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Effect of integrated nutrient management on growth and yield of Turmeric (*Curcuma longa* L.) cv. Waigaon

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ABSTRACT

Abstract: The current study entitled “Effect of integrated nutrient management on growth and yield of Turmeric (*Curcuma longa* L.) cv. Waigaon” was conducted in the spring season during the year of 2025-26 at Pt. Kishori Lal Shukla College of Horticulture and Research Station, Rajnandgaon, (C.G.). The experiment was laid out in a randomized block design (RBD) with nine treatments and three replications. The treatments comprised different combinations of recommended fertiliser doses and organic nutrient sources, viz., Mustard oil cake, Vermicompost, *Pongamia* oil cake, and Lentil oil cake. The results revealed that integrated application of inorganic fertilizers and organic nutrient sources significantly influenced the growth and yield attributes of Turmeric. Among the treatments, T2 (75% RDN + 25% nitrogen through Mustard oil cake) recorded superior performance for plant height in cm (35.63, 51.70 and 56.93 at 60, 90 and 120 DAP) number of leaves per plant (8.87, 18.50 and 20.53 at 60, 90 and 120 DAP), number of primary rhizomes per plant 6.20), number of secondary rhizomes per plant (8.51), maximum finger rhizome length (11.03 cm), fresh weight of rhizomes per plant (210.41 gm), fresh weight of rhizomes per plot (2.52 kg) and fresh weight of rhizomes per hectare (168.33 q). The maximum rhizome diameter (2.00 cm) was recorded in T5 (75% RDN + 25% nitrogen through Lentil oil cake. Treatment T2 (75% RDN + 25% nitrogen through Mustard oil cake) also recorded the highest benefit-cost ratio (2.57), indicating better economic efficiency of integrated nutrient management. In contrast, T1 Control (100% RDF) recorded the lowest values for all parameters and economics.

Keywords: Turmeric, Integrated nutrient management, Mustard oil cake, Vermicompost, *Pongamia* oil cake, Lentil oil cake

Introduction

Turmeric (*Curcuma longa* L.) is an ancient, cross-pollinated tropical spice crop belonging to the family Zingiberaceae and is indigenous to Southeast Asia. Popularly referred to as the “golden spice of India”, it is cultivated for its underground rhizomes and exists as a triploid species ($2n = 3x = 63$). The family Zingiberaceae is fairly large, encompassing around 40 genera and 400 species distributed across the tropics of the Old World (Reshma *et al.*, 2020) [1].

Turmeric (*Curcuma longa* L.) is a perennial herbaceous plant with tall, leafy shoots that can reach up to 2 m in height and bear up to twelve leaves. The leaves are oblong to lanceolate, reaching up to 1 m in length, with a dark green upper surface and pale green lower surface. The flowers are generally sterile and range from pale yellow to reddish, while the bracts are green with purple tinges (Fuloria *et al.*, 2022) [2].

The rhizome, which grows underground, is the primary economic part of the *Curcuma longa* plant and is the main reason for its cultivation. It is characterised by a tough, segmented skin, typically measuring 2.5 to 7.0 cm in length and approximately 2.5 cm in diameter, with a pleasant aroma and a slightly bitter taste. *Curcuma longa* thrives in tropical and subtropical climates (Karłowicz *et al.*, 2017) [3].

According to the 1st advance estimates of the Central Government, 2024-25, the global production of Turmeric is around 11 lakh tonnes per annum. India is the largest producer of Turmeric, followed by China and Myanmar. All-India Turmeric area and production are 2.91 lakh ha and 11.16 lakh tonnes. Major Turmeric-producing states are Maharashtra, Odisha, and Tamil Nadu (Anon., 2024) [4].

In Chhattisgarh, Turmeric is grown in an area of about 11.868 ha, and production is 106.959 million tonnes per ha. Turmeric production is mainly in the major districts of Balrampur 17.280 million tonnes per ha., Raigarh 9.240 million tonnes per ha., and Rajnandgaon 2.058 million tonnes per ha. (Anon., 2024) [5].

