INFLUENCE OF PHOSPHORUS AND BORON ON THE GROWTH AND YIELD OF MUNGBEAN (BARI MUNG-5)

By

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CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF PHOSPHORUS AND BORON ON THE GROWTH AND YIELD OF MUNGBEAN (*greengram*)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN SOIL SCIENCE**, embodies the result of a piece of *bonafide* research work carried out by **MD. KHALED HOSSAIN**, Registration No. 00922 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged by him.

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INFLUENCE OF PHOSPHORUS AND BORON ON THE GROWTH AND YIELD OF MUNGBEAN (BARI MUNG-5)

ABSTRACT

A field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka during the period from March, 2008 to May, 2008 to study the influence of phosphorus and boron alone and in combination on the growth and yield of BARI Mung 5 (*Vigna radiata*). The experiment included four levels of phosphorus viz., 0, 15, 30 and 45 kg P ha^{-1} and four levels of boron viz., 0, 0.5, 1 and 2 kg B ha^{-1}. The experiment was laid out in a Randomized Complete Block Design with three replications. Phosphorus showed significant influence on yield and yield attributes of mungbean. Application of phosphorus @ 30 kg ha^{-1} produced the highest plant height, pod $plant^{-1}$, pod length, seeds pod^{-1}, 1000-seed weight, stover yield except number of branches $plant^{-1}$. In all the cases lower values were found with the control treatment. Boron fertilizer also had significant effect on yield and yield attributes of mungbean. Application of boron @ 1 kg ha^{-1} gave the highest seed yield, pods $plant^{-1}$, seeds pod^{-1}, 1000-seed weight, stover yield except plant height. In all cases the lower values were found with the control treatment. Phosphorus @ 30 kg ha^{-1} was found statistically superior to all other treatments. Phosphorus in combination with boron showed significant effect on yield and yield attributes of mungbean. Combined application of phosphorus @ 30 kg and boron @ 1 kg ha^{-1} resulted the highest seed yield, plant height, stover yield and total content of P and B by mungbean. On the other hand, in all the cases lower values were found in the control treatment. The addition of P and B not only increased the yield but also protect the soil from total exhaustion of nutrients.

LIST OF ABBRIVIATIONS

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
@	At the rate of
B	Boron
cm	Centimeter
cv.	Cultivar(s)
CV%	Percentage of Coefficient of Variance
DAS	Days After Sowing
DMRT	Duncan's Multiple Range Test
e.g.	As for example
et al.	and others
g	Gram
i.e.	that is
K	Potassium
kg	Kilogram
kg ha^{-1}	Kg per hectare
LSD	Least Significant Difference
S	Sulphur
TSP	Triple Super Phosphate
m	Meter
MP	Muriate of Potash
N	Nitrogen
NaOH	Sodium Hydroxide
P	Phosphorus
NS	Not Significant
OM	Organic matter
pH	Negative logarithm of Hydrogen ion concentration
^{0}C	Degree Celsius
%	Percent
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
t ha^{-1}	Ton per hectare

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CHAPTER 1

INTRODUCTION

Pulse is a common item in the daily diet of the people of Bangladesh. Pulses have been considered poor men's meat since they are the source of protein for the underprivileged people who can not afford animal protein. It is taken mostly in the form of soup. Many of the pulse seeds are consumed as raw when they are in green stage. Generally there is no complete dish without "dal" in Bangladesh.

In Bangladesh, daily consumption of pulses is only 13.29 g capita^{-1} (BBS, 2001), while The World Health Organization (WHO) suggested 45 g capita^{-1} for a balanced diet. Due to shortage of production approximately, 108,000 m ton pulses are imported in Bangladesh in each year (BBS, 2001).Moreover, adding of legume in cereal based cropping system can improve soil structure, nutrient exchange and maintain healthy sustainable soil system. Grain legumes are believed to add 20-60 kg N ha^{-1} to the succeeding crop.

The major cropping pattern in Bangladesh consists of two major crops of rice (i.e. winter rice-fellow-summer rice) covering 1.8 million ha. In Bangladesh, more than 75% of the total cropping area is occupied by rice where pulse crop covers only 2.8% of the total cropping area. Mungbean (*Vigna radiata)* is one of the important pulse crops of Bangladesh. Among the pulse crops the largest area is covered by lentil (40.17%) and mungbean is grown in only 6.34% area. The area under mungbean cultivation is gradually decreasing. In the year 2002-2003 the area under mungbean cultivation was 109 thousand acres that declined to 60 thousand acres in the year 2004-2005 (BBS, 2005). The total production of mungbean in Bangladesh from the year 2001-2002 to 2005-2006 was 31, 30, 30, 18 and 17 thousand tones, respectively. In these years the total production of mungbean in this country decreased by 3% to 40% (BBS, 2006). In Bangladesh most of the mungbean area (~65%) is located in the southern part of the country where mungbean is fitted in T.aman rice – mungbean -

fallow or Aus rice - T.aman rice – mungbean cropping system. Pulses contribute about 2% to the total food grain production in Bangladesh.

Pulses are not widely grown in Bangladesh. In the level arable land, wheat and Boro rice crops do not leave much scope for the expansion of pulses, particularly where irrigation is possible. This leaves only the Aus season (spring rice crop) as a possibility for incorporating the pulses and thus making a breakthrough in their acreage and production. There is a definite gap in the Aus season which can be filled with summer pulses, mungbean and blackgram.

Mungbean production in Asia has increased substantially in the past 20 years. In Bangladesh production increased with an annual average growth rate of 6.7% between 1972 and 2002 compared with the average 3.5% for all pulses. During the same period, area under mungbean has doubled, from 5.3% (in all pulses) to 11.5%. In 2002, a total of 45,600 ha were under production and average yield levels were 680 kg ha^{-1}, higher than the neighboring India, but lower than other countries such as Thailand and Myanmar. However, despite the impressive growth of overall production, increase in productivity has actually been rather low. Between 1972 and 2002, average annual yield increases were only 0.1%, compared to yield increase in pulses as a whole at 0.5% and paddy at 2.4%. The profitability of mungbean production ranges from 7,700 Taka/ha to 12,856 Taka/ha. In comparison, the profitability of Boro rice was only 6,424 Taka.

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 4 t ha^{-1} (Ramakrishna *et al.*, 2000). Low yields of grain legumes, including mungbean make the crop less competitive with cereals and high value crops. To enhance the yield, Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangabandhu Sheikh Mujibur Rahman

Agricultural University (BSMRAU) developed 14 mungbean varieties with high yield potentials in recent years.

Among them BARI mung-5 (*Vigna radiata L.*) is one of the most important pulses in Bangladesh. It belongs to the family *Leguminosae*. BARI Mung-5 *(Vigna radiata)* (Reg. No. 2 (03)-07/97) is a bold seeded, high-yielding, photo insensitive variety, tolerant to MYMV disease, and widely adapted to mungbean growing areas in Bangladesh. It was developed from the NM-92 line introduced by AVRDC in 1992. The special characteristic of this variety is its synchronized maturity. It was included in regional yield trials and tested at several locations covering most of the pulse-growing areas over several years.

It is originated in South and Southeast Asia (India, Burma, Thailand etc.). Now it is widely grown in India, Pakistan, Bangladesh, Burma, Thailand, Philipines, China and Indonesia. It is also grown in parts of east and central Africa, the West Indies, USA and Australia. BARIMUNG-5 was released in Bangladesh in 1997 as a high yielding variety. It fits well in crop rotation between two cereal crops and breaks the build up of disease, insect and weed syndrome. It fixes nitrogen in symbiosis with *Rhizobia* and enriches the soil. Its root breaks the plough pan of puddle rice fields.

The excessive uses of urea, imbalanced use of phosphate and potassium fertilizers in the field of different crops without considering the other micro or macronutrients are a common practice in Bangladesh. A balanced supply of essential nutrients is indispensable for optimum plant growth. Continuous use of large amounts of only N, P and K is expected to influence not only the availability of other nutrients to plants because of possible interaction between them but also the build up of some of the nutrients creating imbalances in soils and plants leading to decreased fertilizer use efficiency. The essential elements must be present in soil in optimum levels and in available forms for normal plant growth and development (Nayyar and Chhibba, 1992).

The essential elements must be present in soil in optimum levels and in available forms for normal plant growth and development. It is essential to identify the status of these essential nutrients, how they decrease or increase yield and quality of crop and the way by which their available amounts can be maintained in forms and at levels that can give high crop production in the long-term use. Obviously, it is very difficult to determine the exact reason what occurs. But it is clear that this occurs consistently under a particular soil, crop or seasonal condition and then it is a factor that must be considered in sound fertilizer recommendation (Tandon, 1992).

Phosphorus plays a remarkable role in plant physiological processes. It is an essential constituent of majority of enzymes which are of great importance in the transformation of energy in carbohydrate metabolism in different types of plants and is closely related in cell division and grain development. Phosphorus is a key constituent of ATP and it plays a significant role in the energy transformation in plants (Sankar *et al.*, 1984) and also in various physiological processes (Sivasankar *et al.*1982). It is also essential for energy storage and release in living cells. Experimental findings of Arya and Kalra (1988) revealed that application of phosphorus had no effect on the growth of mungbean, while number of grains per pod, weight of 1000-seeds were found to be increased with increasing level of Phosphorus from zero to 50 kg P_2O_5 ha^{-1}.

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

Although sporadic research works regarding response of mungbean to phosphorus and boron were done but the influence of phosphorus and boron on the yield of mungbean and their interaction (P×B), seed quality and yield are still scanty.

Therefore, to study the influences of phosphorus and boron on the yield of mungbean was undertaken with the following objectives:

Objectives:

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

REVIEW OF LITERATURE

Pulses are important both as human and animal food. They also improve soil health. Pulses play a vital role in the national economy and in the diet. They have been neglected by most pulse growing countries including Bangladesh. Research on the influence of phosphorus and boron on mungbean are limited particularly in Bangladesh.

However, some available information on the effect of phosphorus and boron on growth and yield of mungbean as well as of some other legume crops has been reviewed in this chapter.

Effect of phosphorus on growth and yield of mungbean

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 plants m^{-2}, 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.

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). The protein content in seed increased significantly with application of 60 kg P_2O_5 ha^{-1}.

A study was conducted by Umar *et al.* (2001) in Faysalabad, Pakistan to determine the effect of phosphorus application on growth and yield of mungbean on a sandy clay loam soil under irrigated conditions. Plant height and number 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.

Ram and Dixit (2000) carried out a field trial during 1987 at Faisabad, Uttar Pradesh, India, mungbean cv. K-851 was sown on 20 or 30 March or 9 April and given 0, 20, 40 and 60 kg P ha^{-1} and observed that nodulation increased with the increasing P rates.

Mastan *et al.* (1999) stated that the number of pods $plants^{-1}$ of summer mungbean cv. LGG 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 $P_2O_5ha^{-1}$.

