



ISSN Print: 2618-060X
 ISSN Online: 2618-0618
 NAAS Rating (2026): NAAS
 Rating (2026): 5.20
 IJRA 2026; 9(9): 584-587
www.agronomyjournals.com
 Received: 16-07-2026
 Accepted: 13-07-2026
 Published: 15-08-2026

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Effect of phosphorus and potassium levels on growth, yield and quality parameters of dill (*Anethum graveolens* L.)

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i9.6569>

ABSTRACT

A field experiment entitled “Optimization of Phosphorus and Potassium Levels on Performance of Dill (*Anethum graveolens* L.)” was conducted at the College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences (KSNUAHS), Shivamogga, Karnataka, during summer 2026, to evaluate the effect of graded phosphorus and potassium levels on the growth, yield and quality of dill. The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising ten treatments, replicated thrice. Among the treatments, application of 25 kg N ha⁻¹ + 15 kg P₂O₅ ha⁻¹ + 15 kg K₂O ha⁻¹ (T₁₀) recorded significantly the highest plant height (78.54 cm) and primary branches (15.80 plant-1) at harvest, fresh weight (63.33 q ha⁻¹) and dry weight (7.61 q ha⁻¹) at 45 days after sowing (DAS), the earliest attainment of 50 per cent flowering (48.00 days), and the maximum number of umbels (19.90 plant-1), umbellates (21.70 umbel-1), seeds (25.80 umbellate-1) and seed yield (14.50 q ha⁻¹). The same treatment (T₁₀) also recorded the highest chlorophyll content (1.39 mg g⁻¹ at 90 DAS), ascorbic acid content (90.70 mg 100 g⁻¹), crude fibre content (9.13 per cent in herbage and 21.70 per cent in seed) and shelf life (3.00 and 2.00 days with and without roots, respectively), while the absolute control (T₁) recorded the lowest values for all the parameters studied. The results clearly indicate that combined application of phosphorus and potassium at 15 kg P₂O₅ ha⁻¹ and 15 kg K₂O ha⁻¹, over and above the basal dose of 25 kg N ha⁻¹, is optimum for realizing higher growth, yield and quality of dill grown for dual leafy-vegetable and seed-spice purpose.

Keywords: Dill, Phosphorus, Potassium, Growth, Seed yield, Quality

1. Introduction

Dill (*Anethum graveolens* L.) is an important aromatic and medicinal herb of the family Apiaceae, believed to be native to south-west Asia or south-east Europe, and cultivated since ancient times as a vegetable, spice and medicinal plant (Bailer *et al.*, 2001) [1]. It is valued both for its finely divided, aromatic foliage, used fresh or dried as a leafy vegetable and culinary herb, and for its seeds, which serve as a spice and a source of essential oil rich in carvone (Agarwal *et al.*, 2002) [2]. In India, dill is cultivated over about 31,000 hectares with a production of around 31,000 tonnes and an average productivity of only 1.0 tonne per hectare (Anon., 2021) [3], a productivity level that remains low largely on account of imbalanced nutrient management, particularly with respect to phosphorus and potassium, which are seldom applied to the crop in scientifically determined and locally validated doses.

Among the essential nutrients, phosphorus governs energy transfer through ATP, root proliferation, nucleic acid synthesis and reproductive development, whereas potassium regulates enzyme activation, stomatal behaviour, osmotic adjustment and translocation of photosynthates from source leaves to developing sinks. Since dill is harvested both as a leafy vegetable at the early vegetative stage and as a seed spice at physiological maturity, a balanced and adequate supply of phosphorus and potassium over and above the recommended dose of nitrogen assumes particular significance in governing its dual productivity. Graded fertilizer application has been reported to markedly improve the growth, yield attributes and seed yield of dill (Naher *et al.*, 2016) [4], and similar responses to phosphorus and potassium have been documented in allied Apiaceae spice crops such as coriander and fennel. Keeping this in view, the present investigation was undertaken to evaluate the effect of different levels of phosphorus and potassium on the growth, yield and quality of dill (*Anethum graveolens* L.).