Turmeric is widely used as an everyday spice for its distinctive flavour, aroma, and vibrant golden colour. It is an essential ingredient in various culinary preparations, including curries, soups, pickles, and beverages. Besides its culinary importance, turmeric has a significant role in traditional medicine and has been used for centuries for its anti-inflammatory, antiseptic, and digestive properties. Both dried rhizome powder and turmeric oil are commonly used in traditional remedies (Chattopadhyay *et al.*, 2004) [6].

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Turmeric rhizomes are rich in bioactive and nutritional constituents, containing 1.8–5.4% curcumin, 2.5–7.2% essential oil, 2.6 g fibre, 2.3 mg nicotinic acid, 69.4% carbohydrates, 5.1% fats, 6.3% proteins, 5.0–6.0% volatile oil, and 7.9–10.4% oleoresin. These medicinal and functional properties have contributed to the increasing demand for turmeric in the food, pharmaceutical, healthcare, and personal-care industries (Srinivasan *et al.*, 2018) [7].

The prolonged application of chemical fertilizers at high rates can adversely affect soil health and the surrounding environment. Consequently, there is growing interest among farmers in adopting traditional and more sustainable farming practices with reduced dependence on chemical fertilizers. Organic manures play an important role in maintaining and improving soil fertility and physical properties. Their application enhances soil structure, texture, water-holding capacity and drainage, thereby creating favourable conditions for proper growth, development and rhizome formation in Turmeric (Kale *et al.*, 2023) [8].

The combined application of organic and inorganic fertilizers, referred to as integrated nutrient management (INM), plays an important role in enhancing crop productivity while improving soil health. Organic nutrient sources help maintain soil fertility, nutrient balance and water-holding capacity, whereas inorganic fertilizers provide readily available nutrients, particularly nitrogen, which promotes early vegetative growth. The complementary use of both nutrient sources supports better plant growth and development, ultimately contributing to higher yield. (Anuradha *et al.*, 2022)

Materials and Methods

The present field experiment entitled “Effect of integrated nutrient management on growth and yield of Turmeric (*Curcuma longa* L.) cv. Waigaon” was conducted at Pt. Kishori Lal Shukla College of Horticulture and Research Station, Rajnandgaon, situated in the western part of Chhattisgarh and lies at 21.10° North latitude, 81.03° East longitude, with an average elevation of 307 meters above the mean sea level during the cropping season 2025-26 (August- March). Rajnandgaon has a tropical wet and dry climate, characterised by distinct seasonal variations. The region receives an average annual rainfall of about 1,200 mm, with the majority of precipitation occurring during the South-West Monsoon from June to September. During the crop growth period, the weekly mean maximum and minimum temperatures showed considerable fluctuation, ranging from 33.12 °C to 7.6 °C. A large portion of the precipitation was received during the long period from September to October. The soil of the experimental area was clay-loam with normal organic carbon, low in available nitrogen and phosphorus and medium in available potassium. The field experiment was laid out in a randomized block design (RBD) with nine treatments replicated thrice: T₁ (Control 100% RDF), T₂ (75% RDN + 25% nitrogen through Mustard oil cake), T₃ (75% RDN + 25% nitrogen through Vermicompost), T₄ (75% RDN + 25% nitrogen through *Pongamia* oil cake), T₅ (75% RDN + 25% nitrogen through Lentil oil cake), T₆ (50% RDN + 50% nitrogen through Mustard oil cake), T₇ (50% RDN + 50% nitrogen through Vermicompost), T₈ (50% RDN + 50% nitrogen through *Pongamia* oil cake) and T₉ (50% RDN + 50% nitrogen through Lentil oil cake). The Turmeric variety Waigaon was planted late on 25th August, 2025, in a 1.5 m² plot at a spacing of 30 x 30 cm. One-third of the dose of nitrogen, along with full doses of P₂O₅ and K₂O, was applied at the time of planting. The planting material (rhizomes) was treated with carbendazim 2 gm/kg of seed before planting. The remaining two-thirds of nitrogen was applied at an interval of one month. All other agronomic practices like weeding, irrigation, earthing up, *etc.*, were done during the growing period of the crop. The crop was harvested on 2nd March, 2026. The observations on growth parameters were recorded during the growing period of the crop, and the yield and economic parameters were recorded after harvest. Rhizome yield was recorded on a per-plant (gm) and net plot (kg) basis at harvest. Yield per hectare was calculated based on the yield obtained per plot, considering the net cultivated area.

