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Effect of organic source of nutrients and biofertilizers on growth, yield and quality of turmeric (*Curcuma longa* L.)

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Abstract: Turmeric (*Curcuma longa* L.) being a long crop duration, rhizomatous nature and high productivity it requires heavy input of fertilizers. Keeping this in view, an experiment was conducted at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during 2009-10 and 2010-11 to study the effect of organic source of nutrients and biofertilizers on growth, yield and quality of Turmeric (*Curcuma longa* L.). The results revealed that application of green leaf manure (from *Glyricidia maculata*) @ 12tonnes/ha along with rock phosphate @ 0.2 tonnes/ha, wood ash @ 1 tonnes/ha, *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha (T_5) gave the significantly highest fresh (29.27 tonnes/ha) and dry yield (7.81 tonnes/ha) followed by vermicompost 5 tonnes/ha along with *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha (T_4) (26.30 tonnes/ha and 6.99 tonnes/ha, respectively) which was statistically *at par* with sole application of 30 tonnes/ha farm yard manure (T_2) (26.00 tonnes/ha and 6.77 tonnes/ha, respectively). Next highest dry yield (6.40 tonnes/ha) was recorded in control plots (T_6) of recommended dose of fertilizers at the rate of 80:80:120 kg N, P_2O_5 and K_2O/ ha along farm yard manure @ 15 tonnes/ha. The lowest fresh yield of 19.31 tonnes/ha and dry yield (5.26 tonnes/ha) was recorded in the treatment of sole application of FYM @ 15 tonnes/ha (T_1). Somewhat higher dry recovery percentage was recorded in case of all the organic treatments compared to control treatment (T_6). Maximum dry recovery (27.22%) and curcumin content (5.24%) was recorded in the treatment of sole application of FYM @ 15 tonnes/ha (T_1). It may be concluded that the application of green leaf manure (from *Glyricidia maculata*) @ 12tonnes/ha along with rock phosphate @ 0.2 tonnes/ha, wood ash @ 1 tonnes/ha, *Azospirillum* @ 5kg/ha and PSB @ 5kg/ha was the best treatment followed by application of Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha and application of farm yard manure @ 30 tonnes/ha treatments for dry yield and quality of turmeric.

Keywords: Biofertilizer, Growth, Organic, Quality, Turmeric, Yield

INTRODUCTION

Turmeric (*Curcuma longa* L.) belongs to the family Zingiberaceae is one of the most important and ancient spices of India and a traditional item of export, which is used daily for preparation of different dishes, different auspicious ceremony and as an ingredient of medicinal preparations. Turmeric inhibits the development of cataracts, breast cancer, colon cancer, and lymphoma (Devi and Sangamithra, 2011). Apart from its spice and medicinal value it is also used in the preparation of different cosmetic items. In India it is cultivated with an area of 1.95 lakh hectare (ha) with a production of 9.99 lakh tonnes. In West Bengal, it is cultivated with an area of 15.8 thousand ha and production of 42 thousand tonnes. India is the major producer and exporter of turmeric and earned a foreign exchange of 2000 million $. (Anonymous, 2012). Productivity of turmeric in West Bengal is quite low (2.66 tonnes/ha) compared to national average (5.11 tonnes/ha). The low productivity of West Bengal may be due to the use of low yielding cultivars and poor management practice. Turmeric is being a long duration (8-9 months) and exhaustive crop and requires heavy nutrition for getting higher yield and quality (Govind *et al.,* 2005; Jagadeeswaran *et al.,* 2007). The adverse effects of continuous use of high dose of chemical fertilizers on soil health and environment were realized (Kamal and Yousuf, 2012). Organic manures and biofertilizers offer an alternative to chemical fertilizers and increasingly used in spice crop production including turmeric (Srinivasan *et al.,* 2000). Organic source of nutrients are recommended for retaining productivity of soil, reducing usage of chemical fertilizers, improving soil health and minimize environmental pollution (Hossain and Ishimine, 2007). Application of organic manures also quickly increases soil microbial biomass and their activity (Dinesh *et al.,* 2010). Soil microorganisms and their activities play important roles in transformation of plant nutrients from unavailable to available forms and also helpful for improvement of soil fertility (Yamawaki *et al.,* 2013). Application of biofertilizers like *Azospirillium* is helpful for fixation of substantial amount of atmospheric nitrogen and supplies to the crop and increases soil fertility. Application of PSB