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.

Singh *et al.* (1999) carried out an experiment on mungbean cv. NDM-1 at Faisabad, Uttar Pradesh, India in summer 1996 and noted that number of branches/plant generally increased with up to 26.4kg P 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.

Shukla and Dixit (1996a) studied in a field experiment with mungbean and reported that the application of phosphorus increased the nodulation owing to better root growth, which increased the N uptake in plant.

Shukla and Dixit (1996b) conducted a field trial to study the response of mungbean to different levels of phosphorus. They also reported that application of phosphorus up to 40 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.

Sharma and Singh (1993) stated that higher doses of application of phosphorus decreased the grain and straw yields of greengram and adversely affected the yield contributing characteristics.

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.

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

In a field experiment, 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.

Singh and Hiremath (1990) in a field trail with mungbean reported that application of phosphorus @ 20 kg P_2O_5 ha^{-1} increased 1000-seed weight and seed yield over control.

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}.

Singh and Ram (1989) observed that phosphorus concentration of chickpea increased with applied phosphorus because of greater root proliferation but higher doses of phosphorus decrease the concentration owing to depression effect.

Kalita (1989) conducted an experiment in 1986-88, 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.

An experiment of mungbean was carried out by Arya and Kalra (1988) at Meerut, India The 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.

A field trial was carried out by Sandra and Verma (1987) in New Delhi, India in 1983-84 and observed that application of nitrogen and phosphorus fertilizers resulted in significant increases in number of pods plants^{-1} of mungbean.

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.

Singh and Saxena (1986) reported that phosphorus application significantly increased plant height, phosphorus content but not affect the number branches per plant.

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.

Islam and Noor (1982) showed that percent P and N and their uptake were markedly increased by applying phosphorus up to 60 kg P_2O_5 ha^{-1}, percent protein was hardly affected.

Patil and Somawanshi (1982) reported that application of phosphorus significantly increased the grain and straw yields of greengram.

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

In an experiment, Yein *et al.* (1981) applied nitrogen and phosphorus fertilizers to mungbean and reported that combined application of nitrogen and phosphorus fertilizers increased the number of pods $plants^{-1}$.

Anwar *et al.* (1981) reported beneficial effect of P application on greengram in respect to number of pods $plants^{-1}$, 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.

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

Srivastava and Varma (1981) worked on greengram and reported that P increased grain and straw yield as well as the harvest index.

Ali and Bhuiya (1979) reported that phosphorus applications increased the phosphorus content of mungbean grain and straw on most soils of Bangladesh.

Phosphorus-sulphur interaction was studied by Aulakh and Pasricha (1977). They observed a negative significant interaction between phosphorus and sulphur on growth, yield, quality and concentrations of phosphorus and sulphur in grain as well as straw of mungbean. They found that the grain yield was increased with the application of S and P individually.

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.

Phosphorus application resulted in substantial increase of total nitrogen of mungbean leaves (Arora and Luthra, 1971).

Effect of boron on growth and yield of mungbean

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

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

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

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

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

Yang YongHua and Zhang Hong Yan (1998) observed that the addition of B promoted elongation of epicotyl and hypocotyl of mungbean and increased seedling height and dry weight. High concentrations of B decreased soluble protein.

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

Dwivedi *et al.* (1997) studied that phosphorus had a significant positive effect on protein content of blackgram but higher doses of phosphorus had a detrimental effect on containing amino acid.

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

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

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

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

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

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

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

Sakal *et al.* (1990) carried out field trails at 7 sites in North Bihar, India. They observed the seed yield of chickpea increased from 1.4t with no B to 1.79 t/ha with 3kg B/ha. The yield response to B application was grater on low B soils. It was concluded that on soils <0.35 ppm, 3 kg B/ha was optimum and on soils >0.35 ppm B, 2kg B ha^{-1} was optimum.

Boron concentration in all crops increased significantly with increasing level of applied boron. It is also reported that increased level of boron application in mustard increased tissue B content (Yadav and Manchanda 1982; Dutta *et al.*, 1984 and Yang *et al.*, 1989).

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

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

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

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

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

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

Dugger (1983) and Lewis, (1980) reported that the function of boron is primarily extra cellular and related to lignifications and xylem differentiation, membrane stabilization and altered enzyme reactions. Plants absorb B principally in the form of H_3BO_3 and to a smaller extent as $B_4O_7^{2-}$, H_2BO^{3-} and HBO_3^{2-}. The element plays a vital role in the physiological processes of plants such as cell nutrition, cell elongation and cell division, carbohydrate, protein and nucleic acid metabolism, cytokinins synthesis, auxins and phenol metabolism.

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

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

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

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

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

Gupta (1979) reported that boron is a micronutrient requiring for plant growth relatively to a smaller amount. The total B content of soils lies between 20 and 200 ppm with the available (hot water soluble) B fraction ranging from 0.4 to 0.5 ppm .

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

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

Interaction effect of phosphorus and boron

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

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

Roy *et al.* (1992) observed that combined application of 60 kg P_2O_5 ha^{-1} and 20 kg borax ha^{-1} in soil increased seed yield of lentil.

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

Wani *et al.* (1988) observed that B-enriched superphosphate was more effective than single superphosphate. The application of B-enriched superphosphate or single superphosphate at 100 kg P_2O_5 ha^{-1} gave pod yields of 1.92 and 1.76 t ha^{-1}, protein contents of 28.81and 27.88% and oil contents of 48.67 and 46.25% , respectively compared with 1.42 t/ha, 25.32% and 45.37 %, respectively found in B and P control treatment.

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

Singh and Singh (1983) carried out an experiment on lentil with an alluvial sandy soil of pH 8.5 and 0.43 ppm hot water extractable B, increasing levels of applied B from 0 to 8.0 ppm increased the P content in 6 weeks old lentil shoots from 0.70 to 1.50 % and boron concentration from 56.7 to 413.3 ppm. The dry matter yield decreased from 2.70 to 1.66 g pot^{-1}. Similarly, the application of 0 to 6 ppm B in a non-calcareous sierozem sandy soil of pH 8.2 and 0.43 ppm hot water soluble B under screenhouse condition increased the P content in 6 week old chickpea shoots from 0.75 to 1.60 %.

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

Tanaka (1967) found that addition of P increased the B concentration in radish.

CHAPTER - III
MATERIALS AND METHODS

This chapter includes a brief description of the experimental soil, mungbean variety, land preparation, experimental design, treatments, cultural operations, collection of soil and plant samples etc. and analytical methods followed in the experiment. The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Sher-e-Bangla Nagar, Dhaka during 12^{th} February, 2008 to 5^{th} May, 2008 to find out the effect of phosphorus and boron on the growth and yield of mungbean (variety BARI MUNG 5)

3.1 Experimental site and soil

The experimental site was located at $23^{0}77^{'}$ N latitude and $90^{0}3^{'}$ E longitude with an elevation of 1.0 meter from sea level (Fig. 1). The soil of the experimental site belongs to Tejgaon series under the Agro-ecological zone, Madhupur Tract (AEZ -28), which falls into Deep Red Brown Terrace Soils. Soil samples were collected from the experimental plots to a depth of 0-15 cm before initiation of the experiment and analyzed in the laboratory. The morphological characteristics of the experimental field and initial physical and chemical properties of soil are shown in Tables 3.1 and 3.2.

Figure 1. Map showing the experimental site under study

Table 3.1 Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Farm, Dhaka
AEZ No. and name	AEZ-28, Modhupur Tract
General soil type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of Inundation	Above flood level
Drainage condition	Well drained
Land type	High land

Table 3.2 Initial physical and chemical properties of the experimental soil

Soil properties	Value
A. Physical properties	
1. Particle size analysis of soil.	
% Sand	29.93
% Silt	40.27
% Clay	29.80
2. Soil texture	Clay loam
B. Chemical properties	
1. Soil pH	5.82
2. Organic carbon (%)	0.61
3. Organic matter (%)	1.05
4. Total N (%)	0.08
5. Available P (ppm)	12.78
6. Available K (ppm)	43.29
7. Available S (ppm)	23.74
8. Available B (ppm)	0.36

3.2 Climate

The experimental area has sub tropical climate characterized by heavy rainfall during May to September and scantly rainfall during rest of the year. The annual precipitation of the site is 2152 mm and potential evapotranspiration is 1297 mm. The experiment was carried out during *March to June*, 2008. Air temperature during the cropping period ranged from 23.32^0C to 33.20^0 C. The relative humidity varied from 62.55% to 94.70% and monthly rainfall varied from 2.54 mm to7.7 mm from the beginning of the experiment to harvest. The monthly maximum and minimum temperature, humidity and rainfall of the site during the experimental period are given in appendix Table 1.

3.3 Seeds and variety

BARI Mung-5 *(Vigna radiata)* (Reg. No. 2(03)-07/97) is a bold seeded, high-yielding, photo insensitive variety, tolerant to MYMV disease, and widely adapted to mungbean growing areas in Bangladesh. It was developed from the NM-92 line introduced by AVRDC in 1992. The special characteristic of this variety is its synchronized maturity. It was included in regional yield trials and tested at several locations covering most of the pulse-growing areas over several years.

BARI mung-5 was developed by Bangladesh Agricultural Research Institute characterized as of 40-45 cm in height, life cycle lasts for 55-58 days and synchronous type. The plants are erect, stiff and less branched. Each plant contains 15-20 pods. Each pod is approximately 10 cm. long and contains 8-10 seeds. Seeds are green in colour and drum shaped. On the other hand, the plants of the local variety are 70-80 cm. in height, life cycle lasts for 75-80 days and asynchronous type. The plants are erect and branched. Each plants contains 25-30 pods and the pods are around 6-7 cm. long. Each pod contains 10-12 seeds.

The seeds are small and light green in colour. The seed yield of BARI mung-5 ranges from 1.2 to 1.5 t ha^{-1}, while the local variety gives yield around 1 t ha^{-1}.

