_0B_0 followed by P_0B_3.

Table 4. Response of phosphorus and boron on yield contributing characters of BARI Mung-6

Treatments	Pod length (cm)	Number of pods plant^{-1}	Number of seeds pod^{-1}	1000 seed weight (g)
Effect of phosphorus				
P_o	6.41 c	16.84 d	8.47 c	33.68 c
P_1	8.37 a	23.91 b	10.53 a	37.48 a
P_2	8.47 a	28.80 a	10.69 a	37.53 a
P_3	7.72 b	21.63 c	10.12 b	36.71 b
$LSD_{0.05}$	0.321	1.012	0.252	0.330
Effect of boron				
B_0	6.83 c	18.9 c	9.22 d	34.83 c
B_1	8.52 a	24.5 a	10.6 a	37.23 a
B_2	7.93 b	22.9 b	10.2 b	36.94 a
B_3	7.69 b	21.8 b	9.69 c	36.40 b
$LSD_{0.05}$	0.322	1.010	0.253	0.331
Combined effect of phosphorus and boron				
P_0B_0	6.16 l	15.40 k	8.62 j	32.63 k
P_0B_1	6.70 ij	18.62 ij	9.43 hi	34.43 i
P_0B_2	6.51 jk	17.51 jk	9.18 i	34.06 ij
P_0B_3	6.28 kl	15.84 k	8.65 j	33.60 j
P_1B_0	7.09 gh	19.86 hi	9.72 gh	35.52 gh
P_1B_1	8.76 c	25.66 de	10.85 bc	38.20 a-c
P_1B_2	8.50 cd	23.84 ef	10.60 bc	37.87 b-d
P_1B_3	9.14 b	26.27 cd	10.88 b	38.32 ab
P_2B_0	7.26 g	21.12 gh	9.96 fg	35.93 g
P_2B_1	10.28 a	35.47 a	11.68 a	38.72 a
P_2B_2	8.54 cd	27.86 c	10.90 b	38.52 ab
P_2B_3	7.81 f	30.72 b	10.20 ef	36.94 ef
P_3B_0	6.82 hi	19.33 hij	9.60 h	35.21 h
P_3B_1	8.36 de	23.27 fg	10.53 cd	37.58 c-e
P_3B_2	8.17 e	22.55 fg	10.32 de	37.32 d-f
P_3B_3	7.553 f	21.37 gh	10.04 ef	36.73 f
$LSD_{0.05}$	0.269	2.020	0.284	0.661
CV (%)	8.77	6.24	9.39	7.56

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

P_0 = (Control) B_0 = (Control)

P_1 = 20 kg ha^{-1} B_1 = 1 kg ha^{-1}

P_2 = 30 kg ha^{-1} B_2 = 1.5 kg ha^{-1}

P_3 = 40 kg ha^{-1} B_3 = 2 kg ha^{-1}

4.8Grain yield (t ha^{-1})

4.8.1 Effect of phosphorus on grain yield (t ha^{-1})

Grain yield (t ha^{-1}) of BARI Mung-6differed significantly variation due to the application of different level of phosphorus (Fig.7 and Appendix 6). Result revealed that the highest grain yield(1.95 t ha^{-1}) was recorded from P_2=30 kg ha^{-1}which was statistically identical with P_1 = 20 kg ha^{-1}while the lowest grain yield(0.85 t ha^{-1}) was recorded from P_0 = No phosphors (Control) followed by P_3 = 40 kg ha^{-1}.

4.8.2 Effect of boronon grain yield (t ha^{-1})

Significant variation showed for application of boron on grain yieldof BARIMung-6 (Fig.8 and Appendix 6). Result revealed that the highest grain yield(1.38 t ha^{-1}) was found in B_1 = 1 kg ha^{-1} followed by B_2 = 1.5 kg ha^{-1} where the lowest grain yield(0.94 t ha^{-1}) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.Srivastava*et al.* (1999) reported that the average grain yield of chickpea and other legume crops was 0.1 t ha^{-1} where B was not applied while the yield was 1.4 t ha^{-1} when 0.5 kg ha^{-1} B was applied. Verma*et al.* (1999) observed that in a pot experiment thatboron increased yield and growth parameters, with the best results in terms of seed yield plant^{-1}given when the equivalent of 5 kg borax ha^{-1} was applied at flowering.

