GROWTH AND YIELD OF MUNGBEAN (BARI Mung-6) AS INFLUENCED BY DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS

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CERTIFICATE

This is to certify that the thesis entitled, **“GROWTH AND YIELD OF MUNGBEAN (BARI Mung-6) AS INFLUENCED BY DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS”** 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 **MOSTAFA PATWARY,** Registration No. **08-02888** 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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ABSTRACT

A research work was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka during the period from March, 20014 to July, 2014 to study growth and yield of mungbean (BARI Mung-6) as influenced by different levels of nitrogen and phosphorus. The experiment included four levels of nitrogen viz., 0, 20, 40 and 60 kg N ha^{-1} and three levels of phosphorus viz., 0, 20 and 40 kg P ha^{-1}. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Nitrogen fertilizer had significant effect on growth and yield of mungbean. Application of nitrogen @ 60 kg ha^{-1} gave the highest plant height, number of leaves $plant^{-1}$, number of branches $plant^{-1}$, number of pods $plant^{-1}$, pod length, number of seeds pod^{-1}, 1000-seed weight, seed yield and stover yield. In all cases the lower values were found with the untreated control treatment. Phosphorus fertilizers also had significant effect on growth and yield of mungbean. Application of phosphorus @ 40 kg ha^{-1} produced the highest plant height, number of leaves $plant^{-1}$, number of branches $plant^{-1}$, number of pods $plant^{-1}$, pod length, number of seeds pod^{-1}, 1000-seed weight, seed yield and stover yield. In all the cases lower values were found with the control treatment. Nitrogen @ 60 kg ha^{-1} was found statistically superior to all other treatments. Nitrogen in combination with phosphorus showed significant effect on yield and yield attributes of mungbean. Combined application of nitrogen @ 60 kg ha^{-1} and phosphorus @ 40 kg ha^{-1} resulted the highest plant height, number of leaves $plant^{-1}$, number of branches $plant^{-1}$, number of pods $plant^{-1}$, pod length, number of seeds pod^{-1}, 1000-seed weight, seed yield and stover yield. On the other hand, in all the cases lower values were found in the untreated control treatment.

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Chapter I
INTRODUCTION

Mungbean [*Vigna radiata* (L.) Wilczek] is an important legume and short duration pulse crop of Bangladesh and other South Asian Countries. Mungbean also known as green gram or golden gram is one of the most important pulse crops in Bangladesh. It belongs to the family Leguminosae. It is native to the Indian subcontinent and mainly cultivated in India, China, Thailand, Philippines, Indonesia, Myanmar, Bangladesh, Laos and Cambodia but also in hot and dry regions of Europe and the United States. It is used as a foodstuffs in both savory and sweet dishes.

Mungbean (*Vigna radiata* L.) is an important pulse crops having high nutritive value**.** It not only plays an important role in human diet but also in improving the soil fertility by fixing the atmospheric nitrogen (Ather Nadeem *et al*., 2004). Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses (Anjum *et al*., 2006). Pulse is a popular crop in the daily diet of the people of Bangladesh. Pulses have been considered as “poor men's meat” since pulses contains more protein than meat and also more economical, they are the best source of protein for the underprivileged people. It is taken mostly in the form of soup which is commonly known as "dal". Generally, there is no complete dish without "dal" in Bangladesh. Green pulse seeds also can be consumed as fried peas or can be used in curry.

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

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

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

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

It is recognized that pulses offer the most practical means of solving protein malnutrition in Bangladesh but there is an acute shortage of grain legumes in relation to its requirements because the yield of legumes in farmer's field is usually less than 1 t ha^{-1} against the potential yield of 2 to 4 t ha^{-1} (Ram and Dixit, 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 BARI Mung-6, BARI Mung-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 Chhibbam, 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 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.

Research revealed that mungbean yield and quality could be improved by the use of balanced fertilizers (Choudhury, 2005). Salah Uddin *e al*., (2009) stated that most of the growth components significantly influenced by chemical and biofertilizers. Abbas (1994) reported that application of NPK @ 25-50-75 kg ha^{-1}gave the highest grain yield of 1666 kg ha^{-1}. Studies also reported that grain yield of mungbean was increased by the application of 20 kg N and 40 kg P2O5 whereas K application showed non-significant effects (Singh *et al*., 1993). Khan *et al*., (1999) reported that phosphorus application significantly increased the yield of mungbean. Many other researchers also reported that grain yield of legumes increased with increasing P_2O_5 up to 50 kg ha^{-1} (Thakuria & Saharia, 1990; Patel & Patel, 1991; Rajkhowa *et al*.,1992). Whereas, Tariq *et al*., (2001) stated that application of P_2O_5 and K_2O each @

70 kg ha^{-1} along with N application @ 30 kg ha^{-1} produced the highest grain yield. The maximum seed yield i.e., 224.2 g m^{-2} was obtained when 90 kg N and 120 kg P_2O_5 $ha^{-1}$was applied. The maximum number of pods $plant^{-1}$ (20.87), pods length (8.71 cm), seeds pod^{-1} (8.53), 1000 seeds (27.82 g) and seed yield (1.40 t ha^{-1}) obtained in fertilizer application @ 45:80:55 kg NPK ha^{-1}+ Rhizobium inoculation (Hossain *et al.*,2011). A very little is known about the mungbean response in term of growth attributes toward applied NPK fertilizers. Therefore, the objectives of the present study were to investigate the extent of maximum dose of fertilizer application and to pinpoint that cultivar of mungbean, which are promising in term of growth attributes. The study also aimed to establish a relationship between various growth parameters and seed yield to identify a set of growth traits to be used in future breeding program of mungbean variety.

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

Objectives:

1. To evaluate the response of mungbean to nitrogen and phosphorus.
2. To find out the optimum doses of nitrogen and phosphorus for maximizing the yield of mungbean.
3. To study the combined influence of nitrogen and phosphorus on the growth and yield of mungbean.

Chapter II
REVIEW OF LITERATURE

Many 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 nitrogen on growth, yield and yield contributing characters of mungbean

Azadi *et al.* (2013) observed that different nitrogen levels influenced different growth and yield attributes of mungbean such as plant height, seed yield, stem diameter, number of node and 75 kg N ha^{-1} showed higher values than the other N doses (50, 100 and 150 kg N ha^{-1}).

Achakzai *et al.* (2012) found that different Nitrogen levels influenced most of the growth attributes of the mungbean. Maximum days to flowering, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, plant height, number of branches $plant^{-1}$, leaf area and grain yield recorded for plants subjected to highest dose of applied N fertilizer at 100 kg ha^{-1}.

Sultana *et al.* (2009) reported that application of 20 kg N ha^{-1} as basal dose and 20 kg N $ha^{-1}$with one weeding at vegetative stage showed significantly higher values of all growth parameters like leaf area, shoot dry weight, number of branches, pods $plant^{-1}$ and seed yield.

Sultana (2006) noticed that plant height of mungbean showed superiority at 30 kg N ha^{-1} followed by 40 kg N ha^{-1}. Nitrogen fertilizer significantly influenced plant height at all growth stages of mungbean. At 20, 35, 50, 65 DAS and harvest the maximum heights were observed in the plants treated with 30 kg N ha^{-1}.

Ghosh (2004) used different levels of nitrogen and indicated that number of branches $plant^{-1}$ of mungbean was gradually increased with increasing N level at 25 kg N $ha^{-1.}$

Masud (2003) observed that highest plant height of mungbean with the application of 30 kg N ha^{-1} while Ghosh (2004) at 25 kg N ha^{-1}.

