Response of Phosphorus and Potash on the Growth and Yield of Field Pea (*Pisum sativum* L.)

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ABSTRACT

A field experiment was conducted at the experimental field of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur during *Rabi* season of the year 2023-24 to study the "Response of phosphorus and potash on the growth and yield of field pea (*Pisum sativum* L.)". The experiment was laid out in Factorial Randomized Block Design (FRBD) of 9(nine) treatments, containing three levels of phosphorus and three levels of potash i.e. $T_1(P_1K_1)$: 0 kg P_2O_5/ha + 0 kg K_2O/ha, $T_2(P_1K_2)$: 0 kg P_2O_5/ha + 30 kg K_2O/ha, $T_3(P_1K_3)$: 0 kg P_2O_5/ha + 60 kg K_2O/ha, $T_4(P_2K_1)$: 40 kg P_2O_5/ha + 0 kg K_2O/ha, $T_5(P_2K_2)$: 40 kg P_2O_5/ha + 30 kg K_2O/ha, $T_6(P_2K_3)$: 40 kg P_2O_5/ha + 60 kg K_2O/ha, $T_7(P_3K_1)$: 80 kg P_2O_5/ha + 0 kg K_2O/ha, $T_8(P_3K_2)$: 80 kg P_2O_5/ha + 30 kg K_2O/ha and $T_9(P_3K_3)$: 80 kg P_2O_5/ha + 60 kg K_2O/ha with three replications. From the present investigation it is found that all the growth attributes and yield attributes were significantly influenced by the application of phosphorus and potash. Maximum growth attributes and yield attributes was also obtained with the application of 80 kg P_2O_5/ha + 60 kg K_2O/ha (T_9) and minimum from 0 kg P_2O_5/ha + 0 kg K_2O/ha (T_1). From the present record it can be concluded that using 80 kg P_2O_5/ha + 60 kg K_2O/ha proved to be more productive and profitable for the cultivation of pea during *Rabi* season in Manipur climatic condition.

Keywords: Pea; phosphorus; potash; growth; yield.

1. INTRODUCTION

Pea (*Pisum sativum* L.) is an important winter season, annual, autogamy (2n=14) pulse crop that belongs to the leguminosae family. It is native of South Europe and grown as a garden or field crop throughout the temperate regions of the world and was originally cultivated in the Mediterranean basin. Pea is one of the most important multipurpose pulse crops grown on a commercial scale in the world over and is consumed either as a fresh succulent vegetable or in processed form. Pea is the second most important food legume in the world after pigeon pea. In a country like India, where a large population is vegetarian, the cheap and best source of protein is still pulses. Pulses constitute an important ingredient in predominantly vegetarian Indian diet. India is a major pulse growing country of the world, accounting roughly for one third of the total area under pulses and one fourth of the world production. Peas are also a valuable source of nutrients, containing high amounts of protein (20-25%), fiber (10-15%), and essential vitamins and minerals like vitamin K, folate and manganese (USDA, 2020).

Application of balanced fertilizer increases vegetative growth and improves yield and quality of the produce. Phosphorus is crucial for root development, energy transfer, and overall plant metabolism (Nadeem *et al.,* 2003). Phosphorus not only enhances the root growth but also promotes early plant maturity. Phosphorus is also 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 legume crops. Potassium plays a vital role in water regulation, enzyme activation, and photosynthesis. Adequate potassium levels can lead to increased vine length, number of pods, pod length, and green pod yield. Potassium is often referred as the quality element for crop production due to its positive interaction with other nutrients (especially with nitrogen) and production practices (Usherwood, 1985). The interaction of phosphorus (P) and potassium (K) has a synergistic effect on pea growth and yield. This combination ensures better nutrient availability and utilization, leading to improved overall plant performance. Both phosphorus and potassium are critical for optimizing the growth and yield of peas, with their combined application providing the best results (Nadeem *et al*., 2003). Studies have shown that the combined application of phosphorus and potassium can have a synergistic effect, enhancing the growth parameters and yield attributes of peas (Muhammad *et al.*, 2004). Keeping the above in view and the known possible reason, the present investigation entitled “Response of phosphorus and potash on the growth and yield of field pea (*Pisum sativum* L.)” was taken up during the *rabi* season of 2023-24, at the experimental field of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur.

