INFLUENCE OF PHOSPHORUS AND POTASSIUM ON GROWTH AND YIELD OF MUNGBEAN (BARI Mung-6)

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CERTIFICATE

This is to certify that the thesis entitled, ***"INFLUENCE OF PHOSPHORUS AND POTASSIUM ON GROWTH AND YIELD OF MUNGBEAN (BARI Mung-6)"*** *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*** *in* ***SOIL SCIENCE,*** *embodies the result of a piece of bona fide research work carried out by* ***MD. JAHIDUL ISLAM****, Registration No.* ***07-02415*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:

Place: Dhaka, Bangladesh

(Prof. Mst. Afrose Jahan)

Supervisor

DEDICATED TO

MY BELOVED PARENTS

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INFLUENCE OF PHOSPHORUS AND POTASSIUM ON GROWTH AND YIELD OF MUNGBEAN (BARI Mung-6)

ABSTRACT

The experiment was conducted at the research plot of the department of Soil science of Sher-e-Bangla Agricultural University, Dhaka during the period from February, 2014 to June, 2014 to study the influence of phosphorus and potassium on growth and yield of mungbean. The experiment was designed with three phosphorus level viz. P_0 (0 kg P/ha), P_1 (15 kg P/ha), P_2 (20 kg P/ha) and three different potassium level viz. K_0 (0 kg K/ha), K_1 (15 kg K/ha) and K_2 (20 kg K/ha). The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications. Results showed that different phosphorus and potassium levels significantly differed the growth and yield contributing characters of mungbean. The maximum seed yield (1.65 t ha^{-1}) was recorded in 20 P kg ha^{-1} treatments. The maximum seed yield (1.56 t ha^{-1}) was obtained from 20 K kg ha^{-1} treatment. The highest seed yield (1.90 t ha^{-1}) was recorded with the treatment combination of 20 P kg ha^{-1} with 20 K kg ha^{-1}. On the other hand, the lowest seed yield (0.95 t ha^{-1}) was found in control treatment (no phosphorus and no potassium). The maximum N, P and K concentration in stover and soil was recorded in the 20 kg P/ha treatment. The maximum N, P and K concentration in stover and soil was recorded in the 20 kg K/ha treatment. The highest N, P and K concentration in stover and soil was recorded in 20 kg P/ha with 20 kg K/ha treatment combination. Mungbean yield was increased with increasing the P and K levels.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER 1

INTRODUCTION

Mungbean (*Vigna radiata* L.) is one of the leading pulse crop of Bangladesh. This commonly grown pulse crop belongs to the family leguminosae. Pulses are the main source of protein for the people, particularly for the poor section of Bangladesh and it is called the poor men's meat as it is the cheapest source of protein. But at present pulses are beyond the reach of the poor people because of its high price due to less production. In Bangladesh per capita consumption of pulses is only 14.72 g (BBS, 2012) as against 45.0 g recommended by World Health Organization. To maintain the supply of this level it is needed to import pulse and as a result the Government of Bangladesh has to spend a huge amount of foreign currency every year. So pulse production should be increased urgently to meet up the demand. Mungbean is considered as the best of all pulses from the nutritional point of view. It contains 51% carbohydrate, 26% protein, 4% minerals and 3% vitamins (Kaul, 1982). It holds the 3^{rd} in protein content and 4^{th} in both acreage productions in Bangladesh. It contains almost double amount of protein as compared to cereals. It has a good digestibility and flavor. The green plants are used as animal feed and the residues as manure. Life cycle of mungbean is short; it is also drought tolerant and can grow with a minimum supply of nutrients. In Bangladesh, mungbean grows well all over the country. Among the pulses, it ranks third in area and production but first in market price. The total production of mungbean in Bangladesh in 2011-12 was 19,972 metric tons from an area of 20,117 hectares with average yield is about 0.98 tons ha^{-1} (BBS, 2012).

Cultivation of pulses can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through biological nitrogen fixation from the atmosphere. Besides its stem and leaves are used in preparing a concentrate feed called "Bhushi" which is rich in protein. The husks of the seeds are also used as feed for milch cow. Its roots break the plough pan of puddled rice field and go deep in search of water and nutrients. Mungbean, and other pulse like cowpea and black gram are used as green manuring crop.

Bangladesh is a developing country. The land of our country is limited. But the population is very high. More people need more food. 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. So, at present the cultivation of pulse has gone to marginal land because farmers do not want to use their fertile land in pulse cultivation. Pulse cultivation is also decreasing because of its low yield & production. The long term cereal crop cultivation also effects soil fertility and productivity.

Fertilizer is one of the most important factors that affect crop production. Fertilizer recommendation for soils and crops is a dynamic process (Rafiqul Hoque *et al*., 2004; Singh and Kumar, 2009; Singh *et al*., 2013) and the management of fertilizers is one of the important factors that greatly affect the growth, development and yield of mungbean (Asaduzzaman *et al*., 2008).

The farmers of Bangladesh generally grow mungbean by one ploughing and hardly use phosphorus due to their poor socio-economic condition and lack of proper knowledge. As a result, yield becomes low. There is an ample scope for increasing the yield of mungbean with improved management practices and by using proper dose of fertilizer. Mungbean is highly responsive to phosphorus fertilizers. To fix nitrogen in soil, an adequate phosphorus supply must be satisfied for the legumes, other factors being adequate. As mungbean is a legume crop, it responds well to added phosphorus (Sarkar and Banik, 1991). Phosphorus plays a key role in plant physiological processes. It is needed for energy storage and release in the living cells. Phosphorus deficiency causes yield reduction by limiting the plant growth (Poehlman, 1991). Mungbean responds favourably to phosphorus fertilization (Chovati *et al.,* 1993).

Potassium application under drought moderates the adverse effects of water shortage on plant growth (Sangakkara *et al*., 2001; Singh and Kumar, 2009). Potassium is the third macronutrient required for plant growth, after nitrogen and phosphorus (Abbas *et al*., 2011) and also plays a vital role as macronutrient in plant growth and sustainable crop production (Baligar *et al*., 2001). Its adequate supply during growth period improves the water relations of plant and photosynthesis (Garg *et al*., 2005), maintains turgor pressure of cell which is necessary for cell expansion, helps in osmotic-regulation of plant cell, assists in opening and closing of stomata (Yang *et al.*, 2004), activates more than 60 enzymes (Bukhsh *et al*., 2011), synthesizes the protein, creates resistance against the pest attack and diseases (Arif *et al*., 2008) and enhances the mungbean yield (Ali *et al.*, 2010).

The deficit situation of mungbean production in our country can be overcome either by bringing more area under mungbean cultivation or by increasing the yield through improvement of production technology, such as optimizing the dose of N, P and K fertilizers.

In Bangladesh, many studies have been conducted on nutrient requirements of mungbean but reports are very few on the phosphorus and potassium requirement and on the combined effects of these elements on mungbean. The present study was therefore, undertaken with the following objectives.

1. To determine effects of phosphorus on the growth and yield of mungbean.
2. To determine effects of potassium on the growth and yield of mungbean.
3. To study the interaction effects of phosphorus and potassium on the growth and yield of mungbean.

