DOI : 10.58993/ijh/2026.83.1.13

Indian J. Hortic. 83(1), March 2026: 92-97

Evaluating the influence of graded levels of potassium on growth, yield, quality and economics of fenugreek

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ABSTRACT

Graded levels of potassium significantly influenced the growth, yield, quality, and economic returns of fenugreek, highlighting its critical role in optimizing crop productivity and profitability. The present investigation evaluated the impact of graded potassium levels on fenugreek growth, yield, quality, soil properties and economic returns during the Rabi season of 2023-24 at ICAR-KVK, Bangalore Rural (Karnataka). The field experiment was laid out in Randomized Block design with four replications having ten different combinations of potassium levels i.e. T_1- [Absolute control]. T_2- [PoP as per UAS (B)], T_3- [T_2 + potassium @ 10 kg ha^{-1}], T_4- [T_2 + potassium @ 15 kg ha^{-1}], T_5- [T_2 + potassium @ 20 kg ha$^{-1]}$, T_6 – [T_2 + potassium @ 25 kg ha^{-1}] ,T_7- [T_2 + potassium @ 30 kg ha^{-1}],T_8- [T_2 + potassium @ 35 kg ha^{-1}],T_9- [T_2 + potassium @ 40 kg ha^{-1}] and T_{10}- [T_2 + potassium @ 45 kg ha^{-1}]. The results revealed that combination of recommended dose of fertilizers with 45 kg ha^{-1} potassium application (T_{10}) significantly enhanced seed yield (1,745.75 kg ha^{-1}), haulm yield (2,649.14 kg ha^{-1}) and green leaf yield (6.72 t ha^{-1}). Highest amount of crude protein (18.40%) and fibre content (7.85%) was observed with higher levels of potassium. Economic analysis revealed that T_8 (35 kg ha^{-1} K) had the highest benefit-cost ratio (2.85) making it the most profitable treatment. The study underscores the vital role of potassium in optimizing fenugreek productivity and profitability.

Key words: Fenugreek, potassium, productivity, quality, economics.

INTRODUCTION

India is the "Land of spice" since ancient time known for its maximum production, consumption and export of spices. Fenugreek (*Trigonella foenum-graecum L.*) is one among the important spice crops belongs to *Fabaceae* family and genus *Trigonella* L . Fenugreek is a versatile *Rabi* crop classified under seed spice. Seeds of fenugreek are a good source of protein, vitamins, alkaloid "trigonelline" and essential oil and have an immense medicinal value. Fenugreek is widely used for medicinal purposes because its rich in protein, oil, macronutrients, micronutrients, steroids, saponins, mineral salts and vitamins like legume species (Zuk-Golaszewska *et al.*, 19; Purwin *et al.*, 12 and Amin *et al.,* 1) showed that fenugreek seed extract effectively prevents and inhibits the growth of breast cancer.

Potassium (K) is one of the essential plant nutrients and it is absorbed by plant in larger amounts than any other plant nutrient except N. K is absorbed by plant roots as k^+ and its tissue concentration ranges from 5 to 6 % in dry matter. Total K content in soil ranges between 0.5 to 2.5% but major part of this (90-98%) present in mineral potash due to its higher reactivity and affinity for another element. K is not a component of any biological compound in the plant. K is known as quality element due to its involvement in synthesis and transport of photosynthates to plant reproductive and storage organs (grain, fruit, tuber, etc.) and subsequent conversion into carbohydrates, protein and oil. Cao *et al*. (5) affirmed that with lack of potassium, roots become more easily infected with root-rotting. So, keeping in mind these points a research study was conducted to evaluate the impact of potassium graded dose on growth, yield, quality and economics of fenugreek.

MATERIALS AND METHODS

The present experiment was conducted during *Rabi* season of the year 2023-24 at ICAR, Krishi Vigyan Kendra, Bangalore Rural district, Karnataka. The soil was classified as sandy clay loam with a slightly acidic reaction. It had medium levels of organic carbon (0.43%), nitrogen (228.4 kg ha^{-1}) and potassium (234.14 kg ha^{-1}) but low available phosphorus (20.77 kg ha^{-1}). DTPA-extractable micronutrients Fe (20.16 mg kg^{-1}), Mn (11.08 mg kg^{-1}), Zn (1.67 mg kg^{-1}) and Cu (1.29 mg kg^{-1}) were found to be sufficient. The field experiment was laid out on Randomized complete block design (RCBD)

