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Response of Lathyrus (*Lathyrus sativus* L.) on Different Levels of Phosphorus and Row Spacing on Growth and Yield under Manipur Condition

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A B S T R A C T

A field experiment was conducted to study the response of Lathyrus (*Lathyrus sativus* L.) on different levels of phosphorus and row spacing on growth and yield under Manipur condition during the *rabi* season of 2011-12 and 2012-13 at the Research Farm, College of Agriculture, Central Agricultural University, Imphal. The treatments comprised of two different spacing (20 x 10cm and 30 x 10 cm) and five levels of phosphorus (0, 20, 30, 40 and 50 kg P_2O_5 ha^{-1}). The experiment was laid out in factorial randomized block design with three replications. Wider row spacing (30 cm) produced significantly higher branches/plant (10.23), pods/plant (12.65) and seeds/pod (4.43) than the closer row spacing (20 cm). Application of phosphorus @ 50 kg P_2O_5 ha^{-1} significantly gave the higher number of branches per plant (10.67) than the application of 20 kg P_2O_5 ha^{-1} (7.98) and control (5.90) but remained at par with 30 (10.58) and 40 kg P_2O_5 ha^{-1} (10.62). The spacing of 20 x 10 cm gave the maximum yield (738.69 kg ha^{-1}) and was significantly higher as compared to 30 x 10 cm (660.56 kg ha^{-1}). Significantly higher grain yield was recorded with the application of 50 kg P_2O_5 ha^{-1} (825.01 kg ha^{-1}) and it remained at par with the application of 40 kg P_2O_5 ha^{-1} (794.31 kg ha^{-1}) and 30 kg P_2O_5 ha^{-1} (779.26 kg ha^{-1}). The highest B: C (3.11) was recorded from the application of 30 kg P_2O_5 ha^{-1}. Total N, P and K uptake was significantly higher in wider spacing as well as application of 50 kg ha^{-1} and the lowest in control. Maximum apparent P recovery was obtained from 30 kg P_2O_5 ha^{-1} (18.96) and the lowest from 20 kg P_2O_5 ha^{-1} (12.27). From the above experiment it was found that application of 30 kg P_2O_5 ha^{-1} when planted at a spacing of 20 x 10 cm, found to be the best treatment for obtaining higher yield and also maintaining the soil health besides providing higher income for the farmer.

Introduction

Lathyrus also known as grass pea is a hardy crop, tolerant of extremely dry conditions but still able to tolerate water-logging and poor soils and is commonly grown on heavy clay vertisols. In Manipur most of the fields are lying vacant after the harvest of rice during *rabi* season due to scarcity of water. In such situations field can be brought under cultivation of grass pea due to its hardiness nature. Optimum row spacing have optimally utilized the growth resources, particularly solar radiation as compared to narrow row spacing where plants might have suffered due to mutual shading in case of adjoining rows and more plants within case of wider spacing. Phosphorus is an important plant nutrient involved in several energy transformation and biochemical reactions including biological nitrogen fixation. Phosphatic fertilizers have low efficiency of utilization due to chemical fixation in soil (Gaur, 1983) and poor solubility of native soil phosphorus, sometimes there is buildup of insoluble phosphorus as a result of chemical phosphorus application (Dubey, 1997). Root development, stalk and stem strength, flower and seed formation, crop maturity and production, crop quality and resistance to plant diseases are the attributes associated with phosphorus nutrition. Grain, fiber and forage yield also increases due to proper maintenance of phosphorus fertility. Phosphorus is needed in relatively large amounts by legumes for growth and nitrogen fixation and has been reported to promote leaf area, biomass, yield, nodule number, nodule mass, etc., in a number of legumes (Kashturikrishna and Ahlawat, 1999). Phosphorus deficiency can limit nodulation by legumes and phosphorus fertilizer application can overcome the deficiency (Carsky *et al.*, 2001). Large amount of phosphorus applied as fertilizer enters into the immobile pools through precipitation reaction with highly reactive aluminium (Al^{+}) and iron (Fe^{3+}) in acidic and calcium (Ca^{2+}) in calcareous or normal soils (Gyaneshwar *et al.*, 2002 and Hao *et al.*,2002). Efficiency of phosphorus fertilizer throughout the world is around 10-25 % (Isherword, 1998) and concentration of bioavailable phosphorus in soil is very low reaching the level of 1.0 mg kg^{-1} soil (Goldstein, 1994). Keeping the above points in view, the experiment was undertaken to study the effect of row spacing and different levels of phosphorus on growth and yield of lathyrus (*Lathyrus sativus* L.).