CHAPTER II

REVIEW AND LITERATURE

Mungbean is one of the important pulse crop in Bangladesh as well as many countries of the world. The crop has conventional less concentration by the researcher on various aspects because normally it grows with less care and management practices. For that a very few studies releted to growth, yield and development of mungbean have been carried out of our country as well as many other countries of the world. So, the research so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the phosphorus and potassium so far been done at home and abroad on this crop have been reviewed in this chapter –

2.1 Effect of phosphorus on the growth and yield of mungbean

Growth and yield response of two mungbean (Mung-06 and NM-92) varieties to different application rates of potassium was evaluated under field condition. Plants were fertilized with five K (0, 50, 75, 100 and 125 kg ha^{-1}) levels. The data obtained from the study indicated that there was significant effect of potassium levels on growth, yield and yield components of both varieties. Compared to Mung-06, the variety NM-92 performed well by displaying maximum seed germination, taller plants with more branches, pods, seeds and biological yield. In addition to the recommended rates of nitrogen and phosphorus, the K applied @ 125 kg ha^{-1} significantly increased seed germination, plant height, number of branches per plant, number of pods, seed index and biological yield (kg ha^{-1}) as well. The difference between 125 and 100 kg K ha^{-1} rates for mjority of the growth and yield parameters under study remained non-significant. However, the plants given 75, 50 and 00 kg K ha^{-1} ranked 3rd, 4th and 5th, respectively for all the recorded yield parameters. It is, therefore, concluded that 100 kg K ha^{-1}can be the effective rate for achieving economically higher mungbean yield (Buriro *et al.*, 2015).

Barman *et al.* (2015) conducted 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 P2Zn2 (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.

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 grain per pod, weight of 1000 grain (gm), grain yield (t ha^{-1}) and Stover yield (t ha^{-1}) were counted in 20 kg ha^{-1}level of phosphorus, where as 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 grain yield.

Ali *et al*. (2014) conducted to the efficient supply of nutrients is important to ensure proficient crop production. 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 grains per pod, 1000-grain weight, straw yield and ultimately final crop yield of Mungban.

Parvez *et al.* (2013) conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from October to January 2011 to study the performance of mungbean as affected by variety and level of phosphorus. The experiment comprised four varieties viz. BARI Mung-6, Binamoog-4, Binamoog-6 and Binamoog-8 and four levels of phosphorus viz. 0, 20, 40 and 60 kg P_2O_5 ha^{-1}, and laid out in a Randomized Complete Block Design with three replications. Results revealed that the longest plant, highest number of branches $plant^{-1}$, number of total pods $plant^{-1}$, seeds $plant^{-1}$ and seed weight plant^{-1} was obtained from BARI Mung-6. The longest plant, highest number of branches plant^{-1}, number of total pods plant^{-1}, number of mature pods plant^{-1}, length of pod, seed weight plant^{-1}, 1000-seed weight, seed yield, stover yield and harvest index were obtained when 60 kg P_2O_5 was applied. Binamoog-6 produced the highest seed yield which was as good as Binamoog-8. The second highest and the lowest seed yield were recorded from Binamoog-4 and BARI Mung-6, respectively. The highest stover yield was obtained from Binamoog-8 followed by Binamoog-4. The lowest stover yield was recorded from BARI Mung-6. The highest seed yield was recorded when phosphorus was applied at the rate of 60 kg P_2O_5 ha^{-1}which was statistically identical to 40 kg P_2O_5 ha^{-1}. The intermediate and the lowest seed yield was obtained when phosphorus was applied at the rate of 20 kg P_2O_5 ha^{-1}and control treatment, respectively. The highest stover yield was obtained when 60 kg P_2O_5 ha^{-1}was applied but the lowest stover yield was recorded in control treatment (0 kg P_2O_5 ha^{-1}). The highest plant height, number of branches plant^{-1}, number of total pods plant^{-1} and seeds pod^{-1} were obtained from BARI Mung-6 in combination with 60 kg P_2O_5 ha^{-1}. The highest seed yield was obtained from Binamoog-6 when 60 kg P_2O_5 ha^{-1}was applied which was as good as Binamoog-8 in combination with 60 kg P_2O_5 ha^{-1} and the highest stover yield was recorded from Binamoog-8 with 60 kg P_2O_5 ha^{-1}. It can be concluded that mungbean variety Binamoog-6 or Binamoog-8 can be grown with higher dose of phosphorus (60 kg P_2O_5 ha^{-1}) for higher seed yield

Hussain *et al.* (2012) carried out at the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan during the year 2008 to evaluate the effect of phosphorus with and without rhizobium inoculation on mungbean crop. Four levels of P fertilizers (50% of recommended dose, recommended dose, 150% of recommended dose) were applied by using SSP @1.2, 2.4 and 3.6 g per 14 kg of soil, respectively. Layout system was 2 factorial completely randomized designs with six repeats. The results revealed that 150 percent of recommended P dose with rhizobium inoculation increased P concentration significantly in roots (0.113), shoots (0.223), grains (0.300) and P uptake (25.19 mg plant^{-1}). The same treatment also significantly increased nitrogen concentration in roots (1.74), shoots (1.79), grains (4.14) and N uptake (290.06 mg plant^{-1}). The results further showed that inoculation with rhizobium increased nitrogen fixation in mungbean crop. The combination of phosphorus and inoculation showed maximum positive effect on nitrogen and phosphorus concentration and their uptake by plants.

Rahman et al. (2008) conducted during *kharif* season, 2005 at Soil Science Division, Bangladesh Agricultural Research Institute to study the effect of phosphorus (P), molybdenum (Mo) and *Rhizobium* inoculation on the yield and yield contributing characters of mungbean (*Vigna radiata*) on a silty clay loam soil. The experiment was laid out in RCBD with four replications. Ten treatments were formulated with the combination of 4 levels of P (0, 20, 40, 60 kg ha^{-1}) and 2 levels of Mo (1.0, 1.5 kg ha^{-1}) having a common *Rhizobium* inoculant. P and Mo application at the rate of 40 and 1.0 kg ha^{-1} respectively, significantly increased yield and yield contributing characters of mungbean compared to uninoculated and control. Highest stover (26.67 g $plant^{-1}$) and grain yield (14.61 g $plant^{-1}$) were obtained with P (40 kg ha^{-1}), Mo (1.0 kg ha^{-1}) and *Rhizobium* inoculation. Above these levels of P and Mo decreased yield and yield contributing characters. Dry weight of plant tops, seed yield $plant^{-1}$ and yield-contributing characters were positively correlated with the number of nodules $plant^{-1}$. Combined application of *Rhizobium* inoculants along with 40 kg P and 1.0 kg Mo ha^{-1} was considered to be the suitable combination of fertilizer for mungbean cultivation in silty clay loam soils.

2.2 Effect of potassium on the growth and yield of mungbean

Biswash *et al*. (2014) conducted from February to April, 2013 at the experimental field of the farm of Sher-e-Bangla Agricultural University to study the effect of potassium fertilizer and vermicompost on growth, yield and nutrient contents of mungbean (BARI Mung 5). The two-factorial experiment was conducted by using RCBD (Randomized Completely Block Design) with three replications. During the experiment, following treatments were included: K0 - Control, K_1-K_2O @ 10 kg ha^{-1}, K_2- K_2O @15 kg ha^{-1}, K_3 - K_2O @ 20 kg ha^{-1} and V_0- No Vermicompost, V_1- Vermicompost @ 4 t ha^{-1}, V_2- Vermicompost @ 6 t ha^{-1}, V_3 – Vermicompost @ 8 t ha^{-1}. Potassium and vermicompost doses as well as their interactions showed significant effect on growth and yield parameters. At harvest highest plant height, number of leaves and branches $plant^{-1}$, average dry weight plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1}, 1000-seed weight, seed yield and stover yield were recorded in K_3 (K_2O @ 20 kg ha^{-1}) and it was either closely followed by or statistically similar with the application of K_2O @15 kg ha^{-1} (K_2) and subsequently followed by K_1 (K_2O @ 10 kg ha^{-1}). N, P and K content in seed were recorded in K_3 (K_2O @ 20 kg ha^{-1}) and it was followed by the application of K_2O @15 kg ha^{-1} (K_2) and then K^{-1} (K_2O @ 10 kg ha^{-1}). Lowest results for above parameters were found from the treatment using no potassium fertilizer (K_0). Similarly, the highest values for highest plant height, number of leaves and branches plant^{-1}, average dry weight plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, number of seeds plant^{-1}, 1000-seed weight, seed yield and stover yield were recorded in V_3 (vermicompost @ 8 t ha^{-1}) which was either closely followed by or statistically similar with Vermicompost @ 6 t ha^{-1}and then followed by Vermicompost @ 4 t ha^{-1}. Lowest results were found from the treatment using no vermicompost (V_0).

