EFFECT OF PHOSPHOROUS ON GROWTH AND YIELD OF MUNGBEAN UNDER DIFFERENT ROW SPACINGS

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DECEMBER, 2016

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REGISTRATION NO.15-06952

A Thesis

Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)
IN
AGRONOMY

SEMESTER: JULY- DECEMBER, 2016

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CERTIFICATE

*This is to certify that the thesis entitled, "**EFFECT OF PHOSPHOROUS ON GROWTH AND YIELD OF MUNGBEAN UNDER DIFFERENT ROW SPACINGS** "submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN AGRONOMY,** embodies the results of a piece of bona-fide research work carried out by MD. LOKMAN HOSSAIN, RegistrationNo. 15-06952 under my supervision and my 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.

Dated:

Dhaka, Bangladesh

Prof. Dr. Md. Shahidul Islam

Supervisor

Dedicated to my

Beloved parents

ACKNOWLEDGEMENTS

All praises are due to the Almighty Allah, the Great, Gracious and merciful, whose blessings enabled the author to complete this research work and submit the thesis for the degree of Master of Science (M.S.) in Agronomy. The author is grateful to them all who made a contribution to this research work although it is not possible to mention all by names.

*The author would like to acknowledge the untiring inspiration, encouragement and invaluable guidance provided by his respected teacher and supervisor Professor **Dr. Md. Shahidul Islam,** Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), Dhaka. His constructive criticisms, continuous supervision and valuable suggestions were helpful in completing the research and writing up the manuscript.*

*The author sincerely expresses his heartiest respect, deepest sense of gratitude and profound appreciation to his co-supervisor **Dr. Md. Jafar ullah**, Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for cordial suggestions, and valuable advice during the research period and preparing the thesis.*

*The author wishes to express his sincere respect and profound appreciation to the chairman Professor **Dr. Md. Fazlul Karim and other teachers of the department of Agronomy** for their valuable teaching and sympathetic consideration in connection with the study. Heartiest thanks and gratitude to the officials of Farm Division, Sher-e-Bangla Agricultural University for their support to conduct the research.*

The author feels proud to express his deepest and endless gratitude to Md. Asaduzzaman, Shahriar Gem, Daloar Hossain, Shamim Reza, Kajol to help her in the field and prepare the manuscript.

The author is deeply grateful to his respected mother, brother, sister and other relatives for their moral support, encouragement and love with cordial understanding.

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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka in *kharif-I* season during the period from March 2016 to May 2016 to study the effect of phosphorus on growth and yield of mungbean (BARI Mung-6) under different row spacings . There were two factors viz. phosphorus and different row spacings. Four phosphorus (p) levels viz. (i) P_0 = Control; recommended (R) dose of phosphorus (48 kg P_2O_5 ha^{-1}), (ii) P_1 = 25% less than R dose; 36 kg P_2O_5 ha^{-1}, (iii) P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1} and (iv) P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}. Three different row spacings viz. (i) S_1= 20 cm, (ii) S_2 = 30 cm and (iii) S_3 = 40 cm. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replication. In case of phosphorus levels, the maximum seed yield (1.41 t ha^{-1}) and maximum stover yield (1.67 t ha^{-1}) was recorded from P_0 (48 kg P_2O_5 ha^{-1}) treatment which was statistically identical with P_2 (60 kg P_2O_5 ha^{-1}) treatment and P_3 (72 kg P_2O_5 ha^{-1}) treatment. The minimum seed yield (1.02 t ha^{-1}) and minimum stover yield (1.28 t ha^{-1}) was recorded from P_1 (36 kg P_2O_5 ha^{-1}) treatment. In case of row spacing, the highest seed yield (1.42 t ha^{-1}) and highest stover yield (1.73 t ha^{-1}) was achieved by S_2 (30 cm) row spacing. Whereas, the lowest seed yield (1.13 t ha^{-1}) and stover yield (1.38 t ha^{-1}) was achieved by S_1 (20 cm) row spacing. In case of combined effect the maximum seed yield (1.57 t ha^{-1}) and maximum stover yield (1.86 t ha^{-1}) was recorded from P_0S_2 and minimum from P_1S_1. So, from the results it may be concluded that application of phosphorous at the rate of 48 kg P_2O_5 ha^{-1} under a row spacing of 30 cm was found to be achieving higher yield of mungbean.

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List of Abbreviations

Abbreviations	Full word
AEZ	Agro - ecological zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BSMRAU	Bangabandhu Sheikh Mujibur Rahman Agricultural University
cm	Centimeter
cv.	Cultivar
CV	Coefficient of Variation
DAS	Days After Sowing
EC	Emulsifiable concentrate
et al.	And others (*et alibi*)
FAO	Food and Agriculture Organization
g	Gram
ha	Hectare
HI	Harvest Index
kg	Kilogram
L	Liter
DMRT	Duncan's New Multiple Range Test
m^2	Square Meter
mL	Milliliter
MoP	Muriate of Potash
No.	Number
NPK	Nitrogen phosphorus potassium
NS	Non-Significant
%	Percent
$plant^{-1}$	per plant
Seeds pod^{-1}	Seeds per pod
t ha^{-1}	Ton (s) per hectare
TSP	Triple super phosphate

CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is one of the major pulse crops grown in Bangladesh. It belongs to the family Leguminosae and sub family Papilionaceae. It has a tremendous value in agriculture as a good source of high quality plant protein. Mungbean contains 51% carbohydrate, 24–26% protein, 4% mineral, and 3% vitamins (Afzal *et al.*, 2008). Its edible seed is characterized by good digestibility, flavor, high protein content and absence of any flatulence effects (Ahmed *et al.*, 2008). It can also minimize the scarcity of fodder because the whole plant or its by- product can be used as good animal feed. It is widely used as "Dal" in the country like others pulses. Mungbean is also known as green gram or golden gram. Green pulse seeds also can be consumed as fried peas or can be used in curry.

According to World Health Organization (WHO), per capita per day requirement of pulse is 45 g. However, in Bangladesh, only 12g pulse is available per capita per day. About 6.01 million tons of pulse is required to meet the present per capita requirement of our country.

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.*, 2008). In Bangladesh, BARI mung-6 is a yield potential pulse crop, which was innovated by Bangladesh Agricultural Research Institute (BARI). BARI Mung-6 is well known as short duration and drought tolerant crop. Mungbean is cultivated in both kharif-1 and kharif-2 seasons. It is traditionally grown throughout the country during the month of February to April in kharif-1 and from July to November in kharif-2 seasons. Though mungbean is cultivated throughout the country but its production is not satisfactory. The production area is decreasing day by day. But our population is increasing rapidly. We need more food to feed the increasing people. We have to produce more food in our limited land. To meet up the increased demand of food, farmers are growing more cereal crops. Due to the high population pressure, the total cultivable land is decreasing day by day along with the pulse cultivable land. Among the pulse cultivated area, only 8.10 % lands are used for the cultivation of mungbean (Kabir, 2001). The reasons for low yield are manifold: some are varietals and some are agronomic management practices. Information on optimum seed rate, suitable spacing, improved varieties, judicial application of fertilizer and water management is also limited for mungbean cultivation. Among the various factors of production, use of improved cultural practices and adequate management is important aspect for increased production. Within the cultural practices, suitable method of sowing, optimum spacing, optimum seed rate and inoculation of bio-fertilizer may increase the yield of mungbean. The management of fertilizers is one of the important factors that greatly affect the growth, development and yield of mungbean (Asaduzzaman *et al.*, 2008).

A balanced supply of essential nutrients is indispensable for optimum plant growth. Phosphorous (P) fertilizer is the major mineral nutrient determining yield in legume crops. It is a deficient element in Bangladesh soils and is limiting crop production. This nutrient plays a key role in plant physiological process. 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 seed 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). The farmers hardly use phosphorus due to their poor socio-economic condition and lack of proper knowledge. It is a major cause of low yield. Mungbean responds highly to phosphorus. As a leguminous crop, it can fix atmospheric nitrogen through the symbiosis between the host mungbean and soil bacteria and improve soil fertility. To fix nitrogen in soil, an adequate phosphorus supply must be required for the legumes, other factors being adequate.

Different experiments and works on spacing of mungbean have been conducted in Bangladesh, as well as in other countries to find out the appropriate plant population to get maximum yield (Mondal, 2007). Crop yield can be optimized by regulating plant density. An optimum density is considered a population that ensures minimum plant competition for growth resources resulting in maximum yield. A population, higher than optimum density offers greater competition for growth resources that eventually reducing yield. Improper spacing reduced the yield of mungbean up to 20 to 40% (AVRDC, 1974) due to competition for light, space, water and nutrition. The optimum spacing favors the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients and thus increase seed yield (Miah *et al.*, 1990). Row spacing directly affects the physiological activities through intra-specific competition. The optimum plant density is a pre-requisite for obtaining higher productivity (Rafiei, 2009). Plant density influences plant growth. Though wider space allows individual plants to produce more branches and pods, but it provides smaller number of pods per unit area due to fewer plants per unit area. For higher yield, an appropriate row spacing of mungbean in combination with appropriate dose of phosphorous is to be finding out.

The present study was under taken with the following objectives:

1. To find out the optimum dose of phosphorous for proper growth and yield of mungbean.

2. To study the effect of row spacing on the growth and yield of mungbean.

3. To study the interaction effect of phosphorus and row spacing on the growth and yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

Research and scientific studies have to take guidance from the previous work done in relevant fields. In this chapter, an attempt has been made to review the available information in home and abroad regarding the effect of phosphorus and row spacing on yield of mungbean.

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

Most of the researchers reported that phosphorous was necessary for successful mungbean production.

Rahman *et al.*(2015) conducted an experiment to investigate the response of mungbean **(**BARI Mug 6**)** cultivars to different levels of phosphorus (P) (0, 15, 20 and 25 kg P ha^{-1}) and zinc (Zn) (0, 1.5 and 3 kg Zn ha^{-1}). The results revealed that seed and stover yield of mungbean increased with increasing levels of phosphorus and zinc up to certain level. In case of P the significantly maximum seed yield (1.5 t ha^{-1}) and stover yield (2.47 t ha^{-1}) were obtained with from 25 kg P ha^{-1} and the significantly minimum seed yield (1.11 t ha^{-1}) and stover yield (2.06 t ha^{-1}) were obtained from 0 kg P ha^{-1}.

