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RESPONSE OF ORGANIC AND INORGANIC NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF CUMIN UNDER BUNDELKHAND REGION OF INDIA

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ABSTRACT

A field experiment was conducted during the Rabi season of 2024–25 to evaluate the response of organic and inorganic nutrient management on the growth and yield of cumin under Bundelkhand region. The experiment was laid out in a Randomized Block Design (RBD) with three replications, comprising eight treatment combinations involving different levels of the recommended dose of fertilizers (RDF) along with varying doses of farmyard manure (FYM) and vermicompost. Results showed that the at harvest, highest plant height (35.70 cm), number of primary branches (8.41), fresh weight (45.66 g/plant) and dry weight (12.14 g/plant) were recorded in T_6 (125% RDF + 10 t/ha Vermicompost) which was significantly superior over the treatment$T_{7,}$ T_4, T_3, $T_{2,}$ T_1 and T_0at different growth stages. Similarly, maximum number of umbels per plant (26.12), number of seeds per umbel (71.01), test weight (2.22g), seed yield (7.80 q/ha) and biological yield (21.30 q/ha) were observed with treatment T_6(125% RDF + 10 t/ha Vermicompost). Whereas treatment T_6 remained statically at par with treatment T_5 (125% RDF and 10 t/ha FYM) with respect to the all the parameters studied. Overall, the study indicated that the integrated application of 125% RDF with 10 t/ha vermicompost proved to be the most effective nutrient management strategy for enhancing cumin growth and productivity in the Bundelkhand region.
***Keywords*: Cumin, Farm yard manure, Growth, Recommend dose of fertilizer, Vermicompost, Yield

Introduction

Cumin (*Cuminum cyminum Linn.*) is a traditional herbaceous plant, is a vital seed spice crop in arid and semi-arid regions. It belongs to the family Apiaceous and originating in northern Africa. Cumin is grown mainly in India, Iraq, Iran, Syria, Pakistan, Egypt, China, Turkey, Israel, and Italy. It is globally cultivated for its aromatic and medicinal properties (Dubey *et al.*, 2017). India is the largest producer and exporter of cumin, accounting for 70% of global production. In India, cumin is a valuable crop, cultivated in 8.08 lakh hectares, producing 5.03 lakh tonnes of seeds. As well as cumin is grown mainly in Rajasthan and Gujarat (90% of India's cumin production), covering 6.9 lakh hectares with a production of 4.45 lakh tonnes (Anonymous, 2019).

Rajasthan and Gujarat are divided into Agro-Ecological Sub Regions (AESRs) with varying climatic conditions (Anonymous, 2019). Dried cumin seeds are significant in terms of nutritional value and health benefits because they contain volatile oil (5-7%), fat (20-24%), protein (9-11%), fibre (10-12%), and free amino acids. Cumin seed oil used in the treatment of mild digestive disorders as a carminative and eupeptic and astringent in bronco pulmonary disorders and as a cough remedy, as well as an analgesic. Cumin is a good source of minerals too such as copper and zinc, as well as vitamins like B-complex, riboflavin, thiamine, niacin and antioxidant vitamins such as A, E and C. The shoots of cumin plant are good source of metabolites, fatty acids, phenolic compounds and amino acids. All of these properties reveal the plant's therapeutic potential while also providing valuable information about metabolic responses to salinity stress (Pandey *et al*., 2015).

In present scenario of Indian agriculture, the chemical fertilizers have a major share in supplying the nutrients for crop production as well as for seed production. However, the excess use of these chemical fertilizers has started showing its harmful effects not only on the environment but also on human health. Normally, the nutrient management of cumin is done by the application of chemical fertilizers (Rai *et al*., 2023). However, the heavy use of mineral fertilizer in agriculture accompanies the hazardous effect on the environmental on with-it reason, soil sustainability has gained high importance and requires effective management practices of the soil resources while improving or even maintaining its quality and this can take place through reducing the inputs of production with increasing their efficiency to obtain high production of crops (Aryal *et al*., 2021). Currently the new trends in agriculture are centered on minimizing the use of inorganic fertilizers by replacing them by bio-fertilizers and organic manures as these are economic and eco-friendly (Das *et al*., 2022). Keeping all these points in view, the present investigation is carried out to find the suitable integrated nutrient management practice for better growth and yield of cumin under Bundelkhand region.