Fooladivanda *et al*. (2014) conducted to evaluate the impact of water stress and levels of potassium on yield and yield components of two varieties of mung bean (*Vigna radiata)* (promising lines VC6172 and Indian), an experiment in the form of split factorial, based on randomized complete block design with three replicates was conducted in 2011, at the research farm of Safi-Abad Dezfool, Iran (latitude 32016' N, longitude 48026' E and altitude 82.9 m above sea level) .Water stress in three levels: irrigation at 120 (no stress), 180 (moderate stress) and 240 (severe stress) mm evaporation from pan, were allocated to the main plots and potassium fertilizer at three levels (0, 90, 180 kg ha^{-1}) and two varieties of mung bean (promising line VC6172 and Indian) were allotted to the sub-plots. Results showed that water stress and potassium fertilizer significantly affect all traits. The highest grain yield (2093 kg ha^{-1}) was obtained from no stress treatment in the case of 180 kg ha^{-1} potassium. Total dry matter, number of pods and grain yield, were significantly different between the two varieties. The interaction between fertilizer and variety, on dry matter and grain yield and the interaction between irrigation and variety, on dry matter were significant. We conclude that use of potassium fertilizer can reduce the adverse effects of water stress.

Kumar *et al.* (2014) conducted to study the effect of different potassium levels on mungbean under custard apple based agri-horti system at Agricultural Research Farm of Rajiv Gandhi South Campus, Barkachha, Mirzapur. The experiment was conducted in a complete randomized block design with seven treatments which were replicated thrice. These treatments were different doses of potassium, that is, 0 kg ha^{-1} (T_1), 20 kg ha^{-1} (T_2), 40 kg ha^{-1} (T_3), 60 kg ha^{-1} (T_4), 80 kg ha^{-1} (T_5), 100 kg ha^{-1} (T_6) and 120 kg ha^{-1} (T_7). Potassium application is directly related to growth, plant biomass and yield in crops. Results showed that application of different potassium levels gave varying yield. Lowest yield (700 kg ha^{-1}) was obtained with the application of 0 kg $ha^{-1}$and highest yield (1096 kg ha^{-1}) was obtained with the application of 120 kg ha^{-1}potassium. It is concluded that the application of 80 kg ha^{-1} potassium gave highest Benefit/Cost ratio of mungbean and looks more remunerative in *Vindhyan* region.

Hussain *et al*. (2011) carried out at experimental area of Department of Agronomy, University of Agriculture, Faisalabad during summer 2005. The objective was to find out the best level of potash fertilizer on growth and yield response of two mungbean **(***Vigna radiata* **L.)** cultivars (Niab Mung-92 and Chakwal Mung-06) to different levels of potassium. The experiment was laid out in Randomized Complete Block Design with factorial arrangements and replicated thrice. Treatments were comprised of five levels of potash fertilizer (0, 30, 60, 90,120 Kg ha^{-1}). Different potassium levels significantly affected the seed yield and yield contributing parameters except number of plants per plot. Maximum seed yield (753 Kg ha^{-1}) was obtained with the application of 90 Kg potash per hectare. Genotype M-06 produced higher seed yield than that of NM-92. The interactive effect of Mungbean varieties and Potassium level was found significant in parameter of protein contents (%). Maximum protein contents were observed in case of Mung-06 with application of 90 Kg potash per hectare. It is concluded that the application of Potash fertilizer gave higher yield of mungbean cultivars under agro-climatic conditions of Faisalabad.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the research plot of the department of Soil Science of Sher-e-Bangla Agricultural University, Dhaka, during the period from February, 2014 to June, 2014 to study influence of Phosphorus and Potassium on growth and yield of mungbean. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Description of the experimental site

3.1.1 Site and soil

Geographically the experimental field was located at 23^0 77′ latitude and 88^0 33′E longitudes at an altitude of 9 m above the mean sea level. The soil is belonged to the Agro ecological Zone Modhupur Tract (AEZ 28). The land topography was medium high and soil texture was silt clay with pH 5.56. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-1.

3.1.2 Climate and weather

The climate of the locality is subtropical which is characterized by medium high temperature and heavy rainfall during *Kharif* season (April-September) and scanty rainfall during *Rabi* season (October-March) associated with moderately low temperature.

3.2 Plant materials

BARI mung-6:

BARI mung-6 was used as the planting material. BARI mung-6 was released and developed by Bangladesh Agricultural Research Institute, Joydebur, Gazipur in 2003. Plant height of the cultivar ranges from 40 to 45 cm. It is resistant to cercospora leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 55 to 58 days after emergence. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1800 kg ha^{-1}. The seeds of BARI mung-6 for the experiment were collected from BARI, Joydepur, Gazipur. The seeds were large shaped, deep green and free from mixture of other seeds, weed seeds and extraneous materials.

3.3 Treatments under investigation

There was two factors in the experiment namely phosphorus and potassium levels as mentioned below:

Factor-A: 3 levels of Phosphorus

P_0 = 0 kg P ha^{-1}

P_1 = 15 kg P ha^{-1}

P_2 = 20 kg ha^{-1}

Factor-A: 3 level of Potassium

K_0 = 0 kg K ha^{-1}

K_1 = 15 kg K ha^{-1}

K_2 = 20 kg K ha^{-1}

3.4 Experimental design and layout

The experiment was laid out in a two factors randomized complete block design (RCBD) design having three replications. Each replication had 7 unit plots to which the treatment combinations were assigned randomly. The unit plot size was 3 m^2 (1m ×3m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing respectively.

3.5 Land preparation

The experimental land was opened with a power tiller on 27 February, 2014. Ploughing and cross ploughing were done with country plough followed by laddering. Land preparation was completed on 8^{th} March, 2014 and was ready for sowing of seeds.

3.6 Fertilizer application

The fertilizers were applied as basal dose at final land preparation where N, Ca and S were applied @ 20.27 kg ha^{-1}, 3.3 kg ha^{-1} and 1.8 kg ha^{-1} respectively in all plots. Phosphorus and potassium were applied as per treatment. All fertilizers were applied by broadcasting and mixed thoroughly with soil (Afzal *et al.* 2003).

3.7 Sowing of seeds

Seeds were sown at the rate of 45 kg ha^{-1} in the furrow on March 08, 2014 and the furrows were covered with the soils soon after seeding.

3.8 Intercultural operations

3.8.1 Weed control

Weeding was done once in all the unit plots with care so as to maintain a uniform plant population as per treatment in each plot at 15 DAS.

3.8.2 Thinning

Thinning was done at 20 days after sowing (DAS) and 35 DAS. Plant to plant distance was maintained at 10 cm.

3.8.3 Irrigation and drainage

Pre sowing irrigation was given to ensure the maximum germination percentage. During the whole experimental period, there was a shortage of rainfall in earlier part; however, it was heavier in later one. So it was essential to remove the excess water from the field at later period.

3.8.4 Insect and pest control

Hairy caterpillar was successfully controlled by the application of Malathion 57 EC @ 1.5 L ha^{-1} on the time of 50% pod formation stage (55 DAS).

3.9 Determination of maturity

At the time when 80% of the pods turned brown colour, the crop was considered to attain maturity.

