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Effect of manures and fertilizers on growth, yield and economics of turmeric in lateritic soils of Konkan

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Abstract
A field study was conducted at Research Farm of All India Coordinated Research Project on Agroforestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra to study the "Effect of manures and fertilizers on Growth, Yield and Economics of Turmeric in Lateritic Soils of Konkan" during *Kharif* 2023. An experiment was framed in Randomized Block Design (RBD) with three replications and consisted of ten treatments *viz*., T_1 (Absolute control), T_2 (100% RDF), T_3 (100% RDF + Vermicompost @ 7.5 t ha^{-1}), T_4 (100% RDF + PSB @ 5 kg ha^{-1}), T_5 (50% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}), T_6 (75% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}), T_7 (100% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}), T_8 (Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}), T_9 (Vermicompost @ 7.5 t ha^{-1} alone), T_{10} (PSB @ 5 kg ha^{-1} alone). The data revealed that application of treatment T_7 i.e. 100% RDF + Vermicompost @ 7.5 t/ha + PSB @ 5 kg ha^{-1} resulted in the highest plant height (80.06 cm), number of tillers (4.78) and yield (18.65 t ha^{-1}) of turmeric, which was found to be at par with application of treatment T_6 i.e. 75% RDF + Vermicompost @ 7.5 t/ha + PSB @ 5 kg ha^{-1}. In summary the application of 100% RDF + Vermicompost @ 7.5 t/ha + PSB @ 5 kg ha^{-1} exhibited multifaceted benefits for enhancing crop production and economic returns with B:C ratio (2.61).

Keywords: Turmeric, Vermicompost, PSB, growth, yield, gross monetary returns, net monetary returns and economics

Introduction
Turmeric (*Curcuma longa* L.) belonging to family Zingiberaceae is a herbaceous perennial spice and medicinal crop grown extensively throughout the tropical and sub-tropical parts of the country. A temperature range of 20-35 ºC with an annual rainfall of 1500 mm or more, either rainfed or under irrigated conditions, are highly suitable for turmeric. It can be grown on different types of soils although it thrives best in well drained sandy or clay loam soils with a pH range of 4.5-7.5 and good organic status. Indian turmeric is considered to be the best in the world market because of its high curcumin content. India is the largest producer, consumer and exporter of turmeric in the world. In the year 2022-23, an area of 3.24 lakh ha was under turmeric cultivation with a production of 11.61 lakh tonnes thereby covering 75% of the global turmeric production. More than 30 varieties of turmeric are grown in more than 20 states in the country. The largest turmeric producing states are Maharashtra, Telangana, Karnataka and Tamil Nadu. India has more than 62% share of world trade in turmeric. During 2022-23, 1.53 lac tonnes of turmeric and turmeric products valued at 207.45 million USD were exported by more than 380 exporters. The leading markets of Indian turmeric are Bangladesh, UAE, USA and Malaysia (Anonymous, 2023) [2]. Turmeric, has an advantage of being cultivated in a variety of soil types. However, it has been found that the biochemical properties of turmeric are influenced by the fertility status of the soil mainly due to organic manures (Kadam and Kamble, 2020) [4]. Organic manures like farm yard manure, bio compost, poultry manure, neem cake, vermicompost etc. are regarded important to increase food production (Prakash, 2014). However, the organic matter content of most of the Indian soils is very low (Saravaiya *et al*., 2010 [14] and Navya *et al*., 2017) [10].

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The physical condition of the soil is getting deteriorated with the use of excess chemical fertilizers. Excess use of nitrogenous fertilizers is also responsible for ground water contamination and environmental pollution apart from destroying the ozone layer through N_2O production. The combined application of biofertilizer, organic manures and inorganic fertilizers is found to be effective in increasing the fertility of the soil. Therefore, maximizing the usage of organic waste along with chemical and biofertilizers in the form of integrated nutrient management (INM) is found to be a better alternative (Palkar *et al*., 2022) [11].

Material and methodology

The field trial was conducted at All India Co-ordinated Research Project on Agroforestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during *Kharif*, 2023. Geographically it is located at 17^0 43.518' N and 73^0 17.814' E longitude, having hot and humid climate. Randomized block design was used in the trial. The experiment consisted with ten treatments and three replications. The plot size was 4 m × 4 m and the turmeric rhizomes were planted at a spacing of 60 cm × 60 cm. The treatment combinations were T_1 (Absolute control), T_2 (100% RDF), T_3 (100% RDF + Vermicompost @ 7.5 t ha^{-1}), T_4 (100% RDF + PSB @ 5 kg ha^{-1}), T_5 (50% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}), T_6 (75% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}), T_7 (100% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}), T_8 (Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}), T_9 (Vermicompost @ 7.5 t ha^{-1} alone), T_{10} (PSB @ 5 kg ha^{-1} alone). The variety of turmeric used for the investigation was Salem. The recommended dose for turmeric (var-Salem) was 250:150:150 kg N: P_2O_5: K_2O ha^{-1} along with vermicompost and PSB were used. Growth attributes of turmeric, such as the height of plant samples, were measured by scale from the base of the plant, i.e., from ground level of fully mature plant and number of tillers also recorded. While considering yield at harvest from the observational plant, the average was worked out. The fully developed rhizomes were considered as mature rhizomes. The mature rhizomes from observational plants were collected, and their weight was taken. To assess the effect of different treatments on growth, yield and economics of the turmeric crop, periodical observations were recorded, from five sample plants selected randomly from each treatment. The observations were recorded at 50, 100 DAS and at harvest stage of life period of the turmeric crop. The experimental data was subjected to analysis of variances (ANOVA) and treatment means were compared and significant differences were tested at the 5% significance level as per Panse and Sukhatme (1985) [12].

