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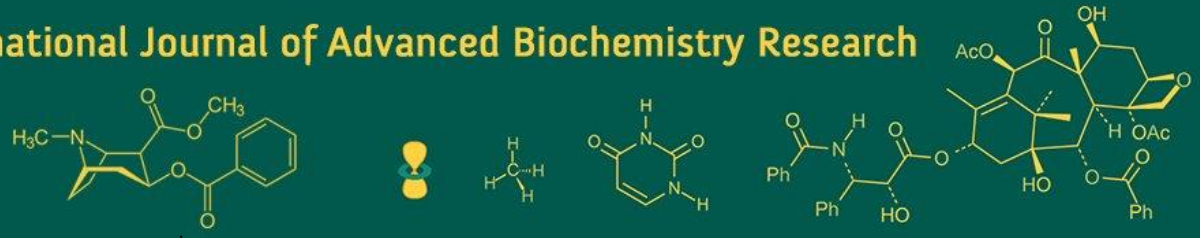

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Growth and yield of turmeric (*Curcuma longa* L.) as influenced by consortium biofertilizers and nutrient levels

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Abstract
Turmeric (*Curcuma longa* L.), an herb native to South East Asia, is a significant spice crop of India belonging to the Zingiberaceae family. It serves as a condiment and coloring agent in various industries, including food, textiles, cosmetics, and pharmaceuticals, particularly for anti-cancer medications. Intensive cultivation necessitates the use of chemical fertilizers alongside organic manures and bio-fertilizers to enhance food safety and sustainability. This study evaluated the impact of integrated nutrient management on turmeric's growth, yield, and quality in northern dry zone Karnataka during the 2022-23 and 2023-24 periods at Dhanvantari Medicinal and Aromatic Plants Garden, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bagalkot. The pooled data findings indicated that treatment T_{10} demonstrated superior growth and yield attributes. Specifically, T_{10} (100% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost) surpassed other treatments in fresh (22.19 t) and dry (7.52 t/ha) rhizome yields, rhizome curing percentage (34.90%), volatile oil content (2.88%), curcumin content (3.94%) and oleoresin content (6.63%), yielding gross returns of Rs. 2,66,280/ha. This suggests that integrating biofertilizers with organic manures reduces the need for recommended fertilizer doses. The second most effective treatment, T_{11} (75% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost), achieved the highest net returns of Rs. 1,23,916.0/ha, while T_{12} (50% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost) exhibited the best benefit-cost ratio (2.03) for commercial turmeric cultivation.

Keywords: Nutrient, integrated management and turmeric

Introduction
Turmeric (*Curcuma longa* L.), an herbaceous perennial from the Zingiberaceae family, is a significant tropical spice crop originating from Southeast Asia. It is cultivated not only in India but also in several countries including Cambodia, China, and Vietnam. India leads in turmeric production and export, covering 2.95 lakh hectares and yielding 11.02 lakh tonnes in 2020-21 (Anon., 2021) [1]. Turmeric represents six percent of the area and ten percent of production within the spices and condiments sector. Turmeric cultivation spans 18 Indian states, with Telangana contributing the most at 14.33%, followed by Odisha and others. Historically recognized for its culinary and coloring properties, turmeric is utilized in textiles, food, cosmetics, and pharmaceuticals, notably in anti-cancer drug formulations (Srivastava *et al.*, 2003) [20].

As a nutrient-exhaustive crop, turmeric necessitates adequate nutrient application to achieve optimal yields. High doses of chemical fertilizers have been shown to adversely affect on soil health and ecological balance (Chanchan *et al.*, 2018) [3]. Low soil fertility and suboptimal farming practices lead to decreased turmeric yield and productivity (Das *et al.*, 2020) [4]. The escalating costs and detrimental impacts of chemical fertilizers have prompted farmers to seek alternative nutrient sources for spice cultivation. Various plant nutrient sources, including organic manures and biofertilizers, are available beyond traditional fertilizers. The practice of Integrated Nutrient Management, which combines organic and inorganic fertilizers, enhances yield and improves soil properties, thereby increasing fertility and water retention.

Utilizing organic sources can help maintain soil nutrient balance, while diverse organic manures like FYM and vermicompost positively affect turmeric growth and yield (Sarma *et al*., 2015) [16]. Moreover, effective management of chemical, organic, and biological nutrients has shown promising results in meeting crop fertilizer requirements (Mohanty *et al.*, 2022) [7].