3.10 Harvesting and sampling

The crop was harvested from prefixed 1.0 m^2 areas. Before harvesting ten plants were selected randomly from each plot and were uprooted for data recording. The rest of the plants of prefixed 1 m^2 area were harvested plot wise and were bundled separately, tagged and brought to the threshing floor.

3.11 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.

3.12 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.

3.13 Recording of characters

I. Plant height (cm)

The height of the selected plant was measured from the ground level to the tip of the plant at 30, 50, and 70 days after sowing.

II. Number of leaves per plant

Number of leaves per plant was counted from each selected plant sample and then averaged at 30, 50, and 70 days after sowing.

III. Number of branches per plant

Number of branches per plant was counted from each selected plant sample and then averaged.

IV. Number of pods per plant

Number of pod per plant was counted from each selected plant sample.

V. Number of seeds per pod

Number of seed per pod from 10 randomly selected pods from each plot were counted and averaged.

VI. Pod length (cm)

Pod length was measured in centimeter (cm) scale from randomly selected ten pods. Mean value of them was recorded as treatment wise.

VII. 1000 seed weight (g)

A composite sample was taken from the yield of ten plants. The 1000-seeds of each plot were counted and weighed with a digital electric balance. The 1000-seed weight was recorded in (g).

VIII. Seed yield per 1 m^2 (g)

Seed yield was recorded on the basis of total harvested seeds per 1 m^2 and was expressed in terms of yield (g). Seed yield was adjusted to 12% moisture content.

IX. Seed yield (kg ha^{-1})

Seed yield was recorded on the basis of total harvested seeds per 1m^2 and was expressed in terms of yield (kg ha^{-1}). Seed yield was adjusted to 12% moisture content.

3.14 Chemical analysis of plant samples

3.14.1 Collection and preparation of plant samples

Stover samples were collected after threshing for N, P and K analyses. The plant samples were dried in an oven at 70 ^{0}C for 72 hours and then ground by a grinding machine (wiley-mill) to pass through a 20-mesh sieve. The samples were stored in plastic vial for analyses of N, P and K. The stover samples were analyzed for determination of N, P and K concentrations. The methods were as follows:

3.14.2 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.5 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml conc. H_2SO_4 were added. The flasks were heated at 160^0 C and added 2 ml 30% H_2O_2 then heating was continued at 360^0 C until the digests become clear and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

3.14.3 Digestion of plant samples with nitric-perchloric acid for P and K

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest by using different standard methods.

3.14.4 Determination of P and K from plant samples

3.14.4.1 Phosphorus

Plant samples (stover) were digested by diacid (Nitric acid and Perchloric acid) mixture and P content in the digest was measured by blue color development (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 5 ml for stover sample from 50 ml digest by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al*., 1982).

3.14.4.2 Potassium

One milli-liter of digest sample for the stover was taken and diluted 20 ml volume to make desired concentration so that the flame photometer reading of samples were measured within the range of standard solutions. The concentrations were measured by using standard curves.

3.15 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P and K contents. The soil samples were analyzed by the following standard methods as follows:

3.15.1 Textural class

Mechanical analysis of soil were done by hydrometer method (Bouyoucos, 1926) and the textural class was determined by plotting the values of % sand, %

silt and % clay to the Marshall's textural triangular co-ordinate following the USDA system.

3.15.2 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1962).

3.15.3 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.15.4 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml H_2SO_4 were added. The flasks were swirled and heated 160 ^{0}C and added 2 ml H_2O_2 and then heating at 360 ^{0}C was continued until the digest was clear and colorless. After cooling, the content was taken into 50 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al*., 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water.

Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink.

The amount of N was calculated using the following formula:

$$\% \text{ N} = \frac{(\text{T}-\text{B}) \times \text{N} \times 0.014 \times 100}{\text{S}}$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.15.5 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated the standard P curve (Page *et al*. 1982).

3.15.6 Available potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al*. 1982).

3.16 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test (Gomez & Gomez, 1986).

Chapter 4

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 three levels of phosphorus and three levels of potassium and their interaction effects on vegetative growth and yield of mungbean. The growth and yield components such as plant height, leaf number, pod length, and yield of mungbean as influenced by phosphorus and potassium are presented in Table and Figures. 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)

The effects of phosphorus on the plant height of mungbean are presented in (Fig. 1). The plant height was significantly influenced by different levels of phosphorus at different days after sowing (DAS). Among the different doses of phosphorus, P_2 (20 kg/ha) showed the highest plant height (23.37, 38.54 and 54.54cm at 30, 50 and 70 DAS, respectively). On the other hand, the lowest plant height (19.59, 29.23 and 44.19 cm at 30, 50 and 70 DAS, respectively) was observed in the P_0 treatment where no phosphorus was applied. The taller plants at the highest doses received more nutrients which might have encouraged more vegetative growth.

Potassium showed statistically significant variation in respect of plant height when fertilizers in different doses were applied (Fig. 2). However among the different doses of fertilizer, K_2 (20 kg/ha) showed the highest plant height (23.74, 38.55 and 53.43 cm at 30, 50 and 70 DAS, respectively). The lowest plant height (18.30, 28.50 and 47.09 cm at 30, 50 and 70 DAS, respectively) was observed in the K_0 treatment where no Potassium was applied.

Combined application of different doses of phosphorus and potassium had significant effect on the plant height of mungbean (Table 1). The lowest plant height (15.44, 25.22 and 40.30 cm at 30, 50 and 70 DAS, respectively) was observed in the treatment combination of P_0K_0 (no phosphorus and no potassium). On the other hand, the highest plant height (25.22, 43.04 and 58.07 cm at 30, 50 and 70 DAS, respectively) was recorded with P_2K_2 treatment.

