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Studies on response of manures and biofertilizers on growth and yield of turmeric (*Curcuma longa* L.)

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ABSTRACT

A field experiment was carried out at Horticultural Research Station, Mondouri , Bidhan Chandra Krishi Viswavidyalaya, during 2012-2014. Compost/vermicompost was applied with three levels of inorganic NP (100 ,75 and 50%) with or without nitrogenous and phosphatic biofertilizers (Azospirillum lipoferum and Glomus fasiculatum). There are altogether 13 treatments including recommended NPK (inorganic) laid in RBD with three replications. The uniform dose of potash was applied to all treatments. Maximum plant height at 150 DAP, number of primary fingers and weight of primary fingers were obtained from the treatment combinations of compost +NP (75%) + Azospirillum + AMF. Maximum breadth of primary fingers and number of tillers at 150 DAP were observed in compost+ NP (100%) + Azospirillum + AMF. Vermicompost + NP (75%) + Azospirillum + AMF recorded the maximum number of leaves at 150 DAP, clump weight, length of primary fingers and projected yield of 34.85 t/ha.

***Keywords*:** Bio-fertilizer, compost, inorganic, organic, vermicompost

Turmeric (*Curcuma longa* L.) is one of the ancient and sacred spices of India. It is originated in South-East Asia. It 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). Curcumin the yellow colour pigment present in the rhizome is gaining importance with ban on artificial colours in food industry. Demand growth rate of turmeric is around 10 per cent pointing to future prospects of turmeric cultivation in the country.

Application of organic manures has been the traditional means of maintaining soil fertility, ecological balance and in recent years there is a great demand for the organically produced turmeric worldwide especially in European countries. The adverse effects of continuous use of high dose of chemical fertilizers on soil health and environment were widely realized, hence the farmers are also showing considerable inclination towards traditional farming with least usage of fertilizers. The role of organic manures in improving soil structure and fertility is well understood. Organic manures have positive influence on soil texture and structure, better water holding capacity and drainage which in turn help for better growth and development of rhizomatous crop like turmeric (Kale *et al*., 1992). Different organic manures influence differently in terms of yield and quality of turmeric. Hence, it is necessary to know the suitable combination of bio-organic inputs which could help in increasing the yield and quality.

MATERIALS AND METHODS

The experiment was carried out at Horticultural Research station, Mondouri, BCKV, Nadia, West Bengal during last week of April, 2012 to January, 2014. The soil at the experimental plot was sandy clay loam with pH 6.8 and 0.58% organic carbon. Available N, P and K in soil were 223.45kg ha^{-1}, 18.07 kg ha^{-1} and 194.49 kg ha^{-1} respectively. The experiment was laid out in RBD with three replications. Raised beds of 3.0×1.0 m and 15 cm high were prepared.

The organic inputs namely compost and vermicompost were applied basally during final land preparation @ 20.0 t and 5.0 t per hectare respectively. Among biofertilizers, arbuscular mycorrhizal fungi (*Glomus fasiculatum*) was applied @ 65 kg ha^{-1} directly to the soil along The biofertilizers along with *Tricoderma viridae* @ 5 g kg^{-1} seed rhizome and Acacia gum (1 tablespoon) as sticker were taken in water in a plastic tray and mixed thoroughly. Healthy seed rhizome (30-35 g) were soaked in biofertilizer mixtures and stirred thoroughly 4-5 times. Recommended dose of inorganic fertilizers was 150:60:150 kg NPK per hectare. The total amount of fertilizers was applied in three split doses. 1/ 3^{rd} of N and full dose of P was applied after 15 days of planting whereas each split of $1/3^{rd}$ N and ½ K will be applied after 45 and 90 days after planting. Urea, SSP and MOP were used as inorganic source of N, P and K respectively.

Treated rhizomes of turmeric were planted to a depth of 3-4 cm, in the last week of April. The beds were with compost / vermicompost. *Azospirillum lipoferum* was incorporated through seed rhizome treatment @ 5g kg^{-1} seed material. mulched with paddy straw at the rate of 10 t ha^{-1} immediately after planting and 5t ha^{-1} at 45 and 90 days after planting. Earthing up was done before

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second and third mulching. Three to four hand weedings were done. Irrigation was given as per requirement.The crop was harvested 8 months after planting, observations on different growth (at 90 and 150 days after planting) and yield attributing parameters were recorded from five randomly selected plants per replication. Rhizome yield was taken on net plot basis at harvest and projected yield was calculated on the basis of yield per plot, considering the 75% area occupied by the crop .