3.4 Design and layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations. Fertilizer treatments consisted of 4 levels of P (0, 15, 30 and 45 kg P ha^{-1} designated as P_0, P_1, P_2 and P_3, respectively) and 4 levels of B (0, 0.5, 1 and 2 kg B ha^{-1} designated as B_0, B_1, B_2 and B_3, respectively). There were 16 treatment combinations. The treatment combinations were as follows:

A. Rates of phosphorus (4):

1. P_0 = No phosphorus
2. P_1 = 15 kg P ha^{-1}
3. P_2 = 30 kg P ha^{-1}
4. P_3 = 45 kg P ha^{-1}

B. Rates of boron (4):

1. B_0 = No boron
2. B_1 = 0.5kg B ha^{-1}
3. B_2 = 1.0 kg B ha^{-1}
4. B_3 = 2.0 kg B ha^{-1}

Treatment Combinations

1. P_0B_0 = Control (without P and B)
2. P_0B_1 = 0 kg P ha^{-1} + 0.5 kg B ha^{-1}
3. P_0B_2 = 0 kg P ha^{-1} + 1 kg B ha^{-1}
4. P_0B_3 = 0 kg P ha^{-1} + 2 kg B ha^{-1}
5. P_1B_0 = 15 kg P ha^{-1} + 0 kg B ha^{-1}
6. P_1B_1 = 15 kg P ha^{-1} + 0.5 kg B ha^{-1}
7. P_1B_2 = 15 kg P ha^{-1} + 1 kg B ha^{-1}
8. P_1B_3 = 15 kg P ha^{-1} + 2 kg B ha^{-1}
9. P_2B_0 = 30 kg P ha^{-1} + 0 kg B ha^{-1}
10. P_2B_1 = 30 kg P ha^{-1} + 0.5 kg B ha^{-1}
11. P_2B_2 = 30 kg P ha^{-1} + 1 kg B ha^{-1}
12. P_2B_3 = 30 kg P ha^{-1} + 2 kg B ha^{-1}
13. P_3B_0 = 45 kg P ha^{-1} + 0 kg B ha^{-1}
14. P_3B_1 = 45 kg P ha^{-1} + 0.5 kg B ha^{-1}
15. P_3B_2 = 45 kg P ha^{-1} + 1 kg B ha^{-1}
16. P_3B_3 = 45 kg P ha^{-1} + 2 kg B ha^{-1}

Fertilizer treatments were randomly distributed in each block. Each block consisted of 16 plots and individual plot was 3m × 2m i.e., 6 sq. m in size. The row to row distance was 30 cm. Seeds were sown in continuous line. The adjacent block and neighboring plots were separated by 1.0 m and 0.5 m, respectively.

3.5 Collection and processing of composite soil sample

Soil samples from the experimental field were collected before land preparation to a depth of 0-15 cm from the surface on the basis of composite sampling method. The collected soil was air-dried, ground and passed through a 2-mm sieve and stored in a clean, dried plastic container for physical and chemical analysis.

3.6 Land preparation

The land was first ploughed with a tractor drawn disc plough on 1 March, 2008. Ploughed soil was brought into desirable tilth condition by four operations of ploughing and harrowing with country plough and ladder. The stubbles of the previous crops and weeds were removed. The land preparation was completed on 3 March, 2008. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

3.7 Application of fertilizers

Recommended doses of N, K and S (20 kg N from urea, 25 kg K from MP and 15 kg S ha^{-1} from gypsum, respectively) were applied.

The whole amounts of Urea, MP and gypsum fertilizer were applied as basal dose during final land preparation. The required amounts of P (from TSP) and B (from boric acid) were applied at a time as per treatment combination after field lay out of the experiment and were mixed properly through hand spading.

3.8 Seed sowing

Seeds were sown continuously on 4 March, 2008 by hand as uniform as possible in the 30cm apart lines. A strip of the same crop was established around the experimental field as border crop. After sowing the seeds were covered with soil and slightly pressed by laddering.

3.9 Weeding and thinning

Weeds of different types were controlled manually and removed from the field. The thinning was done on March 16, 2008. The weeding was done after 25 days of sowing, on March 30, 2008. Care was taken to maintain constant plant population per plot.

3.10 Irrigation

Irrigation was done at one time. The irrigation was given in the field on 35 days after sowing (DAS) through irrigation channel.

3.11 Pest management

The crop was infested with aphids (*Lipaphis erysimi*) at the time of pod initiation. The insects were controlled successfully by spraying Ripcord 10 EC @ 1ml L^{-1} water. The insecticide was sprayed on April 4, 2008. The crop was kept under constant observations from sowing to harvesting. The crop was also affected with brown leaf spot (*Sarcospora sp*). The disease was controlled by spraying Bavistin 10 EC @ 0.2% L^{-1}.

3.12 Harvesting and threshing

The crop was harvested plot wise when 90% pods were matured. After collecting sample plants, harvesting was done on 5 May, 2008. Pods were collected by hands for two times. The harvested pods were carried to the threshing floor. The pods were sun dried on the threshing floor. The seeds were separated from the stover. Per plot yields of grain and straw were recorded after drying the plants in the sun followed by threshing and cleaning. At harvest, grain yield was recorded plot wise and expressed on hectare basis. Oven dried grains were kept in desiccators for chemical analysis.

3.13 Collection of experimental 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:

1. Plant height (cm)
2. Number of primary branch plant^{-1}
3. Number of pod plant^{-1}
4. Pod length (cm)
5. Number of seeds pod^{-1}
6. Weight of 1000 seeds (g)
7. Seed yield (t ha^{-1})
8. Stover yield (t ha^{-1})
9. N, P, K, S and B contents in seed (%)
10. N, P, K, S and B contents in plant (%)
14. N, P, K, S and B contents in post harvest soil.

3.13.1 Plant height

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

3.13.2 No. of branches plant^{-1}

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

3.13.3 No. of pods plant^{-1}

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

3.13.4 No. of seeds pod^{-1}

It was done after harvesting. At first, number of seeds pod^{-1} was counted. Seeds of 10 pods randomly from each plot were counted and averaged.

3.13.5 Pod length

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

3.13.6 Thousand seed weight

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

3.13.7 Grain yield

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

3.13.8 Stover yield

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

3.14 Chemical analysis of the plant and soil samples

3.14.1 Plant sample analysis

The plant samples collected from different treatment combinations were digested with conc. HNO_3 and $HClO_4$ mixture for the determination of total P, K and S.

3.14.1. a) Phosphorous

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

3.14.1. b) Potassium

Ammonium acetate extractable K potassium was extracted from soil by 1N ammonium acetate. The exchangeable potassium content in plant samples were determined by flame photometer (Black, 1965).

3.14.1. c) Sulphur

Sulphur content in the digests were determined by turbidimetric method as described by Hunt (1980) using a Spectrophotometer (LKB Novaspac, 4049).

3.14.1. d) Nitrogen

Plant samples were digested with 30% H_2O_2, conc. 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. Total nitrogen in the digests were 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).

3.14.2 Soil sample analysis

The soil samples collected from the plots were chemically analyzed for the determination of N, P, K, S and B.

3.14.2. a) Particle size analysis of soil

Particle size analysis of the soil was done by hydrometer method (Bouyoucos, 1927). The textural class was determined using Marshall's Triangular co-ordinate as designated by USDA (1951).

3.14.2. b) Organic carbon (%)

Soil organic carbon was determined by Walkley and Black's wet oxidation method as outlined by Jackson (1973) from the samples collected before sowing and also after harvesting the crop.

3.14.2. c) Organic matter (%)

The organic matter content was calculated by multiplying the percent organic carbon with Van Bemmelen factor 1.724 (Piper, 1942)

% organic matter = % organic carbon × 1.724

3.14.2. d) Total nitrogen

Total nitrogen of soil samples were estimated by Micro-Kjeldahl method where soils were digested with 30% H_2O_2 conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Selenium powder in the ratio 100 :10 :1, respectively). Nitrogen in the digests were 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).

3.14.2. e) Available phosphorous (ppm)

Available phosphorous was extracted from the soil by Bray-1 method (Bray and Kurtz, 1945). Phosphorous in the extract was determined by ascorbic acid blue color method (Murphy and Riley, 1962) with the help of a Spectrophotometer (LKB Novaspec, 4049).

3.14.2. f) Available potassium (ppm)

Available potassium was extracted from soil by 1N ammonium acetate. The exchangeable potassium content in plant samples were determined by flame photometer (Black, 1965).

3.14.2. g) Available sulphur (ppm)

Available sulphur was extracted from the soil with Ca $(H_2PO_4)_2$. H_2O (Fox, *et. al.*, 1964). Sulphur in the extract was determined by the turbidimetric method as described by Hunt (1980) using a Spectrophotometer (LKB Novaspec, 4049). The intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

3.14.2. h) Available boron (ppm)

Available boron (B) content in the soil samples were determined by the method described by Hunter (1984). The extracting agent used was monocalcium phosphate $[CaH_4(PO_4)_2 . H_2O]$ solution and colour was developed by curcumin solution. The absorbance was read on spectrophotometer at 555 nm wavelength.

3.14.2. i) Soil pH

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

3.15 Methods for seed analysis

For determination of total N, P, K, S and B contents in seed the samples were first digested with H_2SO_4 and determination of the elements in the digest were performed either by titration (for N) or by colorimetric methods (for B). For N, digestion was done with conc. H_2SO_4 and digest was distilled following the procedure outlined under soil analysis section (3.14.1.d). While for B, digestion was performed by diacid mixture (HNO_3 and $HClO_4$ in the ratio of 2:1). The amount of the element in the digest was estimated following the procedure described under soil analysis section (3.14.2.h).

3.17 Statistical Analysis

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

CHAPTER 4
RESULTS AND DISCUSSION

The results on different yield attributes, yield, nutrient concentrations in the plants and grains and availability of different nutrients in the soil after harvest of mungbean are presented in this chapter.

4.1 Plant height

4.1.1 Effect of phosphorus on the plant height of mungbean

The effects of phosphorus on the plant height of mungbean are presented in Table 4.1. Significant variation was observed on the plant height of mungbean when the field was fertilized with different doses of phosphorus. Among the different doses of phosphorus, P_2 (30 kg P ha^{-1}) showed the highest plant height (40.16 cm) and it was closely followed by (38.14cm) in P_3 (45 kg P ha^{-1}) treatment. On the other hand, the lowest plant height (36.02 cm) was observed in the P_0 treatment where phosphorus was not applied. It was observed that plant height increased gradually with the increment of phosphorus doses. This might be due to higher availability of N P S K and their uptake that progressively enhanced the vegetative growth of the plant. This result is similar with the findings of some other researchers, e.g. Sharma and Singh (1997) found significant increase in plant height of greengram due to the application of 30 kg P ha^{-1}.

Table 4.1 Effect of phosphorus on the growth parameters of mungbean

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}
P_0	36.02 c	8.617 c	14.31 c	9.558 c
P_1	37.71 b	9.083 a	16.26 b	10.67 b
P_2	40.16 a	8.975 ab	17.25 a	11.36 a
P_3	38.14 b	8.842 b	16.21 b	10.88 b
LSD	**0.55**	**0.139**	**0.36**	**0.31**
Significance level	**5%**	**5%**	**5%**	**5%**

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

4.1.2 Effect of boron on the plant height of mungbean

Mungbean showed significant variation in respect of plant height when boron fertilizer in different doses were applied (Table 4.2). Among the different fertilizer doses, B_3 (2 kg B ha^{-1}) showed the highest plant height (38.61cm), which was significantly different from the fertilizer dose B_2 (1 kg B ha^{-1}) and B_1 (0.5 kg B ha^{-1}). On the contrary, the lowest plant height (36.26 cm) was observed in the treatment where no boron fertilizer was applied.