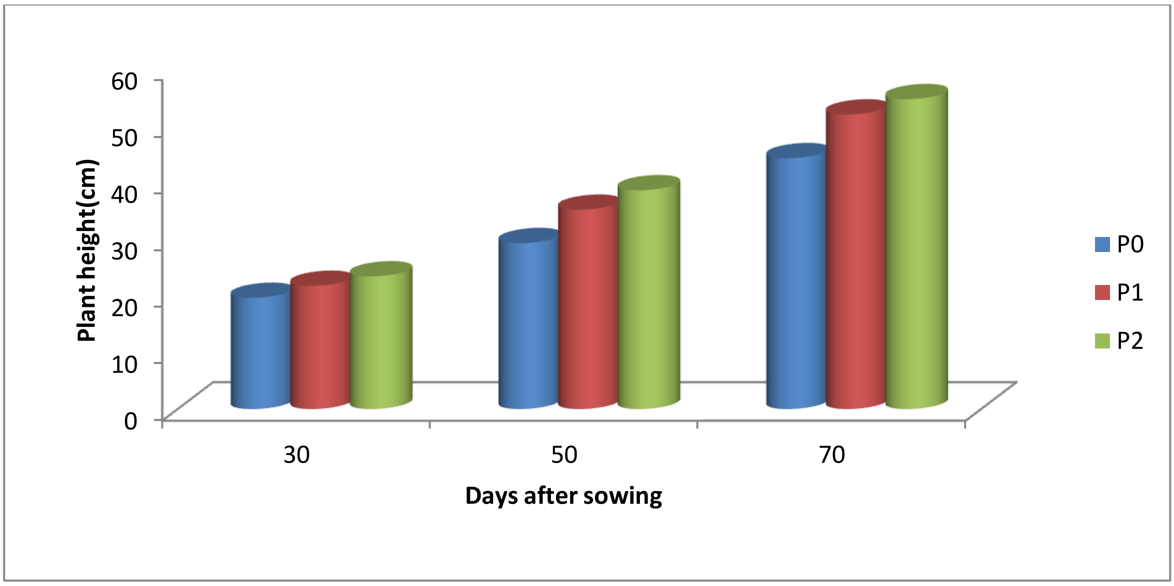

Fig.1. Effect of different levels of phosphorus on plant height of BARI mung-6

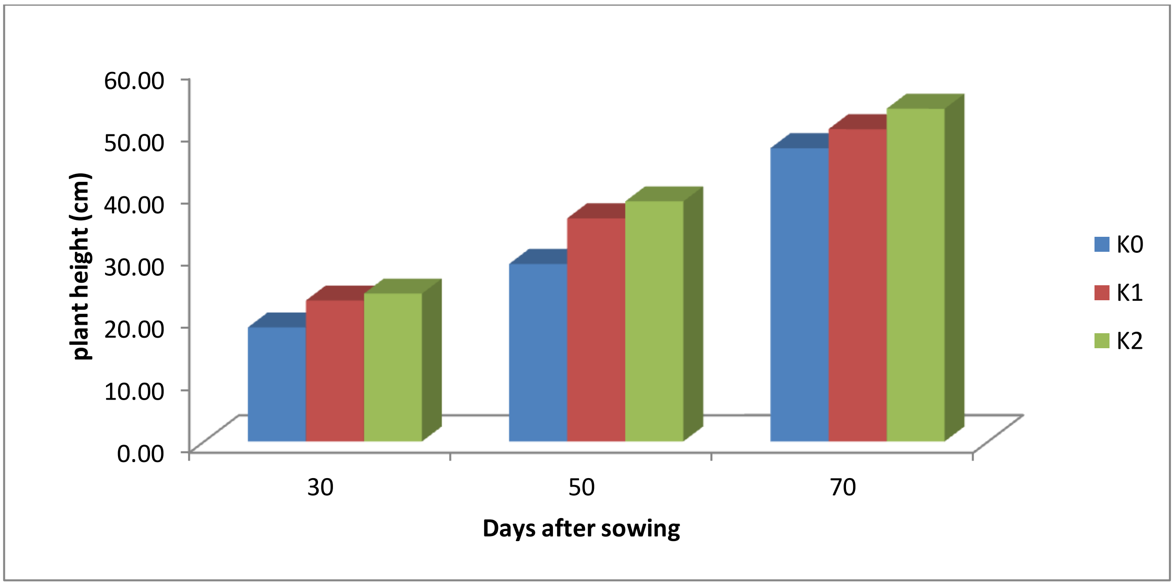

Fig.2. Effect of different level of potassium on plant height of BARI mung-6

Table 1. Combined effects of phosphorus and potassium on plant height of BARI mung-6

Treatment	Plant height(cm)		
	30 DAS	50 DAS	70 DAS
P_0K_0	15.44 e	25.22 f	40.30 f
P_0K_1	21.06 cd	29.92 de	43.50 e
P_0K_2	22.28 bc	32.55 d	48.77 d
P_1K_0	18.89 d	28.27 e	50.39 cd
P_1K_1	22.50 bc	37.01 c	51.83 cd
P_1K_2	23.73 ab	40.06 b	53.45 bc
P_2K_0	20.56 cd	32.01 d	50.59 cd
P_2K_1	24.34 ab	40.57 ab	55.11 b
P_2K_2	25.22 a	43.04 a	58.07 a
$LSD_{(0.05)}$	2.109	2.719	2.903
CV (%)	5.65	5.34	5.95

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

4.2 Number of leaf plant^{-1}

Significant variation was observed in number of leaf plant^{-1} of mungbean when different doses of phosphorus were applied at different days after sowing (Fig. 3). The highest number of leaf plant^{-1} (10.33, 19.16, 29.78 at 30, 50 and 70 DAS, respectively) was recorded in P_2 (20 kg ha^{-1}). The lowest number of leaf plant^{-1} (7.37, 14.98, and 21.82 at 30, 50 and 70 DAS, respectively) was recorded in the control treatment where no phosphorus was applied. The results clearly indicated that the number of leaves per plant gradually increased with the increasing levels of phosphorus but their variation was significant.

Significant variation was observed in number of leaf plant^{-1} of mungbean when different doses of potassium were applied (Fig. 4). Among the different doses of K_2 fertilizers treatment, showed the highest number of leaf plant^{-1} (10.07, 18.56 and 22.96 at 30, 50 and 70 DAS, respectively). On the contrary, the lowest number of leaf plant^{-1} (7.81, 15.61, and 22.96 at 30, 50 and 70 DAS, respectively) was observed with $K_{0,}$ where no fertilizer was applied.

The combined effect of different doses of phosphorus and potassium fertilizer on number of leaf plant^{-1} of mungbean was significant at different days after sowing (Table 2). The highest leaf plant^{-1} (11.33, 21.33, and 33.67 at 30, 50 and 70 DAS, respectively) was recorded with the treatment combination of P_2K_2. On the other hand, the lowest number of leaf plant^{-1} (3.33) was found in P_0K_0 treatment (no phosphorus and no potassium).

