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Effect of integrated nutrient management on yield, quality and economics of turmeric (*Curcuma longa* L) var. IISR Pragathi

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Abstract
A field experiment was carried out on "Effect of integrated nutrient management on yield, quality and economics of turmeric (*Curcuma longa*. L) var. IISR Pragathi" with varied combinations of organic, inorganic and biofertilizers with seven treatments replicated thrice and in complete RBD at PG Students Research Farm, College of Horticulture, SKLTSHU, during *kharif* 2018-19. Among the seven treatments combinations application of 75% NPK (Recommended Dose Fertilizer) + Farm yard manure (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Neem cake (500 kg ha^{-1}) + *Azotobacter* (2 kg ha^{-1}) + Phosphorous solubilizing bacteria (2 kg ha^{-1}) (T_6) enhanced the fresh rhizome yield (29.69 t ha^{-1}), curcumin content (4.74%) where as curing percentage (24%) and benefit cost ratio (4.76) was highest in (T_4): Farm yard manure (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Neem cake (500 kg ha^{-1}) + *Azotobacter* (2 kg ha^{-1}) + Phosphorous solubilizing bacteria (2 kg ha^{-1}).

Keywords: Turmeric, curing, curcumin, farm yard manure, vemicompost, neemcake

Introduction
Turmeric (*Curcuma longa* L.) is very much associated with human civilization, religion, customs and it finds use both in developed and developing countries. The demand for turmeric is increasing due to its wide utility as a spice, natural dye, cosmetics and pharmaceuticals. It is valued for anticancerous, anti-inflammatory and antiseptic properties. India, being the world's largest producer of turmeric, gains importance for oleoresin and cucurmin having medicinal value and ample export opportunity has been created by WTC (Tamil Selvan *et al.*, 1999) [7]. Curcumin the yellow colour pigment present in the rhizome is gaining importance with ban on artificial colours in food industry.
It was used as digestive aid and treatment for fever, inflammation, wounds, infections, dysentery, arthritis, injuries, trauma, jaundice and other liver problems. In Unani, turmeric is considered to be the safest herb of choice for all blood disorders since it purifies, stimulates and builds blood.

Materials and Methods
The experiment was carried out at PG Students Research Farm, College of Horticulture, SKLTSHU, India, during *Kharif* 2018-19. The experiment was laid out in a complete RBD with seven treatments replicated thrice. The seven treatments *viz.*,T_1: Farm yard manure (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Neem cake (500 kg ha^{-1}), T_2: Farm yard manure (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + *Azotobacter* (2 kg ha^{-1}) + Phosphorous solubilizing bacteria (2 kg ha^{-1}), T_3: Farm yard manure (25 t ha^{-1}) + Neem cake (500 kg ha^{-1}) + *Azotobacter* (2 kg ha^{-1}) + Phosphorous solubilizing bacteria (2 kg ha^{-1}),T_4: Farm yard manure (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Neem cake (500 kg ha^{-1})+ *Azotobacter* (2 kg ha^{-1}) + Phosphorous solubilizing bacteria (2 kg ha^{-1}),T_5: 50% NPK (Recommended Dose Fertilizer) + Farm yard manure (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Neem cake (500 kg ha^{-1}) + *Azotobacter* (2 kg ha^{-1}) + Phosphorous solubilizing bacteria (2 kg ha^{-1}),T_6: 75% NPK (Recommended Dose Fertilizer) + Farm yard manure (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Neem cake (500 kg ha^{-1}) + *Azotobacter* (2 kg ha^{-1}) + Phosphorous solubilizing bacteria (2 kg ha^{-1}), T_7: Control – 100% NPK (Recommended Dose Fertilizer). RDF = 50: 60: 108 kg ha^{-1} were imposed. The data recorded on fresh rhizome yield (t ha^{-1}), curing (%), curcumin (%) and B:C ratio.

Curing percentage
A sample of one kilogram of fresh rhizome from each replicated treatment of each plot was weighed and boiled.

The boiling process was continued for about 45 to 60 minutes by which time rhizomes become soft and gave a typical odour. The dry weight was recorded after sun drying and processing percentage was worked out.

$$\text{Curing (\%)} = \frac{\text{Dry weight of rhizome after curing (kg)}}{\text{Fresh weight of rhizome taken (kg)}} \times 100$$

Curcumin content

Curcumin content was estimated at Central Instrumentation Cell (CIC), College of Agriculture, PJTSAU, Rajendranagar, during 2018-19 and expressed in percentage.

Disolved 0.2 – 0.5 g of weighed, moisture – free turmeric powder in 250 ml of absolute ethanol. Reflux the contents in the flask fitted with an air – condenser over a heating mantle for 3-5 hours, compensated alcohol loss if any due to evaporation by adding alcohol freshly into the flask. Cooled and decanted the extract into a volumetric flask and made up the volume of 200ml with absolute alcohol. Take 1ml of aliquot and diluted to 10ml with absolute alcohol. Then Measured the intensity of yellow colour at 425 nm in a double beam spectrophotometer (Sadasivam and Manickam 2008) [6].

$$\text{Curcumin content (g/100 g)} = \frac{0.0025 \times A_{425} \times \text{Volume made up} \times \text{Dilution factor} \times 100}{0.42 \times \text{Weight of the sample (g)} \times 1000}$$

Since 0.42 absorbance at 425nm = 0.0025 g curcumin

Benefit-cost ratio

The prices of the inputs in rupees prevailing at the time of experimentation were considered for working out the cost of cultivation.

