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

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This is to certify that the thesis entitled, **"EFFECT OF PHOSPHORUS AND MOLYBDENUM FERTILIZERS ON GROWTH AND YIELD OF MUNGBEAN"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN SOIL SCIENCE,** embodies the result of a piece of *bona fide* research work carried out by **MD. NUR-E-AL-MAMUN,** Registration No. **08-02867** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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DEDICATED TO

MY

BELOVED PARENTS

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ABSTRACT

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during September, 2013 to December, 2013 to study the effects of phosphorus (P) and molybdenum (Mo) on growth and yield of mungbean. The variety, BARI Mung-5 was used in this experiment as the test crop. The experiment consists of two factors: Factor A: Phosphorus (3 levels) namely, P_0: 0 kg P ha^{-1} (Control), P_1: 20 kg P ha^{-1}, P_2: 40 kg P ha^{-1}, Factor B: Molybdenum (3 levels) namely, Mo_0: 0 kg Mo ha^{-1} (Control), Mo_1: 0.50 kg Mo ha^{-1}, and Mo_2: 1.0 kg Mo ha^{-1}. Data on different yield contributing characters, growth and yield were recorded. There was a positive impact of P and Mo and their interaction on growth, yield and yield attributes of mungbean. All the plant parameters were increased with increasing level of P (up to 40 kg ha^{-1}) and Mo (up to 1.0 kg ha^{-1}). The highest seed yield (1.89t ha^{-1}) and stover yield (3.38t ha^{-1}) were obtained from the treatment P_2Mo_2 due to combined effect of P and Mo which were higher over control treatment respectively. However, from the study it can be concluded that application of P @ 40 kg ha^{-1} and Mo @ 1.0 kg ha^{-1} was the most suitable combination for better yield of mungbeanin Red Brown Terrace Soils of Tejgaon Series in Bangladesh.

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Chapter I

INTRODUCTION

Bangladesh grows various types of pulse crops namely grasspea, lentil, mungbean, blackgram, chickpea, and cowpea which are important pulse crops because they are the cheap source of easily dietary protein. Mungbean (*Vigna radiata L.*) also known as green gram or golden gram is one of the most important pulse in Bangladesh. It belongs to the family Leguminosae. It is native to the Indian subcontinent and mainly cultivated in India, China, Thailand, Philippines, Indonesia, Mayanmar, Bangladesh, Laos and Cambodia but also in hot and dry regions of Europe and the United States. It is used as a foodstuff in both savory and sweet dishes. It is a popular crop in the daily diet of the people of Bangladesh. Pulses have been considered as “poor men's meat” since pulses contains more protein than meat and also more economical, they are the best source of protein for the underprivileged people. It is taken mostly in the form of soup which is commonly known as "dal". Generally, there is no complete dish without "dal" in Bangladesh. Green pulse seeds also can be consumed as fried peas or can be used in curry.

In Bangladesh, daily consumption of pulses is only 14.30g capita^{-1} (BBS, 2010), while The World Health Organization (WHO) suggested 45g capita^{-1} day^{-1} for a balanced diet. Due to shortage of production 291 thousands metric ton pulses was imported in Bangladesh in 2006-07 fiscal year (BBS, 2010). Though total pulse production in Bangladesh is 231 thousand metric ton (BBS, 2011), but to provide the abovementioned requirement of 45g capita^{-1} day^{-1}, the production has to be increased even more than three folds. It has good digestibility and flavor. It contains 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and phosphorus are 132 and 367 mg per 100 grams of seed, respectively (Frauque *et al.,* 2000). Hence, on the nutritional point of view, mungbean is perhaps the best of all other pulses (Khan, 1981 and Kaul, 1982), contains almost triple amount of protein as compared to rice. It can also minimize the scarcity of fodder because the whole plant or its by product can be used as good animal feed. Cultivation of pulses also can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through nitrogen fixation. As a whole, mungbean could be considered as an inevitable component of sustainable agriculture.

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

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

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

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

Phosphorus plays a remarkable role in plant physiological processes. It is an essential constituent of majority of enzymes which are of great importance in the transformation of energy in carbohydrate metabolism in different types of plants and is closely related in cell division and grain development. Phosphorus is a key constituent of ATP and it plays a significant role in the energy transformation in plants and also in various physiological processes (Sivasankar *et al.* 1982). It is also essential for energy storage and release in living cells. Phosphorus shortage restricted the plant growth and remains immature (Hossain, 1990). Experimental findings of Arya and Kalra (1988) revealed that application of phosphorus had no effect on the growth of mungbean, while number of grains per pod, weight of 1000-seeds were found to be increased with increasing level of phosphorus from zero to 50 kg P_2O_5 ha^{-1}. Phosphorus deficiency causes yield reduction by limiting plant growth (Poehlman, 1991). It influences nutrient uptake by promoting root growth and nodulation (Singh *et al*., 1999). Phosphorus enhances the uptake of nitrogen in the crop which increases protein content of mungbean (Soni and Gupta, 1999). Phosphorus is essential constituents, nucleoprotein, phospholipids, many enzymes and other plant substances.

Molybdenum (Mo) is an essential mineral micronutrient for all vascular plants like mungbean. It plays vital roles in the symbiotic nitrogen fixation. Application of molybdenum in combination with phosphate increases growth and uptake of N, P, K, Mo and also effective in symbiotic nitrogen fixation (Kadwe and Badhe, 1973).

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

Objectives:

- To determine the optimum dose of P for attaining maximum yield contributing characters and yield of mungbean in Red Brown Terrace Soil.
- To determine the optimum dose of Mo for attaining maximum yield contributing characters and yield of mungbean in Red Brown Terrace Soil.
- To study the combined influence of P and Mo on the growth and yield of mungbean.

Chapter II

REVIEW OF LITERATURE

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

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

Nigamananda and Elamathi (2007) conducted an experiment during 2005-06 to evaluate the effect of N application time as basal and as DAP (diammonium phosphate) or urea spray and plant growth regulator (NAA at 40 ppm) on the yield and yield components of greengram. Results showed that 2% foliar spray as DAP and NAA, applied at 35 DAS resulted in the highest values for number of pods plant^{-1} (38.3), seeds pod^{-1}, test weight, flower number, fertility coefficient, grain yield (9.66 q ha^{-1}).

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

Tickoo *et al.* (2006) carried out an experiment on mungbean and cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30.0 m spacing and was supplied with 36-46 and 58-46 kg of N/P/ha in a field experiment conducted in New Delhi. India during the kharif season in 2000. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t/ha) respectively compared to cv. Pusa 105. Nitrogen and phosphorus rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both the cultivars.

A field experiment was conducted by Raman and Venkataramana (2006) during February to May 2002 in Annamalainagar. Tamil Nadu. India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of greengram *(V. radiata).* There were 10 foliar spray treatments, consisting of water spray. 2% diammonium phosphate (DAP) at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA, DAP + NAA, DAP + Penshibao, DAP + Zn chelate, DAP + Penshibao + NAA, and DAP + NAA + Zn chelate. Crop nutrient uptake, yield and its attributes (number of pods/plant and number of seeds/pod) of greengram augmented significantly due to foliar nutrition. The foliar application of DAP + NAA + Penshibao was significantly superior to other treatments in increasing the values of N. P and K uptakes, yield attributes and yield. The highest grain yield of 1529 kg/ha was recorded with this treatment.

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

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

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

Oad and Buriro (2005) conducted a field experiment to determine the effect of different NPK levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg/ha) on the growth and yield of mungbean cv. AEM 96 in Tandojam, Pakistan, during the spring season of 2004. The different NPK levels significantly affected the crop parameters. The 10-30-30 kg NPK/ha was the best treatment, recording plant height of 56.3. germination of 90.5%. satisfactory plant population of 162.0. prolonged days taken to maturity of 55.5. long pods of 5.02 crn, seed weight of 10.5 g, seed index of 3.5 g and the highest seed yield of 1205.2 kg/ha. There was no significant change in the crop parameters beyond this level.

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

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

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

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

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

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

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25, and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 in 2001. They observed that number of flowers/plant was found to be significantly higher by 25 kg N ha^{-1}. Number of seeds/pod was significantly affected by varying levels of nitrogen and phosphorus. Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted with maximum seed yield (1.1 ton ha^{-1}).

Satish *et al.* (2003) conducted an experiment in Haryana, India in 1999 and 2000 to investigate the response of mungbean cultivars Asha, MH 97-2, MH 85-111 and K 851 to different P levels (0, 20, 40 and 60 kg P_2O_5/ha). Results revealed that the highest dry matter content in the leaves, stems and pods was obtained in Asha and MH 97-2. The total above-ground dry matter as well as the dry matter accumulation in leaves, stems and pods increased with increasing P level up to 60 kg P/ha. MH 97-2 and Asha produced significantly more number of pods and branches/plant compared to MH 85-111 and K 851. Phosphorus at 40 and 60 kg/ha increased the number of pods/plant grain yield and grains per pod over the control and P at 20 kg/ha. The number of branches plant^{-1} increased with increasing P rates.

