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Effect of integrated nutrient management on growth parameters and yield of turmeric (*Curcuma longa* L.) var. IISR Pragathi

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Abstract
A field experiment was conducted on "Effect of integrated nutrient management on growth parameters and yield of turmeric var. IISR Pragathi" with varied combinations of organic, inorganic and biofertilizers with seven treatments replicated thrice in complete RBD in PG Students Research Farm, College of Horticulture, SKLTSHU, India, during *kharif* 2018-19. Among the seven treatments combinations of organic, inorganic and bio-fertilizers imposed 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) has recorded highest plant height (80.01cm), number of leaves $plant^{-1}$(26.88), number of tillers $clump^{-1}$ (4.82) leaf area index(6.27), fresh rhizome yield t ha^{-1}(29.69) and dry rhizome yield t ha^{-1} (6.81) of turmeric.

Keywords: Farm yard manure, vermicompost, neem cake, azotobacter

Introduction
Turmeric (*Curcuma longa* L.) is an ancient, most valuable and sacred spice of India. It is an herbaceous, perennial belonging to the family of Zingiberaceae, with a thick underground rhizome giving rise to primary and secondary rhizomes called fingers. It contains carbohydrates (69.4%), fats (5.1%), proteins (6.3%), minerals (3.5%), volatile oil (5.06%) and oleoresin (7.9-10.4%) (Srinivasan *et al*., 2018) [12].

In India, turmeric has occupied an area of 2, 22,000 ha with the production of 10, 56,000 MT. (Anon., 2016-2017) [1]. The area in Telangana under turmeric cultivation is 60,906 ha with the production of 3, 77,616 MT ha^{-1} and productivity of 6.2 t ha^{-1}. The main turmeric growing states in India are Telangana (24%), Andhra Pradesh (22%), Tamil Nadu (15%), Orissa (13%), Assam (6%), Maharashtra (4%), Kerala (4%), Karnataka (3%) and Gujarat (1%). (Anon., 2017) [2]. Hence the present study was carried out with different organic and chemical fertilizers.

Turmeric being the heavy feeder harvests abundant quantity of nutrients from the soil. The escalating prices of chemical fertilizers and their detrimental impact on the soil health, environment and human health urged the farmer to adopt alternative source of nutrients for spice production. Therefore, to reduce dependency on chemical fertilizers and conserving the natural resources in align with sustainable production are vital issues in present time which is only possible through integrated plant nutrient supply system (Moakala *et al.*, 2015) [9].

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 experimental site was ploughed and harrowed thoroughly to bring the soil to a fine tilth. A basal dose of well-rotted farm yard manure (25 t ha^{-1}), vermicompost (5 t ha^{-1}), Neem cake (500 kg ha^{-1}), *Azotobacter* (2 kg ha^{-1}) and Phosphorous solubilizing bacteria (2 kg ha^{-1}) was incorporated into the soil before one month of sowing. Nitrogen, phosphorus, and potassium were applied at the rate of 150:60:108 kg ha^{-1} in the form of urea, single super phosphate and muriate of potash, respectively where ever chemical fertilizers are included in the treatment. Nitrogen was incorporated as per treatment in three splits, 1/3rd at planting time and remaining 2/3rd nitrogen were applied in two equal splits at 60 days and 120 days after planting with irrigation. Phosphorus applied as basal, Potassium was incorporated as per treatment in two splits, 1/2 at planting time and remaining 1/2 120 days after sowing.

After rhizome treatment, sowing was done in ridges and furrow method at 60cm × 30cm spacing and seed rhizome @ 2500 kg ha^{-1}. Treated rhizomes were dibbled on ridges of 45^{o} angle and covered with loose soil. Immediately after sowing field was irrigated, further irrigations were given at eight to ten days intervals.

Observations on various growth parameters were recorded at monthly intervals after germination of rhizomes. Number of days taken from dibbling of rhizome to the appearance of first unfurled leaf above the ground level was recorded as number of days taken for sprouting. Five plants were selected randomly from each treatment, tagged and recorded growth parameters *viz.*, Plant height, number of leaves plant^{-1}, leaf area index at 30, 60, 90, 120, 150, 180 DAS and at harvest, number of tillers clump^{-1} at harvest and yield (t ha^{-1}) were recorded at 210 DAS *i.e* at harvest.

