

Sustainable agricultural practices for improving growth, yield and quality of turmeric (*Curcumalonga L.*)

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ABSTRACT

A field experiment was carried out in district-Sangli (Maharashtra) to study the effect of sustainable agricultural practices for improving growth, yield and quality of turmeric (*Curcuma longa L.*) variety Salem during 2018 and 2019. Twelve treatments were evaluated in randomized block design with three replications. The results revealed that plant height, leaves/plant, width of leaves, leaf area index and clumps/plant tended to increase with age of plant and maximum values were recorded at 150 DAP, irrespective to various treatments. Application of 50% RDF + 50% NC resulted in significantly higher fresh weight of primary rhizome (46.5 g), fresh weight of secondary rhizome (55.5 g) and high marketable yield of rhizome (251.2 q ha⁻¹) over control. The total yield of fresh rhizome per plot was comparatively on higher side (418.5g) when compared to control (308.1g) and other treatments. The application of 50% RDF + 50% NC proved superior for enhancing the quality parameters of turmeric such as fats (1.06 %), protein (1.25 %), carbohydrates (9.25 %) and curcumin (5.13 %) content to other treatments. Soil productivity was recorded maximum due to combined application of 50 % RDF + 50 % NC than the application of all these fertilizers alone. Fertility status of post-harvest soil improved with most of the treatments over control and higher values were recorded with 50% RDF + 50% NC treatment.

Keywords: Inorganicfertilizer, organic manures, bio fertilizers, growth, yield, quality, turmeric

INTRODUCTION

Turmeric (*Curcumalonga L.*) is one of the most important traditional spice crop, which is utilized for various dishes and for the preparation of different cosmetics and medicine in India. It has been recognized as a pharmaceutical drug due to the curcumin and essential oil contents. Turmeric is exported to over 129 countries. In the year 2019-20, India has exported turmeric worth of 117.74 USD million (Anonymous, 2020). The uses of chemical fertilizers badly affect the soil fertility and environmental quality (Kamal and Yousuf, 2012). Organic manures and biofertilizers are the best ecofriendly alternative to chemical fertilizers. They have become popular among turmeric growing farmers as they improve yield and quality (Kadam and Kamble, 2020). Organic fertilizers improve the soil health and limit ecological contamination reducing the cost of input on chemical fertilizers. Use of biofertilizers quickly improve soil microbial biomass and their

development (Dinesh *et al.*, 2010). Soil microorganisms develop soil richness (Yamwaski *et al.*, 2013). Use of biofertilizers like Azospirillum is useful for reducing the use of synthetic nitrogenous fertilizers and improves soil fertility. Use of PSB is effective to solubilize fixed phosphorus in the soil. The blend of organic manures and biofertilizers is suitable for improving the yield of turmeric in a sustainable manner (Sreekala, 2015). Utilization of various combinations of organic manures like FYM, Vermicompost and Neem cake greatly influence growth, yield and quality of turmeric (Sharma *et al.*, 2015). The combined applications of biofertilizers and organic manures along with chemical fertilizers play key role in turmeric cultivation (Kadam and Kamble, 2020). With this consideration in mind the present investigation was conducted to study the sustainable agricultural practices through the application of organic manures and biofertilizers for improving growth, yield, curcumin content and soil fertility.

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MATERIALS AND METHODS

The present investigation was carried out at Ashta (Sangli). The latitude and longitude coordinators of study site are 16.86°N and 74.57° E respectively. The average temperature of experimental site is 25.4°C and total annual rainfall is 580 mm. The experiment was conducted on black cotton soil having pH 7.8, organic carbon 4.0 g kg⁻¹, available N 140.2 kg ha⁻¹, P 16.6 kg ha⁻¹ and K 131.2 kg ha⁻¹. The experiment was carried out in randomized block design with three replications. The rhizomes were planted at 70 cm and 30 cm spacing in the field using raised beds of size 3.5 X 2.5 m having 15 cm height. Turmeric rhizomes of variety Salem were planted during the first week of April, 2018 and 2019. The rhizomes were covered with soil properly and watering was done immediately. Treatments were T1: 100% RDF (120:60:40), T2: Farmyard manure 15 t ha⁻¹, T3: Vermicompost 5 t ha⁻¹, T4: Neem Cake 5 t ha⁻¹, T5: Azospirillum-5 K g ha⁻¹, T6: PSB 5 K g ha⁻¹, T7: 50% RDF + 50% FYM, T8: 50% RDF + 50% VC, T9: 50% RDF + 50% NC, T10: 50% RDF + Azospirillum 5 kg/ha, T11: 50% RDF + PSB 5 kg/ha, T12: Control (No any application of fertilizer). The organic inputs namely FYM, VC and Neem cake were applied basally during final land preparation @ 15 t, 5 t, 5 t ha⁻¹, respectively. Azospirillum was applied to the rhizome @ 5 g kg⁻¹ and PSB was directly applied through soil. Urea, single superphosphate and muriate of potash were used as inorganic source of N, P and K, respectively. The crop was irrigated after 15 to 20 days interval by using micro irrigation. Time to time inter cultivation and weeding was done regularly up to harvest. The observations were recorded on growth parameters such as plant height, number of leaves per plant, width of leaves, number of clumps per plant were recorded at 90, 120 and 150 DAP. Leaf area index (LAI) was calculated at 120 and 150 DAP using standard methods by selecting ten plants per treatment randomly. Yield parameters such as weight of primary rhizome, weight of secondary rhizome, fresh rhizome and rhizome yield per plot were recorded at harvest. The crop was harvested after eight months in the month of January at full maturity of rhizome. The harvested rhizomes were dugged out manually and cleaned properly. Moisture content, protein and total fat were determined by AOAC (2006) method. Total carbohydrate was determined by difference, which is calculated by subtracting the measured protein, fat, ash and moisture from 100, phenol