Rajender *et al*. (2002) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on niungbean genotypes MH 85-111 and T44. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect yield. The number of branches, number of pods plant^{-1}, numbers of seeds pod^{-1}. 1000-seed weight and straw yield increased with increasing rates P. whereas grain yield increased with increasing rates up to 40 kg P ha^{-1} only

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

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

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at different levels of nitrogen and phosphorus. Different rates of N

(0, 25 and 60 kg ha^{-1}) and P (0, 25, 50 and 60 kg ha^{-1}) were tested. They observed that the number of pods/plant was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N. They also observed that 1000-seed weight was increased with increasing rates of N up to 40 kg ha^{-1} along with increasing rates of P which was then followed by a decrease with further increase in N.

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

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

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

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

Application of 45 kg P ha^{-1} markedly increased the number of pods $plant^{-1}$. Addition of 30 kg P ha^{-1} was the recommended treatments to obtain the best results for growth, yield and yield components as well as chemical composition of mungbean.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.2. Effect of molybdenum (Mo) on growth, yield and yield contributing characters of mungbean

Rosolem and Caires (1998) reported that a high N-uptake had been observed in limed plots probably due to an increase in molybdenum availability.

Mandal *et al.* (1998) observed that dry matter yield of lentil was increased by the application of lime. P and Mo. Plant dry matter/pot was highest with 100% lime + 50 mg P + 1 mg Mo. Yield response to Mo application was highest, followed by lime and P.

Dwivedi *et al.* (1997) observed that soybean was given 0-12 kg P^Os and 0-1.5 kg Mo/ha. Seed yield increased with increasing P and Mo rates.

Geetha *et al.* (1996) reported that pod yields of mungbean were significantly increased by seed treatment with 8 gm Mo/kg seed.
Sinha *et al.* (1994) observed that lentil cv. B77 was given 0.6 or 1.2 kg B/ha as borax, 4.4 kg Zn/ha as zinc sulphate or 0.5 kg Mo/ha as sodium molybdenum singly or in various combinations. Compared with the control yield, application of the trace elements increased seed yield between 14 and 55%. Application of Mo + Zn gave the highest seed yield of 2.29 t/ha. the highest net return.

Johal and Chahal (1994) noted that nodule numbers and dry weights of mungbean were greatest with 5 ppm Mo. Nodule leghaemoglobin content increased with up to 5 ppm Mo as did nodule nitrogenous activity.

Solaiman *et al.* (1991) carried out an experiment with two varieties of lentil. Utfala and Mymensingh local. They reported the 2 kg Mo/ha when applied with *Rhizobium inoculant* was found stimulating in respect of nodulation and dry matter production of the crop.

Ahmed (1988) observed that Mo application increased seed yield of green gram *(Vigna radiata)* by 28% and DM yield by 34%. All trace element treatments increased yield compared with the control.

Verma *et al.* (1988) observed that application of Mo and P increased the number and weight of nodules. Pod number and seed yield increased with Mo application up to the highest level. Similar trends were noted for seed protein content. Mo is potentially limiting factor for chickpea yields in similar alluvial soil.

Naphade and Wankhade (1987) observed that seed and straw yields of mungbean were increased significantly with 50kg S and 1.5 kg Mo/ha.

Paricha *et al.* (1983) conducted a field experiment with *Vigna radiata L.* and observed that Mo alone increased the yield by 26.4%.

Chapter III
MATERIALS AND METHODS

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

3.1 Experimental site

The field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka- 1207 during the period from 25th September to 3rd December, 2013.

3.2 Soil

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

Table 1. Salient features of the experimental field

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

Table 2. Initial physical and chemical properties of experimental soil analyzed at Soil Resources Development Institute (SRDI), 2013, Farmgate, Dhaka.

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

3.3 Climate

The experimental area has sub-tropical climate characterized by medium temperature, medium rainfall during September, 2013 to January, 2014 and scanty rainfall during rest of the year. The annual precipitation of the site is 2052 mm and potential evapotranspiration is 1286mm, the average maximum temperature is 22.35^{0}C, average minimum temperature is 15.14^{0}C and the average mean temperature is 18.12^{0}C (BBS, 2013).

3.4 Seeds and variety

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

3.5 Design and layout of experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations. Fertilizer treatment consisted of 3 levels of P (0, 61.25, and 122.5 g P/plot designated as $P_{0,}$ $P_{1,}$ and P_2 respectively) and 3levels of Mo (0, 0.567, and 1.134 g Mo/plot designated as $Mo_{0,}$ $Mo_{1,}$ and Mo_2 respectively). There were nine treatment combinations where all the treatments were applied on the allotted plot which was 3.5 m x 1.75 m maintaining 0.5 m gap between each plot.

3.6 Treatments and treatment combinations of experiment

Doses of P & Mo (kg/ha)	Doses of P & Mo (g/plot)
Phosphorus	Phosphorus
1. P_0 = No phosphorus (Control)	1. P_0 = No phosphorus (Control)
2. P_1 = 20 kg	2. P_1 = 12.25 g
3. P_2 = 40 kg	3. P_2 = 24.5g
Molybdenum	Molybdenum
1. Mo_0 = No molybdenum (Control)	1. Mo_0 = No molybdenum (Control)
2. Mo_1 = 0.50 kg	2. Mo_1 = 0.567g
3. Mo_2 = 1.0 kg	3. Mo_2 = 1.134g

Treatment Combinations

1. P_0Mo_0 : Control (without P and Mo)
2. P_0Mo_1 : 0 g P/plot+0.567 g Mo/plot
3. P_0Mo_2: 0 g P/plot +1.134 g Mo/plot
4. P_1Mo_0 : 12.25 g P/plot+0 g Mo/plot
5. P_1Mo_1 : 12.25 g P/plot+0.567 g Mo/plot
6. P_1Mo_2: 12.25 g P/plot+1.134 g Mo/plot
7. P_2Mo_0 : 24.5 g P/plot+0 g Mo/plot
8. P_2Mo_1 : 24.5 g P/plot+0.567 g Mo/plot
9. P_2Mo_2: 24.5 g P/plot+1.134 g Mo/plot

3.7 Land preparation

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

3.8 Fertilizers application

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

3.9 Seed collection and sowing

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

3.10 Cultural and management practices

Various intercultural operations such as thinning of plants, weeding and spraying of insecticides were accomplished whenever required to keep the plants healthy and the field weed free. At the very early growth stage (after l5 days of emergence of seedlings) the plants were attacked by Cutworm, which was removed by applying Malathion. Special care was taken to protect the crop from birds especially after sowing and germination stages. The field was irrigated twice- one at 15 days and the other one at 30 days after sowing.

3.11 Harvesting

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

3.12 Collection of experimental data

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

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Number of branches plant^{-1}
4. Number of pods plant^{-1}
5. Pod length (cm)
6. Number of seeds pod^{-1}
7. Weight of 1000 seeds (g)
8. Seed yield (t ha^{-1})
9. Stover yield (t ha^{-1})

3.12.1 Plant height

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

3.12.2 No. of leaves plant^{-1}

The leaves were counted from selected plants. The average number of leaves was determined. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot during harvest.

3.12.3 No. of branches plant^{-1}

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

3.12.4 No. of pods plant^{-1}

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

3.12.5 Pod length

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

3.12.6 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.

3.12.7 Thousand seed weight

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

3.12.8 Grain yield

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

3.12.9 Stover yield

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

3.13 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 IV

RESULTS AND DISCUSSION

The study was conducted to determine the effect of phosphorus (P) and molybdenum (Mo) on the growth and yield of mungbean. Data on different yield contributing characters and yield were recorded to find out the optimum levels of phosphorus and molybdenum on mungbean The results have been presented and discussed and possible interpretations have been given under the following headings:

4.1 Effect of P and Mo on growth and yield of Mungbean

4.1.1 Plant height

Plant height of mungbean varied significantly due to the application of different level of phosphorus (Table 3). The longest plant (55.78 cm) was recorded under P_2 treated plot which was identicl (52.49 cm) with P_1. While the shortest plant (49.56 cm) was recorded in P_0 treated plot which was statistically different from all other treatments (Table 3). Probably, phosphorus ensured the availability of other essential nutrients. As a result maximum growth was occurred and the ultimate results were the maximum plant height. Edwin *et al,* (2005) reported that maximum plant height (71.20 cm) was obtained in greengram with 60 kg DAP/ha. Malik *et al.* (2006) reported that phosphorus application at 40 kg P_2O_5 ha^{-1} affected the crop positively, while rates below and above this rate resulted in non-significant manner.