Economics of turmeric

The economics of turmeric were worked out as per the following formulae, considering the current standardized value of all assets, the standard market price of crop yields, etc.

GMR = Yield X Selling price

NMR = GMR – COC

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs.)}}{\text{Cost of cultivation (Rs.)}}$$

Where, Gross Monetary Return (GMR)
Net Monetary Return (NMR)
Benefit: Cost Ratio (B:C)
Cost of Cultivation (COC)

Table 1: Plant height and Number of tillers at different growth stages of turmeric as influenced by fertilizers, vermicompost and PSB

Tr.	Treatment	Plant height (cm)	Number of tillers
T_1	Absolute control	57.39	1.82
T_2	100% RDF	72.66	3.92
T_3	100% RDF + Vermicompost @ 7.5 t ha^{-1}	76.73	4.45
T_4	100% RDF + PSB@ 5 kg ha^{-1}	75.71	4.45
T_5	50% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	74.22	4.08
T_6	75% RDF+ Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	78.90	4.53
T_7	100% RDF+ Vermicompost@ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	80.06	4.78
T_8	Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	70.31	3.57
T_9	Vermicompost @ 7.5 t ha^{-1} alone	67.16	3.11
T_{10}	PSB @ 5 kg ha^{-1} alone	65.48	2.97
S.E. (m) ±		2.32	0.12
C.D. at 5%		6.89	0.35

Results and Discussions

Growth: There was a significant and graded increase in growth parameter viz., plant height and number of tillers $plant^{-1}$ recorded at harvest with application of fertilizers, vermicompost and PSB either alone or in combination. Where the highest value of plant height (80.06 cm) was noted with the application of treatment T_7 i.e. 100% RDF+ Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1} (T_7), which was found to be at par with treatments T_3, T_4, T_5 and T_6 (Table 1). The highest number of tillers (4.78) was recorded the in treatment T_7 i.e. 100% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}, which was found to be at par with treatments T_3, T_4 and T_6 (Table 1). The enhanced uptake of nitrogen may be responsible for the growth properties of turmeric that increase with higher nitrogen application through RDF. As an active component of protoplasm, enzymes and chlorophyll, nitrogen functions as a catalytic agent in a various physiological processes. It also speeds up cell division and photo assimilation, all of which promote plant growth and structural improvement. The enhanced vegetative growth of turmeric was achieved with chemical fertilizers applied might be due to the increase absorbed ions and cations ultimately released nutrient slowly for entire crop period. Thus, increased the nutrient utilization and better accumulation among plant parts for superior vegetative growth and biomass (Patel *et al*., 2012) [13]. Increased in plant height may be due to application vermicompost. Mainly because of the slow release of nutrients through the vermicompost for longer period, the plant height increases. Furthermore, the enhanced efficiency of organic manures in combination with inorganic fertilizers may be attributed to the provision of micronutrients at optimal levels by the organic manures. These micronutrients play a crucial role in the synthesis of essential phytohormones, chlorophyll production

and respiratory processes. Application of organic manures might have helped in for better plant metabolic activity as a result of release of micronutrients in the early growth phase, which in turn, encouraged vigorous growth (Kantaiah, 2008) [5]. Khedkar *et al*. (2023) [6] also reported similar results of growth in lateritic soils of Konkan.

Yield and Economics

Yield: The fresh rhizome yield of turmeric varied from 7.14 to 18.65 t ha^{-1}. Treatment T_1 (control) recorded the lowest yield (7.14 t ha^{-1}), which may be due to the cultivation of turmeric crop without any addition of fertilizer. The highest fresh rhizome yield of turmeric (18.65 t ha^{-1}) was observed with the application of 100% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1} (T_7), which was found to be at par with treatments T_3 and T_6 (Table 2).