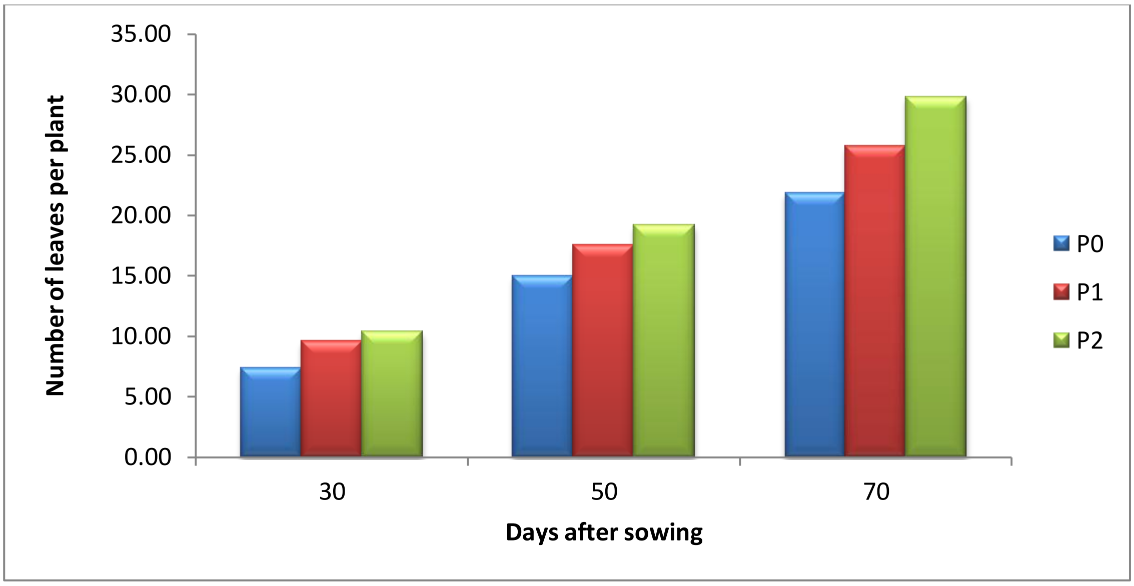

Fig. 3. Effect of phosphorus on number of leaf per plant of BARI mung-6

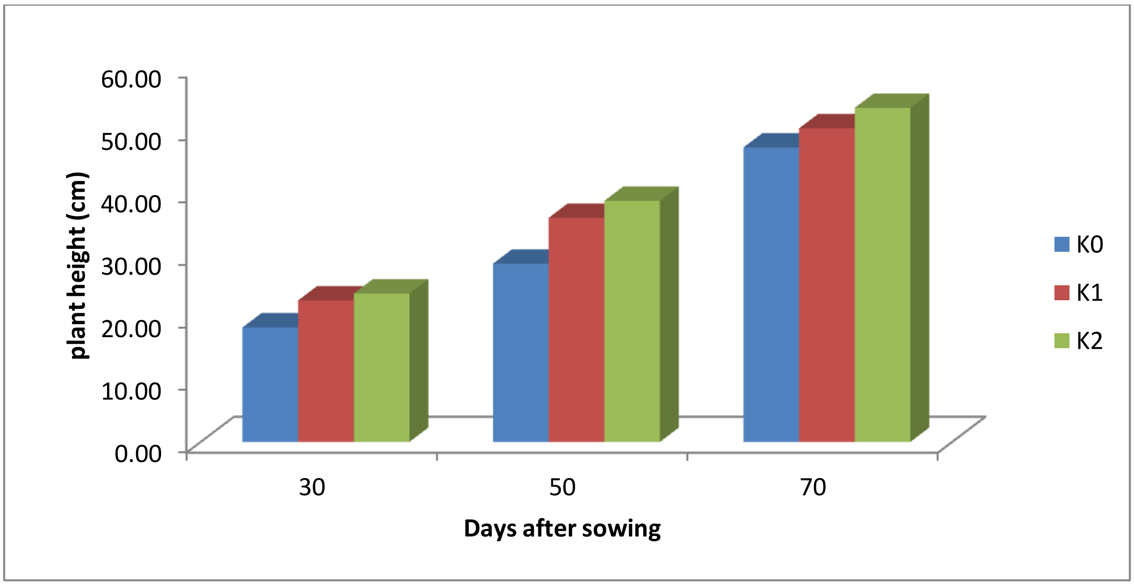

Fig. 4. Effect of different level of potassium on number of leaf per plant of BARI mung-6

Table 2. Combined effects of phosphorus and potassium on number of leaves per plant of BARI mung-6

Treatment	Number of leaves per plant		
	30DAS	50DAS	70DAS
P_0K_0	5.83 e	13.11 e	19.00 e
P_0K_1	7.61 d	15.67 d	22.67 d
P_0K_2	8.67 c	16.17 cd	23.78 cd
P_1K_0	8.50 c	16.67 cd	24.33 cd
P_1K_1	10.00 b	17.67 bcd	25.67 cd
P_1K_2	10.22 b	18.17 bc	27.00 c
P_2K_0	9.11 c	17.06 cd	25.56 cd
P_2K_1	10.56 b	19.09 b	30.11 b
P_2K_2	11.33 a	21.33 a	33.67 a
LSD $_{(0.05)}$	0.62	1.84	3.04
CV (%)	6.18	4.58	5.34

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

4.3 Number of branches per plant

The number of branch per plant as affected by different doses of phosphorus showed a statistically significant variation (Table. 3). Among the different doses of phosphorus the highest number of branch per plant (3.04) was observed in P_2 (20 kg/ha), which was statistically identical (2.48) with N_1 (15 kg ha^{-1}). On the other hand, the lowest number of branch per plant (1.66 cm) was recorded in the P_0 treatment where no phosphorus was applied.

Application of potassium fertilizer at different doses not showed significant variation on the number of branch per plant of mungbean (Table. 4). Among the different fertilizer doses K_2 treatment, showed the highest number of branch per plant (2.64), which was closely followed (2.46) by the fertilizer dose of K_2. On the other hand, the lowest number of branch per plant (2.09) was recorded with K_0 treatment where no potash was applied. Optimum fertilizer doses might be increased the vegetative growth of mungbean that lead to the highest number of branch per plant.

Combined effects of different doses of phosphorus and potassium fertilizers on number of branch per plant showed a statistically significant variation (Table 5). The highest number of branch per plant (3.30) was recorded in the treatment combination of P_2K_2, which was statistically identical with $P_2K_{1.}$ On the other hand, the lowest number of branch per plant (1.24) was found in P_0K_0.

Table 3. Effect of phosphorus on number of branches, number of pods per plant and number of seeds per pod of BARI mung-6

Treatments	Number of branches per plant	Number of pods per plant	Number of seeds per pod
P_0	1.664 b	14.46 c	8.884 b
P_1	2.483 a	17.5 b	10.63 ab
P_2	3.043 a	20.17 a	12.02 a
LSD $_{(0.05)}$	0.685	2.479	2.125
CV (%)	5.95	6.18	6.82

Table 4. Effect of different levels of potassium on number of branches, number of pods per plant and number of seeds per pod of BARI mung-6

Treatments	Number of branches per plant	Number of pods per plant	Number of seeds per pod
K_0	2.09 a	15.77 c	9.15 b
K_1	2.46 a	17.49 b	10.84 a
K_2	2.64 a	18.87 a	11.54 a
LSD $_{(0.05)}$	NS	0.53	0.90
CV (%)	5.95	6.18	6.82

Table 5. Combined effects of phosphorus and potassium on number of branches, number of pods per plant and number of seeds per pod of BARI mung-6

Treatments	Number of branches per plant	Number of pods per plant	Number of seeds per pod
P_0K_0	1.24 g	12.47 i	6.79 h
P_0K_1	1.76 f	15.06 h	9.44 g
P_0K_2	2.00 e	15.83 g	10.42 e
P_1K_0	2.31 d	16.17 f	10.02 f
P_1K_1	2.51 c	17.22 e	10.81 d
P_1K_2	2.63 bc	19.11 c	11.05 c
P_2K_0	2.73 b	18.66 d	10.64 de
P_2K_1	3.11 a	20.18 b	12.26 b
P_2K_2	3.30 a	21.68 a	13.15 a
$LSD_{(0.05)}$	0.19	0.26	0.23
CV (%)	5.95	6.18	6.82

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

4.4 Number of pods per plant

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 (Table.3). The maximum number of pod per plant (20.17) was observed from P_2 (20 kg/ha). The control plants produced the minimum number of pod per plant (14.46).

Number of pod per plant showed significant variation due to the effects of different levels of potassium (Table. 4).The highest number of pod per plant(18.87) was obtained from the grown with the dose of K_2 (20 kg/ha. The lowest number of pod per plant (15.77) was found when the plants were raised without potassium..

The combined effect of different doses of phosphorus and potassium fertilizer showed a statistically significant effect on number of pod per plant of mungbean (Table 5). The highest number of pod per plant (21.68) was recorded with the treatment combination of P_2K_2. On the other hand, the minimum number of pod per plant (12.47) was observed from P_0K_0 treatment (no phosphorus and no potassium).

4.5 Number of seeds per pod

There was significant variation in the number of seed per pod in mungbean when different doses of phosphorus fertilizer were applied (Table. 3). The highest number of seed per pod (12.02) was recorded in P_2 treatment. The lowest number of seed per pod (8.88) was recorded in the P_0 treatment where no phosphorus fertilizer was applied.

Application of potassium fertilizer at different doses showed significant variation on number of seed per pod (table. 4). Among the different fertilizer doses K_2 treatment showed the highest number of seed per pod (11.54). The lowest number of seed per pod (9.15) was recorded with K_0 treatment where no potash was applied. Optimum fertilizer doses might be increased the vegetative growth and development of mungbean that lead to the highest number of seed per pod.

The combined effect of different doses of phosphorus and potassium fertilizer on the number of seed per pod was significant (Table 5). However, the highest number of seed per pod (13.15) was recorded with the treatment combination of P_2K_2. On the other hand, the lowest number of seed per pod (6.79) was found in P_0K_0 treatments.

4.6 Pod length (cm)

There was significant variation in pod length in mungbean when different doses of phosphorus fertilizer were applied (Table. 6). The highest pod length (9.60 cm) was recorded in P_2 treatment. The lowest pod length (6.32 cm) was recorded in the P_0 treatment where no phosphorus fertilizer was applied.

Application of potassium fertilizer at different doses showed no significant variation on pod length (Table 7). Among the different fertilizer doses K_2 treatment showed the highest pod length (8.80 cm). The lowest pod length (6.95) was recorded with K_0 treatment where no potash was applied.

The combined effect of different doses of phosphorus and potassium fertilizer on the pod length was significant (Table 8). However, the highest pod length (10.75 cm) was recorded with the treatment combination of P_2K_2. On the other hand, the lowest pod length (5.51 cm) was found in P_0K_0 treatments.

4.7 Thousand seed weight (g)

There was significant variation in thousand seed weight in mungbean when different doses of phosphorus fertilizer were applied (Table 6). The highest thousand seed weight (43.80 g) was recorded in P_2 treatment. The lowest thousand seed weight (38.96g) was recorded in the P_0 treatment where no phosphorus fertilizer was applied.

Application of potassium fertilizer at different doses showed significant variation on thousand seed weight (Table 7). Among the different fertilizer doses K_2 treatment showed the highest thousand seed weight (43.31 g). The lowest thousand seed weight (39.86) was recorded with K_0 treatment where no potash was applied.

The combined effect of different doses of phosphorus and potassium fertilizer on the thousand seed weight was significant (Table 8). However, the highest thousand seed weight (45.68 g) was recorded with the treatment combination of P_2K_2. On the other hand, the lowest thousand seed weight (37.15) was found in P_0K_0 treatments.

Table 6. Effect of phosphorus on yield and yield contributing character of BARI mung-6

Treatments	Pod length (cm)	Thousand seed weight (g)	Seed yield (t ha^{-1})
P_0	6.32 b	38.96 c	1.10 b
P_1	7.74 b	41.73 b	1.39 ab
P_2	9.60 a	43.8 a	1.65 a
LSD $_{(0.05)}$	1.43	0.84	0.31
CV (%)	5.00	5.88	6.00

Table 7. Effect of phosphorus on yield and yield contributing character of BARI mung-6

Treatments	Pod length (cm)	Thousand seed weight (g)	Seed yield (t ha^{-1})
K_0	6.95 a	39.86 c	1.21 b
K_1	7.91 a	41.32 b	1.36 ab
K_2	8.80 a	43.31 a	1.56 a
LSD $_{(0.05)}$	NS	0.76	0.29
CV (%)	5.00	5.88	6.00

Table 8. Combined effect of different levels of phosphorus and potassium on yield and yield contributing character of BARI mung-6

Treatment	Pod length (cm)	Thousand seed weight (g)	Seed yield (t ha^{-1})
P_0K_0	5.51 i	37.15 h	0.95 h
P_0K_1	6.27 h	38.02 g	1.11 g
P_0K_2	7.18 g	41.70 e	1.24 f
P_1K_0	7.34 f	40.34 f	1.25 f
P_1K_1	7.42 e	42.28 cd	1.36 e
P_1K_2	8.46 c	42.57 c	1.55 c
P_2K_0	8.00 d	42.07 d	1.44 d
P_2K_1	10.06 b	43.66 b	1.61 b
P_2K_2	10.75 a	45.68 a	1.90 a
$LSD_{(0.05)}$	0.08	0.38	0.06
CV (%)	5.00	5.88	6.00

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

4.8 Seed yield (t ha^{-1})

Significant variation was observed on the seed yield of mungbean when different doses of phosphorus fertilizer were applied (Table. 6). The highest seed yield (1.65 t ha^{-1}) was recorded in P_2 (20 kg ha^{-1}) treatment. The lowest seed yield (1.10 t ha^{-1}) was recorded in the P_0 treatment where no fertilizer was applied.

The results of the single effects of different levels of potassium have been shown in (Table 7). From the table it was apparent that K_2 (20 kg ha^{-1}) treatment gave the highest yield (1.56 t ha^{-1}). On the contrary, the lowest seed yield (1.21 t ha^{-1}) was observed with $K_{0,}$ where no potash was applied.

The combined effect of different doses of phosphorus and potassium fertilizer on the seed yield of mungbean was significant (Table 8). The highest seed yield (1.90 t ha^{-1}) was recorded with the treatment combination of $P_2K_{2.}$ On the other hand, the lowest seed yield (0.95 t ha^{-1}) was found in P_0K_0 treatment (no phosphorus and no potassium).

4.9 Nitrogen concentrations in stover of mungbean

N concentration of stover was not significant influenced by the application of different levels of phosphorus (Table 9). The highest N concentration in mungbean stover (0.75 %) was recorded in P_2 (20 kg ha^{-1}), which showed similar result with P_1 (15 kg ha^{-1}) treatment. On the other hand, the lowest Nitrogen concentration in mungbean stover (0.63 %) was recorded in P_0 treatment where no phosphorus was applied.

N concentration of stover was significantly influenced by application of different levels of potassium (Table 10). The highest N concentration in mungbean stover (0.80 %) was recorded in K_2 (20 kg ha^{-1}). On the other hand, the lowest N concentration in mungbean stover (0.60 %) was recorded in K_0 treatment where no potassium was applied.

Significant effect was observed in combined application of different doses of phosphorus and potassium fertilizer on the nitrogen concentration in stover of mungbean (Table 11). The highest concentration of N in the stover (0.63 %) was recorded in the treatment combination of $P_2K_{2.}$ On the other hand, the lowest N concentration (0.53 %) in Stover was found in $P_0K_{0.}$

Table 9. Effect of phosphorus fertilizer on the nitrogen, phosphorus and potassium concentrations in stover of BARI mung-6

Treatments	Stover		
	N (%)	P (%)	K (%)
P_0	0.63 b	0.40 b	0.80 c
P_1	0.72 a	0.56 a	1.13 b
P_2	0.75 a	0.59 a	1.41 a
LSD $_{(0.05)}$	0.19	0.11	0.16
CV (%)	6.88	7.69	6.59

Table 10. Effect of potassium fertilizer on the nitrogen, phosphorus and potassium concentrations in stover of BARI mung-6

Treatments	Stover		
	N (%)	P (%)	K (%)
K_0	0.60 b	0.42 b	1.01 b
K_1	0.70 ab	0.53 ab	1.12 ab
K_2	0.80 a	0.59 a	1.22 a
LSD $_{(0.05)}$	0.16	0.16	0.19
CV (%)	6.88	7.69	6.59

Table 11. Combined effect of phosphorus and potassium fertilizer on nitrogen, phosphorus and potassium concentrations in stover of BARI mung-6

Treatments	Stover		
	N (%)	P (%)	K (%)
P_0K_0	0.53 d	0.31 e	0.61 f
P_0K_1	0.61 c	0.43 d	0.86 e
P_0K_2	0.76 ab	0.45 cd	0.93 de
P_1K_0	0.64 c	0.48 bcd	1.07 cd
P_1K_1	0.77 ab	0.58 abc	1.09 c
P_1K_2	0.81 a	0.62 a	1.24 b
P_2K_0	0.63 c	0.49 bcd	1.36 ab
P_2K_1	0.72 b	0.59 ab	1.40 a
P_2K_2	0.83 a	0.68 a	1.47 a
$LSD_{(0.05)}$	0.08	0.12	0.13
CV (%)	6.88	7.69	6.59

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

4.10 Phosphorus concentration in stover of mungbean

The effect of different doses of phosphorus fertilizer showed a statistically significant variation in the phosphorus concentration in stover (Table 9) of mungbean. Among the different doses of phosphorus fertilizer, P_2 (20 kg ha^{-1}) treatment showed the highest phosphorus concentration (0.59 %) in stover. The lowest value was 0.40 % under control treatment and N_0.

The effect of different doses of potassium fertilizer showed a statistically significant variation in the phosphorus concentration stover (Table 10) of mungbean. The highest total P content (0.59 %) was observed in K_2 (20 kg ha^{-1}) treatment. The lowest value of P (0.42 %) was observed under control (K_0) treatment.

Significant effect of combined application of different doses of phosphorus and potassium fertilizer on the phosphorus concentration was observed in stover of mungbean (Table 11). The highest concentration of phosphorus in stover (0.62 %) was recorded in the treatment combination of P_2K_2. On the other hand, the lowest phosphorus concentration (0.31 %) in post harvest soil was found in $P_0K_{0.}$

4.11 Potassium concentrations in stover of mungbean

K concentration of stover was significantly influenced by application levels of phosphorus (Table 9). The highest potassium concentration in mungbean stover (1.41 %) was recorded in P_2 (20 kg ha^{-1}) treatment. On the other hand, the lowest potassium concentration in mungbean stover (0.80 %) was recorded in P_0 treatment where no phosphorus was applied.

K concentration of stover was significantly influenced by application levels of potassium (Table 10). The highest potassium concentration in mungbean stover (1.22 %) was recorded in K_2 (20 kg ha^{-1}) treatment. On the other hand, the lowest potassium concentration in mungbean stover (1.01 %) was recorded in K_0 treatment where no potassium was applied.

Significant effect of combined application of different doses of phosphorus and potassium fertilizer on the potassium concentration was observed in stover of mungbean (Table 11). The highest concentration of potassium in the stover (1.47 %) was recorded in the treatment combination of P_2K_2. On the other hand, the lowest potassium concentration (0.61 %) in stover was found in P_0K_0.

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the research plot of the department of Soil science of Sher-e-Bangla Agricultural University, Dhaka during the period from February, 2014 to June, 2014 to study influence of Phosphorus and potassium on growth and yield of mungbean. In experiment, the treatment consisted of three phosphorus level viz. P_0 (0 kg P ha^{-1}), P_1 (15 kg P ha^{-1}), P_2 (20 kg P ha^{-1}) and three different potassium level viz. K_0 (0 kg K ha^{-1}), K_1 (15 kg K ha^{-1}) and K_2 (20 kg K ha^{-1}).

The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications. The seeds of BARI mung-6 variety were sown. Seeds were sown at the rate of 45 kg ha^{-1}. Necessary intercultural operations were done as and when necessary.

Results showed that a significant variation was observed among the treatments in respect majority of the observed parameters. The collected data were statistically analyzed for evaluation of the treatment effect.

In the study, it was observed that the plant height was significantly affected due to the different level of phosphorus. The tallest plant height the highest plant height (23.37, 38.54 and 54.54cm at 30, 50 and 70 DAS, respectively) was obtained from level of phosphorus P_2 (20 kg ha^{-1}). The plant height was significantly affected due to the different level of potassium. The tallest plant

(23.74, 38.55 and 53.43 cm at 30, 50 and 70 DAS, respectively) was obtained from K_2 (20 kg K/ha) treatment.

Interaction effect of different level of phosphorus and level of potassium had a significant variation on plant height. The highest plant height (25.22, 43.04 and 58.07 cm at 30, 50 and 70 DAS, respectively) was recorded with P_2K_2 treatment.

Number of leaves was significantly influenced by level of phosphorus. The highest number of leaf $plant^{-1}$ (10.33, 19.16, 29.78 at 30, 50 and 70 DAS, respectively) was recorded in P_2 (20 kg ha^{-1}). Number of leaves per plant was significantly influenced by level of potassium. Among the different doses of K_2 fertilizers treatment, showed the highest number of leaf per plant (10.07, 18.56 and 22.96 at 30, 50 and 70 DAS, respectively). Interaction effect of different level of phosphorus and level of potassium had a significant variation on number of leaves per plant. The highest leaf per plant (11.33, 21.33, and 33.67 at 30, 50 and 70 DAS, respectively) was recorded with the treatment combination of P_2K_2.

The number of branch per plant as affected by different doses of phosphorus showed a statistically significant variation. Among the different doses of phosphorus the highest Number of branch per plant (3.04) was observed in P_2 (20 kg ha^{-1}). The doses K_2 treatment, showed the highest Number of branch per plant (2.64). The highest Number of branch per plant (3.30) was recorded in the treatment combination of P_2K_2.

Number of pods per plant was significantly influenced by level of phosphorus. The highest number of pods per plant (20.17) was observed from P_2 (kg ha^{-1}).

Number of pod per plant showed significant variation due to the effects of different levels of potassium (Fig. 8).The highest Number of pod per plant(18.87) was obtained from the grown with the dose of K_2 (20 kg ha^{-1}). Interaction effect of different row level of phosphorus and level of potassium had a significant variation on number of pods per plant. The highest number of pods per) was recorded with the treatment combination of P_2K_2.

The number of seeds per pod, thousand seed weight and pod length were significantly affected by level of phosphorus. The highest number of seed per pod (12.02), pod length (9.60 cm) and thousand seed weight (43.80 g) were recorded in P_2 treatment. The number of seeds per pod, pod length and thousand seed weight of mungbean (BARI mung-6) were significantly affected by level of potassium. K_2 treatment showed the highest number of seed per pod (11.54), pod length (9.60 cm) and thousand seed weight (43.31 g). Interaction effect of different row level of phosphorus and level of potassium had a significant variation on number of seeds per pod, pod length and thousand seed weight. The highest number of seed per pod (13.15), pod length (10.75 cm) and thousand seed weight (45.68 g) were obtained from P_2K_2 treatment.

The seed yield per hectare was also significantly affected by level of phosphorus. The highest yield of seed (1.65 kg ha^{-1}) was recorded in P_2 (20 kg ha^{-1}) treatment. There was significant variation in the seed yield per hectare due to the different level of potassium. The maximum seed yield (1.56 t ha^{-1}) was obtained from K_2 (20 kg ha^{-1}). Combined effect of different row level of phosphorus and level of potassium had a significant variation on seed yield per hectare. The highest yield of seed (1.90 t ha^{-1}) was recorded with the treatment combination of P_2K_2. On the other hand, the lowest yield of seed (0.95 t ha^{-1}) was found in P_0K_0 treatment (no phosphorus and no potassium).

Effect of P on N, P, K concentration of stover was significantly influenced by the application levels of phosphorus. The highest N concentration in mungbean stover (0.75 %), phosphorus concentration (0.59 % and potassium concentration (1.41 %) was recorded in P_2 (20 kg ha^{-1}). N, P, K concentration of stover was significantly influenced by the application levels of potassium. The highest N concentration in mungbean stover (0.80 %), total P content (0.57 %) and potassium (14.73 %) were recorded in K_2 (20 kg ha^{-1}).

Significant effect was observed in combined application of different doses of phosphorus and potassium fertilizer on the N, P, K concentration in stover of mungbean. The highest concentration of N in the stover (0.63 %), phosphorus in stover (0.62 %) and potassium in the stover (1.47 %), was recorded in the treatment combination of P_2K_2.

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 when application of phosphorus @ 20 kg ha^{-1} with potassium @ 20 kg ha^{-1}. However, to reach a specific conclusion and recommendation more research work on mungbean should be done in different agro ecological zones of Bangladesh.

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APPENDIES

Appendix I: **Soil characteristics of experimental farm of Sher-e-Bangla Agricultural University are analyzed by soil Resources Development Institute (SRDI), Farmgate, Dhaka.**

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	**N/A**

Source: SRDI

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
pH	5.56
Organic matter (%)	1.00
Total N (%)	0.06
Available P (µgm/gm soil)	42.64
Available K (me/100g soil)	0.13

Source: SRDI