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Effect of Levels of Potassium on Yield Attributes, Seed and Stover Yield, and Uptake of Nitrogen, Phosphorus and Potassium by Mustard (*Brassica juncea L.*) Grown in Black Cotton Soil

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Abstract
A field experiment was conducted during the rabi season of 2025-26 at AICRP Mustard, College of Agriculture, Nagpur, on a black cotton soil (Vertisol) to study the effect of graded levels of potassium on yield attributes, seed and stover yield, and the uptake of nitrogen, phosphorus and potassium by mustard (Brassica juncea L.) variety PDKV-Kartik. The experiment was laid out in a Randomized Block Design with seven treatments T1: absolute control, T2: RDF (50:40 kg N:P ha^{-1}), and T3 to T7 comprising RDF supplemented with 10, 20, 30, 40 and 50 kg K ha^{-1}, respectively replicated thrice. Application of potassium significantly and progressively improved yield-attributing characters, with the number of siliquae $plant^{-1}$ and test weight rising from 175.53 and 4.64 g under the control to a maximum of 258.40 and 5.23 g, respectively, at the higher potassium levels. Seed yield increased from 10.55 q ha^{-1} (T1) to 16.62 q ha^{-1} (T7), and stover yield increased from 28.48 q ha^{-1} (T1) to 45.69 q ha^{-1} (T7). Total nitrogen, phosphorus and potassium uptake by the crop (seed + stover) also increased consistently with potassium application, from 55.70, 14.50 and 30.72 kg ha^{-1} under the control to 103.03, 34.20 and 61.60 kg ha^{-1}, respectively, under T7 (RDF + 50 kg K ha^{-1}). The results indicate that balanced fertilization with nitrogen and phosphorus along with an adequate dose of potassium (up to 50 kg K ha^{-1}) is essential for realizing higher yield and nutrient-use efficiency in mustard grown on potassium-fixing black cotton soils of the Nagpur region.

Keywords: Mustard, Brassica juncea, potassium, PDKV-Kartik, seed yield, stover yield, nutrient uptake, black cotton soil

Introduction
Indian mustard (*Brassica juncea L.* Czern & Coss.) is one of the most important oilseed crops of India, contributing substantially to the country's edible oil economy, and Rajasthan, Madhya Pradesh, Haryana, Uttar Pradesh and Maharashtra together account for the bulk of the area and production. Among the essential plant nutrients, potassium is frequently described as the "quality element" for oilseed crops on account of its wide-ranging physiological roles regulation of stomatal behaviour and water-use efficiency, activation of more than sixty enzyme systems, translocation of photosynthates from source to sink and synthesis and accumulation of oil in the developing seed. Adequate potassium nutrition has repeatedly been linked to improved seed filling, higher test weight, better lodging and drought tolerance, and greater seed and oil yield in mustard. The black cotton soils (Vertisols) of the Nagpur region of Vidarbha possess relatively high total potassium reserves, but a large proportion of this potassium is held in fixed or non-exchangeable forms within the clay lattice and is therefore poorly available to the growing crop. Such soils can consequently appear "potassium sufficient" on the basis of total content while still limiting crop response, which makes site-specific evaluation of applied potassium indispensable. Nutrient-response behaviour also varies among mustard varieties owing to differences in rooting pattern, nutrient-uptake efficiency, duration and harvest index, and PDKV-Kartik is a variety recommended specifically for the Vidarbha region.

Generating potassium-response data for this variety is therefore important for arriving at a locally precise, variety-specific fertilizer recommendation rather than relying on data generated for other cultivars or agro-climatic regions.

Keeping this in view, the present investigation was undertaken to study the effect of graded levels of potassium, applied over and above the recommended dose of nitrogen and phosphorus, on the yield-attributing characters, seed and stover yield, and the content and uptake of nitrogen, phosphorus and potassium by mustard variety PDKV-Kartik grown on black cotton soil at Nagpur.

Materials and Methods

Experimental site and soil

The field experiment was conducted during the rabi season of 2025-26 at AICRP Mustard, College of Agriculture, Nagpur, Maharashtra, India. The soil of the experimental site was a black cotton soil (Vertisol), clayey in texture (sand 17.8%, silt 25.8%, clay 56.6%), developed from basaltic parent material and characterized by pronounced shrink-swell behaviour. The soil was alkaline in reaction (pH 7.94), non-saline (EC 0.22 dS m^{-1}) and low in organic carbon (4.79 g kg^{-1}) at the start of the experiment, with initial available nitrogen, phosphorus and potassium status of 264.86, 14.52 and 344.39 kg ha^{-1}, respectively.

