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Response of sesame (*Sesamum indicum* L.) to different levels of phosphorus and potassium on growth and yield

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Abstract

A field experiment was conducted during *kharif* 2025 at the Post Graduate Institute Instructional Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, to study the response of sesame (*Sesamum indicum* L.) different levels of phosphorus and potassium. Sesame variety JLT-408 was evaluated in a split-plot design with three replications, with phosphorus (15, 30 and 45 kg P_2O_5 ha^{-1}) in main plots and potassium (15, 30 and 45 kg K_2O ha^{-1}) in sub-plots. A uniform basal dose of 50 kg N ha^{-1} and 5 t FYM ha^{-1} was applied to all plots. The interaction effect of phosphorus and potassium was significant, and the combination of 45 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1} (P_3K_2) recorded significantly higher plant height (128.36 cm), branches $plant^{-1}$ (3.91) and dry matter $plant^{-1}$ (12.16 g) at harvest. The same combination also recorded the highest seed yield (685 kg ha^{-1}) and straw yield (2274 kg ha^{-1}), indicating a positive synergistic interaction between phosphorus and potassium. Under the conditions of this study, the combined application of 45 kg P_2O_5 and 30 kg K_2O ha^{-1}, along with 50 kg N ha^{-1} and 5 t FYM ha^{-1}, was found most effective in enhancing growth and productivity of sesame, with the highest seed yield among the combinations tested.

Keywords: Sesame, Phosphorus, Potassium, Growth and yield

1. Introduction

Sesame (*Sesamum indicum* L.) is one of the earliest oilseed crops cultivated in India, with its origins tracing back to the Harappan civilization. Belonging to the family Pedaliaceae and genus *Sesamum*, this East Indian flowering plant is widely recognized by various names such as til, gingelly, simsim, and gergelim. Among oilseed crops in India, sesame ranks fifth in importance after groundnut, rapeseed-mustard, soybean, and sunflower. Sesame seeds are notable for their high oil content (38 - 54 %) and substantial protein level (18 - 20 %), providing essential amino acids such as methionine and tryptophan, as well as vitamin B_5 (niacin) and minerals including calcium and phosphorus. They also contain lignans like sesamin and sesamolin; upon hydrolysis, sesamolin produces sesamol, a compound with strong antioxidant properties that contributes to the seeds' extended shelf life and has led to their traditional designation as the "seed of immortality" (Valiki *et al*., 2015) [1].

During the 2025 - 26 *kharif* season, the total area under sesame cultivation in India was recorded at approximately 9.83 lakh hectares (ha), indicating a marginal decline compared to the 10.46 lakh ha observed during the preceding 2024 - 25 season. (Anon., 2025) [2]. Phosphorus and potassium rank among the primary limiting nutrients for plants. Phosphorus serves as a vital nutrient, promoting plant growth and development to boost crop yields. As a key component of essential structures like plasma membranes, nucleic acids, coenzymes, and various phosphorylated organic compounds, it is essential for various physiological functions (Pandey *et al*., 1986) [3]. *Phosphorus excels* at forming energy - rich bonds in plants via compounds such as ADP and ATP (Troeh *et al*., 1993) [4].

Phosphorus application generally promotes greater root density and expansion, allowing plants to better access and deliver nutrients and water to developing areas. This enhances overall growth and yield parameters, leading to higher seed numbers and dry matter production. By contrast, insufficient phosphorus leads to a severe decline in plant growth and development. Such deficiency boosts tri-phosphate accumulation in chloroplasts, thereby limiting sucrose for plant growth (Thomson *et al.,* 1992) [5]. Potassium serves as the "quality element" in crop production. Sufficient potassium nutrition enhances numerous crop quality features, such as oil levels in oilseed crops. Additionally, it helps counteract damaging abiotic stresses in plants (Maser *et al.,* 2002; Cakmak, 2005; Li *et al.,* 2014) [7, 6, 8]. Scarce potassium mine reserves, combined with inefficient fertilizer application, have impeded advances in crop yields (Jin, 2012) [9].