2. Materials and methods

The field experiment was conducted during summer 2026 at the College of Agriculture, Navile, KSNUAHS, Shivamogga, situated in the Southern Transitional Zone of Karnataka (Agro-climatic Zone – VII) at 13° 97' N latitude and 75° 57' E longitude, at an altitude of 667.5 m above mean sea level. The experimental soil was sandy loam in texture, acidic in reaction (pH 5.70), with an electrical conductivity of 0.155 dS m⁻¹ and medium organic carbon content (5.20 g kg⁻¹). The experiment was laid out in a Randomized Complete

Block Design (RCBD) with ten treatments replicated thrice, comprising an absolute control (T_1), the recommended dose of fertilizer alone (T_2 ; $N:P_2O_5:K_2O = 25:0:0 \text{ kg ha}^{-1}$) and eight treatment combinations of 25 kg N ha^{-1} with 0, 10 or $15 \text{ kg P}_2O_5 \text{ ha}^{-1}$ and 0, 10 or $15 \text{ kg K}_2O \text{ ha}^{-1}$ (T_3 to T_{10}), with FYM applied uniformly at 15 t ha^{-1} to all plots. Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash, respectively, with nitrogen applied uniformly as basal and phosphorus and potassium applied as per treatment.

Growth parameters, namely plant height and number of primary branches per plant, were recorded from five randomly tagged plants per plot at 15, 20, 25, 30, 45, 60, 90 DAS and at harvest. At 45 DAS, corresponding to the leafy-vegetable stage, fresh and dry herbage weight were recorded from a one square metre area, along with chlorophyll content (DMSO method; Blanke, 1992) [5], ascorbic acid content (2,6-dichlorophenolindophenol titration; AOAC, 1999) [6] and crude fibre content (acid-alkali digestion; Sadasivam *et al.*, 1992) [7], while post-harvest shelf life of the herbage, with and without roots, was assessed under ambient storage conditions. At final harvest, days to 50 per cent flowering, number of umbels per plant, umbellates per umbel, seeds per umbellate, test weight (1000-seed weight) and seed yield were recorded, and crude fibre content of the seed was also estimated. The data generated were subjected to analysis of variance as per Gomez *et al.* (1984) [8], and treatment means were compared at 5 per cent level of significance.

3. Results and discussion

3.1 Growth parameters

A significant effect of phosphorus and potassium levels on plant height and number of primary branches per plant was observed at all the growth stages (Table 1). Application of $25 \text{ kg N ha}^{-1} + 15 \text{ kg P}_2O_5 \text{ ha}^{-1} + 15 \text{ kg K}_2O \text{ ha}^{-1}$ (T_{10}) recorded the tallest plants at harvest (78.54 cm), significantly superior to $25 \text{ kg N ha}^{-1} + 10 \text{ kg P}_2O_5 \text{ ha}^{-1} + 15 \text{ kg K}_2O \text{ ha}^{-1}$ (T_9 ; 74.00 cm), with which it was statistically on par only during the early stages up to 30 DAS. The absolute control (T_1) remained significantly the shortest throughout the crop period (52.80 cm at harvest). A similar trend was recorded for primary branches per plant, wherein T_{10} recorded the maximum number (15.80 plant^{-1} at harvest), on par with T_9 (14.50) up to 30 DAS but significantly superior thereafter, while T_1 recorded the fewest branches (9.30 plant^{-1}).

Phosphorus promotes ATP-mediated cell division and root proliferation, which in turn raises cytokinin supply to the shoot and stimulates outgrowth of axillary buds into branches, while potassium maintains cell turgidity and facilitates translocation of photosynthates to the growing points, together accounting for the taller and more profusely branched plants under T_{10} . These findings corroborate the reports of Surve *et al.* (2024) [9] in dill and Javiya *et al.* (2017) [10] in coriander, wherein graded phosphorus application progressively increased plant height and branching, and are further supported by Barzegar *et al.* (2020) [11], who recorded taller fennel plants with higher potassium doses. The narrowing gap between T_{10} and T_9 at the later stages, as also reported by Chattopadhyay *et al.* (2017) [12] in dill, suggests that the growth response to phosphorus and potassium tends to plateau beyond a certain combined dose.