A comprehensive integrated plant nutrient system, incorporating fertilizers, manures, and biofertilizers, is critical for sustaining crop production and maintaining soil health and biodiversity. This approach is particularly vital in developing countries, where smallholder farmers dominate the agricultural landscape (Bhupenchandra *et al.*, 2022) [2]. It is widely recognized that prolonged application of synthetic fertilizers detrimentally impacts soil health and biological systems while failing to maintain productivity, even at elevated inorganic fertilizer levels. Furthermore, the efficacy of these fertilizers is compromised by factors such as nitrogenous fertilizers experiencing over 50 percent loss due to denitrification and leaching (Pandey and Kumar, 1989) [11].

Micronutrient elements are essential for various physiological processes in plants, including chlorophyll production, stress response, and the synthesis of proteins and nucleic acids. In Indian agriculture, turmeric farming is particularly reliant on micronutrients to optimize yield and quality. Specifically, iron and zinc deficiencies correlate with diminished turmeric rhizome yields and lower curcumin levels. Research has demonstrated a significant enhancement in both yield and quality of turmeric rhizomes with micronutrient supplementation. The application of micronutrients elevates curcumin concentration, increases essential oil yields, and enhances antioxidant activity in turmeric. A strategic approach to micronutrient management, encompassing both soil and foliar applications, presents a viable method for enhancing the efficiency of turmeric cultivation, thereby maximizing yield and quality for commercial and medicinal uses (Yushma, 2024) [27]. Despite numerous trials focusing on various agronomic factors to boost turmeric production, limited research has been conducted on the effects of micronutrients and microbial consortia. In light of these considerations, the study aimed to examine the effects of bio-fertilizers integrated with consortia and organic and inorganic nitrogen on turmeric, hypothesizing that bio-fertilizers would enhance growth, yield, and economic returns. The present research sought to assess the impacts of bio-fertilizers, manures, and grades of inorganic fertilizer on yield characteristics and economic viability of turmeric in an integrated manner.

Materials and Methods

An investigation entitled “Integrated nutrient management on growth, yield and quality of turmeric (*Curcuma longa* L.) under northern dry zone of Karnataka” was conducted at the Dhanvantari Medicinal and Aromatic Plants Garden (DMAPG), Sector No. 41, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bagalkot, Karnataka during 2022-23 and 2023-24. The materials and methodologies employed in this investigation are outlined below. Bagalkote is located in the northern dry zone of Karnataka at coordinates 16.180 N latitude and 75.70 E longitude, at an elevation of 537.28 m above sea level. The site falls within Zone-3 and Region-3 of Karnataka's agro-climatic zones. The experimental area features red soil with alkaline pH, and soil samples were collected from a depth of 0-15 cm using standard procedures for the analysis of physico-chemical properties and fertility status of the experimental plot. The proposed land was thoroughly prepared through repeated ploughing and harrowing. Experiments were designed with ridges and furrows spaced 60 cm apart in each plot. Well-matured, healthy rhizomes of turmeric cv. Salem from the 2021-22 and 2022-23 harvests were utilized for the 2022-23 and 2023-24 investigations, respectively. Shade-dried rhizomes averaging 30-40 g were treated with Bavistin and Streptocyclin solutions for 30 minutes prior to planting. The experiment was conducted using a Randomized Block Design with three replications.

Growth parameters were recorded from five randomly selected clumps in each replication at monthly intervals, starting 90 days after planting (DAP) until harvest. Leaf area was calculated by multiplying leaf dimensions with a conversion factor (0.72) as per Rao and Swamy (1984) [3]. Chlorophyll content was assessed using the DMSO method by Sadasivam and Manickam (1996) [15] during the grand growth period (135 DAP), expressed in mg per g. The number of mother, primary, and secondary rhizomes was recorded from five randomly chosen plants, with means expressed per plant. The girth of five randomly selected rhizomes was measured with a vernier caliper, yielding average values in centimeters. At harvest, rhizomes from each selected plant were weighed to determine average fresh rhizome yield in grams per plant. The cumulative fresh rhizome yield per plot (17.28 m^2) was expressed in kg, and yield per hectare (t/ha) was calculated based on plot yield and area. The dry weight of rhizome yield was estimated similarly to fresh rhizome weight per plant, plot, and hectare. Based on market price of turmeric cost of cultivation was worked out with fixed cost of cultivation Rs. 90,432 ha^{-1}. Growth and yield data were analyzed using Fisher’s ANOVA as per Sundararaj *et al.* (1972) [22], with CD values calculated at a five percent significance level when the ‘F’ test indicated significant treatment mean differences.