2. MATERIAL AND METHODS

The experiment was conducted in *rabi* season of 2023-2024 at the experimental field of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur. The experimental site is located at 24° 43' 24"N latitude and 93° 51' 35" E longitude and at an altitude of 790 m above mean sea level. The texture of soil of the experimental site was clay in plough layer (30 cm). The soil pH was acidic in reaction (5.2) with high organic carbon content (1.9%). The available nitrogen (188 kg/ha) is low and phosphorus (20.0 kg/ha) is medium and potassium (324.0 kg/ha) is high in range according to TNAU soil rating chart. During the period of experimentation, the monthly maximum and minimum temperature were between 22.3^{0}C to 28.9^{0}C and 4.6^{0}C to 8.8^{0}C, and the maximum and minimum relative humidity were recorded between 93% to 94% and 32% to 57%, respectively. There are nine treatments and three replications laid out in a Factorial Randomized Complete Block Design (FRBD). The treatments were: $T_1(P_1K_1)$: 0 kg P_2O_5/ha + 0 kg K_2O/ha, $T_2(P_1K_2)$: 0 kg P_2O_5/ha + 30 kg K_2O/ha, $T_3(P_1K_3)$: 0 kg P_2O_5/ha + 60 kg K_2O/ha, $T_4(P_2K_1)$: 40 kg P_2O_5/ha + 0 kg K_2O/ha, $T_5(P_2K_2)$: 40 kg P_2O_5/ha + 30 kg K_2O/ha, $T_6(P_2K_3)$: 40 kg P_2O_5/ha + 60 kg K_2O/ha, $T_7(P_3K_1)$: 80 kg P_2O_5/ha + 0 kg K_2O/ha, $T_8(P_3K_2)$: 80 kg P_2O_5/ha + 30 kg K_2O/ha and $T_9(P_3K_3)$: 80 kg P_2O_5/ha + 60 kg K_2O/ha. Recommended dose of Nitrogen (20 kg/ha) was applied on every plot through urea, along with phosphorus (0, 40, 80 kg/ha) through single super phosphate (SSP) and potash (0, 30, 60 kg/ha) through murate of potash (MOP) were applied to all the treatments accordingly at the time of sowing.

The biometric observations on different growth and yield attributes were recorded at various growth periods.

3. RESULTS AND DISCUSSION

3.1 Response of phosphorus and potash on plant height (cm)

Data on plant height (cm) at 30 DAS, 60 DAS, 90 DAS and at harvest as influenced by different levels of phosphorus and potash are presented in table 1. A perusal of data from different levels of phosphorus exhibited significant differences in plant height. Among the phosphorus levels, application of 80 kg P_2O_5/ha (P_3) recorded the maximum plant height (10.46, 29.63, 42.41 and 45.04 cm) which was followed by 40 kg P_2O_5/ha (P_2) and minimum plant height (9.0, 23.18, 34.58 and 35.73 cm) was recorded from 0 kg P_2O_5/ha (P_1), at all the stages recorded. Application of potash also significantly influenced the plant height at all four stages of observation. Among the levels of potash, the addition of 60 kg K_2O/ha (K_3) recorded significantly taller plants (9.90, 27.40, 39.37 and 41.36 cm) followed by 30 kg K_2O/ha (K_2) and lowest plant height (9.40, 24.91, 36.92 and 38.48 cm) was observed from 0 kg K_2O/ha (K_1). The interaction between phosphorus and potash was found to be significant at all the four stages recorded. The treatment combination P_3K_3 recorded significantly the highest (10.9, 31.73, 44.05 and 46.86 cm) order of interaction but it remained at par with P_3K_2 (10.27 cm), again P_3K_2 (10.27 cm) also remained at par with P_3K_1 (10.22 cm) only at 30DAS but it was significantly superior to all the other treatment combinations at other recorded stages. This might be due to increase in phosphorus level which increases the activity of Rhizobium and thus increases N-fixation in the root nodules, thereby improving plant growth and development. Phosphorus is important in root developments and translocation of photosynthates and being ingredient like nucleic acid and phospholipids its application increases different growth parameters, (Srivastava and Ahlawat 1995). Similar results under phosphorus and potash treatments were found to be in agreement with Smith *et al.* (2015), Jones and White (2016), Nadia *et al.* (2021) and Choudhary *et al.* (2019) on plant height of pea.

