EFFECT OF PHOSPHORUS ON THE GROWTH AND YIELD OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled " ***EFFECT OF PHOSPHORUS ON THE GROWTH AND YIELD OF MUNGBEAN***" *submitted to the DEPARTMENT OF SOIL SCIENCE,, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in SOIL SCIENCE, embodies the results of a piece of bonafide research work carried out by* ***MD. KAJAL ISLAM****, Registration No. 17-08282, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.*

I further certify that any help or sources of information received during the course of this investigation have been duly acknowledged.

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Dedicated to

My

Beloved Parents

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THE EFFECT OF PHOSPHORUS ON THE GROWTH AND YIELD OF MUNGBEAN

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Abstract

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, during the *kharif-2* season of July, 2019 to November, 2019 to examine phosphorus (P) effect on growth and yield of mungbean. The variety, BARI Mung-6 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 for higher yield of mungbean. The treatments were six levels of P as 0, 10, 20, 30, 40 & 60 kg P ha^{-1} designated as P_0, P_1, P_2, P_3, P_4 and P_5 respectively. The experiment with Randomized Complete Block Design consisted with three replications. Results of the study revealed that plant height increased with increasing levels of P. The application of P @ 40 kg ha^{-1} (P_4) produced the highest plant height (51.33, 89.17 and 100.12 cm at 30 DAS, 60 DAS and harvesting period respectively). Number of leaves $plant^{-1}$ (30.33 and 26.13 at 60 DAS and harvesting period respectively), number of branches $plant^{-1}$ (1.18 and 0.93 at 60 DAS and harvesting period respectively), number of pods $plant^{-1}$ (22.80), pod length (8.90 cm), number of seeds pod^{-1} (12.44), weight of 1000-seeds (39.39 g), grain yield (1.57 t ha^{-1}), stover yield (2.27 t ha^{-1}) and biological yield (3.59 t ha^{-1}) were observed maximum in P_4 treatmentwhereas the control treatment (P_0) showed the least performance. It was also observed that P_3 treatment (P @ 30 kg ha^{-1}) showed statistically similar result compared to P_4 treatment. Therefore, it can be concluded from the above study that application of P @ 30 kg ha^{-1} can be the economically suitable dose for the better yield of mungbean in Shallow Red Brown Terrace Soils of Bangladesh.

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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
Kg	kilogram
m	Meter
m^2	square meter
MoA	Ministry of Agriculture
MSE	Mean square of the error
No.	Number
P	Phosphorus
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
J.	Journal
kg ha^{-1}	Kilograms per hector
t ha^{-1}	Ton per hectare

CHAPTER I

INTRODUCTION

Mungbean [*Vigna radiate* (L.) 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 food stuffs in both savory and sweet dishes.

In Bangladesh, daily consumption of pulses is only 17.80g capita^{-1} (BBS, 2017), 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 2016-17 fiscal year (BBS, 2017). Though total pulse production in Bangladesh is 270 thousand metric ton (BBS, 2017), 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 48% protein, 1-3% fat, 50.4% carbohydrates, 3.5-4.5% fibers and 4.5-5.5% ash, while calcium and P 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 it's by product can be used as good animal feed. 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. Cultivation of pulses also can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through N 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 3.1% of the total cropping area (BBS, 2017). 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, 2017). The cultivation of mungbean in Bangladesh is tends to increase and it covers 55, 56 and 67 thousand acres respectively in the 2014-15, 2015-16 and 2016-17 fiscal years (BBS, 2017). At present the average yield of mungbean grain in our country is about 281 kg acre^{-1} (BBS, 2017). So mungbean can be a good solution for the increasing need of plant protein.

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 MujiburRahman 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 N, P 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. P 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. P shortage restricted the plant growth and remains immature (Hossain, 1990). Experimental findings of Arya and Kalra (1988) revealed that application of P 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 P from zero to 50 kg P.

Objectives:

- To study the influence of P on the growth and yield of mungbean
- To determine the optimum dose of P for attaining maximum yield contributing characters and yield of mungbean

CHAPTER II

REVIEW OF LITERATURE

The main purpose of this chapter is to review the previous studies, which are related to the present. Review of literature is helpful to know the present status of the problem, what has been done and what is left to be done. Review of some research works relevant to the present studies, which have been conducted in the recent past are discussed below:

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 Super Phosphate (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 (l7.4) was obtained with 60 kg DAP/ha.

Malik *et al.* (2006) conducted a field experiment in Faisalabad, Pakistan in 2000 and 2001 to evaluate the interactive effects of irrigation and P on green gram *(Vignaradiata*, cv. NM-54). Five P doses (0, 20, 40, 60 and 80 kg P ha^{-1}) were arranged in a split plot design with four replications. P application at 40 kg P_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 P 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. N and P rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both the cultivars.

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}).