RESULTS AND DISCUSSION

Plant height : At 90 DAP, application of vermicompost + NP (100%) recorded maximum plant height (128.00 cm) followed by compost + NP (100%) [127.34 cm] as compared to minimum plant height in recommended NPK (109.67 cm). At 150 DAP, the maximum plant height (161.30 cm) was recorded in treatment combination of compost + NP (75%) + *Azospirillum* + AMF followed by vermicompost + NP (100%) (156.50 cm) as compared to least height under vermicompost + NP (50%) [144.92 cm].

Number of tillers : At 90 DAP, the NP (100%) produced maximum tiller (1.49) followed by vermicompost + NP (100%) [1.36] and compost + NP (75%) + *Azospirillum* + AMF (1.34) as compared to least tiller number (0.79) under recommended NPK (inorganic). At 150 DAP, the plants grown under compost + NP (100%) + *Azospirillum* + AMF produced maximum tiller (2.70) followed by vermicompost + NP (75%) + *Azospirillum* + AMF (2.64) and vermicompost + NP (100%) + *Azospirillum* + AMF (2.42) as compared to least tiller (1.18) under recommended NPK (inorganic).

Number of leaves: At 90 DAP, the maximum leaf number (9.58) was observed in plants growth with vermicompost + NP (100%) + *Azospirillum* + AMF followed by compost + NP (50%) + *Azospirillum* + AMF (9.50) as compared to minimum leaf number (8.33) in vermicompost + NP (50%) combination. At 150 DAP, application of vermicompost + NP (75%) + *Azospirillum* + AMF occupied the first position for production maximum number of leaves (14.40), followed by vermicompost + NP (100%) (13.70) as compared to minimum leaf number of 12.27 under compost + NP (75%)+ *Azospirillum* + AMF combination.

Compared to the availability of nutrients from the compost, the release of nutrients from the added vermicompost is more and could be the reason for higher leaf number. Compared to the availability of nutrients from most of the bulky organic manures, the release of nutrients from the added vermicompost is more and could be the reason for higher leaf number. The result of the present investigation is in agreement with the findings of Nirmalatha (2009) and Shamrao *et al.* (2013).The result of the present investigation is in agreement with the findings of Nirmalatha (2009) and Shamrao *et al.* (2013). Similarabove ground plant growth responses to biofertilizer as observed as in the present investigation have been reported by Patil and Kundel (1988) and Balashanmugan (1994) in turmeric.

Length and breadth of leaves : At 150 DAP, the treatment combination compost + NP (100%) + *Azospirillum* + AMF longest leaf (57.08 cm) followed by vermicompost + NP (75%) + *Azospirillum* + AMF (56.30 cm) as compared to minimum leaf length (49.79 cm) under vermicompost + NP (50%). At 150 DAP, the plants raised under compost + NP (75%) + *Azospirillum* + AMF produced leaves with widest breadth (16.42 cm) followed by vermicompost + NP (50%) + *Azospirillum* + AMF (16.31 cm) and vermicompost + NP (75%) + *Azospirillum* + AMF (16.08 cm) as compared to minimum leaf breadth (14.42 cm) under vermicompost + NP (50%).

Clump weight : The treatment combination of vermicompost + NP (75%) + *Azospirillum* + AMF was found superior for production of highest clump weight of 351.30 g, 405.46 g and 378.38 g respectively in the year 2012, 2013 and in pooled data. The next best treatment in this respect was compost + NP (100%) + *Azospirillum* + AMF (303.15 g, 387.25 g and 345.20 g respectively) followed by vermicompost + NP (100%) + *Azospirillum* + AMF (321.59 g, 395.83 and 358.71 g respectively). The lowest clump weight of 242.35 was noticed in the compost + NP (50%).

Primary finger: As per pooled data maximum number of primary finger (10.72) was recorded with compost + NP (75%) + *Azospirillum* + AMF followed by vermicompost + NP (75%) [10.28] and vermicompost + NP (100%) (9.78) as compared to minimum number of primary finger (6.89) under recommended NPK (inorganic).