Application of molybdenum showed statistically significant variation in terms of plant height of mungbean (Table 3). The longest plant (55.29 cm) was recorded in Mo_2 which was statistically similar (52.45) with Mo_1 and the shortest plant (50.09 cm) was recorded in MO_0(Table 3). Combined effect of phosphorus and molybdenum showed statistically significant variation for plant height under the trial. The longest plant (61.44 cm) was recorded in P_2Mo_2 which was statistically different from all other treatments. The shortest plant

(47.36 cm) was recorded in P_0Mo_0 treatment combination, comprising untreated control plot (Table 4).

4.1.2 Number of leaves plant^{-1}

Number of leaves per plant of mungbean differed significantly due to the application of different level of phosphorus. The maximum number of leaves per plant (24.22) was recorded in P_2 which was statistically different from other two treatments, while the minimum number of leaves per plant (17.54) was recorded in P_0, comprising untreated control plot (Table 3). Probably, phosphorus ensured the availability of other essential nutrients as a result maximum growth was occurred and the ultimate results is the maximum number of leaves per plant. Bhat *et al.* (2005) observed 60 kg P/ha significantly improved the yield attributes compared to the control. Statistically significant variation in terms of number of leaves per plant of mungbean was recorded for the application of molybdenum. The maximum number of leaves per plant (23.56) was recorded from MO_2 which was statistically different from all other treatments, while the minimum number of leaves per plant (18.42) was recorded from Mo_0 (Table 3).

Combined effect of phosphorus and molybdenum showed statistically significant variation for number of leaves per plant. The maximum number of leaves plant^{-1} (27.38) was recorded in P_2Mo_2 which was statistically different from all other treatments and the minimum number of leaves per plant (15.57) was recorded in P_0Mo_0 Treatment combination (Table 4).

Tabie 3. Main effect of phosphorus and molybdenum on the yield contributing characters of mungbean

Level of Phosphorus and Molybdenum	Plant height (cm)	Number of leaves/plant	Number of branches/plant	Number of pods/plant	Pod length (cm)
Effect of Phosphorus					
P_0	49.56 b	17.54 c	10.60 c	12.45 c	6.85 c
P_1	52.49 ab	21.68 b	13.94 b	14.60 b	8.01 b
P_2	55.78 a	24.22 a	16.46 a	16.76 a	9.21 a
LSD (0.05)	**4.50**	**1.20**	**1.35**	**1.3**	**0.674**
CV (%)	8.55	5.69	9.87	7.05	8.41
Effect of Molybdenum					
Mo_0	50.09 b	18.42 c	11.78 b	12.84 b	7.08 c
Mo_1	52.45 ab	21.46 b	13.95 a	15.01 a	8.14 b
Mo_2	55.29 a	23.56 a	15.27 a	15.97 a	8.85 a
LSD(0.05)	**4.50**	**1.20**	**1.35**	**1.30**	**0.674**
CV (%)	**8.55**	**5.69**	**9.87**	**7.05**	**8.41**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 4. Combined effect of phosphorus and molybdenum on the yield contributing characters of mungbean

Phosphorus x Molybdenum	Plant height (cm)	Number of leaves/plant	Number of branches/plant	Number of pods/plant	Pod length (cm)
P_0Mo_0	47.36 f	15.57 f	9.27 f	11.15 f	6.02 e
P_0Mo_1	50.34 e	18.08 e	11.22 ef	13.05 e	7.26 d
P_0Mo_2	50.98 de	18.98 de	11.32 def	13.16 e	7.26 d
P_1Mo_0	51.05 de	19.51 cde	12.95 cde	13.28 de	7.52 cd
P_1Mo_1	52.97 bc	21.21 c	13.65 cd	14.97 cd	8.01 bcd
P_1Mo_2	53.44 b	24.32 b	15.23 bc	15.56 bc	8.52 bc
P_2Mo_0	51.85 cd	20.19 cd	13.12 cde	14.09 cde	7.71 cd
P_2Mo_1	54.05 b	25.09 b	16.98 ab	17.02 b	9.15 b
P_2Mo_2	61.44 a	27.38 a	19.27 a	19.18 a	10.76 a
LSD(0.05)	**1.505**	**2.083**	**2.336**	**1.783**	**1.168**
CV (%)	**8.55**	**5.69**	**9.87**	**7.05**	**8.41**

In a column, means having similar letters are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.3 Number of branches plant^{-1}

Number of branches per plant of mungbean varied significantly due to the application of different level of phosphorus. The maximum number of branches per plant (16.46) was recorded in P_2 which was statistically different from all other two ,treatments. On the other hand the minimum number of branches per plant (10.60) was recorded in P_0 treated plot (Table 3). Probably, phosphorus ensured the availability of other essential nutrients as a result maximum growth was occurred and the ultimate results is the maximum number of branches per plant.

Number of branches per plant of mungbean differed significantly due to the application of molybdenum. The maximum number of branches per plant (15.27) was recorded in Mo_2 which was statistically identical with Mo_1 (13.95), while the minimum number of branches per plant (11.78) was recorded in Mo_0 (Table 3).

Combined effect of phosphorus and molybdenum showed statistically significant differences for number of branches per plant. The maximum number of branches per plant (19.27) was recorded in P_2Mo_2 which was statistically identical with P_2Mo_1, P_1Mo_2, P_1Mo_1, P_2Mo_0, P_1Mo_0, P_0Mo_2, P_0Mo_1 and the minimum number of branches per plant (9.27) was recorded in P_0Mo_0 (Table 4).

4.2.1 Number of pods plant^{-1}

Application of different level of phosphorus influenced significantly on the number of pods per plant of mungbean. The maximum number of pods per plant (16.76) was recorded in P_2 which was statistically different from all other treatments. On the other hand the minimum number of pods per plant (12.45) was recorded in control plot (P_0) (Table 3). Probably, phosphorus ensured the availability of other essential nutrients as a result maximum growth was occurred and the ultimate results is the maximum number of pods per plant.

Application of molybdenum showed statistically significant variation in terms of number of pods per plant of mungbean. The maximum number of pods per plant (15.97) was recorded in Mo_2 which was statistically identical with Mo_1 (15.01), while the minimum number of pods per plant (12.84) was recorded in Mo_0 (Table 3). Verma and Mishra (1988) reported that pod number and seed yield increased with Mo application up to the highest level.

Combined effect of phosphorus and molybdenum showed statistically significant variation for number of pods per plant. The maximum number of pods per plant (19.18) was recorded from P_2Mo_2 which was statistically different from all other treatments and the minimum number of pods per plant (11.15) was recorded from P_0Mo_0 (Table 4).

4.2.2 Effect of phosphorus on yield contributing characters at different doses

Significant variation was observed in number of pods plant^{-1} and seeds pod^{-1} as well as yield of mungbean due to fertilizer doses (Fig. 1)., it revealed that higher number of pods plant^{-1} (16.76) and seeds pod^{-1} (11.38) as well as yield (1.36 t/ha) of mungbean were found in the treatment P_2 (40 kg P_2O_5/ha) which was significantly higher over P_1 (20 kg P_2O_5/ha) treatment and the minimum number of pods plant^{-1} (12.45) and seeds pod^{-1} (8.24) as well as yield (0.67 t/ha) of mungbean were found in P_0 (control) treatment. That is the best treatment (P_2) increased significantly by the application of phosphorus at 40 kg per hacter over control.