3.2 Yield parameters

Fresh and dry herbage weight recorded at 45 DAS, days to 50 per cent flowering, and yield attributes recorded at harvest were significantly influenced by phosphorus and potassium levels (Table 1). The highest fresh weight (63.33 q ha^{-1}) and dry weight (7.61 q ha^{-1}) were recorded under T_{10} , significantly superior to all other treatments, while the absolute control (T_1) recorded the lowest fresh (22.67 q ha^{-1}) and dry weight (2.47 q ha^{-1}). T_{10} also attained 50 per cent flowering earliest (48.00 days), on par with T_9 (50.00 days), whereas T_1 took the longest (60.00 days), on par with the RDF-alone treatment T_2 (58.50 days).

The number of umbels per plant (19.90), umbellates per umbel (21.70) and seeds per umbellate (25.80) were all recorded highest under T_{10} , each significantly superior to the remaining treatments, barring seeds per umbellate where T_{10} was on par with T_9 (25.00). Test weight followed a similar numerical trend (3.48 to $3.58 \text{ g } 1000 \text{ seeds}^{-1}$ from T_1 to T_{10}), but the treatment differences were statistically non-significant, indicating that seed size is governed more by stored reserves than by the prevailing fertility level once seed set has occurred. Consequently, the highest seed yield (14.50 q ha^{-1}) was recorded under T_{10} , significantly superior to T_9 (11.30 q ha^{-1}) and T_7 (11.00 q ha^{-1}), which were themselves statistically on par, while the RDF-alone treatment (T_2) recorded only 8.05 q ha^{-1} and the absolute control (T_1) the lowest yield of 4.10 q ha^{-1} .

Herbage and seed yield in dill are cumulative expressions of plant height, branching, umbel and umbellate number, and seed set, all of which were consistently highest under T_{10} . Phosphorus supports pollen germination and pollen-tube growth besides supplying the energy required for cell division during umbel and umbellate differentiation, while potassium sustains photosynthate translocation to the developing reproductive sinks and maintains floral turgor during pollination. These results are in agreement with Elsayed *et al.* (2020) [13], who reported higher dill herbage yield with improved nutrition, Koyani *et al.* (2015) [14], who recorded more umbels and umbellates in fennel with higher phosphorus, and Singh *et al.* (2016) [15], who reported higher dill seed yield with combined nutrient sources. That the RDF-alone treatment gave only a marginal improvement over the control, similar to the observation of Zaki *et al.* (2010) [16] in fennel, confirms that nitrogen alone cannot fully realize the yield potential of dill in the absence of adequate phosphorus and potassium.