Weight of primary finger was significantly influenced by the application of graded levels of inorganics with biofertilizer and organic manures in both the years and in pooled data. Application of compost + NP (75%) + *Azospirillum* + AMF was found to be best with respect to maximum weight of primary finger (173.64 g), followed by vermicompost + NP (75%) + *Azospirillum* + AMF (165.15 g) and compost + NP (100%) *Azospirillum* + AMF (161.21 g), as compared to the lowest weight (98.04 g) under compost + NP (50%). The weight of primary finger under recommended NPK (inorganic) was only 130.26 g.

The longest finger (9.05 cm) was recorded with vermicompost + NP (75%) + *Azospirillum* + AMF followed by compost + NP (100%) + *Azospirillum* + AMF followed by compost + NP (100%) + *Azospirillum* + AMF (8.76 cm) and compost + NP (75%) [8.59 cm] as compared to shortest finger (6.36 cm) under compost + NP (50%). The length of primary finger was 7.96 cm under recommended NPK (inorganic).

Maximum breadth (2.48 cm) was observed with compost + NP (100%) + *Azospirillum*+ AMF followed by vermicompost + NP (100%) + *Azospirillum* + AMF

Table 1: Effect of manures, nitrogenous and phosphatic biofertilizers on plant height, tiller and leaf number, length and breadth of turmeric

Treatments	Plant height (cm)		Number of tiller		Number of leaves		Length	Breadth
	90 DAP	150 DAP	90 DAP	150 DAP	90 DAP	150 DAP		
Compost + NP 100% + *Azospirillum* + AMF	117.00	151.33	1.08	2.70	9.16	13.10	57.08	15.58
Compost + NP 75% + *Azospirillum* + AMF	122.00	161.30	1.34	2.28	8.83	12.27	55.30	16.42
Compost + NP 50% + *Azospirillum* + AMF	113.00	150.55	0.87	1.65	9.50	12.83	49.27	15.67
Vermicompost + NP 100% + *Azospirillum* + AMF	120.50	150.12	1.49	2.42	9.58	13.07	52.87	15.17
Vermicompost + NP 75% + *Azospirillum* + AMF	112.17	152.90	1.24	2.64	8.83	14.40	56.30	16.08
Vermicompost + NP 50% + *Azospirilllum* + AMF	111.67	143.30	0.97	1.93	8.33	13.35	50.29	16.31
Compost + NP 100%	127.34	152.34	1.03	1.93	8.83	12.68	54.71	15.83
Compost + NP 75%	121.17	154.30	0.80	2.35	8.66	12.57	54.45	15.58
Compost + NP 50%	115.50	145.67	0.83	1.86	8.47	12.44	53.53	14.53
Vermicompost + NP 100%	128.00	156.50	1.36	2.12	8.76	13.70	53.32	15.66
Vermicompost + NP 75%	113.17	143.10	0.89	1.34	8.67	12.73	51.65	15.33
Vermicompost + NP 50%	112.00	144.92	0.94	1.65	8.33	13.35	49.79	14.42
Recommended NPK (Inorganic)	109.67	145.77	0.79	1.18	9.15	12.46	50.28	15.17
SEm(±)	**2.70**	**2.09**	**0.14**	**0.21**	**0.38**	**0.19**	**2.43**	**0.43**
LSD(0.05)	**7.68**	**5.93**	**NS**	**0.60**	**1.09**	**0.53**	**6.91**	**1.22**

Table 2: Effect of manures, nitrogenous and phosphatic biofertilizers onclump weight and primary finger characters of turmeric