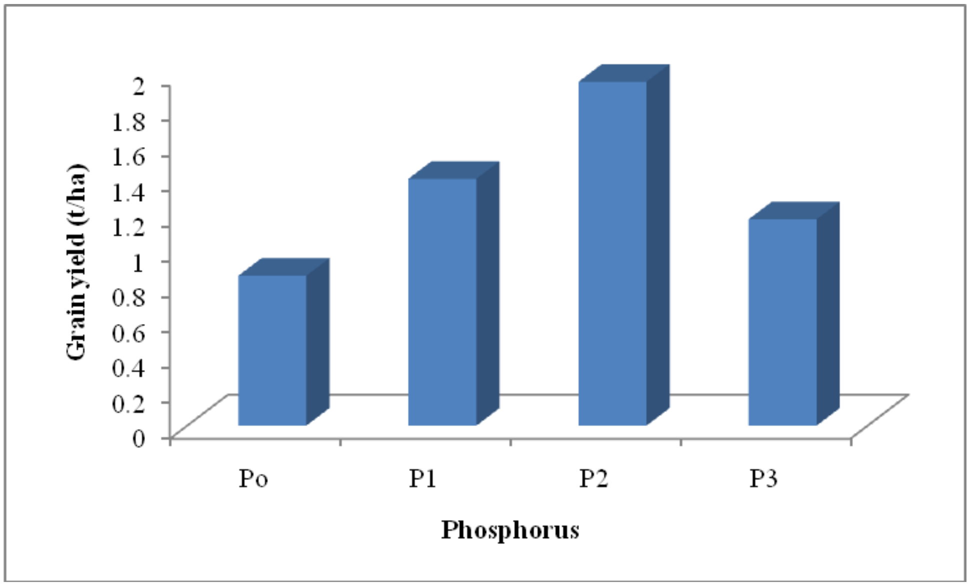

Fig. 7. Response of phosphorus on grain yield of BARI Mung-6
P_0 = (Control), P_1 = 20 kg ha^{-1}, P_2 = 30 kg ha^{-1}, P_3 = 40 kg ha^{-1}

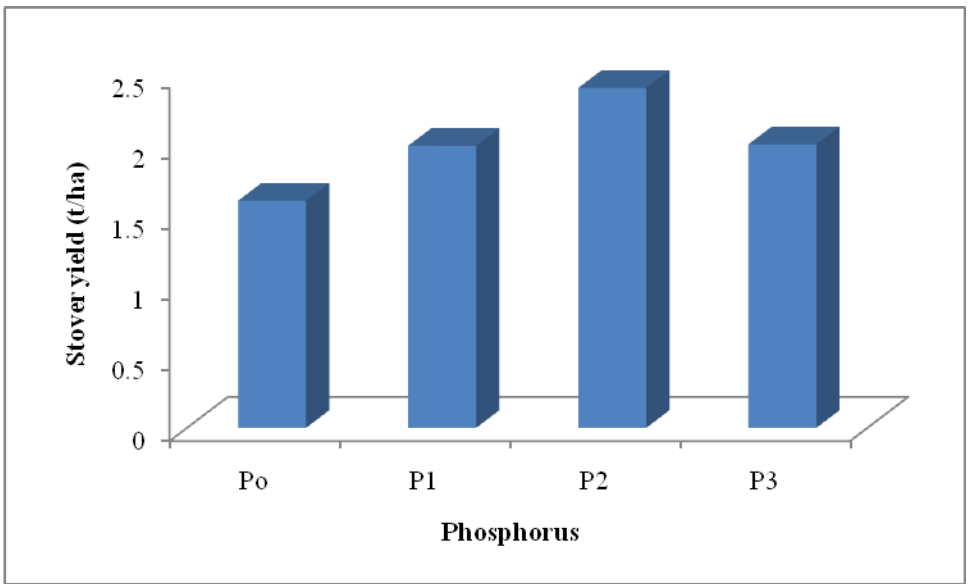

Fig. 8. Response of boron on grain yield of BARI Mung-6
B_0 = (Control), B_1 = 1 kg ha^{-1}, B_2 = 1.5 kg ha^{-1}, B_3 = 2 kg ha^{-1}

4.8.3 Combined effect of phosphorus and boronon grain yield (t ha^{-1})

The experimental findings showed the significant variationof combined effect of phosphorus and boronon grain yieldof BARIMung-6(Table 5 and Appendix 6).The findings revealed that the highest grain yield(1.81 t ha^{-1}) was recorded from P_2B_1which was statistically same with $P_2B_2$where the minimum grain yieldof BARI Mung-6 (0.81 t ha^{-1}) which was statistically similar with $P_0B_3$and P_0B_2followedby P_0B_1 and P_3B_0.