3.3 Quality parameters

Chlorophyll content, ascorbic acid content, crude fibre content and post-harvest shelf life of dill herbage were all significantly influenced by phosphorus and potassium levels (Table 2). The highest chlorophyll content (1.39 mg g^{-1} at 90 DAS) and ascorbic acid content ($90.70 \text{ mg } 100 \text{ g}^{-1}$ at 90 DAS) were recorded under T_{10} , closely followed by T_9 (1.34 mg g^{-1} and $85.20 \text{ mg } 100 \text{ g}^{-1}$, respectively), while T_1 recorded the lowest values (0.76 mg g^{-1} and $49.30 \text{ mg } 100 \text{ g}^{-1}$, respectively) at every stage of sampling. Crude fibre content followed the same trend, with T_{10} recording the highest content in herbage at 45 DAS (9.13%) and in seed (21.70%), against the lowest values under T_1 (6.33% and 16.80%, respectively). Shelf life, both with roots (3.00 days) and without roots (2.00 days), was longest under T_{10} , on par with T_9 , and shortest under T_1 (1.10 and 1.00 days, respectively). Phosphorus provides the energetic and biosynthetic precursors required for chlorophyll and ascorbic-acid synthesis, while potassium keeps stomata functional for carbon assimilation and delays chloroplast senescence, together accounting for the superior pigment and vitamin-C status of T_{10} . These findings are consistent with Jama-Rodzeńska *et al.* (2022) [17] in lettuce and Sruthy *et al.* (2023) [18] in palak, both of whom reported higher chlorophyll and ascorbic acid content under improved phosphorus and potassium nutrition. The higher crude fibre content under T_{10} reflects the role of phosphorus in supplying energy for cell-wall polysaccharide synthesis and of potassium in enzyme-mediated cell-wall thickening, in line with Subba *et al.* (2016) [19] in carrot. Since shelf life is governed largely by post-harvest moisture loss and cell-wall integrity, the combined effect of higher fibre content, stronger cell walls and greater antioxidant (ascorbic acid) status under T_{10} translated into the longest shelf life, corroborating the observations of Biesiada *et al.* (2019) [20] and Słupski *et al.* (2005) [21], who linked the post-harvest quality of dill to its nutrient and mineral status at harvest.

4. Conclusion

Among the different levels of phosphorus and potassium evaluated, application of $25 \text{ kg N ha}^{-1} + 15 \text{ kg P}_2O_5 \text{ ha}^{-1} + 15 \text{ kg K}_2O \text{ ha}^{-1}$ (T_{10}) consistently recorded the best performance for all the growth, yield and quality parameters studied, followed by $25 \text{ kg N ha}^{-1} +$

10 kg P₂O₅ ha⁻¹ + 15 kg K₂O ha⁻¹ (T₉), while the absolute control (T₁) and the RDF-alone treatment (T₂) remained inferior throughout. It may therefore be concluded that combined application of phosphorus and potassium at 15 kg P₂O₅ ha⁻¹ and 15 kg K₂O ha⁻¹, over and

above the basal nitrogen dose, can be recommended for realizing higher growth, seed yield and quality of dill grown for dual leafy-vegetable and seed-spice purpose, and may be considered for further validation across locations and seasons.

Table 1. Effect of phosphorus and potassium levels on growth and yield attributing characters of dill at harvest

Treatment	Plant height (cm)	Primary branches (No. plant ⁻¹)	Fresh weight (q ha ⁻¹)	Dry weight (q ha ⁻¹)	Days to 50% flowering	Umbels (No. plant ⁻¹)	Umbellates (No. umbel ⁻¹)	Seeds (No. umbellate ⁻¹)	Test weight (g 1000 seeds ⁻¹)	Seed yield (q ha ⁻¹)
T ₁ - Absolute control	52.80	9.30	22.67	2.47	60.00	13.10	16.80	17.20	3.48	4.10
T ₂ - RDF (N:P ₂ O ₅ :K ₂ O = 25:0:0 kg ha ⁻¹)	57.60	10.40	35.30	4.30	58.50	14.20	17.50	18.80	3.52	8.05
T ₃ - 25 kg N + 10 kg P ₂ O ₅ + 0 kg K ₂ O ha ⁻¹	61.80	11.20	40.32	4.70	57.00	15.20	17.90	19.60	3.53	9.20
T ₄ - 25 kg N + 15 kg P ₂ O ₅ + 0 kg K ₂ O ha ⁻¹	64.20	12.00	47.33	5.53	55.50	16.00	18.30	21.40	3.54	10.20
T ₅ - 25 kg N + 0 kg P ₂ O ₅ + 10 kg K ₂ O ha ⁻¹	62.90	11.50	44.30	5.17	56.50	15.70	18.10	20.70	3.53	9.85
T ₆ - 25 kg N + 10 kg P ₂ O ₅ + 10 kg K ₂ O ha ⁻¹	68.30	12.80	52.67	6.20	53.50	16.90	18.80	23.00	3.55	10.90
T ₇ - 25 kg N + 15 kg P ₂ O ₅ + 10 kg K ₂ O ha ⁻¹	72.10	14.00	54.11	6.57	51.50	17.80	19.40	24.20	3.56	11.00
T ₈ - 25 kg N + 0 kg P ₂ O ₅ + 15 kg K ₂ O ha ⁻¹	66.50	12.40	48.00	5.67	54.50	16.40	18.60	22.30	3.54	10.55
T ₉ - 25 kg N + 10 kg P ₂ O ₅ + 15 kg K ₂ O ha ⁻¹	74.00	14.50	56.45	6.77	50.00	18.50	20.20	25.00	3.57	11.30
T ₁₀ - 25 kg N + 15 kg P ₂ O ₅ + 15 kg K ₂ O ha ⁻¹	78.54	15.80	63.33	7.61	48.00	19.90	21.70	25.80	3.58	14.50
S.Em ±	1.52	0.42	1.70	0.25	0.82	0.29	0.22	0.42	0.03	1.39
CD (P = 0.05)	4.51	1.25	5.00	0.72	2.43	0.87	0.66	1.24	NS	4.00