Treatments	Clump	Primary finger			
	Weight (g)	Number	Weight (g)	Length (cm)	Breadth (cm)
Compost + NP 100% + *Azospirillum* + AMF	345.20	9.66	161.21	8.76	2.48
Compost + NP 75% + *Azospirillum* + AMF	368.76	10.72	173.64	8.49	1.92
Compost + NP 50% + *Azospirillum* + AMF	264.23	8.31	113.55	7.10	2.20
Vermicompost + NP 100% + *Azospirillum* + AMF	358.71	9.75	158.76	8.50	2.36
Vermicompost + NP 75% + *Azospirillum* + AMF	378.38	8.92	165.15	9.05	2.33
Vermicompost + NP 50% + *Azospirilllum* + AMF	276.91	8.34	131.53	6.95	1.81
Compost + NP 100%	317.38	8.89	135.65	7.29	2.15
Compost + NP 75%	273.90	9.33	119.75	8.59	2.29
Compost + NP 50%	242.35	9.06	98.04	6.36	1.78
Vermicompost + NP 100%	324.82	9.78	140.25	7.63	2.31
Vermicompost + NP 75%	292.63	10.28	128.91	7.21	2.23
Vermicompost + NP 50%	248.65	8.53	98.53	8.04	2.04
Recommended NPK (Inorganic)	296.52	6.89	130.26	7.96	2.25
SEm(±)	**5.218**	**0.433**	**3.472**	**0.476**	**0.167**
LSD(0.05)	**14.834**	**1.231**	**9.870**	**1.353**	**NS**

Table 3: Effect of manures, nitrogenous and phosphatic biofertilizers on root characters and projected yield of turmeric

Treatments	Root			Projected yield
	Weight (g)	Long (cm)	Small (cm)	(t ha^{-1})
Compost + NP 100% + *Azospirillum* + AMF	12.81	20.50	6.81	30.82
Compost + NP 75% + *Azospirillum* + AMF	11.75	21.20	6.97	33.68
Compost + NP 50% + *Azospirillum* + AMF	10.31	16.58	5.83	23.35
Vermicompost + NP 100% + *Azospirillum* + AMF	13.29	18.29	5.63	32.71
Vermicompost + NP 75% + *Azospirillum* + AMF	15.82	20.87	6.69	34.85
Vermicompost + NP 50% + *Azospirilllum* + AMF	8.38	17.04	4.85	26.35
Compost + NP 100%	11.93	18.63	6.42	28.43
Compost + NP 75%	9.90	19.32	6.27	25.66
Compost + NP 50%	8.93	19.71	6.75	21.70
Vermicompost + NP 100%	11.25	21.08	7.16	29.38
Vermicompost + NP 75%	10.05	17.75	5.90	27.41
Vermicompost + NP 50%	10.02	17.54	6.42	22.83
Recommended NPK (Inorganic)	8.65	18.33	5.42	27.63
SEm(±)	**1.49**	**0.97**	**0.41**	**0.95**
LSD(0.05)	**4.24**	**2.75**	**NS**	**2.69**

(2.36 cm) and vermicompost + NP (75%) + *Azospirillum* + AMF (2.33 cm) as compared to least breadth (1.78 cm) under compost + NP (50%). The breadth of primary finger under NPK (100%) was 2.25 cm.

Weight of roots : Pooled data (15.82 g) in the treatment combination of vermicompost + NP (75%) + *Azospirillum* + AMF. gave the best results. The next best treatment was vermicompost + NP (100%) + *Azospirillum* + AMF (13.29 g), followed by compost + NP (100%) + *Azospirillum* + AMF (12.81 g). The minimum weight of roots was observed in the treatment combination of vermicompost + NP (50%) + *Azospirillum* + AMF (8.38 g).

Length of long and small roots : The maximum length of 21.20 cm was observed with the treatment combination of compost + NP (75%) + *Azospirillum* + AMF followed by 21.08 cm in the treatment combinations of vermicompost + NP (100%) and least in the treatment combinations of compost + NP (50%) + *Azospirillum* + AMF (16.58 cm).

In small category of root, maximum length of 6.97 cm was observed in the treatment combination of compost + NP 75% + *Azospirillum* + AMF as compared to minimum length of 4.85 cm under vermicompost + NP 50% + *Azospirillum* + AMF

Projected yield : The highest yield was recorded with vermicompost + NP (75%) + *Azospirillum* + AMF (34.85 t ha^{-1}), followed by compost + NP (75%) + *Azospirillum* + AMF (33.68 t/ha) and vermicompost + NP (100%) + *Azospirillum* + AMF (32.71 t/ha). The lowest yield (21.70 t ha^{-1}) was observed in treatment combination compost + NP (50%). The plants grown under recommended NPK (inorganic) exhibited the projected yield of 27.63 t ha^{-1} only, indicating the favourable effect of bio-inoculants and organic manures in enhancing the production of turmeric over recommended dose of fertilizer and also indicating a chance of saving of 25 per cent inorganic fertilizer without hampering the yield of turmeric.

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