Tickoo *et al.* (2006) carried out an experiment in New Delhi, India during the kharif season of 2000 with mungbean cultivars Pusa 105 and Pusa Vishal, which were sown at 22.5 and 30.0 cm row spacing and was supplied with 36-46 and 58-46 kg of N-P ha^{-1}. Cultivar Pusa Vishal recorded higher biological and seed yield (3.66 and 1.63 t ha^{-1})

respectively) compared to cultivar Pusa 105. Nitrogen and phosphorus rates had no significant effects on both the biological yield and seed yield of the crop. Row spacing at 22.5 cm resulted in higher seed yields in both the cultivars.

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 Randomized Complete Block Design with four replications. Phosphorus application at 40 kg P_2O_5 ha^{-1} affected the crop positively, while below and above this rate resulted in no significant effects. Interactive effects of two irrigations and 40 kg P_2O_5 ha^{-1} were the most effective. The rest of the combinations remained statistically non-significant to each other. It may be concluded that green gram can be successfully grown with phosphorus at 40 kg P_2O_5 ha^{-1}.

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 ha^{-1} . The increase in phosphorus levels decreased the days to flowering and increased the branches $plant^{-1}$, number of pods $plant^{-1}$, 1000-seed weight and seed yield. The highest yield of 1022 kg ha^{-1} was obtained at the phosphorus level of 100 kg ha^{-1} compared to a 774 kg ha^{-1} yield in the control. However, the most economical phosphorus level was 40 kg ha^{-1} because it produced a seed yield statistically comparable to 100 kg ha^{-1}.

Manpreet *et al.* (2004) conducted a field experiment in Ludhiana, Punjab, India during summer 2000 to investigate the response of mungbean genotypes (SML 134 SML 357 and SML 668) to P application (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) under irrigated conditions. Yield attributes such as number of branches/plant and pods/plant was significantly higher in SML 357 and SML 134. Whereas pod length and 100 seed weight were higher in SML 668, which accounted for higher seed yield in this cultivar compared to SML 134 but was at par with SML 357. The straw yield showed the reverse trend with significantly higher value for SML 134, thus lowering the harvest index significantly compared to SML 668 and SML 357. Phosphorus application showed a non-significant effect on number of branches $plant^{-1}$, number of seeds pod, 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 seed 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}.

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 seed pod^{-1} and 1000 seed weight. Phosphorus level of 35 kg ha^{-1} produced the maximum seed yield.

Satish *et al.* (2003) conducted an experiment to investigate the response of mungbean cultivars to different P levels (0, 20, 40 and 60 kg /ha). They found that P at 40 and 60 kg ha^{-1} increased the number of pods $plant^{-1}$, seed yield and seed pod^{-1} over the control and P at 20 kg ha^{-1}

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

Yadav and Rathore (2002) carried out a field trial to find out the effect of phosphorus and iron fertilizer on yield, protein content and nutrient uptake in mungbean on loamy sandy soil in India. The results indicated that the seed and stover yield were 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.* (1998). Yadav and Jakhar (2001) observed that seed and straw yields of mungbean were increased up to 60 kg P_2O_5 ha^{-1} application.

Umar *et al*. (2001) observed that plant height and numbers of branches per plant were significantly increased by phosphorus application. Number of pods $plant^{-1}$, number of seeds pod^{-1}, 1000 seed weight and seed 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 seed and straw and the yield of the plant.

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.

Mastan et al. (1999) stated that the number of pods $plants^{-1}$ of summer mungbean cv. LOG 127 increased with increasing P rates. Raj *et al.* (1999) reported that application of 60 kg P_2O_5 ha^{-1} produced a maximum seed yield of 300.12 kg ha^{-1}. However, it did not differ significantly with 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.

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

Shukla and Dixit (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 vigor 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 BishanathChariali, Assam, India. The results indicated that plant height was unaffected by phosphorus application.

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

Satter and Ahmed (1992) reported that phosphorus application up to 60 kg P_2O_5 ha^{-1} on mungbean progressively and significantly increased nodulation, shoot length and weight, seed yield and total protein content.

Tank *et al.* (1992) showed that application of 80 kg P_2O_5 ha^{-1} gave the highest yield (808 kg ha^{-1}) which was statistically identical to 40 kg P_2O_5 ha^{-1} (807 kg ha^{-1}).

Arya and Kalra (1988) conducted an experiment on summer mungbean variety S-8 and revealed that application of phosphorus had no effect on the growth of summer mungbean, while number of pods $plant^{-1}$, weight of pods $plant^{-1}$, weight of seeds $plant^{-1}$, number of seeds pod^{-1}, seed yield, dry matter and harvest index were found to be increased with increasing levels of phosphorus up to 50 kg P_2O_5 ha^{-1} .

Barman *et al.* (2015) conducted an experiment at the Sher-e-Bangla Agricultural University Farm, Dhaka 1207, during the kharif season of 2014 to study the effects of Phosphorus and Zinc on the concentrations of N, P, K, S and Zn in Mungbean stover and seed (BARI mug 6). Four levels of phosphorus (P) (0, 15, 20 and 25 kg P ha^{-1}) and three levels of zinc (Zn) (0, 1.5 and 3 kg Zn ha^{-1}) were used in the study. The results revealed that the N, P, K and S concentration of mungbean plant increased significantly from control to P, Zn (20 kg P ha^{-1}+ 3 kg Zn ha^{-1}) treatment combination and again decreased with increasing phosphorus more than 20 kg P ha^{-1}. Application of phosphorus and zinc increase organic carbon, N, P, K and S status of postharvest soil significantly.

Ali *et al*. (2014) conducted an experiment to study the effect of efficient supply of nutrients. They observed that adequate supply of Phosphorus is essential at early stage of crop growth when the limited root system is not yet capable of absorbing the Phosphorus reserves of the soil. Increasing levels of phosphorus enhanced the plant growth, yield parameters like, nodules per plant, dry weight of nodules, and number of pods per plant, number of seeds pod^{-1}, 1000-seed weight, straw yield and ultimately final crop yield of Mungban.

Habibullah *et al.* (2014) conducted at Agronomy Farm in Sher-e-Bangla Agricultural University, Dhaka-1207, during Kharif season, 2012 to evaluate the performance of phosphorus level on growth, yield and quality of BARI MUNG-6. Randomized completely block designed (RCBD) was laid out to determine this experiment with three replications. Phosphorus fertilizer was applied at four treatments like as P_0, control; P_1, 15 kg ha^{-1}; P_2, 20 kg ha^{-1}; P_3, 25 kg ha^{-1} respectively. Highest plant height (cm), no. of branches per plant, no. of pods per plant, pod length (cm), no. of seed per pod, weight of 1000 seed (g), seed yield (t ha^{-1}) and Stover yield (t ha^{-1}) were counted in 20 kg ha^{-1} level of phosphorus, whereas minimum was showed in control application of phosphorus fertilizer. Significant variation on concentration of N, P, K and S was found at 20 kg ha^{-1} application of phosphorus, where as minimum was observed with control treatment in both stover and seed yield.

Adebisi *et al*. (2013) reported that in tropical soybean lots with small seed size had maximum seed germination (97%) and emergence (90%) while those with large seed size produced the highest seed (88) per $plant^{-1}$, pods (54)) $plant^{-1}$ and seed yield (9.72 g) $plant^{-1}$.

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

Mozumder *et al.* (2012) conducted an experiment at the Horticulture Field Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University during December 2007 to July 2008 of *Eryngium foetidum*at different spacing. They found that thousand seed weight were higher in wider spacing but marketable fresh yield and seed yield per unit area was better in medium (10 cm×10 cm) spacing.

Malekmelki *et al*. (2012) reported that, with increasing plant density increased biological yield and seed yield of lentil. Row spacing at 22.5 cm resulted in higher seed yields in both crops (Tickoo *et al*., 2006).

Islam *et al.* (2011) conducted a field experiment at the Horticultural farm of the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and found that number of fruits per plant, fruit length, individual fruit weight, yield plant^{-1} were significantly increased with the increasing plant spacing. Bakry *et al*. (2011) and Yucel (2013) who reported that pod number decreased with increasing plant density.

Ahmed *et al*. (2010) reported that increasing population density decreased number of pods plant^{-1} and the seed yield plant^{-1}. They further stated that plant population had a significant effect on most yield components. Osman et al. (2010) stated that the maximum yield was obtained with the highest plant density.

Raghuwanshi (2009) conducted a field trial at Tikamagarh, Madhya Pradesh in 2008 kharif (monsoon) season, sesame cv. TKG-9, JLSC-8 and JT-7 produced mean seed yields of 2.53, 2.80, 2.92 and 1.86 t ha^{-1} respectively. Yield averaged 2.05 and 3.00 t with spacing of 30x15 cm and 10x10cm, and 3.99, 1.85 and 1.75 t when sown at the onset of monsoon (1 July) or 10 or 20 d after this date.

Idris (2008) indicated that increasing plant spacing increased number of pods per plant and consequently gave the highest seed yield. Reddy and Reddi (2006) reported that, plant density brings out certain modifications in the growth of plants. Plant height increases with the increase in plant population in extreme level due to competition for highest plant height.

Ahmed *et al.* (2005) conducted a field experiment in 2000 to investigate the effect of P fertilizer and plant density on the yield and yield components of mungbean cm. NM-92 in Faisalabad, Punjab, Pakistan. They found highest seed yield at 30 cm row spacing while pod length, pods plant^{-1}, seeds pod^{-1} and 1000 seed weight were highest with 45 cm row spacing.

Sarkar *et al.* (2004) reported that, in Bangladesh, planting density of 30x10 cm gave higher yield of mungbean than 20x20 cm or 40x30 cm planting density.

Row and plant spacing influence plant yield, yield attributes and yields of mungbean (Ihsanullah *et al.* 2002).

Khan et al. (2004) conducted an experiment with mungbean during the summer season of 2000, in Peshawar, Pakistan. The row spacing treatments were 25 and 50 cm, while plant spacing were 5, 7.5 and 10 cm. Emergence of seedlings m^{-2}, days to flowering, days to maturity, number of seeds pod^{-1}, number of branches plant^{-1}, plant height (cm), 1000 seed weight (g), percent hard seed (%), biological yield (kg)and seed yield (kg ha^{-1}) were significantly affected by row and plant spacing, pods number plant^{-1} and harvest index were not significantly affected at 5% level of significance with row and plant spacing. The results revealed that a spacing of 50 cm between rows and 10 cm within rows produced the maximum number of pods plant^{-1}, seeds pod^{-1}, 1000 seed weight, low percent hard seed and high biological yield, harvest index and seed yield (kg ha^{-1}).