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

4.9.1 Effect of phosphoruson stover yield (t ha^{-1})

Stover yield (g) of BARI Mung-6 differed significantly due to the application of different level of phosphorus (Fig.9 and appendix 6). Result revealed that the highest stover yield (2.41 t ha^{-1}) was recorded from P_2=30 kg ha^{-1}followed by P_3 = 40 kg ha^{-1}while the lowest stover yield (1.61 t ha^{-1}) was recorded from P_0 = No phosphors (Control) followed by P_1= 20 kg ha^{-1}.

4.9.2 Effect of boronon stover yield (t ha^{-1})

Significantvariation in terms of stover yield of BARI Mung-6 was recorded for the application of boron(Fig. 10and Appendix 6).Result revealed that the highest stover yield (2.29 t ha^{-1}) was found in B_1 = 1 kg ha^{-1} which was statistically identical with B_2 = 1.5 kg ha^{-1} where the lowest stover yield (1.76t ha^{-1}) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.

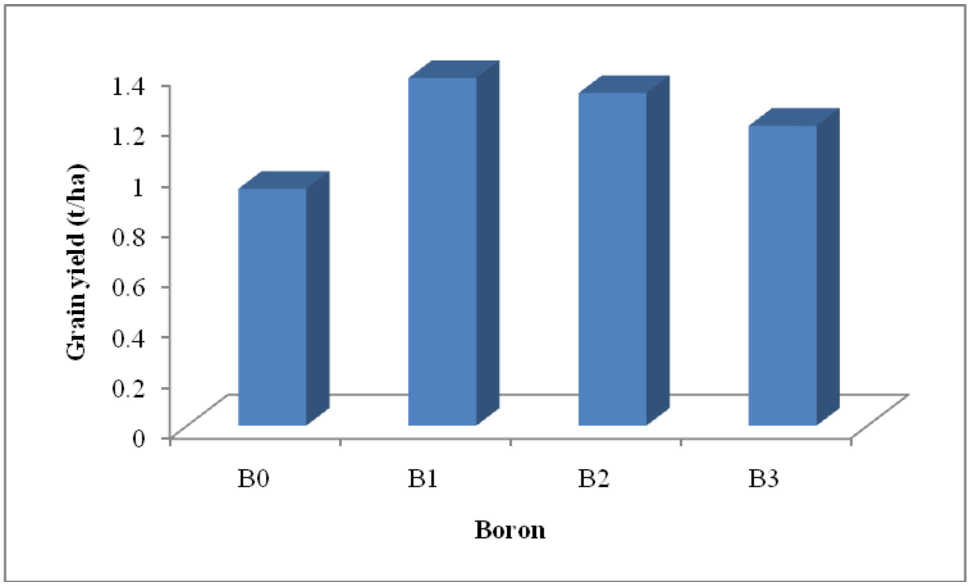

Fig. 9. Response of phosphorus on stover yield of BARI Mung-6
P_0 = (Control), P_1 = 20 kg ha^{-1}, P_2 = 30 kg ha^{-1}, P_3 = 40 kg ha^{-1}