Experimental design and treatments

The experiment was laid out in a Randomized Block Design (RBD) comprising seven treatments, each replicated thrice, giving a total of twenty-one plots (gross plot size 4.5 m × 4.0 m; net plot size 3.6 m × 3.8 m). The treatments were: T1- Absolute control; T2- RDF (50:40 kg N:P ha^{-1}); T3- T2 + 10 kg K ha^{-1}; T4- T2 + 20 kg K ha^{-1}; T5- T2 + 30 kg K ha^{-1}; T6- T2 + 40 kg K ha^{-1}; and T7 - T2 + 50 kg K ha^{-1}. Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. The full dose of phosphorus and potassium was applied basally at sowing, while nitrogen was applied in two equal split doses half at sowing and the remaining half at 30 days after sowing.

Crop cultivation and management

Mustard variety PDKV-Kartik was sown on 14 November 2025 by drilling at a spacing of 45 cm × 10 cm using a seed rate of 5 kg ha^{-1}, and the crop was harvested on 25 March 2026. Standard recommended package of practices, including thinning, gap filling, hoeing, weeding and seven irrigations at critical growth stages, was followed uniformly in all the plots.

Observations recorded

Yield-attributing characters, namely the number of siliquae $plant^{-1}$ and test weight (g), were recorded from five randomly selected plants per plot. Seed yield and stover yield were recorded plot-wise after sun drying and threshing and were expressed on a q ha^{-1} basis. Representative seed and stover samples from each plot were oven-dried, ground and analysed for nitrogen, phosphorus and potassium content by standard analytical procedures. Nutrient uptake by seed and stover was computed by multiplying the respective nutrient content (%) by the seed or stover yield (kg ha^{-1}), and total uptake was obtained by summing the uptake through seed and stover. The data generated were subjected to analysis of variance (ANOVA) as applicable to the Randomized Block Design, and treatment means were compared using the critical difference (CD) at the 5 per cent level of probability.

Results and Discussion

Yield-attributing characters

Data on the number of siliquae $plant^{-1}$ and test weight as influenced by potassium levels are presented in Table 1. Potassium application had a significant and progressive effect on the number of siliquae $plant^{-1}$, which increased from the lowest value of 175.53 recorded under the absolute control (T1) to a maximum of 258.40 under T7 (RDF + 50 kg K ha^{-1}), with T6 (256.87) remaining statistically comparable to T7. Test weight followed a similar increasing trend, rising from 4.64 g under T1 to a peak of 5.23 g under T6 (RDF + 40 kg K ha^{-1}), beyond which a marginal decline to 5.10 g was noted at the highest potassium level (T7), suggesting that the response of test weight to potassium had plateaued at around 40 kg K ha^{-1}.

These improvements can be attributed to the key physiological roles of potassium in plant metabolism promotion of strong cell-wall development, enhanced pollen germination and floret fertility, and improved translocation of photosynthates towards developing siliquae all of which favour greater siliqua-setting and more effective seed filling. Comparable increases in siliqua number and test weight with increasing potassium (and, in combination with zinc) application have been reported for mustard by Ram *et al.* (2017) [4] and are consistent with the trend observed by Bahuguna *et al.* (2025) [2] for combined potassium-zinc nutrition.

Seed yield

Potassium application exerted a clear, positive and consistent effect on seed yield (Table 1). The absolute control (T1) recorded the lowest seed yield of 10.55 q ha^{-1}. Introduction of the recommended dose of nitrogen and phosphorus alone (T2) raised seed yield sharply to 14.58 q ha^{-1}, after which yield increased more gradually with each increment of potassium, reaching a maximum of 16.62 q ha^{-1} under T7 (RDF + 50 kg K ha^{-1}) an increase of about 57.5 per cent over the absolute control and 14.0 per cent over RDF alone. This steady rise reflects the multiple roles of potassium in driving photosynthesis, activating enzymes involved in protein and carbohydrate synthesis, regulating stomatal opening for efficient water use, and moving photosynthates from source leaves towards the developing seed during the critical seed-filling period. A similar positive seed-yield response to potassium in mustard, reaching 19.6 q ha^{-1} (26.4% over control) at 60 kg K_2O ha^{-1}, has been reported by Singh *et al.* (2020) [6], while Yadav *et al.* (2013) [7] recorded 8.3–14.6 per cent higher seed yield with potassium application on the coarse-textured soils of southern Haryana.