Results and Discussions

The scientific approach of integrated nutrient management aims at efficient and judicious use of all the major sources of plant nutrients in an integrated manner to realize maximum yield without any deleterious effects on soil fertility and environment besides less dependency on chemical fertilizers in crop production. Turmeric being a nutrient exhaustive crop, requires heavy dose of fertilizers (Subramanian *et al.*, 2003) [21]. Intensive crop cultivation requires the supplementation of chemical fertilizers with organic manures and bio-fertilizers as they are most effective, eco-friendly and efficient inputs to produce safer food for consumption. Under the holistic approach the present experiment was taken up to study the effect of integrated nutrient management on growth, yield and quality of turmeric in field condition. Application of microbial consortium in combination with inorganic fertilizers and organic manures has augmented the growth, and yield as confirmed by many research reports in rhizomatous crops. With this background, the results obtained in the present investigation of both years 2022-23 and 2023-24 are discussed below.

The most obvious effect of nutrition is to bring changes in the growth attributes of any crop. The climatic factors also influenced the growth and yield of turmeric during growing period of 2022-23 and 2023-24. The temperature, relative humidity and distribution of rainfall had their impact on crop growth and development during cropping period. The growth parameters like plant height, number of tillers, number of leaves, plant spread (N-S and E-W) and leaf area were significantly influenced by the integrated nutrient management in turmeric *cv*. Salem (Tables 1). In early stage of crop growth, they did not show definite pattern of nutrient influence on vegetative growth of turmeric. The maximum plant height (143.76 cm), number of tillers per plant (6.20), number of leaves per plant (13.30), plant spread (N-S: 58.49 cm^2) and (E-W: 55.13 cm^2) and leaf area (600.4 cm^2/plant) were recorded in the treatment T_{10} (100% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost) during the both years of the experiment.

This might be due to the sustained release of nutrients initially by fertilizers followed by regular release of nutrients later by vermicompost which resulted in balancing the demand and supply system in soil. Hence, integrated application of both organic, inorganic and micronutrient special helped in the increased growth and development of plants in spite of deficit of rainfall during their establishment, growth and development stages (August to October). The quantity of rainfall received was above normal during 2022-23 but lower than the normal during 2023-24. However, at rhizome development stage of both year (September to January), the amount of rainfall distribution was very minimal from the normal mean of 10 years, resulted in slow crop growth in both year of the experiments. Nitrogen is also an important component of amino acids and co-enzymes have considerable role in biological reactions, which favours the better synthesis of carbohydrates resulted in vigorous growth of plants. Similarly, mechanism by which PSB augmented plant growth are through phosphate dissolution and in the biosynthesis of bio-active substances has considerable role in promotion of growth (Sattar and Gaur, 1987) [17]. This increase in growth parameters of turmeric might be due to higher availability of nutrients in the initial period through the application of direct fertilizers and also regular availability of macro and micro nutrients from microbial consortium, micronutrient special and vermicompost throughout the crop growth period. The positive effect of vermicompost on plant growth has been reported by Velmurugan and Chezhiyan (2008) [28] in turmeric and (Sreekala and Jayachandran, 2003) [19] in ginger. These results suggest that the combined application of inorganic, bio-fertilizers and vermicompost was superior over individual application for better plant growth.

During 135 DAP the chlorophyll content was examined in both the years and showed significantly highest chlorophyll content in leaves (2.02 mg/g) which was recorded in T_{10} (100% RDF + consortium (10 kg/ha) + Micronutrient special + Vermicompost). This might be due to the fact that nitrogen is a component of chlorophyll, which caused increase in chlorophyll content. Moreover, higher number of leaves and maximum size of leaves under this treatment may have also attributed to higher chlorophyll content. These results are in accordance with the findings of Kanaujia *et al.* (2018) [6] in turmeric, Padmapriya *et al.* (2007a) [9]. Earlier, Nanda *et al.* (2012) [8] and Yanthan *et al.* (2010) [26] also reported positive effect on ginger.

