Research Article

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Integrated nutrient management in turmeric (*Curcuma longa* L.) cv. GNT-2

P. P. Manasa Bhat, Bhalerao* and B. M. Tandel

Department of Plantation, Spices, Medicinal and Aromatic Crops, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat - 396 450

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Abstract

The present experiment was carried out, with a view to study the "Integrated nutrient management in turmeric (*Curcuma longa* L.) cv. GNT-2" during *kharif* season of the year 2021-22 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India. The experiment was conducted in randomized block design (RBD) which included ten treatments and three replications consisting *viz*., T_1: RDF (FYM @ 20 t/ha + 60:60:60 NPK kg/ha), T_2: FYM 15 t/ha + 75 % RDF, T_3: FYM 20 t/ha + 50 % RDF, T_4: Vermicompost 10 t/ha + 75 % RDF, T_5: Vermicompost 15 t/ha + 50 % RDF, T_6: Bio-compost 10 t/ha + 75 % RDF, T_7: Bio-compost 15 t/ha + 50 % RDF, T_8: FYM 15 t/ha + 50 % RDF + Novel organic liquid nutrients 5 %, T_9: Vermicompost 10 t/ha + 50 % RDF + Novel organic liquid nutrients 5 % and T_{10}: Bio-compost 10 t/ha + 50 % RDF + Novel organic liquid nutrients 5 %. The results revealed that growth parameters *i.e.* plant height (29.71 cm), number of leaves (5.20), length of leaf (25.15 cm) and breadth of leaf (10.39 cm) were recorded maximum at 45 days after planting when the plots are treated with T_1: RDF (FYM @ 20 t/ha + 60:60:60 NPK kg/ha). Among the all treatments, application of FYM 15 t/ha + 50 % RDF + Novel organic liquid nutrients 5 % (T_8) gave the maximum plant height (62.78 cm, 130.13 cm and 135.47 cm), number of tillers per plant (1.60, 3.43 and 5.22), number of leaves per plant (7.08, 9.77 and 12.27), length of leaf (32.65 cm, 58.50 cm and 81.21 cm) and breadth of leaf (12.13 cm, 14.44 cm and 18.09 cm) at 75, 135 and 195 DAP, respectively.In case of yield and yield attributes, the maximum number of mother rhizomes per plant (3.54), number of fingers rhizomes per plant (18.57), weight of mother rhizomes (53.26 g per plant) and fresh rhizomes yield (317.80 g per plant and 34.26 t per ha) were observed under the application of FYM 15 t/ha + 50 % RDF + Novel organic liquid nutrients 5 % (T_8). Quality aspects *viz.*, curcumin content (4.93 %) and essential oil (3.67 %) were found significantly higher in T_9 (Vermicompost 10 t/ha + 50 % RDF + Novel organic liquid nutrients 5 %). Regarding economics, the highest benefit cost ratio (3.77) and the maximum net realization (Rs.6,76,970/ha) was obtained under FYM 15 t/ha + 50 % RDF + Novel organic liquid nutrients 5 % (T_8). Moreover, application of FYM 20 t/ha+ 50 % RDF (T_3) improved the soil nutrient status.

Keywords : *Turmeric, nutrient, growth, yield and quality*

Introduction

Turmeric (*Curcuma longa* L.), a member of Zingiberaceae family and native to South East Asia. In India, turmeric is grown in area of 2,73,000 ha with an average production of 11,32,000 MT. Major states leading in commercial cultivation of turmeric are Telangana, Andhra Pradesh, Karnataka, Gujarat, Maharashtra, Kerala, Tamil Nadu, Orissa, West Bengal, Mizoram, Haryana and Assam. In Gujarat it is grown in the districts of Dahod, Navsari, Surat, Mahisagar, Panchmahal, Dang and Anand in an area of 4100 ha with 78900 MT production (Anon., 2021). India has been a traditional producer, consumer and exporter of turmeric, but the productivity of turmeric in India is low (6.43 t/ha) in the world. In the present-day agriculture, supplementary and complementary role of organics is being increasingly felt for sustainable productivity keeping the soil health in good condition. The nutrient requirement of turmeric is quite high due to shallow rooting and capacity to