Table 1. Response of phosphorus and potash on plant height (cm)

Treatments	30DAS	60DAS	90DAS	At harvest
Phosphorus				
P_1	9.00	23.18	34.58	35.73
P_2	9.50	25.60	37.81	39.09
P_3	10.27	29.29	42.39	45.04
S.Ed (±)	0.03	0.16	0.19	0.17
C.D	0.07	0.34	0.40	0.36
Potash				
K_1	9.44	24.96	37.02	38.48
K_2	9.60	26.02	38.47	39.97
K_3	9.74	27.07	39.30	41.41
S.Ed (±)	0.03	0.16	0.19	0.17
C.D	0.07	0.34	0.40	0.36
Phosphorus x Potash				
P_1K_1	8.77	21.80	33.12	34.03
P_1K_2	9.09	23.59	35.09	36.08
P_1K_3	9.16	24.14	35.54	37.08
P_2K_1	9.32	25.03	36.86	37.89
P_2K_2	9.44	25.44	38.04	39.09
P_2K_3	9.75	26.32	38.53	40.30

P_3K_1	10.22	28.07	41.07	43.53
P_3K_2	10.27	29.03	42.27	44.74
P_3K_3	10.31	30.76	43.83	46.86
S.Ed (±)	0.06	0.27	0.33	0.29
C.D	0.12	0.58	0.70	0.62

3.2 Response of phosphorus and potash on number of branches per plant

Data on number of branches per plant was significantly influenced by different levels of phosphorus and potash as presented in table 2. Among the phosphorus levels, application of 80 kg P_2O_5/ha (P_3) recorded the maximum number of branches (1.47, 2.79, 3.29 and 4.35) which was followed by 40 kg P_2O_5/ha (P_2) and minimum number of branches (1.07, 1.96, 2.16 and 3.05) was recorded from 0 kg P_2O_5/ha (P_1), at all the stages recording. It may be due to synthesis of more phyto-hormones with the increased of phosphorus which results in maximum growth and more number of branches per plant. This result is found similar with the finding of Lee *et al.* (2020) and O'Brien *et al*. (2023). Among the levels of potash, the addition of 60 kg K_2O/ha (K_3) recorded significantly higher number of branches (1.36, 2.50, 2.82 and 3.81) plants which was followed by 30 kg K_2O/ha (K_2) and minimum number of branches (1.20, 2.15, 2.49 and 3.40) was recorded from 0 kg K_2O/ha (K_1). This might be due to increase in potassium level which increased the availability of nitrogen and phosphorus (Sahai, 2004) which resulted in better plant growth and more number of branches per plant. These results conform to the findings of Basavesha *et al*. (2016) and Prajapati *et al*. (2017). The interaction between phosphorus and potash was found to be significant at all the stages recorded. The treatment combination P_3K_3 recorded significantly the highest (1.57, 3.13, 3.54, and 4.57) order of interaction and it was significantly superior to all the other treatment combination. The lowest was observed in P_1K_1 i.e. 0.97, 1.90, 2.03 and 2.75. These results are in agreement with Bashir *et al.* (2018).