Materials and Methods

The experimental research was carried out during *Rabi* season of 2024-25 at Dept. of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi. Geographically, the Farm is situated on 78°36'15.6" E longitude and 25°27'37.5" N latitude about 307 m above mean sea level. Bundelkhand possesses tropical and subtropical climate conditions. The average annual rainfall is 884.6 mm, with 90-95 percent of that raining during the south west monsoon, which commences in June and reaches a peak in August and ends with October and two to three showers of winter rainfall is also getting off the ground. The experimental field soil was sandy loam in the contest of soil texture and regard to organic carbon is (0.32%) low where, available nitrogen (151.00 kg ha^{-1}) is low, phosphorus (9.30 kg ha^{-1}) and potassium (142.00 kg ha^{-1}) have medium range, with electrical conductivity found to a safe range. The experiment was conducted in randomized block design (RBD) with eight treatments, including control *viz* T_0-Control: 100% RDF, T_1-75% RDF+ 15t/ha FYM, T_2-75% RDF +15 t/ha Vermicompost, T_3-100% RDF+ 15t/ha FYM, T_4-100% RDF + 15t/ha vermicompost, T_5-125% RDF + 10t/ha FYM, T_6-125% RDF + 10t/ha vermicompost, T_7-50% RDF + 50% FYM + Azotobacter + PSB which were replicated thrice. The fertilizers used in the study were urea for N, DAP (Di-Ammonium phosphate) for P and MOP for K. Cumin variety 'GC-4' was sowing was done by hand seed drill at a spacing of 22 × 10 cm apart row to row and plant to plant respectively, and the crop was sown on 14^{th} November 2024. Before sowing the seeds were treated with Bavistin @ 2 g kg^{-1} of seed and the treated seeds were dried in shade for one night and sown the next day. Reseeding of fresh treated seed was done at 7 days after sowing wherever gaps of more than 10 cm existed in the rows. The thinning operation was done to maintain the plant-to-plant distance in rows of around 10 cm and remove overcrowded plants. Standard methods were used to gather data. From each plot randomly select five plants excluding border row and measure them to estimate growth attributes, including plant height (cm), number of primary branches per plant, fresh weight ($plant^{-1}$), dry weight ($plant^{-1}$) and yield attributes, including number of umbels per plant, number of seed per umbel, test weight (g), seed yield (q/ha), biological yield (q/ha) and harvest index (%). Data on yield was gathered during the harvest by harvesting the net plot to measure the yield of grain and stover. Analysis using the method outlined by Gomez and Gomez, (1984), with statistical significance determined at $p < 0.05$. Mean differences can be compared using values of Standard Error of the Mean (SEm±) and Critical Difference (CD).

Results and Discussion

Growth Attributes

Plant height (cm)

Cumin growth attributes was significantly influenced by different organic and inorganic nutrient management practices (Table 1). Plant height recorded at 40, 80 days after sowing (DAS), and at harvest was significantly influenced by different nutrient management treatments. At 40 DAS, the lowest plant height (9.20 cm) was observed under the control treatment (T_0: 100% RDF), the significantly maximum height (12.10 cm) was recorded in T_6 (125% RDF + 10 t/ha vermicompost). Similarly, at 80 DAS, plant height ranged from 21.09 cm in the control to 27.50 cm in T_6. At harvest, the trend continued, with T_6 producing the tallest plants (35.70 cm) compared to the shortest height in the control (27.87 cm). The progressive increase in plant height across all growth stages under treatments involving combined application of higher doses of recommended fertilizer and vermicompost suggests enhanced nutrient availability and uptake. Vermicompost, being rich in essential nutrients and beneficial microbes, likely improved soil fertility and stimulated root growth, thereby promoting better shoot development. The superior performance of T_6 over other treatments indicates that integrated nutrient management effectively supports vegetative growth, resulting in taller plants.

These results align with previous research, which demonstrated that combining organic and inorganic nutrient sources accelerates crop growth and development by improving soil physical and biological properties. The consistent increase in height from 40 DAS to harvest under integrated treatments reflects sustained nutrient supply and efficient utilization, which are critical for optimum crop productivity. Overall, the findings emphasize the importance of balanced nutrient management in enhancing plant growth parameters throughout the crop lifecycle.

Number of primary branches

The number of primary branches per plant recorded at 40 DAS, 80 DAS, and at harvest showed significant differences among the various nutrient management treatments. At 40 DAS, the minimum number of branches (2.97) was observed in the control (T_0: 100% RDF), while the maximum (3.95) was recorded under T_6 (125% RDF + 10 t/ha vermicompost). At 80 DAS, the number of branches increased substantially, ranging from 7.14 in the control to 8.22 in T_6. At harvest, T_6 maintained its superiority and significance with 8.47 primary branches per plant, compared to 7.39 in the control. The higher number of primary branches in treatments combining inorganic fertilizer with vermicompost (especially T_6) suggests enhanced nutrient availability and improved soil health, which promotes vegetative growth and branch proliferation. Vermicompost likely contributed to better microbial activity and nutrient mineralization, facilitating optimal nutrient uptake. This integrated nutrient management approach supports the development of more branches, which can positively influence canopy architecture and potential yield. The gradual increase in primary branches from early growth to harvest under integrated nutrient management treatments indicates sustained nutrient supply, which is essential for better crop development and productivity. Overall, the results highlight the importance of balanced organic and inorganic nutrient inputs for enhancing plant structural growth.