Materials and Methods

A field experiment was conducted at Research Farm, College of Agriculture, Central Agricultural University, Imphal during *rabi* season of 2011-12 and 2012-13 to study the effect of row spacing and different levels of phosphorus on growth and yield of lathyrus (*Lathyrus sativus* L.). The soil was clay loam with pH (5.4), organic carbon (0.58%), available N (213.60 kg ha^{-1}), P (12.33 kg ha^{-1}) and K (225 kg ha^{-1}) respectively. The experiment consist of two row spacing (20 cm and 30 cm) with five different levels of phosphorus (0, 20, 30, 40 and 50 kg P_2O_5 ha^{-1}) and replicated thrice in factorial randomize block design.

Required quantities of phosphorus in the form of Single Super Phosphate (16% P_2O_5) was applied as per treatment one day before sowing of the crop in the entire plot and was mixed properly with the soil. A uniform dose of 20 kg N ha^{-1} in the form of Urea (46% N) and 30 kg K_2O ha^{-1} in the form of Muriate of Potash (60% K_2O) was applied as basal to all the plots along with phosphorus. Lathyrus variety '*Biol 212'* was sown in the first week of November and harvested in the last week of March during both the years. A rainfall of 88.3 mm was received during the month of November. But there was no rain during the month of December and January. The crop was raised under rainfed condition without any irrigation. Rest of the management practices were in accordance with the recommended package of practices for the crop.

Agronomic efficiency (kg grain/kg P applied) = $(Y_t - Y_0)$ /Pa

Where, Y_t = grain yield (kg/ha) in test treatment; Y_0 = grain yield (kg/ha) in the control plot; Pa = Phosphorus applied in test treatment (kg/ha).

The apparent P recovery was worked out as follows:

$$\text{Apparent P recovery (\%)} = \frac{\text{(P uptake in treated plot} - \text{P uptake in control plot)}}{\text{P Fertilizer dose}} \text{x100}$$

Economics of different treatments was worked out on the basis of input and output on the prevailing market prices.

Results and Discussion

Growth and yield attributes

The different row spacing as well as different levels of phosphorus influence growth and yield of grass pea. Data in Table 1 shows that closer spacing produced significantly higher plant height (24.74 cm) than the wider spacing (22.45 cm). It may be due to lack of enough space due to which the plants grew vertically, resulting into taller plants. Similar finding was also reported by Mansoor *et al.,* (2010). Plant height increases with increase in levels of phosphorus. Plant height recorded from the application of 50 kg P_2O_5 /ha (25.30 cm) was found to be at par with the application of 20, 30 and 40 kg P_2O_5 /ha and the lowest from control (20.17 cm). The results obtained are in line with the findings of Kanaujia *et al.,* (1999).

Wider row spacing (30 cm) produced significantly higher branches /plant (10.23), pods/plant (12.65) and seeds/pod (4.43) than the closer row spacing (20 cm). It may be due to the better growth of plants under broader spacing and it exhibited better vegetative growth due to less plant population density and competition resulted in more horizontal growth and plant canopy area compared to those under narrow spacing. The observations recorded were supported by the findings of Sajid *et al.,* (2012). Application of phosphorus @ 50 kg P_2O_5 ha^{-1} significantly gave the higher number of branches per plant (10.67) than the application of 20 kg P_2O_5 ha^{-1} (7.98) and control (5.90) but remained at par with 30 (10.58) and 40 kg P_2O_5 ha^{-1} (10.62). The interaction effect between spacing and phosphorus were found to be non-significant.

The maximum number of nodules was obtained at a wider spacing of 30 x 10 cm than the closer spacing of 20 x 10 cm. The result obtained was similar with the findings of Luikham *et al.,* (2009). Phosphorus fertilizer increased the number of nodules over the control (without phosphorus). The number of nodules significantly increased with the application of 50 kg P_2O_5 ha^{-1} (16.03) as compared with other levels of phosphorus.