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in four replication having ten treatments i.e. T_1- [Absolute control]. T_2- [PoP as per UAS (B)], T_3- [T_2 + potassium @ 10 kg ha^{-1}], T_4- [T_2 + potassium @ 15 kg ha^{-1}], T_5- [T_2 + potassium @ 20 kg ha^{-1}], T_6 – [T_2 + potassium @ 25 kg ha^{-1}] ,T_7- [T_2 + potassium @ 30 kg ha^{-1}],T_8- [T_2 + potassium @ 35 kg ha^{-1}],T_9- [T_2 + potassium @ 40 kg ha^{-1}] and T_{10}- [T_2 + potassium @ 45 kg ha^{-1}]. The fenugreek was sown with seed rate of 40 kg ha^{-1} having spacing of 30 X 10 cm on 4th January 2024. Farmyard manure (12.5 t ha^{-1}) was uniformly applied 15 days before sowing, except in control plots. Fertilization followed recommended guidelines, with NPK applied at 10:50:0 kg ha^{-1} using urea, single superphosphate (except control treatment) and graded doses of potassium through muriate of potash as a basal application. Rhizobium @ 1g kg^{-1} seed was used for seed treatment.

RESULTS AND DISCUSSION

The data revealed that plant height, number of primary branches and number of secondary branches increased progressively with increase doses of potassium application across all growth stages of fenugreek. At 30 days after sowing the maximum plant height (14.27 cm) was recorded in treatment T_{10} (PoP + 45 kg K ha^{-1}) which was significantly higher than the control (T_1: 10.77 cm) and recommended PoP treatment (T2: 12.50 cm). However, it was statistically at par with T_9 (14.15 cm) and T_8 (14.00 cm). A similar trend was observed at 60 DAS and 90 DAS where T_{10} recorded the tallest plants (33.83 cm and 44.77 cm respectively) significantly superior to the lower potassium treatments and control. At both stages, T_{10} was at par with T_9 and T_8 while the shortest plants were consistently observed in the control treatment followed by T_2 (Table 1). This increase in plant height may be attributed to the vital role of potassium in various physiological processes, including photosynthesis, enzyme activation and osmoregulation, which are essential for plant growth. Similar result was observed in the study of Kumar *et al.* (16) and Ahmed *et al*. (17).

T_{10} recorded the highest number of primary branches at all growth stages. At 30 DAS, T_{10} produced 4.16 primary branches plant^{-1}, significantly higher than T_1 and T_2, and statistically at par with T_7, T_8 and T_9. This trend persisted at 60 and 90 DAS, with T_{10} maintaining maximum primary branches (6.43 and 6.55, respectively), significantly surpassing T_1 and T_2 while remaining comparable to T_8 and T_9.A similar response was observed for secondary branches. At 60 DAS, T_{10} recorded the maximum number of secondary branches (11.42), significantly higher than T_1 and at par with T_8 and T_9. At 90 DAS, T_{10} again registered the highest value (15.87), statistically comparable with T_7, T_8 and T_9. The enhanced branching under higher potassium levels may be attributed to its role in enzyme activation, protein synthesis and osmotic regulation, which promote vegetative growth (Meena *et al.*, 2018).

Crude protein content in fenugreek seed showed positive correlation with increasing potassium levels (Table 2), ranging from 12.79% in the control (T_1) to 18.40% in T_{10} (RDF + FYM + 45 kg ha^{-1} K). This was statistically on par with T_8 (RDF + FYM + 35 kg ha^{-1} K: 16.73%) and T_9 (RDF + FYM + 40 kg ha^{-1} K: 17.75%). The increase in protein content may be

Table 1: Effect of graded levels of potassium on growth parameters of fenugreek at different growth stages.

Sr. No.	Treatment	Plant height (cm)			Number of primary branches			Number of secondary branches	
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS
T_1	Absolute control	10.77	24.10	30.83	3.23	4.74	5.57	9.64	14.85
T_2	PoP as per UAS (B)	12.50	26.45	34.41	3.36	5.67	5.76	10.52	15.62
T_3	T_2 + potassium @ 10 kg ha^{-1}	13.46	28.26	36.46	3.53	5.82	5.89	10.64	15.67
T_4	T_2 + potassium @ 15 kg ha^{-1}	13.85	29.46	37.72	3.65	5.94	6.06	10.72	15.71
T_5	T_2 + potassium @ 20 kg ha^{-1}	13.88	30.15	39.84	3.72	6.09	6.16	10.81	15.75
T_6	T_2 + potassium @ 25 kg ha^{-1}	13.91	31.20	41.37	3.78	6.25	6.60	10.92	15.78
T_7	T_2 + potassium @ 30 kg ha^{-1}	13.97	32.32	42.35	3.86	6.29	6.35	10.98	15.82
T_8	T_2 + potassium @ 35 kg ha^{-1}	14.00	32.73	43.44	3.92	6.32	6.46	11.22	15.84
T_9	T_2 + potassium @ 40 kg ha^{-1}	14.15	33.44	44.56	4.02	6.36	6.51	11.38	15.85
T_{10}	T_2 + potassium @ 45 kg ha^{-1}	14.27	33.83	44.77	4.16	6.43	6.55	11.42	15.87
SEm±		0.27	0.73	0.57	0.05	0.10	0.02	0.13	0.01
CD @ 5%		0.79	2.18	1.69	0.15	0.28	0.07	0.39	0.03