Table 4.2 Effect of boron on the growth parameters of mungbean

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}
B_0	36.26 b	8.692 b	15.81 b	10.34 b
B_1	37.86 b	8.925 a	15.91 b	10.63 ab
B_2	37.69 b	9.017 a	16.48 a	10.93 a
B_3	38.61 a	8.883 a	15.83 b	10.57 b
LSD	**0.55**	**0.39**	**19.25**	**0.31**
Significance level	**5%**	**5%**	**5%**	**5%**

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

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

Combined application of different doses of phosphorus and boron fertilizers had significant effect on the plant height of mungbean (Table 4.3). The lowest plant height (34.93 cm) was observed in the treatment combination of P_0B_0 (No phosphorus and No boron). On the other hand, the highest plant height (41.78 cm) was recorded with P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) treatment.

Table 4.3 Interaction effect of phosphorus and boron on the growth parameters of mungbean

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}
P_0B_0	34.93 h	7.83 g	14.03 f	9.03 g
P_0B_1	35.56 gh	9.17 ab	14.10 ef	9.67 f
P_0B_2	37.40 e	8.97 bc	14.83 e	9.77 f
P_0B_3	36.19 fg	9.40 a	14.27 ef	9.77 f
P_1B_0	37.62 e	9.20 ab	15.67 d	10.10 ef
P_1B_1	37.32 ef	8.97 bc	16.10 cd	10.27 d-f
P_1B_2	37.93 de	9.07 bc	16.70 bc	11.17 a-c
P_1B_3	37.95 de	9.10 ab	16.57 bc	11.13 a-c
P_2B_0	39.77 bc	8.97 bc	16.87 bc	11.47 ab
P_2B_1	39.43 bc	8.93 b-d	17.23 b	11.37 ab
P_2B_2	41.78 a	9.40 a	18.10 a	11.83 a
P_2B_3	40.36 bc	8.60 ef	16.80 bc	10.77 b-e
P_3B_0	39.13 cd	8.77 c-e	16.67 bc	10.87 b-d
P_3B_1	38.19 de	8.63 ef	16.20 cd	11.10 bc
P_3B_2	38.03 de	8.63 d-f	16.27 cd	10.93 b-d
P_3B_3	37.21 ef	8.43 f	15.70 d	10.63 c-e
LSD	**1.11**	**0.27**	**0.72**	**0.63**
Significance level	**5%**	**5%**	**5%**	**5%**

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

4.2 No. of branches plant^{-1}

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

Significant variation was observed in the number of branches plant^{-1} of mungbean when different doses of phosphorus were applied (Table 4.1). The highest number of branches plant^{-1} (9.083) was recorded in P_1 (15 kg P ha^{-1}) which was statistically similar with the P_2 (30 kg P ha^{-1}) treatment. The lowest number of branches plant^{-1} (8.617) was recorded in the P_0 treatment where no phosphorus was applied. Singh *et al*. (1999) also found similar results with increasing rate of P and they noted that the no. of branches plant^{-1} generally increased with the application of P.

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

Different doses of boron fertilizer showed significant variations in respect of number of branches plant^{-1} (Table 4.2). Among the different doses of boron, B_2 (1 kg B ha^{-1}) showed the highest number of branches plant^{-1} (9.017) which was statistically similar with B_1 and B_3 treatments. On the contrary, the lowest number of branches plant^{-1} (8.692) was observed with B_0, where no boron fertilizer was applied. Dutta *et al.* (1984) also found similar results with the application of 1 kg B ha^{-1}.

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

The combined effect of different doses of P and B fertilizers on the number of branches plant^{-1} of mungbean was significant (Table 4.3). The highest number of branches plant^{-1} (9.40) was recorded with the treatment combination of P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) and P_0B_0. On the other hand, the lowest number of branches plant^{-1} (7.83) was found in P_0B_0 treatment (control treatment).

4.3 Number of pods plant^{-1}

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

Significant variation was observed in number of pods plant^{-1} of mungbean when different doses of phosphorus were applied (Table 4.1). The highest number of pods plant^{-1} (17.25) was recorded in P_2 (30 kg P ha^{-1}) which was statistically different from other treatment. The lowest number of pods plant^{-1} (14.31) was recorded in the P_0 treatment where no phosphorus was applied. Mastan *et al.* (1999), Kalita (1989) and Reddy *et al.* (1990) also found similar results.

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

Different doses of boron fertilizers showed significant variations in respect of number of pods plant^{-1} (Table 4.2). Among the different doses of fertilizers, B_2 (1 kg B ha^{-1}) showed the highest number of pods plant^{-1} (16.48). On the contrary, the lowest number of pods plant^{-1} (15.81) was observed with B_0 and was statistically identical with B_1 and B_2 treatment. Dutta *et al.* (1984) also found similar results with the application of 1 kg B ha^{-1}.

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

The combined effect of different doses of P and B fertilizers on number of pods plant^{-1} of mungbean was significant (Table 4.3). The highest number of pods plant^{-1} (18.10) was recorded with the treatment combination of P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) which was statistically different from the rest of the treatments. On the other hand, the lowest number of pods plant^{-1} (14.03) was found in P_0B_0 treatment.

4.4 Number of seeds pod^{-1}

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

Significant variation was observed in number of seeds pod^{-1} of mungbean when different doses of phosphorus were applied (Table 4.1). The highest number of seeds pod^{-1} (11.36) was recorded in P_2 (30 kg P ha^{-1}). The lowest number of seeds pod^{-1} (9.55) was recorded in the P_0 treatment where no phosphorus was applied.

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

Different doses of boron fertilizers showed significant variations in respect of number of seeds pod^{-1} (Table 4.2). Among the different doses of fertilizer, B_2 showed the highest number of seeds pod^{-1} (10.93) which was statistically similar with the B_1 (0.5 kg B ha^{-1}) treatment. On the contrary, the lowest number of seeds pod^{-1} (10.34) was observed with B_0, where no boron fertilizer was applied.

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

The combined effect of different doses of P and B fertilizer on number of seeds pod^{-1} of mungbean was significant (Table 4.3). The highest number of seeds pod^{-1} (11.83) was recorded with the treatment combination of P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}). On the other hand, the lowest number of seeds pod^{-1} (9.03) was found in P_0B_0 treatment (control).

4.5 Pod length (cm)

4.5.1 Effect of phosphorus on pod length of mungbean

The pod length as affected by different doses of phosphorus showed statistically significant variation (Table 4.4). Among the different doses of P the highest pod length (7.3 cm) was observed in P_2 (30 kg P ha^{-1}) which was statistically identical (7.281cm) with P_1 (15 kg P ha^{-1}). The lowest pod length (7.01 cm) was recorded in the P_0 treatment where no P was applied.

4.5.2 Effect of boron on pod length of mungbean

Application of B fertilizers at different doses showed significant variation on the pod length of mungbean (Table 4.5). Among the different B fertilizer doses, B_2 (1 kg B ha^{-1}) showed the highest pod length (7.3 cm), which was statistically similar with B_3 (2 kg B ha^{-1}) treatment. The lowest pod length was similar with the control (B_0) treatment.

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

Combined effects of different doses of P and B fertilizers on pod length showed a statistically significant variation (Table 4.6). The highest pod length (7.65 cm) was recorded in the treatment combination of P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) which was statistically identical with the treatment combinations of P_2B_1 ((30 kg P ha^{-1} + 0.5 kg B ha^{-1}) and P_1B_3 (15 kg P+ 2 kg B ha^{-1}) treatment. On the other hand, the lowest pod length (6.80 cm) was found in P_0B_0.

Table 4.4 Effect of phosphorus on yield and yield contributing characters of mungbean

Treatments	Pod length (cm)	1000-seed wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
P_0	7.010 c	39.00 d	0.916 c	1.63 d
P_1	7.281 a	41.25 b	0.978 b	1.92 c
P_2	7.399 a	40.89 b	1.141 a	2.21 a
P_3	7.145 b	41.76 a	1.116 b	2.11 b
LSD	**0.123**	**0.29**	**0.037**	**0.04**
Significance level	**5%**	**5%**	**5%**	**5%**

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

4.6 Weight of 1000 seed (g)

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

A significant variation was observed on the weight of 1000 seed of mungbean when different doses of P were applied (Table 4.4). The highest weight of 1000 seed (41.76 g) was recorded in P_3 (45 kg P ha^{-1}). The lowest weight of 1000 seed (39.00 g) was recorded in the P_0 treatment where no P was applied.

4.6.2 Effect of boron on weight of 1000 seed of mungbean

Different doses of B fertilizers showed significant variations in respect of the weight of 1000 seed (Table 4.5). Among the different doses of B fertilizers, B_2 (1 kg B ha^{-1}) showed the highest weight of 1000 seed (41.19g) and it was identical with B_1 (0.5 kg B ha^{-1}) treatment. On the contrary, the lowest weight of 1000 seed (39.77 g) was observed with B_0 where no B fertilizer was applied.

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

The combined effect of different doses of P and B fertilizers on the weight of 1000 seed of mungbean was significant (Table 4.6). The highest weight of 1000 seed (42.79 g) was recorded with the treatment combination of P_2B_2 which was statistically similar with P_2B_3 treatment. On the other hand, the lowest weight of 1000 seed (36.44 g) was found in P_0B_0 treatment (control).

Table 4.5 Effect of boron on yield and yield contributing characters of mungbean

Treatments	Pod length (cm)	1000-seed wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
B_0	7.122 c	39.77 c	0.988	1.63 c
B_1	7.202 b	41.07 a	0.993	1.86 a
B_2	7.319 a	41.19 a	1.006	1.75 b
B_3	7.302 ab	40.78 b	1.018	1.50 d
LSD	**0.123**	**0.291**	**NS**	**0.046**
Significance level	**5%**	**5%**	**5%**	**5%**

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

4.7 Grain yield of mungbean (t/ha^{-1})

4.7.1 Effect of phosphorus on the grain yield of mungbean

Significant variation was observed on the grain yield of mungbean when different doses of P were applied (Table 4.4). The highest grain yield of mungbean (1.141 t ha^{-1}) was recorded in P_2 (30 kg P ha^{-1}) which was statistically different from other treatments. The lowest grain yield of mungbean (0.916 t ha^{-1}) was recorded in the P_0 treatment where no P was applied. These findings are similar with the findings of Satter and Ahmed (1992).

4.7.2 Effect of B on the grain yield of mungbean

Different doses of B fertilizers showed insignificant effect of grain yield of mungbean (Table 4.5). Among the different doses of B fertilizers, B_3 (2 kg B ha^{-1}) showed the highest grain yield of mungbean (1.018 t ha^{-1}). B_1 and B_2 fertilizer dose of B_1 (0.5 $kgha^{-1}$) and B_2 (1kg ha^{-1}) showed 0.993 t ha^{-1} and 1.006 t ha^{-1}. On the contrary, the lowest grain yield of mung (0.988 t ha^{-1}) was observed with B_0 where no B fertilizer was applied.

