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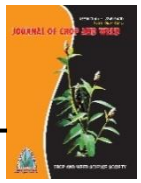

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Response of black turmeric (*Curcuma cassia* Roxb.) to organic manures, bio-fertilizers and graded levels of fertilizers under alluvial zone of West Bengal

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ABSTRACT

An investigation was carried out during 2020-2021 to find out the response of black turmeric to organic manures, bio-fertilizers and graded levels of fertilizers at the Horticultural Research Station (HRS), Mondouri, BCKV, Nadia, West Bengal. Total 13 treatments including control were included in the field trial following RBD with 3 replications. Three levels of inorganic (100%, 75%, and 50% of RDF), four types of organic manures (compost @ 25 t ha^{-1}, vermicompost @ 5 t ha^{-1}, neem cake and mustard cake @ 3 t ha^{-1} each) and three biofertilizers (Azotobacter chroococcum, Bacillus polymixa and Fraturia aurantia @ 20 kg ha^{-1}) were included. Among the different treatments, maximum plant height, number of leaves, , number of primary and secondary finger, weight of clump and secondary finger, length of clump, breadth of primary and secondary finger, plot yield and projected yield (24.65 t ha^{-1}) were recorded in NPK (100%) + vermicompost + biofertilizer treatment. The plants under NPK (100%) + compost + biofertilizer recorded maximum tiller, breadth of clump, weight and length of primary finger. The yield under control (inorganic) was 18.07 t ha^{-1}. Taking into account the expected yield, the most successful treatment combination was NPK (100%) + vermicompost + biofertilizer followed by NPK (100%) + compost + biofertilizer. The findings revealed a 25% feasibility of reducing the application of inorganic NPK by incorporating organic manure, and biofertilizers in black turmeric cultivation under alluvial zone of West Bengal.

Keywords: Biofertilizers, black turmeric, compost, mustard cake, neem cake and vermicompost.

Black turmeric (*Curcuma cassia* Roxb.) is a significant plant having tremendous medicinal properties, belongs to the family Zingiberaceae. It is indigenous to the north eastern regions of India (Arya *et al.,* 2018). These medicinal plants are utilized extensively worldwide to treat a wide range of chronic as well as acute illnesses, and are considered the backbone of traditional medicine (Mazumdar and Rahman, 2008). As it contains number of beneficial important chemicals, the crop is recognized in the name of "Chemical Goldmines" (Joy *et al.,* 1998). Black turmeric has a significant economic aspect due to its therapeutic qualities. The inner portion of the rhizome emits sweet aroma having bluish-black in colour, due to presence of essential oil (Pandey and Chowdhury, 2003). It is utilized for the treatment of inflammations, psoriasis, eczema, wounds, menstrual disorders, diabetes, high cholesterol, and jaundice etc. Rhizome and leaves of kali haldi used as a tonic for the brain and the heart (Sarangthem and Haokip, 2010). Beside this black turmeric possess strong antioxidant, anti-inflammatory, antibacterial and anticancer activity (Das and Mondal, 2013).

High dose of nutrient is required as the duration of crop is 210 to 240 days. But continuous use of high dose of chemical inputs in agriculture for higher yields causes contamination of different environmental components, reduces soil fertility, decreases soil microbial populations and poses a health risk to human being.

Short communication

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The appropriate use of manures and/or crop residues in cropping systems, either alone or in conjunction with organic inputs, could mitigate the negative effects of agricultural practices. (Mandal *et al.,* 2007).

Now a days, bio fertilisers are important part of the nutrient supply chain (Ghosh *et al.,* 2001). Several researchers have established the role of different bio fertilisers, such as *Azospirillum* and *Azotobacter*, in atmospheric nitrogen fixation (Chandrashekhar, 2003; Indiresh *et al.,* 2003). Microorganisms may improve the accessibility of essential nutrients by enhancing the amount of organic matter in soil (Singh and Rai 2003; Parthasarathy *et al.,* 2012). The prudent application of chemical and biological source of plant nutrients as well as their proper management encourages in maintaining soil health and productivity through partial substitution of inorganic inputs. Given this background, this investigation was aimed to evaluate the influence of bio-fertilizers along with the manures and graded levels of inorganic fertilizers on growth and yield of black turmeric raised from single node cutting under new alluvial plains of West Bengal.

The current investigation was carried out at Horticultural Research Station, Mondouri, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during 2020-2021. The experimental site is at 23.5°N latitude and 89°E longitude, with an average elevation of 9.75 m above mean sea level. The selected land of experimental site was prepared through thorough ploughing at a depth of 30 cm in order to make soil well friable and pulverized. The experiment was laid out in Randomized Block Design, with 13 treatments and three replications. In the last week of June, seed rhizomes weighing 20-25 g were planted on raised beds measuring 3.0x1.0 m^2 and 15 cm high, with a spacing of 25 x 20 cm. Rhizome bits were treated with *Trichoderma viride* @5g kg^{-1} seed rhizome with *Acacia* gum prior to planting.