In view of the important roles of phosphorus and potassium in plant growth, development and yield formation, their balanced application is essential for improving sesame productivity.

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2. Materials and Methods

The field experiment was conducted during the *kharif* season of 2025 - 26 at the Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahilyanagar, Maharashtra. The experimental site was situated at 19°19′ to 19°57′ N latitude and 74°19′ to 74°32′ E longitude with an elevation of 495 - 596 m above mean sea level. The soil of the experimental field was clayey in texture, alkaline in reaction with pH 8.06, electrical conductivity of 0.38 dS m^{-1} and organic carbon 0.54%. The soil was low in available nitrogen (191 kg ha^{-1}), medium in available phosphorus (17.56 kg ha^{-1}) and very high in available potassium (377 kg ha^{-1}).

The experiment was laid out in a Split Plot Design with three replications and 27 experimental plots. Three phosphorus levels were assigned to the main plots viz., P_1: 15 kg P_2O_5 ha^{-1}, P_2: 30 kg P_2O_5 ha^{-1} and P_3: 45 kg P_2O_5 ha^{-1}, while three potassium levels were assigned to the sub-plots viz., K_1: 15 kg K_2O ha^{-1}, K_2: 30 kg K_2O ha^{-1} and K_3: 45 kg K_2O ha^{-1}. Sesame variety JLT-408 was used for the investigation. The gross plot size was 4.50 × 3.15 m and net plot size was 4.10 × 2.25 m, with spacing of 45 × 10 cm. A recommended dose of 50:00:00 N:P_2O_5: K_2O kg ha^{-1} was followed, with phosphorus and potassium applied according to the respective treatments. Seed treatment with *Azotobacter,* PSB and KMB was common to all treatments.

Five randomly selected plants from each net plot were used for recording biometric observations. Plant height and number of branches $plant^{-1}$ were recorded at 30 and 60 days after sowing and at harvest, while dry matter was recorded during crop growth. Seed, straw and biological yields were recorded and expressed on hectare basis.

3. Results and Discussion

3.1 Effect of phosphorus levels

The application of phosphorus significantly influenced the growth and yield. At harvest, progressive improvement in growth attributes was observed with increasing phosphorus levels. Plant height increased from 114.40 cm with 15 kg P_2O_5 ha^{-1} (P_1) to 122.06 cm with 30 kg P_2O_5 ha^{-1} (P_2) and further to 125.40 cm with 45 kg P_2O_5 ha^{-1} (P_3) which at par with (P_2). Similarly, number of branches $plant^{-1}$ increased from 3.50 in 15 kg P_2O_5 ha^{-1} (P_1) to 3.73 in 30 kg P_2O_5 ha^{-1} (P_2) and 3.83 in 45 kg P_2O_5 ha^{-1} (P_3), while dry matter production increased from 10.89 g in 15 kg P_2O_5 ha^{-1} (P_1) to 11.58 g in 30 kg P_2O_5 ha^{-1} (P_2) and 11.89 g $plant^{-1}$ in 45 kg P_2O_5 ha^{-1} (P_3) which at par with (P_2). The higher growth under P_3 may be attributed to the important role of phosphorus in root development, energy transfer and other physiological processes, which favoured better plant growth and dry matter accumulation. Similar beneficial effects of phosphorus application on growth and yield of sesame have been reported by Priyadarshini *et al.* (2021) [10] and Thakur *et al.* (2015) [11].

The increasing phosphorus level also improved yield performance. Seed yield increased significantly from 516 kg ha^{-1} under P_1 to 609 kg ha^{-1} under P_2 and 649 kg ha^{-1} under P_3 which at par with (P_2) and Straw yield increased from 1742 (P_1) to 2038 (P_2) and 2162 kg ha^{-1} under (P_3) which at par with (P_2). The improvement in yield with phosphorus application could be associated with better crop growth and efficient utilization of nutrients, resulting in greater biomass production and seed formation. The results agree with the findings of Priyadarshini *et al.* (2021) [10], who reported improved growth and yield of sesame with increasing phosphorus levels.