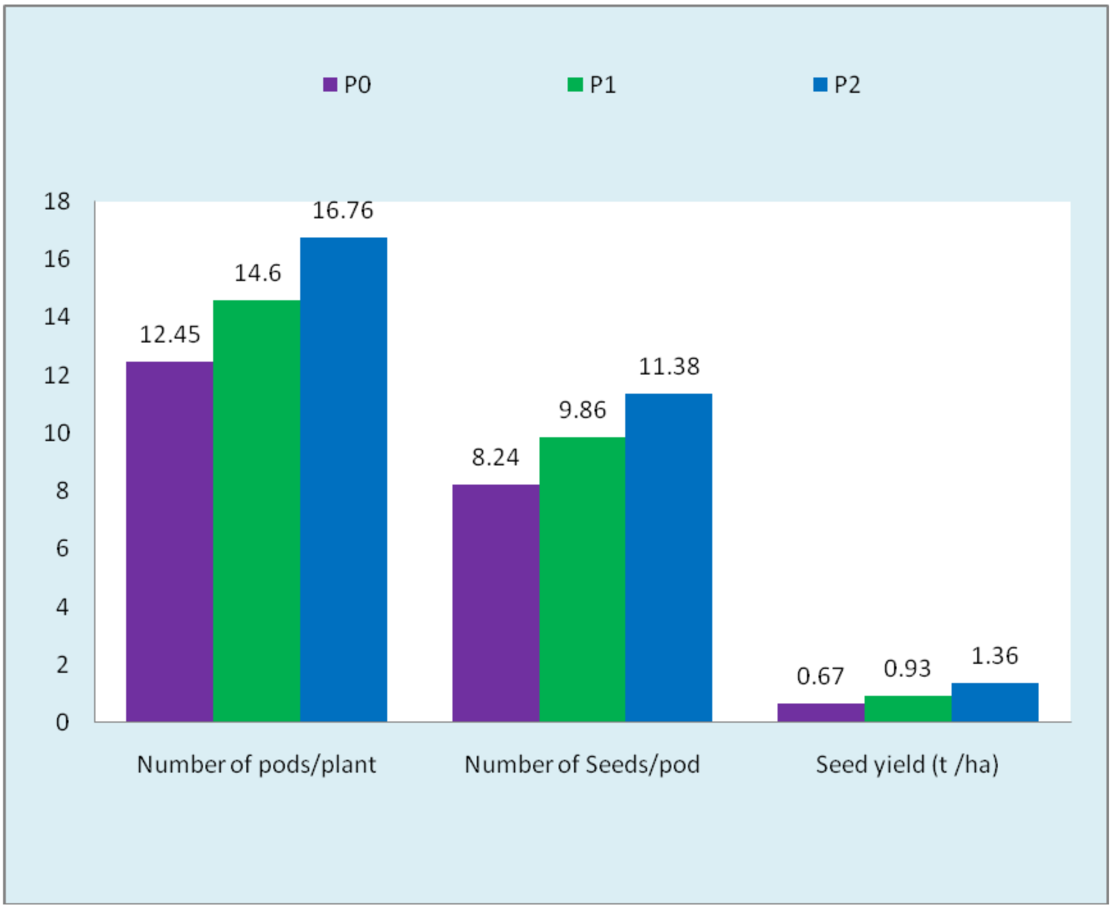


Figure 1 : Effect of different phosphorus level on the number of pods plant^{-1} & seeds pod^{-1} And yield of mungbean

4.2.3 Pod length (cm)

Pod length of mungbean varied significantly due to the application of different levels of phosphorus. The maximum pod length (9.21 cm) was recorded in P_2 treated plot which was statistically different from all other treatments. On the other hand the minimum pod length (6.85 cm) was recorded under P_0 treatment (Table 3). Bhat *et al.* (2005) observed 60 kg P/ha significantly improved the yield attributes compared to the control.

Application of molybdenum showed statistically significant variation in terms of pod length of mungbean. The maximum pod length (8.85 cm) was recorded in Mo_2 which was statistically different from all other treatments, while the minimum pod length (7.08 cm) was recorded under MO_0 treatment (Table 3).

Combined effect of phosphorus and molybdenum showed statistically significant variation for pod length. The maximum pod length (10.76 cm) was recorded in P_2Mo_2 treatment plot which was statistically different from all other treatments and the minimum pod length (6.02 cm) was recorded in P_0Mo_0 treatment plot (Table 4).

4.2.4 Number of seeds pod^{-1}

Number of seeds per pod of mungbean varied significantly due to the application of different level of phosphorus. The maximum number of seeds per pod (11.38) was recorded in P_2 which was statistically different from all other treatments and the minimum number of seeds per pod (8.24) was recorded in P_0 (Table 5). Application of molybdenum showed statistically significant variation in terms of number of seeds per pod of mungbean. The maximum number of seeds per pod (10.91) was recorded in Mo_2 which was significantly higer over Mo_1 and the minimum number of seeds per pod (8.62) was recorded in Mo_0 (Table 5).

Combined effect of phosphorus and molybdenum showed statistically significant variation for number of seeds per pod. The maximum number of seeds per pod (13.36) was recorded in P_2Mo_2 treated plot which was significantly higher over P_2Mo_1, P_1Mo_2, P_1Mo_1, P_2Mo_0, P_1Mo_0, P_0Mo_2, P_0Mo_1 and the minimum number of seeds per pod (7.13) was recorded in P_0 Mo_0 treated plot (Table 6).

Table 5. Main effect of phosphorus and molybdenum on the yield and yield attributes of mungbean

Level of Phosphorus and Molybdenum	Number of seeds/pod	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)
Effect of Phosphorus				
P_0	8.24 c	33.21 b	0.67 c	1.63 c
P_1	9.86 b	36.45 a	0.93 b	2.58 b
P_2	11.38 a	38.65 a	1.36 a	2.97 a
LSD (0.05)	**0.6201**	**4.606**	**0.07741**	**0.1731**
CV (%)	**6.31**	**8.83**	**8.10**	**7.21**
Effect of Molybdenum				
Mo_0	8.62 c	28.76 b	0.73 c	1.99 c
Mo_1	9.94 b	35.63 ab	1.01 b	2.47 b
Mo_2	10.91 a	38.91a	1.22 a	2.71 a
LSD(0.05)	**0.6201**	**4.606**	**0.07741**	**0.1731**
CV (%)	**6.31**	**8.83**	**8.10**	**7.21**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.3.1 Weight of 1000 seeds

Weight of 1000 seeds of mungbean varied significantly due to the application of different level of phosphorus. The maximum weight of 1000 seeds (55.73 g) was recorded in P_2 which was statistically identical (53.11) with P_1 and the minimum weight of 1000 seeds (47.80 g) was recorded in P_0 (Table 5). Srinivas *et al* (2002) observed that 1000-seed weight was increased with increasing rates of N up to 40 kg ha^{-1}.

Table 6. Combined effect of phosphorus and molybdenum on the yield and yield attributes of mungbean

Phosphorus x Molybdenum	Number of seeds/pod	Weight of 1000 seeds (g)	Seed yield (t/ha)	Stover yield (t/ha)
P_0Mo_0	7.13 f	28.23 c	0.59 f	1.05 f
P_0Mo_1	8.55 e	32.41 bc	0.68 ef	1.85 e
P_0Mo_2	9.03 de	32.46 bc	0.72 def	1.99 e
P_1Mo_0	9.21 de	33.87 bc	0.77 de	2.39 d
P_1Mo_1	10.01 cd	35.66 ab	0.99 c	2.58 cd
P_1Mo_2	10.35 bc	35.41 ab	1.04 c	2.76 bc
P_2Mo_0	9.51 cde	37.22 bc	0.83 d	2.55 cd
P_2Mo_1	11.27 b	38.42 ab	1.35 b	2.97 b
P_2Mo_2	13.36 a	40.21 a	1.89 a	3.38 a
LSD(0.05)	**1.074**	**7.979**	**0.1341**	**0.2998**
CV (%)	**6.31**	**8.83**	**8.10**	**7.21**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Application of different rates of molybdenum differed with significant variation in terms of weight of 1000 seeds of mungbean. The maximum weight of 1000 seeds (55.14 g) was recorded in Mo_2 treated plot and the minimum weight of 1000 seeds (49.45 g) was recorded in Mo_0 treatment (Table 5).

Combined effect of phosphorus and molybdenum showed statistically significant variation for weight of 1000 seeds. The maximum weight of 1000 seeds (60.28 g) was recorded in P_2Mo_2 and the minimum weight of 1000 seeds (45.53 g) was recorded in P_0Mo_0 treated plot (Table 6).

4.3.2 Seed yield (t/ha)

Statistically significant variation was recorded in terms of seed yield of mungbean due to application of phosphorus at different level. The maximum seed yield (1.36 t/ha) was recorded in P_2 treated plot which was statistically different from all other treatments and the minimum seed yield (0.67 t/ha) was recorded in P_0 (Table 5). Malik *et al.* (2006) reported that phosphorus application at 40 kg P_2o_5 ha^{-1} affected the crop positively, while rates below and above this rate resulted in non-significant effects. Bhat *et al.* (2005) observed the highest seed yield with 90 kg P/ha, which was as per with 60 kg P/ha and both were significantly superior to 30 kg P/ha. Likewise, 60 kg P/ha significantly improved the yield attributes except test weight compared to the control condition.

Application of different rates of molybdenum showed significant variation in terms of seed yield of mungbean. Seed yield of mungbean increased with increasing level of Mo up to certain level. The maximum seed yield (1.22 t/ha) was recorded in Mo_2 treated plot that differ from Mo_1 and the minimum seed yield (0.73 t/ha) was recorded in Mo_0 treated plot (Table 5).

Application of phosphorus along with molybdenum showed statistically significant variation for seed yield. The maximum seed yield (1.89 t/ha) was recorded in P_2Mo_2 which was statistically different from all other treatments and the minimum seed yield (0.59 t/ha) was recorded in P_0Mo_0 treated plot (Table 6). Dwivedi *et al.* (1997) observed that soybean was given 0-12 kg P_2o_5 and 0-1.5 kg Mo/ha. Seed yield increased with increasing P and Mo rates.