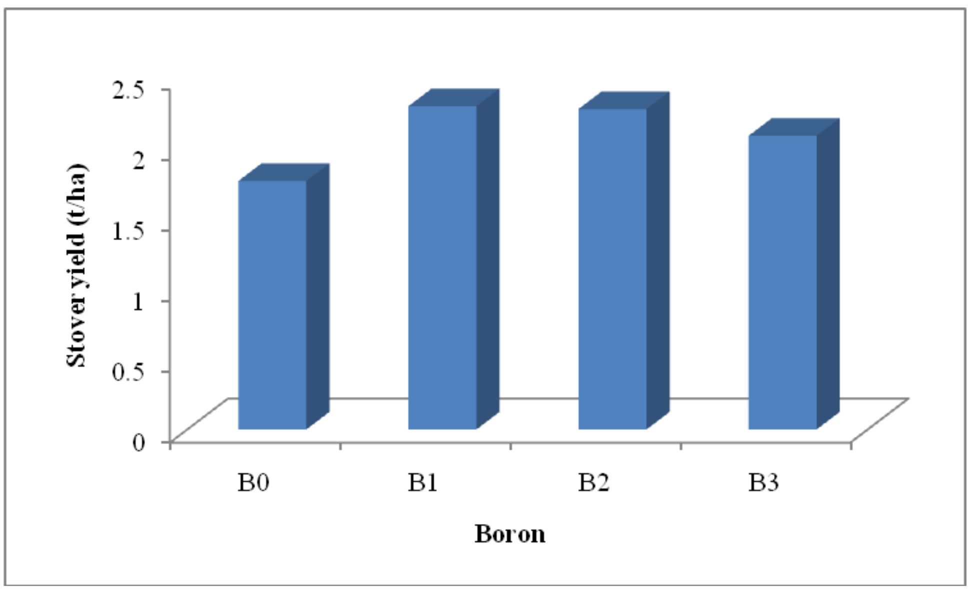

Fig. 10. Response of boron on stover yield of BARI Mung-6
B_0 = (Control), B_1 = 1 kg ha^{-1}, B_2 = 1.5 kg ha^{-1}, B_3 = 2 kg ha^{-1}

4.9.3 Combined effect of phosphorus and boronon stover yield (t ha^{-1})

High significant variation was found in combined effect of phosphorus and boron on stover yield of BARIMung-6(Table 5 and Appendix6). The findings revealed that the highest stover yield (2.86 t ha^{-1}) was recorded from P_2B_1 which was statistically same with P_2B_2, P_1B_3 and statistically similar with $p_1b_1$where the minimum stover yield of BARI Mung-6 (1.56 t ha^{-1}) was recorded from P_0B_0followed by P_0B_2, P_0B_3 and P_0B_1.

Table 5. Response of phosphorus and boron on grain yield and stoveryield of BARI Mung-6

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
P_0B_0	**0.81 k**	**1.56 i**
P_0B_1	**0.89 ij**	**1.67 hi**
P_0B_2	**0.86 i-k**	**1.64 i**
P_0B_3	**0.84 jk**	**1.58 i**
P_1B_0	**0.99 gh**	**1.75 g-i**
P_1B_1	**1.49 c**	**2.54 ab**
P_1B_2	**1.41 d**	**2.48 b**
P_1B_3	**1.61 b**	**2.73 a**
P_2B_0	**1.04 g**	**1.88 e-g**
P_2B_1	**1.81 a**	**2.86 a**
P_2B_2	**1.74 a**	**2.82 a**
P_2B_3	**1.19 f**	**2.06 c-e**
P_3B_0	**0.93 hi**	**1.84 f-h**
P_3B_1	**1.34 d**	**2.08 cd**
P_3B_2	**1.26 e**	**2.15 c**
P_3B_3	**1.13 f**	**1.95 d-f**
$LSD_{0.05}$	**0.075**	**0.175**
CV (%)	**8.24**	**11.67**

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

P_0 = (Control) B_0 = (Control)

P_1 = 20 kg ha^{-1} B_1 = 1 kg ha^{-1}

P_2 = 30 kg ha^{-1} B_2 = 1.5 kg ha^{-1}

P_3 = 40 kg ha^{-1} B_3 = 2 kg ha^{-1}

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

4.10.1 Effect of phosphorus on biological yield (t ha^{-1})

Biological yield (t ha^{-1}) of BARI Mung-6 differed significantly by the application of different level of phosphorus (Table 6 and Appendix 6). Result revealed that the highest Biological yield (4.36 t ha^{-1}) was recorded from P_2= 30 kg ha^{-1}which was significantly different from all other treatments.The lowest Biological yield (2.46 t ha^{-1}) was recorded from P_0 = No phosphors (Control) followed by P_3 = 40 kg ha^{-1}.

4.10.2 Effect of boron on biological yield (t ha^{-1})

Significant variation was found for different level of boron application on biological yield of BARI Mung-6 (Table 6 and Appendix 6). Result revealed that the highest Biological yield (3.67 t ha^{-1}) was found in B_1 = 1 kg ha^{-1} which was statistically identical with B_2 = 1.5 kg ha^{-1} where the lowest biological yield (2.70 t ha^{-1}) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.

