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Effect of Phosphorus on Different Varieties on Growth and Yield of Field Pea (*Pisum sativum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

During the *rabi* season 2023-24, a field experiment was carried out at Pandit Deen Dayal Upadhyay Institute of Agriculture Science, Utlou, Bishnupur District, Manipur, India. The treatment comprised of three different phosphorus levels (0,40 and 60 kg/ha) and three varieties V_1 – Prakash, V_2 – Rachna, V_3 – Aman with a total of 9 treatment combinations. The experiment was laid out in a factorial randomized block design (FRBD) with three replications. The results reveal that the most of the growth character viz. plant height(cm), number of branches per plant, fresh

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weight and dry weight per plant(g), number and dry weight of nodules were recorded maximum on Aman (V_3) and minimum values were recorded on Prakash (V_1).The maximum yield character such as number of pods per plant, number of seed per pod, pod length(cm), stover yield (q/ha), test weight (g), harvest index (%) were recorded significantly higher under variety Aman (V_3) followed by Rachna(V_2) and Prakash(V_1).Among the phosphorus levels 60 kg P_2O_5/ha recorded higher growth attribute, yield attribute and yield of pea as compared to to other phosphorus which was followed by 40 kg P_2O_5/ha and 0 kg P_2O_5/ha. The treatment combination 60 kg P_2O_5/ha + Aman (P_3V_3) was found best for pea cultivation. Therefore, it can be concluded that using 60 kg P_2O_5/ha + Aman (P_3V_3) proved to be more productive and profitable for the cultivation of pea during rabi season in Manipur climate condition.

Keywords: Field pea; phosphorus; varieties; growth; yield.

1. INTRODUCTION

Field pea (*Pisum sativum* L.) is one of the important pulse crops in the world. It is cultivated in a 6.2 million hectares area with a total production of 20.5 million tonnes annually (FAOSTAT-2021). The important field pea-growing countries are Canada, Russia, the USA, 28 China & India. Canada ranks first in the world in respect of production followed by Russia. In India (2020 -21), field pea occupies an area of 0.64 million ha with an annual production of 0.88 million tonnes (ICAR-IIPR). Uttar Pradesh is the major field pea-growing state. Besides, Uttar Pradesh, Madhya Pradesh and Bihar are the major field pea-producing states (ICARIIPR). It is highly nutritious and approximately 21–33% protein, 56–74% carbohydrates, with an average iron, selenium, zinc, and molybdenum of about 97, 42, 41, and12 ppm, respectively. Parihar et al*.* (2021). The response of phosphorus depends upon many factors like climate, variety of soil type and availability of nutrients during growth period. The application of phosphorus increased the production of pulse crops. Phosphorus is the vital component of DNA, RNA, ATP and photosynthetic system apart from that it also catalyzes a number of biochemical reactions from the beginning of seedling growth through the formation of grains at maturity. Singh et al*.* (2018). One of the advantages of feeding plants with phosphorus is to create deeper and more abundant roots Sharma et al*.* (2004). It also raises the efficiency of plants for photosynthesis, enhances the activity of rhizobia and increases the number of branches and pod per plants, consequently producing a higher total yield of pea. Phosphorus is very crucial for root development, energy transfer, and overall plant metabolism Nadeem et al. (2003). The genetic diversity within pea varieties is significant, in which variety display distinct characteristics and adaptations. This diversity is essential for breeding programs focused on enhancing yield, disease resistance, and adaptability to different environmental conditions.

2. MATERIALS AND METHODS

The field experiment was conducted during Rabi seasons 2023-24 at Pandit Deen Dayal Upadhyay Institute of Agriculture Science, Utlou, Bishnupur District, Manipur, India.

The experimental site is located at 24°43’22.4” N latitude, 93°51’35.2” E longitude and at an altitude of 790 m above mean sea level. The soil texture and nature of the experimental field was clay with acidic reaction (pH 5.2), high organic carbon (1.9%), low in available nitrogen (188 kg/ha), medium available phosphorus (20 kg P/ha) and medium in available potash (216.18 kg K/ha). The experiment was laid out in a factorial randomized block design (FRBD) with three replications. The treatments P_1, P_2 and P_3 represents Phosphorus concentration i.e.0 kg P_2O_5/ha,40 kg P_2O_5/ha and 60 kg P_2O_5/ha and V_1, V_2 and V_3 represents Varieties i.e. Prakash, Rachna and Aman respectively.T_1 - 0 kg P_2O_5/ha + Prakash,T_2 - 0 kg P_2O_5/ha + Rachna,T_3 - 0 kg P_2O_5/ha + Aman,T_4- 40 kg P_2O_5/ha + Prakash,T_5 - 40 kg P_2O_5/ha + Rachna,T_6- 40 kg P_2O_5/ha + Aman,T_7 - 60 kg P_2O_5/ha + Prakash,T_8 - 60 kg P_2O_5/ha +Rachna,T_9 - 60 kg P_2O_5/ha + Aman. A uniform dose of 20 kg nitrogen (as urea), 60 kg phosphorus (SSP) and 40 kg potash (MOP) was applied to all the treatments. The biometric observations on different characteristics *viz*., plant height, number of branches were recorded at various stages of crop growth. The grain yield (kg/ha) was also recorded from each net plot at the time of harvest. Mean values of data obtained from the experiment are computed for statistical analysis to test significance and interpretation of results.