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

The combined effect of different doses of P and B fertilizers on the grain yield of mungbean was significant (Table 4.6). The highest grain yield of mungbean (1.195 t ha^{-1}) was recorded with the treatment combination of P_2B_2 which was statistically similar with the fertilizer dose of P_2B_3 and P_2B_1 treatments. On the other hand, the lowest grain yield of mungbean (0.913 t ha^{-1}) was found in P_0B_0 treatment (No P and No B).

Table 4.6 Interaction effects of phosphorus and boron on yield and yield contributing characters of mungbean

Treatments	Pod length (cm)	1000 seed wt. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})
P_0B_0	6.80 e	36.44 g	0.913 e	1.63 f
P_0B_1	7.00 de	39.47 f	0.917 e	1.86 e
P_0B_2	7.20 b-d	39.86 ef	0.923 e	1.75 bc
P_0B_3	7.04 c-e	40.25 de	0.912 e	1.50 g
P_1B_0	7.23 b-d	40.62 d	1.058 c-e	1.92 d-e
P_1B_1	7.20 b-d	41.32 c	1.078 b-e	2.13 c
P_1B_2	7.26 b-d	41.58 bc	1.083 b-e	2.42 b
P_1B_3	7.43 ab	41.48 c	1.095 a-e	2.33 bc
P_2B_0	7.31 bc	40.29 de	1.142 a-c	2.21 bc
P_2B_1	7.43 ab	41.88 b	1.153 ab	2.43 b
P_2B_2	7.65 a	42.79 a	1.195 a	2.36 b-c
P_2B_3	7.21 b-d	42.15 ab	1.147 ab	2.66 a
P_3B_0	7.14 b-d	41.71 bc	1.139 a-c	2.11 cd
P_3B_1	7.18 b-d	41.34 c	1.123 a-d	2.36 bc
P_3B_2	7.17 b-d	40.54 d	1.111 a-d	2.02 d
P_3B_3	7.09 cd	39.58 f	1.051 de	1.93 ab
LSD	**0.24**	**0.58**	**0.07**	**0.09**
Significance level	**5%**	**5%**	**5%**	**5%**

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

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

4.8.1 Effect of P on the stover yield of mungbean

Significant variation was observed on the stover yield of mungbean when different doses of P were applied (Table 4.4). The highest stover yield of mungbean (2.21 t ha^{-1}) was recorded in P_2 (30 kg P ha^{-1}), which was statistically different from other treatments. The lowest stover yield (1.63 t ha^{-1}) was recorded in the P_0 treatment where no P was applied.

4.8.2 Effect of B on the stover yield of mungbean

Different doses of B fertilizers showed significant variations in respect of stover yield of mungbean (Table 4.5). Among the different doses of B fertilizers, B_1 (0.5 kg B ha^{-1}) showed the highest stover yield (1.86 t ha^{-1}), which was statistically different from other treatments. On the contrary, the lowest stover yield (1.50 t ha^{-1}) was observed with B_3 treatment.

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

The combined effect of different doses of P and B fertilizers on the stover yield was significant (Table 4.6). The highest stover yield (2.66 t ha^{-1}) was recorded with the treatment combination of P_2B_3 (30 kg P ha^{-1} + 2 kg B ha^{-1}). On the other hand, the lowest stover yield (2.53 t ha^{-1}) was found in P_0B_3 treatment (No P and 2 kg B ha^{-1}).

4.9 Total nitrogen concentrations in mungbean stover

4.9.1 Effect of P on nitrogen content in mungbean stover

Application of P showed significant variation on the nitrogen concentration in mungbean stover (Table 4.7). The highest nitrogen concentration in stover (0.66 %) was recorded in P_2 (30 kg P ha^{-1}) treatment which was statistically similar with P_2 (15 kg P ha^{-1}) and P_3 (45 kg P ha^{-1}). On the other hand, the lowest nitrogen concentration in stover (0.535 %) was recorded in the P_0 treatment where no P was applied.

4.9.2 Effect of B on nitrogen content in mungbean stover

The effect of different doses of boron showed statistically significant difference on nitrogen concentration in mungbean stover (Table 4.8). The highest nitrogen concentration (0.6325 %) among the treatments of boron was observed in B_2 (1 kg B ha^{-1}) treatment which was statistically similar with B_3 (2 kg B ha^{-1}) treatment. The lowest nitrogen concentration 0.5750 % was observed in B_0 (control).

4.9.3 Interaction effect of P and B on nitrogen concentrations in mungbean stover

Significant effect of combined application of different doses of P and B fertilizers on the nitrogen concentration was observed in the stover of mungbean (Table 4.9). The highest nitrogen concentration in stover (0.70 %) was recorded in P_2B_2 (30 kg P ha^{-1}+ 1 kg B ha^{-1}) treatment and lowest nitrogen concentration was recorded in the control treatment (P_0B_0).

4.10 Total phosphorus concentrations in mungbean stover

4.10. 1 Effect of P on phosphorus content in mungbean stover

Application of P showed significant variation in the phosphorus concentration in mungbean stover (Table 4.7). The highest phosphorus concentration in stover (0.4550 %) was recorded in P_2 (30 kg P ha^{-1}) which was statistically similar with P_3 (45 kg P ha^{-1}). On the other hand, the lowest phosphorus concentration in stover (0.3175 %) was recorded in the P_0 treatment where no P was applied.

4.10.2 Effect of B on phosphorus content in mungbean stover

The effect of different doses of boron showed statistically significant difference on phosphorus concentration in mungbean stover (Table 4.8). The highest phosphorus concentration among the treatments of boron (0.4100%) was observed in B_2 (1 kg B ha^{-1}) which was statistically similar with B_3 (2 kg B ha^{-1}) and B_1 (0.5 kg B ha^{-1}). The lowest phosphorus concentration of 0.3775 % was observed in B_0 treatment.

4.10.3 Interaction effect of P and B on phosphorus concentrations in mungbean stover

A significant effect of combined application of different doses of P and B fertilizers on the phosphorus concentration was observed in the stover of mungbean (Table 4.9). The highest concentration of phosphorus in the stover (0.49 %) was recorded with the P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) treatment. On the other hand, the lowest phosphorus concentration (0.28 %) in stover was found in P_0B_0 treatment.

Table 4.7 Effect of phosphorus on total N P K S and B concentrations in mungbean stover

Treatments	Total N %	Total P (%)	Total K (%)	Total S (%)	Total B (%)
P_0	0.535 c	0.3175 d	0.7625 c	0.1010	0.0046
P_1	0.605 b	0.3925 c	0.8400 b	0.1073	0.0054
P_2	0.665 a	0.4550 a	0.9575 a	0.1077	0.0060
P_3	0.593 b	0.4225 b	0.8175 b	0.1050	0.0052
LSD	**0.037**	**0.026**	**0.026**	-----------	------------
Significance level	**5%**	**5%**	**5%**	**NS**	**NS**

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

4.11 Total potassium concentrations in mungbean stover

4.11.1 Effect of P on potassium content in stover

A statistically insignificant variation was observed on potassium concentration in stover of mungbean with different doses of phosphorus (Table 4.7). However the highest potassium concentration (0.9575 %) among the different doses of phosphorus was recorded in P_2 (30 kg P ha^{-1}). On the other hand, the lowest potassium concentration (0.7625 %) was recorded in the P_0 treatment where no P was applied.

4.11.2 Effect of B on potassium content in mungbean stover

The effect of different doses of B fertilizers showed a significant variation on the potassium concentration in mungbean stover (Table 4.8). The highest potassium concentration (0.8675 %) among the different doses of B fertilizers was recorded with B_3 (2 kg B ha^{-1}) treatment which was statistically similar with B_1 and B_2 treatments. The lowest potassium concentration (0.8050 %) was observed in the B_0 treatment.

4.11.3 Interaction effect of P and B on total potassium content in mungbean stover

A significant effect of combined application of different doses of P and B fertilizers on the potassium concentration was observed in stover of mungbean (Table 4.9). The highest concentration (1.08 %) of potassium in the stover was recorded with P_2B_3 (30 kg P ha^{-1} + 2 kg B ha^{-1}). On the other hand, the lowest potassium concentration (0.69 %) was found in P_0B_0 treatment.

4.12 Total sulphur concentrations in mungbean stover

4.12.1 Effect of P on sulphur content in mungbean stover

A nonsignificant variation was observed on sulphur concentration in the mungbean with different doses of P (Table 4.7). Among the different doses of P the highest phosphorus concentration in plant (0.1077 %) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest phosphorus concentration (0.1010 %) was recorded in the P_0 treatment where no P was applied.

4.12.2 Effect of B on sulphur content in mungbean stover

The effect of different doses of B fertilizers showed insignificant variation on the sulphur concentration in stover of mungbean (Table 4.8). The highest sulphur concentration (0.1070 %) in plant among different doses of B fertilizers was recorded with B_3 treatment. The lowest sulphur concentration (0.1018 %) was observed in the treatment B_0 where no B fertilizer was applied.

Table 4.8 Effect of boron on total N P K S and B concentrations in mungbean stover

Treatments	Total N %	Total P (%)	Total K (%)	Total S (%)	Total B (%)
B_0	0.5750 b	0.3775 b	0.8050 b	0.1018	0.0043
B_1	0.5775 b	0.3975 ab	0.8475 a	0.1053	0.0055
B_2	0.6325 a	0.4100 a	0.8575 a	0.1037	0.0057
B_3	0.6125 ab	0.4025 ab	0.8675 a	0.1070	0.0057
$LSD_{0.05}$	0.0372	0.0263	0.0263	-----------	-------------
Significance level	**5%**	**5%**	**5%**	**NS**	**NS**

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

4.12.3 Interaction effect of P and B on sulphur content in mungbean stover

Insignificant effect of combined application of different doses of P and B fertilizers on the sulphur concentration was observed in stover of mungbean (Table 4.9). However, the highest concentration of sulphur in the stover (0.11 %) was recorded P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) treatment. On the other hand, the lowest phosphorus concentration (0.096 %) was found in P_0B_0 treatment.

4.13 Total boron concentrations in mungbean stover

4.13.1 Effect of P on boron content in mungbean stover

A non-significant variation was observed on boron concentration in stover of mungbean with different doses of P (Table 4.7). Among the different doses of P the highest boron concentration in plant (0.0060 %) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest boron concentration (0.0046 %) was recorded in the P_0 treatment where no P was applied.

4.13.2 Effect of B on boron content in mungbean stover

The effect of different doses of B fertilizers showed a statistically insignificant variation on the boron concentration in stover of mungbean (Table 4.8). However, the highest boron concentration in stover (0.0057%) among different doses of B fertilizers was recorded with B_2 and B_3 treatments. The lowest boron concentration (0.0043 %) was observed in the B_0 treatment where no B fertilizer was applied.