sulphuric method as given by AOAC (2006). Ash content was determined by drying the sample in oven at 100°C and then it was ashed in muffle furnace at 550°C for 5 hrs (AOAC 2006). Curcumin content of fresh rhizome was determined as per the method given by FSSAI (2016). Soil samples collected from experimental plots were analyzed for available nitrogen by alkaline potassium permanganate method (Subbiah and Asija, 1956), phosphorus by the method of Brays and Kurtz (1945), potassium by flame photometer. The organic carbon was determined by Walkley-Black chromic acid wet oxidation method. The economics of turmeric production was calculated depending on input cost and market price. The data were statistically analyzed for least significance difference (LSD) at 5% probability level and coefficient of correlations by analysis of variance (ANOVA) using data analysis tool pack of MS Excel (2013).

RESULTS AND DISCUSSIONS

Growth Parameters

It was observed that the plant height, number of leaves, width of leaves and leaf area index (LAI) were increased with the application of organic manures and biofertilizers than the inorganic fertilizers and control (Table 1). Among the treatment of organic manures and biofertilizers, maximum plant height (43.7, 77.3 and 79.8 cm), number of leaves (8.7, 22.8 and 27.8), width of leaves (8.0, 8.9 and 10.1 cm) were recorded by neem cake (T₄) alone at 90, 120 and 150 DAP along with the increased leaf area index (0.94 and 1.48) at 120 and 150 DAP. The increase in number of clumps (4.03, 4.9 and 6.1) was recorded with neem cake (T₄). The increases in growth characters may be attributed to increased availability of nutrients in soil. The maximum plant height (54.6, 105.2 and 108.2 cm), number of leaves (10.6, 25.6 and 30.6), width of leaves (8.9, 9.2 and 10.8) and LAI (1.31 and 1.66) at 120 and 150 DAP and number of clumps (4.6, 5.4 and 6.4) were observed with 50% RDF + 50% neem cake followed by the T₄, T₁₀ and T₁₁ treatments as compared with inorganic fertilizers and control. The beneficial effect of organic manure on growth characters might be due to additional supply of nutrients as well as improvement in physico-chemical properties of soil. These findings are in good agreement with those of Kumar *et al.*, (2018).

Table: 1. Effect of different treatments on growth characters of turmeric (pooled for two years)

Treatments	Plant height (cm)			Leaves per plant			Width of leaves (cm)			LAI	
	DAP			DAP			DAP			DAP	
	90	120	150	90	120	150	90	120	150	120	150
T ₁	41.0	74.0	74.0	7.6	24.8	25.8	7.1	8.0	9.8	0.81	1.37
T ₂	42.1	75.6	75.6	8.1	25.9	26.3	7.2	8.1	9.9	0.83	1.40
T ₃	43.3	76.1	76.1	8.6	26.0	27.1	7.6	8.3	10.1	0.86	1.44
T ₄	43.7	77.3	79.8	8.7	22.8	27.8	8.0	8.9	10.1	0.94	1.48
T ₅	40.9	74.9	74.9	6.9	22.4	27.1	7.8	9.0	10.2	0.92	1.38
T ₆	41.2	74.8	74.8	6.8	21.5	26.3	7.9	9.1	10.3	0.93	1.41
T ₇	45.1	100.4	100.4	8.9	25.5	27.9	8.0	9.1	10.4	1.2	1.52
T ₈	49.6	104.3	104.3	9.2	26.4	28.4	8.8	9.1	10.7	1.3	1.60
T ₉	54.6	105.2	108.2	10.6	25.6	30.6	8.9	9.2	10.8	1.316	1.66
T ₁₀	41.4	75.2	75.2	7.9	23.5	28.8	7.8	8.8	10.0	0.90	1.40
T ₁₁	42.0	76.0	76.0	8.0	24.5	26.5	7.9	8.9	10.1	0.92	1.41
T ₁₂	37.8	72.4	72.4	5.8	22.0	23.9	6.7	7.0	8.0	0.79	1.06
SE±	1.30	3.93	1.19	0.32	0.50	0.41	0.17	0.12	0.09	0.05	0.028
LSD	9.6	29.1	8.8	2.3	3.7	3.1	1.2	0.9	0.6	0.42	0.21
CV %	9.7	15.7	3.7	12.7	6.8	5.0	7.1	4.8	2.9	19.0	6.4