Crop yield

Among the two rows spacing, the wider spacing of 30 x 10 cm gave the maximum number of pods per plant (12.65) and was significantly higher than the closer spacing of 20 x 10 cm (11.28) which gave the minimum number of pods per plant. The increase in the number of pods per plant in wider row spacing may be due to vigorous plant as in wider spacing, plant grew vigorously and produced more branches which resulted in high number of pods per plant. These findings are in line with Idris *et al.,* (2008) and Sajid *et al.,* (2012). Among the phosphorus levels the application of 50 kg P_2O_5 ha^{-1} significantly gave the higher number of pods (13.83) which was at par with 40 kg P_2O_5 ha^{-1} (13.77) and 30 kg P_2O_5 ha^{-1} (13.48). The lowest number of pods per plant was obtained in control (7.50). The interaction between spacings and phosphorus levels showed significant effect on number of pods per plant. The row spacing of 30 x 10 cm significantly gave the maximum number of seeds per pod (4.43) than the closer spacing of 20 x 10 cm (4.25). It may be due to less plant population which might have resulted in less competition for light, space and nutrients.

Table.1 Effect of row spacing and different levels of phosphorus on growth, yield attributes, yield and economics of grass pea (mean for two years)

Treatment	Plant height (cm)	Branches /plant	Pods/ plant	Seeds/ pod	Test weight (g)	Grain yield (kg/ ha)	Straw yield (kg/ha)	Number of nodules/plant at 60 DAS
Row spacing								
20 cm x 10 cm	24.74^{b}	8.07^{a}	11.28^{a}	4.25^{a}	88.73	739^{b}	989^{b}	11.31
30 cm x 10 cm	22.45^{a}	10.23^{b}	12.65^{b}	4.43^{b}	89.09	661^{a}	913^{a}	12.39
S.Em.(±)	0.75	0.44	0.13	0.05	0.59	21.92	25.31	0.41
C.D. (P=0.05)	2.24	1.31	0.38	0.16	NS	65.09	75.17	NS
***Levels of Phosphorus* (kg P_2O_5/ha)**								
0	20.17^{a}	5.90^{a}	7.50^{a}	2.52^{a}	87.70	428^{a}	613^{a}	7.10^{a}
20	23.27^{ab}	7.98^{a}	11.23^{b}	4.72^{b}	88.58	672^{b}	851^{b}	10.30^{b}
30	24.47^{b}	10.58^{b}	13.48^{c}	4.80^{b}	89.25	780^{c}	1063^{c}	12.52^{c}
40	24.77^{b}	10.62^{b}	13.77^{c}	4.82^{b}	89.43	794^{c}	1078^{c}	13.30^{c}
50	25.30^{b}	10.67^{b}	13.83^{c}	4.83^{b}	89.58	825^{c}	1149^{c}	16.03^{d}
S.Em.(±)	1.19	0.70	0.20	0.09	0.93	34.66	40.02	0.65
C.D. (P=0.05)	3.54	2.08	0.85	0.26	NS	102.92	118.85	1.92
Interaction								
S.Em.(±)	1.68	0.99	0.29	0.12	1.32	49.01	56.60	0.92
C.D. (P=0.05)	NS	NS	0.85	NS	NS	NS	NS	NS

*** Means followed by same superscripts within the same column are not significantly different at the 5% level of probability based on Duncan's Multiple Range Test.**

Table.2 Effect of row spacing and different levels of phosphorus on nutrient uptake, available nutrient in soil after the harvest of grass pea

Treatment	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Row spacing						
20 cm x 10 cm	20.49^{a}	12.52^{a}	29.36^{a}	207.47	11.19	189.74
30 cm x 10 cm	21.95^{b}	13.31^{b}	31.52^{b}	211.48	11.32	192.56
S.Em.(±)	0.16	0.10	0.16	2.57	0.07	1.09
C.D. (P=0.05)	0.48	0.31	0.48	NS	NS	NS
Levels of Phosphorus						
0	16.13^{a}	8.38^{a}	24.24^{a}	187.35^{a}	8.74^{a}	172.00^{a}
20	20.05^{b}	10.83^{b}	27.62^{b}	202.25^{b}	10.89^{b}	190.66^{b}
30	21.53^{c}	14.07^{c}	31.53^{c}	211.93^{bc}	11.56^{c}	193.83^{bc}
40	23.53^{d}	15.05^{d}	33.98^{d}	217.44^{c}	12.35^{d}	198.06^{cd}
50	24.85^{e}	16.23^{e}	34.84^{e}	228.42^{c}	12.73^{e}	201.18^{d}
S.Em.(±)	0.25	0.17	0.26	4.07	0.11	1.72
C.D. (P=0.05)	0.76	0.49	0.76	12.09	0.34	5.11
Interaction						
S.Em.(±)	0.36	0.23	0.36	5.76	0.16	2.43
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