DAS: Days after sowing; NS: Non-significant; RDF and FYM (15 t ha⁻¹) applied commonly to T₂ to T₁₀.

Table 2. Effect of phosphorus and potassium levels on quality parameters of dill

Treatment	Chlorophyll content at 90 DAS (mg g ⁻¹)	Ascorbic acid content at 90 DAS (mg 100 g ⁻¹)	Crude fibre content at 45 DAS (%)	Crude fibre content in seed (%)	Shelf life with roots (days)	Shelf life without roots (days)
T ₁ - Absolute control	0.76	49.30	6.33	16.80	1.10	1.00
T ₂ - RDF (N:P ₂ O ₅ :K ₂ O = 25:0:0 kg ha ⁻¹)	0.87	54.00	6.75	17.50	1.40	1.10
T ₃ - 25 kg N + 10 kg P ₂ O ₅ + 0 kg K ₂ O ha ⁻¹	0.98	59.80	7.16	17.90	1.60	1.20
T ₄ - 25 kg N + 15 kg P ₂ O ₅ + 0 kg K ₂ O ha ⁻¹	1.08	64.90	7.56	18.30	2.00	1.40
T ₅ - 25 kg N + 0 kg P ₂ O ₅ + 10 kg K ₂ O ha ⁻¹	1.02	62.80	7.36	18.10	1.85	1.30
T ₆ - 25 kg N + 10 kg P ₂ O ₅ + 10 kg K ₂ O ha ⁻¹	1.18	72.20	8.01	18.80	2.40	1.60
T ₇ - 25 kg N + 15 kg P ₂ O ₅ + 10 kg K ₂ O ha ⁻¹	1.27	79.30	8.44	19.40	2.60	1.80
T ₈ - 25 kg N + 0 kg P ₂ O ₅ + 15 kg K ₂ O ha ⁻¹	1.12	68.00	7.82	18.60	2.20	1.50
T ₉ - 25 kg N + 10 kg P ₂ O ₅ + 15 kg K ₂ O ha ⁻¹	1.34	85.20	8.79	20.20	2.80	1.90
T ₁₀ - 25 kg N + 15 kg P ₂ O ₅ + 15 kg K ₂ O ha ⁻¹	1.39	90.70	9.13	21.70	3.00	2.00
S.Em ±	0.02	1.30	0.08	0.31	0.07	0.05
CD (P = 0.05)	0.05	3.77	0.22	0.91	0.20	0.15

DAS: Days after sowing; RDF and FYM (15 t ha⁻¹) applied commonly to T₂ to T₁₀.

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How to cite this article: Dharshika D, Jayaprakash SM, Sankalpa CP, Chaitanya HS, Ullasa MY. Effect of phosphorus and potassium levels on growth, yield and quality parameters of dill (*Anethum graveolens* L.). *International Journal of Research in Agronomy*. 2026;9(9):584-587. doi: <https://www.doi.org/10.33545/2618060X.2026.v9.i9.6569>

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