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increases the uptake of phosphorus which readily fixed in the soil (Wanj and Qui, 2006). Use of organic manure and bio-fertilizer combination is suitable for sustainable production (Sreekala, 2015). With keeping this view, the present experiment was undertaken to study the effects of different organic nutrient sources with biofertilizers on growth, yield and quality of turmeric under terai zone of West Bengal.

MATERIALS AND METHODS

The experiment was carried out at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during two consecutive year 2009-10 and 2010-11. The experimental soil was sandy clay loam having pH 5.7, 0.91% organic carbon, 132.99 kg/ha available nitrogen, 46.36 kg/ha available phosphorus and 60.15 kg/ha potash. The climatic condition of this region is sub-tropical humid in nature. The experiment was laid out in Randomized Block Design with five replications. Raised beds of 3 m X 1 m size and 15 cm height were prepared. Turmeric rhizome of the variety Suranjana was planted during the first week of April 2009 and 2010, respectively. Two biofertilizers namely *Azospirillium* and phosphate solubilizing bacteria (PSB), five different organic nutrient sources *viz.* Farm yard manure, vermicompost, green leaf manure, wood ash and rock phosphate were included in this experiment. Apart from the above inorganic chemical source of N, P_2O_5 and K_2O were applied as per treatment combinations. Different treatments in this experiment were- T_1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T_2 = FYM @ 30 tonnes/ha, T_3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha and T_6 = N: P_2O_5:K_2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha. The organic inputs and rock phosphate were applied as basal. *Azospirillium* and PSB were inoculated as seed treatment (2.5g/kg rhizome). For inorganic treatment full dose of P_2O_5 and 1/3 dose of N was applied as basal, rest 2/3rd N and K_2O were applied in two equal splits at 45 and 90 days after planting. Singh *et al.* (2012) also carried out the experiment on integrated response of inorganic and bio-fertilizers on yield and yield attributes of turmeric by adopting randomized block design. Observations on different morphological and yield attributing characters were recorded from ten randomly selected plants from each plots. Rhizome yield per hectare was calculated on the plot weight basis. For determination of dry recovery percentage the harvested turmeric rhizome was washed and dried properly till a constant weight was obtained. Curcumin content of dry turmeric rhizome was estimated as suggested by Sadasivam and Manickam (1996). Statistical analysis of the data was done as per method suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The data on different growth and yield attributing characters have been presented in Tables 1-3. Data on different growth and yield attributing characters showed significant differences among the different treatments.

Growth parameters: In this experiment plant height varied from 92.95 – 109.05 cm. The maximum plant height was recorded in the plots treated with green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha (T_5) which was statistically *at par* with application of N: P_2O_5 : K_2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha (T_6) (107.15 cm) and application of Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha (T_4) (105.00cm) whereas, significantly the lowest plant height was recorded in the sole application of FYM @15 tonnes/ha (T_1). Maximum leaf length and leaf breadth (56.72 cm and 12.14 cm respectively) was recorded in T_5 treatment i.e. Green leaf manure @ 12 tonnes/ha + rock phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha. Higher leaf length and leaf breadth was also recorded in T_4 treatment i.e. Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha (55.32 cm and 12.16 cm respectively) and T_2 treatment i.e. FYM @ 30 tonnes/ha (52.96 cm and 12.15 cm respectively). The higher values in plant height, leaf length and leaf breadth in the T_5, T_4 and T_2 treatments might be due to supply of all the essential mineral nutrients in a balanced amount which results better growth and development. Mohapatra and Das (2009) also reported that organic manure and biofertilizer increased the vegetative growth and biomass production of turmeric effectively. Sarma *et al.,* (2015) also reported that application of different combinations of organic manure, influenced the growth and yield and yield attributes of turmeric.