4.10.3 Combined effect of phosphorus and boron on biological yield (t ha^{-1})

The experimental results on biological yield showed significant variation due to combined effect of phosphorus and boron (Table 6 and Appendix 6). The findings revealed that the highest biological yield (4.67 t ha^{-1}) was recorded from P_2B_1 which was statistically same with P_1B_3 andP_2B_2 where the minimum grain yield of BARI Mung-6 (2.37 t ha^{-1}) which was statistically similar with P_0B_1 and P_0B_2.

4. 11Harvest index

4.11.1 Effect of phosphorus on harvest index

Harvest index of BARI Mung-6 differed significantly due to the application of different level of phosphorus (Table 6 and Appendix 6). The highest harvest index (37.31%) was recorded from P_2=30 kg ha^{-1} closelyfollowed by P_3 = 40 kg ha^{-1}while the lowest harvest index (34.50%) was recorded from P_0 = No phosphors (Control) followed by P_1= 20 kg ha^{-1}. Manpreet*et al.* (2004) reported that phosphorus application showed a non-significant effect on number of branchesplant^{-1}, number of seedspod^{-1}, pod length and 1000-seed weight.

However, the increase in P level showed significant increase in grain and straw yields at higher levels (40 and 60 kg ha^{-1}) compared to lower levels (0 and 20 kg ha^{-1}) of P. Harvest index remained unaffected with P application.

4.11.2 Effect of boronon harvest index

Significant variation in terms of harvest index of BARI Mung-6 was recorded for the application of boron (Table 6 and appendix 6). Result revealed that the highest harvest index (37.03%) was found in B_1 = 1 kg ha^{-1} which was statistically similar B_2 = 1.5 kg ha^{-1} where the lowest harvest index (35.37%) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kgha^{-1}.

4.11.3 Combined effect of phosphorus and boronon harvest index

Highly significant variation for combined effect of phosphorus and boron showed on harvest index of BARIMung-6(Table 6 and Appendix 6). The highest harvest index (38.80%) was recorded from P_2B_1 which was statistically similar with $P_2B_2$where the minimum harvest index of BARI Mung-6 (34.15 %) was recorded from P_0B_0 followed by P_0B_2, P_0B_3 and P_0B_1.

Table 6. Response of phosphorus and boron on biological yield harvest indexof BARI Mung-6

Treatments	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
Effect of phosphorus		
P_o	2.46 d	34.50 c
P_1	3.40 b	36.66 b
P_2	4.36 a	37.31 a
P_3	3.18 c	37.03 ab
$LSD_{0.05}$	0.117	0.478
Effect of boron		
B_0	2.70 c	35.37 c
B_1	3.67 a	37.03 a
B_2	3.59 a	36.59 ab
B_3	3.27 b	36.50 b
$LSD_{0.05}$	0.101	0.470
Combined effect of phosphorus and boron		
P_0B_0	2.37 j	34.15 i
P_0B_1	2.56 hi	34.89 g-i
P_0B_2	2.50 i	34.35 i
P_0B_3	2.42 j	34.62 hi
P_1B_0	2.74 f-h	36.16 ef
P_1B_1	4.03 b	37.05 c-e
P_1B_2	3.89 c	36.29 ef
P_1B_3	4.34 a	37.13 c-e
P_2B_0	2.92fg	35.70 fg
P_2B_1	4.67 a	38.80 a
P_2B_2	4.56 a	38.19 ab
P_2B_3	3.25 de	36.53 d-f
P_3B_0	2.77f-h	35.49 f-h
P_3B_1	3.42 d	37.40 b-d
P_3B_2	3.41 d	37.53 b-d
P_3B_3	3.08 f	37.71 bc
$LSD_{0.05}$	0.226	0.955
CV (%)	10.36	9.28

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

P_0 = (Control) **B_0 = (Control)**

$P_1 = 20\ kg\ ha^{-1}$ **$B_1 = 1\ kg\ ha^{-1}$**

$P_2 = 30\ kg\ ha^{-1}$ **$B_2 = 1.5\ kg\ ha^{-1}$**

$P_3 = 40\ kg\ ha^{-}$ **$B_3 = 2\ kg\ ha^{-1}$**

4. 12 Protein content

4.12.1 Effect of phosphorus on protein content

Protein content of BARI Mung-6 differed significantly by the application of different level of phosphorus (Table 7 and Appendix 6). The highest protein content (13.65%) was recorded from P_2= 30 kg ha^{-1}followed by P_1 = 20 kg $ha^{-1}$where the lowest protein content (10.83%) was recorded from P_0 = No phosphors (Control) followed by P_3= 40 kg ha^{-1}.