4.3.3 Effect of Molybdenum on yield contributing characters at different doses

As depicted in the Figure 2, it was revealed that maximum number of pods plant^{-1} (15.97) and seeds pod^{-1} (10.91) as well as yield (1.22 t/ha) of mungbean were found in the treatment Mo_2 (1.5 kg Mo/ha) which was significantly higher over Mo_1 (0.75 kg Mo/ha) treatment and the minimum number of pods plant^{-1} (12.84) and seeds pod^{-1} (8.62) as well as yield (0.73 t/ha) of mungbean were found in Mo_0 (control) treatment. That is the best treatment (Mo_2) increased maximum number of pods plant^{-1} and seeds pod^{-1} as well as yield over control.

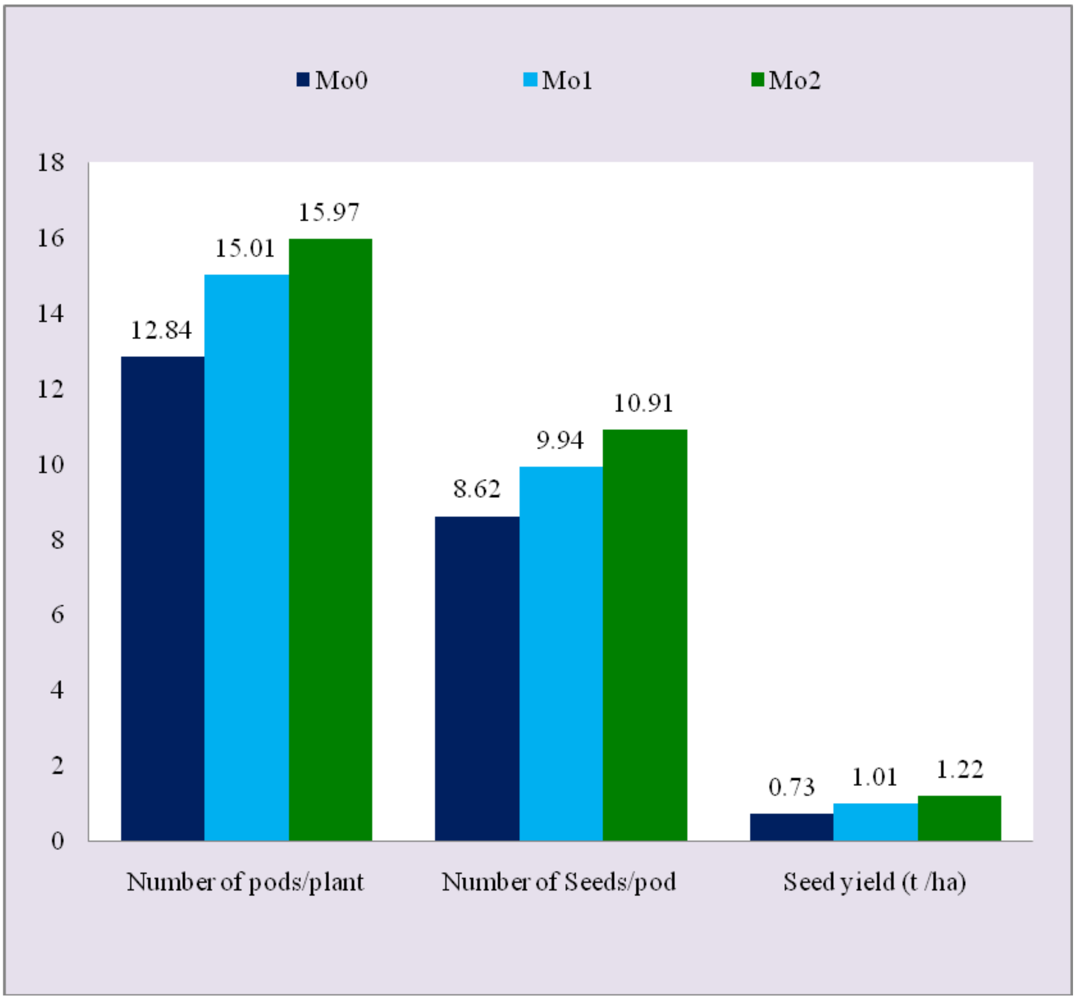


Figure 2 : Effect of different molybdenum level on the number of pods plant^{-1} & seeds pod^{-1} and yield of mungbean

4.3.4 Stover yield (t/ha)

Stover yield of mungbean varied significantly due to the application of different level of phosphorus. The maximum stover yield (2.97 t/ha) was recorded in P_2 which was statistically different from all other treatments and the minimum stover yield (1.63 t/ha) was recorded in P_0 treated plot (Table 5).

Application of molybdenum showed statistically significant variation in terms of stover yield of mungbean. The maximum stover yield (2.71 t/ha) was recorded in Mo_2 and the minimum stover yield (1.99 t/ha) was recorded in M_0 (Table 5). Naphade and Wankhade (1987) observed that seed and straw yields of mungbean were increased significantly with 1.5 kg Mo/ha.

Combined effect of phosphorus and molybdenum showed statistically significant variation for stover yield. The maximum stover yield (3.38 t/ha) was recorded in P_2Mo_2 which was statistically different from all other treatments and the minimum stover yield (1.05 t/ha) was recorded in P_0 Mo_0 treated plot (Table 6).

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

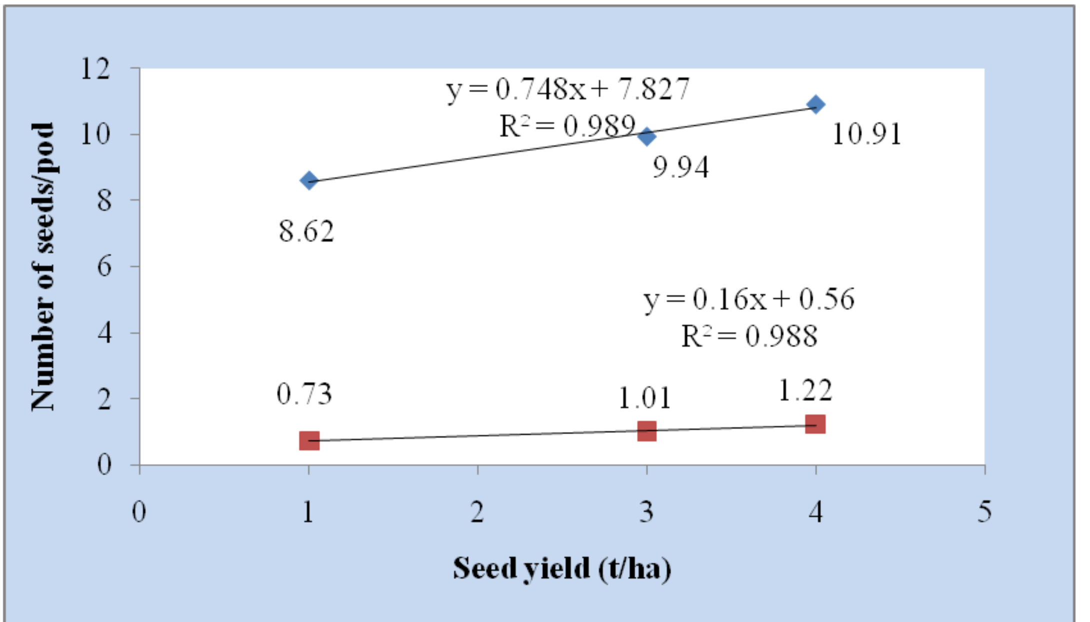


Figure 3: Linear relationship between number of seeds pod^{-1} and seed yield(t ha^{-1})

Correlation study was done to establish the relationship between the number of seeds pod^{-1} and yield of mungbean. From the study it revealed that highly significant correlation (R^2 = 0.989) was observed between the parameters (Figure 3). It was evident from the Figure 3 that the equation y = 0.748x + 7.827 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.989) showed that, fitted regression line had a significant regression co-efficient. From these relations it can be concluded that yield of mungbean was strongly (R^2 = 0.988) correlated with the number of seeds pod^{-1}, i.e., the yield of mungbean increased with the increase of number of seeds pod^{-1}.

Chapter V

SUMMARY AND CONCLUSION

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during September, 2013 to January, 2014 to study the effect of phosphorus and molybdenum on the growth and yield of mungbean. The variety, BARI Mung-5 was used in this experiment as the test crop. Data on different yield contributing characters & yield were recorded to find out the optimum levels of P and Mo for higher yield of mungbean.

Different plant and yield parameters were significantly influenced by different levels of phosphorus. The highest plant height (55.78 cm), number of leaves/plant (24.22), number of branches/plant (16.46), number of pods/plant (16.76), pod length (9.25 cm), number of seeds/pod (11.38), weight of 1000-seeds (38.91 g), seed yield (1.36 t/ha) and stover yield (2.96 t/ha) produced by P_2 treatment. The lowest plant height (49.56 cm), number of leaves/plant (17.55), number of branches/plant (10.51), number of pods/plant (12.42), pod length (6.81 cm), number of seeds/pod (8.24), weight of 1000-seeds (47.84g), seed yield (0.65 t/ha) and stover yield(1.63 t/ha) produced by control (P_0) treatment.