3. RESULTS AND DISCUSSION

3.1 Effect of Phosphorus and Varieties of Plant Height (cm)

The present investigation resulted that the data on plant height was significantly influenced by application of different concentration of phosphorus and varieties in field pea as shown in Table 1. Application of treatment (0,40,60 P_2O_5/ha) showed an increase in plant height as compared to control phosphorus. At 30 DAS the plant height could not give significant changes over control as compared to other phosphorus application of 40 and 60 kg P_2O_5/ha. In the subsequent 3 stages (60,90 and at harvest) the maximum height was observed at 60 kg P_2O_5/ha which remain superior as compared to other phosphorus level. Application of phosphorus 60 kg P_2O_5/ha recorded higher plant height due to higher phosphorus level to grow taller which causes a positive effect of phosphorus on root multiplication, nodulation and speeding up the height of the plant. Phosphorus and variety interaction was found to be non-significant for the plant height of pea. These findings were supported by Tripathi et al. (2020) and Thakare et al. (2022). Among the varieties, the maximum height was observed in the variety Aman(V_3). followed by Rachna (V_2) and the lowest plant height variety is recorded at Prakash (V_1). The differences in plant height among the varieties may be attributed to variations in genetic composition and the rate of cell division at various growth stages. Similarly, variation of plant height with different varieties was also reported by Sen et al. (2016) in pulse crops.

3.2 Effect of Phosphorus and Varieties of Number of Branches Per Plant

The data on number of branches was found to be significantly influenced by phosphorus and varieties in field pea as shown in Table 2. The effect of different doses of phosphorus on a number of branches per plant was evident from the fact that the number of branches per plant in different does not vary considerably. At 30 DAS the number of branches did not differ significantly over control as well as between 40 and 60 kg P_2O_5/ha. In the subsequent 3 stages (60, 90 DAS and at harvest) it increases significantly with increased level of phosphorus at 40 and 60 kg P_2O_5/ha. Phosphorus and variety interaction was found to be non-significant for the number of branches per plant of field pea. An increase in phosphorus level boosts rhizobium activity, which improves N fixation in the root nodules and promotes better growth and development which leads to enhanced cell division causing cells to produce more branches. A similar result was also reported by Chaurasiya et al. (2024). However, in the last three stages of recording (60, 90 DAS and at harvest), the maximum number of branches was observed in the variety Aman (V_3) which remains par with Prakash (V_1). Again, Prakash (V_1) remains par with Rachna (V_2) in the last three stages of recording. It might be due to the varietal differences due to genetics characters. This finding was supported by Singh et al. (2023).

Table 1. Effect of phosphorus and varieties on plant height (cm) of field pea

	Plant height (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**At Harvest**
	Phosphorus levels			
P_1 (0 kg P_2O_5/ha)	8.72	27.79	37.76	38.42
P_2 (40 kg P_2O_5/ha)	9.04	29.32	40.12	41.24
P_3 (60 kg P_2O_5/ha)	9.60	31.23	42.39	43.60
S.Ed (±)	0.15	0.18	0.63	0.67
C.D. (P = 0.05)	0.32	0.38	1.34	1.41
	Varieties levels			
V_1 (Prakash)	8.91	28.74	39.27	40.45
V_2 (Rachna)	9.12	29.59	39.72	40.69
V_3 (Amana)	9.33	30.00	41.29	42.12
S.Ed (±)	0.15	0.18	0.63	0.67
C.D. (P = 0.05)	0.32	0.38	1.34	1.41

Table 2. Effect of phosphorus and varieties on number of branches per plant of field pea

Treatment	Number of branches per plant			
	30 DAS	60 DAS	90 DAS	At harvest
	Phosphorus levels			
P_1 (0 kg P_2O_5/ha)	0.99	1.44	2.60	2.70
P_2 (40 kg P_2O_5/ha)	1.21	1.92	2.71	3.06
P_3 (60 kg P_2O_5/ha)	1.33	2.24	3.10	3.31
S.Ed (±)	0.06	0.11	0.10	0.08
C.D. (P = 0.05)	0.13	0.24	0.21	0.18
	Varieties levels			
V_1 (Prakash)	1.11	1.70	2.66	2.89
V_2 (Rachna)	1.18	1.88	2.83	3.06
V_3 (Amana)	1.24	2.03	2.92	3.12
S.Ed (±)	0.06	0.11	0.10	0.08
C.D. (P = 0.05)	0.12	0.24	0.21	0.18