Rudreshhappa and Halikatti (2002) explained the effect of N levels (0, 12.5 and 25 kg) on growth, yield and nutrient uptake of green gram in paddy fallows. Application of 12.5 kg N ha^{-1} was recorded to produce significantly higher seed yield. Further increase in N doses (25 kg ha $^{-1}$) did not significantly increase the yield.

Srinivas *et al.* (2002) examined the effects of N (0, 20, 40 and 60 Kg ha^{-1}) and P_20_5, 50 and 75 Kg ha^{-1}) along with seed inoculation with *Rhizobium* culture on the growth, yield and yield components of mungbean. They observed that number of pods $plant^{-1}$, pod length and seeds pod^{-1} were increased with increasing rates of P and with increasing rates of N up to 40 kg ha^{-1} and also observed that 1000 seed weight in greengram.

Tank *et al.* (1992) found that mungbean fertilized with 20 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} produced significantly higher number of pods $plant^{-1}$ over the unfertilized control.

Pathak *et al*. (2001) evaluated the effect of N levels (0, 10, 20 and 30 kg ha^{-1}) on growth and yield of mungbean under rainfed condition during the summer of 1999 and found that application of 20 kg N ha^{-1} yielded poorer than 30 kg N ha^{-1}.

Hamid (1999) revealed the effects of foliar application of nitrogen on mungbean cv. Mubarik. In both pot and field trials he showed 10 kg N ha^{-1} increased the number of pods $plant^{-1}$.

Mandal and Sikdar (1999) laid out a greenhouse pot experiment where mungbean (BARI Mung-5) grown on saline soil and given 0, 50 or 100 kg N ha^{-1} and 0, 75 or 150 kg P ha^{-1}. Growth and yield increased significantly with N application while P significantly increased the setting of pods and seeds. Root growth was significantly improved by both individual and combined application of these two fertilizers.

Mozumder (1998) studied the effect of five N levels (0, 20, 40, 60 and 80 kg N ha $^{-1}$) and two varieties of summer mungbean, BINA Mung-2 and Kanti, found that N exerted negative effect on the harvest index.

In an experiment with the foliar application of nutrients on the growth and yield of mungbean cv. Kowmy-1, Abd-El-Latif *et al.* (1998) revealed that application of urea increase the number of branches $plant^{-1}$ on mungbean plant.

Provorov *et al*. (1998) observed the effect of seed inoculation of mungbean with strain CIAMI 901 of *Bradyrhizobium* and found that the seed yield was increased by 39.2% and 1000 seed weight 16%. These results were equivalent to applying 120 kg N ha^{-1}. Best results obtained with inoculations + 60 kg N ha^{-1}.

Satyanarayanamma *et al.* (1996) in a field experiment found that spraying of 2% urea at flowering and pod development stage produced the highest seed yield (1.59 t ha^{-1}) over the control.

Kaneria and Patel (1995) reported that the application of 10 kg N ha^{-1} to mungbean significantly increased seed yield attributes.

Quah and Jafar (1994) noted that plant height of mungbean was significantly increased by the application of nitrogen fertilizer with 50 kg ha^{-1} and also noted that 1000 seed weight of mungbean increased significantly by the application of N at 50 kg ha^{-1}.

Gopala *et al.* (1993) found that the response of mungbean cultivars (Pusa Baishakhi, LGG 407, LGG 410 and MS 267) to a uniform dose of 20 kg N ha^{-1} and found that plant height, net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR) were increased at 20 kg N ha^{-1}.

Tank *et al.* (1992) observed that mungbean fertilized with 40 kg N ha^{-1} produced the highest seed yield $plant^{-1}$ while the lowest was observed in control treatment (0 kg N ha^{-1}).

Sarkar and Banik (1991) revealed that application of 10 kg N ha^{-1} to mungbean resulted in appreciable improvement in yield attributes. They found that the stover yield of mungbean increased significantly due to use of N up to 10 kg N ha^{-1}. On an average, the stover yield increased by 24% due to the application 10 kg N ha^{-1} over no N. they also observed that application of 10 kg N ha^{-1} to mungbean resulted in appreciable improvement in number of pods $plant^{-1}$ over no N.

Suhartatik (1991) also reported that NPK fertilizers significantly increased the plant height of mungbean.

Agbenin *et al.* (1991) revealed that application of N significantly increased plant height, seed yield, dry weight, crop growth rate and nutrient uptake of mungbean over control.

Leelavathi *et al.* (1991) reported that different levels of N showed significant difference in seed yield of mungbean up to a certain level.

Samiullah *et al.* (1987) recorded that number of seeds pod^{-1} were the highest with 10 kg N + 75 kg P_2O_5 + 60 kg K_2O in summer mungbean.

Mahmud and Gad (1988) observed that application of N increased the stover yield up to a certain level under different row spacing of mungbean.

Patel and Parmer (1986) observed that increasing N application to rainfed mungbean (*Vigna radiata* cv. Gujrat-1) from 0-45 kg ha^{-1} increase average seed yield from 0.83 to 0.94 t ha^{-1} and also increased protein content, plant height, number of branches plant^{-1}, pods plant^{-1}, seeds plant^{-1} and 1000 seed weight.

Patel *et al.* (1993) studied that, in summer season on clayey soil application of 0, 10, 20 and 30 kg N ha^{-1} significantly increased the number of pods plant^{-1}.

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

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

Tickoo *et al.* (2006) carried out an experiment on mungbean and cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30.0 m spacing and was supplied with 36-46 and 58-46 kg of N/P/ha in a field experiment conducted in New Delhi. India during the kharif season of 2000. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}) respectively compared to cv. Pusa 105. Nitrogen and 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 $P^2O^5ha^{-1}$) 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 greengram cv. AAU-34. The highest number of branches $plant^{-1}$ (3.23) was obtained with 30 kg MRP + 30 kg SSP ha^{-1}. Single super phosphate at 60 kg/ha gave the highest number of clusters $plant^{-1}$ (4.36). Pod length (7.34 cm), seeds pod^{-1} (10.5). 1000 seed weight (34.9 g) and seed yield (15.1 q ha^{-1}). Maximum plant height (31.2 cm), dry matter $plant^{-1}$ (36.1 g) and number of pods $plant^{-1}$ (l 7.4) was obtained with 60 kg DAP ha^{-1}.

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 (1.1ton 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 mungbean genotypes MH 85-111 and T44. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N did not affect yield. The number of branches, number of pods plant^{-1}, numbers of seeds pod^{-1}. 1000 seed weight and straw yield increased with increasing rates P. whereas grain yield increased with increasing rates up to 40 kg P ha^{-1} only

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

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

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at different levels of nitrogen and phosphorus. Different rates of N (0, 25 and 60 kg ha^{-1}) and P (0, 25, 50 and 60 kg ha^{-1}) were tested. They observed that the number of pods/plant was increased with the increasing rates of N up to 40 kg ha^{-1} followed by a decrease with further increase in N. They also observed that 1000-seed weight was increased with increasing rates of N up to 40 kg ha^{-1} along with increasing rates of P which was then followed by a decrease with further increase in N.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Bayan and Saharia (1996) carried out an experiment to study the effect of phosphorus on mungbean during the kharif seasons of 1994-95 in Bishanath

Chariali Assam, India. The results indicated that plant height was unaffected by phosphorus application.

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

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

Singh and Choudhury (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 60kg 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 (77.33 kg 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 was running 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.