The yield attributes of mother rhizomes, primary and secondary rhizomes were significantly influenced by the integrated nutrient management in turmeric *cv.* Salem (Table 2). Maximum number of mother rhizomes per plant (2.77), girth of primary (4.05 cm) and secondary rhizomes (3.21 cm) per plant, length of primary rhizomes (8.24 cm), secondary rhizomes (3.35 cm), weight of mother rhizomes (42.49 g), primary rhizomes (177.00 g) and secondary rhizomes (149.00 g), fresh (22.19 t) and dry (7.52 t/ha) rhizome yield per hectare were recorded in the treatment (T_{10}) where application of 100% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost. Whereas, plants supplied with 75% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost (T_{11}) recorded maximum number of primary and secondary rhizomes per plant (6.20 and 10.80, respectively). Maximum length of mother rhizomes (8.30 cm) was recorded in 50% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost (T_{12}). Increased dry rhizome yield could be attributed to increase in fresh yield of rhizomes and also the integrated way of nutrient application in T_{10}, T_{11} and T_{12} treatments resulted in synergistic effects and encouraged the various growth attributes ultimately helped in better absorption and utilization of nutrients by the plants. Increase in fresh weight of rhizomes could be attributed to luxurious vegetative growth due to the influence of balanced nutrition this could also be related to better absorption and uptake of nutrients that recorded in maximum accumulation of dry matter due to the combined effect of organic, inorganic and biofertilizers. These findings are also confirmed with Singh *et al*. (2012) [12], Roy and Hore (2009) [14], Paropkar, *et al*. (2012) [12] and Padmapriya *et al*. (2007a) [9] in turmeric.

The quality is an important parameter which ultimately decides the market value, demand and premium price in the market. Experiment showed significant influence of nutrients on the curing percentage, volatile oil, oleoresin and curcumin contents during both the years (2022-23 and 2023-24) (Table 3). A maximum of 34.90 percent of rhizome curing, curcumin content (3.94%) and oleoresin content (6.63%) were recorded in T_{10} (100% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost). Maximum volatile oil contents of 2.88 percent was registered in T_{12} (50% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost) in both year and pooled data of the experiment, respectively. A highest dry recovery percentage, volatile oil content, oleoresin content and curcumin content could be due to the higher assimilation of carbohydrates and accumulation of dry matter production in rhizomes. Similar reports were also corroborated by earlier findings in turmeric [Padmapriya *et al.* (2005) [10] and Nanda *et al*. (2012)] [8] who opined that increase in curcumin content due to increased activity of phenyl ammonia lyase enzyme which involved in curcumin biosynthesis. Uphadhayay and Mishra (1999) [23] also found that greater uptake of nutrients increased curcumin content in turmeric rhizome. Vishwanath *et al.* (2004) [25] also reported higher curing percentage mainly due to the less moisture and higher lignifications in turmeric rhizome due to increased crop duration.

The benefit cost ratio is an important and ultimate factor which decides the optimum level of input to be used for maximization of production and returns of any crop. In the present study, the benefit cost ratio was worked out for

different levels of NPK fertilizers, organic manures and microbial consortium (Fig. 1). Among the treatments, T_{10} (100% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost) recorded the highest gross returns (Rs. 2,66,280/ha). The highest net returns (Rs. 1,23,916.0/ha) was obtained in T_{11} (75% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost) and highest benefit cost ratio (2.03) was found in T_{12} ((50% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost)). The least B: C ratio (1.53) was found in T_9 [50% RDF + Vermicompost (2.5 t/ha)]. Increase in the benefit: cost ratio was mainly attributed to the increase in the fresh and cured rhizome yield and minimum cost for production which contributed more towards this value. The least B: C ratio was due to lower returns compared to cost of inputs. The additional supply of bioferlizers in combination with organic manures and inorganic fertilizers helped in increasing yield and reducing the cultivation cost (Table 28). Similar results were reported in turmeric by Nanda *et al*. (2012) [8] and in henbane by Gupta ***et al***. (2011) [5].