A field experiment was conducted by Raman and Venkataramana (2006) during February to May 2002 in Annamalainagar. Tamil Nadu. India to investigate the effect of foliar nutrition on crop nutrient uptake and yield of greengram*(V. radiata).* There were 10 foliar spray treatments, consisting of water spray. 2% diammonium phosphate (DAP) at 30 and 45 days after sowing, 0.01% Penshibao, 0.125% Zn chelate, 30 ppm NAA, DAP + NAA, DAP + Penshibao, DAP + Zn chelate, DAP + Penshibao + NAA, and DAP + NAA + Zn chelate. Crop nutrient uptake, yield and its attributes (number of pods/plant and number of seeds/pod) of greengram augmented significantly due to foliar nutrition. The foliar application of DAP + NAA + Penshibao was significantly superior to other treatments in increasing the values of N. P and K uptakes, yield attributes and yield. The highest grain yield of 1529 kg ha^{-1} was recorded with this treatment.

Bhat*et al.* (2005) conducted a study during the summer of 2004 in Uttar Pradesh, India to examine the effects of P levels on greengram. Four P rates (0. 30, 60 and 90 kg/ha) were used. All the P 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 P rates, the stover yield followed the trend observed in seed yield.

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.

Khan *et al.* (2004) conducted a study to determine the effect of different levels of P on the yield components of mungbean cv. NM-98 in D.I. Khan in 2000. Treatments comprised: 0, 20, 40, 60, 80, and 100 kg P/ha. The increase in P 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 P level of 100 kg/ha compared to a 774-kg/ha yield in the control. However, the most economical P level was 40 kg/ha, because it produced a grain yield statistically comparable to 100 kg P/ha.

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

Mahboob and Asghar (2002) studied the effect of seed inoculation at different N 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}).

A field experiment was conducted by Manpreet*et al.* (2004) in Ludhiana. Punjab.India during summer 2000 to investigate the response of mungbean genotypes (SML 134.SML 357 and SML 668) to P application (0. 20. 40 and 60 kg P_2O_5 ha^{-1}) under irrigated conditions. Yield attributes such as number of branches plant^{-1} and pods plant^{-1} were significantly higher in SML 357 and SML 134, whereas pod length and 100-seed weight were higher in SML 668 which accounted for higher grain yield in this cultivar compared to SML 134 but was at par with SML 357. The straw yield showed the reverse trend with significantly higher value for SML 134, thus lowering the harvest index significantly compared to SML 668 and SML 357. P 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^{-1}) compared to lower levels (0 and 20 kg ha^{-1}). Harvest index remained unaffected with P application. The economic optimum P level for all the 3 summer mungbean genotypes was found to be 46.1 kg P_2O_5 ha^{-1}.

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

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of N (0, 25, and 50 kg ha^{-1}) and P (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 N and P. Growth and yield components were significantly affected by varying levels of N and P. A fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted with maximum seed yield (1.1 ton ha^{-1}).

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

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 P2O5/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

Ashaproduced significantly more number of pods and branches/plant compared to MH 85-111 and K 851. P 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.

Yadav and Rathore (2002) carried out a field trial to find out the effect of P 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 P 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).

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.

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

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

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

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 farmer’s practices, while the highest yield was obtained by the fertilizer application (0.77 ton ha^{-1}).

Thakur *et al.* (1996) conducted an experiment with greengram*(Vignaradiata)* 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. P uptake was also highest with 50 kg P_2O_5 ha^{-1}.

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

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 P to mungbean cv. PS 16 increased the number of branches $plant^{-1}$upto 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.

Satter and Ahmed (1992) reported that P application up to 60 kg $P_2O_5ha^{-1}$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 P had beneficial effect on branches per plant, yield attributes and yield. Application of 30 kg $P_2O_5ha^{-1}$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 P decrease the grain and other parameters. P application at the rate of 60 kg P_2O_5 ha^{-1}significantly increased nodule number, dry weight of plant tops and mungbean yield.

Bayan and Saharia (1996) carried out an experiment to study the effect of P on mungbean during the *kharif*seasons of 1994-95 in BishanathChariali Assam, India. The results indicated that plant height was unaffected by P application.Rajkhowa*et al,* (1992) reported that application of P 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.

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 Soil description of experimented area

The Research work was done to study the effects of P fertilization on growth, yield and yield contributing characters of mungbean at Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during kharif-2 season 2019. The experimental location situated at $23^0$77 N and $90^0$33 E longitudes with an elevation of 1 meter from sea level.

3.2 Description of soil

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

Table 3.1 Morphological characteristics of experimental field

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

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

%Sand(2-0.02 mm)	32.20
%Silt(0.02-0.002 mm)	34.46
%Clay(<0.002 mm)	33.34
Textural Class	Clay Loam

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

pH	6.46
Organic Matter(%)	0.88
Total N(%)	0.079
Available P (ppm)	15
Exchangeable K (ppm)	12.1
Available S (ppm)	11.9

3.3 Climate

The experimental area has sub-tropical climate characterized by medium temperature, medium rainfall during May, 2019 to September, 2019 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 30-35^{0}C, average minimum temperature is 16.4^{0}C and the average mean temperature is 28.12^{0}C (BBS, 2019).