2.3. Interaction effect of nitrogen and phosphorus on growth, yield and yield contributing characters of Mungbean

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

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}.

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}).

Srinivas *et al.* (2002) examined the effects of N (0, 20, 40 and 60 Kg ha^{-1}) and P_20_5, 50 and 75 Kg ha^{-1}) along with seed inoculation with *Rhizobium* culture on the growth, yield and yield components of mungbean. They observed that number of pods plant^{-1}, pod length and seeds pod^{-1} were increased with increasing rates of P and with increasing rates of N up to 40 kg ha^{-1} and also observed that 1000 seed weight in greengram.

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.

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

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

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}.

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 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}).

Sardana and Verma (1987) made a field trial in Delhi, India with combined application of aldicarb (for the control of various insect pests) with nitrogen, phosphorus and potassium fertilizers and reported that plant height, leaf surface area, number and length of pods, 100 grain weight and yield of green gram were significantly increased.

Mandal and Sikdar (1999) laid out a greenhouse pot experiment where mungbean (BARI Mung-5) grown on saline soil and given 0, 50 or 100 kg N ha^{-1} and 0, 75 or 150 kg P ha^{-1}. Growth and yield increased significantly with N application while P significantly increased the setting of pods and seeds. Root growth was significantly improved by both individual and combined application of these two fertilizers.

Tank *et al.* (1992) found that mungbean fertilized with 20 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} produced significantly higher number of pods $plant^{-1}$ over the unfertilized control.

Chapter III
MATERIALS AND METHODS

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

3.1 Location

The field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka- 1207 during the period from March to July, 2014 (Kharif-I season).

3.2 Soil

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

Table 1. Salient features of the experimental field

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

Table 2. Initial physical and chemical properties of experimental soil analyzed at Soil Resources Development Institute (SRDI), 2014, Farmgate, Dhaka.

Characteristics	Value
Particle 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 (meq/100 g soil)	0.15

3.3 Climate

The experimental area has sub-tropical climate characterized by high temperature, heavy rainfall during May to September and scanty rainfall during rest of the year. The annual precipitation of the site is 2052 mm and potential evapo-transpiration is 1286mm, the average maximum temperature is 30-35^{0}C, average minimum temperature is 14-21^{0}C and the average mean temperature is 12-25^{0}C (BBS, 2014). The experiment was carried out during kharif-I season (March-July), 2014.

3.4 Seeds and variety

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

3.5 Design and layout of experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four levels of nitrogen and three levels of phosphorus fertilizer treatment combinations. Fertilizer treatment consisted of 4 levels of N (0, 20, 40 and 60 kg N ha^{-1} designated as N_0, N_1, N_2 and N_3, respectively) and 3 levels of P (0, 20 and 40 kg P ha^{-1} designated as P_0, P_1, and P_2, respectively). There were twelve (12) treatment combinations. The treatment combinations were as follows:

3.6 Treatments and treatment combinations of experiment

A. Rates of nitrogen (4 levels):

1. N_0 = No nitrogen (control)
2. N_1 = 20 kg N ha^{-1}
3. N_2 = 40 kg N ha^{-1}
4. N_3 = 60 kg N ha^{-1}

B. Rates of phosphorus (3 levels)

1. P_0= No phosphorus (control)
2. P_1 = 20 kg P ha^{-1}
3. P_2 = 40 kg P ha^{-1}

Treatment Combinations

1. $N_0 P_0$ = Control (without N and P)
2. $N_0 P_1$ = 0 kg N ha^{-1}+20 kg P ha^{-1}
3. N_0P_2= 0 kg N ha^{-1}+40 kg P ha^{-1}
4. N_1P_0 = 20 kg N ha^{-1}+0 kg P ha^{-1}
5. N_1P_1 = 20 kg N ha^{-1}+20 kg P ha^{-1}
6. N_1P_2= 20 kg N ha^{-1}+40 kg P ha^{-1}
7. N_2P_0 = 40 kg N ha^{-1}+0 kg P ha^{-1}
8. N_2P_1 = 40 kg N ha^{-1}+20 kg P ha^{-1}
9. N_2P_2= 40 kg N ha^{-1}+40 kg P ha^{-1}
10. $N_3 P_0$=60 kg N ha^{-1}+0 kg P ha^{-1}
11. $N_3 P_1$=60 kg N ha^{-1}+20 kg P ha^{-1}
12. $N_3 P_2$=60 kg N ha^{-1}+40 kg P ha^{-1}

3.7 Land preparation

The plot selected for the experiment was opened by power tiller driven rotovator on the 15th February 2014; 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) and all the fertilizers were applied during the final land preparation except urea. Well rotten cow dung (10 t ha^{-1}) 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-6 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Seeds were sown in the main field on the 17^{th} March, 2014having 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-57 EC. 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 in three times. The crop was finally harvested at maturity on 9^{th} June, 2014. 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 Number of leaves plant^{-1}

Leaves were counted at 45 DAS stage. Leaves of 10 plants randomly counted from each plot and then averaged.

3.12.3 Number 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 Number 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 Number 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 seeds weight

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

3.12.8 Seed yield

Seeds obtained from 1m^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 Soil Sample

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

3.14 Statistical Analysis

The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Least Significant Difference value was determined with appropriate levels of significance and the means were tabulated. The mean comparison was carried out by LSD technique at 5% level of probability (Gomez and Gomez, 1984). The statistical package Statistix 10 (2013) was used for this purpose.

Chapter IV

RESULTS AND DISCUSSION

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

4.1 Plant height

4.1.1 Effect of nitrogen on the plant height of mungbean

The effects of nitrogen 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 nitrogen. Among the different doses of nitrogen, N_3 (60 kg N ha^{-1}) showed the highest plant height (56.09 cm) which was statistically identical with N_2 (40 kg N ha^{-1}) treatment. On the other hand, the lowest plant height (44.99 cm) was observed in the N_0 treatment where nitrogen was not applied. It was observed that plant height increased gradually with the increment of nitrogen doses. This might be due to higher availability of NPK 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. Agbenin *et al.* (1991) revealed that application of N significantly increased plant height, seed yield, dry weight, crop growth rate and nutrient uptake of mungbean over control. Suhartatik (1991) also reported that NPK fertilizers significantly increased the plant height of mungbean.

Table 4.1 Effect of nitrogen on the growth parameters of mungbean

Treatments	Plant height (cm)	No. of leaves plant^{-1}	No. of branches plant^{-1}	No. of pods plant^{-1}
N_0	44.99 c	16.48 c	9.18 d	10.39 c
N_1	50.39 b	20.87 b	10.86 c	14.09 b
N_2	54.15 ab	22.31 ab	12.13 b	15.86 a
N_3	56.09 a	22.97 a	13.06 a	16.59 a
$LSD_{(0.05)}$	3.9207	1.5856	0.5987	1.2001
CV (%)	7.80	7.85	5.41	8.62

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

4.1.2 Effect of phosphorus on the plant height of mungbean

Mungbean showed significant variation in respect of plant height when phosphorus fertilizer in different doses were applied (Table 4.2). Among the different fertilizer doses, P_2 (40 kg P ha^{-1}) showed the highest plant height (54.17 cm), which was significantly different from other fertilizer dose of P_1 (20 kg P ha^{-1}). On the contrary, the lowest plant height (47.25 cm) was observed in the treatment where no phosphorus fertilizer was applied.