3.2 Effect of potassium levels

Potassium application showed a progressive numerical improvement in growth, yield and economic performance of sesame. At harvest, plant height increased from 117.62 cm with 15 kg K_2O ha^{-1} (K_1) to 121.14 cm with 30 kg K_2O ha^{-1} (K_2) and 123.10 cm with 45 kg K_2O ha^{-1} (K_3) which at par with (K_2). Number of branches $plant^{-1}$ increased from 3.60 in 15 kg K_2O ha^{-1} (K_1) to 3.70 in 30 kg K_2O ha^{-1} (K_2) and 3.76 in 45 kg K_2O ha^{-1} (K_3) which at par with (K_2), while dry matter increased from 11.18 in 15 kg K_2O ha^{-1} (K_1) to 11.50 in 30 kg K_2O ha^{-1} (K_2) and 11.68 g $plant^{-1}$ in 45 kg K_2O ha^{-1} (K_3) which at par with (K_2). The increase in growth with potassium application may be related to its role in enzyme activation, regulation of water relations and efficient translocation of photosynthates within the plant. Similar improvement in sesame growth with potassium nutrition was reported by Fang *et al.* (2024) [12] and Olaniyi (2011) [13].

Yield performance was also improved with increasing potassium levels. Seed yield increased from 557 kg ha^{-1} under K_1 to 599 kg ha^{-1} under K_2 and 619 kg ha^{-1} under K_3 which at par with K_2. Straw yield increased from 1871 to 2002 and 2069 kg ha^{-1} under K_3 which at par with K_2. The improvement in yield under higher potassium supply may be due to better photosynthetic activity, assimilate translocation and overall crop growth. Similar positive responses of sesame yield to potassium application have been reported by Ahmad *et al.* (2018) [14], Fang *et al.* (2024) [12] and Olaniyi (2011) [13].

3.3 Interaction effect of phosphorus and potassium

The interaction effect between phosphorus and potassium levels on plant height of sesame was found to be significant at harvest. However, the treatment combination P_3K_2 (45 kg P_2O_5 + 30 kg K_2O ha^{-1}) recorded the numerically highest plant height was 128.36 cm at harvest. The lowest plant height at harvest was recorded under P_1K_1 (15 kg P_2O_5 + 15 kg K_2O ha^{-1}), with 110.10 cm. The favourable numerical response under combined phosphorus and potassium application may be associated with improved nutrient availability and vegetative growth. Similar favourable effects of combined phosphorus and potassium application on sesame growth were reported by Priyadarshini *et al.* (2021) [10].

The interaction between phosphorus and potassium levels significantly influenced the number of branches $plant^{-1}$ of sesame at harvest. At harvest, P_3K_2 recorded the maximum number of branches (3.91 $plant^{-1}$), which was at par with P_3K_3 (3.82 $plant^{-1}$) and P_2K_3 (3.80 $plant^{-1}$). The minimum number of branches was recorded under P_1K_1 (2.52 $plant^{-1}$). The improvement in branching may be attributed to the complementary roles of phosphorus and potassium in plant growth and nutrient utilization. Similar findings were reported by Priyadarshini *et al.* (2021) [10] and Gobika *et al.* (2023) [15].

The interaction effect between phosphorus and potassium levels on dry matter production $plant^{-1}$ of sesame was significant at harvest. At harvest, P_3K_2 recorded the maximum dry matter production of 12.16 g $plant^{-1}$, which was at par with P_3K_3 (11.88 g $plant^{-1}$) and P_2K_3 (11.83 g $plant^{-1}$). The lowest dry matter production at harvest was recorded under P_1K_1 (10.49 g $plant^{-1}$). The increase in dry matter production may be associated with improved vegetative growth and nutrient utilization. Similar responses of sesame to phosphorus fertilization were reported by Hafiz *et al.* (2012) [16] and Ibrahim *et al.* (2014) [17].