3.4 Description of mungbean variety

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

3.5 Preparation of the field

The selected plot for the experimental plot was opened by power tiller driven rotovator on the 2 July, 2019. Afterwards several times the land was ploughed and cross-ploughed followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. Finally, the land was leveled and the experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in the following section (Fig 1).

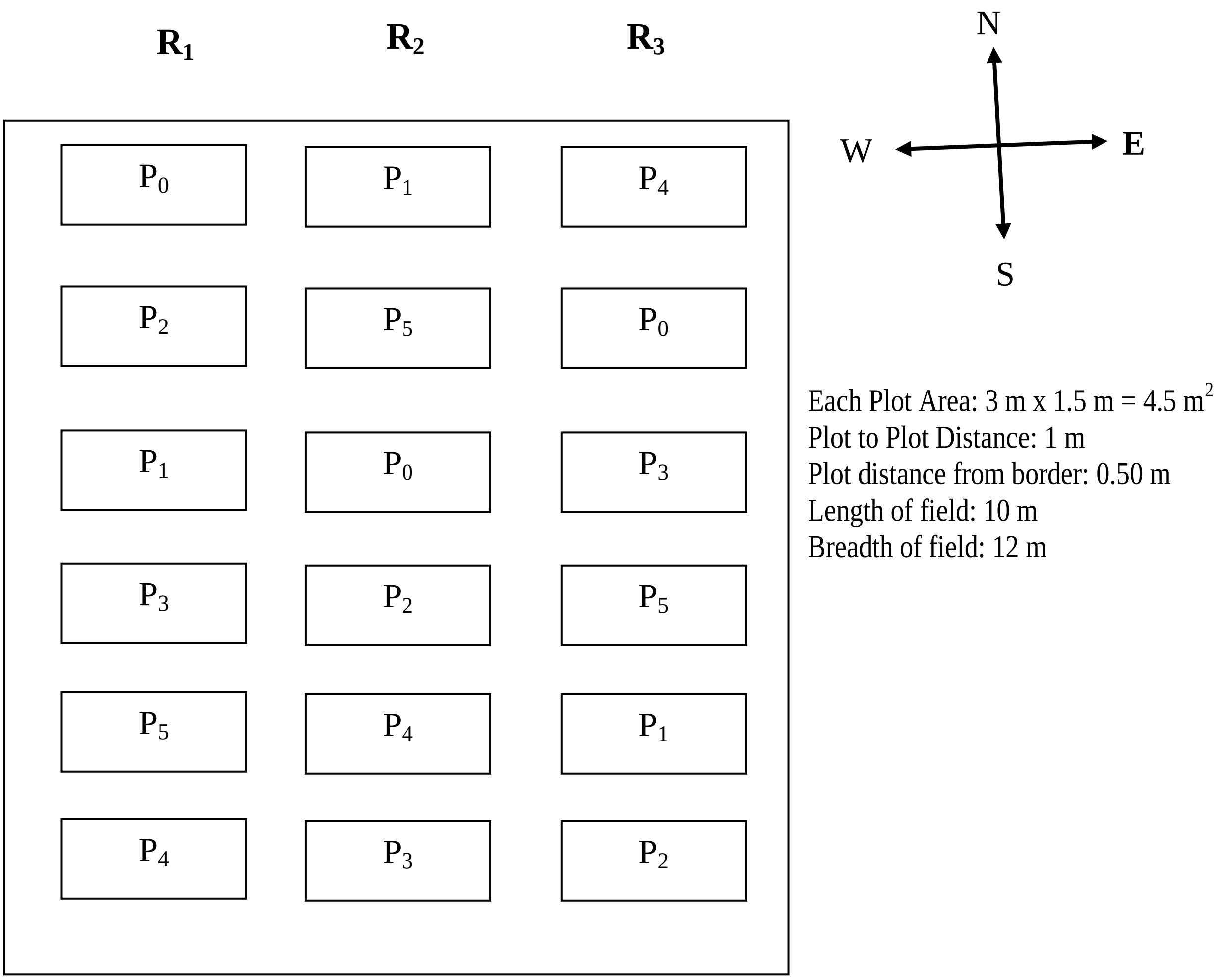

Figure 1: Layout of experimental plot

3.6 Treatments

Fertilizer treatment consisted of 6 levels of P (0, 10, 20, 30, 40 and 60 kg P ha^{-1}) designed as RCBD. The following treatments doses were comprised for the experiment.

Rate of Phosphorus:

P0: 0 kg P ha-1

P1: 10 kg P ha-1

P2: 20 kg P ha-1

P3: 30 kg P ha-1

P4: 40 kg P ha-1

P5: 60 kg P ha-1

3.7 Application of fertilizers:

Recommended doses of N, S, K, Zn and B (40 kg N from Urea, 20 kg K ha^{-1} from MoP, 2 kg Zn ha^{-1} from $ZnSO_4$ and 1 kg B ha^{-1} from boric acid, respectively) were applied. The whole amounts of TSP, $ZnSO_4$, Boric acid and half of the urea fertilizer were applied as basal dose during final land preparation. The remaining half of urea was top dressed after 22 days of germination.