Table 4.2 Effect of phosphorus on the growth parameters of mungbean

Treatments	Plant height(cm)	No. of leaves plant^{-1}	No. of branches plant^{-1}	No. of pods plant^{-1}
P_0	47.25 b	17.66 c	9.69 c	11.27 b
P_1	52.79 a	21.31 b	11.41 b	15.21 a
P_2	54.17 a	23.00 a	12.83 a	16.24 a
$LSD_{(0.05)}$	3.3954	1.3731	0.5185	1.0393
CV (%)	7.80	7.85	5.41	8.62

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

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

Combined application of different doses of nitrogen and phosphorus fertilizers had significant effect on the plant height of mungbean (Table 4.3). The lowest plant height (43.01 cm) was observed in the treatment combination of N_0P_0 (No nitrogen and No phosphorus). On the other hand, the highest plant height (60.22 cm) was recorded with N_3P_2 (60 kg N ha^{-1} + 40 kg P ha^{-1}) treatment which was statistically similar with N_2P_2 (58.31 cm), N_3P_1 (58.01 cm) and N_2P_1 (55.61 cm) treatments.

4.2 Number of leaves plant^{-1}

4.2.1 Effect of nitrogen on the number of leaves of mungbean

Statistically significant variation in terms of number of leaves per plant of mungbean was recorded for the application of nitrogen. The maximum number of leaves per plant (22.97) was recorded from N_3 (60 kg N ha^{-1}) which was statistically identical (22.31) with N_2 (40 kg N ha^{-1}) treatment, while the minimum number of leaves per plant (16.48) was recorded from N_0 (control).

4.2.2 Effect of phosphorus on the number of leaves of mungbean

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 (23.00) was recorded in P_2 which was statistically different from all other treatments, while the minimum number of leaves per plant (17.54) was recorded in P_0, comprising untreated control plot (Table 4.2). Bhat *et al.* (2005) observed 60 kg P ha^{-1} significantly improved the yield attributes compared to the control.

4.2.3 Interaction effect of nitrogen and phosphorus on the number of leaves plant^{-1} of mungbean

The combined effect of nitrogen and phosphorus showed statistically significant variation for number of leaves plant^{-1}. The maximum number of leaves plant^{-1} (26.72) was recorded in N_3P_2 which was statistically different from all other treatment combinations and the minimum number of leaves per plant (15.01) was recorded on the untreated control plot N_0P_0 (Table 4.3).

Table 4.3 Interaction effect of nitrogen and phosphorus on the growth and yield contributing parameters of mungbean

Treatments	Plant height(cm)	No. of leaves plant^{-1}	No. of branches plant^{-1}	No. of pods plant^{-1}
N_0P_0	43.01 e	15.01 e	8.02 h	9.11 f
N_0P_1	45.87 de	16.75 de	9.54 g	11.03 ef
N_0P_2	46.09 de	17.67 de	9.98 g	11.05 ef
N_1P_0	47.45 de	18.01 d	10.07 fg	11.71 e
N_1P_1	51.65 bcd	22.08 c	11.03 ef	14.93 d
N_1P_2	52.07 bcd	22.53 bc	11.51 de	15.65 cd
N_2P_0	48.51 de	18.51 d	10.12 fg	12.02 e
N_2P_1	55.61 abc	23.30 bc	12.41 cd	17.32 bc
N_2P_2	58.31 ab	25.09 ab	13.87 b	18.25 ab
N_3P_0	50.03 cd	19.11 d	10.55 efg	12.23 e
N_3P_1	58.01 ab	23.08 bc	12.65 c	17.55 bc
N_3P_2	60.22 a	26.72 a	15.98 a	20.01 a
$LSD_{(0.05)}$	6.7908	2.7463	1.0370	2.0786
CV (%)	7.80	7.85	5.41	8.62

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

4.3 Number of branches plant^{-1}

4.3.1 Effect of nitrogen on the number of branches plant^{-1} of mungbean

Different doses of nitrogen fertilizer showed significant variations in respect of number of branches plant^{-1} (Table 4.1). Among the different doses of nitrogen, N_3 (60 kg N ha^{-1}) showed the highest number of branches plant^{-1} (13.06) which was statistically different from all other treatments. On the contrary, the lowest number of branches plant^{-1} (9.18) was observed with N_0, where no nitrogen fertilizer was applied. In an experiment with the foliar application of nutrients on the growth and yield of mungbean cv. Kowmy-1, Abd-El-Latif *et al.* (1998) revealed that application of urea increases the number of branches plant^{-1} on mungbean plant.

4.3.2 Effect of phosphorus on number 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 4.2). The highest number of branches plant^{-1} (12.83) was recorded in P_2 (40 kg P ha^{-1}) which was statistically different from all other treatments. The lowest number of branches plant^{-1} (9.69) was recorded in the P_0 treatment where no phosphorus was applied. Singh *et al.* (1999) also found similar results with increasing rate of P and they noted that the number of branches plant^{-1} generally increased with the application of P.

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

The combined effect of different doses of N and P fertilizers on the number of branches plant^{-1} of mungbean was significant (Table 4.3). The highest number of branches plant^{-1} (15.98) was recorded with the treatment combination of N_3P_2 (60 kg Nha^{-1} + 40 kg P ha^{-1}). On the other hand, the lowest number of branches plant^{-1} (8.02) was found in N_0P_0 treatment (control treatment).

4.4 Number of pods plant^{-1}

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

Different doses of nitrogen fertilizers showed significant variations in respect of number of pods plant^{-1} (Table 4.1). Among the different doses of fertilizers, N_3 (60 kg N ha^{-1}) showed the highest number of pods plant^{-1} (16.59) which was statistically identical with N_2 (15.86). On the contrary, the lowest number of pods plant^{-1} (10.39) was observed with N_0 (control). Tank *et al.* (1992) found that mungbean fertilized with 50 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1} produced significantly higher number of pods plant^{-1} over the unfertilized control.

4.4.2 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 4.2). The highest number of pods plant^{-1} (16.24) was recorded in P_2 (40 kg P ha^{-1}) which was statistically different from other treatment. The lowest number of pods plant^{-1} (11.27) 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.

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

The combined effect of different doses of N and P fertilizers on number of pods plant^{-1} of mungbean was significant (Table 4.3). The highest number of pods plant^{-1} (20.01) was recorded with the treatment combination of N_3P_2 (60 kg N ha^{-1}+ 40 kg P ha^{-1}) which was statistically different from the rest of the treatments. On the other hand, the lowest number of pods plant^{-1} (10.39) was found in N_0P_0 treatment. Srinivas *et al.* (2002), observed that number of pods plant^{-1}, pod length and seeds pod^{-1} were increased with increasing rates of P and with increasing rates of N up to 40 kg ha^{-1} and also observed that 1000-seed weight in greengram.

4.5 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 P fertilizer doses. It revealed that higher number of pods plant^{-1} (16.24) and seeds pod^{-1} (11.27) of mungbean were found in the treatment P_2 (40 kg P ha^{-1}) which was significantly higher over P_1 (20 kg P ha^{-1}) treatment as well as highest seed yield (1.17 t ha^{-1}) also found in this treatment and the minimum number of pods plant^{-1} (11.27) and seeds pod^{-1} (8.38) as well as minimum seed yield (0.93 t ha^{-1}) also found in untreated control treatment (P_0). That is the best treatment (P_2) increased significantly by the application of phosphorus at 40 kg per hectare over control.