Plant Fresh Weight (g plant^{-1})

Plant fresh weight measured at 40 DAS, 80 DAS, and at harvest showed significant variation among different nutrient management treatments. At 40 DAS, the lowest fresh weight (2.54 g/plant) was recorded in the control treatment (T_0: 100% RDF), the significantly highest fresh weight (3.60 g/plant) was observed in T_6 (125% RDF + 10 t/ha vermicompost). At 80 DAS, fresh weight ranged from 23.40 g/plant in the control to 31.60 g/plant in T_6. At harvest, the trend persisted with T_6 recorded the significant and maximum fresh weight of 45.66 g/plant and it was higher than the control (34.01 g/plant). The increased fresh weight in treatments combining higher fertilizer doses with vermicompost (T_6) can be attributed to improved nutrient availability, enhanced soil microbial activity, and better moisture retention, which collectively promote vigorous vegetative growth. Vermicompost, rich in macro and micronutrients along with beneficial microorganisms, likely facilitated enhanced nutrient uptake and assimilation, resulting in greater biomass accumulation. These findings are in agreement with previous research that demonstrated integrated nutrient management significantly enhances plant growth parameters by improving soil fertility and plant physiological processes. The consistent increase in fresh weight from early growth stages to harvest under T_6 reflects sustained nutrient supply and efficient utilization, indicating the effectiveness of combining organic and inorganic nutrient sources for improving crop biomass and potential yield.

Plant Dry Weight (g plant^{-1})

Plant dry weight recorded at 40 DAS, 80 DAS, and at harvest showed significant differences among the nutrient management treatments. At 40 DAS, the lowest dry weight was found in the control (T_0) with 0.30 g/plant, whereas the significant and highest dry weight of 0.42 g/plant was recorded under T_6 (125% RDF + 10 t/ha vermicompost). At 80 DAS, dry weight increased from 4.84 g/plant in the control to 6.20 g/plant in T_6. Similarly, at harvest, the significant and maximum dry weight of 12.14 g/plant was observed in T_6 compared to 9.20 g/plant in the control. The superior dry weight accumulation in T_6 reflects the positive impact of integrated nutrient management involving both organic and inorganic sources. Vermicompost likely improved soil structure, nutrient availability, and microbial activity, resulting in enhanced photosynthetic efficiency and biomass production. The higher fertilizer dose combined with vermicompost ensured sustained nutrient supply throughout the growth period, which contributed to greater dry matter accumulation. The consistent increase in dry weight from early growth stages to harvest indicates efficient nutrient uptake and utilization under integrated treatments. Thus, the combination of 125% RDF with vermicompost proves to be an effective strategy for optimizing crop growth and biomass accumulation.

Yield Attributes

The data presented in Table 2 showed the significant variation in the different organic and inorganic nutrient management practices yield attributes

Number of Umbels per Plant

Among the treatments, the highest number of umbels per plant (26.12) was recorded under T_6 (125% RDF + 10 t/ha vermicompost), indicating the superior impact of integrated use of elevated inorganic fertilizers in combination with vermicompost. This treatment was found at par with T_5 (125% RDF + 10 t/ha FYM) and T_4 (100% RDF + 15 t/ha vermicompost), which recorded 24.12 and 23.72 umbels per plant, respectively. T_6 was significantly superior over T_7, T_3 T_2 T_1 and T_0. The lowest number of umbels per plant was recorded in the control treatment (T0) with 19.10, confirming the need for enhanced and balanced nutrient management to achieve optimal reproductive performance in crops. Treatments involving balanced combinations of organic and inorganic sources generally outperformed those with either input alone. Notably, T_3 (100% RDF + 15 t/ha FYM) recorded 23.31 umbels, which was significantly higher than the control (T_0: 100% RDF alone) that recorded only 19.10 umbels per plant, highlighting the role of organic matter in enhancing nutrient availability and crop productivity. The treatment involving integrated nutrient management with biofertilizers, T_7 (50% RDF + 50% FYM + Azotobacter + PSB), produced 21.89 umbels, suggesting that microbial inoculants can positively contribute to yield attributes even with reduced chemical inputs (Moradzadeh *et al.,* 2021).