3.8 Seed sowing

Seeds of BARI Mung-6 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Seeds were sown in the main field on the 17th July, 2019 having line to line distance of 30 cm and plant to plant distance of 10 cm.

3.9 Weeding and thinning

Weeds of different types were controlled manually and removed from the field. The weeding and thinning were done after 25 days after sowing, on August 14, 2019. Care was taken to maintain constant plant population per plot.

3.10 Pest Management

To rescue the plant from the infested Cutworm at the seedling stage and application of Dursban-25EC @ 2.5ml $Liter^{-1}$ was done twice on August15 and 23, 2019. Special care was taken to protect the crop from birds especially after sowing and germination stages.

3.11 Harvesting

The crop was harvested at maturity on 6th November 2019. The harvested crop of each individual plot was bundled separately. Grain and straw yields were recorded plot wise and the yields were expressed in t ha^{-1}.

3.12 Sampling

Samples were collected from different places of each plot leaving undisturbed very small in the center. 10 plants were selected as a sample.

3.13 Threshing

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

3.14 Drying, cleaning and weighing

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

3.15 Collection of data

Ten (10) plants from each plot were selected at random and were tagged for the data collection. Data collections were done on the following parameters:

Plant height (cm)
Number of leaves plant^{-1}
Number of primary branches plant^{-1}
Number of pods plant^{-1}
Pod length plant^{-1} (cm)
Number of seeds pod^{-1}
Thousand seed weight (g)
Grain yield (t ha^{-1})
Stover yield (t ha^{-1})
Biological yield

3.15.1 Plant height

The plant height was measured from the ground level to the top of the plant. 10 plants were selected randomly from each plot at 30 DAS, 60 DAS and harvesting stage. Plant height was measured and averaged.

3.15.2 Number of leaves plant^{-1}

Numbers of leaves were counted at 60 DAS and harvesting stage. 10 plants were selected randomly from each plot and number of leaves were counted and averaged.

3.15.3 Number of primary branches plant^{-1}

10 plants were selected randomly from each plot at 60 DAS and harvesting stage. Number of primary branches were counted and averaged.

3.15.4 Number of pods plant^{-1}

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

3.15.5 Length of pods plant^{-1}

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

3.15.6 Number of seeds pod^{-1}

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

3.15.7 1000 seeds weight

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

3.15.8 Grain yield

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

3.15.9 Stover yield

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

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

The summation of seed yield and above ground Stover yield was the biological yield. Biological yield = seed yield + stover yield.

3.16 Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Effect of phosphorus on plant height of mungbean

Different P level showed significant results on plant height of mungbean (Table 4.1). Significant variation was observed on the plant height of mungbean when the field was fertilized with six levels of P dose (*eg.* 0, 10, 20, 30, 40 and 60 kg P ha^{-1}). Among the different doses of P,P_4 showed the highest plant height (51.33 cm, 89.17 cm, 100.12 cm at 30 DAS, 60 DAS and harvesting period respectively) at 30 DAS which was statistically similar (41.83 cm) with P_3 treatment. At 60 DAS from the Table 4.1showed significant variation and P_3 treatment showed statistically similar result (86.20 cm). During harvest P_2, P_3 and P_5treatment showed statistically similar result (92.22 cm, 95.56 cm and 93.44 cm respectively) with P_4 treatment. On the other hand, the lowest plant height (39.33 cm, 56.33 cm and 79.44 cm at 30 DAS, 60 DAS and harvest period respectively) was observed in the P_0 treatment where no P was applied. Plant height increased with increasing levels of P up to maximum level of P application.

Table 4.1: Effect of phosphorus on plant height of mungbean

	Plant height(cm)		
Treatment	**30 DAS**	**60 DAS**	**Harvest**
P_0	39.33^{d}	56.33^{e}	79.44^{c}
P_1	41.83^{cd}	69.20^{d}	86.67^{bc}
P_2	46.67^{bc}	78.73^{c}	92.22^{ab}
P_3	48.50^{ab}	86.20^{ab}	95.56^{a}
P_4	51.33^{a}	89.17^{a}	100.12^{a}
P_5	45.67^{bc}	81.47^{bc}	93.44^{a}
$LSD_{0.05}$	2.93	4.73	8.18
CV (%)	16.82	18.09	14.33

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

In Table 4.2, significant variation was observed in the number of leaves plant^{-1} of mungbean when different doses of P were applied. Treatment P_4 showed the highest number of leaves plant^{-1} was 30.33 at 60 DAS which was statistically similar with all other treatments except control (P_0). During harvesting period the highest value of number of leaves plant^{-1} (26.13) was observed in P_4 treatment which was only statistically significant in variation against control (P_0). The lowest number of leaves plant^{-1} (21.33 and 23.73 at 60 DAS and at harvesting period respectively) was recorded in the P_0 treatment where no P was applied. From Table 4.2 showed increased dose of P application results increased the number of leaves plant^{-1}.