**Corresponding author: pankaj5bhalerao@nau.in*

produce large amount of dry matter per unit area. Thus, the need-based application of essential nutrients through organic and inorganic manures is required to get optimum growth. Integrated uses of inorganic with organic manures are necessary for sustaining soil fertility and productivity. Application of organic manures is eco-friendly and helps to increase the soil microbial biomass rapidly. Soil micro-organisms and their activities play an important role in transformation of plant nutrients from unavailable form to readily available forms and also helpful for improvement of soil fertility. In south Gujarat, as the area of turmeric cultivation increasing, getting a higher production with the better quality is the prime requirement. In view of considering the above facts, an experiment was laid out to study the effect of combination of organic and inorganic fertilizerson performance of turmeric cv. GNT-2.

Materials and methods

Integrated nutrient management in turmeric (*Curcuma longa* L.) cv. GNT-2 was carried out during *kharif* season of the year 2021-22 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India. This trial was conducted in randomized block design (RBD) which included ten treatments and three replications consisting *viz*., T_1: RDF (FYM @ 20 t/ha + 60:60:60 NPK kg/ha), T_2: FYM 15 t/ha + 75 % RDF, T_3: FYM 20 t/ha + 50 % RDF, T_4: Vermicompost 10 t/ha + 75 % RDF, T_5: Vermicompost 15 t/ha + 50 % RDF, T_6: Bio-compost 10 t/ha + 75 % RDF, T_7: Bio-compost 15 t/ha + 50 % RDF, T_8: FYM 15 t/ha + 50 % RDF + Novel organic liquid nutrients 5 %, T_9: Vermicompost 10 t/ha + 50 % RDF + Novel organic liquid nutrients 5 % and T_{10}: Bio-compost 10 t/ha + 50 % RDF + Novel organic liquid nutrients 5%. Organics *viz.,* FYM (OC: 31.89%, N: 1.62%, P: 1.99% and K: 0.66%), vermicompost (OC: 32.84%, N: 1.68%, P: 1.18% and K: 1.06%) and bio-compost (OC: 28.58%, N: 1.34%, P: 0.92% and K: 1.66%) was applied at the time of planting whereas, inorganic (N-Urea, P-SSP and K-MOP) *i.e*., nitrogen and potash were applied in three equal splits (basal, 30 and 60 DAP) while, full dose of phosphorus was applied at the time of planting. The foliar application of Novel organic liquid nutrients (having major macro and micronutrients like N: 0.071%, 0.016%, K: 0.158%, Fe: 742.0 ppm, Mn: 11.53 ppm, Zn: 2.30 ppm and Cu: 0.26 ppm) was done at 60, 90 and 120 days after planting. The soil of the experimental site was dark greyish black type having medium to poor drainage, clay in texture and high water holding capacity. The pH values of 0-15 cm and 15-30 cm depths were 7.9 and 8.1, respectively whereas, the initial values of soil properties having organic carbon: 0.72%, available N: 307.3 kg/ha, P: 40.90 kg/ha and P: 309.56 kg/ha. Before the start of experiment, total 30 experimental plots with size of 4.20 m X 4.20 m (gross plot having 189 plants) and 1.30 m X 1.30 m (net plot having 45 plants) of each were prepared by one deep ploughing followed by one harrowing. The raised bed (height 30 cm) of 110 cm width were prepared for planting of turmeric rhizomes of variety GNT-2 and planted with a spacing of 30cm x 20cm during the last week of May, 2020. The cultural practices were carried out as par university recommendations. Observations on different growth parameters was recorded at four of crop periods *viz.,*45, 75, 135 and 195 days after planting from five randomly selected plants from each plot whereas, yield attributing characters were recorded after harvesting of crop and rhizome yield per hectare was calculated on the plot weight basis. The quality parameters *viz.,* curcumin content (%) of turmeric rhizomes was estimated by Manjunath *et al.* (1991) however, the essential oil (%) was estimated by distillation method. The chemical properties of the soil from the depth of 15-30 cm were determined before and after the experiment by Jackson (1973) methods.