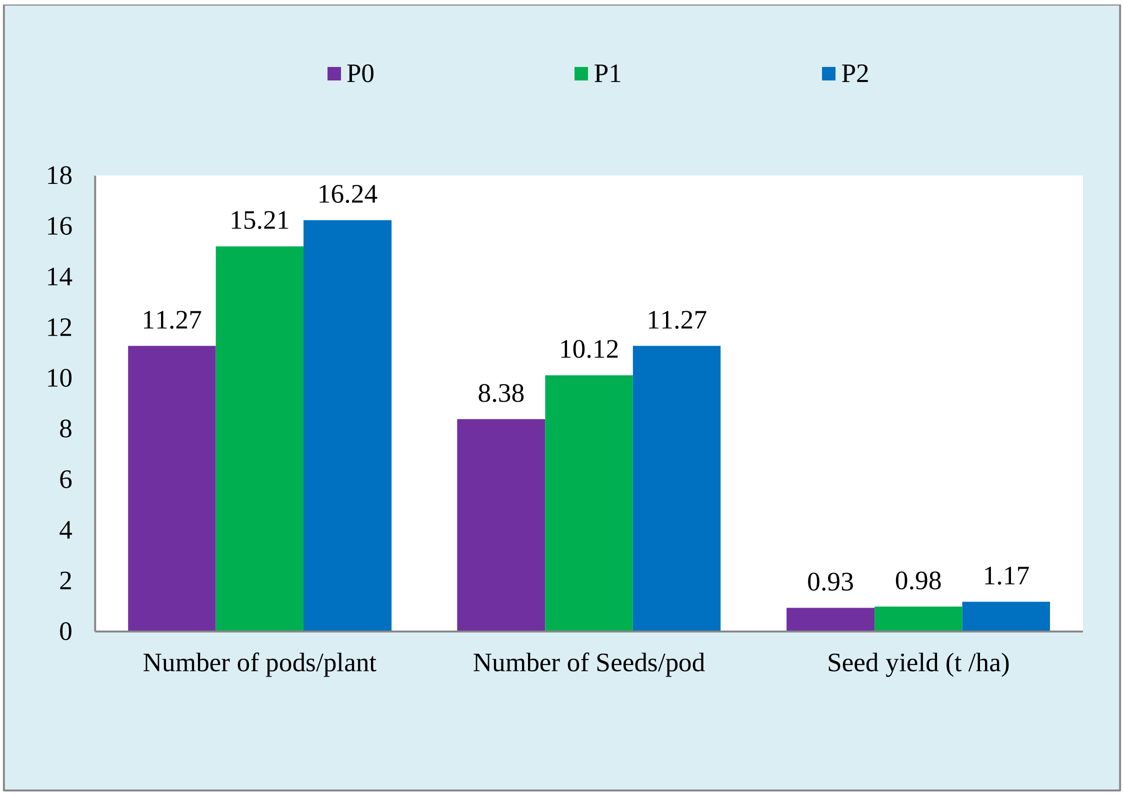

Figure 1: Effect of different phosphorus level on the number of pods plant^{-1} and seeds pod^{-1} and yield of mungbean

4.6 Pod length (cm)

4.6.1 Effect of nitrogen on pod length of mungbean

Application of N fertilizers at different doses showed significant variation on the pod length of mungbean (Table 4.4). Among the different N fertilizer doses, N_3 (60 kg N ha^{-1}) showed the highest pod length (10.77 cm) which was statistically different from all other treatments. The lowest pod length (6.34 cm) was recorded in the N_0 (control) treatment where no N was applied.

4.6.2 Effect of phosphorus on pod length of mungbean

The pod length as affected by different doses of phosphorus showed statistically significant variation (Table 4.5). Among the different doses of P the highest pod length (10.46 cm) was observed in P_2 (40 kg P ha^{-1}) which was statistically different from other treatment. The lowest pod length (6.92 cm) was recorded in the P_0 treatment where no P was applied.

4.6.3 Interaction effect of nitrogen and phosphorus on pod length of mungbean

Combined effect of different doses of N and P fertilizers on pod length showed a statistically significant variation (Table 4.6). The highest pod length (13.76cm) was recorded in the treatment combination of N_3P_2 (60 kg N ha^{-1}+ 40 kg P ha^{-1}) which was statistically different from all other treatment combinations. On the other hand, the lowest pod length (6.04 cm) was found in N_0P_0 (no nitrogen and no phosphorus).

4.7 Number of seeds pod^{-1}

4.7.1 Effect of nitrogen on the number of seeds pod^{-1} of mungbean

Different doses of nitrogen fertilizers showed significant variations in respect of number of seeds pod^{-1} (Table 4.4). Among the different doses of fertilizer, N_3 showed the highest number of seeds pod^{-1} (11.49) which was statistically different from all other treatments. On the contrary, the lowest number of seeds pod^{-1} (7.86) was observed with N_0, where no nitrogen fertilizer was applied.

4.7.2 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 4.5). The highest number of seeds pod^{-1} (11.27) was recorded in P_2 (40 kg P ha^{-1}). The lowest number of seeds pod^{-1} (8.38) was recorded in the P_0 treatment where no phosphorus was applied.

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

The combined effect of different doses of N and P fertilizer on number of seeds pod^{-1} of mungbean was significant (Table 4.6). The highest number of seeds pod^{-1} (13.99) was recorded with the treatment combination of N_3P_2 (60 kg N ha^{-1} + 40 kg P ha^{-1}). On the other hand, the lowest number of seeds pod^{-1} (7.13) was found in N_0P_0 treatment (control).

Table 4.4 Effect of nitrogen on yield and yield contributing characters of Mungbean

Treatments	Pod length (cm)	No. of seeds pod^{-1}	1000-seed wt. (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
N_0	6.34 d	7.86 d	41.96 c	0.64 c	1.05 c
N_1	8.26 c	9.61 c	45.60 bc	1.03 b	1.84 b
N_2	9.65 b	10.74 b	48.11 ab	1.07 b	2.31 a
N_3	10.77 a	11.49 a	51.18a	1.37 a	2.45 a
$LSD_{(0.05)}$	0.5778	0.6343	3.7819	0.1040	0.1765
CV (%)	6.75	6.54	8.28	10.37	9.44

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

4.8 Weight of 1000-seed (g)

4.8.1 Effect of nitrogen on weight of 1000-seed of mungbean

Different doses of N fertilizers showed significant variations in respect of the weight of 1000-seed (Table 4.4). Among the different doses of N fertilizers N_3 (60 kg N ha^{-1}) showed the highest weight of 1000 seed (51.18 g) and it was identical (48.11 g) with N_2 (40 kg N ha^{-1}) treatment. On the contrary, the lowest weight of 1000 seed (41.96g) was observed with N_0 (control) where no N fertilizer was applied.

4.8.2 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 4.5). The highest weight of 1000 seed (50.09 g) was recorded in P_2 (40 kg P ha^{-1}), which was statistically dissimilar with P_1 (20 kg P ha^{-1}) treatment. The lowest weight of 1000-seed (43.61 g) was recorded in the P_0 treatment where no P was applied.

4.8.3 Interaction effect of nitrogen and phosphorus on weight of 1000-seed of mungbean

The combined effect of different doses of N and P fertilizers on the weight of 1000-seed of mungbean was significant (Table 4.6). The highest weight of 1000 seed (58.89g) was recorded with the treatment combination of N_2P_2 which was statistically different from all other combinations of treatment. On the other hand, the lowest weight of 1000-seed (40.11g) was found in N_0P_0 treatment (control). 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 kg N-P-K ha^{-1} application. Again they revealed that seed inoculation with 50-50-0 kg N-P-K ha^{-1} exhibited superior performance in respect of seed yield (955 kg ha^{-1}).