4.12.2 Effect of boron on protein content

Significant variation in terms of protein content of BARI Mung-6 was recorded by boron application (Table 7 and appendix 6). Result revealed that the highest protein content (12.97%) was found in B_1 = 1 kg ha^{-1} which was statistically identical with B_2 = 1.5 kg ha^{-1} where the lowest protein content (11.69%) was recorded from B_0 = No boron (Control) followed by B_3 = 2 kg ha^{-1}.

4.12.3 Combined effect of phosphorus and boron on protein content

Significant variation was found by the combined effect of phosphorus and boron on protein content of BARI Mung-6 (Table 7 and Appendix 6). The highest protein content (14.78%) was recorded from P_2B_2 which was statistically identical with P_2B_1followed by P_1B_3 where the lowest protein content (10.42%) was recorded from P_0B_0which was statistically similar with P_0B_3 followed by P_0B_2, and P_0B_1.

Table 7. Response of phosphorus and boron on protein contentof BARI Mung-6

Treatments	Protein content (%)
Effect of phosphorus	
P_o	10.83 d
P_1	12.95 b
P_2	13.65 a
P_3	12.52 c
$LSD_{0.05}$	0.653
Effect of boron	
B_0	11.69 c
B_1	12.97 a
B_2	12.88 a
B_3	12.42 b
$LSD_{0.05}$	0.231
Combined effect of phosphorus and boron	
P_0B_0	10.42 h
P_0B_1	11.19 fg
P_0B_2	10.88 g
P_0B_3	10.84 gh
P_1B_0	11.72 f
P_1B_1	13.12 c
P_1B_2	13.04 c
P_1B_3	13.93 b
P_2B_0	12.48 d
P_2B_1	14.71 a
P_2B_2	14.78 a
P_2B_3	12.62 d
P_3B_0	12.13 e
P_3B_1	12.87 d
P_3B_2	12.80 d
P_3B_3	12.28 e
$LSD_{0.05}$	0.554
CV (%)	5.387

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

P_0 = (Control) B_0 = (Control)

P_1 = 20 kg ha^{-1} B_1 = 1 kg ha^{-1}

P_2 = 30 kg ha^{-1} B_2 = 1.5 kg ha^{-1}

P_3 = 40 kg ha^{-1} B_3 = 2 kg ha^{-1}

CHAPTER V

SUMMERY, CONCLUSION AND RECOMMENDATION

The study was conducted at the farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, to find out the effect of different combinations of phosphorus and boron on growth and yield of a selected BARI Mung-6.The treatment of the experiment was laid out with Randomized Complete Block Design (RCBD) with three replication. There were two factors *viz*. phosphorus and boron. Four phosphorus levels *viz*. (i) P_0 = (Control), (ii) P_1 = 20 kgha^{-1}, (iii) P_2 = 30kg ha^{-1} and (iv) P_3 = 40kg ha^{-1} and four levels boron *viz*. (i) B_0 = (Control), (ii) B_1 = 1 kg ha^{-1}, (iii) B_2 = 1.5kg ha^{-1} and (iv) B_3 = 2kg ha^{-1} were considered. Recorded data were collected and analyzed statistically. Data were recorded on different parameters. All the parameters were significantly influenced by different levels of phosphorus and boron. The experimental evidence revealed that to produce more production of BARI mugbean-6 both of phosphorus and boron are effectively needed.