Stover yield

Stover yield showed a trend similar to seed yield, increasing from 28.48 q ha^{-1} under the absolute control (T1) to 37.90 q ha^{-1} with RDF alone (T2) and further to a maximum of 45.69 q ha^{-1} under T7 (RDF + 50 kg K ha^{-1}). The sustained increase in stover yield with increasing potassium dose can be linked to potassium's role in maintaining stomatal regulation and water-use efficiency, activating enzymes involved in carbohydrate and protein synthesis, and promoting the translocation of assimilates to the stem, branches and leaves, thereby favouring greater vegetative dry-matter accumulation. Kumbhare and Daniel (2023) [3] similarly reported the highest stover yield of mustard at the highest potassium level tested, with a decline in stover yield at the lowest potassium dose.

Table 1: Effect of levels of potassium on yield-attributing characters, seed yield and stover yield of mustard

Treatment	No. of siliquae plant⁻¹	Test weight (g)	Seed yield (q ha⁻¹)	Stover yield (q ha⁻¹)
T1 - Absolute control	175.53	4.64	10.55	28.48
T2 - RDF (50:40 N:P kg ha⁻¹)	198.27	4.70	14.58	37.90
T3 - T2 + 10 kg K ha⁻¹	188.93	4.64	15.22	41.08
T4 - T2 + 20 kg K ha⁻¹	226.40	4.81	15.58	42.06
T5 - T2 + 30 kg K ha⁻¹	245.20	5.10	15.96	43.09
T6 - T2 + 40 kg K ha⁻¹	256.87	5.23	16.31	44.43
T7 - T2 + 50 kg K ha⁻¹	258.40	5.10	16.62	45.69
SEm±	10.57	0.04	0.24	0.19
CD at 5%	32.58	0.12	0.73	0.59

Nitrogen content and uptake

Nitrogen content in both seed and stover increased progressively with increasing levels of potassium (Table 2). Seed nitrogen content increased from 3.84 per cent under the absolute control (T1) to a maximum of 4.15 per cent under T7 (RDF + 50 kg K ha^{-1}), while stover nitrogen content increased correspondingly from 0.53 per cent to 0.75 per cent. Total nitrogen uptake by the crop (seed + stover) rose sharply from 55.70 kg ha^{-1} under T1 to 80.59 kg ha^{-1} with RDF alone (T2), and further, more gradually, to a maximum of 103.03 kg ha^{-1} under T7 an increase of about 85 per cent over the absolute control. The improvement in nitrogen content and uptake with increasing potassium supply can be explained by potassium's role in maintaining physiological activity of the leaves, improving photosynthetic efficiency, and facilitating the synthesis and translocation of nitrogenous compounds and carbohydrates from vegetative tissue towards the reproductive parts, together with the larger biomass (and hence larger nitrogen sink) produced at higher potassium levels. These results are in close agreement with Atkari *et al.* (2022) [1], who, working under similar rabi mustard cultivation at Nagpur, reported an almost identical increase in total nitrogen uptake, from 55.70 kg ha^{-1} under the control to 103.03 kg ha^{-1} with the highest potassium treatment.

Table 2: Effect of levels of potassium on content and total uptake of nitrogen by mustard

Treatment	Seed N content (%)	Stover N content (%)	Total N uptake (kg ha⁻¹)
T1 - Absolute control	3.84	0.53	55.70
T2 - RDF (50:40 N:P kg ha⁻¹)	3.95	0.61	80.59
T3 - T2 + 10 kg K ha⁻¹	4.01	0.66	88.29
T4 - T2 + 20 kg K ha⁻¹	4.05	0.69	91.99
T5 - T2 + 30 kg K ha⁻¹	4.08	0.71	95.57
T6 - T2 + 40 kg K ha⁻¹	4.11	0.73	99.60
T7 - T2 + 50 kg K ha⁻¹	4.15	0.75	103.03
SEm±	0.006	0.006	**1.27**
CD at 5%	0.017	0.017	**3.91**

Phosphorus content and uptake

Phosphorus content in seed and stover increased significantly with increasing potassium levels (Table 3). The highest seed and stover phosphorus content (0.72% and 0.49%, respectively) was recorded under T7 (RDF + 50 kg K ha^{-1}), as against the lowest values of 0.51 per cent and 0.32 per cent under the absolute control (T1). Total phosphorus uptake by the crop increased from 14.50 kg ha^{-1} under T1 to 21.90 kg ha^{-1} under RDF alone (T2) and further to a maximum of 34.20 kg ha^{-1} under T7, representing an increase of more than double over the absolute control. The increase in phosphorus content and uptake with potassium application may be attributed to potassium's role in maintaining root activity, membrane function and nutrient transport processes, which together improve the acquisition and translocation of phosphorus to the developing seed and stover, in addition to the larger biomass produced under adequate potassium nutrition. Similar potassium-induced increases in phosphorus uptake by mustard have been reported by Singh *et al.* (2017) [4], who recorded an increase in mean phosphorus uptake from 28.0 kg ha^{-1} under the state-recommended dose of nitrogen and phosphorus to 32.0 kg ha^{-1} with the addition of 20 kg K ha^{-1}.