Table 4.2: Effect of phosphorus on number of leaves plant^{-1} and number of primary branch plant^{-1} of mungbean

Treatment	Number of leaves plant^{-1} (60 DAS)	Number of leaves plant^{-1} (Harvest)	Number of primary branch plant^{-1} (60 DAS)	Number of primary branch plant^{-1} (harvest)
P_0	21.33^{b}	23.73^{b}	0.55	0.43^{c}
P_1	28.56^{ab}	24.07^{a}	0.77	0.53^{bc}
P_2	28.78^{ab}	24.40^{a}	0.85	0.53^{bc}
P_3	29.27^{a}	24.67^{a}	1.10	0.80^{ab}
P_4	30.33^{a}	26.13^{a}	1.18	0.93^{a}
P_5	28.77^{ab}	24.47^{a}	0.89	0.73^{a-c}
$LSD_{0.05}$	7.54	2.24	NS	0.30
$LSD_{0.05}$	7.54	2.24	NS	0.30
CV (%)	12.37	10.95	10.91	14.96

4.3 Effect of phosphorus on primary branch number plant^{-1} of mungbean

From Table 4.2 different level of P had no significant effect on the number of primary branches plant^{-1} of mungbean. The highest number of primary branches plant^{-1} was recorded as 1.18 at 60 DAS in P_4 treatment which was non-significant in variations. At harvesting period, the highest number of primary branch plant^{-1} (0.93) was also recorded in P_4 treatment which was statistically similar with P_3 and P_5 treatment. The lowest number of primary branches plant^{-1} (0.55 and 0.43 at 60 DAS and at harvest respectively) was recorded in the P_0 treatment where no P was applied.

Table 4.3: Effect of phosphorus on number of pods plant^{-1} and pod length of mungbean

Treatment	Number of pods plant^{-1}	Pod length(cm)
P_0	12.73^{d}	8.32^{b}
P_1	13.33^{cd}	8.43^{ab}
P_2	15.33^{b-d}	8.44^{a}
P_3	22.73^{a}	8.77^{a}
P_4	22.80^{a}	8.90^{a}
P_5	18.80^{ab}	8.69^{a}
$LSD_{0.05}$	3.95	0.29
CV (%)	8.67	6.08

Table 4.4: Effect of phosphorus on number of seeds pod^{-1} and weight of 1000 seeds ofmungbean

Treatment	Number of seeds pod^{-1}	Weight of 1000 seeds (g)
P_0	11.00^{d}	37.22^{b}
P_1	11.33^{cd}	38.40^{ab}
P_2	11.56^{bc}	38.80^{ab}
P_3	12.11^{a}	38.90^{ab}
P_4	12.44^{a}	39.39^{a}
P_5	11.89^{b}	38.84^{ab}
$LSD_{0.05}$	0.36	1.92
CV (%)	8.02	8.77

4.4 Effect of phosphorus on pod length of mungbean

The different level of P application showed significant effect on pod length plant^{-1}of mungbean (Table 4.3). The largest pods (8.90 cm) was recorded in P_4 treatment which was statistically similar with all others treatment except control (P_0). The smallest pod (8.32 cm) was recorded in P_0 where no P was applied. Increased number of pod length plant^{-1} may be due to positive effects of P.

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

The different level of P application showed significant effect on number of pods plant^{-1}of mungbean (Table 4.3). The highest value of number of pods plant^{-1} (22.80) was recorded in P_4 treatment which was statistically similar with P_3 and P_5 treatments. The smallest pod (12.73) was recorded in P_0 where no P was applied.

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

The different level of P application showed significant effect on number of seeds pod^{-1} of mungbean (Table 4.4). The highest value of number of seeds pod^{-1} (12.44) was recorded in P_4 treatment which was statistically significant with others. The smallest pod (11.00) was recorded in P_0 where no P was applied.

4.7 Effect of phosphorus on1000 seeds weight of mungbean

1000 seeds weight of mungbean response to different level of P application was represented in Table 4.4.From Table 4.4, significant variation was observed on the weight of 1000 seeds of mungbean when different doses of P were applied. The highest value of 1000seed weight of mungbean (39.33 g/1000 seeds) was obtained in P_3treatment which was statistically similar (38.95 and 38.78 g/1000 seeds respectively) with $P_2$and P_1treatment. The lowest value of 1000seed weight (38.11 g/100 seeds) was recorded in the P_0(no P applied) treatment. It was also showed that the weight of seeds was increased upto 23.85% at the maximum dose of P compared to control (no P application). The increased grain weight may be due to the favorable effects of P on the vegetative growth and accumulation of plant growth materials that helped proper growth and development of the mungbean seeds.