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

Treatments	Pod length (cm)	No. of seeds pod^{-1}	1000-seed wt. (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
P_0	6.92 c	8.38 c	43.61 b	0.93 b	1.36 c
P_1	8.89 b	10.12 b	46.43 b	0.98 b	2.03 b
P_2	10.46 a	11.27 a	50.09 a	1.17 a	2.35 a
$LSD_{(0.05)}$	0.5004	0.5493	3.2753	0.0901	0.1529
CV (%)	6.75	6.54	8.28	10.37	9.44

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

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

4.9.1 Effect of nitrogen on the seed yield of mungbean

Different doses of nitrogen fertilizers showed insignificant effect of seed yield of mungbean (Table 4.4). Among the different doses of N fertilizers, N_3 (60 kg N ha^{-1}) showed the highest seed yield of mungbean (1.37 t ha^{-1}). N fertilizer dose of N_2 (40 kg ha^{-1}) showed 1.07 t ha^{-1}. On the contrary, the lowest seed yield of mungbean (0.64 t ha^{-1}) was observed with N_0 where no N fertilizer was applied.

4.9.2 Effect of phosphorus on the seed yield of mungbean

Significant variation was observed on the seed yield of mungbean when different doses of P were applied (Table 4.5). The highest seed yield of mungbean (1.17 t ha^{-1}) was recorded in P_2 (40 kg P ha^{-1}) which was statistically different from other treatments. The lowest seed yield of mungbean (0.93 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).

4.9.3 Interaction effect of nitrogen and phosphorus fertilizers on seed yield of mungbean

The combined effect of different doses of N and P fertilizers on the seed yield of mungbean was significant (Table 4.6). The highest seed yield of mungbean (1.81 t ha^{-1}) was recorded with the treatment combination of N_3P_2 which was statistically different from all other treatments. On the other hand, the lowest seed yield of mungbean (0.59 t ha^{-1}) was found in N_0P_0 treatment (no N and no P).

4.10 Interaction effect of nitrogen and phosphorus on the seed and stover yield (t ha^{-1}) of mungbean

Statistically significant variation was recorded in terms of seed and stover yield of mungbean due to combined application of nitrogen and phosphorus at different level. The maximum seed and stover yield (1.81 t ha^{-1} and 3.21 t ha^{-1}) were recorded in N_3P_2 treated plot which was statistically different from other treatments and the minimum seed and stover yield (0.59 t ha^{-1} and 0.98 t ha^{-1}) were recorded in N_0P_0 (Fig. 2). Malik *et al.* (2006) reported that phosphorus application at 40 kg P ha^{-1} affected the crop positively, while rates below and above this rate resulted in non-significant effects. That is the best treatment (N_3P_2) increased maximum seed and stover yield over control.

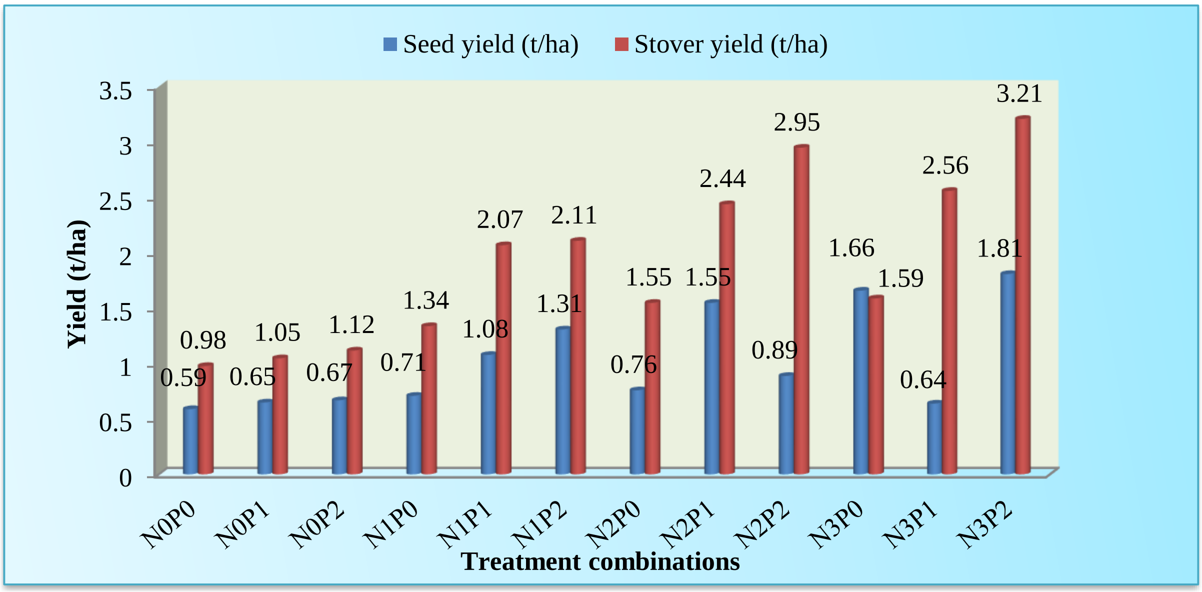

Figure 2: Combined effect of nitrogen and phosphorus on the seed and stover yield (t ha^{-1}) of mungbean

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

Treatments	Pod length (cm)	No. of seeds pod^{-1}	1000-seed wt. (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
N_0P_0	6.04 h	7.13 g	40.11 d	0.59 f	0.98 f
N_0P_1	6.23 gh	8.01 fg	42.73 cd	0.65 f	1.05 ef
N_0P_2	6.76 fgh	8.45 f	43.03 cd	0.67 f	1.12 ef
N_1P_0	7.00 fgh	8.49 f	43.54 cd	0.71 ef	1.34 de
N_1P_1	8.02 e	10.03 de	46.23 bcd	1.08 d	2.07 c
N_1P_2	9.76 d	10.32 d	47.04 bc	1.31 c	2.11 c
N_2P_0	7.09 efg	8.89 f	45.12 bcd	0.76 ef	1.55 d
N_2P_1	10.32 cd	11.01 cd	47.78 bc	1.55 b	2.44 b
N_2P_2	11.54 b	12.32 b	51.43 b	0.89 e	2.95 a
N_3P_0	7.55 ef	9.02 ef	45.67 bcd	1.66 ab	1.59 d
N_3P_1	11.01 bc	11.45 bc	48.98 bc	0.64 f	2.56 b
N_3P_2	13.76 a	13.99 a	58.89 a	1.81 a	3.21 a
$LSD_{(0.05)}$	1.008	1.0986	6.5505	0.1801	0.3058
CV (%)	6.75	6.54	8.28	10.37	9.44

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

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

4.11.1 Effect of nitrogen on the stover yield of mungbean

Different doses of N fertilizers showed significant variations in respect of stover yield of mungbean (Table 4.4). Among the different doses of N fertilizers, N_3 (60 kg N ha^{-1}) showed the highest stover yield (2.45 t ha^{-1}), which was statistically identical (2.31 t ha^{-1}) with N_2 (40 kg N ha^{-1}) treatment. On the contrary, the lowest stover yield (1.05 t ha^{-1}) was observed with N_0 (control) treatment.