Different plant and yield parameters were significantly influenced by different levels of molybdenum. The highest plant height (55.29 cm), number of leaves/plant (23.56), number of branches/plant (15.17), number of pods/plant (15.97), pod length (8.85 cm), number of seeds/pod (10.91), weight of 1000-seeds (38.91 g), seed yield (1.22 t/ha) and stover yied (2.71 t/ha) produced by Mo_2 treatment. The lowest plant height (45.09 cm), number of leaves/plant (18.42), number of pods/plant (11.78), pod length (7.08 cm), number of seeds/pod (8.62), weight of 1000-seeds (47.80 g), seed yield (0.73 t/ha) and stover yield (1.99 t/ha) produced by control (Mo_0) treatment.

Seed yield of mungbean responded significantly to the combined application of phosphorus and molybdenum. The highest seed yield (1.89 t/ha) was recorded in P_2Mo_2 treatment. The lowest seed yield (0.59 t/ha) was recorded in the control viz. P_0Mo_0 treatment which received neither phosphorus nor molybdenum. Like seed yield the highest stover yield (3.38 t/ha) was recorded in P_2Mo_2 treatment and the lowest stover yield (1.05 t/ha) was recorded in the control viz. P_0Mo_0 treatment. Tallest plant (61.44 cm) and shortest plant (47.36 cm) were produced in P_2Mo_2 and P_0Mo_0 treatments, respectively. The treatment combination P_2Mo_2 produced highest number of branches/plant (19.27), number of pods/plant (19.18), pod length (10.76 cm), number of seeds/pod (13.36), weight of 1000-seeds (40.21 g). The control treatment P_0Mo_0 produced lowest number of leaves/plant (15.57), number of branches/plant (9.27), number of pods/plant (11.15), pod length (6.02 cm) and number of seeds/pod (7.13).

The results in this study indicated that the plants performed better in respect of seed yield in P_2Mo_2 treatment than the control treatment (P_0Mo_0) showed the least performance. It can be therefore, concluded from the above study that the treatment (application of phosphorus P_2o_5 @ 40 kg /ha and molybdenum MO @ 1.0 kg/ha) was found to the most suitable combination for the highest yield of mungbean in Red Brown Terrace Soils of Bangladesh.

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

1. The individual and combined effects of P and Mo on yield and yield attributes of mungbean were found positive and significant.
2. Application of P @ 40 kg/ha and MO @ 1.0 kg/ha was the most suitable combination for higher yield of mungbean in Deep Red Brown Terrace Soils of Bangladesh.

This experiment was an individual one conducted in this soil type. For proper fertilizer recommendation, further regional trials should be conducted.

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

Chapter VI

REFERENCES

Ahmed, R., Ikraam, M., Ehsan Ullah and Asif, M.. (2003). Influence of different fertilizer levels on the growth and productivity of three mungbean (*Vigna radiata* L.) cultivars. *Int. J. Agric. Bio.* **5** (3): 335-338

Ahmed, I. U., Rahman, S., Begum, N. and Islam, M. S. (1986). Effect of phosphorus and zink on the growth, yield and protein content of mungbean (*Vigna radiata*). *J. Ind. Soc. Soil Sci.* **34** (2): 305-308.

Ahmed, Z. U., Shaikh, M. A. Q., Khan, A. L. and Kaul, A. K. (1978). Evaluation of local, exotic and mutant germplasm of mungbean for varietal charecters and yield in Bangladesh. *SABRAO J.* **10**: p. 48.

Anon. (2005). Fertilizer Recommendation Guide 2005. Bangladesh Agricultural Research Council (BARC), Bangladesh.

Anwar, M. N., M. S. Islam and Rahman, A. F. M. H. (1981). Effect of phosphorus on the growth and yield of pulses. Annual report, BARI, Gazipur, p. 174.

Arya, M. P. S. and Karla, G. S. (1988). Effect of phosphorus on the growth, yield and quality of summer mung and soil nitrogen. *Ind. J. Agron. Res.* **22** (1): 23-30.

Asif, M., Hossain, N., and Aziz, M. (2003). Impact of different levels of phosphorus on growth and yield of mungbean genotype. *Asain J. Plant Sci.* **2** (9): 677-679.

Bayan, H. C. and Shaharia, P. (1996). Effect of weed management and phosphorus on kharif mungbean. *J. Agril. Sci. Soc.* **9** (2): 151-154.

BBS (2013). Year Book of Agricultural Statistics of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh. Dhaka. p: 37.

BBS. (2010). Statistical Year Book of Bangladesh. Statistics Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh. Dhaka. p: 6l-63 and 581.

BBS. (2005). Year Book of Agricultural Statistics of Bangladesh. Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh. Dhaka. p: 141.

Black , C.A. (1965). Methods of Soil Analysis. Part-l and 2. *American Society of Agron*. Inc. Publisher, Madison, Wisconsin, U.S.A.

Edwin, L., Jamkhogin, L. and Singh, A. I. (2005). Influence of sources and levels of phosphorus on growth and yield of green gram (*Vigna radiata L*.). legume Research. **28** (1): 59-61.

FAO (Food and Agricultural Organization). (1984). Mungbean. A Guide Book on Production of Pulses in Bangladesh. FAO Project Manual, Khamarbari, Farmgate, Dhaka.

Frauque, A., T. Haraguchi, O. Hirota and Md. Abiar Rahman. (2000). Growth analysis, yield, and canopy structure in maize, mungbean intercropping. *Bu. Inst. of Tropical Agric*. Kyushu University Fukuoka, Japan, 23: 61-69.

Gopala, R. P., Shrajee, A.M., Roma R. K. and Reddy, T. R. K. (1993). Response of mungbean (*Vigna radiata*) cultivars to levels of phosphorus. *Indian J. Agron.* **38** (2): 317-318.

Gowda, C. L. L. and A. K. Kaul. (1982). Pulses in Bangladesh, Bangladesh Agricultural Reasearch Institute, Joydebpur, Gazipur. P:119-472.

Hossain, M. E. (1990). Effect of different sources of nutrients and mulching on the growth and yield of amaranth. MS Thesis, Dept. of Hort., Bangladesh Agril. Univ., Mymensingh, Bangkadesh. pp. 95

Jackson, M. L. (1973). Soil Chemical Analysis. Prentice Hall of India Privat Limited. New Delhi.

Kalita, M. M. (1989). Effect of phosphorus and growth regulator on mungbean (*Vigna radiata*). *Ind. J. Agron.* **34** (2): 236-237.

Karle, A. S. and Power, G. G. (1998). Effect of legume residue incorporation and fertilizer in mungbean-safflower cropping system. *J. Maharasthsa Agril. Univ.* **23** (3): 333-334.

Kaul, A. K. (1982). Pulses in Bangladesh. Bangladesh Agril. Res. Coun., Farm Gate, Dhaka. p. 27.

Khan, E. A., Khan, F. U., M. A. Karim (2004). Effect of phosphorus levels on the yield and yield components of mungbean. *Indus J. of Plant Sci*. **3** (4): 446-449.

Khan, M.R.I. (1981). Nutritional quality characters in pulses. In: Proc. MAT. Workshop Pulses. pp 199 -206.

Kay, D. E. (1979). Food legumes crop and product digest no. 3. Tropical Products Institute, London.

Mahboob, A. and Asghar, M. (2002). Effect of seed inoculation and different nitrogen levels on the grain yield of mungbean. *Asian J. Plant. Sci*. **1** (4): 314-315.

Malik, A., Fayyaz, H., Abdul, W., Ghulam, Q. and Rehana, A. (2006). Interactive effects of irrigation and phosphorus on greengram (*Vigna radiata* L.). *Pakistan J. Botany*. **38** (4): 1119-1126.

Malik, M. A., Saleem, M. F., Asghar, A. and Ijaz, M. (2003). Effect of nitrogen and phosphorus application an growth, yield and quality of mungbean (*Vigna radiata* L.). pakistan J. Agril. Sci. **40** (3-4): 133-136.

Mandal, R. and Sikdar, B. C. (1999). Effect of nitrogen and phosphorus on growth and yield of mungbean grown in saline soil of Khulna, Bangladesh. *J. Dhaka Univ*. **12** (1-2): 85-88.

Manpreet, S., Oad, F. C. and and Buriro U. A. (2005). Influence of different NPK levels on the growth and yield of mungbean. *Indus. J. Plant Sci*. **4** (4): 474-478.

Manpreet, S., Sekhon, H. S. and Jagrup, S. (2004). Response of summer mungbean (*Vigna radiata* L.) genotypes to different phosphorus levels. *Environment and Ecology*. **22** (1): 13-17.