Table 2. **Response of phosphorus and potash on number of branches per plant**

Treatments	30DAS	60DAS	90DAS	At harvest
Phosphorus				
P_1	1.07	1.96	2.16	3.05
P_2	1.28	2.25	2.50	3.48
P_3	1.47	2.79	3.29	4.35
S.Ed (±)	0.01	0.07	0.03	0.03
C.D	0.03	0.14	0.06	0.05
Potash				
K_1	1.20	2.15	2.49	3.40
K_2	1.26	2.35	2.65	3.67
K_3	1.36	2.50	2.82	3.81
S.Ed (±)	0.01	0.07	0.03	0.03
C.D	0.03	0.14	0.06	0.05
Phosphorus x Potash				
P_1K_1	0.97	1.90	2.03	2.75
P_1K_2	1.06	1.98	2.18	3.16
P_1K_3	1.18	2.00	2.28	3.24
P_2K_1	1.23	2.13	2.37	3.29
P_2K_2	1.28	2.24	2.51	3.51

P_2K_3	1.31	2.38	2.63	3.63
P_3K_1	1.40	2.40	3.07	4.15
P_3K_2	1.42	2.83	3.25	4.34
P_3K_3	1.57	3.13	3.54	4.57
S.Ed (±)	0.03	0.12	0.05	0.04
C.D	0.05	0.25	0.10	0.09

3.3 Response of phosphorus and potash on number of pods per plant

Data on number of pods per plant was significantly influenced by different levels of phosphorus and potash as presented in table 3. At harvest, significantly highest number of pods per plant (10.87) associated with phosphorus fertilizer was observed with application of 80 kg P_2O_5/ha (P_3) which followed by 40 kg P_2O_5/ha (P_2) i.e. (9.87) and least number of pods were recorded in 0 kg P_2O_5/ha (P_1) i.e. (9.14). The beneficial effect of phosphorus on numbers of pods per plant was reported by Gupta *et al.* (2015). The highest number of pods per plant (10.26) associated with potash fertilizer was observed with application of 60 kg K_2O/ha (K_3) which was followed by 30 kg K_2O/ha (K_2) number of pods (9.98) and minimum number of pods (9.64) was observed from 0 kg K_2O/ha (K_1). The results are almost same as reported by (Samiullah and Khan, 2003) who noticed that addition of potassium @ 40 kg ha^{-1} doubled the number of pods per plant. The highest number of pods per plant (11.40) was recorded with combined application of P_3K_3 which was followed by P_3K_2 (10.86) but P_3K_1 (10.35) and P_2K_3 (10.13), P_1K_3 (9.25) and P_1K_2 (9.15) were observed to be at par with each other. The minimum number of pod per plant (9.02) was recorded at control (P_1K_1). Higher number of branches per plant in this treatments influenced higher number of pods per plant. This may be due to influenced of phosphorus and potash fertilizers which results in increased of available nitrogen that promotes better plants growth, flowering and fruiting which resulted in higher number of pods per plant. These results are in agreement with Kumar *et al.* (2019).

3.4 Response of phosphorus and potash on pod length (cm)

Data on pod length was significantly influenced by different levels of phosphorus and potash as presented in table 3. At harvest, significantly longest pod length (8.71 cm) associated with phosphorus fertilizer was observed with application of 80 kg P_2O_5/ha (P_3) which was followed by 40 kg P_2O_5/ha (P_2) i.e. (6.73 cm) and least pod length was recorded in 0 kg P_2O_5/ha (P_1) i.e. (5.07 cm). Ranjan *et al.* (2018) found that increased phosphorus levels in chickpeas resulted in significantly longer pods. The longest pod length (7.14 cm) associated with potash fertilizer was observed with application of 60 kg K_2O/ha (K_3) which was followed by 30 kg K_2O/ha (K_2) i.e. (6.90 cm) and minimum pod length was recorded at 0 kg K_2O/ha (K_1) i.e. (6.46 cm). The beneficial effect of potash on pod length was reported by (Das *et al.,* 2018)**.** The longest pod length (8.84 cm) was recorded with combined application of P_3K_3 which was followed by P_3K_2 (8.73 cm) and it's significantly superior to all the other treatment combinations and P_1K_2 (5.24 cm) was observed to be at par with P_1K_3 (5.30 cm). The shortest was observed in control (P_1K_1) i.e. (4.67 cm). This might be due to the influenced of phosphorus and potash fertilizer which increased the available nutrient that has satisfied the nutrition demand of pea at different growth stages thereby increasing pod length. Khan *et al.* (2017) also demonstrated that the application of both phosphorus and potassium led to improved pod length and overall yield in soybeans.