Rhizome characters: The highest clump length (19.28 cm) was recorded in the plots treated with green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha (T_5) treatment which was statistically *at par* with the application of Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha (T_4) (18.71 cm). Significantly the lowest clump length was recorded in sole application of FYM @ 15 tonnes/ha (T_1) (16.50 cm). Highest mother rhizome length, primary rhizome length and secondary rhizome length were recorded in T_5 treatment (7.30 cm, 7.82 and 6.31 cm respectively) and lowest in T_1 treatment (6.93 cm, 6.76 cm and 6.31 cm respectively). Similarly like rhizome length, higher mother rhizome diameter, primary rhizome diameter and secondary rhizome diameter (3.30 cm, 2.47 cm and 2.01 cm respectively) were also

Table 1. Plant height, leaf length, leaf breadth and clump length of turmeric under organic sources of nutrient including biofertilizer.

Treatments	Plant height (cm)			Leaf length (cm)			Leaf breadth (cm)			Clump length (cm)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
T_1	90.80	95.10	92.95	42.36	44.60	43.48	10.94	1.52	10.73	16.64	16.36	16.50
T_2	99.40	105.60	102.50	52.04	53.88	52.96	12.26	12.04	12.15	18.30	18.64	18.47
T_3	96.90	100.30	98.60	47.62	49.72	48.67	11.34	11.20	11.27	17.34	17.24	17.29
T_4	102.60	107.40	105.00	49.84	54.84	52.34	12.36	11.96	12.16	18.50	18.92	18.71
T_5	107.40	110.70	109.05	53.92	56.72	55.32	12.52	12.36	12.44	19.22	19.34	19.28
T_6	105.70	108.60	107.15	51.34	50.64	50.99	12.16	11.60	11.88	18.26	18.52	18.39
SEm±	1.68	1.55	1.58	1.12	1.03	1.06	0.44	0.25	0.37	0.35	0.28	0.28
CD (P=0.05)	5.35	4.93	4.53	3.51	3.22	3.04	1.31	0.74	1.05	1.06	0.84	0.78

T_1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T_2 = FYM @ 30 tonnes/ha, T_3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha and T_6 = N: P_2O_5 : K_2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha.

Table 2. Length and diameter of mother and primary rhizome of turmeric under organic sources of nutrient including biofertilizer.

Treatments	Mother rhizome length (cm)			Mother rhizome diameter (cm)			Primary rhizome length (cm)			Primary rhizome diameter (cm)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
T_1	6.96	6.90	6.93	2.91	2.95	2.93	6.80	6.72	6.76	2.06	2.09	2.08
T_2	7.38	7.27	7.33	3.11	3.16	3.14	7.84	7.88	7.86	2.27	2.30	2.28
T_3	7.14	7.01	7.08	2.98	2.92	2.95	7.36	7.26	7.31	2.17	2.14	2.15
T_4	7.42	7.50	7.46	3.20	3.17	3.18	7.82	7.90	7.86	2.5	2.37	2.36
T_5	7.56	7.82	7.69	3.26	3.35	3.30	8.04	8.18	8.11	2.48	2.45	2.47
T_6	7.28	7.31	7.30	3.15	3.09	3.12	7.76	7.88	7.82	2.29	2.26	2.28
SEm±	.20	0.15	0.13	0.09	0.08	0.07	0.18	0.15	0.14	0.05	0.04	0.04
CD (P=0.05)	0.60	0.45	0.36	0.25	0.24	0.20	0.53	0.46	0.40	0.15	0.13	0.11

T_1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T_2 = FYM @ 30 tonnes/ha, T_3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha and T_6 = N: P_2O_5 : K_2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha.