Number of Seeds per Umbel

The number of seeds per umbel was significantly influenced by the different nutrient management practices. Among all treatments, the maximum number of seeds per umbel (71.01) was recorded under T_6 (125% RDF + 10 t/ha vermicompost). This treatment showed a clear advantage over all others, suggesting that higher levels of nutrient inputs through both chemical and organic sources significantly enhance seed development within umbel (Omar *et al.,* 2022). This was followed by T_5 (125% RDF + 10 t/ha FYM), which recorded 66.93 seeds per umbel and T_4 (100% RDF + 15 t/ha vermicompost) with 64.54 seeds, indicating the beneficial effects of integrated nutrient use. T_3 (100% RDF + 15 t/ha FYM) also performed well, recording 63.76 seeds per umbel, while T_2 (75% RDF + 15 t/ha vermicompost) and T_1 (75% RDF + 15 t/ha FYM) recorded 60.37 and 59.98 seeds per umbel, respectively. The integrated nutrient management treatment T_7 (50% RDF + 50% FYM + Azotobacter + PSB) resulted in 61.32 seeds per umbel, outperforming both the control and some of the reduced input treatments, indicating the positive role of microbial inoculants in supporting seed development. These results align with previous findings (Ali *et al.*, 2022; and Ebrahimi, 2023).

Test Weight (g)

The test weight (g) of the crop was significantly influenced by the various nutrient management treatments. Among all treatments, the highest and significantly, test weight (2.22 g) was observed under T_6 (125% RDF + 10 t/ha vermicompost), indicating a marked improvement in seed development and grain filling due to balanced and enhanced nutrient availability (Kakraliya *et al*., 2017). This treatment T6 remains at par with treatment T_5 and T_4. The results reflect the substantial role of organic inputs like vermicompost and FYM in improving seed quality, likely due to better nutrient uptake, improved soil aeration, and microbial activity. Treatment T_3 (100% RDF + 15 t/ha FYM) also showed a promising test weight of 1.88 g, whereas T_2 (75% RDF + 15 t/ha vermicompost) and T_1 (75% RDF + 15 t/ha FYM) recorded slightly lower values of 1.75 g and 1.69 g, respectively. These findings suggest that even a partial replacement of chemical fertilizers with organics positively influenced grain weight.

The integrated nutrient management treatment T_7 (50% RDF + 50% FYM + Azotobacter + PSB) also resulted in a moderate test weight of 1.75 g, which was higher than the control (T_0: 100% RDF) that recorded the lowest test weight (1.52 g).

Seed Yield (q ha^{-1})

The seed yield of the crop was significantly influenced by the various combinations of organic and inorganic nutrient management practices. The significantly highest seed yield (7.80 q/ha) was recorded under treatment T_6 (125% RDF + 10 t/ha vermicompost), which reflects the synergistic effect of enhanced inorganic fertilization combined with the beneficial properties of vermicompost, such as improved nutrient availability, enhanced microbial activity, and better soil structure (Methyeb *et al.,* 2023). This T6 remains at par with T_5. Treatment T_5 (125% RDF + 10 t/ha FYM) also produced a high yield (7.24 q/ha), followed by T_4 (100% RDF + 15 t/ha vermicompost) and T_3 (100% RDF + 15 t/ha FYM) which recorded 6.89 q/ha and 6.74 q/ha, respectively. These treatments demonstrate that increasing the RDF level alongside organic amendments significantly boosts productivity by improving soil fertility and nutrient uptake efficiency (Imran *et al.*, 2022). The superior seed yield under T_6 may be attributed to the combined effects of higher nutrient availability, improved physical and biological soil conditions, and better plant physiological responses due to vermicompost. Vermicompost is rich in macro and micronutrients, enzymes, and growth-promoting substances that support enhanced root growth and nutrient uptake, ultimately translating into higher yields.

Biological Yield (kg ha^{-1})

The biological yield was significantly influenced by the application of different combinations of organic and inorganic nutrient sources. Among all treatments, T_6 (125% RDF + 10 t/ha vermicompost) recorded the significantly highest biological yield of 21.30 q/ha, indicating the beneficial impact of higher nutrient availability and improved soil health through vermicompost application. However, this T_6 remains at par with T_5. This was followed by T_5 (125% RDF + 10 t/ha FYM) with 19.62 q/ha and T_4 (100% RDF + 15 t/ha vermicompost) with 18.97 q/ha, both of which also showed significantly higher yields than the control. Treatment T_3 (100% RDF + 15 t/ha FYM) and T_7 (50% RDF + 50% FYM + Azotobacter + PSB) yielded 18.50 q/ha and 18.80 q/ha, respectively, indicating that even at lower levels of chemical fertilizers, integration with organic sources and biofertilizers could sustain higher biomass accumulation. The harvest index of cumin did not show any significant effect of different nutrient management practices.