4.13.3 Interaction effect of P and B on boron content in mungbean stover

Insignificant effect of combined application of different doses of P and B fertilizers on the boron concentration was observed in stover of mungbean (Table 4.9).However, the highest concentration of boron in the stover (0.0066 %) was recorded with the P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) treatment. On the other hand, the lowest boron concentration (0.0041 %) was found in P_0B_0 treatment.

Table 4.9 Interaction effect of phosphorus and boron on N P K S and B concentrations in mungbean plant

Treatments	Total nitrogen (%	Total phosphorus (%)	Total potassium (%)	Total sulphur (%)	Total boron (%)
P_0B_0	0.49 h	0.28 h	0.69 e	0.096	0.0041
P_0B_1	0.53 f-h	0.31 gh	0.78 d	0.102	0.0045
P_0B_2	0.57 d-h	0.35 e-g	0.80 cd	0.100	0.0047
P_0B_3	0.55 e-h	0.33 f-h	0.78 d	0.106	0.0051
P_1B_0	0.57 d-h	0.37 d-f	0.84 cd	0.103	0.0043
P_1B_1	0.59 c-g	0.40 b-e	0.84 cd	0.105	0.0056
P_1B_2	0.68 ab	0.41 b-e	0.85 c	0.101	0.0057
P_1B_3	0.64 a-d	0.39 c-e	0.83 cd	0.107	0.0060
P_2B_0	0.61 b-f	0.42 b-d	0.85 c	0.105	0.0045
P_2B_1	0.62 a-e	0.45 a-c	0.95 b	0.108	0.0065
P_2B_2	0.70 a	0.49 a	0.95 b	0.110	0.0066
P_2B_3	0.67 a-c	0.46 ab	1.08 a	0.108	0.0065
P_3B_0	0.63 a-e	0.44 a-c	0.84 cd	0.103	0.0043
P_3B_1	0.51 gh	0.44 a-c	0.82 cd	0.106	0.0055
P_3B_2	0.64 a-d	0.41 b-e	0.83 cd	0.104	0.0058
P_3B_3	0.59 c-g	•0.40 b-e	0.78 d	0.107	0.0052
LSD	**0.07**	**0.05**	**0.05**	-------------	-----------
Significance level	**5%**	**5%**	**5%**	**NS**	**NS**

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

4.14 Total nitrogen concentrations in mungbean seed

4.14.1 Effect of P on nitrogen content in mungbean seed

Application of P resulted significant variation on the nitrogen concentration in mungbean seed (Table 4.10). The highest nitrogen concentration in seed (6.45 %) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest nitrogen concentration in seed (5.4 %) was recorded in the P_0 treatment where no P was applied.

4.14.2 Effect of B on nitrogen content in mungbean seed

The effect of different doses of boron showed statistically significant difference on nitrogen concentration in mungbean seed (Table 4.11). The highest nitrogen concentration (6.2 %) among the treatments of boron was observed in B_2 (1 kg B ha^{-1}). The lowest nitrogen concentration (5.9 %) was observed in B_0 treatment.

4.14.3 Interaction effect of P and B on nitrogen concentrations in mungbean seed

Significant effect of combined application of different doses of P and B fertilizers on the nitrogen concentration was observed in the seed of mungbean (Table 4.12). The highest concentration of nitrogen in the seed (6.9 %) was recorded with the treatment P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) treatment combination. On the other hand, the lowest nitrogen concentration (4.9 %) in seed was found in P_0B_0 treatment.

Table 4.10 Effect of phosphorus on total N P K S and B concentrations in mungbean grain

Treatments	Total N %	Total P (%)	Total K (%)	Total S (%)	Total B (%)
P_0	5.420 c	0.4050 c	1.010 d	0.2550 c	0.00555
P_1	6.008 b	0.4575 b	1.605 c	0.3150 b	0.00642
P_2	6.452 a	0.5000 a	1.970 a	0.3500 a	0.00685
P_3	5.990 b	0.4575 b	1.670 b	0.3250 ab	0.00627
LSD	**0.074**	**0.037**	**0.037**	**0.0263**	---------------
Significance level	**5%**	**5%**	**5%**	**5%**	**NS**

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

4.15 Total phosphorus concentrations in mungbean seed

4.15. 1 Effect of P on phosphorus content in mungbean seed

Application of P showed significant variation on the phosphorus concentration in mungbean seed (Table 4.10). The highest phosphorus concentration in seed (0.500 %) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest phosphorus concentration in seed (0.405 %) was recorded in the P_0 treatment where no P was applied. Arya and Kalya (1988) found the similar result. They noted that P content in seed was influenced by application of P.

4.15.2 Effect of B on phosphorus content in mungbean seed

The effect of different doses of boron showed statistically significant difference in phosphorus concentrations in mungbean seed (Table 4.11). The highest phosphorus concentration (0.4675 %) among the treatments of boron was observed with B_2 (1 kg B ha^{-1}) treatment which was statistically identical with B_3 treatment. The lowest phosphorus concentration 0.44 % was observed in B_0 treatment.

4.15.3 Interaction effect of P and B on phosphorus concentrations in mungbean seed

Significant effect of combined application of different doses of P and B fertilizers on the phosphorus concentration was observed in the seed of mungbean (Table 4.12). The highest concentration of phosphorus in the seed (0.54 %) was recorded with the treatment P_3B_2 (45 kg P ha^{-1} + 1 kg B ha^{-1}). On the other hand, the lowest phosphorus concentration (0.39 %) in seed was found in P_0B_0 treatment.

4.16 Total potassium concentrations in mungbean seed

4.16.1 Effect of P on potassium content in seed

A statistically insignificant variation was observed on potassium concentration in seed of mungbean with different doses of P (Table 4.10). The highest potassium concentration (1.97 %) among the different doses of P was recorded in P_2 (30 kg Pha^{-1}). On the other hand, the lowest potassium concentration in mungbean seed (1.01 %) was recorded in the P_0 treatment where no P was applied.

4.16.2 Effect of B on potassium content in mungbean seed

The effect of different doses of B fertilizers showed a statistically significant variation on the potassium concentration in mungbean grain (Table 4.11). The highest potassium concentration (1.73 %) among the different doses of B fertilizers was recorded with B_2 treatment in seed. The lowest potassium concentration (1.498 %) in seed was observed with the B_0 treatment.

4.16.3 Interaction effect of P and B on potassium content in mungbean seed

Significant effect of combined application of different doses of P and B fertilizers on the potassium concentration was observed in seed of mungbean (Table 4.12). The highest concentration of potassium in the seed (2.11 %) was recorded with the treatment of P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}) treatment and the lowest K content (0.95%) in mungbean seed was recorded in P_0B_0 treatment.

4.17 Total sulphur concentrations in mungbean seed

4.17.1 Effect of P on sulphur content in mungbean seed

A statistically significant variation was observed on sulphur concentration in seed of mungbean with different doses of P (Table 4.10). Among the different doses of P the highest sulphur concentration in seed (0.35%) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest phosphorus concentration in seed (0.255 %) was recorded in the P_0 treatment where no P was applied.

Table 4.11 Effect of boron on total N P K S and B concentrations in mungbean seed

Treatments	Total N %	Total P (%)	Total K(%)	Total S (%)	Total B (%)
B_0	5.910 b	0.44 c	1.498 c	0.2900	0.004925
B_1	5.910 b	0.45 b	1.347 d	0.3225	0.006650
B_2	6.218 a	0.46 a	1.737 a	0.3200	0.006800
B_3	5.832 b	0.46 a	1.673 b	0.3125	0.006725
LSD	**0.074**	**0.03**	**0.037**	**0.2900**	---------------
Significance level	**5%**	**5%**	**5%**	**5%**	**NS**

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

4.17.2 Effect of B on sulphur content in mungbean seed

The effect of different doses of B fertilizers showed a statistically non-significant variation on the sulphur concentration in mungbean grain (Table 4.11). The highest sulphur concentration in seed (0.3225 %) was recorded with B_1 (0.5 kg B ha^{-1}) treatment. The lowest sulphur concentration (0. 2900 %) in seed was observed in the treatment B_0 where no boron fertilizer was applied.

4.17.3 Interaction effect of P and B on sulphur content in mungbean seed

Significant effect of combined application of different doses of P and B fertilizers on the sulphur concentration was observed in seed of mungbean (Table 4.12). The highest concentration of sulphur in the seed (0.39 %) was recorded with P_2B_2 (30 kg P ha^{-1}+ 1 kg B ha^{-1}). On the other hand, the lowest sulphur concentration (0.24 %) in seed was found in P_0B_0 treatment.

4.18 Total boron concentrations in mungbean seed

4.18.1 Effect of P on boron content in mungbean seed

A statistically insignificant variation was observed on boron concentration in mungbean grain with different doses of P (Table 4.10). Among the different doses of P the highest boron concentration in seed (0.0068 %) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest boron concentration in seed (0.0055 %) was recorded in the P_0 treatment where no P was applied.

4.18.2 Effect of B on boron content in mungbean seed

The effect of different doses of B fertilizers showed a statistically insignificant variation in the boron concentration in mungbean grain (Table 4.11). However, the highest boron concentration in seed (0.0068 %) among different doses of B fertilizers was recorded with B_2 (1 kg B ha^{-1}). The lowest boron concentration (0.0049 %) in seed was observed in the treatment B_0 where no B fertilizer was applied.

4.18.3 Interaction effect of P and B on boron content in mungbean seed

Insignificant effect of combined application of different doses of P and B fertilizers on the boron concentration was observed in seed of mungbean (Table 4.12). The highest concentration of boron in the seed (0.0076 %) was recorded with the P_3B_1 (45 kg P ha^{-1} + 0.5 kg B ha^{-1}). On the other hand, the lowest boron concentration (0.0035 %) in seed was found in P_0B_0 treatment.

Table 4.12 Interaction effect of phosphorus and boron on N P K S and B concentration in mungbean seed

Treatments	Total nitrogen (%)	Total phosphorus (%)	Total potassium (%)	Total sulphur (%)	Total boron (%)
P_0B_0	4.95 i	0.39 e	0.95 j	0.24 f	0.0035
P_1B_0	5.45 h	0.41 c-e	0.13 k	0.26 d-f	0.0060
P_2B_0	5.61 g	0.42 c-e	1.46 i	0.25 ef	0.0062
P_3B_0	5.67 g	0.40 de	1.50 hi	0.27 c-f	0.0065
P_0B_1	5.96 d-f	0.43 b-e	1.50 hi	0.30 b-e	0.0050
P_1B_1	5.86 f	0.45 b-e	1.56 gh	0.33 bc	0.0068
P_2B_1	6.27 c	0.47 a-e	1.73 e	0.31 b-e	0.0069
P_3B_1	5.94 d-f	0.48 a-d	1.63 fg	0.32 b-d	0.0076
P_0B_2	6.34 bc	0.46 a-e	1.83 d	0.30 b-e	0.0056
P_1B_2	6.46 b	0.49 a-c	1.65 ef	0.35 ab	0.0070
P_2B_2	6.96 a	0.51 ab	2.11 a	0.39 a	0.0072
P_3B_2	6.05 d	0.54 a	1.93 c	0.36 ab	0.0069
P_0B_3	6.39 bc	0.48 a-d	1.71 ef	0.32 b-d	0.0056
P_1B_3	5.87 ef	0.46 a-e	1.69 ef	0.34 ab	0.0068
P_2B_3	6.03 de	0.47 a-e	2.01 b	0.33 bc	0.0065
P_3B_3	5.67 g	0.42 c-e	1.63 fg	0.31 b-e	0.0062
LSD	**0.14**	**0.07**	**0.07**	**0.05**	----------
Significance level	**5%**	**5%**	**5%**	**5%**	**NS**

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

4.19 Total nitrogen concentrations in the post harvest soil in mungbean field

4.19.1 Effect of P on nitrogen content in soil

Application of P showed insignificant variation on the nitrogen concentration in post harvest soil (Table 4.13). However, the highest nitrogen concentration in soil (0.054 %) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest nitrogen concentration in seed (0.042 %) was recorded in the P_0 treatment where no P was applied.