In this experiment, the longest plant (60.66, 77.89 and 81.05 cm at 30 and 45 DAS and at harvest, respectively) and the maximum number of leaves plant^{-1} (11.76, 14.93 and 22.97 at 30 45 DAS and at harvest, respectively) was achieved from P_1 = 20 kg ha^{-1} but the maximum number of branches plant^{-1} (2.96, 4.71 and 5.95 at 30 45 DAS and at harvest, respectively), highest pod length (8.47 cm), highest number of pods plant^{-1} (28.91),highest number of seeds pod^{-1} (10.53), highest 1000 seed weight (37.53 g), highest grain yield (1.95 t ha^{-1}), highest stover yield (2.41 t ha^{-1}), highest biological yield (4.36 t ha^{-1}),highest harvest index (37.31%) and highest protein content (13.65%) were recorded from $P_{2=}$30 kg ha^{-1}while the shortest plant (51.03, 72.76 and 76.36 cm at 30 and 45 DAS and at harvest, respectively), minimum number of leaves plant^{-1} (10.27, 12.78 and 19.44 at 30 and 45 DAS and at harvest, respectively), minimum number of branches plant^{-1} (2.22,3.03 and 4.36 at 30 and 45 DAS and at harvest, respectively), lowest pod length (6.41), lowest number of pods plant^{-1} (16.84), lowest number of seeds pod^{-1} (8.47), lowest 1000 seed weight (33.68 g), lowest grain yield (0.85 t ha^{-1}), lowest stover yield (1.61 t ha^{-1}), lowest biological yield (2.46 t ha^{-1}), lowest harvest index (34.50%) and lowest protein content (10.83%) were recorded from P_0 = Control.

Micronutrients like boron also have the significant effect to achieve the potential yield of mungbean. Intensification of cropping system with adoption of high yielding varieties has resulted in the mining of nutrients from soils leading to nutrients deficiency. The findings showed that, the longest plant (59.65, 75.64 and 80.82 cm at 30 and 45 DAS and at harvest, respectively), maximum number of leaves plant^{-1} (11.65, 14.17 and 22.05 at 30 and 45 DAS and at harvest, respectively), maximum number of branches plant^{-1} (2.95, 4.10 and 5.02 at 30 and 45 DAS and at harvest, respectively), highest of pod length (8.52 cm), highest number of pods plant^{-1} (24.5), highest number of seeds pod^{-1} (10.6), highest 1000 seed weight (37.23 g), highest grain yield (1.38 t ha^{-1}), highest stover yield (2.29 t ha^{-1}), highest biological yield (3.67 t ha^{-1}),highest harvest index (37.03%) and highest protein content (12.97%) were found in B_1 = 1 kg ha^{-1}where thelowest plant height (52.15, 72.90 and 78.34 cm at 30 and 45 DAS and at harvest, respectively), minimum number of leaves plant^{-1} (10.61, 14.01and 20.36 at 30 and 45 DAS and at harvest, respectively), minimum number of branches plant^{-1} (2.37, 3.30 and 4.65 at 30 and 45 DAS and at harvest, respectively), lowest pod length (6.83 cm), lowest number of pods plant^{-1} $^{(}$18.9), lowest number of seeds pod^{-1} (9.22), lowest 1000 seed weight (34.83 g), lowest grain yield (0.94 t ha^{-1}), lowest stover yield (1.76t ha^{-1}), lowest biological yield (2.70 t ha^{-1}),lowest harvest index (35.37%) and lowest protein content (11.69%) were recorded from B_0 = (Control).

Combined effect of phosphorus and boron also showed significant variation of all growth and yield parameter of BARI mugbean-6. The experimental findings revealed that the longest plant (76.75, 77.53 and 83.71 cm at 30 and 45 DAS and at harvest, respectively), maximum number of leaves plant^{-1} (12.85 15.38 and 23.27 at 30 and 45 DAS and at harvest, respectively), maximum number of branches plant^{-1} (3.78, 4.95 and 5.86 at 30 and 45 DAS and at harvest, respectively), highest pod length (10.28 cm), highest number of pods plant^{-1} (35.47), highest number of seeds pod^{-1} (11.60), highest 1000 seed weight (38.72 g), highest grain yield (1.81 t ha^{-1}), highest stover yield (2.86 t ha^{-1}), highest biological yield (4.67 t ha^{-1}) and the highest harvest index (38.80%) were recorded from P_2B_1 while the shortest plant (50.92, 72.20 and 75.25 cm at 30 and 45 DAS and at harvest, respectively), minimum number of leaves plant^{-1} (9.23, 11.02 and 18.44 at 30 and 45 DASand at harvest, respectively), minimum number of branches plant^{-1} (2.10, 2.85 and 4.18 at 30 and 45 DASand at harvest, respectively), lowest pod length (6.16 cm), minimum number of pods plant^{-1} (15.40), minimum number of seeds pod^{-1} (8.62), lowest 1000 seed weight (32.63 g), lowest grain yield (0.81 t ha^{-1}), minimum stover yield (1.56 t ha^{-1}), lowest biological yield (2.37 t ha^{-1}),lowest harvest index (34.15 %) and lowest protein content (10.42%) was recorded from P_0B_0. The highest protein content (14.78%) was recorded from P_2B_2.