4.11.2 Effect of phosphorus on the stover yield of mungbean

Significant variation was observed on the stover yield of mungbean when different doses of P were applied (Table 4.5). The highest stover yield of mungbean (2.35 t ha^{-1}) was recorded in P_2 (40 kg P ha^{-1}), which was statistically different from other treatments. The lowest stover yield (1.36 t ha^{-1}) was recorded in the P_0 treatment where no P was applied.

4.11.3 Interaction effect of nitrogen and phosphorus on stover yield of mungbean

The combined effect of different doses of N and P fertilizers on the stover yield was significant (Table 4.6). The highest stover yield (3.21 t ha^{-1}) was recorded with the treatment combination of N_3P_2 (60 kg N ha^{-1} + 40 kg P ha^{-1}). On the other hand, the lowest stover yield (0.98 t ha^{-1}) was found in N_0P_0 treatment (no nitrogen and no phosphorus).

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

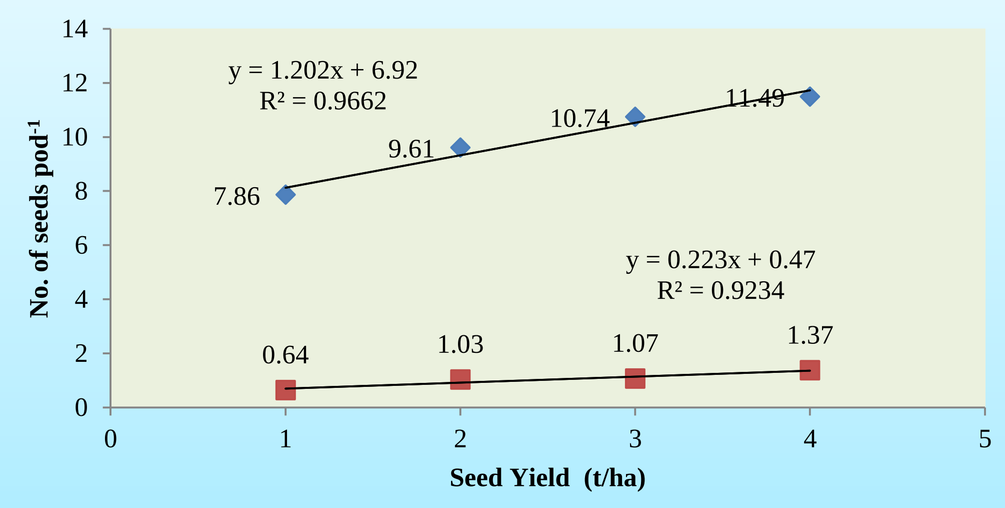

Figure 3: Linear relationship between number of seeds pod^{-1} and seed yield (t ha^{-1})

Correlation study was done to establish the relationship between the number of seeds pod^{-1} and seed yield of mungbean. From the study it revealed that highly significant correlation (R^2 = 0.966) was observed between the parameters (Figure 3). It was evident from the Figure 3 that the equation y = 1.202x + 6.92 gave a good fit to the data, and the co-efficient of determination (R^2 = 0.966) 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 = 0.923) 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 research work was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka (Tejgaon soil series under AEZ No. 28) during the kharif-I season of March, 2014 to July, 2014 to study the growth and yield of mungbean (BARI Mung-6) as influenced by different levels of nitrogen and phosphorus. Two factor experiments with Randomized Complete Block Design (RCBD) was followed with 12 treatments having unit plot size of 2.5m x 2m ($5m^2$) and replicated thrice. Two factors were nitrogen and phosphorus. The data were collected plot wise for plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1}, number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, weight of l000-seed (g), seed yield (t ha^{-1}) and stover yield (t ha^{-1}). All the data were statistically analyzed following LSD and the mean comparison was made by LSD. Plant height was significantly affected by different levels of N and P. Plant height increased with increasing levels of N and P individually. The individual application of N @ 60 kg ha^{-1} (N_3) produced the tallest plant (56.09 cm), whereas application of P @ 40 kg ha^{-1} (P_2) produced the tallest plant of 54.17 cm height. The tallest plant (60.22 cm) was found in N_3P_2 treatment combination, which was higher over other treatments.

The individual application of N and P showed positive effect on the number of leaves plant^{-1}, number of branches plant^{-1}, number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, weight of l000-seed (g), seed yield (t ha^{-1}) and stover yield (t ha^{-1}). All the plant characters increased with increasing levels of N and P up to higher level except 1000-seed weight. Like all other plant characters, seed yield was influenced significantly due to application of N. Grain yield increased with increasing levels of N up to certain level. The highest grain yield (1.37 t ha^{-1}) was found in plants receiving N @ 60 kg ha^{-1} and the lowest was recorded in untreated control treatment. Individual application of phosphorus also showed significant effect in seed yield. Application P @ 40 kg ha^{-1} (P_2) produced the highest seed yield (1.17 t ha^{-1}). The combined application of N and P had positive effect on seed yield of mungbean. The highest seed yield of mungbean was recorded in N_3P_2 (1.81 t ha^{-1}) treatment combination which was statistically different with each other treatment combinations. The lowest yield was recorded in N_0P_0 treatment combination that is untreated control plot. Combined application of N @ 60 kg ha^{-1} and P @ 40 kg ha^{-1} produced higher seed yield compared to untreated control treatment significantly.

The results of this research work indicated that the plants performed better in respect of seed yield in N_3P_2 treatment over the control treatment (N_0P_0) showed the least performance. It can be therefore, concluded from the above study that the treatment (application of nitrogen, N @ 60 kg ha^{-1} and phosphorus P @ 40 kg ha^{-1}) was found to the most suitable treatment combination for the highest yield of mungbean in Deep Red Brown Terrace Soils of Bangladesh.

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

- ❖ The combined application of nitrogen and Phosphorus fertilizers @ 60 kg N ha^{-1} and 40 kg P ha^{-1} may be recommended in Tejgaon series under AEZ No. 28 to get better 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.