Table 1: Effect of growth retardant and nipping practice of growth attributes of turmeric Cv. Salem

Treatment	Plant height (cm)	No. of Tillers	No. of leaves	Plant spread		Leaf area (cm^2)	Chlorophyll content (mg/g)
				N-S	E-W		
T_1: 100% RDF + Consortium (10 kg/ha)	123.19	5.87	12.50	52.04	48.33	474.7	1.73
T_2: 75% RDF + Consortium (10 kg/ha)	121.07	5.93	13.50	51.30	41.08	465.4	1.75
T_3: 50% RDF + Consortium (10 kg/ha)	123.60	5.73	12.30	48.50	35.37	498.3	1.63
T_4: 100% RDF + Micronutrient special (5 g/lt)	137.93	5.60	12.30	48.62	43.61	465.4	1.67
T_5: 75% RDF + Micronutrient special (5 g/lt)	129.11	6.20	12.70	45.60	39.49	467.5	1.63
T_6: 50% RDF + Micronutrient special (5 g/lt)	130.86	5.47	12.50	38.11	48.72	493.2	1.70
T_7: 100% RDF + Vermicompost (2.5 t/ha)	125.54	6.20	12.90	46.07	42.77	522.6	1.79
T_8: 75% RDF + Vermicompost (2.5 t/ha)	119.45	5.93	12.10	46.56	42.15	507.1	1.81
T_9: 50% RDF + Vermicompost (2.5 t/ha)	116.42	6.00	12.10	38.42	41.40	549.7	1.70
T_{10}:T_1 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	143.76	6.20	13.30	58.49	55.13	600.4	2.02
T_{11}:T_2 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	143.26	6.07	13.40	55.06	49.34	568.9	1.94
T_{12}:T_3 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	142.09	6.20	12.80	54.52	48.11	558.6	1.86
T_{13}: RDF (Standard check)	113.80	5.93	11.90	36.75	40.38	556.6	1.72
Mean	128.47	5.95	12.64	47.69	44.30	517.6	1.77
S.Em.±	1.42	0.16	0.15	0.22	0.16	0.9	0.02
C.D @ 5%	4.15	0.48	0.42	0.65	0.47	2.7	0.05

Table 2: Effect of growth retardant and nipping practice of yield attributes of turmeric Cv. Salem

Treatment	No of rhizomes			Girth of rhizomes (cm)			Length of rhizomes (cm)			Weight of rhizomes (g)			Fresh weight of rhizomes		
	MR	PR	SR	MR	PR	SR	MR	PR	SR	MR	PR	SR	Per plant (g)	Per plot (kg)	Per hectare (ton)
T_1: 100% RDF + Consortium (10 kg/ha)	2.03	3.97	7.43	2.91	3.05	2.23	6.93	4.75	2.91	37.02	144.81	116.81	298.64	31.09	17.99
T_2: 75% RDF + Consortium (10 kg/ha)	2.37	4.43	7.70	3.25	3.41	2.26	7.03	5.00	3.31	35.73	144.73	116.73	297.19	30.94	17.90
T_3: 50% RDF + Consortium (10 kg/ha)	1.97	4.30	7.77	3.37	3.70	2.32	6.87	5.30	3.09	33.34	142.35	114.35	290.03	30.19	17.47
T_4: 100% RDF + Micronutrient special (5 g/lt	2.23	4.17	7.57	3.49	3.87	2.40	7.11	5.62	3.14	37.67	144.58	116.57	298.81	31.10	18.00
T_5: 75% RDF + Micronutrient special (5 g/lt)	2.10	4.63	8.77	3.07	3.78	2.48	6.85	6.14	3.18	35.19	143.67	115.66	294.52	30.66	17.74
T_6: 50% RDF + Micronutrient special (5 g/lt)	2.10	4.43	8.37	3.59	3.96	2.55	6.91	6.21	2.95	33.95	145.42	117.42	296.78	30.89	17.88
T_7: 100% RDF + Vermicompost (2.5t/ha)	2.70	4.70	8.90	3.11	3.85	2.62	6.72	6.49	3.04	31.64	142.57	114.56	288.76	30.06	17.39
T_8: 75% RDF + Vermicompost (2.5 t/ha)	2.50	4.63	8.77	3.28	3.85	2.75	7.06	6.73	3.17	31.19	142.58	114.58	288.35	30.02	17.37
T_9: 50% RDF + Vermicompost (2.5 t/ha)	2.50	4.70	8.90	3.11	3.77	2.95	7.65	7.03	3.13	29.98	141.44	113.44	284.86	29.65	17.16
T_{10}:T_1 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	2.77	5.63	10.63	3.43	4.05	3.21	8.13	8.24	3.30	42.49	177.00	149.00	368.50	38.35	22.19
T_{11}:T_2 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	2.43	5.70	10.80	3.36	4.03	2.78	7.92	7.79	3.35	40.72	170.20	142.20	353.13	36.75	21.27
T_{12}:T_3 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	2.70	5.30	10.07	3.51	3.97	3.02	8.30	7.04	3.33	40.49	160.42	132.42	333.33	34.69	20.08
T_{13}: RDF (Standard check)	2.43	4.37	8.23	3.13	3.66	2.61	6.95	5.58	2.98	36.97	145.78	117.78	307.19	31.28	18.10
Mean	2.37	4.69	8.76	3.28	3.76	2.23	7.26	6.30	3.15	35.88	149.65	121.66	298.64	31.97	18.50
S.Em.±	0.15	0.21	0.40	0.02	0.05	0.01	0.08	0.16	0.01	0.21	0.54	0.54	1.25	0.13	0.08
C.D @ 5%	0.4	0.6	1.2	0.1	0.1	0.03	0.2	0.5	0.03	0.6	1.6	1.6	3.7	0.4	0.2