Yield attributes and yield

The maximum values of primary rhizome (46.5 g), secondary rhizome (55.5g), fresh wt. of rhizome (418.5 g) and Rhizome yield per plot (19.9 kg/m², 251.2qha⁻¹) were recorded with 50 % RDF + 50 % NC followed by treatments T10 and T11. The increase in yield due to 50% RDF + 50% NC was 25% over control which may be attributed to increased availability of nutrients in soil as a result of inorganic fertilizer and organic manure addition (Roy and Hore, 2011). These findings are in accordance with the results

reported by Kamal and Yousuf (2012), Kumar *et al.*, (2018) and Singh *et al.*, (2015) who reported that the application of FYM, vermicompost, along with the inorganic fertilizer had positive impact on growth, yield parameters and quality of turmeric. Among the different treatments, the positive influence of combined applications of organic manures and biofertilizers was observed for the growth, yield and quality of turmeric over inorganic fertilizer alone and control. The minimum values of yield attributes were recorded under control owing to poor soil fertility.

Table 2: Effect of different fertilizer treatments on yield attributes of turmeric (pooled for two years)

Treatments	Clumps/plant			Primary Rhizome (g)	Secondary Rhizome(g)	Fresh weight of rhizomes/Plant (g)	Rhizome yield (kg/m ²)	Rhizome yield (qha ⁻¹)
	90	120	150					
T ₁	4.1	5.0	5.3	40.7	45.5	378.3	15.9	201.0
T ₂	4.2	5.1	5.4	40.9	46.8	371.5	17.6	221.5
T ₃	3.9	4.9	6.0	43.2	48.9	382.2	17.8	224.7
T ₄	4.1	5.1	6.2	43.2	53.8	398.2	18.6	234.2
T ₅	4.0	5.0	6.1	42.1	44.8	391.0	17.9	225.1
T ₆	4.1	4.9	6.2	43.0	48.9	390.1	18.0	226.9
T ₇	4.2	5.2	6.3	41.9	43.9	403.0	19.4	244.6
T ₈	4.5	5.3	6.4	44.6	55.2	408.5	19.6	247.1
T ₉	4.6	5.4	6.4	46.5	55.5	418.5	19.9	251.2
T ₁₀	3.9	4.9	6.1	42.1	44.9	397.0	18.6	234.1
T ₁₁	4.0	5.0	6.1	43.2	49.0	400.0	18.6	234.8
T ₁₂	3.8	4.2	4.9	36.4	42.3	308.1	13.5	170.0
SE±	0.06	0.05	0.1	0.49	1.28	3.32	0.50	6.40
LSD	0.47	0.39	0.8	3.6	9.5	24.6	3.6	49.4
CV %	5.0	3.4	6.1	3.8	8.7	2.7	9.7	9.7

Quality Parameters

The curcumin content was increased due to organic manures and biofertilizers than those of inorganic fertilizers alone and control (Table 3). The higher curcumin content (4.81%) was recorded in treatment having neem cake as compared to other organic manure, inorganic fertilizer and control. Kumar *et al.* (2018) reported that curcumin content was enhanced by the combination of organic manures + inorganic fertilizer + biofertilizers. The highest curcumin content (5.13%) was recorded with application of 50 % RDF + 50%neem cake followed by 50 % RDF + PSB (4.97 %) indicating that the integrated use of organic manures and biofertilizers had significant effect on curcumin

content in the rhizome. Similar results were also reported by Singh *et al.*, (2015). The integrated use of inorganic fertilizer, organic manure and biofertilizer significantly improved the biochemical constituents of rhizome over control and other alone treatments (Table 3). The application of 50% RDF +50% neem cake emerged as the most superior treatment over control and other treatments. The significant increase in fats (1.06%), protein (1.25 %) and carbohydrate (9.25 %) was recorded with T₉ treatment. It may be used as potentially attractive source of protein, carbohydrates and curcumin. The results of the study support the development of sustainable agricultural practices for turmeric cultivation (Jain and Parihar, 2017, Mane *et al.*, 2018).