Economic analysis

The variable cost of Turmeric cultivation comprised expenditures on land preparation, seed rhizomes, rhizome treatment with fungicides, planting, plant protection, weeding, organic manures, inorganic fertilizers and their application, irrigation, and harvesting. Gross returns were estimated based on the prevailing average market price of turmeric during the experimental period. Net returns were obtained by deducting the total cost of cultivation, including fixed and variable costs, from the gross returns. The benefit–cost ratio (B:C ratio) for each treatment was determined by relating the net returns to the total cost of cultivation, and all economic values were expressed in Rs/ha.

Results and Discussion

Growth and yield

Effect of integrated nutrient management on plant height at 60, 90 and 120 DAP, and number of leaves per plant at 60, 90 and 120 DAP. The results revealed that the maximum plant height (35.63, 51.70 and 56.93 cm at 60, 90 and 120 DAP, respectively), number of leaves (8.87, 18.50 and 20.53 at 60, 90 and 120 DAP, respectively) were recorded significantly in Turmeric with the application of 75% RDN + 25% nitrogen through Mustard oil cake T₂, which was statistically at par with treatment T₅, 75% RDN + 25% nitrogen through Lentil oil cake. In contrast, the significantly minimum plant height (18.33, 40.07 and 46.48 cm at 60, 90 and 120 DAP, respectively) and number of leaves (4.00, 13.00 and 15.07 at 60, 90 and 120 DAP, respectively) were recorded in Turmeric with the application of 100% RDF through an inorganic source T₁, Control.

This response may be attributed to the improved water use efficiency associated with Mustard oil cake, which likely promoted rapid shoot growth during the crop growth period by reducing vapour pressure deficit and minimizing evaporation losses. Moreover, combining mustard oil cake with RDN may have produced a synergistic effect, enhancing nutrient availability and uptake by the crop. A similar beneficial effect may also be attributed to applying Lentil oil cake with RDN in Turmeric. These findings are in agreement with Kumar *et al.* (2022) [9], Anuradha *et al.* (2018) and Kamal *et al.* (2012) [10] in Turmeric.

Effect of integrated nutrient management on number of primary rhizomes per plant

Among the applied treatment found the significantly effect of integrated nutrient management was observed on the number of primary rhizomes per plant. The maximum number of primary rhizomes per plant (6.20) was recorded in treatment T₂, 75% RDN + 25% nitrogen through Mustard oil cake, which was followed by treatment T₅, 75% RDN + 25% nitrogen through Lentil oil cake (6.07). The minimum number of primary rhizomes (3.08) was observed in treatment T₁ Control, 100% RDF. The increased production of primary rhizomes under integrated nutrient management may be attributed to the balanced and gradual availability of macro- and micronutrients from organic manures. These nutrients could have promoted vegetative growth, enhanced photosynthetic activity and increased the production of assimilates. The efficient translocation of these assimilates towards the developing rhizomes may have subsequently favoured rhizome initiation and development, resulting in a greater number of primary rhizomes per plant. Similar findings were reported by Mondal *et al.* (2022) [11], Kumar *et al.* (2013) [12].