Mokhtar (2001) reported that increasing plant density negatively influences numbers of branches and pods per plant. In addition, Ben (2003) found the same results.

Pookpakdi and Pataradilok (1993) reported about decreased yield of mungbean and Black gram with decreasing plant density, while pod length, pods plant^{-1} increased with decreasing density.

Kumar and Sharma (1989) who reported higher biological yield at narrow row spacing.

Panwar and Sirohi (1987) reported that yield ha^{-1} and number of seeds pod^{-1} increased with increasing plant density whereas yield plant^{-1} and number of pods plant^{-1} decreased with increasing plant density in mungbean.

Muchow and Edwards (1982) reported significantly positive linear trends of dry matter production in three varieties of mungbean to increasing density. Narrow spacing significantly increased dry matter production in pigeon pea (Madhavan *et al*., 1986). Mackenzie *et al.* (1975) reported that the number of pods plant^{-1} of mungbean decreases as density increases.

CHAPTER III

MATERIALS AND METHODS

A field experiment was conducted at the Sher-e-Bangla agricultural University farm to study the effect of phosphorus on the growth and yield of mungbean under different row spacings. The materials used and methodologies followed for conducting the experiment and analyzing the data are discussed in this chapter.

3.1. Site description

3.1.1. Geographical location

The experimental area was situated at 23°77´N and 90°35´E longitude at an altitude of 8.6 meter above the sea lavel.

3.1.2. Agro-ecological zone

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3. Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace soils under Tejgaon series having pH 5.8 and organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depth were collected from experimental fields. The analyses were done by Soil Resource and Development Institute (SRDI, Dhaka). The chemical properties of the soil are presented in Appendix II.

3.2. Planting material

The Planting material used in this study was BARI Mung-6 (*Vigna radiata* L. Wilczek). The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur.

3.2.1. Description of the cultivars

BARI released BARI Mung-6 variety in the year 2003. The plant attains a height of 35-40 cm, the leaves look light green and its life duration is about 75-80 days. Seeds are larger than local variety and light brown yellow in color. Seed contains 20-25 % protein. Thousand seed weight is 35-40 g. Under proper management practices it may give 1.6-2.0 t ha^{-1} seed yields.

3.3. Treatments

Two sets of treatments were included in the experiment as follows:

Factor A: **phosphorus (4 levels)**

P_0 = Control; recommended (R) dose of phosphorus (48 kg P_2O_5 ha^{-1})

P_1 = 25% less than R dose; 36 kg P_2O_5 ha^{-1}

P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}

P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}

Factor B: **Row Spacing (3 levels)**

S_1= 20cm

S_2 = 30cm

S_3= 40cm

There were 12 (4 × 3) treatment combinations viz., P_0S_1, P0S2, P_0S_3, P_1S_1, P_1S_2, P_1S_3, P_2S_1, P_2S_2, P_2S_3, P_3S_1, P_3S_2 and P_3S_3.

3.3.1. Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 12 treatment combinations were randomly assigned in the 12 plots of each replication. Total number of plots were 36. The unit plot size was 2.2m × 2 m = 4.4m^2.

3.4. Land preparation

The land was opened with a power tiller on 12 March 2016 and after two ploughing it was exposed to sun light for three days. Afterwards, the land was further ploughed and cross ploughed by power tiller and leveled by laddering. Weeds, stubble and crop residues were removed. The corners of the experimental plots were spaded properly. The clods were broken manually and the soil was brought into good tilth. The final land preparation was done on 15 March 2016. The field layout as per experimental design was done on 16 March 2016.

3.5. Fertilizer dose

The whole amount of Urea (45 kg $ha^{-1)}$ and (MoP 58 kg ha^{-1}) as per recommendation (Afjal *et al.*, 1998) and TSP (as per treatment) were applied at the time of final land preparation.

3.6. Method of fertilizer application

Whole amount of Urea, TSP and MoP fertilizers were applied as basal dose during final land preparation.

3.7. Sowing of seeds

Before sowing Seeds were treated with fungicide provex-200 to protect them from seed borne diseases. Seeds were sown continuously in rows on 16 March, 2016 arranging row to row distance as per treatment. Seedling emergence from 80% seed was recorded plot wise.

3.8. Intercultural operations

3.8.1. Weeding and thinning

The experimental crop plants were found to be infested with weeds of different kinds. Two weedings were done, first at 17 days and second at 45 days after sowing. Thinning was done to maintain plant to plant distance 10 cm in each row. The first thinning was done at 9 days after sowing (DAS) and second one was done at 25 days after sowing (DAS).

3.8.2. Irrigation and drainage

Two irrigations were applied, first one at 10 DAS and second at 30 DAS. Proper drainage system was also made for draining out excess water.

3.8.3. Application of insecticides

The mungbean plants were infested with insect and disease. The fungicide Bavistin 0.2% @ 25g/18L water was sprayed at 24 days after sowing and insecticide Ripcord 10 EC @ 50 mL/20Lwater was sprayed at 32 days after sowing to control pest.

3.9. Harvesting

The crops were harvested from central 1.0 m^2 area of each plot for yield data on different dates as they attained maturity. Five randomly selected plants from each plot were marked for recording data on plant height, pods $plant^{-1}$, pod length and seeds pod^{-1}. Pods were collected thrice throughout the growing period.

3.10. Threshing

The pods were then threshed by a bamboo stick to separate seeds from the plants.

3.11. Drying, cleaning and weighing

The collected seeds were dried in the sun for reducing the moisture to about nearly 12% level. The dried seeds and stover were cleaned and weight of seeds $plot^{-1}$ was recorded.

3.12. General observations

The crop was frequently monitored to note any change in plant characters. The crop looked promising since the initial stage and in maintained a satisfactory growth till harvest.

3.13. Determination of maturity

At the time when 80% of the pods turned blackish in colour, the crop was assessed to attain maturity.

3.14. Recording of data

Different growth and yield data were recorded from the experiment.

A. Growth characters

i. Plant height at 15, 25, 35, 45 and 55 days after sowing (DAS).

ii. Dry weight plant^{1} at 15, 25, 35, 45 and 55 days after sowing (DAS).

iii. Days to 80% emergence

iv. Days to 80% flowering

v. Days to 80% pod maturity

B. Yield and yield components

i. Plant height (cm)

ii. Pod length (cm)

iii. Number of pods plant^{-1}

iv. Number of seeds pod^{-1}

v. Weight of 1000 seeds (g)

vi. Seed yield (t ha^{-1})

vii. Stover yield (t ha^{-1})

viii. Biological yield (t ha^{-1})

ix. Harvest index (%)

3.15. Procedure of recording data

The detail outline of data recording is given below.

3.15.1. Plant height (cm)

The height of pre-selected five plants were measured from the ground level to tip of the plants and then averaged. Plant height was taken at 15, 25, 35, 45 and 55 days after sowing from the selected plants.

3.15.2. Dry weight plant^{-1} (g)

Five plants were collected randomly from each plot at 15, 25, 35, 45 and 55 days after sowing. The whole plant are packed in paper and dried in oven at 72^0C for 72 hours. Then the dry weight were taken in an electric balance and mean values were calculated. After vegetative stage, the dry weight of reproductive parts was also recorded to obtain total dry weight of plant.

3.15.3. Days to 80% emergence

Days to 80% emergence was considered when 80% of the plants within a plot were emerged from soil. The number of days to 80% emergence was recorded from the date of sowing.

3.15.4. Days to 80% flowering

Days to 80% flowering was considered when 80% of the plants within a plot were showed up with flowers. The number of days to 80% flowering was recorded from the date of sowing.

3.15.5. Days to 80% pod maturity

Days to 80% pod maturity was considered when 80% of the plants within a plot become blackish in color. The number of days to 80% maturity was recorded from the date of sowing.

3.15.6. Pod length (cm)

Five pods were selected at random from the total number of pods harvested from tagged five plants. The length of each pod was measured and average was calculated out and expressed as number of seeds per pod.

3.15.7. Number of pods plant^{-1}

The total number of pods from randomly selected five plants was counted and their mean were calculated.

3.15.8. Number of seeds pod^{-1}

The number of seed of each randomly selected ten pod was counted and the mean was found out by dividing the number of pods.

3.15.9. Weight of 1000 seeds (g)

One thousand seeds were randomly taken from the harvest sample of each plot. The seeds were then sun dried for seven days and weighted with a sensitive electrical balance. The 1000 seeds weight was recorded at 12% moisture level.

3.15.10. Seed yield (t ha^{-1})

The pods from the central four lines were harvested plot wise as per experimental treatments and threshed. Seeds were then cleaned and sun dried for five days and weighted with a sensitive electrical balance.

3.15.11. Stover yield (t ha^{-1})

After separation of seeds from plant, the straw and shell harvested area was sun dried and the weight was recorded and then converted into t ha-1.

3.15.12. 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.