4.8 Effect of phosphorus on grain yield of mungbean

The effect of Pongrain yield of mungbean was represented in Table 4.5 which was showed positive relationship between P application and grain yield. Significant variation was observed on the grain yield of mungbean when different doses of P were applied. The highest grain yield of mungbean (1.57t ha^{-1}) was recorded in P_4 treatment which was statistically similar with P_3treatment(1.43 t ha^{-1}). The lowest grain yield (1.11 t ha^{-1}) was recorded in the P_0 treatment where no P was applied.

4.9 Effect of phosphorus on 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 (2.27 t ha^{-1}) was recorded in P_4, which was statistically similar with $P_3$and P_5 treatments (2.04 and 1.94 t ha^{-1} respectively). On the other hand, the lowest stover yield (1.40t ha^{-1}) was obtained in the control (no P application).

4.10 Effect of phosphorus on biological yield of mungbean

The different level of P application showed significant effect on biological yield of mungbean (table 4.5). The highest value of biological yield (3.59 t ha^{-1}) was recorded in P_4 treatment which was statistically significant from others. The smallest biological yield (2.99 t ha^{-1}) was recorded in P_0 where no P was applied. Increased number of pod length $plant^{-1}$ may be due to positive effects of P.

Table 4.5: Effect of phosphorus on grain yield, stover yield and biological yield of mungbean

Treatment	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})
P_0	0.98^{c}	1.40^{c}	2.99^{d}
P_1	1.08^{bc}	1.62^{bc}	3.25^{c}
P_2	1.13^{bc}	1.68^{b}	3.36^{b}
P_3	1.43^{a}	2.04^{ab}	3.46^{b}
P_4	1.57^{a}	2.27^{a}	3.59^{a}
P_5	1.23^{b}	1.94^{ab}	3.39^{b}
$LSD_{0.05}$	0.16	0.29	0.11
CV (%)	12.33	14.67	10.96

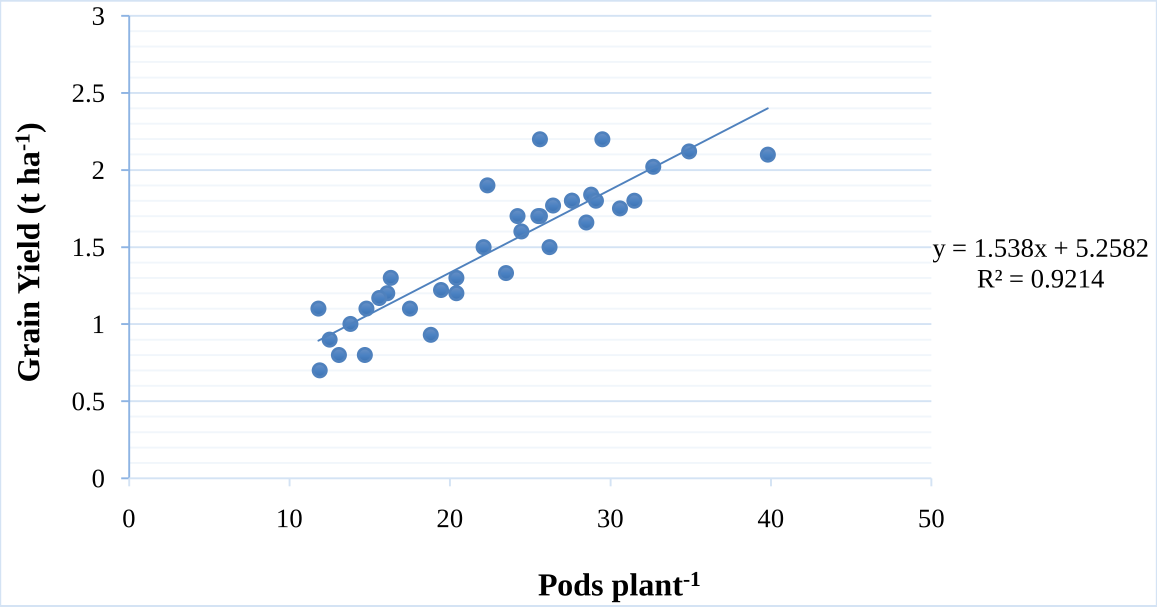

Figure2: Linear relationship between pods plant^{-1} and grain yield of mungbean

Correlation study was done to establish the relationship between the number of pod plant^{-1}and yield of mungbean. From the study it revealed that highly significant correlation (R^2 = 0.9214) was observed between the parameters (Figure 2). It was evident from the Figure 2 that the equation y = 1.538x + 5.2582 gave a good fit to the data, and the co-efficient of determination (R^2 =0.9214) 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 = 0.9214) correlated with the number of podsplant^{-1}, *i.e.*, the yield of mungbean increased with the increase of number of podsplant^{-1}.