Table 2: Effect of graded levels of potassium on quality parameters of fenugreek.

Sr. no.	Treatment	Crude fibre (%)	Crude protein (%)
T_1	Absolute control	7.06	12.79
T_2	PoP as per UAS (B)	7.38	14.98
T_3	T_2 + potassium @ 10 kg ha^{-1}	7.53	15.42
T_4	T_2 + potassium @ 15 kg ha^{-1}	7.56	15.56
T_5	T_2 + potassium @ 20 kg ha^{-1}	7.26	16.04
T_6	T_2 + potassium @ 25 kg ha^{-1}	7.69	16.35
T_7	T_2 + potassium @ 30 kg ha^{-1}	7.73	16.42
T_8	T_2 + potassium @ 35 kg ha^{-1}	7.79	16.73
T_9	T_2 + potassium @ 40 kg ha^{-1}	7.81	17.75
T_{10}	T_2 + potassium @ 45 kg ha^{-1}	7.85	18.40
SEm±		0.22	0.48
CD @ 5%		NS	1.44

attributed to potassium's role in nitrogen uptake and protein synthesis making it essential for optimizing crop protein levels (Asgharali *et al*., 2).

Crude fibre content of ranged from 7.06% in the control (T_1) to 7.85% in T_{10} (RDF + FYM + 45 kg ha^{-1} K). A gradual increase was observed with rising potassium levels from 7.38% in T_2 to 7.53% in T_3, reaching 7.85% in T_{10}. However, the effect was statistically non-significant (Table 2). The trend may be attributed to potassium's role in cell wall development though the variations were not substantial within the experimental context (Ayub *et al*., 3).

Among all treatments T_{10} (PoP + 45 kg K ha^{-1}) recorded the maximum number of pods per plant (36.51), which was significantly higher than T_1 (25.45) and T_2 (31.17). However, T_{10} was at par with T_9 (36.40) and T_8 (36.27) indicating that beyond 35 kg K ha^{-1} the increase in the number of pods was marginal (Table 3). The minimum number of pods was observed in the absolute control treatment followed by T_2 and T_3. Similar observations were reported by Dixit *et al*. (14) on application of 40 kg ha^{-1} potassium.

In case of pod length a consistent increase was observed with increasing potassium levels. The longest pods (13.47 cm) were recorded in T_{10}, which was significantly higher than T_1 (10.38 cm) and also superior to T_2 (12.12 cm). However, the pod length in T_{10} was at par with T_9 (13.42 cm), T_8 (13.33 cm) and T_7 (13.18 cm) indicating that potassium application beyond 30 kg ha^{-1} resulted in only marginal gains in pod elongation. The shortest pod length was recorded in control treatment followed by T_2 and T_3 (Table 3). Thesiya *et al*. (15) revealed that there was a significant effect of potash levels on length of in black gram due the pronounced effect of potassium and its initial role in crop nutrition and physiology. A similar trend was evident in the number of seeds per pod where T_{10} produced the maximum number of seeds (14.30) which was significantly higher than T_1 (11.85) and T_2 (13.46).

The highest green leaf yield (6.72 t ha^{-1}) was recorded in T_{10} (RDF + FYM + 45 kg ha^{-1} K), which was statistically on par with T_8 (6.69 t ha^{-1}) and T_9 (6.71 t ha^{-1}). The lowest yield (3.06 t ha^{-1}) was observed in the absolute control (T_1) (Table 4). Potassium enhances the efficiency of photosynthesis by regulating the opening and closing of stomata, thereby facilitating better CO_2 uptake and consequently, higher production of carbohydrates. These carbohydrates are crucial for biomass accumulation, including leaf growth (Pettigrew, 11).

Table 3: Effect of graded levels of potassium on yield attributes of fenugreek.