3.15.13. Harvest index (HI)

It denotes the ratio of seed yield (economic yield) to biological yield and was calculated with the following formula (Gardner *et al.*, 1985):

$$\text{Harvest index (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

3.16. Statistical analyses

All the recorded data on growth, yield and yield contributing characters were compiled, tabulated and subjected to statistical analysis. Analysis of variance (ANOVA) was done with the help of computer package programme MSTAT-C software. The mean differences among the treatments were tested with Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

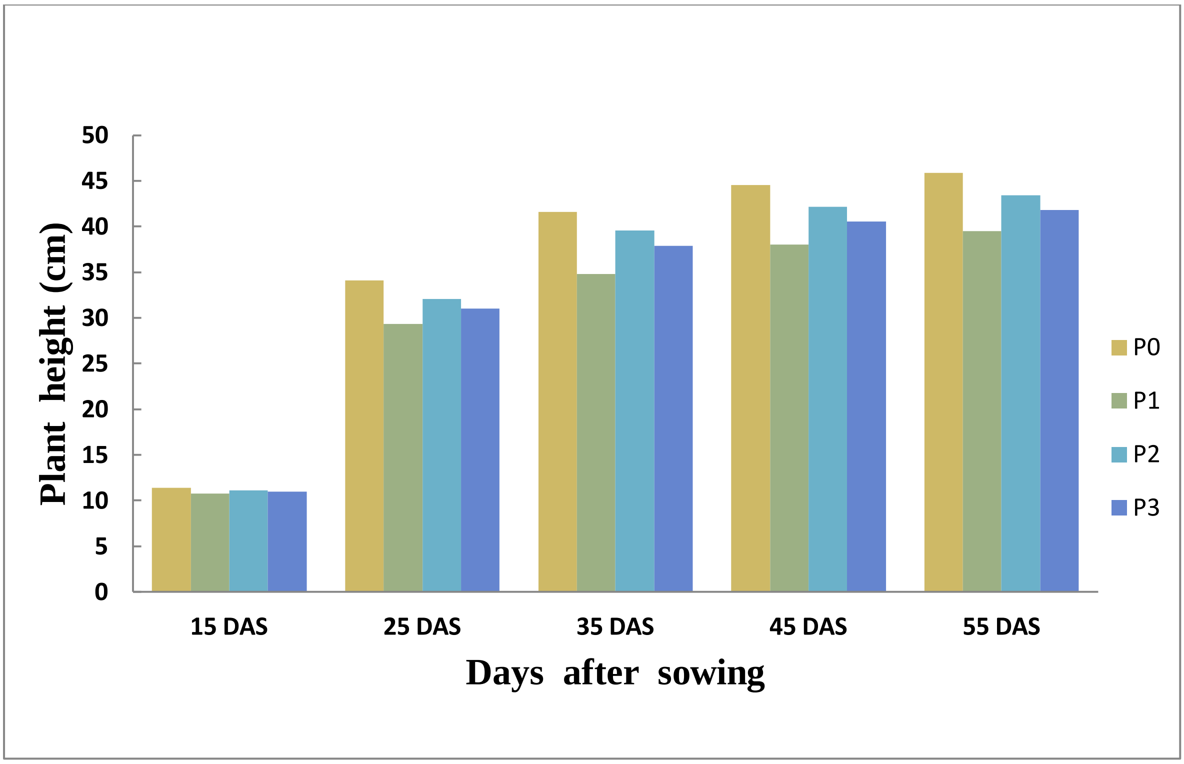
This chapter comprises the presentation and discussion of the results obtained from the experiment. The experiment was conducted to determine the effects of four levels of phosphorus and three levels of row spacing and their interaction effects on vegetative growth and yield of mungbean. The growth and yield components such as plant height, dry weight, pod length, and yield of mungbean as influenced by phosphorus and spacing are presented in Tables. The results of each parameter have been adequately discussed and possible interpretations whenever necessary have been given under the following headlines:

4.1. Plant height (cm)

Plant height of mungbean differed significantly due to the application of different levels of phosphorus at 25, 35, 45, and 55 DAS except 15 DAS (Appendix III). At 15, 25, 35, 45, and 55 DAS the longest plant (11.37 cm, 34.09 cm, 41.62 cm, 44.55 cm, and 45.90 cm) was recorded from P_0 (48 Kg P_2O_5 ha^{-1}). At 35 and 45 DAS, highest result was statistically identical with the result obtained from P2 (60 Kg P_2O_5 ha^{-1}) treatment (39.58 cm and 37.87 cm) and P_3 (72 Kg P_2O_5 ha^{-1}) treatment (42.19 cm and 40.53 cm). Again, the shortest plant (10.78 cm, 29.31 cm, 34.79 cm, 38.01 cm, and 39.49 cm) was found from P_1 (36 Kg P_2O_5 ha^{-1}) (Figure 1). Phosphorus fertilizer ensures favorable condition for the growth of mungbean with optimum vegetative growth and the ultimate results was the tallest plant. Umar *et al.* (2001) observed that plant height and numbers of branches per plant were significantly increased by phosphorus application.

Plant height differed significantly due to row spacing at 25, 35, 45, and 55 DAS except 15 DAS (Appendix III). Results showed that at 15, 25, 35, 45, and 55 DAS, medium row spacing (S_2 = 30cm) showed the tallest plant (11.21, 35.17, 42.95, 46.05 and 47.39 cm respectively). On the other hand, at the same DAS the shortest plant (11.01, 28.13, 34.54, 36.77, and 37.09 cm) was measured from lower row spacing (S_1 = 20 cm) respectively (Figure 2). It was revealed that with the increases of row spacing plant height showed decreasing trend. The results obtained from S_3 (40 cm row spacing) showed intermediate results compared to highest and lowest plant height.

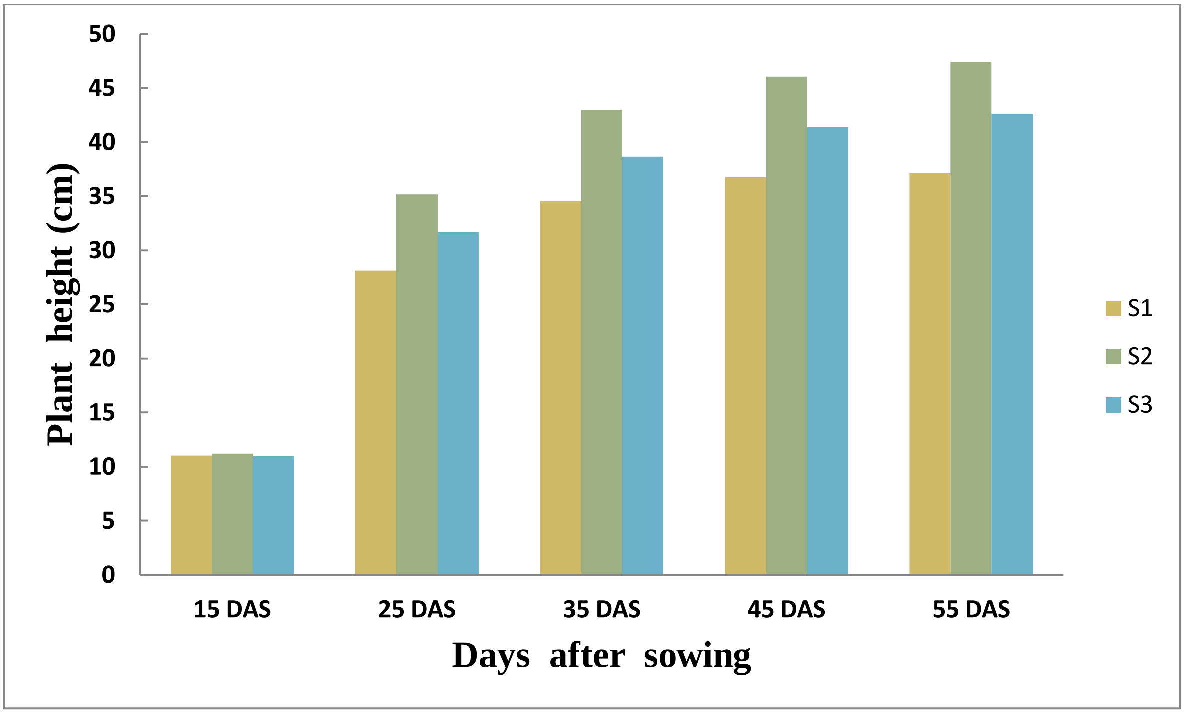
Interaction effect of phosphorus and row spacing was non-significant on plant height at all the sampling days i.e. 15, 25, 35, 45, and 55 DAS (Appendix III). Numerically the highest plant height was found in P_0S_2 treatment combination and the lowest one was found in P_1S_1 treatment combination at all sampling dates (Table 1).



P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}.

Figure 1. Effect of phosphorus on plant height of mungbean at different days after sowing.

(LSD $_{0.05}$ = 3.51, 5.93, 6.31, 4.72 at 25, 35, 45, 55 DAS and NS at 15 DAS , respectively)



S_1= 20cm, S_2 = 30cm, S_3= 40cm

Figure 2. Effect of row spacing on plant height of mungbean plant at different days after sowing.

(LSD $_{0.05}$ = 4.07, 5.13, 5.47, 5.48 at 25, 35, 45, 55 DAS and NS at 15 DAS, respectively)

Table1. Interaction effect of phosphorus and row spacing on plant height of mungbean at different days after sowing (DAS)

Treatment	**Plant height (cm)**				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
P_0S_1	11.18	30.20	37.00	39.60	40.82
P_0S_2	11.63	37.88	46.25	49.50	51.02
P_0S_3	11.31	34.09	41.62	44.55	45.92
P_1S_1	10.70	26.05	31.81	34.05	35.10
P_1S_2	10.80	32.57	39.77	42.57	43.88
P_1S_3	10.85	29.31	35.78	38.31	39.49
P_2S_1	11.20	28.63	35.68	37.41	38.57
P_2S_2	11.34	35.79	43.73	47.08	48.22
P_2S_3	10.80	32.18	39.35	42.09	43.39
P_3S_1	10.96	27.57	33.66	36.03	37.14
P_3S_2	11.09	34.47	42.08	45.04	46.43
P_3S_3	10.82	31.02	37.87	40.53	41.78
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
CV (%)	4.99	10.57	8.92	6.88	11.56