Four organic manures namely, compost @ 25 t ha^{-1} , vermicompost @ 5 t ha^{-1}, mustard cake @ 3 t ha^{-1} and Neem Cake @ 3 t ha^{-1}, and three bio-fertilizers namely, nitrogen fixing biofertilizer (*Azotobacter chroococcum*), phosphate solubilizing bacteria (*Bacillus polymixa*) and potassic mobilizer (*Fraturia aurantia*) were included along with three levels *i.e.,* 100%, 75% and 50% of recommended dose of inorganic fertilizer (150:60:150 kg ha^{-1}) (Medda, 2000). As there is no fertilizer recommendation for black turmeric is available, RDF of normal turmeric (*Curcuma longa* L.) had been considered for the present experiment. The treatments consisting T_1 : 100% NPK + compost + biofertilizer, T_2 : 75% NPK + compost + biofertilizer, T_3 : 50% NPK + compost + biofertilizer, T_4 : 100% NPK + vermicompost + biofertilizer, T_5 : 75% NPK + vermicompost + biofertilizer, T_6 : 50% NPK + vermicompost + biofertilizer, T_7 : 100% NPK + Neem Cake + biofertilizer, T_8 : 75% NPK + Neem cake + biofertilizer, T_9 : 50% NPK + Neem cake + biofertilizer, T_{10} : 100% NPK + Mustard cake + biofertilizer, T_{11} : 75% NPK + Mustard cake + biofertilizer, T_{12} : 50% NPK + Mustard cake + biofertilizer, T_{13} : Control (100% NPK). Three biofertilizers @ 20 kg ha^{-1}, were applied concurrently along with respective organic manures during final land preparation. Urea, single super phosphate and muriate of potash were applied in order to adjust the requirement of nitrogen, phosphorus and potash. The nitrogenous fertilizer was applied in three split doses: one third of the nitrogen along with full of the phosphorus were applied as basal @ 25 t ha^{-1} 15 days after application of bio-fertilizers; the potassic fertiliser was applied in two split doses- after 45 and 90 days of planting; and the remaining amounts of potassium and nitrogen were added in two equal doses at a rate of ½ K and 1/3 of N.

After planting, the first irrigation was given. The next irrigations were given based on availability of soil moisture condition. Rhizome bits were planted at a depth of 3–4 cm. Paddy straw was used as mulch @ 10 t ha^{-1} immediately after planting, subsequently @ 5 t ha^{-1} at 45 and 90 days after planting. Prior to the second and third of mulching, earthing up was done. The observations on growth parameters were taken at four, five and six months after planting. After harvesting, the observations on yield parameters were recorded.

Significant variations were observed regarding the growth and yield of black turmeric, when subjected to different combinations of inorganic fertilizers, organic manures and biofertilizers (Tables 1-3). In most cases, the bio-organic combinations outperformed the recommended fertiliser dose. Among the various treatments, the maximum plant height (151.24

cm), number of leaves (16.58), primary (8.42) and secondary (5.26) finger, weight of clump (202.26 g) and secondary finger (29.57gm), length of clump (14.36 cm), breadth of primary (1.63 cm) and secondary finger (1.15 cm), plot yield (9.86 kg) and projected yield (24.65 t ha^{-1}) were recorded in NPK (100%) + vermicompost + biofertilizer (BF) treatment. The plants under NPK (75%) + vermicompost + BF recorded maximum secondary finger length (3.47 cm). The plot and projected yield under NPK (75%) + vermicompost + BF treatment were 8.53 kg $3m^{-2}$ and 21.32 t ha^{-1} respectively.

The plants under NPK (100%) + compost + BF recorded maximum tiller (3.58), breadth of clump (10.8cm), weight (140.38gm) and length of primary finger (7.62 cm). The plot and projected yield under NPK (100%) + compost + BF treatment was 8.92 kg 3 m^{-2} and 22.31 t ha^{-1}, respectively. The plants under NPK (75%) + compost + BF recorded maximum weight of mother rhizome (42.07 g). The plot and projected yield under NPK (75%) + compost + BF treatment were 7.84 kg $3m^{-2}$ and 19.60 t ha^{-1} respectively.