Table 3: Effect of levels of potassium on content and total uptake of phosphorus by mustard

Treatment	Seed P content (%)	Stover P content (%)	Total P uptake (kg ha⁻¹)
T1 - Absolute control	0.51	0.32	14.50
T2 - RDF (50:40 N:P kg ha⁻¹)	0.57	0.36	21.90
T3 - T2 + 10 kg K ha⁻¹	0.63	0.40	26.02
T4 - T2 + 20 kg K ha⁻¹	0.65	0.42	27.79
T5 - T2 + 30 kg K ha⁻¹	0.67	0.45	30.09
T6 - T2 + 40 kg K ha⁻¹	0.69	0.47	31.98
T7 - T2 + 50 kg K ha⁻¹	0.72	0.49	34.20
SEm±	0.01	0.01	0.27
CD at 5%	0.02	0.02	0.84

Potassium content and uptake

The content of potassium in seed and stover, and the resulting total potassium uptake, increased consistently and significantly with each increment in the applied potassium level (Table 4). Seed potassium content increased from 0.59 per cent under the absolute control (T1) to 0.82 per cent under T7 (RDF + 50 kg K ha^{-1}), while stover potassium content increased from 0.86 per cent to 1.05 per cent over the same range. Total potassium uptake by the crop increased from 30.72 kg ha^{-1} under T1 to a maximum of 61.60 kg ha^{-1} under T7, an increase of about 30.9 kg ha^{-1} (roughly double) over the absolute control.

The progressive rise in potassium content and uptake reflects the greater availability of potassium in the soil solution under increasing fertilization, together with potassium's central role in cellular ionic balance, enzyme activation, osmotic regulation and assimilate transport, which promotes its accumulation in both reproductive and vegetative tissue. These findings corroborate the report of Yadav *et al.* (2013) [7], who observed that potassium application increased both potassium content and potassium uptake in Indian mustard grown on the coarse-textured soils of southern Haryana.

Table 4: Effect of levels of potassium on content and total uptake of potassium by mustard

Treatment	Seed K content (%)	Stover K content (%)	Total K uptake (kg ha^{-1})
T1 - Absolute control	0.59	0.86	30.72
T2 - RDF (50:40 N:P kg ha^{-1})	0.63	0.89	42.97
T3 - T2 + 10 kg K ha^{-1}	0.68	0.93	48.56
T4 - T2 + 20 kg K ha^{-1}	0.71	0.95	51.01
T5 - T2 + 30 kg K ha^{-1}	0.74	1.00	54.75
T6 - T2 + 40 kg K ha^{-1}	0.78	1.03	58.52
T7 - T2 + 50 kg K ha^{-1}	0.82	1.05	61.60
SEm±	0.01	0.01	0.35
CD at 5%	0.02	0.02	1.07

Conclusion

The present investigation clearly demonstrated that graded application of potassium, over and above the recommended dose of nitrogen and phosphorus, progressively and significantly improved yield-attributing characters (number of siliquae $plant^{-1}$ and test weight), seed yield, stover yield, and the content and total uptake of nitrogen, phosphorus and potassium by mustard variety PDKV-Kartik grown on the potassium-fixing black cotton soil of Nagpur. The highest seed yield (16.62 q ha^{-1}), stover yield (45.69 q ha^{-1}) and total N, P and K uptake (103.03, 34.20 and 61.60 kg ha^{-1}, respectively) were recorded with the application of RDF (50:40 kg N:P ha^{-1}) together with 50 kg K ha^{-1} (T7). Since yield attributes and stover yield tended to plateau beyond 40 kg K ha^{-1}, application of RDF along with 40–50 kg K ha^{-1} may be recommended as an economically sound and nutritionally balanced fertilizer schedule for realizing higher productivity and nutrient-use efficiency of mustard on black cotton soils of the Vidarbha region. Long-term multi-location trials are suggested to validate this recommendation across seasons and soil types.

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