Effect of integrated nutrient management on number of secondary rhizomes per plant

The data revealed significant differences among the treatments in terms of the number of secondary rhizomes per plant. The maximum number of secondary rhizomes per plant (8.51) was recorded under T₂, 75% RDN + 25% nitrogen supplied through mustard oil cake. This treatment was statistically at par with T₅ (8.07), in which 75% RDN was supplemented with 25% nitrogen through Lentil oil cake. Conversely, the minimum number of secondary rhizomes per plant

(5.00) was observed under T₁ Control, where the entire recommended dose of fertilizers (RDF) was supplied through inorganic sources. The improvement in secondary rhizome production under integrated nutrient management may be attributed to enhanced vegetative growth, which increases leaf number and leaf area, thereby improving photosynthetic efficiency and carbohydrate synthesis. The greater availability of photosynthates and their subsequent translocation towards the developing rhizomes may have contributed to improved rhizome development and an increased number of secondary rhizomes per plant. Similar findings were reported by Mondal *et al.* (2022) [11], Kumar *et al.* (2013) [12] in Turmeric.

Effect of integrated nutrient management on finger rhizome length (cm)

Among the applied treatments, a significant effect of integrated nutrient management on rhizome length was observed. The maximum rhizome length (11.03 cm) was found in T₂, 75% RDN + 25% nitrogen through Mustard oil cake, which was followed by T₅, 75% RDN + 25% nitrogen through Lentil oil cake (9.33 cm). The minimum rhizome length (6.07 cm) was observed in treatment T₁ Control, 100% RDF. The increased finger rhizome length under this treatment may be attributed to the enhanced availability of nitrogen and other essential nutrients through the combined effect of inorganic fertilizers and Mustard oil cake, which promoted better cell division and elongation in the developing rhizomes. Similarly, the maximum rhizome length was reported by Mondal *et al.* (2022) [11].

Effect of integrated nutrient management on finger rhizome diameter (cm)

Among the applied treatments, a significant effect of integrated nutrient management was observed on rhizome diameter. The maximum rhizome diameter (2.00 cm) was found in (T₅) 75% RDN + 25% nitrogen through Lentil oil cake, which was followed by (T₆) 50% RDN + 50% nitrogen through Mustard oil cake (1.70 cm). The minimum rhizome diameter (0.73 cm) was observed in treatment (T₁) Control 100% RDF. The increased finger rhizome length under this treatment may be attributed to the enhanced availability of nitrogen and other essential nutrients through the combined effect of inorganic fertilizer and mustard oil cake, which promoted better cell division and elongation in the developing rhizomes.

Effect of integrated nutrient management on fresh weight of rhizomes per plant (gm)

The data revealed significant differences among the treatments in terms of the fresh weight of rhizomes per plant. The maximum fresh weight of rhizomes per plant (210.41 g) was recorded in T₂ (75% RDN + 25% nitrogen through Mustard oil cake), followed by T₅ (204.50 g), whereas the minimum (95.00 g) was recorded in T₁ (100% RDF). The superior performance of T₂ may be attributed to the gradual release and balanced availability of nutrients from Mustard oil cake, particularly nitrogen (5.27%), which promoted rhizome initiation, enlargement and carbohydrate accumulation Singh (2024) [13] Kamal *et al.* (2012) [10]. Despite the delayed planting of turmeric on 25th, August, satisfactory rhizome fresh weight was observed, indicating that appropriate integrated nutrient management

supported rhizome development under late-planting conditions. Similar results were reported by Singh *et al.* (2015) [14].