Mastan, S. C., Reddy, S. N., Reddy, T. M. M., Shaik, M. and Mohammad, S. (1999). Productivity potential of rice-sunflower-mungbean cropping system as influenced by rational use of phosphorus. *Ind. J. Agron*. **44** (2): 232-236.

Mitra, S., Bdattacharya and Datta, S. K. (1999). Effect of variety, rock phosphate and phosphate stabilizing bacteria on growth and yield of mungbean (*Vigna radiata)* in acid soils of Tripura. Environ. Ecol. **17** (4): 926-930.

Murphy, J, and Riley, J. P. (1962). A modified single solution method for the determination of phosphate in natural waters. *Anal. Chim. Acta.* 27: 31-36.

Nadeem, M. A., Ahmed, R. and Ahmed, M. S. (2004). Effect of seed inoculation and different fertilizers levels on the growth and yield of mungbean (*Vigna radiata*). *J. Agron*. **3** (1): 40-42.

Naeem, M., Iqbal, J., Alias, M. A. and Bakhsh, H. A. (2006). Comperative study of inorganic fertilizers and organic manures on yield and yield components of mungbean (*Vigna radiata* L.). *J. Agric. Soc. Sci.* 1813-2235/02-4-227-229.

Nayyar, V. K. and I. M. Chibbam. (1992). Interactions of zinc with other plant nutrients in soils and crops. In: Management of Nutrient Interactions in Agriculture. (Ed. H. L. S. Tandon). FDCO, New Delhi , India. Pp:116-142.

Nigamananda, B. and Elamathi, S. (2007). Studies on the time of nitrogen, application of foliar spray of DAP and growth regulators on yield attributes, yield and economics of green gram (*Vigna radiata* L.). inter. *J. of Agric. Sci.* **3** (1): 168-169.

Oad, F. C. and Buriro, U. A. (2005). Influence of different NPK levels on the growth and yield of mungbean. *Indus J. Plant Sci.***4** (4): 474-478.

Oad, F. C., Shah, A.N., Jamro, G. H. and Ghaloo, S. H. (2003). Phosphorus and potassium requirements of mungbean (*Vigna radiata*). *J. Applied Sci.* **3** (6): 428-431.

Patel, F. M. and Patel, L. R. (1991). Response of mungbean(*Vigna radiata)* varities to phosphorus and *Rhizobium* inoculation. *Ind. J. Agron.* **36** (2): 295-297.

Patel, M. L., Gami, R. C. and Patel, P. V. (1993). Effect of farmyard manure and NPK fertilizars on bulk density of deep black soil under rice-wheat-mungbean rotation. Gujrat Agril. *Univ. Res. J.* **18** (2): 109-111.

Patel, J. S., and Parmar, M. T. (1986). Response of green gram to varying levels of nitrogen and phosphorus. *Masdras Agric. J.* **73**(6): 355-356.

Patel, R. G., Patel, M. P., Patel, H. C. and Patel, R. B. (1984). Effect of graded levels of nitrogen and phosphorus on growth, yield and economics of summer mungbean. *Ind. J. Agron.* **29** (3): 291-294.

Poehlman, J. M. (1991). The mungbean. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India, pp. 14-27.

Prassad, J., Kerketta, R. and Ram, H. (2000). Soil fertility as influenced by different cropping sequences. *Ind. J. Agron.* **61** (1): 16-19.

Prasad, M. R., Singh, A. P. and Singh, B. (2000). Yield, water use efficiency and potassium uptake by summer mungbean as affected by varying levels of potassium and moisture stress. *J. Indian Soc. Soil Sci.* **48** (4): 827-828.

Rajkhowa, D. T., Thakuria, K. and Baroova, S. R. (1992). Response of summer green (*Phaseolus radiatas*). Varieties to sources and level of phosphorus. *Ind. J. Agron.* **37** (3): 589-590.

Rajput, O. P. and Verma, B.S. (1982). Yield and yield components of summer mungbean (*Vigna radiata*) as affected by varieties, seedling rates and rates of phosphate fertilizer. Legume Res. **5** (1): 8-12.

Ramamoorthy, K. and Raj, A. (1997). Studies on phosphorus economy in rainfed green gram. Univ. Ag. Sci., Bangalore. **26** (11): 208-209.

Rajander, K., Singh, V. P., Singh, R. C. (2002). Effect of N and P fertilization on summer planted mungbean (*Vigna radiata* L.). *Crop Res. Hisar.* **24** (3): 467-470.

Raundal, P. U., Sabale, R. N. and Dalvi, N. D. (1999). Effect of phosphorus manures on crop yield in mungbean-wheat cropping system. *J. M. Maharashtra Agril. Univ*. **24** (2): 151-154.

Reddy, B. G. and Reddy, M. S. (1998). Soil health and crop productivity in Alfisols with integrated plant nutrient supply system. *J. Australian Agric.* **96**: 55- 59.

Reddy, S. N., Singh, B.G. and Rao, I. V. S. (1990). An analysis of dry matter production, growth and yield in mungbean and blackgram with phosphate fertilizer. *J. M. Maharashtra Agril. Uni*v. **15** (2): 189-191.

Samiullah, M., Akter, M., Afridi, M. M. R. K. and Ansari, S. A. (1987). Effect of nitrogen and phosphorus levels in paddy fallows. *Karnataka J. Agril. Sci.* **15** (1): 4-7.

Samiullah, M. A., Akter, M., Afridi, N. M. R. K. and Khan, F. A. (1986). Foliar application of phosphorus on mungbean. *Ind. J. Agron.* **31** (2): 182-183.

Sarkar, R. K. and Banik, P. (1991). Response of mungbean (*Vigna radiata*) to nitrogen, phosphorus and molybdenum. *Ind. J. Agron.* **36** (1): 91-94.

Satter, M. A. and Ahmed, S. U. (1992). Response of mungbean(*Vigna radiata*) to inoculation with *Bradyrhizobium* as affected by phosphorus levels. Proc. Of Commission Conference, Bangladesh. 1-3 December, 1992. Pp. 419-423.

Satish, K., Singh, R. C. and Kadian, V. S. (2003). Response of mungbean genotypes to phosphorus application. *Indian J. Pulses Res.* **16** (1): 65-66.

Sharma, B. M. and Yadav, J. S. P. (1976). Availability of phosphorus to gram as influenced by phosphate fertilization and irrigation regime. *Ind. J. Agric. Sci.* **46** (5): 205-210.

Sharma, C. K. and Sharma, H. K. (1999). Effect of different production factors on growth, yield and economics of mungbean (*Vigna radiata* L. Wilezeck). *Hill farming*. **12** (1-2): 29-31.

Sharma, M. P. and Singh, R. (1997). Effect of phosphorus and sulphar on mungbean (*Vigna radiata*). *Ind. J. Agron.* **42** (4): 650-653.

Sharma, C. K. and Sharma, H. K. (1991). Effect of different production factors on growth, yield and economics of mungbean (*Vigna radiata* L. Wilezeck). Hill Farming. **12** (1-2) : 29-31.

Shukla, S. K. and Dixit, R. S. (1996). Effect of Rhizobium inoculation, plant population and phosphorus on growth and yield of summer mungbean (*Vigna radiata*). *Ind. J. Agron.* **41** (4): 611-615.

Sing, H.P. and D.P. Sing, (1999). Recent Advances in Urdbean and Mungbean Production.

Singh, A. P., Chaudhury, R. K., and Sharma, R. P. R. (1993). Effect of inoculation and fertilizer levels on yield, nutrient uptake and economics of summer pulses. *J. Potassium Res.* **90**: 176-178.

Singh, A. V. and Ahlawat, I. P. S. (1998). Studies on N-economy in rainy season maize as affected by P-fertilizer and stover management in preceding summer mungbean (*Vigna radiata*). *Crop. Res. Hisar.* **16** (2): 171-179.

Singh, C. and Yadav, B. S. (1978). Production potential of mungbean and gaps limiting its productivity in India. Proc. First Intl. Mungbean Symp. Aug. 16-19. (1977), Loss Banos, Philipines.

Sivasankar, A., P. R. Reddy and Singh, B. G. (1982). Effect of phosphorus on N-fixation and dry matter partitioning legume. *Res.* **7**: 105.

Sohrabi, M., (1991). The results of munbean variety, 70 research institutes, seed and plant breeding, Cereals Research Department, Project Number, 69242-12-100.

Soni, K. C. and Gupta, S. C. (1999). Effects of irrigation schedule and phosphorus on yield, quality and water use efficiency of summer mungbean (*Phaseolus radius*). *Ind. J. Agron*. **44** (1): 130-133.

Solaiman, A. R. M., M. A. Satter, A. F. M. S. Islam. And M. A. Khan. (1991). Response of *Rhizobium* inoculated greengram to nitrogen and phosphorus application under field conditions. *Bangladesh J. Soil. Sci.* **22** (1-2): 51-58.