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

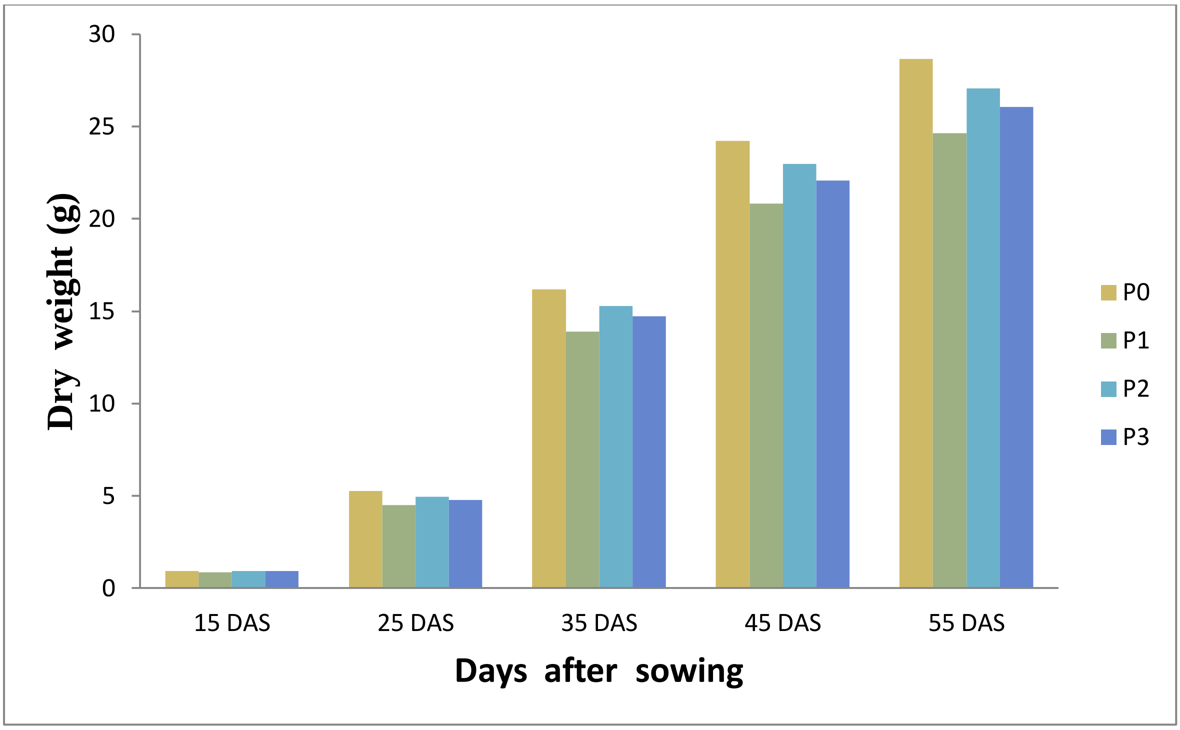
P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}, S_1= 20 cm, S_2 = 30 cm, S_3= 40cm, NS= Non significant , LSD= Least Significant Difference, CV = Co-efficient of variation

4.2. Dry weight plant^{-1} (g)

Dry weight of mungbean plant varied significantly due to application of phosphorus at 35 and 55 DAS but did not vary significantly at 15, 25, and 45 DAS (Appendix IV). Results revealed that, plant dry weight was increased progressively with the advancement of time.

The highest dry weight of plant (28.65g) was recorded from P_0 (48 Kg P_2O_5/ha) treatment and the lowest dry weight of plant (24.64 g) was found in P_1 (36 Kg P_2O_5 ha^{-1}) treatment at 55 DAS. The results obtained from P2 (60 Kg P_2O_5 ha^{-1}) treatment and P_3 (72 Kg P_2O_5 ha^{-1}) treatment showed intermediate results compared to highest and lowest plant height (Figure 3).

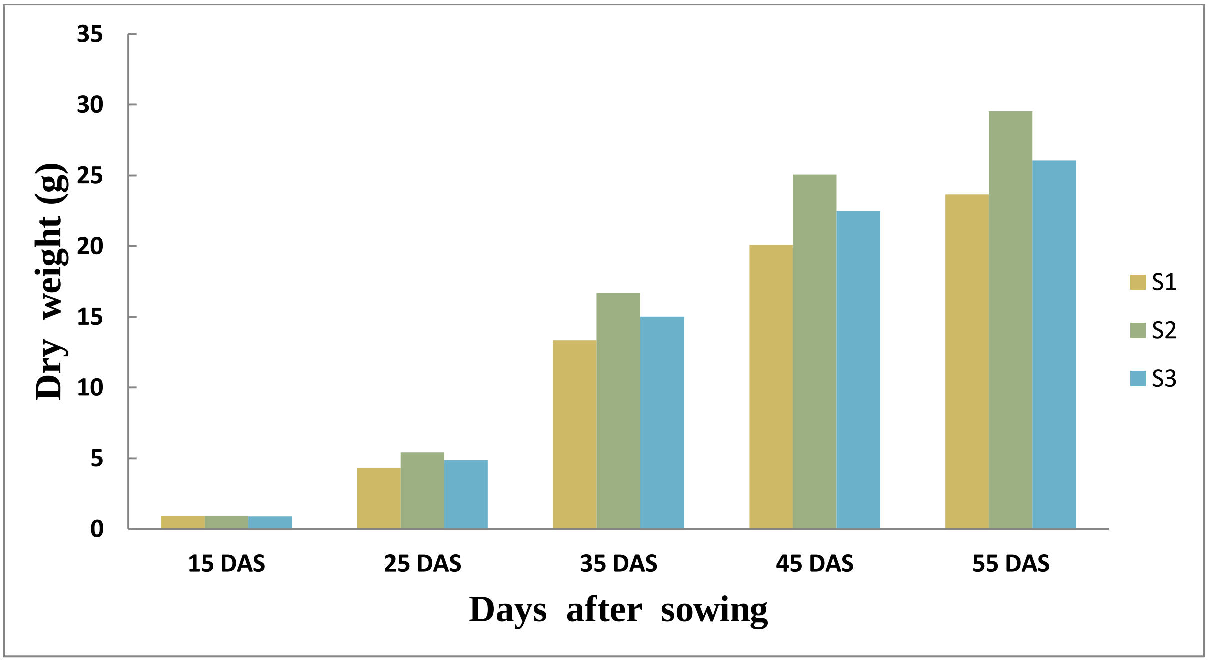
Dry weight of mungbean plant differed significantly due to different row spacing at all the sampling dates i.e. 25, 35, 45, and 55 DAS except 15 DAS (Appendix IV). From the Figure (4) it was observed that, at 15, 25, 35, 45, and 55 DAS, the highest plant dry weight was found from medium row spacing (S_2 = 30cm) and the lowest one was found in lower row spacing (S_1 = 20cm).



P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}.

Figure 3. Effect of phosphorus on dry weight $plant^{-1}$ of mungbean at different days after sowing.

(LSD $_{0.05}$ = 2.07, 3.45 at 35, 55 DAS and NS at 15, 25, 45 DAS, respectively)



S_1= 20cm, S_2 = 30cm, S_3= 40cm

Figure 4. Effect of row spacing on dry weight plant^{-1} of mungbean at different days after sowing.

(LSD $_{0.05}$ = 0.64, 3.2o, 3.21, 4.12 at 25, 35, 45, 55 DAS and NS at 15 DAS, respectively)

The interaction between phosphorus and row spacing had shown statistically non -significant effect on dry weight of mungbean plant at all sampling dates i.e. 15, 25, 35, 45, and 55 DAS (Appendix IV).

At 15, 25, 35, 45, and 55 DAS, numerically the highest plant dry weight was obtained in P_0S_2 treatment combination but the lowest plant dry weight was recorded in P_1S_1 treatment combination (Table 2).

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Table 2. Interaction effect of phosphorus and row spacing on dry weight plant^{-1} of mungbean at different days after sowing (DAS)

Treatment	**Dry weight (g)**				
	15 DAS	**25 DAS**	**35 DAS**	**45 DAS**	**55 DAS**
P_0S_1	0.94	4.67	14.38	21.53	25.47
P_0S_2	0.94	5.84	17.98	26.92	31.84
P_0S_3	0.92	5.25	16.18	24.22	28.65
P_1S_1	0.91	4.01	12.36	18.52	21.90
P_1S_2	0.83	5.01	15.46	23.15	27.38
P_1S_3	0.81	4.51	13.91	20.83	24.64
P_2S_1	0.94	4.40	13.59	20.67	24.07
P_2S_2	0.92	5.51	16.98	25.43	30.08
P_2S_3	0.90	4.95	15.29	22.88	27.07
P_3S_1	0.93	4.28	13.08	19.59	23.17
P_3S_2	0.94	5.31	16.36	24.65	28.97
P_3S_3	0.88	4.77	14.72	22.04	26.07
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
CV (%)	7.30	11.90	12.41	12.80	13.93

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

P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}, S_1= 20 cm, S_2 = 30 cm, S_3= 40cm, NS= Non significant , LSD= Least Significant Difference, CV = Co-efficient of variation

4.3. Days to 80% emergence

Significant differences were observed due to the application of different doses of phosphorus at initial stage on days to 80% emergence (Appendix V). The maximum days to 80% emergence (3.66 days) was recorded from P_1 (36 kg P_2O_5 ha^{-1}) treatment and the minimum days to 80% emergence (3.11 days) was recorded from P_0 (48 kg P_2O_5 ha^{-1}) treatment (Table 3).

Days to 80% emergence at initial stage varied significantly due to different row spacing (Appendix V). The maximum days to 80% emergence (3.66 days) was recorded in wider row spacing S_3 (40cm). On the other hand the minimum days to 80% emergence (3.08 days) was recorded in medium row spacing (S_2 = 30cm) (Table 4). Interaction effect of phosphorus and row spacing had non-significant effect on days to 80% emergence (Appendix V).

4.4. Days to 80% flowering

Significant differences were observed due to the application of different levels of phosphorus on days to 80% flowering (Appendix V). The maximum days to 80% flowering (38.66 days) was recorded from P_1 (36 Kg P_2O_5 ha^{-1}) treatment and the minimum days to 80% flowering (37.33 days) was recorded from P_0 (48 Kg P_2O_5 ha^{-1}) treatment (Table 3).

Row spacing had non-significant effect on days to 80% flowering (Appendix V). The maximum days to 80% flowering was recorded from S_3 (40cm) and minimum days to 80% flowering was recorded from S_2 = 30 cm row spacing (Table 4). Similarly Interaction effect of phosphorus and row spacing had non-significant effect on days to 80% flowering (Appendix V). The maximum days to 80% flowering (39.00 days) was recorded from P_1S_3 treatment and the minimum days to 80% flowering (37.00 days) was recorded from P_0S_2 treatment (Table 5).

4.5. Days to 80% pod maturity

Days to 80% pod maturity varied significantly due to different doses of phosphorus (Appendix V). The maximum days to 80% pod maturity (51.44 days) was recorded from P_3 (72 Kg P_2O_5 ha^{-1}) treatment and the minimum days to 80% pod maturity (35.00 days) was recorded from P_0 (48 Kg P_2O_5 ha^{-1}) treatment (Table 3).

Days to 80% pod maturity did not vary significantly due to different row spacing (Appendix V). The maximum days to 80% pod maturity (38.25 days) was recorded from S_3 = 40 cm treatment and the minimum days to 80% pod maturity (38.16 days) was recorded from S_2 = 30cm treatment (Table 4).