Sr. No.	Treatment	Number of pods per plant	Pod length (cm)	Number of seed per pod
T_1	Absolute control	25.45	10.38	11.85
T_2	PoP as per UAS (B)	31.17	12.12	13.46
T_3	T_2 + potassium @ 10 kg ha^{-1}	33.62	12.36	13.65
T_4	T_2 + potassium @ 15 kg ha^{-1}	34.37	12.69	13.79
T_5	T_2 + potassium @ 20 kg ha^{-1}	34.93	12.81	13.91
T_6	T_2 + potassium @ 25 kg ha^{-1}	35.17	12.96	14.03
T_7	T_2 + potassium @ 30 kg ha^{-1}	35.63	13.18	14.15
T_8	T_2 + potassium @ 35 kg ha^{-1}	36.27	13.33	14.23
T_9	T_2 + potassium @ 40 kg ha^{-1}	36.40	13.42	14.27
T_{10}	T_2 + potassium @ 45 kg ha^{-1}	36.51	13.47	14.30
SEm±		0.19	0.38	0.39
CD @ 5%		0.98	1.13	1.15

Table 4: Effect of graded levels of potassium on yield parameters of fenugreek.

Sr. No.	Treatment	Green leaf yield (t ha^{-1})	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	Absolute control	3.06	964.42	1420.34
T_2	PoP as per UAS (B)	4.59	1185.37	1764.75
T_3	T_2 + potassium @ 10 kg ha^{-1}	5.20	1395.67	2291.4
T_4	T_2 + potassium @ 15 kg ha^{-1}	5.79	1424.47	2313.44
T_5	T_2 + potassium @ 20 kg ha^{-1}	5.96	1485.18	2441.15
T_6	T_2 + potassium @ 25 kg ha^{-1}	6.29	1652.46	2478.17
T_7	T_2 + potassium @ 30 kg ha^{-1}	6.52	1709.32	2572.17
T_8	T_2 + potassium @ 35 kg ha^{-1}	6.69	1734.58	2604.44
T_9	T_2 + potassium @ 40 kg ha^{-1}	6.71	1740.66	2621.75
T_{10}	T_2 + potassium @ 45 kg ha^{-1}	6.72	1745.75	2649.14
SEm±		0.17	45.37	69.6
CD @ 5%		0.51	134.80	206.9

Seed yield increased with increase potassium level. The highest yield (1,745.75 kg ha^{-1}) was recorded in T_{10} (45 kg ha^{-1} K), which was statistically on par with T_8 (1,734.58 kg ha^{-1}) and T_9 (1,740.66 kg ha^{-1}). A similar trend was observed in haulm yield, with the highest (2,649.14 kg ha^{-1}) in T_{10} (Table 4). Potassium improves water use efficiency, helps in the synthesis of starch all these result into increase plant height, number of branches and number of pod as well as increase the seed yield. Similar results were reported by Gupta *et al*. (8), Maamoun and Ahmed (10), Bairwa *et al*. (4) and Kumar *et al*. (9).

The regression analysis indicated that there is strong positive linear relationship between seed yield and potassium levels (Fig. 1). The interpretation of equation suggests that approximately 15.79 kg ha^{-1} seed yield increased due to application of 1 kg ha^{-1} potassium. The coefficient of determination (R^2 = 0.876) indicates that 87.6% variation is seed yield is due to difference in different levels of potassium application.

Regression equation for seed yield (kg ha^{-1})

$$\text{Seed yield (kg ha}^{-1}\text{)} = 15.79 \times \text{K (kg ha}^{-1}\text{)} + 1156.46$$