MR: Mother rhizomes, PR: Primary rhizomes and SR: Secondary rhizomes

Table 3: Effect of integrated nutrient management on quality parameters of turmeric *cv.* Salem

Treatment	Percent curing	Volatile oil content (%)	Curcumin content (%)	Oleoresin content (%)
T_1: 100% RDF + Consortium (10 kg/ha)	25.80	1.99	3.02	6.29
T_2: 75% RDF + Consortium (10 kg/ha)	24.18	1.82	3.24	6.26
T_3: 50% RDF + Consortium (10 kg/ha)	22.26	2.67	2.73	5.93
T_4: 100% RDF + Micronutrient special (5 g/lt)	23.56	2.23	3.25	6.17
T_5: 75% RDF + Micronutrient special (5 g/lt)	23.36	2.22	3.54	6.43
T_6: 50% RDF + Micronutrient special (5 g/lt)	24.24	2.26	3.35	6.27
T_7: 100% RDF + Vermicompost (2.5 t/ha)	25.72	2.06	3.22	6.36
T_8: 75% RDF + Vermicompost (2.5 t/ha)	24.08	2.11	3.34	6.48
T_9: 50% RDF + Vermicompost (2.5 t/ha)	22.90	2.01	3.24	6.56
T_{10}:T_1 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	34.90	2.03	3.94	6.63
T_{11}:T_2 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	33.54	2.08	3.78	6.52
T_{12}:T_3 + Micronutrient special (5 g/lt) + Vermicompost (2.5 t/ha)	31.47	2.88	3.62	6.40
T_{13}: RDF (Standard check)	23.34	2.05	2.60	5.50
Mean	26.10	2.18	3.30	6.29
S.Em.±	0.11	0.04	0.03	0.03
C.D @ 5%	0.30	0.1	0.1	0.1