Similarly Interaction effect of phosphorus and spacing had non-significant effect on days to 80% pod maturity (Appendix V). The maximum days to 80% pod maturity (52.33 days) was recorded from P_3S_3 treatment and the minimum days to 80% pod maturity (49.00 days) was recorded from P_0S_2 treatment(Table 5).

Table 3. Effect of phosphorus on 80% emergence, 80% flowering and 80% pod maturity of mungbean

Treatment	**80% emergence**	**80% flowering**	**80% pod maturity**
$\mathbf{P_0}$	3.11 b	37.33 b	50.00 b
$\mathbf{P_1}$	3.66 a	38.66 a	51.00 ab
$\mathbf{P_2}$	3.44 ab	38.22 a	51.44 a
$\mathbf{P_3}$	3.55 ab	38.44 a	51.44 a
$\mathbf{LSD_{(0.05)}}$	0.52	0.56	1.27
CV (%)	11.85	4.54	3.93

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

P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}, LSD= Least Significant Difference; CV = Co-efficient of variation; NS= Non significant

Table 4. Effect of row spacing on 80% emergence, 80% flowering and 80% pod maturity of mungbean

Treatment	80% Emergence	80% Flowering	80% pod maturity
S_1	3.58 a	38.16	51.00
S_2	3.08 b	38.08	50.41
S_3	3.66 a	38.25	51.50
$LSD_{(0.05)}$	0.45	NS	NS
CV (%)	11.85	4.54	3.93

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

S_1= 20cm, S_2 = 30cm, S_3= 40cm, LSD= Least Significant Difference , CV = Co-efficient of variation , NS= Non significant

Table 5. Interaction effect of phosphorus and row spacing on 80% emergence, 80% flowering and 80% pod maturity of mungbean

Treatment	**80% Emergence**	**80% Flowering**	**80% pod maturity**
P_0S_1	3.00	37.33	50.33
P_0S_2	3.00	37.00	49.00
P_0S_3	3.33	37.66	50.66
P_1S_1	4.00	37.66	50.33
P_1S_2	3.33	38.33	51.00
P_1S_3	3.66	39.00	51.66
P_2S_1	3.33	38.33	52.00
P_2S_2	3.00	38.00	51.00
P_2S_3	4.00	38.33	51.33
P_3S_1	4.00	38.33	51.33
P_3S_2	3.00	39.00	50.66
P_3S_3	3.66	38.00	52.33
$LSD_{(0.05)}$	NS	NS	NS
CV (%)	11.85	4.54	3.93

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

P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}, S_1= 20 cm, S_2 = 30 cm, S_3= 40cm, NS= Non significant , LSD= Least Significant Difference, CV = Co-efficient of variation

4.6. Number of pods plant^{-1}

The variations in respect of number of pod per plant due to the effects of different levels of phosphorus were found to be statistically significant (Appendix VI). The maximum number of pod per plant (13.81) was observed from P_0 (48 Kg P_2O_5 ha^{-1}) treatment. The lowest number of pods plant^{-1} (11.18) was recorded from P_1 (36 Kg P_2O_5 ha^{-1}) treatment followed by P2 (60 Kg P_2O_5 ha^{-1}) treatment and P_3 (72 Kg P_2O_5 ha^{-1}) treatment (Table.6).

The number of pods plant^{-1} was found to be significantly influenced by the different row spacing (Appendix VI). The highest pods number in a plant (14.08) were recorded in medium row spacing (S_2 = 30cm) treatment which was closely followed by wider row spacing (S_3 = 40cm) and the lowest (11.27) in lower spacing (S_1= 20cm) (Table 7). Pookpakdi and Pataradilok (1993) found that pod number plant^{-1} was increased with increasing row spacing. Islam *et al.* (2011) reported similar results for sweet pepper (*Capsicum annuum* L.).

Combined effects of different doses of phosphorus and different row spacing on number of pods plant^{-1} of mungbean showed a statistically non-significant variation (Table 8). The highest pods plant^{-1} found (9.80) in P_0S_2 treatment and lowest pods plant^{-1} found (6.73) in P_1S_1 treatment.

4.7. Pod length (cm)

Pod length (cm) of mungbean differed significantly due to the application of different level of phosphorus (Appendix VI). Result revealed that the highest pod length (8.15 cm) was recorded from P_0 (48 Kg P_2O_5 ha^{-1}) treatment which was closely followed by P_2 (60 Kg P_2O_5 ha^{-1}) treatment.

The lowest pod length (7.33 cm) was recorded from P_1 (36 Kg P_2O_5/ha) treatment (Table 6).

The influence of row spacing on pod length of mungbean was found to be significant (Appendix VI) in this experiment. Pod length increased after increasing row spacing. The highest pod length (8.96 cm) was recorded in wider row spacing (S_3 = 40cm). The lowest pod length (6.62cm) was recorded at shortest row spacing (S_1= 20cm) which followed by medium row spacing (S_2 = 30cm) (Table 7). Baloch (2004) found yield components depicted better performance under wider row spacing.

Combined effects of different doses of phosphorus and different row spacing on pod length of mungbean showed a statistically non-significant variation (Appendix VI). Numerically the longest pod length (9.40 cm) was observed in P_0S_3 treatment combination and shortest pod length (5.97cm) found in P_1S_1 treatment combination (Table 8).

4.8. Number of seeds pod^{-1}

There was significant variation in the number of seed per pod in mungbean when different doses of phosphorus fertilizer were applied (Appendix VI). The highest number of seed per pod (8.91) was recorded in P_0 (48 Kg P_2O_5 ha^{-1}) treatment which followed by P_3 (72 Kg P_2O_5 ha^{-1}) treatment. The lowest number of seed per pod (7.66) was recorded in the P_1 (36 Kg P_2O_5 ha^{-1} (Table 6).

Number of seeds pod^{-1} was significantly influenced by different row spacing (Appendix VI). Results showed that higher row spacing indicated higher number of seeds pod^{-1}. Under the present study, the highest number of seeds pod^{-1} (9.54) was achieved by wider row spacing (S_3 = 40cm). The lowest (7.33) number of seeds pod^{-1} was recorded at shortest row spacing (S_1 = 20cm) which followed by medium row spacing (S_2 = 30 cm) (Table 7). Similar treat of findings were found by Ahmad *et al.* (2005).

Interaction effects of different doses of phosphorus and different row spacing on number of seed per pod of mungbean showed a statistically non-significant variation (Appendix VI). Numerically the maximum number of seed per pod (10.33) was observed in P_0S_3 treatment combination and minimum number of seed per pod (6.81) found in P_1S_1 treatment combination (Table 8).

4.9. Weight of 1000 seeds

Weight of 1000 seeds (g) of mungbean differed significantly due to the application of different level of phosphorus (Appendix VI). The highest weight of 1000 seeds (45.30 g) was recorded in P_0 (48 Kg P_2O_5 ha^{-1}) treatment. While the lowest weight of 1000 seeds (43.23 g) was recorded in P_1 (36 Kg P_2O_5 ha^{-1}) treatment (Table 6).

Weight of 1000 seeds was significantly influenced by different row spacing (Appendix VI). Under the present study, the highest 1000 seeds weight (44.92 g) was achieved by medium row spacing (S_2 = 30cm). Whereas, the lowest (44.35 g) was achieved by shortest row spacing (S_1 = 20cm) (Table 7).

Combined effects of different doses of phosphorus and different row spacing on weight of 1000 seeds of mungbean showed a statistically non-significant variation (Appendix VI). Numerically the maximum weight of 1000 seeds (46.50g) was observed in P_0S_2 treatment combination and minimum weight of 1000 seeds (42.70 g) found in P_1S_3 treatment combination (Table 8).

Table 6. Effect of phosphorus on pod $plant^{-1}$, pod length, seeds pod^{-1}, 1000-seed weight of mungbean

Treatment	Pod $plant^{-1}$	Pod length(cm)	Seeds pod^{-1}	1000-seed weight(g)
P_0	8.81 a	8.15 a	8.91 a	45.30 a
P_1	7.58 b	7.33 b	7.66 c	43.23 d
P_2	8.31 ab	7.69 ab	8.41 ab	44.86 b
P_3	8.02 ab	7.41 b	8.10 bc	43.83 c
$LSD_{(0.05)}$	1.02	0.71	0.70	0.22
CV (%)	13.02	9.68	8.87	6.71

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

P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}, LSD= Least Significant Difference; CV = Co-efficient of variation; NS= Non significant

Table 7. Effect of row spacing on pod $plant^{-1}$, pod length, seeds pod^{-1}, 1000-seed weight of mungbean

Treatment	pod $plant^{-1}$	pod length(cm)	seeds pod^{-1}	1000-seed weight (g)
S_1	7.27 b	6.62 b	7.33 b	44.35 b
S_2	9.08 a	7.36 b	7.94 b	44.92 a
S_3	8.18 ab	8.96 a	9.54 a	43.65 c
$LSD_{(0.05)}$	1.18	0.82	0.82	0.19
CV (%)	13.02	9.68	8.87	6.71

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

S_1= 20cm, S_2 = 30cm, S_3= 40cm, LSD= Least Significant Difference

CV = Co-efficient of variation , NS= Non significant

Table 8. Interaction effect of phosphorus and row spacing on pod plant^{-1}, pod length, seeds pod^{-1}, 1000-seed weight of mungbean

Treatment	pod plant^{-1}	pod length(cm)	seeds pod^{-1}	1000-seed weight(g)
P_0S_1	7.81	7.25	7.90	45.10
P_0S_2	9.80	7.79	8.49	46.50
P_0S_3	8.82	9.40	10.33	44.30
P_1S_1	6.73	5.97	6.81	44.00
P_1S_2	8.42	7.15	7.43	43.00
P_1S_3	7.57	8.87	8.73	42.70
P_2S_1	7.40	6.68	7.41	45.00
P_2S_2	9.20	7.44	8.04	45.40
P_2S_3	8.33	8.94	9.78	44.20
P_3S_1	7.14	6.58	7.10	43.30
P_3S_2	8.90	7.05	7.79	44.80
P_3S_3	8.00	8.61	9.31	43.40
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	13.02	9.68	8.87	6.71

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

P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}, S_1= 20 cm, S_2 = 30 cm, S_3= 40cm, NS= Non significant , LSD= Least Significant Difference, CV = Co-efficient of variation

4.10. Seed yield (t ha^{-1})

Significant variation was observed on the seed yield of mungbean when different doses of phosphorus fertilizer were applied (Appendix VI). Result revealed that the highest seed yield (1.41 t ha^{-1}) was recorded in P_0 (48 Kg P_2O_5 ha^{-1}) treatment which was statistically identical with P_2 (60 Kg P_2O_5 ha^{-1}) treatment and P_3 (72 Kg P_2O_5 ha^{-1}) treatment. The lowest seed yield (1.02 t ha^{-1}) was recorded in P_1 (36 Kg P_2O_5 ha^{-1}) treatment (Table 9).