Since N is a constituent of chlorophyll, amino acids, etc. and has a role in cell expansion, the increase in yield with applied N was expected (Sharma, 1990) [15]. The improved vegetative growth brought about by N fertilization, which facilitates photosynthesis and increases the translocation of organic food materials from the stem and leaves towards the sink, may be responsible for the increase in turmeric yield. This process accelerated the formation and development of greater sink size and weight, which in turn increased the yield of rhizomes. The vegetative growth of the turmeric as influenced by the use of various organic manures revealed an increase in crop yield (Dudhat *et al*., 1997) [3]. Similarly, Kumar *et al*. (2018) [7] recorded that utilization of FYM, vermicompost, NPK (100:80:60), 50% integrated and 100% integrated doses have a positive impact on yield of turmeric. The possible reasons for increased yield per plant could be attributed to the increase in the vegetative growth, which might have promoted greater yield (Mujawar, 2012) [9]. The combined application of chemical fertilizer and biofertilizers might have showed better response to yield of turmeric. Similar observations were also noted by Singh *et al*. (2012) [16].

Table 2: Yield of turmeric as influenced by fertilizers, vermicompost and PSB

Tr.	Treatment	Fresh Rhizome yield (t ha^{-1})
T_1	Absolute control	7.14
T_2	100% RDF	11.17
T_3	100% RDF + Vermicompost @ 7.5 t ha^{-1}	16.53
T_4	100% RDF + PSB@ 5 kg ha^{-1}	15.70
T_5	50% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	15.27
T_6	75% RDF+ Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	17.10
T_7	100% RDF+ Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	18.65
T_8	Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	10.96
T_9	Vermicompost @ 7.5 t ha^{-1} alone	9.95
T_{10}	PSB @ 5 kg ha^{-1} alone	7.47
S.E. (m) ±		0.7434
C.D. at 5%		2.2088

Economics: The economics of turmeric were beneficial for the farmers by applying 100% RDF along with vermicompost @ 7.5 t ha^{-1} and PSB @ 5 kg ha^{-1} in the overall experiment (Table 3). Significantly maximum gross + PSB @ 5 kg ha^{-1} which was closely related with treatment T_6 (Rs. 1282500). Further, the net monetary return was also significantly higher in treatment T_7 (Rs. 862333.18 ha^{-1}) which was closely related with treatment T_6 (Rs. 781318.33 ha^{-1}). While the benefit-cost ratio (B:C ratio) of turmeric was observed to be significantly higher in treatment T_7 (2.61) receiving 100% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1} than other treatments and this treatment was closely related with treatment T_6 (2.56). The lowest GMR (Rs. 535750 ha^{-1}), NMR (Rs. 272228.33 ha^{-1}) and benefit cost ratio (2.03) was recorded in treatment T_1. The results obtained were also observed by Amala *et al*. (2019) [1], who reported that the maximum gross income (Rs.620200 ha^{-1}), net income (Rs. 512520 ha^{-1}) and benefit cost ratio (4.76) were recorded with the application of FYM (25 t ha^{-1}) + Vermicompost (5 t ha^{-1}) + Neem cake (500 kg ha^{-1}) + Azotobacter (2 kg ha^{-1}) + PSB (2 kg ha^{-1}). These results are in conformity with several researchers (Kadam and Kamble, 2020 [4] and Lohar and Hase, 2021) [8].

Table 3: Economics of turmeric as influenced by fertilizers, vermicompost and PSB

Tr.	Treatment	GMR (Rs. ha^{-1})	NMR (Rs. ha^{-1})	B: C ratio
T_1	Absolute control	535750	272228.33	2.03
T_2	100% RDF	837500	478594.43	2.33
T_3	100% RDF + Vermicompost @ 7.5 t ha^{-1}	1240000	730956.10	2.44
T_4	100% RDF + PSB@ 5 kg ha^{-1}	1177500	711219.02	2.53
T_5	50% RDF + Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	1145000	675606.80	2.44
T_6	75% RDF+ Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	1282500	781318.33	2.56
T_7	100% RDF+ Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	1398500	862333.18	2.61
T_8	Vermicompost @ 7.5 t ha^{-1} + PSB @ 5 kg ha^{-1}	822000	408363.75	1.96
T_9	Vermicompost @ 7.5 t ha^{-1} alone	746250	345945.00	1.86
T_{10}	PSB @ 5 kg ha^{-1} alone	560000	255005.42	1.84
	S.E. (m) ±	55756.22	46463.51	0.09
	C.D. at 5%	165666.36	138055.30	0.28

Market selling price of turmeric Rs.75000 per quintal

Conclusion

On the basis of data obtained from the present investigation, application of 100% RDF + Vermicompost @ 7.5 t/ha + PSB @ 5 kg ha^{-1} (T_7) has recorded the highest growth and yield of turmeric plant, which was found to be at par with the application of 75% RDF + Vermicompost @ 7.5 t/ha + PSB

@ 5 kg ha^{-1} (T_6). Thus, considering the economic returns, application of 100% RDF + Vermicompost @ 7.5 t/ha + PSB @ 5 kg ha^{-1} to turmeric seems beneficial in lateritic soils of Konkan.

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