The interaction effect between phosphorus and potassium levels on seed yield of sesame indicated that the highest numerical seed yield of 685 kg ha^{-1} was recorded under P_3K_2 (45 kg P_2O_5 + 30 kg K_2O ha^{-1}) at par with P_3K_3 (656 kg ha^{-1}) and P_2K_3 (653 kg ha^{-1}). The lowest seed yield of 486 kg ha^{-1} was recorded under P_1K_1 (15 kg P_2O_5 + 15 kg K_2O ha^{-1}). The higher seed yield under P_3K_2 suggests that the combination of 45 kg P_2O_5 and 30 kg K_2O ha^{-1} provided a favourable nutrient balance for sesame seed production under the experimental conditions. Similar beneficial effects of appropriate nutrient management on sesame growth and yield were reported by Gobika *et al.* (2023) [15] and Fang *et al.* (2024) [12].

The interaction effect between phosphorus and potassium levels on straw yield of sesame showed that the highest straw yield of 2,274 kg ha^{-1} was recorded under P_3K_2 (45 kg P_2O_5 + 30 kg K_2O ha^{-1}). This treatment was at par with by P_3K_3 (2,185 kg ha^{-1}) and P_2K_3 (2,178 kg ha^{-1}). The lowest straw yield of 1,649 kg ha^{-1} was recorded under P_1K_1 (15 kg P_2O_5 + 15 kg K_2O ha^{-1}). The higher straw yield under the combined application of phosphorus and potassium may be associated with better vegetative growth and greater ac

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cumulation of plant biomass. The present results are supported by Priyadarshini *et al.* (2021) [10]

Table 1. Effect of phosphorus and potassium on growth contributing characters of sesame as influenced by different treatment

Sr. No.	Treatments		At harvest		
			Plant height (cm)	Number of branches	Dry matter (g)
A.	Main plot: Phosphorus levels (P_2O_5)				
	P_1	15 kg ha^{-1}	114.40	3.50	10.89
	P_2	30 kg ha^{-1}	122.06	3.73	11.58
	P_3	45 kg ha^{-1}	125.40	3.83	11.89
	SE m ±		0.91	0.03	0.08
	CD at 5 %		3.55	0.10	0.32
B.	Sub plot: Potassium levels (K_2O)				
	K_1	15 kg ha^{-1}	117.62	3.60	11.18
	K_2	30 kg ha^{-1}	121.14	3.70	11.50
	K_3	45 kg ha^{-1}	123.10	3.76	11.68
	SE m ±		0.79	0.02	0.07
	CD at 5 %		2.44	0.07	0.22
C.	Interaction (P × K)				
	Between two potassium levels means at same level of phosphorus levels means				
	SE m ±		1.37	0.04	0.12
	CD at 5 %		4.22	0.12	0.39
	Between two phosphorus levels means at same level of potassium levels means				
	SE m ±		1.44	0.04	0.13
	CD at 5 %		4.92	0.14	0.45
	General mean		120.62	3.69	11.45

Table 1.1. Interaction effects between phosphorus and potassium levels on plant height of sesame at harvest

Phosphorus levels / Potassium levels	Plant height (cm)			
	P_1	P_2	P_3	Mean
K_1	110.10	120.17	122.59	117.62
K_2	113.77	121.31	128.36	121.14
K_3	119.35	124.70	125.26	123.10
Mean	114.40	122.06	125.40	120.62
Source			SE m ±	CD at 5 %
Between two potassium levels mean at same level of phosphorus levels mean			1.37	4.22
Between two phosphorus levels mean at same level of potassium levels mean			1.44	4.92

Table 1.2. Interaction effects between phosphorus and potassium levels on number of branches plant-$_1$ of sesame at harvest