Table 3: Effect of different treatments on biochemical composition of fresh turmeric rhizomes (Pooled for two years)

Treatments	Total fat (%)	Carbohydrates (%)	Proteins (%)	Curcumin (%)
T ₁	0.77	6.68	0.89	4.61
T ₂	0.81	8.11	0.92	4.64
T ₃	0.84	8.18	0.91	4.78
T ₄	0.82	8.15	0.94	4.81
T ₅	0.71	6.78	0.88	4.87
T ₆	0.78	6.98	0.92	4.88
T ₇	0.98	8.97	1.01	4.91
T ₈	1.03	9.12	1.21	5.11
T ₉	1.06	9.25	1.25	5.13
T ₁₀	0.99	7.95	1.01	4.95
T ₁₁	1.01	8.01	1.05	4.17
T ₁₂	0.82	6.54	0.79	3.98

Soil fertility

Available nitrogen, phosphorus, potassium and organic carbon status of the post harvest soil increased significantly with the application of organic manures and biofertilizers alone (Table 4). The values of nitrogen, phosphorus, potassium and organic carbon contents also increased with integrated use of inorganic fertilizer with organic and biofertilizer treatments (T₇, T₈, T₉, T₁₀ and T₁₁). The highest values of these parameters were recorded with application of 50% RDF + 50% neem cake in post harvest soil. Similar trend was reported by Sanwal (2007) who noted that application of organic manure had positive impact on fertility of soil. Application of organic manures like FYM, vermicompost and biofertilizers like Azospirillum, PSB improved soil fertility and yield of turmeric

(Dinesh *et al.*, 2010). The minimum values of organic carbon, available nitrogen, phosphorus and potassium were recorded under control.

Economics

It was revealed from the data (Table 4) that a significant increase in rhizome yield (251.2 q ha⁻¹) was obtained with turmeric variety Salem under the treatment of 50% RDF + 50% neem cake with maximum net return of Rs. 11, 34,258 ha⁻¹ and cost benefit ratio 1: 4.04 followed by 50% RDF + 50% Vermicompost which gave the net return of Rs. 11, 09,479.00 ha⁻¹ and cost benefit ratio 1: 3.97. These results are in conformity with several researchers (Nanda *et al.*, 2012, Kadam and Kamble, 2020). The lower values of net return and C: B ratios were recorded under control.

Table 4: Effect of different fertilizer treatments on available nutrients and organic carbon (g kg^{-1}) in post harvest soil and economics (Pooled over 2 years)

Treatments	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	OC (g kg^{-1})	Gross incomes (Rs ha^{-1})*	Net income (Rs ha^{-1})	C:B Ratio
T ₁	189.3	17.8	164.3	4.00	1206480	805325.4	1:3.00
T ₂	197.6	21.3	180.2	4.28	1329120	912662.4	1:3.19
T ₃	213.4	21.8	183.0	4.23	1348680	927217.5	1:3.20
T ₄	220.7	25.7	185.1	4.68	1405500	979165	1:3.29
T ₅	231.3	22.1	183.7	5.12	1351140	982954.4	1:3.66
T ₆	235.1	21.3	184.1	5.20	1361580	986010.9	1:3.62
T ₇	258.9	24.3	189.5	5.33	1467720	1064097	1:3.63
T ₈	268.7	24.5	191.3	5.46	1482600	1109479	1:3.97
T ₉	272.4	26.7	192.0	5.51	1507320	1134258	1:4.04
T ₁₀	248.3	21.3	154.1	5.24	1405140	1014043	1:3.59
T ₁₁	243.2	12.6	156.1	5.27	1408920	1014422	1:3.57
T ₁₂	146.2	16.6	132.2	3.80	1020540	678659.1	1:2.98

* Average market rate of turmeric rhizome Rs. 6000/q,

**Total expenditure cost includes the expenditure from land preparation to harvesting of turmeric

It may be concluded from the results that, turmeric variety Salem showed promising results with the application of inorganic +neem cake and inorganic fertilizer with biofertilizer. There was significant improvement with these treatments in growth, yield attributes and quality of turmeric with respect to biochemical constituents and curcumin content. The integrated use of

inorganic fertilizer + neem cake + biofertilizer was found to be highly effective to improve the soil fertility. The cost benefit ratio obtained with these treatments was comparatively higher indicating that such treatments can be recommended to the farmers for the sustainable cultivation practice for higher production of turmeric crop.

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