Seed yield was significantly influenced by different row spacing (Appendix VI). Under the present study, the highest seed yield (1.42 t ha^{-1}) was achieved by medium row spacing (S_2 = 30cm). Whereas, the lowest seed yield (1.13 t ha^{-1}) was achieved by narrowest row spacing (S_1= 20cm). Wider row spacing (S_3 = 40cm) showed intermediate results (1.2 t ha^{-1}) compared to highest and lowest seed yield (Table 10). Similar findings were found by Ahmad *et al*. (2005) and Khan *et al*. (2004).

Seed yield did not vary significantly due to combined effects of different doses of phosphorus and different row spacing (Appendix VI). Numerically the highest seed yield (1.57 t ha^{-1}) was observed in P_0S_2 treatment combination and the lowest seed yield (0.91 t ha^{-1}) found in P_1S_1 treatment combination (Table 11).

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

Stover yield of mungbean differed significantly due to the application of different level of phosphorus (Appendix VI). Result revealed that the highest stover yield (1.67 t ha^{-1}) was recorded in P_0 (48 Kg P_2O_5/ha) treatment which was statistically identical with P_2 (60 Kg P_2O_5 ha^{-1}) treatment and P_3 (72 Kg P_2O_5 ha^{-1}) treatment. The lowest stover yield

(1.28 t ha^{-1}) was recorded in P_1 (36 Kg P_2O_5 ha^{-1}) treatment (Table 9). These findings are similar with the findings of Satter and Ahmed (1992).

The effect of different row spacing on stover yield of mungbean was also significant (Appendix VI). Under the present study, the highest stover yield (1.73 t ha^{-1}) was achieved by medium row spacing (S_2 = 30cm). Whereas, the lowest stover yield (1.38 t ha^{-1}) was achieved by narrowest row spacing (S_1 = 20cm). Wider row spacing (S_3 = 40cm) showed intermediate results (1.55 t ha^{-1}) compared to highest and lowest seed yield (Table 10).

Stover yield did not vary significantly due to combined effects of different doses of phosphorus and different row spacing (Appendix VI). Numerically the highest stover yield (1.86 t ha^{-1}) was observed in P_0S_2 treatment combination and the lowest stover yield (1.14 t ha^{-1}) found in P_1S_1 treatment combination (Table 11).

4.12. Biological yield (t ha^{-1})

Significant variation was observed on the biological yield of mungbean when different doses of phosphorus fertilizer were applied (Appendix VI). The highest biological yield (3.07 t ha^{-1}) was recorded in P_0 (48 Kg P_2O_5 ha^{-1}) treatment which was statistically identical with P_2 (60 Kg P_2O_5 ha^{-1}) and P_3 (72 Kg P_2O_5 ha^{-1}) treatment. The lowest biological yield (2.30 t ha^{-1}) was recorded in P_1 (36 Kg P_2O_5 ha^{-1}) treatment (Table 9).

Biological yield was significantly influenced by different row spacing (Appendix VI). The highest biological yield (3.07 t ha^{-1}) was achieved by medium row spacing (S_2 = 30cm) which was statistically identical with wider row spacing (S_3 = 40cm). Whereas, the lowest biological yield

(2.51t ha^{-1}) was achieved by narrowest row spacing (S_1 = 20cm) (Table 10).

Combined effects of different doses of phosphorus and different row spacing on biological yield of mungbean showed a statistically non-significant variation (Appendix VI). Numerically the highest biological yield (3.42t ha^{-1}) was observed in P_0S_2 treatment combination and the lowest biological yield (2.04 t ha^{-1}) found in P_1S_1 treatment combination (Table 11).

4.13. Harvest index (%)

Application of different doses of phosphorus had non-significant effect on harvest index (Appendix VI). Numerically the maximum harvest index (45.73 %) was recorded from P_0 (48 Kg P_2O_5 ha^{-1}) treatment and the minimum harvest index (44.30 %) was recorded from P_3 (72 Kg P_2O_5 ha^{-1}) treatment (Table 9).

The effect of different row spacing on harvest index was also non-significant (Appendix VI). Numerically the maximum harvest index (45.69 %) was recorded from narrowest row spacing (S_1 = 20cm) and the minimum harvest index (44.08 %) was recorded from wider row spacing (S_3 = 40cm) (Table 10).

Combined effects of different doses of phosphorus and different row spacing on harvest index of mungbean showed a statistically non-significant variation (Appendix VI). Numerically the highest harvest index (48.33 %) was observed in P_2S_1 treatment combination and the lowest harvest index (42.21 %) found in P_2S_3 treatment combination (Table 11).

Table 9. Effect of phosphorus on seed yield, stover yield, biological yield and harvest index of mungbean

Treatment	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
P_0	1.41 a	1.67 a	3.07 a	45.73
P_1	1.02 b	1.28 b	2.30 b	44.33
P_2	1.36 a	1.66 a	2.97 a	45.29
P_3	1.29 a	1.62 a	2.91 a	44.30
$LSD_{(0.05)}$	0.19	0.22	0.39	NS
CV (%)	11.36	10.87	10.78	6.54

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

P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}, LSD= Least Significant Difference; CV = Co-efficient of variation; NS = Non significant

Table 10. Effect of row spacing on seed yield, stover yield, biological yield and harvest index of mungbean

Treatment	**Seed yield ($t\ ha^{-1}$)**	**Stover yield ($t\ ha^{-1}$)**	**Biological yield ($t\ ha^{-1}$)**	**Harvest index (%)**
S_1	1.13 b	1.38 b	2.51 b	45.69
S_2	1.42 a	1.73 a	3.07 a	44.96
S_3	1.27 ab	1.55 ab	2.87 a	44.08
$LSD_{(0.05)}$	0.16	0.19	0.34	NS
CV (%)	11.36	10.87	10.78	6.54

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

S_1= 20cm, S_2 = 30cm, S_3= 40cm, LSD = Least Significant Difference, CV = Co-efficient of variation , NS = Non significant

Table 11. Interaction effect of phosphorus and row spacing on seed yield, stover yield, biological yield and harvest index of mungbean

Treatment	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
P_0S_1	1.25	1.48	2.73	45.71
P_0S_2	1.57	1.86	3.42	45.79
P_0S_3	1.41	1.67	3.07	45.70
P_1S_1	0.91	1.14	2.04	44.35
P_1S_2	1.14	1.43	2.56	44.40
P_1S_3	1.02	1.28	2.30	44.22
P_2S_1	1.22	1.47	2.68	48.33
P_2S_2	1.53	1.84	3.03	45.34
P_2S_3	1.35	1.65	3.20	42.21
P_3S_1	1.15	1.44	2.59	44.36
P_3S_2	1.44	1.81	3.24	44.31
P_3S_3	1.29	1.62	2.91	44.22
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	11.36	10.87	10.78	6.54

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

P_0 = Control; recommended (R) dose of phosphorous (48 kg P_2O_5 ha^{-1}), P_1 = 25% less then R dose; 36 kg P_2O_5 ha^{-1}, P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1}, P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1}, S_1= 20 cm, S_2 = 30 cm, S_3= 40cm, NS= Non significant , LSD= Least Significant Difference, CV = Co-efficient of variation

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at Sher-e-Bangla Agricultural University farm Dhaka, in the kharif-I season during the period from March 2016 to May 2016 to study the effect of phosphorus on the growth and yield of mungbean (BARI Mung-6) under different row spacings . There were two factors viz. phosphorus and different row spacings. Four phosphorus (P) levels viz. (i) P_0 = Control; recommended (R) dose of phosphorus (48 kg P_2O_5 ha^{-1})**,** (ii) P_1 = 25% less than R dose; 36 kg P_2O_5 ha^{-1} , (iii) P_2 = 25% more than R dose; 60 kg P_2O_5 ha^{-1} and (iv) P_3 = 50% more than R dose; 72 kg P_2O_5 ha^{-1} . Three different row spacing viz. (i) S_1= 20 cm, (ii) S_2 = 30 cm and (iii) S_3= 40 cm.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replication. Total number of unit plots was 36. The unit plot size was 2.2m × 2 m = 4.4m^2. Mungbean (BARI Mung-6) seeds were sown on 16 March, 2016 by hand as per experimental specification. The seed rate was maintained at 30 kg ha^{-1}. All other agronomic practices were given properly to ensure a healthy growth of the crop. The crop was harvested at full maturity. The collected data were analyzed statistically and the values of the means differences were adjusted by Duncan's New Multiple Range Test (DMRT) with the help of MSTAT-C programme. The data were recorded on two broad parameters such as growth and yield characters. Growth study was started from 15 DAS and continued up to 55 DAS at 10 days interval. For taking data on growth parameters like plant height and dry weight five plants from each plot were randomly selected and uprooted at each time. At maturity, five plants were selected randomly from each unit plot and uprooted before harvesting for recording of necessary data on yield contributing characters. After sampling, the crop from each unit plot (1 m^2 area) was harvested to record the data on seeds and stover yield.