Phosphorus levels / Potassium levels	Number of branches plant^{-1}			
	P_1	P_2	P_3	Mean
K_1	3.38	3.67	3.74	3.60
K_2	3.48	3.71	3.91	3.70
K_3	3.65	3.80	3.82	3.76
Mean	3.50	3.73	3.83	3.69
Source			SE m ±	CD at 5 %
Between two potassium levels mean at same level of phosphorus levels mean			0.04	0.12

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Phosphorus levels / Potassium levels	Number of branches plant^{-1}			
	P_1	P_2	P_3	Mean
Between two phosphorus levels mean at same level of potassium levels mean			0.04	0.14

Table 1.3. Interaction effects between phosphorus and potassium levels on dry matter production plant$_{-1}$ of sesame at harvest

Phosphorus levels / Potassium levels	Dry matter production plant^{-1} (g)			
	P_1	P_2	P_3	Mean
K_1	10.49	11.41	11.63	11.18
K_2	10.83	11.52	12.16	11.50
K_3	11.34	11.83	11.88	11.68
Mean	10.89	11.58	11.89	11.45
Source			SE m ±	CD at 5 %
Between two potassium levels mean at same level of phosphorus levels mean			0.12	0.39
Between two phosphorus levels mean at same level of potassium levels mean			0.13	0.45

Table 2. Effect of phosphorus and potassium on seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of sesame as influenced by different treatment.

Sr. No.	Treatments		Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
A.	Main plot: Phosphorus levels (P_2O_5)			
	P_1	15 kg ha^{-1}	516	1742
	P_2	30 kg ha^{-1}	609	2038
	P_3	45 kg ha^{-1}	649	2162
	SE m ±		10	32
	CD at 5 %		40	125
B.	Sub plot: Potassium levels (K_2O)			
	K_1	15 kg ha^{-1}	557	1871
	K_2	30 kg ha^{-1}	599	2002
	K_3	45 kg ha^{-1}	619	2069
	SE m ±		7	23
	CD at 5 %		23	70
C.	Interaction (P × K)			
	Between two potassium levels means at same level of phosphorus levels means			
	SE m ±		13	39
	CD at 5 %		39	122
	Between two phosphorus levels means at same level of potassium levels means			
	SE m ±		15	45
	CD at 5 %		51	159
	General mean		592	1981

Table 2.1. Interaction effects between phosphorus and potassium levels on seed yield of sesame at harvest

Phosphorus Potassium levels / levels	Seed yield (kg ha^{-1})			
	P_1	P_2	P_3	Mean
K_1	486	577	607	557
K_2	514	597	685	599
K_3	549	653	656	619
Mean	516	609	649	592

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Phosphorus Potassium levels levels	Seed yield (kg ha^{-1})			
	P_1	P_2	P_3	Mean
Source			SE m ±	CD at 5 %
Between two potassium levels mean at same level of phosphorus levels mean			13	39
Between two phosphorus levels mean at same level of potassium levels mean			15	51

yield of sesame at harvest

Table 2.2. Interaction effects between phosphorus and potassium levels on straw

Phosphorus Potassium levels levels	Straw yield (kg ha^{-1})			
	P_1	P_2	P_3	Mean
K_1	1649	1937	2026	1871
K_2	1734	1999	2274	2002
K_3	1844	2178	2185	2069
Mean	1742	2038	2162	1981
Source			SE m ±	CD at 5 %
Between two potassium levels mean at same level of phosphorus levels mean			39	122
Between two phosphorus levels mean at same level of potassium levels mean			45	159

Conclusion

Based on a single season trial, it can be concluded that application of phosphorus 45 kg ha^{-1} and potassium 30 kg ha^{-1} (P_3K_2) along with recommended dose of nitrogen 50 kg ha^{-1} is beneficial for the growth and yield of sesame.

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Conflict of interest

The authors declare there are no conflict of interest relevant to this article

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