Results and discussion

Effect on growth parameters

Growth parameters of turmeric significantly affected by different integrated nutrient management practices. At 45 days after planting, treatment T_1: RDF (FYM @20 t/ha+ 60:60:60 NPK kg/ha)

resulted in the maximum plant height (29.71 cm), number of leaves (5.20), length of leaf (25.15 cm) and breadth of leaf (10.39 cm). Among all the treatments, FYM 15 t/ha+ 50 % RDF + Novel organic liquid nutrients 5% (T_8) gave the maximum plant height (62.78 cm, 130.13 cm and 135.47 cm), number of tillers per plant (1.60, 3.43 and 5.22) number of leaves per plant (7.08, 9.77 and 12.27), leaf length (32.65 cm, 58.50 cm and 81.21 cm), leaf breadth (12.13 cm, 14.44 cm and 18.09 cm) at 75, 135 and 195 DAP, respectively. This might be due to the application of FYM with narrow C:N ratio may produce more humic acid and humic substances contained in it form chelates with phosphorus. The chelated phosphorous has been reported to be more soluble in water, which could make it easily available to crop. FYM induces the higher uptake of nutrients especially iron and magnesium from the soil resulting in greater photosynthetic area and therefore lengthier and broader leaves. This might have led to increased plant height in turmeric by Kumar *et al*. (2016). Another reason may be the beneficial effect of FYM on available K may be ascribed to the direct potassium addition to the potassium pool of the soil besides the reduction in potassium fixation and its release due to interaction of organic matter with clay particles. The beneficial effects of integration of organic manures + chemical fertilizers in promoting inherent fertility status of soil were earlier reported by Kumar *et al*. (2021) in fennel. The growth promoting effect of FYM as a source of plant nutrients and humus improved the soil physiological condition by increasing its capacity to absorb and store water, improving aeration and favouring beneficial microbial activity in black musli (Joy *et al*., 2005). Another reason for increase in growth parameters might be due to spraying of Novel organic liquid nutrient, which contains plant growth regulators such as NAA, gibberllic acid, cytokinin and macronutrients, micronutrients which enhance the cell elongation (Chawla *et al*., 2018).

Table 1. Effect of integrated nutrient management on periodical growth attributes of turmeric cv. GNT-2