Srinivas, M., Shahik, M. and Mohammad, S. (2002). Performance of greengram (*Vigna radiata* L. Wilczek) and response functions as influenced by different levels of nitrogen and phosphorus. Crop Res. Hisar. **24** (3):458-462.

Teotia, J. L., Naresh, C., Gangiah, B., and Dikshit, H. K. (2001). Performance of mungbean (*Vigna radiata*) varities at different row spacings and nitrogen phosphorus fertilizer levels. *Ind. J. Agron.* **76** (9): 564-565.

Thakur, V. R., Giri, D. and Deshmukh, J. P. (1996). Influence of different sources and levels of phosphorus on yield and uptake of greengram (*Vigna radiata* L.) *Annals of Plant Physiol*. **10** (2): 145-147.

Thakuria, K. and P. Saharia. (1990). Response of greengram genotypes to plant density and phosphorus levels in summer. *Ind. J. Agron.* **35** (4): 416-417.

Tickoo, J. L., Naresh, C., Gangaiah, B. and Dikshit, H. K. (2006). Performance of mungbean (*Vigna radiata*) varities at different row spacings and nitrogen phosphorus fertilizer levels. *Indian J. Agric. Sci*. **76** (9): 564-565.

Umar, M., Khaliq, A. and Tariq, M. (2001). J. Bio. Sci. Issue 6, pp:427-428, Vol: 1, Year: 2001.

Vikrant, K., Harbir, S., Singh, K. P., Malik, C. V. S. and Singh, B. P. (2005). Effect of FYM and phosphorus application on the grain and protein yield of greengram. *Haryana J. Agron*. **21** (2): 125-127.

Yadav, O. P. and Rathore, J. P. (2002). Effect of phosphorus and iron fertilizer in mungbean on loamy sandy soil in India. *J. Ind. Soc. Soil Sci*. **23** (2): 203-205.

Agarwala, S. C., Sharma, P. N., Chatterjee, C. and Sharma, C. P. 1981. Development and enzyme changes during pollen development in boron deficient plants. *J plant Nutr.* 3: 329-336.

BARI (Bangladesh Agricultural Research Institute), 2003. Annual Report for 2003/Mungbean in Bangladesh, 2004. P: 27.

Mandal, B., Pal, S. and Mandal, L.N. 1998. Available boron and molybdenum content in some alluvial acidic soils of north Bengal. *Ind. J Agric. Sci.* 61 (7): 502-504.

Tanaka H. 1967. Boron absorption by crop plants as affected by other nutrients of the medium. Soil Sci. Plant Nutr. 13,41-44.

USDA. (1951). Soil survey manual by soil survey stuff. Bureau of plant industry, soil and agricultural engineering. Hand book no. 18, 205. US Govt. printing Office, Washington D.C.

Verma, R.J. and Mishra, P. H. 1999. Effect of doses and methods of boron application on growth and yield of mungbean. *Ind. J Pulse Res.* 12 (1): 115-118.

Vinay-Singh and Singh, S. P. 1984. Studies on boron toxicity in lentil and *barley.lnd. J of Agron.* 29 (4): 545-546.

Wang, Z., F. Zhang, and Shen, K. 1999. Comparative analysis of free amino acid in mustard *(Brassica napus L.)* under different boron levels of China Agric. Univ. 1 (1): 73-78.

Wani, B. B., Patil, G. D. and Patil, M. D. 1988. Effects of levels of single superphosphate and boronated superphosphate on the yield and quality of groundnut. *J Maharastra Agric. Uni.* 13 (3): 302-304.

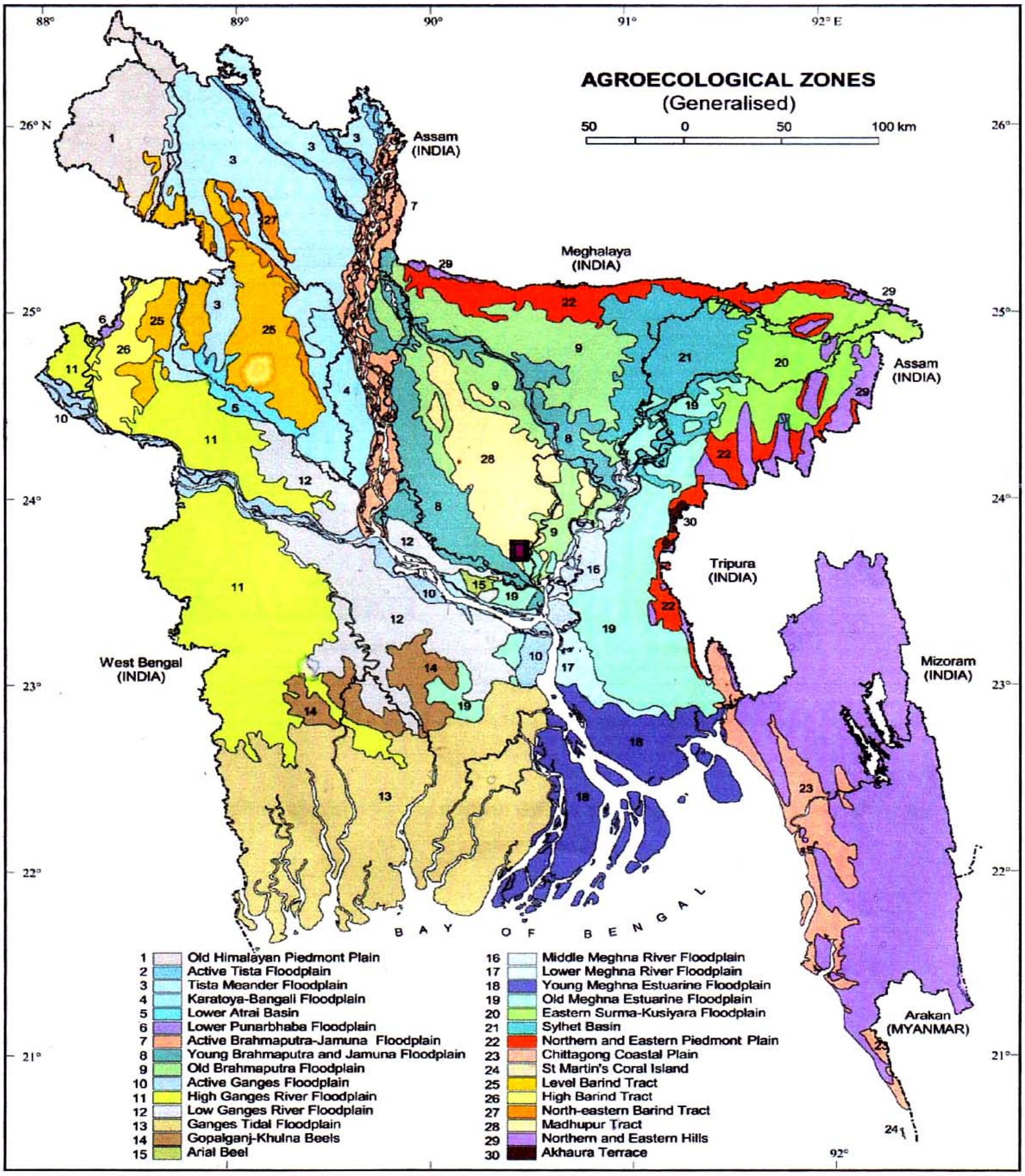
Yadav, O. P. and H. R. Manchanda. 1982. Effect of boron application in mustard *(Brassica napus L.)* on a sierozem sandy soil. *J Ind. Soc. Soil Sci.* 30 (3): 408-410.

Yong Hua and Zhang Hong Yan. 1998. Boron amelioration of aluminium toxicity in mungbean seedlings. J. Plant. Nutri. 21(5): 1045-1054.

chapter VII

APPENDIX

Appendix 1. Map showing the experimental site under study



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

Month	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
September, 2013	23	16	45	61
October, 2013	25	18	55	137
November, 2013	23	15	72	245
Decemver, 2013	22	17	79	315
January, 2014	21	16	79	329

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

Appendix 3: Commonly used symbols and abbreviations

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

CEC	Cation Exchange Capacity
Cm	Centi-meter
CV%	Percentage of coefficient of variation
Df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
EC	Emulsifiable concentration
et al	and others
Etc	Etcetera
FAO	Food and Agricultural Organization
G	Gram
H	Hours
J.	Journal
kg ha^{-1}	Kilograms per hector
t ha^{-1}	Ton per hector
Kg	kilogram
M	Meter
m^2	square meter
MOA	Ministry of Agriculture
MSE	Mean square of the error
No.	Number
Ppm	parts per million
RCBD	randomized complete block design
Rep.	replication
Res.	research
SAU	Sher-e-Bangla Agricultural University
Sc.	Science
SE	Standard Error