The plants under NPK (100%) + mustard cake + BF recorded highest secondary finger breadth (1.21cm). The plot and projected yield under NPK (100%) + mustard cake + BF treatment was 7.65 kg $3m^{-2}$ and 19.12 t ha^{-1} respectively. The plants under NPK (75%) + mustard cake + BF recorded weight of mother rhizome (20.92g), primary finger length (5.71cm). The plot and projected yield under NPK (75%) + mustard cake + BF treatment were 6.85 kg $3m^{-2}$ and 17.14 t ha^{-1} respectively. In respect to projected yield per hectare, the most promising treatment was NPK (100%) + vermicompost + BF (24.65 t ha^{-1}) followed by NPK (100%) + compost + BF (22.31 t ha^{-1}) as compared to the lowest yield (15.37 t ha^{-1}) in mustard cake and bio-fertilizer combinations. Application of recommended NPK recorded yield of 18.07 t ha^{-1}, which is lower than the treatment of NPK (100%) + vermicompost + BF and NPK (100%) + compost + BF.

During the initial growth stage, nitrogen plays a crucial role in promoting various plant growth parameters. Inorganic sources of nutrients typically result in the rapid release of nitrogen, leading to increased plant height, number of leaves, number of tillers, and other factors compared to bio-organic inputs, which release nutrients at a slower pace. However, in the present experiments, plots treated with 75% NPK + Organic Manure + BF and even 50% NPK + Organic Manure + BF exhibited taller plants and a greater number of leaves than those treated with 100% NPK (RDF) at 120 DAP. Additionally, in terms of the number of tillers, the 75% NPK treatment was found to be more effective compared to 100% NPK (with or without bio-organics) at 120 DAP. Application of inorganics were completed within 90 DAP, which may involve both immediate release of nutrients and loss of nutrients, particularly nitrogen, due to different factors. On the contrary, the release of nutrients from bio-organic inputs were slow and continuous process due to build-up of microbial populations. Black turmeric is a long duration crop requiring nutrients for growth and developments over a long span. This may be the probable reason for getting the higher vegetative parameters as compare to the full inorganic sources.

Combined application of organic, biofertilizers, and inorganic fertilisers had beneficial effect on yield and yield contributing characters. These findings are consistent with previous research on ginger (Chitra and Vinothini, 2020) and turmeric (Kanaujia *et al.*, 2018). Increased fertiliser application may cause plants to absorb more nutrients like potassium, phosphate, and nitrogen, which will increase the production of metabolites in the plant that aid in the development of plant tissues. Compost enhances aeration and soil tilth, elevates water retention capacity, and promotes microorganism activity, making plant food components of the soil readily available to the crop as compared to only inorganic source of NPK (100%) without any organic source. The beneficial effect of biofertilisers on various growth and yield parameters observed in the study was due to increased nutrient uptake by the plants (Bhardwaj *et al.*, 2014). *Azotobacter* promotes plant growth by fixing nitrogen, and they are also known to aid in the synthesis of growth-promoting substances such as IAA and GA (Sumbul *et al.*, 2020).

Aside from increasing the availability of phosphorus, PSB are also recognized for producing vitamins, amino acids as well as growth-promoting substances such as GA and IAA, which further stimulate plant growth. This might have played a role in the increased growth in PSB-inoculated plots. Application of organic manures increased soil porosity by improving soil

aggregates and creating a favourable natural geometry, paving the way for healthy rhizome growth beneath the soil (Kumar *et al.,* 2017). Apart from providing nutrients to plants directly, organic manures also aid to stabilize existing forms of nutrients in the soil, which may account for some of the positive effects of their combination treatment with biofertilizers on yield as well as yield characteristics. These organic manures increase the soil porosity, structural stability, and ability to hold water by creating a reservoir of organic matter. Therefore, improvements in the physical and chemical properties of the soil must have encouraged root growth, increased enzymatic activity, and boosted the population of beneficial soil microorganisms, all of which aided in the absorption of more water and nutrients from a greater area. The experimental results clearly indicate the superiority of bioorganic combination with inorganic fertilizer (100% NPK + vermicompost + biofertilizer) over full inorganic fertilization for production of black turmeric under alluvial zone of West Bengal.

Table 1: Influence of organic, biofertilizers and graded levels of inorganic fertilizer on vegetative parameters of black turmeric