*** Means followed by same superscripts within the same column are not significantly different at the 5% level of probability based on Duncan's Multiple Range Test.**

Table.3 Effect of row spacing and different levels of phosphorus on economics and phosphorus use efficiency of grass pea

Treatment	Gross return (□ /ha)	Net return (□ /ha)	B:C ratio	APUE (kg of grain increased /kg of p applied)	Apparent P recovery (%)
Row spacing					
20 cm x 10 cm	59095 ^{b}	38643	2.86	8.34	11.93
30 cm x 10 cm	52845 ^{a}	33946	2.77	8.08	13.52
S.Em.(±)	1753	1753	0.09	0.68	0.28
C.D. (P=0.05)	5208	NS	NS	NS	0.82
Levels of Phosphorus					
0	34219 ^{a}	17628 ^{a}	2.06 ^{a}	0.00	0.00
20	53745 ^{b}	35029 ^{b}	2.87 ^{b}	12.20 ^{b}	12.27 ^{a}
30	62341 ^{c}	42299 ^{b}	3.11 ^{b}	11.72 ^{b}	18.96 ^{c}
40	63545 ^{c}	42517 ^{b}	3.02 ^{b}	9.16 ^{a}	16.68 ^{b}
50	66001 ^{c}	44001 ^{b}	3.00 ^{b}	7.95 ^{a}	15.70 ^{b}
S.Em.(±)	2772	2772	0.13	1.08	0.44
C.D. (P=0.05)	8234	8234	0.40	3.21	1.30
Interaction					
S.Em.(±)	3921	3921	0.19	1.53	0.62
C.D. (P=0.05)	NS	NS	NS	NS	NS

***Selling price of grass pea grain = □ 80/kg under Manipur condition**
*** Means followed by same superscripts within the same column are not significantly different at the 5% level of probability based on Duncan's Multiple Range Test.**

Similar results were also reported by Idris *et al.*, (2008). The phosphorus application was significantly higher compared to control. The test weight did not differ significantly with row spacing as well as different levels of phosphorus. However, in contrast to the number of seeds per pod, the wider spacing gave the heavier seed weight. These findings are supported by Rajput *et al.*, (1984).

The spacing of 20 x 10 cm gave the maximum yield (738.69 kg ha^{-1}) and was significantly higher as compared to 30 x 10 cm (660.56 kg ha^{-1}). The closer spacing resulted in higher seed yield due to more number of plants per unit area as compared to wider spacing. The effect of narrow spacing has often been explained by the fact that thick canopy may intercept a large percentage of solar radiation, thereby increasing photosynthesis. The result obtained was similar with the findings of Luikham *et al.*, (2009), Bruin and Pederson (2008). Significantly higher grain yield was recorded with the application of 50 kg P_2O_5 ha^{-1} (825.01 kg ha^{-1}) and it remained at par with the application of 40 kg P_2O_5 ha^{-1} (794.31 kg ha^{-1}) and 30 kg P_2O_5 ha^{-1} (779.26 kg ha^{-1}). However, significantly lower grain yield was recorded with the application of 20 kg P_2O_5 ha^{-1} (671.81 kg ha^{-1}) and control

(427.74 kg ha^{-1}). Application of phosphorus resulted in higher root volume and also enhanced the activity of rhizobia and increased the formation of root nodules and thereby helping in fixing more atmospheric nitrogen which bushed up the yield of the crop. These results are in line with the findings of Malik *et al.,* (2006) and Singh *et al.,* (2011). The interaction between spacing and levels of phosphorus could not bring significant effect on grain yield of grass pea. In the same trend significantly higher straw yield was obtained at the spacing of 20 x 10 cm (988.69 kg ha^{-1}) than 30 x 10 cm (913.43 kg ha^{-1}).The different levels of phosphorus and row spacing could not bring significant difference in the harvest index of grass pea.