Net returns per hectare were calculated by deducting the cost of cultivation from a gross return. Benefit-cost ratio was worked out as follows

$$\text{Benefit-Cost ratio} = \frac{\text{Net return (Rs) ha}^{-1}}{\text{Cost of cultivation (Rs) ha}^{-1}}$$

Results and Discussions

The data releated to the fresh rhizome yield (t ha^{-1}), curing percentage, curcumin content (%), Gross returns, Net returns and Benefit cost ratio were presented in Table:1 and 2 respectively.

Fresh rhizome yield (t ha^{-1})

The data revealed that (Table-1) fresh yield (t ha^{-1}) differed significantly with treatments imposed.

The fresh rhizome yield was highest (29.69 t ha^{-1}) in T_6 which was significantly superior to other treatments but was on par with T_5 (27.77 t ha^{-1}) and T_7 (26.38 t ha^{-1}).The lowest fresh rhizomes yield t ha^{-1}**(**16.77 t) was recorded in T_2

The addition of organic manures *viz.,* FYM, VC, NC along with biofertilizer combination would have resulted in higher stimulating effect on increased nutrient uptake which increased growth parameters like plant height, number of leaves plant^{-1}, leaf area index, number of tillers clump^{-1}and ultimately resulted in higher dry weight of rhizomes in treatment T_4.The present investigations are concurrence with earlier findings of Reddy and Rao (1978) [4]. Rao and Rao (1988) [5] and Velmurugan (2002) in turmeric.

Curing percentage

Curing percentage is considered very important for recovery of high dry rhizome yield. The curing percentage was highest (24.36%) in T_4 which was significantly superior to other treatments but was on par with T_6 (23.00%) and T_5 (22.90%). The lowest curing percentage (17.60%) was recorded in T_2.

Curcumin content (%)

Curcumin content is considered very important for quality in Turmeric production. In the present study, the data recorded on curcumin content (%) differed significantly with treatments imposed (Table: 1)

The curcumin content was highest (4.74%) in T_6 which was significantly superior to other treatments but was on par with T_5 (4.61%) and T_4 (4.54%). The lowest curcumin content (3.29%) was recorded in T_7

Quality parameters *viz.,* curing and curcumin were significantly influenced by combined application of organic manures (FYM, VC and NC) over inorganic fertilizers. 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, VC and NC. Among the micronutrients particularly Zn which is responsible for translocation of Carbon metabolites, sugar, amino acid, organic acids from leaves to rhizomes and their utilization for biosynthesis of curcumin (Kumar *et al.,* 2004) [1]. It is also reported that increased curcumin content was due to application of organic manures and bio-fertilizers. The present results are in conformity with Velmurugan *et al.* 2008 results.

Benefit cost ratio

The maximum gross income (Rs.6,20,200/ha), net income (Rs. 5,12,520/ha) and benefit cost ratio (4.76) were recorded in T_4 which was significantly superior to other treatments but on par with T_7 (4.44) and T_3(4.09). The lowest gross income (Rs.3,12,550/ha), net income (Rs. 2,09,370/ha) and benefit cost ratio (2.03) was recorded in T_2.Earlier several workers also reported increase in yield and net returns in organic cultivation over inorganic fertilizers, (Roy and Hore, 2011 [3]. and Nanda *et al.* 2012) [2]. in turmeric. The maximum gross income (Rs.5,49,300/ha), net income (Rs. 4,26,403/ha) and benefit cost ratio (4.46) were recorded in integrated fertilizer management followed by fully inorganic fertilizer with benefit: cost ratio of 3.80 (Singh 2012) [6]. These findings conforming the present results.

Table 1: Effect of integrated nutrient management on fresh rhizome yield t ha^{-1}, curing percentage (%) and curcumin content (%)

Treatments	Fresh rhizome yield (t ha^{-1})	Curing percentage (%)	Curcumin content (%)
T_1	17.77	20.00	3.63
T_2	16.77	17.60	3.37
T_3	20.66	21.77	4.00
T_4	24.23	24.36	4.54
T_5	27.77	22.90	4.61
T_6	29.69	23.00	4.74
T_7	26.38	19.50	3.29
S.Em±	1.20	0.75	0.23
C.D.at 5%	3.96	2.30	0.71

Table 2: Effect of integrated nutrient management on Benefit cost ratio in turmeric

Treatments	Gross income (Rs/ha)	Total cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio*
T_1	369250.00	107600	261650.00	2.43
T_2	312550.00	103180	209370.00	2.03
T_3	472500.00	92680	379820.00	4.09
T_4	620200.00	107680	512520.00	4.76
T_5	445900.00	109195	336705.00	3.08
T_6	476933.33	109952	403632.00	3.66
T_7	360266.67	66130	294136.67	4.44
S.Em±	25987.78	-	28233.23	0.30
C.D.at 5%	80075.54	-	86994.40	0.93

* Sale price of turmeric rhizomes for organic treatments was taken @ Rs-1,05,000/t and for INM and control treatments @ Rs-70.000/t

Conclusion

Among all treatments fresh rhizome yield t ha^{-1}, curcumin content was highest in T_6: 75% NPK (Recommended Dose Fertilizer) + Farm yard manure (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Neem cake (500 kg ha^{-1}) + *Azotobacter* (2 kg ha^{-1}) + Phosphorous solubilizing bacteria (2 kg ha^{-1}) which was significantly on par with T_5, T_4 and T_3 where as curing percentage was highest in T_4 which was significantly on par with T_6 and T_5

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