Treatments	Plant height (cm)			Number of leaves per clump			Number of tiller per clump		
	120 DAP	150 DAP	180 DAP	120 DAP	150 DAP	180 DAP	120 DAP	180 DAP	150 DAP
T_1	94.56	130.14	149.23	10.72	13.02	16.18	2.08	2.62	3.58
T_2	91.03	122.73	144.85	11.46	13.94	15.26	1.25	2.28	3.17
T_3	87.35	116.54	139.40	10.14	12.15	14.02	0.86	1.93	2.56
T_4	98.36	126.48	151.24	11.32	14.62	16.58	1.96	2.86	3.26
T_5	95.10	128.42	148.39	10.16	12.04	14.51	2.02	2.25	3.42
T_6	86.36	119.06	142.16	9.24	11.96	13.64	1.39	2.34	2.82
T_7	89.43	116.29	145.09	10.59	12.97	15.62	2.16	2.45	3.17
T_8	86.26	118.44	141.45	9.94	11.05	13.85	1.76	2.73	3.05
T_9	83.46	116.06	128.12	8.72	10.82	11.36	0.94	1.18	2.12
T_{10}	92.72	118.49	135.69	10.26	13.25	15.36	1.39	1.82	2.64
T_{11}	87.45	115.36	131.40	9.62	12.16	15.54	1.12	1.96	2.82
T_{12}	81.92	112.35	129.71	8.85	11.92	13.16	0.78	1.56	1.49
T_{13}	84.26	108.36	132.41	9.56	10.72	14.74	1.26	2.16	2.96
S.Em. (±)	**1.378**	**1.746**	**2.171**	**0.236**	**0.325**	**0.390**	**0.134**	**0.131**	**0.155**
C.D. (P=0.05)	**4.134**	**5.248**	**6.513**	**0.708**	**0.975**	**1.176**	**0.402**	**0.393**	**0.475**

Table 2: Influence of organic, bio-fertilizer and graded level of fertilizer on weight of mother rhizome and clump and primary finger in turmeric

Treatments	Weight of mother Rhizome (g)	Clump character			Primary finger			
		Weight (g)	Length (g)	Breadth (g)	Number	Weight (g)	Length (cm)	Breadth (cm)
T_1	24.98	185.06	13.72	10.84	8.05	140.38	7.62	1.52
T_2	42.07	172.32	13.83	10.25	7.56	112.94	6.59	1.39
T_3	21.28	150.75	11.47	9.63	7.21	109.88	5.56	1.32
T_4	41.03	202.25	14.36	10.26	8.42	131.68	6.92	1.63
T_5	25.08	181.38	13.24	9.85	7.35	134.76	7.01	1.43
T_6	21.38	157.52	11.56	8.74	7.16	112.57	6.12	1.40
T_7	40.43	175.25	12.96	10.45	7.95	114.84	6.68	1.48
T_8	38.77	167.57	13.28	9.85	7.43	113.99	6.73	1.36
T_9	25.86	128.38	10.86	9.92	7.12	186.05	5.86	1.38
T_{10}	35.12	153.26	12.27	9.26	6.95	113.16	6.04	1.31
T_{11}	20.92	136.72	11.42	9.53	6.35	99.62	5.71	1.39
T_{12}	22.17	119.56	9.38	9.76	6.25	82.32	6.07	1.21
T_{13}	27.47	138.28	11.36	9.18	7.05	91.21	6.25	1.35
S.Em. (±)	**2.330**	**2.740**	**0.395**	**0.156**	**0.171**	**2.202**	**0.163**	**0.028**
C.D. (P=0.05)	**6.991**	**8.221**	**1.185**	**0.468**	**0.513**	**6.610**	**0.489**	**0.084**

Table.3: Influence of organic, bio fertilizer and graded level of inorganic fertilizer on secondary finger and yield of black turmeric

Treatments	Secondary finger				Yield per plot (kg $3m^{-2}$)	Projected yield (t ha^{-1})
	Number	Weight (g)	Length(cm)	Breadth(cm)		
T_1	4.75	19.69	2.66	0.97	8.92	22.31
T_2	4.42	17.31	2.35	1.08	7.84	19.60
T_3	3.65	19.52	1.92	1.09	6.94	16.35
T_4	5.26	29.57	2.25	1.15	9.86	24.65
T_5	4.52	21.54	3.47	1.12	8.53	21.32
T_6	3.85	23.37	2.13	0.96	6.92	17.30
T_7	5.15	19.88	3.10	0.95	8.26	20.65
T_8	4.75	14.72	2.75	1.03	7.92	19.82
T_9	3.74	16.47	2.54	1.08	6.35	15.87
T_{10}	4.65	21.24	2.02	1.21	7.65	19.12
T_{11}	4.16	16.18	2.19	1.05	6.85	17.14
T_{12}	3.74	15.07	2.34	0.94	6.15	15.37
T_{13}	4.62	18.82	2.03	0.86	7.23	18.07
S.Em. (±)	**0.149**	**1.108**	**0.126**	**0.027**	**0.302**	**0.756**
C.D. (P=0.05)	**0.447**	**3.324**	**0.380**	**0.081**	**0.907**	**2.267**

CONCLUSION

Considering the yield under different treatment combination, most effective treatment is NPK (100%) + vermicompost + biofertilizer followed by NPK (100%) + compost + biofertilizer. The findings also indicated the feasibility of reducing 25% of the application of inorganic NPK by incorporating organic manure, and bio-fertilizers in black turmeric cultivation under alluvial zone of West Bengal.

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