4.19.2 Effect of B on nitrogen content in soil

The effect of different doses of boron showed statistically insignificant variation on nitrogen concentration in mungbean seed (Table 4.14). All the treatments of B showed no observable variation in the nitrogen content of post harvest soil.

4.19.3 Interaction effect of P and B on nitrogen concentrations in soil

There is an insignificant effect of combined application of different doses of P and B fertilizers on the nitrogen concentration in the seed of mungbean (Table 4.15). However, the highest concentration in the seed (0.057 %) was recorded with the treatment P_2B_1 (30 kg P ha^{-1} + 0.5 kg B ha^{-1}). On the other hand, the lowest nitrogen concentration (0.37 %) in seed was found in P_0B_0 treatment.

Table 4.13 Effect of phosphorus on total N P K S and B concentrations in post harvest soil

Treatments	Total N %	Total P (%)	Total K (%)	Total S (%)	Total B (%)
P_0	0.042	8.425 c	0.5525 c	0.12	0.0039
P_1	0.052	10.71 b	0.7025 b	0.13	0.0044
P_2	0.054	12.14 a	0.8625 a	0.14	0.0049
P_3	0.043	12.52 a	0.7175 b	0.13	0.0043
LSD	------------	**0.46**	**0.0263**	------------	------------
Significance level	**NS**	**5%**	**5%**	**NS**	**NS**

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

4.20 Total phosphorus concentrations in soil

4.20. 1 Effect of P on phosphorus content in soil

Application of P showed significant variation on the phosphorus concentration in post harvest soil (Table 4.13). The highest phosphorus concentration in seed (12.52 %) was recorded in P_3 (45 kg P ha^{-1}), which was statistically identical with P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest phosphorus concentration in seed (8.42 %) was recorded in the P_0 treatment where no P was applied.

4.20.2 Effect of B on phosphorus content in soil

The effect of different doses of boron showed statistically significant difference in phosphorus concentration in soil (Table 4.14). The highest phosphorus concentration (11.31 %) among the treatments of boron was observed in B_3 (2 kg B ha^{-1}) treatment. Which is statistically identical with B_2 treatment.

4.20.3 Interaction effect of P and B on phosphorus concentrations in soil

Significant effect of combined application of different doses of P and B fertilizers on the phosphorus concentration was observed in soil (Table 4.15). The highest concentration of phosphorus in the soil (13.12 %) was recorded with the treatment P_2B_3 (30 kg P ha^{-1} + 2 kg B ha^{-1}). On the other hand, the lowest phosphorus concentration (7.98 %) in soil was found in P_0B_0 treatment.

4.21 Total potassium concentrations in soil

4.21.1 Effect of P on potassium content in soil

A statistically significant variation was observed on potassium concentration in post harvest soil with different doses of P (Table 4.13). The highest potassium concentration (0.8625 %) among the different doses of P was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest potassium concentration in mungbean seed (0.5525 %) was recorded in the P_0 treatment where no P was applied.

4.21.2 Effect of B on potassium content in soil

The effect of different doses of B fertilizers showed a statistically significant variation on the potassium concentration in mungbean grain (Table 4.14). The highest potassium concentration in soil (0.75 %) among the different doses of B fertilizers was recorded with B_2 treatment. The lowest potassium concentration (0.675 %) in soil was observed in the B_0 treatment.

4.21.3 Interaction effect of P and B on potassium content in soil

Significant effect of combined application of different doses of P and B fertilizers on the potassium concentration was observed in soil (Table 4.15). The highest concentration of potassium in the soil (0.91 %) was recorded with the treatment of P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}). which was statistically identical with P_2B_1 treatment and the lowest potassium concentration (0.47 %) in soil was observed in the B_0 treatment.

4.22 Total sulphur concentrations in soil

4.22.1 Effect of P on sulphur content in soil

A statistically insignificant variation was observed on sulphur concentration in soil with different doses of P (Table 4.13). The highest sulphur concentration in seed (0.148 %) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest phosphorus concentration in seed (0.125 %) was recorded in the P_0 treatment where no P was applied.

Table 4.14 Effect of boron on total N P K S and B concentrations in soil

Treatments	Total N %	Total P (%)	Total K(%)	Total S (%)	Total B (%)
B_0	0.04700	10.54 b	0.6750 c	0.1335	0.0038
B_1	0.04800	10.87 ab	0.6975 bc	0.1377	0.0044
B_2	0.04800	11.07 a	0.7500 a	0.1395	0.0046
B_3	0.04833	11.31 a	0.7125 b	0.1350	0.0046
LSD	------------	**0.46**	**0.0263**	------------	-----------
Significance level	**NS**	**5%**	**5%**	**NS**	**NS**

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

4.22.2 Effect of B on sulphur content in soil

The effect of different doses of B fertilizers showed a statistically insignificant variation on the sulphur concentration in post harvest soil (Table 4.11). The highest sulphur concentration in soil (0.13 %) among different doses of B fertilizers was recorded with B_2 (1 kg B ha^{-1}). The lowest sulphur concentration (0. 13 %) in soil was observed in the treatment B_0 where no boron fertilizer was applied.

4.22.3 Interaction effect of P and B on sulphur content in soil

A statistically insignificant effect of combined application of different doses of P and B fertilizers on the sulphur concentration was observed in soil (Table 4.15). The highest concentration of sulphur in the soil (0.154 %) was recorded with P_2B_2 (30 kg P ha^{-1}+ 1 kg B ha^{-1}). On the other hand, the lowest sulphur concentration (0.122 %) in soil was found in P_0B_0 treatment.

4.23 Total boron concentrations in soil

4.23.1 Effect of P on boron content in soil

Application of P showed insignificant variation on the boron concentration in post harvest soil (Table 4.13). However, the highest boron concentration in soil (0.0049%) was recorded in P_2 (30 kg P ha^{-1}) treatment. On the other hand, the lowest boron concentration in soil (0.0039 %) was recorded in the P_0 treatment where no P was applied.

4.23.2 Effect of B on boron content in soil

The effect of different doses of B fertilizers showed statistically insignificant variation on the boron concentration in post harvest soil (Table 4.14). All the treatments of B showed no observable variation in the boron content in post harvest soil.

Table 4.15 Interaction effect of phosphorus and boron on N P K S and B concentration in soil

Treatments	Total nitrogen (%)	Total phosphorus (%)	Total potassium (%)	Total sulphur (%)	Total boron (%)
P_0B_0	0.037	7.98 d	0.47 j	0.122	0.0036
P_0B_1	0.040	8.24 d	0.58 hi	0.127	0.0038
P_0B_2	0.044	8.92 d	0.59 hi	0.131	0.0040
P_0B_3	0.049	8.56 d	0.57 i	0.121	0.0042
P_1B_0	0.051	9.93 c	0.63 gh	0.136	0.0038
P_1B_1	0.052	10.68 c	0.67 fg	0.135	0.0044
P_1B_2	0.050	10.56 c	0.78 cd	0.138	0.0046
P_1B_3	0.053	11.68 b	0.73 de	0.141	0.0048
P_2B_0	0.052	12.04 b	0.81 bc	0.140	0.0040
P_2B_1	0.057	12.24 ab	0.87 a	0.138	0.0049
P_2B_2	0.056	12.67 ab	0.91 a	0.154	0.0056
P_2B_3	0.050	13.12 a	0.86 ab	0.146	0.0052
P_3B_0	0.048	12.21 ab	0.79 c	0.136	0.0039
P_3B_1	0.044	12.32 ab	0.67 fg	0.151	0.0046
P_3B_2	0.042	12.15 ab	0.72 ef	0.135	0.0045
P_3B_3	0.040	11.89 b	0.69 ef	0.132	0.0042
LSD	------------	**0.93**	**0.05**	----------	-----------
Significance level	**NS**	**5%**	**5%**	**NS**	**NS**

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

4.23.3 Interaction effect of P and B on boron content in soil

There is an insignificant effect of combined application of different doses of P and B fertilizers on the boron concentration in the post harvest soil (Table 4.15). However, the highest concentration of boron in the soil (0.0056 %) was recorded with the P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}). On the other hand, the lowest boron concentration (0. 0036 %) in soil was found in P_0B_0 treatment.

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was conducted at the Sher-e-Bangla Agricultural University Farm Dhaka 1207 (Tejgaon series under AEZ No.28) during the *kharif* season of March, 2008 to May, 2008 to study the "(Influence of phosphorus and boron on the growth and yield of mungbean)". The soil was silty clay loam in texture having pH 5.82 and organic carbon content of 0.61 %. Two factor experiment with randomized complete block design was followed with 16 treatments having unit plot size of 3m x 2m ($6m^2$) and replicated thrice. Two factors were phosphorus and boron. The treatments were P_0B_0 control (No phosphorus + No boron), P_1B_0 (15 kg P ha^{-1} + No boron), P_2B_0 (30 kg P ha^{-1} + No boron), P_3B_0 (45 kg P ha^{-1} + No boron), P_0B_1 (No phosphorus + 0.5 kg B ha^{-1}), P_1B_1 (15 kg P ha^{-1} + 0.5 kg B ha^{-1}), P_2B_1 (30 kg P ha^{-1} + 0.5 kg B ha^{-1}), P_3B_1 (45 kg P ha^{-1} + 0.5 kg B ha^{-1}), P_0B_2 (No phosphorus + 1 kg B ha^{-1}), P_1B_2, (15 kg P ha^{-1} + 1 kg B ha^{-1}), P_2B_2 (30 kg P ha^{-1} + 1 kg B ha^{-1}), P_3B_2 (45 kg P ha^{-1} + 1 kg B ha^{-1}), P_0B_3 (No phosphorus + 2 kg B ha^{-1}), P_1B_3 (15 kg P ha^{-1} +2 kg B ha^{-1}), P_2B_3 (30 kg P ha^{-1} + 2 kg B ha^{-1}) and P_3B_3 (45 kg P ha^{-1} + 2 kg B ha^{-1}).