3.3 Effect of Phosphorus and Varieties of Number of Pods Per Plant

Number of pods per plant data revealed a significant impact of both phosphorus levels and pea varieties in the field experiment as shown in Table 3. The individual effect of phosphorus and varieties on the number of pods per plant of pea could not bring a significant difference in the number of pods per plant. The maximum number of pods per plant is recorded with the application of 60 kg P_2O_5/ha. The lowest number of pods per plant was recorded at control phosphorus. Phosphorus and variety interaction was found to be non-significant for the number of pods per plant of field pea. An increase in the number of pods per plant might be because of the essential role of phosphorus in photosynthesis, fast energy transfer may have enhanced photosynthetic efficiency and consequently photosynthesis availability which further results in an increase in overall biomass production and plant part translocation. A similar result was also reported by Hangsing et al. (2020). Among the variety (V_3) Aman recorded a maximum number of pods per plant as compared to variety (V_1) Prakash and (V_2) Rachna. However, (V_1) Prakash and (V_2) Rachna did not differ significantly in terms of number of pods per plant. The variation in number of pods per plant might be due to differences in genetic differences. These findings were supported by the findings of Tripathi et al. (2020).

3.4 Effect of Phosphorus and Varieties of Seed Yield (q/ha)

Seed yield data revealed a significant impact of both phosphorus levels and pea varieties in the field experiment as shown in Table 3. Phosphorus also increased the photosynthesis and translocation of assimilates to different plant parts for enhanced growth and yield attributing characters of the crop as observed in the number of pods per plant. The application of 60 kg P_2O_5/ha resulted in a significant and maximum seed yield. Phosphorus and variety interaction was found to be non-significant for the seed yield of field pea. This may be attributed to enhanced root proliferation, better root development, increased nutrient availability and uptake, improved energy conversion, and boosted plant metabolic activities. Such result was also reported by Khajuria et al. (2023), Singh et al. (2018) and Chaurasiya et al. (2024). Among the varieties maximum seed yield was recorded in the variety (V_3) Aman and the lowest one was recorded in the variety (V_1) Prakash. The higher seed yield in (V_3) Aman might be due to higher test weight which was significantly superior to the other two varieties. These findings were supported by the findings of Yumnam et al. (2018)

3.5 Effect of Phosphorus and Varieties of Stover Yield (q/ha)

Stover yield data revealed a significant impact of both phosphorus levels and pea varieties in the field experiment as shown in Table 3. Application of phosphorus increases significantly with increased levels of phosphorus up to 60 kg P_2O_5/ha shows a significant difference in stover yield. The combined effect of phosphorus and varieties on the stover yield of pea was found to be significant. The higher stover yield with a suitable dose of phosphorus might be contributed by better growth of the plant as expressed in

Table 3. Effect of phosphorus and varieties on number of pods per plant, seed yield (q/ha) and stover yield (q/ha) of field pea

Treatment	No of pods per plant	Seed Yield (q/ha)	Stover Yield (q/ha)
	Phosphorus levels		
P_1 (0 kg P_2O_5/ha)	8.50	10.00	26.34
P_2 (40 kg P_2O_5/ha)	10.27	14.79	28.92
P_3 (60 kg P_2O_5/ha)	11.17	19.80	29.71
S.Ed (±)	0.08	0.28	0.31
C.D. (P = 0.05)	0.18	0.59	0.65
	Varieties levels		
V_1 (Prakash)	9.74	13.70	27.59
V_2 (Rachna)	9.97	14.71	28.48
V_3 (Amana)	10.24	16.17	28.91
S.Ed (±)	0.08	0.28	0.31
C.D. (P = 0.05)	0.18	0.59	0.65

terms of plant height, number of branches per plant, and fresh and dry weight of the plant. Similar result was also reported by Siddiqui et al. (2022). Maximum stover yield was recorded in the variety (V_3) Aman and the lowest one was recorded in the variety (V_1) Prakash. The variation in stover yield may be due to differences in growth characteristics among the varieties, influenced by their genetic makeup. Such variation in stover yield in different varieties was also reported by Yadav et al. (2016). Phosphorus and variety interaction was found to be non-significant for the stover yield of field pea.

4. CONCLUSION

Based on the result from the experiment it can be concluded that the effect of phosphorus on different varieties on growth and yield of field pea (*Pisum sativum* L.) significantly increases the growth parameters, yield attribute characters and yield under 60 Kg P_2O_5/ha + Aman.The higher yield under treatment 60 Kg P_2O_5/ha + Aman might be because phosphorus plays a vital role in root development, energy transfer and overall plant metabolism. The experiment may further be repeated at least for one or two years to validate/confirm the finding of the current study

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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