Treatments	Plant height (cm)				Number of tillers per plant			Number of leaves per plant				Length of leaves (cm)				Breadth of leaves (cm)			
	45 DAP	75 DAP	135 DAP	195 DAP	75 DAP	135 DAP	195 DAP	45 DAP	75 DAP	135 DAP	195 DAP	90 DAP	150 DAP	210 DAP	195 DAP	90 DAP	150 DAP	210 DAP	195 DAP
T_1: RDF (FYM @ 20 t ha^{-1} + 60:60:60 NPK kg ha^{-1})	29.71	57.29	113.47	118.47	1.20	2.60	4.60	5.20	6.30	8.30	10.43	25.15	28.39	46.73	72.33	10.39	11.03	12.92	15.82
T_2: FYM 15 t ha^{-1} + 75 % RDF	27.67	54.33	112.96	117.96	1.10	2.57	4.59	5.07	6.20	8.17	10.37	21.89	27.61	46.00	72.00	10.14	10.93	12.69	15.69
T_3 : FYM 20 t ha^{-1} + 50 % RDF	26.61	53.49	107.96	113.63	1.10	2.53	4.53	4.90	6.13	7.80	10.08	21.45	27.47	44.03	71.67	9.95	10.37	12.19	15.63
T_4 : Vermicompost 10 t ha^{-1} + 75 % RDF	23.92	49.73	107.87	112.87	1.07	2.50	4.52	4.60	5.90	7.73	10.07	19.97	26.87	43.77	69.60	9.31	10.31	12.11	15.40
T_5: Vermicompost 15 t ha^{-1} + 50 % RDF	23.41	50.36	101.70	107.37	1.03	2.47	4.40	4.58	5.70	7.67	9.87	19.78	26.19	43.43	68.83	9.10	10.28	11.66	15.27
T_6 : Bio-compost 10 t ha^{-1} + 75 % RDF	23.39	49.21	101.53	106.53	1.03	2.43	4.03	4.43	5.63	7.60	9.63	19.57	25.58	43.07	68.19	8.57	10.26	11.59	14.79
T_7 :Bio-compost 15 t ha^{-1} + 50 % RDF	20.47	46.97	99.49	104.82	1.00	2.40	3.57	4.20	5.60	7.57	8.47	17.31	24.43	42.43	63.40	8.33	9.79	11.29	14.26
T_8 :FYM 15 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	26.58	62.78	130.13	135.47	1.60	3.43	5.22	4.70	7.08	9.77	12.27	21.23	32.65	58.50	81.21	9.49	12.13	14.44	18.09
T_9 :Vermicompost 10 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	26.48	62.06	124.53	129.53	1.30	2.73	5.05	4.66	6.43	8.80	10.70	20.64	29.19	51.42	75.63	9.47	11.93	14.12	17.85
T_{10}:Bio-compost 10 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	25.21	61.62	121.53	126.53	1.27	2.67	4.93	4.63	6.33	8.77	10.53	20.56	28.75	49.47	73.34	9.33	11.77	13.83	16.10
S. Em.±	1.13	2.68	5.06	4.93	0.09	0.18	0.19	0.15	0.25	0.31	0.56	1.13	1.27	2.20	2.59	0.30	0.35	0.43	0.64
C.D. at 5%	3.35	7.96	15.04	14.64	0.26	0.54	0.56	0.43	0.74	0.91	1.67	3.36	3.78	6.55	7.70	0.89	1.05	1.26	1.91
C.V. %	7.70	8.47	7.82	7.28	13.07	12.06	7.23	9.14	9.69	10.55	9.49	9.44	7.95	8.14	6.27	5.49	5.64	5.81	7.02

Table 2. Effect of of integrated nutrient managementon yield and quality of turmeric cv. GNT-2

Treatments	No. of mother rhizomes/ plant	No. of finger rhizomes /plant	Finger rhizomes: mother rhizomes ratio	Weight of mother rhizomes (g/plant)	Rhizome yield (g/plant)	Rhizome yield (t/ha)	Curcumin content (%)	Essential oil (%)
T_1: RDF (FYM @ 20 t ha^{-1} + 60:60:60 NPK kg ha^{-1})	3.10	15.39	4.97	48.56	282.30	27.49	4.23	3.23
T_2: FYM 15 t ha^{-1} + 75 % RDF	3.09	14.86	4.81	48.32	273.92	26.33	4.13	3.20
T_3 : FYM 20 t ha^{-1} + 50 % RDF	2.95	14.16	4.81	47.78	263.85	24.89	4.04	3.12
T_4 : Vermicompost 10 t ha^{-1} + 75 % RDF	2.84	13.57	4.83	47.11	260.94	24.67	4.26	3.25
T_5: Vermicompost 15 t ha^{-1} + 50 % RDF	2.76	13.11	4.76	46.96	252.13	23.78	4.23	3.23
T_6 : Bio-compost 10 t ha^{-1} + 75 % RDF	2.17	10.21	4.71	46.40	246.33	22.69	3.80	2.97
T_7 : Bio-compost 15 t ha^{-1} + 50 % RDF	2.03	9.29	4.58	40.42	234.94	21.98	3.56	2.63
T_8 :FYM 15 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	3.54	18.57	5.24	53.26	317.80	34.26	4.50	3.48
T_9 :Vermicompost10 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	3.42	17.86	5.30	49.54	310.11	31.76	4.93	3.67
T_{10}:Bio-compost 10 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	3.37	17.04	5.07	48.61	291.78	27.73	4.36	3.30
S. Em.±	0.14	0.43	0.23	1.41	6.88	0.86	0.13	0.08
C.D. at 5%	0.41	1.26	NS	4.18	20.45	2.55	0.40	0.23
C.V. %	8.17	5.11	8.18	5.11	4.36	5.60	5.50	4.16