Results and Discussions

The data related to days taken for sprouting, plant height, number of leaves plant^{-1}, leaf area index are presented in Table-1, 2, 3 and number of tillers clump^{-1}, fresh and dry rhizome yield t ha^{-1} are presented in Table- 4 respectively.

Days taken for sprouting.

The results revealed that days taken for sprouting did not differ significantly among the treatments. However, early sprouting was recorded in control: 100% (Recommended Dose fertilizers) T_7 (26 days) presented in Table: 1

Plant height (cm)

The data in Table: 1 revealed that the plant height in all the treatments increased with increase in the age of the plant upto 150 DAS and later showed decreasing trend upto harvest. Significantly higher (80.01cm cm) plant height was recorded in T_6 and lower (65.30 cm) in T_2 at 150 DAS. The increased plant height may be due to application of FYM, Vermicompost with narrow C: N ratio might have 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. This might have led to increased plant height in turmeric (Kumar *et al.*, 2016) [8].

Number of leaves plant^{-1}

The data in Table: 2 revealed that the number of leaves plant^{-1} in all the treatments increased with increase in the age of the plant upto 150 DAS and later showed decreasing trend upto harvest. Significantly highest number of leaves plant^{-1}(26.88) was recorded in T_6, whereas lower (22.64) in T_2 at 150 DAS.

The increase in a number of leaves is due to the solubilization effect of plant nutrients by addition of farm yard manure, neem cake, vermicompost and applied plant nutrients as well as the chelating effect on metal ions leading to higher subsequent uptake of NPK in garlic (Bandari *et al*., 2012) [4] Farm yard manure, neem cake, vermicompost might have enhanced the efficiency of chemical fertilizers also. Compared to the availability of nutrients from most of the bulky organic manures, the release of nutrients from vermicompost could be the reason for higher leaf number. The result of the present investigation is in agreement with the findings of Nirmalatha (2009) [10] in turmeric and Waghachavare (2004) [13] in onion.

Leaf area index (LAI)

The data presented in Table: 3 revealed that general trend of leaf area index was increased with increase in age of plant upto 150 DAS and later showed decreased trend till the harvest. The leaf area index at 30 DAS, 60 DAS and at harvest did not differ significantly among the treatments. Significantly highest (6.27) leaf area index was recorded in T_6 and lowest (3.83) in T_2 at 150 DAS.

The probable reason for increase in number of leaves plant^{-1} and LAI might be improved soil properties (organic carbon) and optimum availability of plant nutrients which acted as growth enhancing factor for turmeric. It made available plant nutrients throughout the growth period which resulted in enhanced soil fertility and nutrient use efficiency and there by increased no of leaves and LAI in turmeric (Kumar *et al.*, 2016) [8]. Kamal and Yousuf (2012) [7] also reported higher LAI of turmeric plants treated with organic fertilizers *viz.*, Cow dung, Poultry manure, Mustard cake, Neem cake.

Number of tillers clump^{-1} at the time of harvest.

Data recorded on number of tillers clump^{-1} at the time of harvest as influenced by the application of organic manures and inorganic fertilizers is presented in Table: 3. the number of tillers clump^{-1} at the time of harvest was recorded highest (4.82) in T_6 and lowest (2.20) in T_2. The numbers of tillers plant^{-1} was significantly increased with soil application of chemical fertilizers along with organic manures like farm yard manure, vermicompost and in turmeric (Balakrishnamurty *et al.*, 2009) [3]. The results obtained in the present study was also supported by the findings of Singh (2015) [11] in ginger crop.

Yield

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 dry rhizomes yield was recorded highest (6.81 t ha^{-1}) in T_6 which was significantly superior to other treatments but was on par with T_5 (6.37 t ha^{-1}). The lowest fresh rhizomes yield t ha^{-1} (2.98 t ha^{-1}) was recorded in T_2 (Table: 4).

In T_6, the favourable effect of integrated application of organic manure, biofertilizer and inorganic fertilizer supplied all essential nutrients in balanced ratio and also improves the fertility status of soil. The application of Neem cake provided the best option for production of turmeric being an exhaustive crop because neem cake acts as manure with pesticidal properties and enhances the organic carbon content of soil. Besides this neem cake is an effective nitrification inhibitor which helps to avoid loss of N and extends the availability of nitrogen for such high exhaustive crop like turmeric. Biofertilizer also might have played a vital role in increasing the rhizome yield by improving soil microbial activity. Another reason was vermicompost and FYM in INM would have improved the physical, chemical and biological properties of soil which helps in better nutrients absorption and utilization by plant resulting higher rhizome yield as reported by Kanaujia *et al*. (2016) [6]. Highest dry rhizome yield was recorded with the combined application of FYM, VC and NC along with inorganic fertilizers of NPK. The higher yield might be due to increase in plant height, number of leaves plant^{-1}, leaf area index, number of tillers clump^{-1} and ultimately due to increased photosynthetic rate. This was in conformity with results of Dinesh *et al.* (2010) [5].