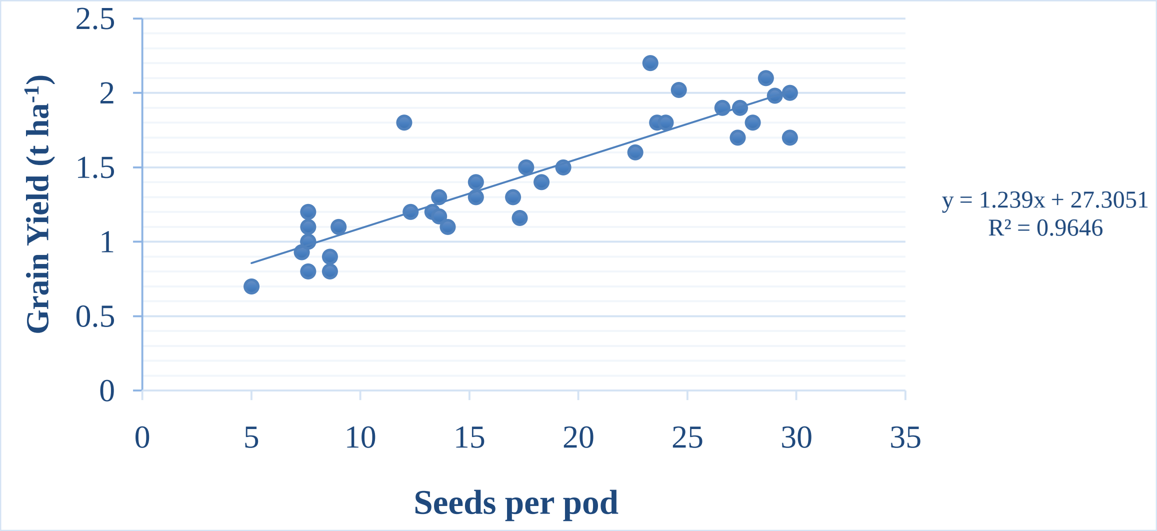

Figure 3: Linear relationship between seeds per podand grain yield of mungbean

Correlation study was done to establish the relationship between the number of seeds pod^{-1} and yield of mungbean. From the study it revealed that highly significant correlation (R^2 = 0.9646) was observed between the parameters (Figure 3). It was evident from the Figure 2 that the equation y = 1.239x + 27.3051gave a good fit to the data, and the co-efficient of determination (R^2 = 0.9646) 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 = 0.9646) 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 July, 2019 to November, 2019 to study the effect of P on the growth and yield of mungbean. The variety, BARI Mung-6 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 for higher yield of mungbean.

The experiments with Randomized Complete Block Design (RCBD) was followed with treatments having unit plot size of 3m x 1.5 m ($5m^2$) and replicated thrice. The different levels of the single factor, P were0, 10, 20, 30, 40 and 60 kg ha^{-1} denoted as P_0, P_1, P_2, P_3, P_4 and P_5 respectively. The data were collected plot wise to get plant height (cm), number of leaves $plant^{-1}$, number of branches $plant^{-1}$, number of pods $plant^{-1}$, pod length (cm), number of seeds pod^{-1}, weight of l000-seed (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield. All the data were statistically analyzed following LSD and the mean comparison was made by LSD. Plant height was significantly affected by different levels of P. Plant height increased with increasing levels of P.

Different plant and yield parameters were significantly influenced by different levels of P. The highest plant height (51.33, 89.17 and 100.12 cm at 30 DAS, 60 DAS and harvesting period respectively) was observed in P_4 treatment which was statistically similar with P_3 treatment. The highest value of number of leaves $plant^{-1}$ (30.33 and 26.13 at 60 DAS and harvesting period respectively), number of branches $plant^{-1}$ (1.18and 0.93 at 60 DAS and harvesting period respectively), number of pods $plant^{-1}$ (22.80), pod length (8.90 cm), number of seeds pod^{-1} (12.44),weight of 1000-seeds (39.39 g), grain yield (1.57 t ha^{-1}), stover yield (2.27 t ha^{-1}) and biological yield (3.59 t ha^{-1}) produced by P_4treatment.The lowest plant height (39.33, 56.33 and 79.44cm at 30 DAS, 60 DAS and harvesting period respectively), number of leaves $plant^{-1}$ (21.33 and 23.73at 60 DAS and harvesting period respectively), number of branchesplant^{-1}(0.55 and 0.43 at 60 DAS and harvesting period respectively), number of pods $plant^{-1}$(12.73), pod length (8.32 cm), number of seeds pod^{-1} (11.44), weight of 1000-seeds (38.11 g), seed yield (0.98 t ha^{-1}) and stover yield(1.40 t ha^{-1}) and biological yield (2.99 t ha^{-1}) produced by control (P_0) treatment.

The results in this study indicated that the plants performed better in respect of seed yield in P_4treatment than the control treatment (P_0) showed the least performance. It was also observed that P_3 treatment showed statistically similar result compared to P_4 treatment. It can be therefore, concluded from the above study that the treatment P_3 (P@ 30 kg ha^{-1}) was foundeconomicallysuitable dose for the better yield of mungbean in Shallow Red Brown Terrace Soils of Bangladesh.