Table 3. Effect of of integrated nutrient management on soil properties

Treatments	pH	EC(dS m^{-1})	Organic Carbon (%)	Available N(kg/ha)	Available P_2O_5 (kg/ha)	AvailableK_2O (kg/ha)
Initial	**7.65**	**0.38**	**0.72**	**307.3**	**40.90**	**309.56**
T_1 : RDF (FYM @ 20 t ha^{-1} + 60:60:60 NPK kg ha^{-1})	7.90	0.39	0.81	290.30	40.41	313.33
T_2: FYM 15 t ha^{-1} + 75 % RDF	7.93	0.41	0.75	255.24	46.22	317.35
T_3 :FYM 20 t ha^{-1} + 50 % RDF	7.90	0.45	0.85	321.57	50.24	328.52
T_4 :Vermicompost 10 t ha^{-1} + 75 % RDF	7.77	0.40	0.79	310.77	43.39	299.78
T_5: Vermicompost 15 t ha^{-1} + 50 % RDF	7.92	0.41	0.81	294.44	43.95	289.57
T_6 :Bio-compost 10 t ha^{-1} + 75 % RDF	7.99	0.37	0.67	301.10	44.77	262.65
T_7 : Bio-compost 15 t ha^{-1} + 50 % RDF	7.88	0.39	0.75	279.84	45.98	283.20
T_8 : FYM 15 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	7.86	0.42	0.82	312.43	46.53	322.00
T_9 : Vermicompost 10 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	7.96	0.42	0.81	306.00	45.60	311.79
T_{10} : Bio-compost 10 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	7.79	0.39	0.80	293.90	45.44	306.62
Em±	0.09	0.03	0.02	10.15	1.59	12.64
CD at 5 %	NS	NS	0.07	30.14	4.74	37.57
CV %	1.99	12.92	4.99	5.93	6.10	7.22

Influence on yield attributing characters

Integrated nutrient management practices significantly influenced the yield and yield attributing characters. The maximum number of mother rhizomes per plant (3.54), number of fingers rhizomes per plant (18.57), weight of mother rhizomes (53.26 g per plant) and fresh rhizomes yield (317.80 g per plant and 34.26 t per ha) were observed under the application of FYM 15 t/ha+ 50 % RDF + Novel organic liquid nutrients 5% (T_8). Whereas, number of finger rhizome: number of mother rhizomes was remaining significantly unaffected.

The increase in yield with integrated nutrient approach might be attributed to the increased growth of plants in respect to height of plant and number of leaves. The healthy top growth

might be responsible for the higher rate of photosynthesis, might have accumulated carbohydrates which resulted in increased number of primary rhizomes per plant, secondary rhizomes per plantand ultimately the overall yield (Amala *et al.,* 2019). Another reason might be due to the fact that, plants require number of macro and micro elements for their normal and healthy growth which were subsequently supplied by FYM (Dhakad *et al*., 2019). Organic manures activate many species of living organisms which release phytohormones and may stimulate the plant growth and absorption of nutrients and such organisms need nitrogen for multiplication. This might be due to gradual and steady release of nutrient during the growth period as well as enhanced biological activity and proper nutrition to the crop (Nainwal *et al*., 2015).

Influence of Novel organic liquid nutrients in case of yield attributes might be due to presence of lavish amount of macro and micro nutrients in it which ameliorate photosynthetic activity leads to production of carbohydrates and which ultimately increases the yield and yield attributing characters. Moreover, the nutrient application accelerates an uptake of water and nutrients which results in higher photosynthesis and photosynthates accumulation which in turn increases the production.Another reason might be due balance in NPK ratio along with easy assimilation of nutrients attributed to higher yield (Singhal *et al.,* 2015).