Number of nodules

The number of nodules per plant was not affected by the different row spacing. However, the maximum number of nodules was obtained at a wider spacing of 30 x 10 cm than the closure spacing of 20 x 10 cm. the result obtained was similar with the findings of Luikham *et al.,* (2009). Phosphorus fertilizer increased the number of nodules over the control. The number of nodules significantly increased with the application of 50 kg P_2O_5 ha^{-1} at 60 DAS.

Nutrient uptake

The row spacing could not show significant effect on the total nitrogen uptake. Numerically more nitrogen uptake was observed in wider spacing of 30 x 10 cm (21.95 kg ha^{-1}) than closer spacing of 20 x 10 cm (20.49 kg ha^{-1}). The different levels of phosphorus showed significant effect on the total nitrogen uptake. Significantly higher nitrogen uptake was observed in phosphorus level of 50 kg P_2O_5 ha^{-1} (24.85 kg ha^{-1}) and the lowest in control (16.13 kg ha^{-1}). Similarly, total P and K uptake was also significantly higher in wider spacing as well as application of 50 kg ha^{-1} and the lowest in control. Interaction between spacing and levels of phosphorus for total N, P and K was found to be non-significant. The higher total uptake of total nitrogen, phosphorus and potassium with higher levels of phosphorus application may be due to the maximum yield and yield attributes obtained in this treatment. The higher nutrient utilization by the crop may be due to adequate supply of phosphorus which enhanced the protein synthesis in pods per plant. The results are almost in line with the findings of Bhat *et al.,* (2002).

Available nutrients in soil

Data in Table 2 shows that wider spacing of 30 x 10 cm significantly resulted in higher nitrogen content (211.48 kg ha^{-1}) than 20 x 10 cm (207.47 kg ha^{-1}). The phosphorus application @ 50 kg ha^{-1} significantly resulted in higher nitrogen content (228.42 kg ha^{-1}) than control (187.35 kg ha^{-1}). In the same trend the available P_2O_5 and K_2O was also significantly higher in wider spacing of 30 cm x 10 cm and the application of 50 kg P_2O_5 ha^{-1}. The decrease in available nitrogen in soil may be due to more uptake of nitrogen by the plants due to which the activity of rhizobia increased and which enhanced nodulation with the application of phosphorus. The decrease in available phosphorus may be due to more uptake by the plants which enhanced the plant growth, other yield attributing characters and yield of the crop and decrease in available potassium may be due to more uptake of potassium by the plant which enhanced better growth of the crop.

Economics

Gross return was significantly higher in 20 cm row spacing (Rs. 59,095 ha^{-1}) as compared to 30 cm row spacing (Rs. 52,845 ha^{-1}). It might be due to more number of pods per unit area resulting into more yield. Among the different doses of phosphorus 30 kg P_2O_5 ha^{-1}, 40 kg P_2O_5 ha^{-1} and 50 kg P_2O_5 ha^{-1} were found to be at par regarding the gross return. The B: C ratio was not influenced significantly by the different row spacings. The different doses of phosphorus influenced significantly on the B : C. The highest B : C (3.11) was recorded from the application of 30 kg P_2O_5 ha^{-1} as compared to other doses though it was at par with 40 kg P_2O_5 ha^{-1} and 50 kg P_2O_5 ha^{-1}. The results are in line with the findings of Sen *et al.,* (2010).

Efficiency indices

Data in Table 3 shows that agronomic phosphorus use efficiency was higher in closer spacing than wider spacing as well as decreased with increase in levels of phosphorus. In contrast, apparent phosphorus recovery was significantly higher in wider spacing than closer spacing. Among the different levels of phosphorus, apparent phosphorus recovery was increased significantly with increase up to 30 kg P_2O_5 ha^{-1} and decreases with increased in levels of phosphorus. Maximum apparent P recovery was obtained from 30 kg P_2O_5 ha^{-1} (18.96) and the lowest from 20 kg P_2O_5 ha^{-1} (12.27). The declined in APUE with higher level of phosphorus might be due to fixation of phosphorus in the soil. Similar result was also reported by Kumar and Kushwaha (2006).

From the above investigation it can be concluded that lathyrus can be grown profitably at a spacing of 30 cm x 10 cm with the application of 40 kg P_2O_5 ha^{-1} during *rabi* season under Manipur condition.

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