From the above results of the present study, it may be concluded that single application of P and B had significant result contribution to improving the yield of BARI Mung-6. The treatments showed the positive effect in most cases and hence may be used for the improvement of yield and quality of BARI Mung-6. From the above findings it can also be concluded that the treatment combination of P_2B_1 (30 kg ha^{-1}phosphorus and 1 kg ha^{-1}boron) along with recommended rate of N, K and Zn fertilizers significantly increased plant growth, yield and protein content ofBARI Mung-6 and this treatment combination can be treated as the best treatment considering all other combination in respect of yield and yield contributing characters.

Recommendations

The following recommendations are proposed here under:

1. In order to produce higher grain yield and quality mungbean, farmers may apply 30 kg P ha^{-1}, and 1 kg B ha^{-1} from TSP, and boric acid, respectively.

2. Before making final conclusion, further trials with the same treatment combinations on different locations of Bangladesh would be useful. However, further investigation is necessary for the other soil types under different AEZ in Bangladesh.

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APPENDICES

Appendix 1. Monthly records of Temperature, Rainfall, and Relative humidity of the experiment site during the period from April 2015 to July 2015

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2015	April	33.50	25.90	299.20	68.50	1.00	194.10
2015	May	34.90	27.00	30.95	61.00	2.00	221.50
2015	June	35.60	29.30	32.45	72.65	2.50	229.40
2015	July	35.80	29.60	32.70	75.70	2.70	230.50

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

Appendix 2. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (meq)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.83

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix 3. Response of phosphorus and boron on plant height of BARI Mung-6

Source of variation	Degrees of freedom	Mean square of plant height (cm)		
		30 DAS	45 DAS	At harvest
Replication	2	1.117	0.336	1.512
Factor A	2	6.242*	4.016**	6.336*
Factor B	2	10.212*	9.627*	9.523*
AB	4	14.123*	6.873*	3.623*
Error	16	2.665	2.581	1.697

Appendix 4. Response of phosphorus and boron on number of leaves per plant of BARI Mung-6

Source of variation	Degrees of freedom	Mean square of number of leaves per plant		
		30 DAS	45 DAS	At harvest
Replication	2	0.469	0.553	0.248
Factor A	2	5.227**	5.329*	3.161**
Factor B	2	7.262*	8.118*	5.064*
AB	4	11.03*	4.014**	6.426*
Error	16	2.223	1.365	1.428

Appendix 5. Response of phosphorus and boron on number of branches plant^{-1} of BARI Mung-6

Source of variation	Degrees of freedom	Mean square of number of branches per plant		
		30 DAS	45 DAS	At harvest
Replication	2	0.311	1.125	2.314
Factor A	2	7.275*	3.328*	8.4641*
Factor B	2	9.111*	6.137*	14.146**
AB	4	5.475**	8.638*	12.149*
Error	16	2.318	2.626	1.311

Appendix 6. Response of phosphorus and boron on yield contributing characters of BARI Mung-6

Source of variation	Degrees of freedom	Mean square of		
		Pod length (cm)	Number of pods plant^{-1}	Number of seeds pod^{-1}
Replication	2	0.086	0.383	0.384
Factor A	2	5.616*	4.562*	5.632*
Factor B	2	8.231*	8.474**	8.256**
AB	4	5.383**	7.188*	3.624*
Error	16	1.064	2.278	2.379

Appendix 7. Response of phosphorus and boron on yield and yield contributing characters of BARI Mung-6

Source of variation	Degrees of freedom	Mean square of					
		Weight of 1000 seeds (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Protein content (%)
Replication	2	0.664	0.223	3.317	1.353	2.948	0.126
Factor A	2	9.59*	5.214*	2.039*	5.392**	6.636*	3.276*
Factor B	2	7.07*	9.726**	1.797*	8.486*	6.674**	4.299**
AB	4	4.63**	6.247*	2.613*	6.349*	7.238**	6.327*
Error	16	1.652	2.788	1.127	1.147	2.127	0.376