Effect of integrated nutrient management on fresh weight of rhizomes per plot (kg)

The data revealed significant differences among the treatments in terms of the fresh weight of rhizomes per plot. The maximum fresh weight of rhizomes (2.52 kg plot⁻¹) was recorded in T₂ (75% RDN + 25% nitrogen through Mustard oil cake), followed by (2.45 kg plot⁻¹) T₅ (75% RDN + 25% nitrogen through Lentil oil cake), whereas the minimum (1.14 kg plot⁻¹) was recorded in T₁ (100% RDF). The superior performance of T₂ may be attributed to the gradual release and balanced availability of nutrients from Mustard oil cake, particularly nitrogen (5.27%), which promoted rhizome initiation, enlargement and carbohydrate accumulation. Similar results were reported by Singh (2024) [13], Kumar *et al.* (2022) [9]. Despite the delayed planting of turmeric on 25th, August, satisfactory rhizome fresh weight was observed, indicating that appropriate integrated nutrient management supported rhizome development under late-planting conditions. Similar results were reported by Singh *et al.* (2015) [14].

Effect of integrated nutrient management on fresh weight of rhizomes per hectare (q)

The data revealed significant differences among the treatments in terms of the fresh weight of rhizomes per hectare. The maximum fresh weight of rhizomes (168.33 q ha⁻¹) was recorded in T₂, 75% RDN + 25% nitrogen through Mustard oil cake, followed by (163.60 q ha⁻¹) in T₅, 75% RDN + 25% nitrogen through Lentil oil cake, whereas the minimum (76.00 q ha⁻¹) was recorded in T₁, 100% RDF. The superior performance of T₂ may be attributed to the gradual release and balanced availability of nutrients from Mustard oil cake, particularly nitrogen (5.27%), which promoted rhizome initiation, enlargement and carbohydrate accumulation. Similar results were reported by Singh (2024) [13], Kumar *et al.* (2022) [9]. Despite the delayed planting of Turmeric on 25th August, satisfactory rhizome fresh weight was observed, indicating that appropriate integrated nutrient management supported rhizome development under late-planting conditions. Similar results were reported by Singh *et al.* (2015) [14].

Economics

The results revealed that the highest gross return of Rs. 8,41,650.00 ha⁻¹ was obtained from T₂, 75% RDN + 25% nitrogen through Mustard oil cake, followed by T₅, 75% RDN + 25% nitrogen through Lentil oil cake, which recorded a gross return of Rs. 8,18,000.00 ha⁻¹. The lowest gross return of Rs. 3,80,000.00 ha⁻¹ was recorded under T₁, Control 100% RDF. Shadap *et al.* (2018) [15]. The maximum net return of Rs. 5,14,345.17 ha⁻¹ was obtained under T₂, 75% RDN + 25% nitrogen through Mustard oil cake, followed by T₅, 75% RDN + 25% nitrogen through Lentil oil cake, with a net return of Rs. 4,84,587.17 ha⁻¹. On the other hand, the minimum net return of Rs. 98,032.17 ha⁻¹ was recorded under T₁, Control 100% RDF. The maximum B:C ratio (2.57) was recorded in treatment T₂, 75% + 25% nitrogen through Mustard oil cake, followed by (2.45) obtained in T₅, 75% RDN + 25% nitrogen through Lentil oil cake and the lowest B:C ratio (1.35) was recorded in T₁, Control, 100% RDF. Lepcha *et al.* (2022) [16], Sagwal *et al.* (2022).

Table 1. Effect of integrated nutrient management on growth of Turmeric cv. Waigaon

Treatments	Plant height (cm)			Number of leaves per plant		
	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
T ₁	18.33	40.07	46.48	4.00	13.00	15.07
T ₂	35.63	51.70	56.93	8.87	18.50	20.53
T ₃	23.65	42.88	49.40	5.49	14.23	16.00
T ₄	27.09	45.63	51.00	6.73	15.33	17.19
T ₅	33.28	49.28	53.65	8.10	17.02	19.23
T ₆	31.00	47.00	53.00	7.60	16.83	18.23
T ₇	21.33	42.20	48.75	5.00	13.73	15.60
T ₈	26.00	43.24	50.33	6.07	15.00	17.00
T ₉	29.53	46.00	52.66	7.05	16.03	18.00
S.E. (m)	1.03	1.34	1.39	0.22	0.55	0.64
C.D.	3.08	4.02	4.16	0.66	1.64	1.92
C.V.	6.52	5.13	4.68	5.84	6.12	6.37