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

1. The effects of P on yield and yield attributes of mungbean were found positive and significant.
2. Application of P @ 30 kg/ha was suitable combination for higher yield of mungbean in Shallow Red Brown Terrace Soils of Bangladesh.
3. 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 works on mungbean should be done in different Agro-ecological zones of Bangladesh.

CHAPTER VI

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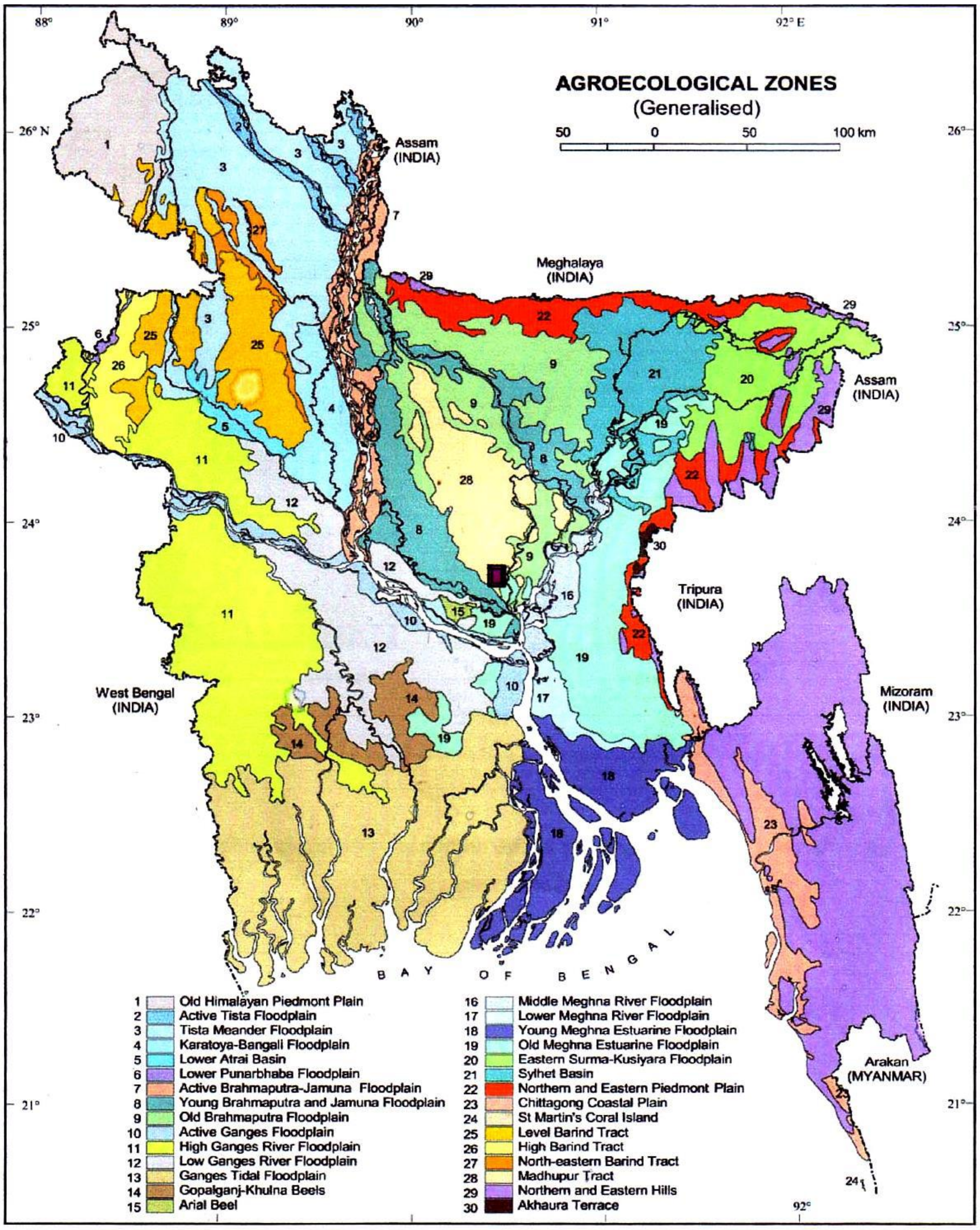
CHAPTER VII

APPENDICES

Appendix 1. Map showing the experimental site under study



Appendix II: Monthly records of meteorological observation at the period of experiment (July, 2019 to November, 2019)

Month	Temperature (°C)		Humidity (%)	Rainfall (mm)
	Minimum	Maximum		
July	34.10	37.20	58.18	500.20
August	23.40	35.60	55.63	656.30
September	21.90	34.50	54.14	439.40
October	20.10	32.20	53.12	240.50
November	18.30	28.60	48.24	100.20

Source: Weather Yard, Bangladesh Meteorological Department, Dhaka.