Table 1: Effect of integrated nutrient management on plant height (cm) at 30, 60, 90, 120, 150, 180 DAS and at harvest

Treatments	Days taken for sprouting	Plant height (cm)						
		30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS	At Harvest
T_1	28.23	24.33	39.30	58.06	63.27	72.61	42.01	33.33
T_2	27.11	21.11	42.55	54.13	56.27	65.30	46.22	26.31
T_3	27.06	16.80	38.99	51.59	57.79	66.13	44.32	32.33
T_4	27.74	19.21	46.72	58.44	61.88	72.90	54.12	30.00
T_5	27.85	25.77	44.65	58.61	67.46	73.28	56.05	32.00
T_6	28.23	28.16	51.27	65.07	70.06	80.01	60.35	32.67
T_7	26.00	30.1	46.85	57.79	65.01	71.03	50.07	31.57
S.Em±	0.66	1.39	2.61	1.99	2.12	1.592	1.61	1.46
C.D.at 5%	NS	4.35	8.12	6.19	6.60	4.956	4.96	NS

Table 2: Effect of integrated nutrient management on number of leaves plant^{-1} at 30, 60, 90, 120, 150, 180 DAS and at harvest

Treatments	Number of leaves plant^{-1}						
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS	At Harvest
T_1	1.34	5.40	10.50	16.95	24.83	17.11	10.63
T_2	1.67	5.63	10.29	14.96	22.64	13.94	10.53
T_3	1.80	5.20	10.68	20.32	24.91	18.32	10.83
T_4	1.48	5.33	11.40	21.12	26.79	19.44	12.00
T_5	1.73	5.90	12.38	21.51	26.86	21.89	12.06
T_6	1.76	5.80	12.56	23.00	26.88	22.27	13.40
T_7	2.03	5.13	11.04	20.78	24.83	19.99	11.30
S.Em±	0.57	0.21	0.41	0.55	0.63	0.74	0.62
C.D.at 5%	NS	NS	1.294	1.735	1.963	2.323	NS

Table 3: Effect of integrated nutrient management on Leaf area index at 30, 60, 90, 120, 150, 180 DAS, at harvest

Treatments	Leaf area index(LAI)						
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS	At Harvest
T_1	0.13	0.42	1.18	2.59	4.40	2.85	0.63
T_2	0.14	0.61	1.01	2.15	3.83	2.77	0.53
T_3	0.13	0.51	1.28	3.06	4.54	3.12	0.64
T_4	0.15	0.61	1.38	3.29	6.04	3.45	0.72
T_5	0.16	0.64	1.38	3.56	5.02	3.77	0.77
T_6	0.16	0.72	1.51	3.56	6.27	3.90	0.78
T_7	0.16	0.61	1.32	3.11	4.74	3.39	0.68
S.Em±	0.01	0.03	0.08	0.24	0.31	0.15	0.07
C.D.at 5%	NS	0.09	0.23	0.75	0.97	0.46	NS

Table 4: Effect of integrated nutrient management on no of tillers clump^{-1} at the time of harvest, fresh rhizome yield t ha^{-1}, and dry rhizome yield t ha^{-1}

Treatments	No of tillers clump^{-1} at Harvest	Fresh rhizome yield t ha^{-1}	Dry rhizome yield t ha^{-1}
T_1	2.58	17.77	3.51
T_2	2.20	16.77	2.98
T_3	2.86	20.66	4.50
T_4	3.10	24.23	5.91
T_5	4.23	27.77	6.37
T_6	4.82	29.69	6.81
T_7	3.10	26.38	5.15
S.Em±	0.18	1.20	0.30
C.D.at 5%	0.56	3.96	0.94

Conclusions

The growth parameters and yield were significantly highest in plants supplied with $T_{6;}$ 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}) but was on par with $T_{5;}$ 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}).

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