Table 4. Effect of integrated nutrient management on economics (Rs./ha) and BCR of turmeric cv. GNT-2

Treatments	Rhizome yield (t/ha)	Treatment cost (Rs./ha)	Fixed cost (Rs./ha)	Total cost (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha	BCR
T_1 : RDF (FYM @ 20 t ha^{-1} + 60:60:60 NPK kg ha^{-1})	27.49	124369	42959	167328	687336	520009	3.11
T_2: FYM 15 t ha^{-1} + 75 % RDF	26.33	120235	41142	161377	658276	496899	3.08
T_3 : FYM 20 t ha^{-1} + 50 % RDF	24.89	121102	38893	159995	622293	462298	2.89
T_4 : Vermicompost 10 t ha^{-1} + 75 % RDF	24.67	162735	38551	201286	616823	415537	2.06
T_5: Vermicompost 15 t ha^{-1} + 50 % RDF	23.78	186102	37157	223259	594516	371256	1.66
T_6 : Bio-compost 10 t ha^{-1} + 75 % RDF	22.69	118735	35459	154194	567350	413156	2.68
T_7 : Bio-compost 15 t ha^{-1} + 50 % RDF	21.98	120102	34344	154446	549501	395056	2.56
T_8 : FYM 15 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	34.26	126062	53535	179597	856567	676970	3.77
T_9 : Vermicompost 10 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	31.76	168562	49632	218194	794110	575916	2.64
T_{10} : Bio-compost 10 t ha^{-1} + 50 % RDF + Novel organic liquid nutrients 5 %	27.73	124562	43335	167897	693362	525465	3.13

Selling price of turmeric: Rs. 25/kg

Quality characters

Quality characters of turmeric were significantly affected by integrated nutrient management. Among the all treatments, application of vermicompost 10 t/ha+ 50 % RDF + Novel organic liquid nutrients 5 % (T_9) recorded maximum curcumin content (4.93%) and essential oil (3.67%).The possible explanation for the beneficial effect of vermicompost may be due to accumulation of mobile substances in earthworm casts as reported by many workers. Earth worms are reported to excrete plant growth promoting substances into castes (Nielson, 1965). The application of organic manures improved the soil aggregates resulting in favourable pore geometry, which in turn increased the soil porosity thereby paving the way for good development of rhizomes under the soil. Potassium (K) is the principal component involved in curcumin formation in turmeric. The increased content of curcumin is also attributed to increased availability of micronutrients from different organic sources supplied in the form of FYM and vermicompost. It is also reported that increased curcumin content was due to application of organic manures and bio-fertilizers (Amala *et al.,* 2019). Another possible reason could be

that earthworm casts stimulate nitrase reductase activity in plants which regulates nitrogen availability to plants. The improved nitrogen metabolism through nitrate reductase activity might have contributed to higher essential oil content. Moreover, Novel organic liquid nutrients increase the cation exchange capacity of roots and make them potent in absorbing other nutrient ions (Parikh, 2020).

Soil status

The maximum organic carbon (0.85 %), available N (321.57 kg per ha), available P_2O_5 (50.24 kg per ha) and K_2O (328.52 kg per ha) were noted from the plot treated with FYM 20 t/ha + 50 % RDF (T_3). Application of organic manures showed positive effect on availability of all the nutrients studied in the present investigation. The reason for more availability of nutrients could be due to increasing activities of microbes due to the application of organics (Sharma *et al.,* 2009). These factors might have reduced the fixation of nutrients and addition of nutrients through mineralization of organic residues. Increase in available nutrients with FYM application due to mineralization of nutrients from organic manures in soil (Yaduvanshi, 2001).

Economics of the treatments

The highest benefit cost ratio (3.77) and the maximum net realization (6,76,970 Rs./ ha) was obtained under FYM 15 t/ha + 50 % RDF + Novel organic liquid nutrients 5% (T_8). This might be due to higher yield and lower investment in this treatment which in turns lead to maximum net profit as compared to other treatments.Similar results were obtained by Kadam and Kamble (2020) in turmeric.

Conclusion

Based on the results obtained in the present investigation, it can be concluded that application of FYM 15 t ha^{-1}+ 50 % RDF + Novel organic liquid nutrients 5% was effective for improving the growth as well as maximum yield with higher net realization of turmeric cv. GNT-2 under South Gujarat agro-climatic conditions. Whereas, application of vermicompost 10 t ha^{-1}+ 50 % RDF + Novel organic liquid nutrients 5% resulted in noted quality improvement.

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