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Response of Phosphorus and Potash on the 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

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 monitor 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 +

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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 were obtained with the application of 80 kg P_2O_5/ha + 60 kg K_2O/ha (T_9) and the lowest were observed 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; yields.

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 to Southern 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 the predominantly vegetarian Indian diet. India is a major pulse-growing country in 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).

The 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. MATERIALS AND METHODS

The experiment was conducted in the *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, phosphorus (20.0 kg/ha) is medium and potassium (324.0 kg/ha) is high in range according to the 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. The 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 the 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 the 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 of P_3K_3 recorded significantly the highest (10.9, 31.73, 44.05 and 46.86 cm) 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 the increased level of phosphorus in the root nodules, which increases the activity of Rhizobium and thus increases N-fixation, thereby improving plant growth and development. Phosphorus is important in root developments and translocation of photosynthates, and being ingredient like nucleic acid and phospholipids, it increases different growth parameters, (Srivastava and Ahlawat 1995). Similar results under phosphorus and potash treatments were found to be in agreement with Mubeen et al*.* (2013) and Araei et al*.* (2014)**.**

3.2 Response of Phosphorus and Potash on Number of Branches Per Plant

Data on the 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 the 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 recorded. The positive effect of phosphorus on number of branches per plant could be due to the significant role of the element on cell division and elongation, which resulted in the production of more lateral buds that developed into branches (Namakka et al*.* 2017). These results were in agreement with the finding of Ayodele and Oso (2014). Among the levels of potash, the addition of 60 kg K_2O/ha (K_3) recorded a 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). The increased number of branches per plant due to increased application of K fertilizer as reported by Nibedita et al*.* (2017) corroborated the present findings. The interaction between phosphorus and potash was found to be significant at all the stages recorded. The treatment combination of P_3K_3 recorded significantly the highest (1.57, 3.13, 3.54, and 4.57), 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) and Muhammad et al*.* (2015).

3.3 Response of Phosphorus and Potash on Number of Pods Per Plant

Data on the number of pods per plant was significantly influenced by different levels of phosphorus and potash, as presented in Table 3. At harvest, the significantly highest number of pods per plant (10.87) associated with phosphorus fertilizer was observed with the application of 80 kg P_2O_5/ha (P_3) which was followed by 40 kg P_2O_5/ha (P_2) i.e. (9.87) and the 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 Saurav et al. (2024). The highest number of pods per plant (10.26) associated with potash fertilizer was observed with the application of 60 kg K_2O/ha (K_3) which was followed by 30 kg K_2O/ha (K_2) i.e. (9.98) and the minimum number of pods (9.64) was observed from 0 kg K_2O/ha (K_1). The results are almost the same as reported by (Samiullah and Khan, 2003) who noticed that the 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 the 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 pods per plant (9.02) was recorded at control (P_1K_1). 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. The higher number of branches per plant has also influenced the higher number of pods per plant. These results are in agreement with Muhammad et al. (2015).

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, the significantly longest pod length (8.71 cm) associated with phosphorus fertilizer was observed with the 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). The longest pod length (7.14 cm) associated with potash fertilizer was observed with the application of 60 kg K_2O/ha (K_3) which was followed by

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

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

30 kg K_2O/ha (K_2) i.e. (6.90 cm) and the minimum pod length was recorded at 0 kg K_2O/ha (K_1) i.e. (6.46 cm). The longest pod length (8.84 cm) was recorded with the 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 have satisfied the nutrition demand of pea at different growth stages, thereby increasing pod length. Nadeem et al. (2003) demonstrated that the individual and interaction effect of phosphorus and potassium led to improved pod length significantly in pea.

3.5 Response of Phosphorus and Potash on Seed yield (q/ha)

Data on the seed yield was significantly influenced by different levels of phosphorus and potash, as presented in Table 3. At harvest, the significantly higher seed yield (17.25 q/ha) associated with phosphorus fertilizer was observed with the 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

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

favors better yield of the crop. The beneficial effect of phosphorus on seed yield in hybrid maize was reported by Nanthakumar et al. (2014). The higher seed yield (13.53 q/ha) associated with potash fertilizer was observed with the 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 the minimum seed yield was recorded at 0 kg K_2O/ha (K1) i.e. (11.26 q/ha). A similar observation was also recorded by Dudhade et al. (2021) on the seed yield of summer groundnut. The highest seed yield (18.32 q/ha) was recorded with the 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 Ahmed et al. (2024) in maize.

4. CONCLUSION

The results obtained from this trial indicated that application of 80 kg P_2O_5/ha + 60 kg K_2O/ha under the *rabi* season of Manipur, was found to be superior in increasing growth and yield attributing factors of filed pea compared to other treatments. This concludes that application of 80 kg P_2O_5/ha + 60 kg K_2O/ha is recommended for better growth and yield of field pea.

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 the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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