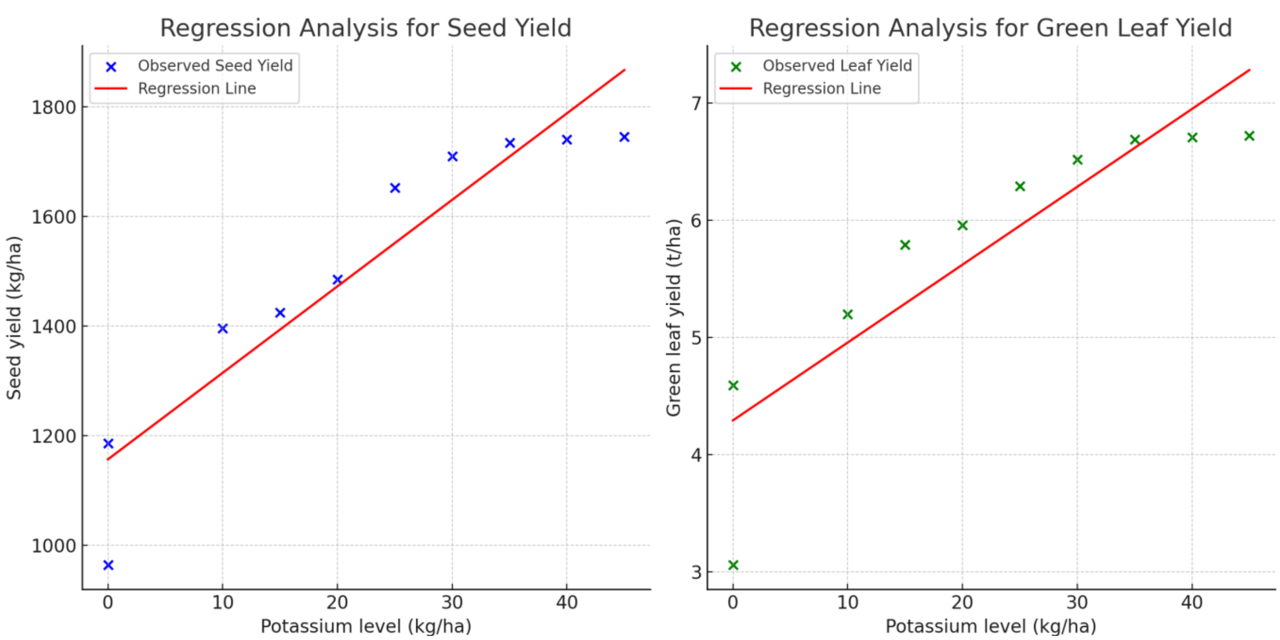

Fig. 1. Regression analysis for seed yield (kg ha^{-1}) and green leaf yield (t ha^{-1}).

Table 5: Effect of graded levels of potassium on economics of fenugreek.

Sr. No.	Treatment	Cost of cultivation (Rs/ha.)	Gross return (Rs/ha.)	Net return (Rs/ha.)	B: C ratio
T_1	Absolute control	55720	94340.7	38620.7	1.69
T_2	PoP as per UAS (B)	58039.06	117224.3	59185.26	2.02
T_3	T_2 + potassium @ 10 kg ha^{-1}	58656.32	138013.9	79357.61	2.35
T_4	T_2 + potassium @ 15 kg ha^{-1}	58964.66	141550.6	82585.93	2.40
T_5	T_2 + potassium @ 20 kg ha^{-1}	59272.99	147509	88236	2.49
T_6	T_2 + potassium @ 25 kg ha^{-1}	59581.32	163278.3	103697	2.74
T_7	T_2 + potassium @ 30 kg ha^{-1}	59889.66	168929.2	109039.5	2.82
T_8	T_2 + potassium @ 35 kg ha^{-1}	60197.99	171528	111330	2.85
T_9	T_2 + potassium @ 40 kg ha^{-1}	60506.32	172135.5	111629.2	2.84
T_{10}	T_2 + potassium @ 45 kg ha^{-1}	60814.66	172652	111837.4	2.84

Similar to seed yield the green leaf yield also showed positive linear response to potassium levels. The regression equation revealed that for application of 1 kg ha^{-1} potassium there is an increment of 0.0665 t ha^{-1} in green leaf yield. (R^2=0.795)

Regression equation for green leaf yield (t ha^{-1})

Green leaf yield (t ha^{-1}) = 0.0665 × K (kg ha^{-1}) + 4.29

The highest cost of cultivation (Rs. 60,814.66 ha^{-1}), gross returns (Rs. 1,72,652 ha^{-1}) and net returns (Rs. 1,11,837.4 ha^{-1}) were recorded in T_{10} (45 kg ha^{-1} K + RDF + FYM). However the highest benefit-cost (B: C) ratio was observed in T_8 (2.85) which was on par with T_9 (2.84) and T_{10} (2.84). The lower B: C ratio in T_{10} was due to the marginal increase in gross returns (Rs. 1,72,652) compared to T_9 (Rs. 1,72,135.5), despite the higher cultivation cost (Table 5). Thus, T_8 achieved the most favourable economic efficiency. The result is in conformity with the findings of Kumar *et al*. (9) and Goud *et al*. (7).

AUTHOR'S CONTRIBUTION

Conceptualization of research (A, PV, VU); Designing of the experiment (PV, VU); Execution of field/lab experiment and data collection (A, VU, R); Analysis of data and interpretation (A, AA, S, DS); Preparation of manuscript (A, R, DS).

DECLARATION

The authors declare that they have no conflict of interest.

ACKNOWLEDGMENTS

The authors are grateful to the administration and staff of Department of Soil Science, University of Agricultural Sciences, Bangaluru, India for providing the necessary facilities, guidance, and support to carry out this research.

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(Received : December, 2025; Revised : March, 2026;
Accepted : March, 2026)