Table 3. Length and diameter of secondary rhizome of turmeric under organic sources of nutrient including biofertilizer.

Treatments	Length of secondary rhizome (cm)			Diameter of secondary rhizome (cm)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
T_1	5.62	5.66	5.64	1.79	1.77	1.78
T_2	6.14	6.08	6.11	1.98	1.94	1.96
T_3	5.89	5.87	5.88	1.86	1.9	1.88
T_4	6.21	6.25	6.23	1.97	1.94	1.96
T_5	6.30	6.33	6.31	1.98	2.04	2.01
T_6	6.17	6.11	6.14	1.83	1.85	1.84
SEm±	0.11	0.08	0.08	0.04	0.04	0.03
CD (P=0.05)	0.31	0.24	0.24	0.12	0.13	0.09

T_1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T_2 = FYM @ 30 tonnes/ha, T_3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ ha + PSB @ 5 kg/ha, T_4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha and T_6 = N: P_2O_5 : K_2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha.

recorded in plots treated with green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ ha (T_5) and lowest in sole application of FYM @ 15 tonnes/ha (T_1) (2.93 cm, 2.08 cm and 1.78 cm respectively). Lower magnitude of mother, primary and secondary rhizome length and diameter in sole application of FYM @ 15 tonnes/ha (T_1) were might be due to the lower availability of essential plant nutrients. Apart from the plots treated with green leaf manure @ 12 tonnes/ha +rock phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ ha (T_5), application of vermicompost 5 tonnes/ha along with *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha (T_4) and sole application of 30 tonnes/ha farm yard manure (T_2) also gave the higher magnitude of the above parameters. Higher values in T_5, T_4 and T_2 treatments might be due to the higher magnitude of growth parameters which ultimately provided longer and higher photosynthesis process and transfer the food material from source to sink. Organic manures improved soil productivity and fertility which in turns improved yield and quality of such long duration crop like turmeric In this experiment, application of higher dose of farm yard manure (FYM) and vermicompost increased the growth, dry matter accumulation, yield and quality of turmeric Similar findings was also recorded by Hossain and Ishimine (2007); Manhass and Gill (2010); Mohapatra and Das (2009). The combined application of farmyard manure, vermicompost, leaf manure along with *Azospirillum* and PSB recorded the supremacy for yield attributes of turmeric in the present experiment which was also similar with the finding of Velmurugan *et al.* (2007).

Rhizome yield: Rhizome yield of turmeric varied significantly with the application of different organic manures and biofertilizes (Table 4). The results revealed that application of green leaf manure (from *Glyricidia maculata*) @ 12tonnes/ha along with rock phosphate @ 0.2 tonnes/ha, wood ash @ 1 tonnes/ha, *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha (T_5) gave the significantly highest fresh (29.27 tonnes/ha) and dry yield (7.81 tonnes/ha) followed by vermicompost 5 tonnes/ha along with *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha (T_4) (26.30 tonnes/ha and 6.99 tonnes/ha, respectively) which was statistically *at par* with sole application of 30 tonnes/ha farm yard manure (T_2) (26.00 tonnes/ha and 6.77 tonnes/ha, respectively). Next highest dry yield (6.40 tonnes/ha) was recorded in control plots (T_6) of recommended dose of fertilizers at the rate of 80:80:120 kg N, P_2O_5 and K_2O/ ha along farm yard manure @ 15tonnes/ha. The lowest fresh yield of 19.31 tonnes/ha and dry yield (5.26 tonnes/ha) was recorded in the treatment of sole application of FYM @ 15 tonnes/ha (T_1). T_5, T_4 and T_2 treatments produced 22.03 per cent, 9.22 per cent and 5.78 per cent higher dry yield respectively with respect to control treatment (T_6). Application of organic manures like farmyard manure, vermicompost and biofertilizers like *Azospirillum, Phosphobacteria* and VAM improved soil productivity and fertility, which improve the yield of long duration crop like turmeric (Velmurugan *et al.,* 2007; Dinesh *et al.,* 2010).