Chapter VI

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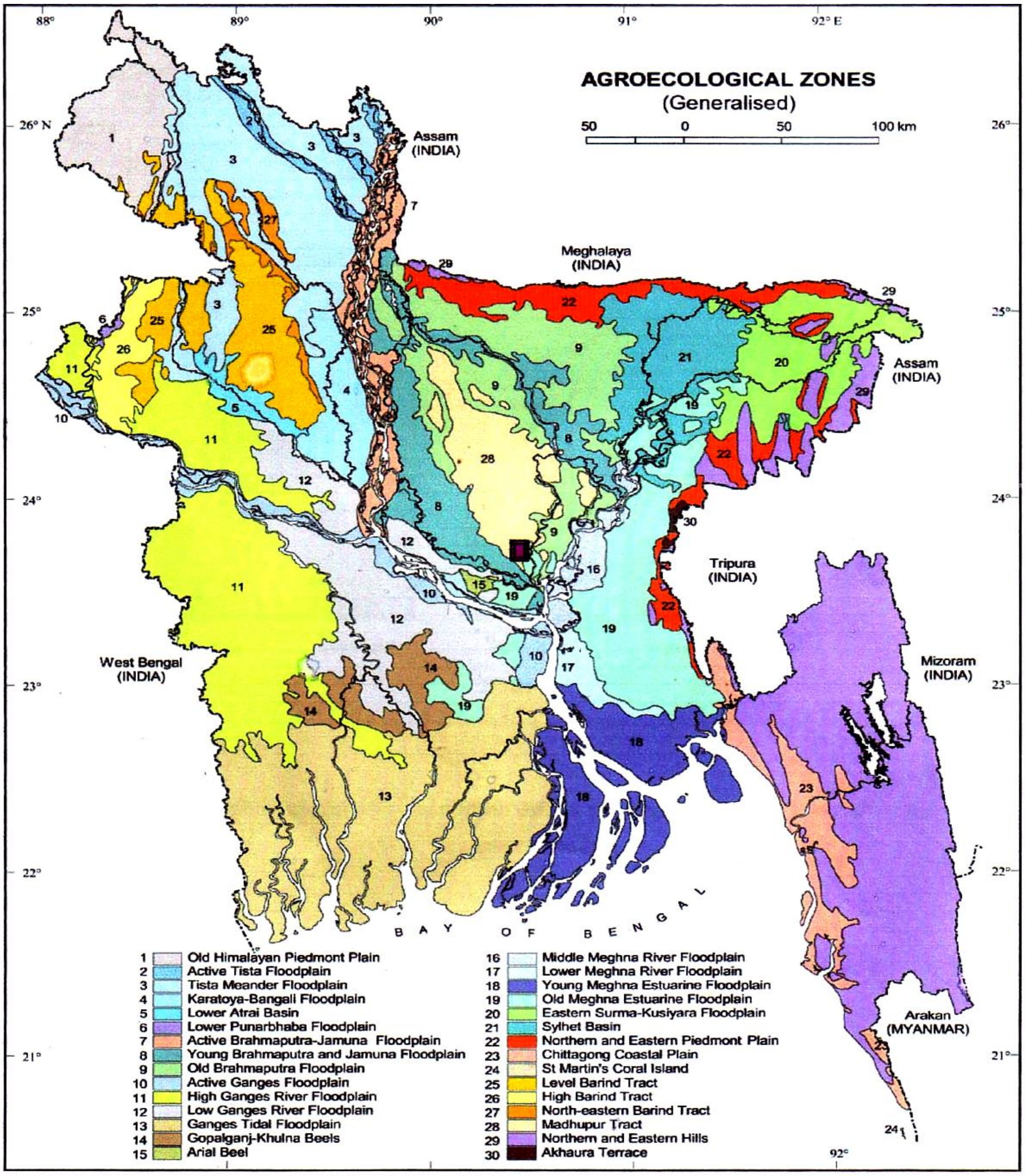
Chapter VII

APPENDIX

Appendix 1. Map showing the experimental site under study



Appendix 2. Monthly meteorological information during the period from March, 2014 to July, 2014

Month	Air temperature (^0C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
March, 2014	31	21	44	62
April, 2014	33	24	56	135
May, 2014	33	24	71	247
June, 2014	32	25	78	316
July, 2014	31	22	78	328

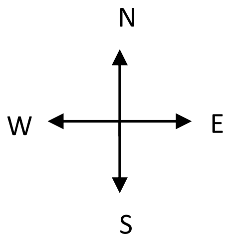
Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212

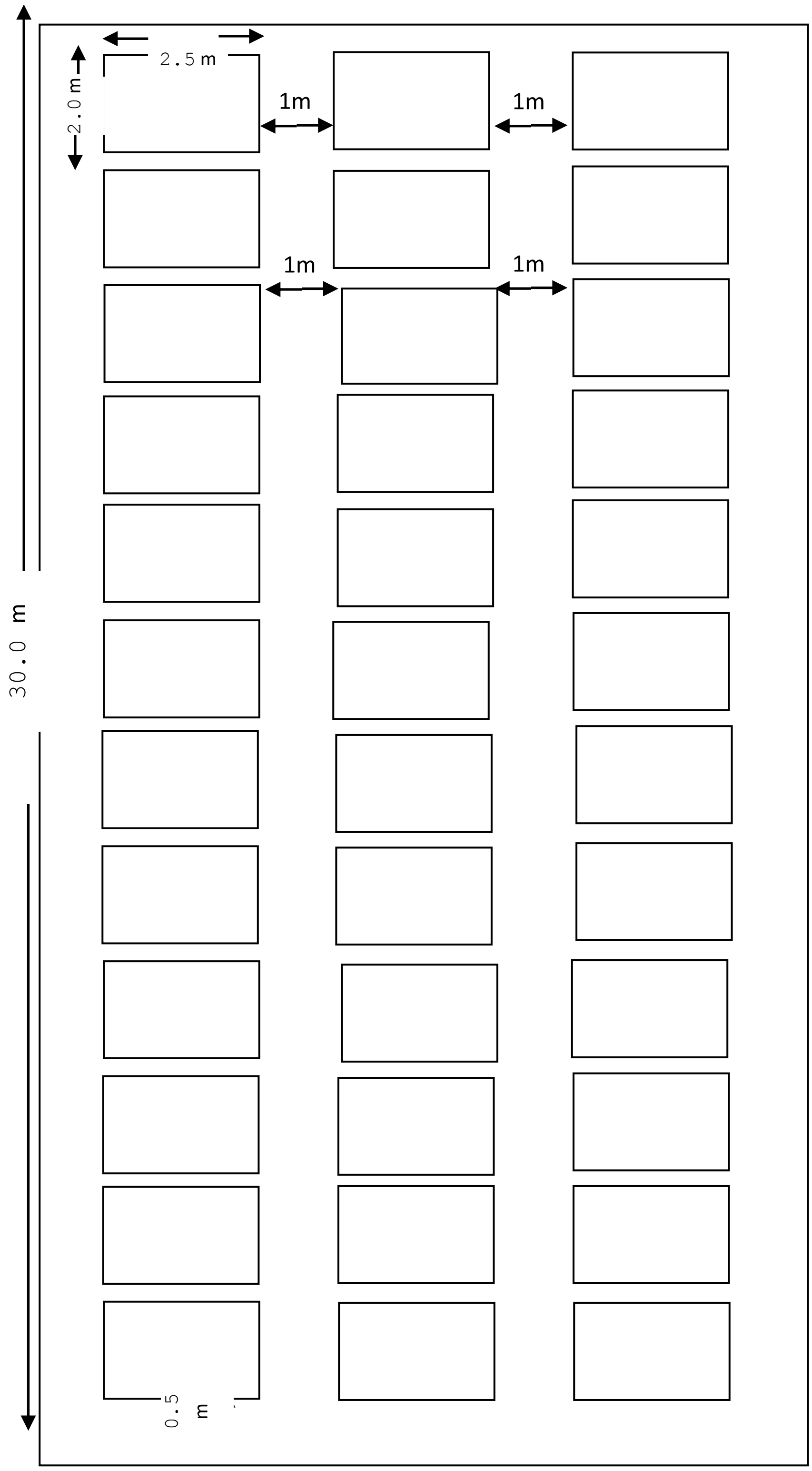
Appendix 3: Commonly used symbols and abbreviations

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
LSD	Least Significant Difference
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 hectare

Abbreviations	Full word
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
Sci.	Science
SE	Standard Error
Univ.	University
var.	variety

Appendix 4 . Layout of the experimental plot





Plot size: 2.5 m × 2.0 m

Plot spacing: 50 cm

Between replication: 1.0 m

Factor A: Nitrogen (N)
1. N_0 = 0 kg N ha^{-1})Control(
2. N_1 = 20 kg N ha^{-1}
3. N_2 = 40 kg N ha^{-1}
4. N_3 = 60 kg N ha^{-1}

Factor B: Phosphorus (P)
1. P_0 = 0 kg P ha^{-1})Control(
2. P_1 = 20 kg P ha^{-1}
3. P_2 = 40 kg P ha^{-1}