RDF =150: 125:250 kg NPK/ha + FYM 25 t/ha

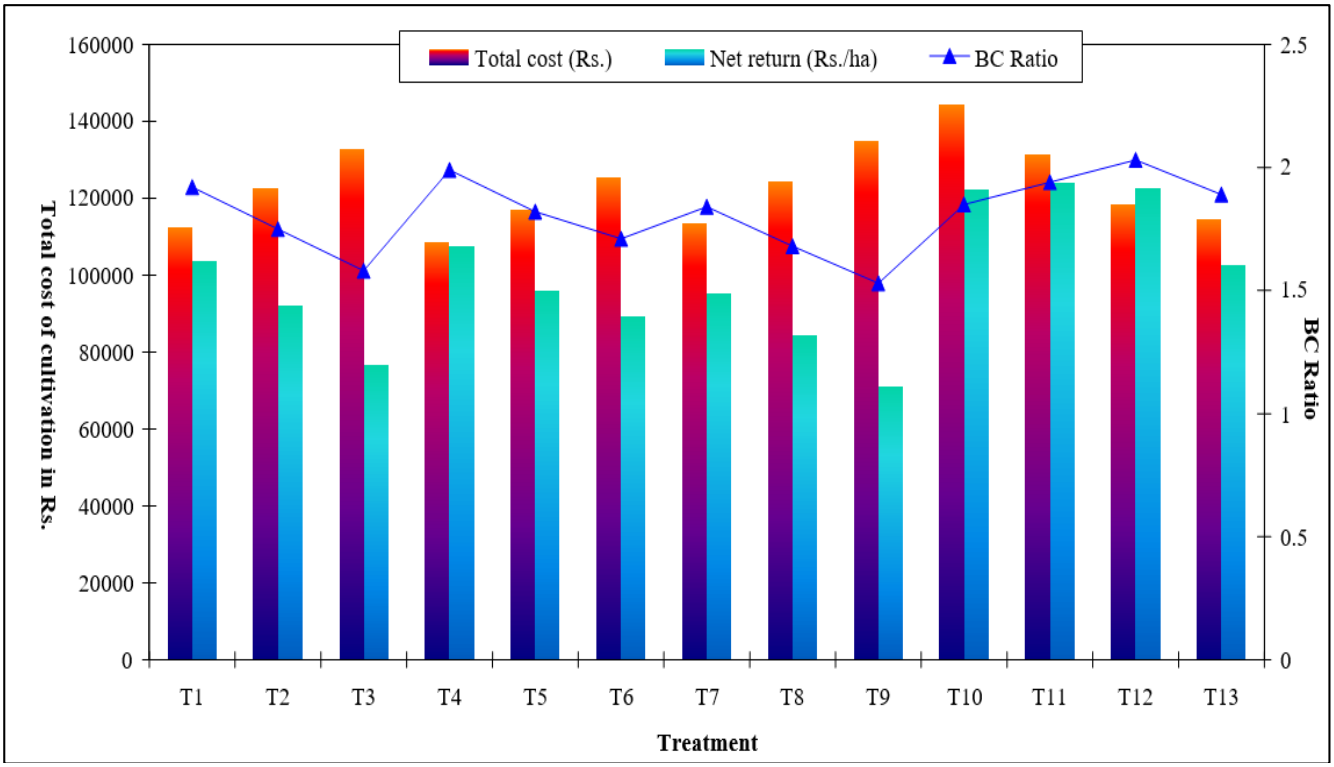

Fig 1: Economics of turmeric cv. Salem influenced by integrated nutrient management

Treatment

T_1: 100% RDF + Consortium (10 kg/ha)
T_2: 75% RDF + Consortium (10 kg/ha)
T_3: 50% RDF + Consortium (10 kg/ha)
T_4: 100% RDF + Micronutrient special (5 g/l)
T_5: 75% RDF + Micronutrient special (5 g/l)
T_6: 50% RDF + Micronutrient special (5 g/l)
T_7: 100% RDF + Vermicompost (2.5 t/ha)
T_8: 75% RDF + Vermicompost (2.5 t/ha)
T_9: 50% RDF + Vermicompost (2.5 t/ha)
T_{10}: T_1 + Micronutrient special (5 g/l) + Vermicompost (2.5 t/ha)
T_{11}: T_2 + Micronutrient special (5 g/l) + Vermicompost (2.5 t/ha)
T_{12}: T_3 + Micronutrient special (5 g/l) + Vermicompost (2.5 t/ha)
T_{13}: RDF (Standard check)

Conclusion

From experiment, it can be inferred that treatments T_{10} exhibited superior performance in growth and yield attributes. Furthermore, T_{10} outperformed alternative treatments in fresh rhizome yield (22.19 t), dry rhizome yield (7.52 t/ha) per hectare, rhizome curing percentage (34.90%), volatile oil content (2.88%), curcumin content (3.94%) and oleoresin content (6.63%) and gross returns (Rs. 2,66,280/ha) in both year and pooled data. Demonstrating that the integration of biofertilizers with organic manures diminishes the requirement for the recommended fertilizer dosage. The second most effective treatment was T_{11}-75% RDF + Consortium (10 kg/ha) + Micronutrient special + Vermicompost recorded highest net returns (Rs. 1,23,916.0 /ha) based on the cost of cultivation and yield but the highest benefit cost ratio (2.03) was found in T_{12} ((50% RDF + Consortium (10 kg/ha) + Micronutrient

special + Vermicompost)) for the commercial cultivation of turmeric.

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