Conclusion

Based on the present findings, it can be concluded that the application of 125% RDF + 10t/ha vermicompost (T_6) resulted in higher yield (Seed yield and biological yield). Cumin crop as nitrogen is highly relevant and indispensable to crop growth and yield. Crop growth and development improved with increasing dosage of nitrogen by applying both organic and inorganic sources 125% RDF + 10t/ha vermicompost is at par with T_5 (125% RDF + 10t/ha FYM) in producing good yields. Since the application of (125% RDF + 10t/ha Vermicompost) generally improved cumin performance, it is therefore preferred most suitable and recommended for better performance of cumin in the condition of Bundelkhand region of Uttar Pradesh.

Table 1 : Response of Organic and Inorganic Nutrient Management on growth attributes of cumin

Treatments	Plant height (cm)			Number of primary branches			Fresh weight (g palnt^{-1})			Dry weight (g plant^{-1})		
	40 DAS	80 DAS	At Harvest	40 DAS	80 DAS	At Harvest	40 DAS	80 DAS	At Harvest	40 DAS	80 DAS	At Harvest
T_0 (Control: 100% RDF)	9.20	21.09	27.87	2.97	7.14	7.39	2.54	23.40	34.01	0.30	4.84	9.20
T_1 (75% RDF+ 15t/ha FYM)	10.35	24.10	29.11	3.53	7.18	7.43	2.70	26.18	36.60	0.34	5.18	10.37
T_2 (75% RDF +15 t/ha vermicompost)	10.40	24.50	29.30	3.59	7.33	7.58	2.73	26.50	36.64	0.35	5.42	10.47
T_3 (100% RDF+ 15t/ha FYM)	11.37	25.10	31.85	3.75	7.47	7.72	2.80	28.01	39.18	0.36	5.57	11.09
T_4 (100% RDF + 15t/ha vermicompost)	11.43	25.30	32.08	3.81	7.52	7.77	3.11	28.79	39.71	0.38	5.82	11.43
T_5 (125% RDF + 10t/ha FYM)	11.47	26.88	32.40	3.89	7.60	7.85	3.18	29.59	39.85	0.41	5.85	11.50
T_6 (125% RDF + 10t/ha vermicompost)	12.10	27.50	35.70	3.95	8.22	8.41	3.60	31.60	45.66	0.42	6.20	12.14
T_7 (50% RDF + 50% FYM + Azotobacter + PSB)	10.57	24.90	31.20	3.68	7.40	7.62	2.74	27.43	38.49	0.35	5.56	11.01
SEm±	0.48	0.82	1.40	0.16	0.20	0.19	0.13	1.23	1.74	0.02	0.25	0.23
CD (P=0.05)	1.46	2.49	4.25	0.48	0.60	0.58	0.40	3.74	5.29	0.05	0.75	0.70

Table 2 : Response of Organic and Inorganic Nutrient Management on yield attributes of cumin

Treatments	Number of Umbels Per Plant	Number of Seed Per Umbel	Test Weight (g)	Seed Yield (q/ha)	Biological Yield (q/ha)	Harvest Index (%)
T_0 (Control: 100% RDF)	19.10	55.03	1.52	5.50	15.60	35.44
T_1 (75% RDF+ 15t/ha FYM)	21.12	59.98	1.69	6.10	17.20	35.47
T_2 (75% RDF +15 t/ha vermicompost)	21.70	60.37	1.75	6.22	17.23	36.10
T_3 (100% RDF+ 15t/ha FYM)	23.31	63.76	1.88	6.74	18.50	36.43
T_4 (100% RDF + 15t/ha vermicompost)	23.72	64.54	1.95	6.89	18.97	36.32
T_5 (125% RDF + 10t/ha FYM)	24.12	66.93	2.02	7.28	19.62	36.90
T_6 (125% RDF + 10t/ha vermicompost)	26.12	71.01	2.22	7.80	21.30	36.62
T_7 (50% RDF + 50% FYM + Azotobacter + PSB)	21.89	61.32	1.75	6.45	18.80	34.31
SEm±	1.01	2.73	0.08	0.19	0.82	1.29
CD (P=0.05)	3.05	8.28	0.25	0.59	2.49	**NS**

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