Quality parameters: Perusal of the data on dry recovery and curcumin content has been presented in Table 4. Maximum dry recovery (27.22%) was recorded in the treatment of sole application of FYM @ 15 tonnes/ ha (T_1) which was statistically *at par* with the application of FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha(T_3) and significantly lowest dry recovery per cent was recorded in the plot treated with recommended dose of fertilizers at the rate of 80:80:120 kg N, P_2O_5 and K_2O/ ha along farm yard manure @ 15tonnes/ha. (T_6). From the Table 4, it was also clear that the higher dry recovery was recorded in all the treatments that contain organic sources of nutrients and with or without biofertilizers. Maximum curcumin content (5.24%) was recorded in the treatment of sole application of FYM @ 15 tonnes/ha (T_1) and it was lowest in in the plot treated with recommended dose of fertilizers at the rate of 80:80:120 kg N, P_2O_5 and K_2O/ ha along farm yard manure @ 15tonnes/ha (T_6). Organic treatments with or without biofertilizers produced higher curcumin content than the plot treated

Table 4. Yield, dry recovery and curcumin content of turmeric under organic sources of nutrient including biofertilizer.

Treatments	Fresh Yield (tonnes/ha)			Dry recovery (%)			Dry yield (tonnes/ha)			Curcumin (%)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
T_1	19.63	18.98	19.31	27.16	27.28	27.22	5.33	5.18	5.26	5.26	5.22	5.24
T_2	25.76	26.24	26.00	25.84	26.22	26.03	6.66	6.88	6.77	5.17	5.23	5.20
T_3	23.73	22.32	23.03	26.70	26.80	26.75	6.34	5.98	6.16	5.22	5.20	5.21
T_4	26.82	25.78	26.30	26.54	26.62	26.58	7.12	6.86	6.99	5.20	5.21	5.21
T_5	28.73	29.81	29.27	26.46	26.92	26.69	7.60	8.02	7.81	5.24	5.19	5.22
T_6	25.94	24.97	25.46	24.84	25.41	25.14	6.44	6.34	6.40	5.06	5.05	5.06
SEm±	0.39	0.41	0.35	0.20	0.15	0.20	0.12	0.13	0.12	0.06	0.05	0.05
CD (P=0.05)	1.15	1.22	1.01	0.61	0.44	0.56	0.36	0.38	0.34	0.19	0.16	0.15

T_1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T_2 = FYM @ 30 tonnes/ha, T_3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha and T_6 = N: P_2O_5 : K_2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha.

with recommended dose of fertilizers at the rate of 80:80:120 kg N, P_2O_5 and K_2O/ ha along farm yard manure @ 15tonnes/ha. (T_6). Organic manure treatment supplied the nutrient content throughout growth period in balanced form which increased the curcumin content of turmeric which was also similar with the findings of Velmurugan *et al.,* (2007). Singh *et al.,* (2015) also carried out an experiment was conducted to find out the effect of bio-fertilizers and organic manures on quality parameters of turmeric (*Curcuma longa* L.) and they reported that application of organic manures increased the yield and quality considerably as compared to inorganic fertilizer alone. Which is similar in the findings of the present experiment

Conclusion

The present study concluded that application of green leaf manure (from *Glyricidia maculata*) @ 12tonnes/ ha along with rock phosphate @ 0.2 tonnes/ha, wood ash @ 1 tonnes/ha, *Azospirillum* @ 5kg/ha and PSB @ 5kg/ha was the best treatment followed by application of Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha and application of farm yard manure @ 30 tonnes/ha treatments for dry yield and quality of turmeric.

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