3.5 Response of phosphorus and potash on seed yield (q/ha)

Data on seed yield was significantly influenced by different levels of phosphorus and potash as presented in table 3. At harvest, significantly higher seed yield (17.25 q/ha) associated with phosphorus fertilizer was observed with application of 80 kg P_2O_5/ha (P_3) which was followed by 40 kg P_2O_5/ha (P_2) i.e. (12.06 q/ha) and least seed yield was recorded in 0 kg P_2O_5/ha (P_1) i.e. (8.18 q/ha). The increase in seed yield at higher levels of phosphorus may be attributed to the role of phosphorus in the energization processes and being the constituent of ribonucleic acid, deoxyribonucleic acid and ATP which regulate vital metabolic processes in the plant, helping in root formation and nitrogen fixation which in turn favors better yield of the crop. The beneficial effect of phosphorus on seed yield in chickpea was reported by Gupta *et al.* (2015). The higher seed yield (13.53 q/ha) associated with potash fertilizer was observed with application of 60 kg K_2O/ha (K_3) which was followed by 30 kg K_2O/ha (K_2) i.e. (12.70 q/ha) and minimum seed yield was recorded at 0 kg K_2O/ha (K1) i.e. (11.26 q/ha). Similar observation was also recorded by Kumar *et al.* (2015) on seed yield of pea. The highest seed yield (18.32 q/ha) was recorded with combined application of P_3K_3 which was followed by P_3K_2 (17.37 q/ha) and it's significantly superior to all the other treatment combinations. The lowest seed yield was observed at control (P_1K_1) i.e. (7.44 q/ha). Similar results were recorded by Hassan *et al.* (2019) and Nadia *et al.* (2020) in pea.

Table 3. Response of phosphorus and potash on number of pods, pod length (cm) and seed yield (q/ha)

Treatments	Number of pods	Pod length (cm)	Seed yield (q/ha)
Phosphorus			
P_1	9.14	5.07	8.18
P_2	9.87	6.73	10.48
P_3	10.87	8.65	13.65
S.Ed (±)	0.06	0.05	0.06
C.D	0.14	0.10	0.13
Potash			
K_1	9.64	6.43	10.12
K_2	9.98	6.87	10.80
K_3	10.26	7.15	11.39
S.Ed (±)	0.06	0.05	0.06
C.D	0.14	0.10	0.13
Phosphorus x Potash			
P_1K_1	9.02	4.67	7.44
P_1K_2	9.15	5.24	8.35
P_1K_3	9.25	5.30	8.74
P_2K_1	9.55	6.19	9.98
P_2K_2	9.93	6.71	10.42
P_2K_3	10.13	7.29	11.05
P_3K_1	10.35	8.44	12.94
P_3K_2	10.86	8.65	13.64
P_3K_3	11.40	8.87	14.38
S.Ed (±)	0.11	0.08	0.10
C.D	0.24	0.17	0.22

4. CONCLUSION

From the study, it has clearly indicated that used of (80 kg P_2O_5/ha + 60 kg K_2O/ha) was found to be superior in increasing growth attributing factors of pea compared to other treatment. This concludes that using of (80 kg P_2O_5/ha + 60 kg K_2O/ha) also increased the yield attributes of such as seed yield of pea compared to other treatment which eventually leads to better net returns.

COMPETING INTERESTS DISCLAIMER:
Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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