With some exception, the effect of phosphorus was found to be significant on almost all the parameters of growth, yield and yield contributing characters. The highest value for growth parameters like plant height and total dry weight was observed from P_0 (48 Kg P_2O_5 ha^{-1}) treatment and the lowest value was found from P_1 (36 Kg P_2O_5 ha^{-1}) at different days after sowing. On the other hand, in case of yield and yield contributing characters, the maximum value of plant height (cm), number of pods $plant^{-1}$, pod length (cm), number of seeds pod^{-1}, weight of 1000 seeds (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%)was observed from P_0 (48 Kg P_2O_5 ha^{-1}) but the highest number of days to 80% emergence, days to 80% flowering was recorded in P_1 (36 Kg P_2O_5 ha^{-1}) and maximum number of days to 80% pod maturity was observed in P_3 (72 Kg P_2O_5 ha^{-1}) treatment. The lowest plant height (cm), number of pods $plant^{-1}$, pod length (cm), number of seeds pod^{-1}, weight of 1000 seeds (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) was observed from P_1 (36 Kg P_2O_5 ha^{-1}) treatment but the lowest number of days to 80% emergence, days to 80% flowering and days to 80% pod maturity was recorded in P_0 (48 Kg P_2O_5 ha^{-1}) treatment.

The effect of row spacing was found to be significant on all the parameters of growth, yield and yield contributing characters except days to 80% flowering, 80% pod maturity and harvest index (%). With some exception, the highest value for growth parameters like plant height and total dry weight was observed in medium spacing (S_2 = 30cm) and the lowest value was found in lower spacing (S_1 = 20cm) at different days after sowing. On the other hand, in case of yield and yield contributing characters, the maximum value of plant height (cm), number of pods plant^{-1} , weight of 1000 seeds (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield (t ha^{-1}) was observed from medium spacing (S_2 = 30cm) but the highest pod length (cm) and number of seeds pod^{-1} was recorded from wider row spacing (S_3 = 40cm). The maximum number of days to 80% emergence was found in lower spacing (S_1 = 20 cm). The lowest plant height (cm), number of pods plant^{-1} , pod length (cm), number of seeds pod^{-1}, seed yield (t ha^{-1}), stover yield (t ha^{-1})and biological yield (t ha^{-1}) was observed from lower spacing (S_1 = 20 cm) but the lowest number of days to 80% emergence and weight of 1000 seeds (g) was recorded from medium spacing (S_2 = 30cm) and wider row spacing (S_3 = 40cm) respectively.

The interaction effect of phosphorus and row spacing was found to be non-significant on all the parameters of growth, yield and yield contributing characters. The highest value for growth parameters like plant height (cm) and dry weight plant^{-1} (g) was observed in P_0S_2 treatment combination and the lowest value was found in P_1S_1 treatment combination at different days after sowing. On the other hand, in case of yield and yield contributing characters, the maximum value of number of pods plant^{-1} , weight of 1000 seeds (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield (t ha^{-1}) was observed in P_0S_2 treatment combination. Whereas, the highest value for pod length (cm) and number of seeds pod^{-1} was observed in P_0S_3 treatment combination. Maximum harvest index (%) was recorded in P_2S_1 treatment combination. The lowest value for number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, seed yield (t ha^{-1}), stover yield (t ha^{-1}) and biological yield (t ha^{-1}) was found in P_1S_1 treatment combination. The minimum value for weight of 1000 seeds (g) and harvest index (%) was observed in P_1S_3 and P_2S_3 treatment combination respectively. In case of interaction effect of phosphorus and row spacing on days to 80% emergence, 80% flowering and 80% pod maturity of mungbean, different treatment combination produced identical result.

From the results of the study, it may be concluded that the performance of mungbean cv. BARI mung-6 was better in respect of growth, yield and yield components with application of phosphorus @ 48 kg ha^{-1} under a row spacing of 30 cm under conditions of the experiment. Further studies may be conducted at different agro-ecological zones of Bangladesh with different phosphorus levels and row spacings.

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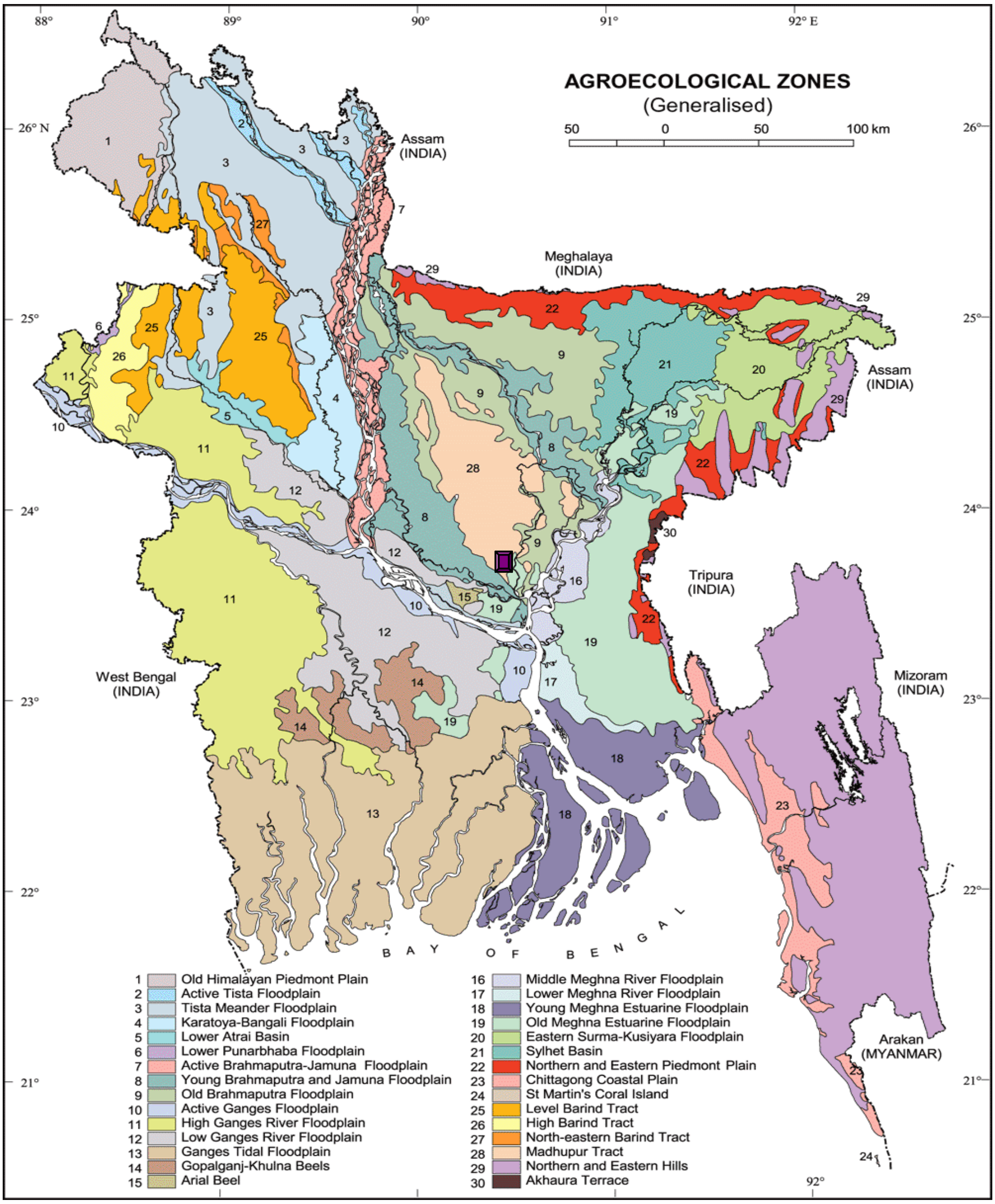
APPENDICES

Appendix I. Map showing the experimental site under the study



The experimental site under study

Appendix II: Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	**Characteristics**
Location	Agronomy research field, SAU, Dhaka.
AEZ	Madhupur Tract (28)
General soil type	Shallow red brown terrace soil
Land type	Medium high land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B . Mechanical analysis

Constituents	**Percentage (%)**
Sand	27
Silt	43
Clay	30

C. Chemical analysis

Soil Properties	**Amount**
Soil pH	5.8
Organic carbon (%)	0.45
Total Nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (%)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III. Analysis of variance of the data on plant height (cm) of mungbean as influenced by phosphorus under different row spacings

Source of variation	Degrees of freedom	Mean square of plant height				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.042	0.070	7.958	11.151	4.992
Factor(A): Phosphorus	3	0.567*	36.393*	55.483**	62.579**	65.990*
Error	6	0.449	5.365	3.546	3.952	10.900
Factor(B) : Row spacing	2	0.232	148.685**	212.680**	258.176**	269.706**
Interaction (A×B)	6	0.076	0.149	0.289	0.304	0.271
Error	16	0.305	13.418	21.308	24.181	24.319

**: Significant at 0.01 level of probability   *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on dry weight of mungbean as influenced by phosphorus under different row spacings

Source of variation	Degrees of freedom	Mean square of dry weight				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.012	0.024	0.118	0.030	1.098
Factor(A): Phosphorus	3	0.012	0.871*	8.222*	18.465*	25.684**
Error	6	0.007	0.219	1.181	4.307	3.428
Factor(B) : Row spacing	2	0.008	3.478**	33.567**	73.823**	104.991**
Interaction (A×B)	6	0.002	0.005	0.033	0.093	0.105
Error	16	0.009	0.336	3.472	8.316	13.740

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on days to 80% emergence, 80% flowering and 80% pod maturity of mungbean as influenced by phosphorus under different row spacings

Source of variation	Degrees of freedom	Mean square		
		80% emergence	80% flowering	80% pod maturity
Replication	2	0.111	0.333	0.861
Factor(A): Phosphorus	3	0.519*	3.074**	4.176**
Error	6	0.074	0.407	0.343
Factor(B): Row spacing	2	1.194**	0.083	3.528*
Interaction (A×B)	6	0.269	0.491	1.009
Error	16	0.167	0.347	0.972

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield and yield contributing attributes of mungbean as influenced by phosphorus under different row spacings

Source of variation	Degrees of freedom	Mean square							
		Pod plant^{-1}	Pod length	Seeds pod^{-1}	1000-seed weight	Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.003	0.069	0.605	0.002	0.001	0.000	0.043	3.683
Factor (A): Phosphorus	3	2.421*	1.217**	2.496**	8.002	0.271**	0.004**	1.095**	4.629
Error	6	0.354	0.129	0.297	2.886	0.008	0.009	0.075	6.215
Factor (B): Row spacing	2	9.810**	17.102**	15.626**	4.887	0.248**	0.379**	0.950**	7.693
Interaction (A×B)	6	0.013	0.132	0.056	1.152	0.001	0.001	0.049	6.827
Error	16	1.134	0.547	0.538	8.826	0.021	0.029	0.092	8.630

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability