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Studies on Effect of Phosphorous Levels on Growth and Yield of *Kharif* Mungbean (*Vigna radiata* L. wilczek)

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ABSTRACT

The experiment was conducted at the Postgraduate student research farm, Department of Agronomy, School of Agriculture, Lovely Professional University, Jalandhar, Punjab, during the kharif season (June-September) of 2016 to find out the Impact of phosphorous levels on the relative yield of kharif mungbean (Vigna radiata (L.) Wilczek). The experiment was laid out in Factorial Randomized Complete Block Design with three replications and constitute of four levels of phosphorous levels viz., 15 kg P_2O_5 ha^{-1}, 30 kg P_2O_5 ha^{-1}, 45 kg P_2O_5 ha^{-1}, control (no phosphorous application). Results revealed that most of the growth characters such as plant height, number of branch $plant^{-1}$, dry weight of leaf, stem, root and total dry weight were significantly increased due to application of phosphate fertilizer over control on the similar way application of phosphorous significantly increased the yield and yield contributing characters also, such as number of pods per plant, pod length, number of seeds per plant, seed index, seed yield, straw yield and harvest index. The highest grain yield (1262.81 kg ha^{-1}) was obtained with 45 kg P_2O_5 ha^{-1} having an increase of 63.51% over the control and the lowest with no phosphorous application (673.08) while the highest grain yield was obtained by the treatment having an interaction of 45 kg P_2O_5 ha^{-1}.

Key words: *Vigna radiata (L.) Wilczek, Phosphorous levels, Growth and Yield characters of mung bean.*

INTRODUCTION

Pulses are the prominent dietary commencement of proteins for the vegetarians as it contributes about 14% of the aggregate protein content of an average Indian diet[3]. In India, mung bean is considered as the third important pulse crop among the Phenerogamae (flowering plants) after chickpea and pigeon pea. It is a short duration legume crop with wider adaptability of 650 genera and about 20,000 species[5]. Therefore, it is an indispensable approach for agriculture scientists to hasten the production aspects of pulses to face the protein requirement of the increasing population of the nation.

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The main reason of low productivity of mungbean agrology is due to improper use of fertilizer doses on marginal and sub marginal lands results in low fertility in soils. Phosphorus is an essential nutrient next to nitrogen for plant growth[1]. Indian soils are poor to medium in available phosphorus status so the role of P in pulses is more important than any other nutrient. Phosphorus has been identified as one of the most limiting nutrient elements in crop production in tropical soils[17], which is responsible for the reduction of the total vegetative growth, secondary branches, leaf development and finally yields of mung bean on all types of soil.

It is an indispensable constituent of nucleic acid, phospholipids, protein, coenzyme, NAD, NADP, ADP and ATP and various enzymes[28]. It has beneficial effects on nodule stimulation, root development, growth and it also hastens maturity as well as improving quality of crop produce. It plays a major role in energy transfer, stimulation of early growth and development, fruiting and seed formation[17]. It also plays a vital role in the formation and translocation of carbohydrates, root development, crop maturation and resistance to pathogens and also a major component in compounds whose function is related to growth, root development and ripening[22]. which helps in increasing the yield and improves its quality. Thus the study of phosphorus to legumes is more important than that of nitrogen as it plays a vital role in the nitrogen fixing process.

MATERIALS AND METHODS

The present research work was carried out on an experimental research farm, School of agriculture, Lovely Professional University, Punjab during the term from July to October 2015 in the *kharif* season, to study the impact of phosphorous levels on the yield of *kharif mung* bean. The experimental location was situated geographically at 31022′31.81'N latitude and 75023′03.02 E longitude with an altitude of 252 m above sea level, which falls under the central plain zone of Agra climatic zone of Punjab. Previously soil sample was collected randomly from the experimental site and analyzed for physiochemical properties. However, the soil of the experimental site was found to be sandy clay loam and pH of the soil varied from 7.83 to 7.98. The soil of this farm represents the sandy clay loam soil tract of Punjab.

The variety SML-668 was used for the present study. The experiment was laid out in randomized block design (RBD) with four phosphorous levels which replicated thrice. There were a total of 12 unit plots.

The details of different treatments with Phosphorous levels are as follows-

T1= P_0 (Control)
T2= P_1 (15 kg ha^{-1})
T3= P_2 (30 kg ha^{-1})
T4= P_3 (45 kg ha^{-1})

RESULTS AND DISCUSSION

Effects of phosphorous levels on growth characters of mung bean

i) Plant height

The plant height as influenced by different levels of phosphorus was recorded at 25, 40 and 55 DAS, and presented in Table 1. At 25 DAS, maximum plant height (20.90 cm) was recorded with P_3 (45 kg P_2O_5 ha^{-1}) followed by 20.03 cm with P_2 (30 kg P_2O_5 ha^{-1}). P0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (16.97 cm).At 40 DAS, P_3 (30 kg P_2O_5 ha^{-1}) recorded maximum plant height (35.66 cm) followed by 35.33cm with P_2 (45 kg P_2O_5 ha^{-1}).P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (28.34 cm).P_3 (45 kg P_2O_5 ha^{-1}) recorded maximum plant height at 55 DAS (43.49 cm) followed by 42.48 cm with P_2 (30 kg P_2O_5 ha^{-1}).P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (38.32 cm).

The plant height gradually increased in successive growth stages with the increase in phosphorus levels. Maximum plant height was recorded in treatment T_4 with 45 kg P_2O_5 ha^{-1} followed by T_3 with 30 kg P_2O_5 ha^{-1}. Minimum plant height was recorded in the control plots in which no fertilizer was applied i.e. T_1. Increased plant height might have been due to the adequate availability of plant nutrient through appropriate nutrient supply and sunlight to each plant required for its growth and development. An appropriate phosphorous supply which indirectly helps in providing nitrogen supply and its availability helped the plants to attain more vigour in terms of plant height. These findings were in agreement with the results of Erman *et al*[6]., reported the Phosphorus application had a significant effect on the plant height, number of branches, root and shoot dry weight, number of nodules, seed and biomass yield, number of pods, crude protein rate and phosphorus content of seeding both years.

ii) Number of branches plant^{-1}

The number of branch plant^{-1} as influenced by different levels of phosphorus recorded at 25, 40 and 55 DAS are presented in Table 2 . Different levels of phosphorus had non-significant effect on branch plant^{-1} at 25 DAS. At harvest, P_3 (45 kg P_2O_5 ha^{-1}) recorded the maximum number of branch plant^{-1} (5.91) followed by 5.75 with P_2 (30 kg P_2O_5 ha^{-1}) and P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (4.56). Higher number of branch plant^{-1} might have been possible due to more vigor and strength attained by the plants as a result of better photosynthetic activities with sufficient availability of light, spacing between the plants and supply of nutrients in balanced quantity to the plants at growing stages. Mathur *et al*[12]., while working on moth bean in Jodhpur reported that plant height and number of branches per plant were significantly higher with the application of 20 Kg N + 40 Kg P_2O_5 ha^{-1} (100% RDF).

iii) Dry matter

(a) Root dry weight plant^{-1}

The root dry weight of plant as influenced by different levels of phosphorous recorded in the different stages of growth studies is presented in Table 3 (a). The difference in the root dry weight of the plant due to different levels of phosphorus was significant. At 25 DAS, maximum root dry weight (0.33 g) was recorded with P_3 (45 kg P_2O_5 ha^{-1}) followed by 0.32 g with P_2 (30 kg P_2O_5 ha^{-1}). P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (0.19 g). At 40 DAS, P_3 (45 kg P_2O_5 ha^{-1}) recorded maximum root dry weight (0.44 g) followed by 0.42 g with P_2 (30 kg P_2O_5 ha^{-1}). P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (0.34 g) and P_3 (45 kg P_2O_5 ha^{-1}) recorded maximum root dry weight at 55 DAS (0.57 g) followed by 0.56 g with P_2 (30 kg P_2O_5 ha^{-1}). P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (0.46 g).

The plants attained more vigour with different combinations of phosphorus as compared to control due to adequate supply and availability of nitrogen, phosphorus, potassium and spacing in balanced combination, resulting into increased root dry weight of the plant. Better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants might have also resulted in higher root dry weight of the plant. Results reported by Erman *et al*[6]., and Neelamegam[16] are more or less similar to these findings. Pandya *et al*[18]., also reported similar results in cowpea.

(b) Leaf dry weight plant^{-1}

The leaf dry weight of plant as influenced by different levels of phosphorus, recorded at the different stages of growth studies is presented in Table 3 (b). The difference in the leaf dry weight of the plant due to different levels of phosphorus was significant. At 25 DAS, maximum leaf dry weight (0.66g) was recorded with P_3 (45 kg P_2O_5 ha^{-1}) followed by 0.66 g with P_2 (30 kg P_2O_5 ha^{-1}). P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (0.562 g). At 40 DAS, P_3 (45 kg P_2O_5 ha^{-1}) recorded maximum leaf dry weight (0.82 g) followed by 0.73 g with P_1 (15 kg P_2O_5 ha^{-1}). P_3 (45 kg P_2O_5 ha^{-1}) recorded the minimum (0.68 g). P_3 (45 kg P_2O_5 ha^{-1}) recorded maximum leaf dry weight at 55 DAS (0.83 g) followed by 0.83 g with P_2 (30 kg P_2O_5 ha^{-1}). P_1 (15 kg P_2O_5 ha^{-1}) recorded the minimum (0.66 g). The plants attained more vigour with different combinations of phosphorus as compared to control, due to adequate supply and availability of nitrogen, phosphorus, potassium and spacing in balanced combination, resulting into increased root dry weight of the plant. Better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants might have also resulted in higher root dry weight of the plant. Rathore *et al*[23]., at Bikaner, reported that the application of 20 kg N + 40 kg P_2O_5 ha^{-1} significantly improved the plant height, dry matter accumulation and leaf area in cluster bean than lower doses of N and P or control.

(c) Total dry weight plant^{-1}

The dry weight of plant as influenced by different levels of phosphorus, is presented in Table 3(c). The difference in the dry weight of the plant due to levels of phosphorus was significant. Phosphorus level P_3 (45 kg P_2O_5 ha^{-1}) recorded maximum dry weight of plant (1.58 g) followed by 1.57 g with P_2 (30 kg P_2O_5 ha^{-1}). P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (0.96 g). The plants attained more vigour with phosphorus as compared to control, due to adequate supply and availability of nitrogen, phosphorus, potassium and spacing in balanced combination, resulting in increased dry weight of the plant. Better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants might have also resulted in higher dry weight of the plant. The above reported that application of phosphorous 45 kg ha^{-1} to mungbean grown in *kharif* season significantly increased the dry matter production. Results reported by Aga *et al*[2]., Erman *et al*[6]., and Neelamegam[16] are in close conformity with these findings. Pandya *et al*[18]., also reported similar results in wheat.

Effect of phosphorous levels on yield and yield attributes of mung bean

i) Number of pods plant^{-1}

The number of pods plant^{-1} recorded at harvest is presented in Table 4 (a). The data show that there was a significant effect of different levels of phosphorus in the number of pods plant^{-1}. The number of pods plant^{-1} as influenced by different levels of phosphorus is presented in Table 4 (a) and graphically shown in Fig. 4 (i). Different levels of phosphorus had non-significant effect on pods plant^{-1} at 25 DAS. At harvest, P_3 (45 kg P_2O_5 ha^{-1}) recorded the maximum number of pods plant^{-1} (27.12) followed by 25.27 with P_2 (30 kg P_2O_5 ha^{-1}) and P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (21.66). Higher number of pods plant^{-1} might have been possible due to more vigour and strength attained by the plants as a result of better photosynthetic activities with sufficient availability of light, and supply of nutrients in balanced quantity of the plants at growing stages.

ii) Pod Length

The length of pod recorded under different treatments and their combinations is presented in Table 4(b). The data reveals that the length of the pod was significantly influenced by levels of phosphorus. Maximum length of the pod (7.84 cm) was recorded with P_3 (45 kg P_2O_5 ha^{-1}) followed by 7.40 cm with P_2 (30 kg P_2O_5 ha^{-1}). P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (5.68 cm). Higher vigour index and plant growth attained by the plants treated with different combinations of phosphorus 30x10 cm resulted into a higher length of the pod. Results reported by Nadeem *et al*[15]., and Prasad *et al*[21]., is in conformity with these findings.

iii) Number of seeds plant^{-1}

The number of seed plant^{-1} is presented in Table 4(c). The data show that there was a significant effect of different levels of phosphorus on the number of seed plant^{-1}. P_3 (45 kg P_2O_5 ha^{-1}) recorded the maximum number of seed plant^{-1} (258.24) followed by 238.18 with P_2 (30 kg P_2O_5 ha^{-1}). P_0 (0 kg P_2O_5 ha^{-1}) recorded the minimum (141.60). Sufficient availability of nutrients (nitrogen, phosphorus, potassium and spacing) and their absorption by the plants, together with better photosynthetic activity due to proper light and spacing between the plants increased the vigour and plant growth thereby resulting in greater number of seed plant^{-1}. These findings are similar to the results reported by Meena *et al*[13]., Bhattarai *et al*[4]., Nadeem *et al*[15]., Sundara *et al*[25]., Prasad *et al*[21]., and Swapna *et al*[26].

iv) 1000- seed weight

The test weight recorded in different treatment combinations is presented in Table 4(d). The data show a significant effect of levels of phosphorus on test weight. Maximum test weight (47.20 g) was recorded with P_3 (45 kg P_2O_5 ha^{-1}) followed by 44.48 g with P_2 (30 kg P_2O_5 ha^{-1}), whereas, the minimum (36.97 g) remained with P_0 (0 kg P_2O_5 ha^{-1}). Higher vigour and growth attained by the plants due to sufficient absorption of nutrients might have resulted in higher test weight. Results reported by Meena *et al*[13]., Aga *et al*[2]., Muhammad *et al*[14]., Sundara *et al*[25]., Prasad *et al*[21]., Kumar *et al*[10]., are almost in conformity with these findings.

v) Grain yield

The grain yield per hectare worked out for different levels of phosphorus is presented in Table 4(e). The data reveal that the grain yield was significantly influenced by different levels of phosphorus. Maximum grain yield (1262.81 kg ha^{-1}) was recorded with P3 (45 Kg P_2O_5 ha^{-1}) followed by 1138.43q ha^{-1} with P_1 (15 kg P_2O_5 ha^{-1}), whereas, the minimum (673.08q ha^{-1}) was recorded with P_0 (0 kg P_2O_5 ha^{-1}). Grain yield per hectare was commensurate with yield attributes like number, and length of pod, number of seed pod^{-1}. P (45 kg P_2O_5 ha^{-1}) was most appropriate and suitable levels of phosphorus for grain yield per hectare. Grain yield gradually increased with the increase in the levels of phosphorus as compared to control. Patra and Bhattacharya[20], Johstan *et al*[8]., Bhattarai *et al*[4]., Karamanos *et al*[9]., Nadeem *et al*[15]., Aga *et al*[2]., Lal[11], Muhammad *et al*[14]., Reddy *et al*[24]., Sundara *et al*[25]., Yadav and Luthra[27], Patil *et al*[19]., Erman *et al*[6]., and Jat *et al*[7]., reported almost similar results in their experiments.

vi) Straw yield

The fodder yield per hectare worked out for different levels of phosphorus is presented in Table 4(f). The data contained in the Table shows that the fodder yield was significantly influenced by different levels of phosphorus. P_3 (45 kg P_2O_5 ha^{-1}) recorded maximum fodder yield (1954.64 kg ha^{-1}) followed by 1909.06 kg ha^{-1} with P_1 (15 kg P_2O_5 ha^{-1}). The minimum (1361.77 kg ha^{-1}) was recorded with P_0 (0 kg P_2O_5 ha^{-1}). Fodder yield per hectare was commensurate with pod yield. P_3 (45 kg P_2O_5 ha^{-1}) Results reported by Meena *et al*[13]., Aga *et al*[2]., and Jat *et al*[7]., are more or less similar to these findings.

vii) Harvest index

Phosphorous show significant influences on the harvest index presented in table 4(g). Data calculated for harvest index, revealed that phosphate fertilizer exerted significant influences on harvest index (table). While maximum was recorded (41.48%) when T_4 – 45 kg P_2O_5 $ha^{-1}$was applied, but similar to 15 and 30 Kg P_2O_5 $ha^{-1}$and minimum (32.64%) with control. From the above results, it was apparent that growth, yield and yield attributes of mung bean were increased with the application of phosphate fertilizer up to 45 kg P_2O_5 $ha^{-1}$and some of the above parameters differed among the mung bean spacing's.

Table 1: Impact of different phosphorous levels on plant height at different days after sowing

Treatments	Plant Height(cm)		
	25 DAS	40 DAS	55 DAS
P_0	16.976	28.340	38.320
P_1	18.715	33.560	41.834
P_2	20.038	35.335	42.488
P_3	20.905	35.668	43.495
SEm±	0.059	0.105	0.493
CD(P=0.05)	0.182	0.267	0.583
CD (P=0.01)	0.254	0.358	0.799

Table 2: Impact of different phosphorous levels on number of branches $plant^{-1}$

Treatments	Number of Branches/Plant	% Increase in Number of Branches Over Control
P_0	4.565	16.03
P_1	5.471	29.93
P_2	5.750	33.33
P_3	5.916	35.20
SEm±	0.035	
CD(P=0.05)	0.147	
CD(P=0.01)	0.192	

Table 3(a). Impact of different phosphorous levels on root dry weight at 25, 40 and 55 DAS

Treatments	Root dry weight (g)		
	25DAS	40DAS	55DAS
P_0	0.190	0.347	0.466
P_1	0.284	0.421	0.560
P_2	0.325	0.423	0.565
P_3	0.334	0.458	0.572
SEm±	0.001	0.002	0.003
CD(P=0.05)	0.011	0.015	0.012
CD (P=0.01)	0.010	0.018	0.024

Table 3(b). Impact of different phosphorous levels on leaf dry weight at different days after sowing

Treatments	Leaf dry weight (g)		
	25DAS	40DAS	55DAS
P_0	0.562	0.706	0.670
P_1	0.636	0.732	0.661
P_2	0.662	0.680	0.833
P_3	0.663	0.823	0.882
SEm±	0.002	4.773	0.017
CD(P=0.05)	0.018	0.007	0.104
CD (P=0.01)	0.013	0.007	0.146

Table 4(a). Impact of different phosphorous levels on Number of pods per plant at harvest

Treatments	Number of Pods/Plant	% Increase in Number of Pods Over Control
P_0	21.666	12.69
P_1	24.815	23.77
P_2	25.278	30.26
P_3	27.125	25.16
CD(P=0.05)	1.311	
CD (P=0.01)	1.777	

Table 4(b). Impact of different phosphorous levels effect on pod length

Treatments	Pod Length (cm)	% Increase in Pod Length over Control
P_0	5.683	5.27
P_1	6.903	22.01
P_2	7.846	31.39
P_3	7.405	27.30
CD(P=0.05)	0.151	
CD (P=0.01)	0.212	

Table 4(c). Impact of different phosphorous levels on Number of seeds plant^{-1}

Treatments	No of Seeds per Plant	% Increase in no of Seeds per Plant over Control
P_0	141.603	17.72
P_1	199.126	41.49
P_2	238.188	51.08
P_3	258.245	54.88
CD(P=0.05)	9.771	
CD (P=0.01)	13.163	

Table 4(d). Impact of different phosphorous levels on seed index

Treatments	Seed Index	% Increase in Seed Index over Control
P_0	36.975	5.11
P_1	41.161	14.73
P_2	44.483	21.10
P_3	47.206	25.65
CD(P=0.05)	0.240	
CD (P=0.01)	0.333	

Table 4(e). Impact of different phosphorous levels effect on grain yield per hectare

Treatments	Grain Yield per Hectare	% Increase in Grain Yield over Control
P_0	673.083	31.54
P_1	1138.435	59.52
P_2	861.750	46.53
P_3	1262.815	63.51
CD(P=0.05)	32.864	
CD (P=0.01)	44.252	

Table 4(f). Impact of different phosphorous levels on straw yield

Treatments	Straw Yield (Kg ha-1)	% Increase in Straw Yield over Control
P_0	1361.778	13.43
P_1	1909.065	38.25
P_2	1555.351	24.20
P_3	1954.648	39.69
CD(P=0.05)	31.512	
CD (P=0.01)	42.442	

Table 4(g). Impact of different phosphorous levels on harvest index

Treatments	Harvest Index	% Increase in Harvest Index over Control
P0	32.648	14.02
P1	37.089	24.24
P2	35.341	20.50
P3	41.482	32.26
CD(P=0.05)	3.478	
CD (P=0.01)	4.673	

CONCLUSIONS

Observations were recorded on growth parameters like plant height, number of branches per plant, root dry weight, leaf dry weight, stem dry weight and total dry weight of the plant and yield attributes viz., number of pods per plant, pod length, seed yield, straw yield, seed index, number of seeds per plant. Data was also harvest index, percentage increase over control and benefit cost ratio for different treatments. All the above mentioned parameters of green gram were influenced by graded levels of phosphorous. At 25, 40 and 55 DAS taller plants (35.66 cm and 43.49 cm, respectively) were produced by application of 45 kg P_2O_5 ha^{-1} which was however statistically at par with treatment of 30 kg P_2O_5 ha^{-1}. Application of 45 kg P_2O_5 ha^{-1} was found significantly superior and increased the dry weight of the crop at all stages of 40 (2.06 g m^{-2}) and 55 DAS (2.46 g m^{-2}) over other treatments. Application of phosphorus at the dosage of 45 kg P_2O_5 ha^{-1} produced the highest number of branches (6.22 branches plant^{-1}) which was followed (5.89 branches plant^{-1}) with the amount of 30 kg P_2O_5 ha^{-1} while without the application of phosphorus fertilizer (4.56 branches plant-1) least number of branches per plant were produced. The highest pod length (7.84 cm) was reported at 45 kg P_2O_5 ha^{-1} which was significantly superior over others and was at par with 30 kg P_2O_5 ha^{-1} (7.40 cm). The seed index (47.20 g) obtained with 45 kg P2O5 ha^{-1} was significantly superior over others. The highest grain yield (1262.81Kg ha^{-1}) was recorded with 45 kg P_2O_5 ha^{-1} which was significantly superior to other treatments. The lowest grain yield (673.08 kg ha^{-1}) was recorded in the control (no phosphorous). Mung bean fertilized with 45 kg P_2O_5 ha^{-1} produced a significantly more straw yield (1954.64 kg ha^{-1}) but it was on par with 30 kg P_2O_5 ha^{-1} and significantly superior over control. With respect to phosphorous, highest harvest index (41.48 %) was associated with the application of 45 kg P_2O_5 ha^{-1} which was significantly superior over other treatments and lowest harvest index (32.64 %) was observed with control.

In view of the findings and the results presented above, it may be concluded that among the four phosphorous levels, P_4 (45 kg P_2O_5 ha^{-1}) significantly dominated others. Of the four treatments, P_4 (45 kg P_2O_5 ha^{-1}) emerged as the best one for growth and yield of mungbean to suit to the environmental conditions of the Punjab region. However, since this is based on one-year experiment, further trails may be needed to substantiate the results.

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