Table 2. Effect of integrated nutrient management on yield of Turmeric cv. Waigaon

Treatments	Number of primary rhizomes per plant	Number of secondary rhizomes per plant	Length of finger rhizomes (cm)	Diameter of finger rhizomes (cm)	Fresh weight of rhizomes per plant (gm)	Fresh weight of rhizomes per plot (kg)	Fresh weight of rhizomes per ha (q)
T ₁	3.08	5.00	6.07	0.83	95.00	1.14	76.00
T ₂	6.20	8.51	11.03	1.50	210.41	2.52	168.33
T ₃	4.00	6.02	7.00	1.10	134.30	1.61	107.44
T ₄	4.67	7.11	8.74	1.25	160.46	1.92	128.37
T ₅	6.07	8.07	9.33	2.00	204.50	2.45	163.60
T ₆	5.28	7.45	9.24	1.70	187.63	2.25	150.10
T ₇	3.50	5.41	6.73	1.04	119.04	1.42	95.23
T ₈	4.20	6.40	7.84	1.16	149.84	1.79	119.87
T ₉	5.00	7.22	9.01	1.39	175.96	2.11	140.77
S.E. (m)	0.23	0.28	0.37	0.06	5.18	0.07	5.01
C.D.	0.68	0.85	1.12	0.18	15.54	0.21	15.01
C.V.	8.40	7.22	7.76	7.74	5.62	6.20	6.79

Table 3. Effect of integrated nutrient management on economics of Turmeric cv. Waigaon

Treatments	Yield (q./ha.)	Total cost of cultivation (Rs. ha ⁻¹)	Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B: C ratio
T ₁	76.00	2,81,967.83	3,80,000.00	98,032.17	1.35
T ₂	168.33	3,27,304.83	8,41,650.00	5,14,345.17	2.57
T ₃	107.44	3,052,10.83	5,37,200.00	2,31,989.17	1.76
T ₄	128.37	3,46,708.83	6,41,850.00	2,95,141.17	1.85
T ₅	163.60	3,33,412.83	8,18,000.00	4,84,587.17	2.45
T ₆	150.10	3,72,574.83	7,50,500.00	3,77,925.17	2.01
T ₇	95.23	3,28,360.83	4,76,150.00	1,47,789.17	1.45
T ₈	119.87	4,11,382.83	5,99,350.00	1,87,967.17	1.46
T ₉	140.77	3,85,726.83	7,03,850.00	3,18,123.17	1.82

Conclusion

Integrated nutrient management significantly influenced the growth, yield, and economics of Turmeric cv. Waigaon. Among all treatments, T₂ (75% RDN + 25% nitrogen through Mustard oil cake) recorded the highest values for most growth and yield attributes. This superior performance is attributed to the balanced, continuous availability of nutrients from combined organic and inorganic sources. Mustard oil cake, containing 5.27% nitrogen, enhanced nutrient availability and uptake, thereby promoting vigorous vegetative growth and improved rhizome development. Treatment T₅ (75% RDN + 25% nitrogen

through Lentil oil cake) recorded the largest finger rhizome diameter and ranked second for several parameters. T₂ also recorded the highest fresh rhizome yield of 168.33 q/ha along with the highest benefit-cost ratio (2.57), confirming its economic superiority. Although the crop was planted late, on 25th, August, beyond the normal planting window, resulting in a shortened growth period, T₂ still produced a satisfactory rhizome yield. This indicates that integrated nutrient management effectively sustained crop growth and productivity even under delayed planting conditions. The combined application of organic and inorganic nitrogen sources improved overall nutrient use efficiency. Hence, the application of 75% RDN + 25% nitrogen through

Mustard oil cake (T₂) can be recommended as the most effective and profitable nutrient management practice for enhancing turmeric productivity under similar agro-climatic conditions.

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