Recommended blanket doses of N, K and S (20 kg N ha^{-1} from urea, 25 kg K ha^{-1} from MP and 15 kg S ha^{-1} from gypsum, respectively) were applied.

The whole amounts of Urea, MP and Gypsum fertilizer were applied as basal dose during final land preparation. The required amounts of P (from TSP) and B (from boric acid) were applied at a time as per treatment combination after field lay out of the experiment and were mixed properly through hand spading.

Mungbean seeds were sown on 4th March 2008 and the crop was harvested on 5th May 2008. The data were collected plot wise for plant height (cm), number of primary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, pod length (cm), weight of 1000-seed (g), grain yield (t ha^{-1}) and stover yield (t ha^{-1}) .

The post harvest soil samples from 0-15 cm depth were collected plot wise and analyzed for N, P, K, S and B contents. Seed and plant samples were also chemically analyzed for total N, P, K, S and B contents. All the data were statistically analyzed following LSD and the mean comparison was made by DMRT. The results of the experiment are stated below.

Plant height was significantly affected by different levels of P and B. Plant height increased with increasing levels of P and B individually. The individual application of P @ 30 kg ha^{-1}(P_2) produced the tallest plant (40.16 cm), whereas application of B @ 2 kg ha^{-1} (B_3) produced the tallest plant of 38.61cm height. The tallest plant (41.28 cm) was found in P_2B_2 treatment, which was higher over other treatments.

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

Like all other plant characters, grain yield was influenced significantly due to application of P. Grain yield increased with increasing levels of P up to certain level. The highest grain yield (1.141 t ha^{-1}) was found in plants receiving P @ 30 kg ha^{-1} and the lowest was recorded in P_0 treatment. But individual application of boron did not show significant effect in grain yield. Application B @ 2 kg ha^{-1} (B_3) produced the highest grain yield (1.018 t ha^{-1}). The combined application of P and B had positive effect on grain yield of mungbean. The highest grain yield of mungbean was recorded in P_2B_2 treatment followed by P_2B_1 which was statistically identical with each other. The lowest yield was recorded in P_0B_0 treatment. Combined application of P @ 30 kg ha^{-1} and B @ 1 kg ha^{-1} produced higher grain yield compared to control treatment significantly.

Nutrient contents (N, P, K, S and B) in stover were positively affected due to P and B fertilization. The interaction effect of P and B was also found remarkable. The N, P, K, S and B content in stover varied from 0.49 % in P_0B_0 treatment to 0.70 % in P_2B_2 treatment, 0.28 % in P_0B_0 treatment to 0.49 % in P_2B_2 treatment, 0.69 % in P_0B_0 treatment to 1.08% in P_2B_3 treatment, 0.096 % in P_0B_0 treatment to 0.11 % in P_2B_2 and 0.0041 % in P_0B_0 to 0.0066 % in P_2B_2 treatment, respectively. Nitrogen (N), K, B and S contents in stover increased with increasing levels of P and B up to certain level.

Nutrient contents (N, P, K, S and B) in seeds were positively affected due to P and B fertilization. The interaction effect of P and B was also found remarkable. The N, P, K, S and B content in seeds varied from 4.95 % in P_0B_0 treatment to 6.96 % in P_2B_2 treatment, 0.39 % in P_0B_0 treatment to 0.54 % in P_3B_2 treatment, 0.13 % in P_1B_0 treatment to 2.11 % in P_2B_2 treatment, 0.24 % in P_0B_0 treatment to 0.39 % in P_2B_2 and 0.0035 % in P_0B_0 to 0.0076 % in P_3B_1 treatment, respectively. Nitrogen (N), K, B and S contents in seeds also increased with increasing level of P and B up to certain level.

Nutrient content in post harvest soil was also influenced by different levels of P and B application. The total N, available P, available K, available S and available B of post harvest soil varied from 0.037 to 0.057%, 7.98 to 13.12 %, 0.47 to 0.91 %, 0.122 to 0.158 % and 0.0036 to 0.0056 %, respectively due to combined application of P and B at different levels. The addition of P and B not only increased the yield but also protect the soil from total exhaustion of nutrients.

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

- ❖ Significantly higher growth and yield performance of mungbean was observed by the P_2B_2 treatment i.e., by the combined application of phosphorus and boron fertilizers @ 30 kg P ha^{-1} and 1 kg B ha^{-1}.

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

- ❖ The combined application of Phosphorus and boron fertilizers @ 30 kg P ha^{-1} and 1 kg B ha^{-1} may be recommended in Tejgaon series under AEZ No.28 to get higher growth and yield of mungbean and also to maintain soil fertility and productivity compared to their individual applications.

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

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APPENDICES

Appendix Table 1. Records of meteorological information (monthly) during the period from January , 2008 to May, 2008

Month	Air temperature (^{o}C)		Relative humidity		Rainfall (mm)
	Maximum	Minimum	Morning 6am (%)	Evening 6pm (%)	
January, 2008	24.38	13.32	88.16	72.90	2.54
February, 2008	24.63	13.79	88.16	62.55	3.06
March, 2008	32.6	19.6	93.38	72.38	6.8
April , 2008	33.2	23.1	95.70	72.90	7.7
May , 2008	32.9	24.5	94.70	62.55	7.3

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

Summary of analysis of variance of growth character of mungbean

Appendix Table 2. Summary of analysis of variance of yield and yield attributes of mungbean as influenced by different level of phosphorus and boron

Sources of variation	Degrees of freedom	Mean square (MS)				
		Plant height(cm)	No. of pod $plant^{-1}$	No. of branchs $plant^{-1}$	No. of Seeds pod^{-1}	Pod length
Replication	2	0.115	0.376	0.003	0.138	0.034
Phosphorus	3	34.812*	18.137*	0.485*	6.975*	0.340 *
Boron	3	2.029*	1.194*	0.225*	0.690*	0.080 *
Phosphorus × Boron	9	1.674*	0.471*	0.544*	0.444*	0.048 *
Error	30	0.443	0.190	0.228	0.144	0.022

* Significant at 5% level of probability

Appendix Table 3. Summary of analysis of variance of yield and yield attributes of mungbean as influenced by different level of phosphorus and boron

Sources of variation	Degrees of freedom	Mean square (MS)		
		1000 grain weight(g)	Grain Yield (t ha^{-1})	Stover Yield (t ha^{-1})
Replication	2	0.011	0.016	0.979
Phosphorus	3	17.242*	0.040*	1.576*
Boron	3	5.026*	0.001NS	1.115*
Phosphorus × Boron	9	3.552*	0.002*	0.245*
Error	30	0.122	0.002	0.169

* Significant at 5% level of probability

NS= Non significant.

Field view of the experiment

Appendix Figure 1. Field view of experimental plot at 20 DAS.

Appendix Figure 2. Field view of experimental plot at 50 DAS.

Appendix Figure 3. Field view of experimental plot at 60 DAS.

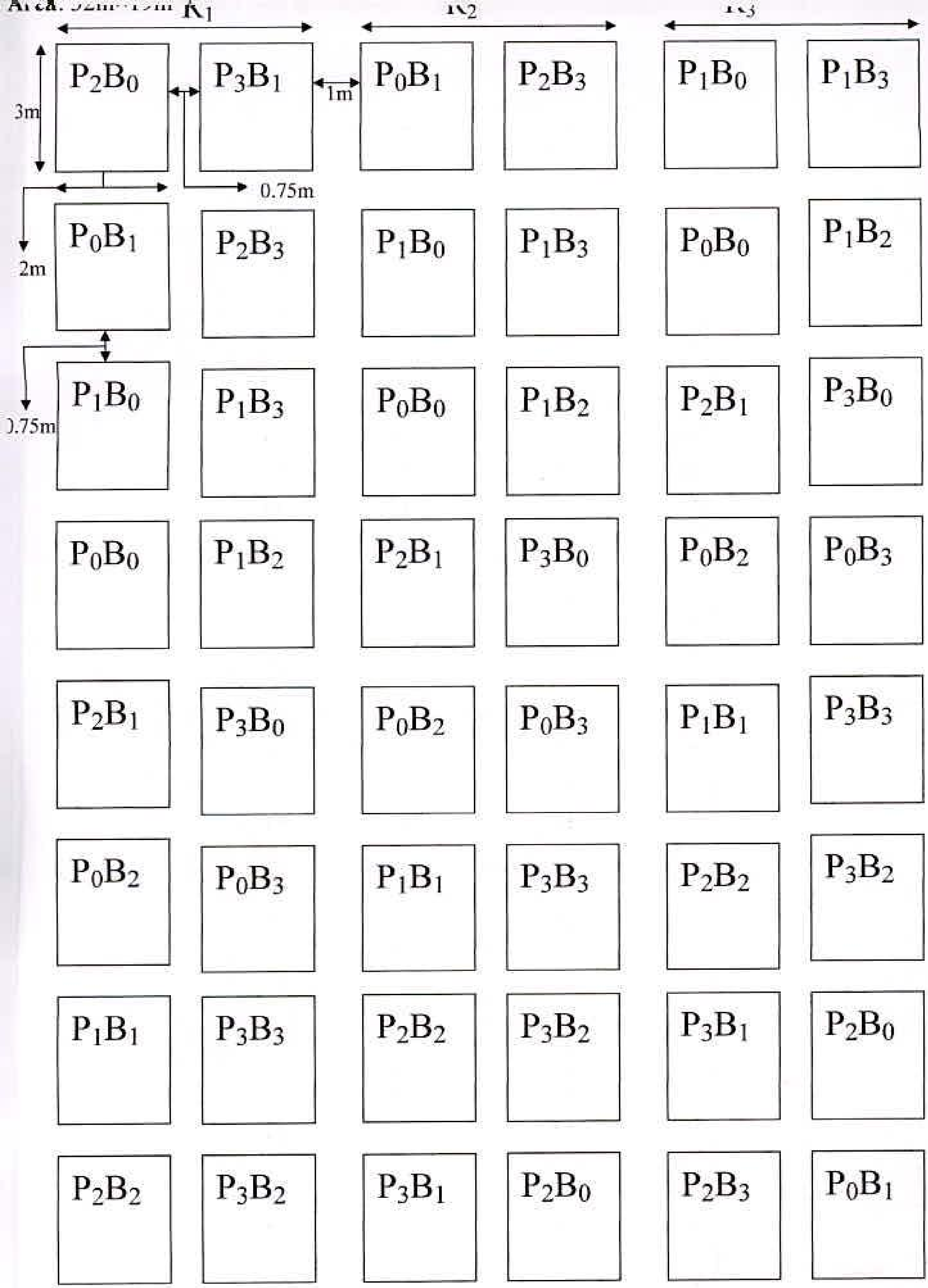

Figure: Layout for the RCBD Design of an Experiment