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Effect of organic manures and biofertilizers on growth, yield, and quality of turmeric intercropped in arecanut garden

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Abstract

The combination of organic manures *viz*. compost, vermicompost, phosphocompost and mustard cake and microbial inoculants *viz. Azospirillum brasilense* and Arbuscular mycorrhiza (*Glomus fasciculatum*) were tried for the organic production of turmeric cv. Suguna grown as intercrop in six years old arecanut cv. Mohitnagar plantation. The experiment was laid out at Horticultural Research Station, Mondouri, BCKV, Nadia, West Bengal in RBD with three replication and eleven treatments for consecutive two years (2005-2006). Compost along with neem cake @ 25 kg and 3.0 kg/palm/year, respectively were applied during pre-monsoon (June) and post-monsoon (September) periods. A significant difference in the rhizome yield was noticed when organic manure-microbial inoculants combination was compared with recommended dose of fertilizers (inorganic). Among the different treatment combinations tried, the most effective treatment was vermicompost + *Azospirillum* + AM (28.94 t/ha), followed by compost + *Azospirillum* + AM (26.93 t/ha), as compared to recommended inorganic fertilizers (150:60:150 kg/NPK/ha) (24.11 t/ha). The quality characters such as curcumin and oleoresin content were significantly differed due to organic and biofertilizer combination treatments. Maximum curcumin content (6.71 %) was recorded with compost + *Azospirillum* + AM followed by vermicompost + *Azospirillum* + AM (6.46 %) as compared to the lowest curcumin (5.54 %) with phosphocompost + AM. The rhizomes grown with vermicompost + *Azospirillum* + AM had the highest oleoresin content (11.10 %) followed by compost + *Azospirillum* + AM (10.83 %). The plants grown with combination of phosphocompost + *Azospirillum* yielded rhizomes with minimum oleoresin content (9.81 %).

Keywords: Arbuscular mycorrhiza, Azospirillum, mustard cake, neem cake, phosphocompost, vermicompost

Introduction

Turmeric (*Curcuma longa* L.) is an important spice crop which comes up well under shaded condition (Nybe, 2007). The compatibility and feasibility of growing turmeric in arecanut based cropping system is also established (Singh *et al*., 1986; Roy *et al*., 2000). As turmeric is a shade loving crop, the interspaces of arecanut can be profitably utilized for turmeric cultivation. Health consciousness among consumers is increasing and food safety has become the watch word in the global spice market. There is a great demand for organic spice products both in domestic and foreign market (Anon, 2003; ITC, 2004). Among the organic spice exported from India, turmeric holds the most important position next to chili. Growing demand for natural colours in industry, fast food chains, pharmaceuticals offer a potential scope for organic production of turmeric. There is a great demand for organic turmeric in USA, Germany, France and Japan.

Turmeric is a nutrient exhausting crop and responds well to organic manures and fertilizers (Balashanmugam *et al*., 1989). However, information on the use of organic manures and microbial inoculants on yield and quality of turmeric grown as intercrop in arecanut garden is meager. Hence, the present investigation was undertaken to study the effect of organic manures and microbial inoculants on growth, yield and quality of turmeric grown under arecanut garden.

Materials and Methods

The experiment was carried out in six years old arecanut (cv. Mohitnagar) plantation at Horticultural

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Research Station, Mondouri, BCKV during 2005 and 2006 between April to December. The research station is located at 23.5^0 N latitude and 89^0 E longitude and at an altitude of 9.75 m above the MSL. The physico-chemical properties of the soil (0-25 cm depth) are: pH – 6.8, organic carbon – 0.51 %, available nitrogen – 231.66 kg/ha, available phosphorus – 17.09 kg/ha and available potassium – 204.49 kg/ha. The experiment was laid out in RBD with three replications. Raised beds of 1.5 m x 1.5 m and 15 cm height were prepared in the interspaces of four areca palms leaving 75.0 cm radius from the base of each palm.

Two biofertilizers namely *Azospirillum brasilense* and Arbuscular mycorrhiza (*Glomus fasciculatum*) and four organic manures (compost, vermicompost, phosphocompost and mustard cake) were included as bio-organic inputs. The biofertilizers were applied singly and in combination with organic manures. There are altogether 13 treatments including 100% recommended inorganic fertilizers (150:60:150 kg/NPK/ha). The experiment was laid out in RBD with three replications.

The organic inputs namely compost, vermicompost, phosphocompost and mustard cake were applied basally during final land preparation @ 20 t, 5 t, 10 t and 3 t/ha, respectively. AM was applied @ 65 kg/ha directly to the soil and *Azospirillum* was incorporated through seed treatment @ 5 g/kg seed rhizome. Biofertilizers were collected from Nodule Research Laboratory, BCKV, Mohanpur. *Trichoderma viride* @ 5 g/kg seed rhizome and *Acacia* gum (1 tablespoonful) as sticker were taken in water in a plastic tray (50 x 30 x 10 cm) and mixed thoroughly with rhizomes. Seed rhizomes (30-35 g) were soaked in biofertilizer mixture for 30 min. and stirred thoroughly 4-5 times to confirm uniform soaking. After soaking, rhizome bits were dried under shade in open place.

For inorganic treatment, turmeric was fertilized @ 150:60:150 kg NPK per hectare in three splits, $1/3^{rd}$ N and full dose of P were applied as basal, $1/3^{rd}$ N and ½ K at 45 and 90 days after planting (DAP). Urea, Single super phosphate and Muriate of potash were used as inorganic source of N, P, and K, respectively.

Turmeric rhizomes of were planted to a depth of 3-4 cm, in the middle of April during both the years. Crops were mulched immediately with paddy straw @10 t/ha after planting and 5 t/ha at 45 and 90 DAP. Earthing up was done before second and third mulching. Three to four hand weedings were done. Irrigation was given as per requirement.

As the experiment was under complete bio-organic management, the scheduled nutrient management practices could not be followed in arecanut under both intercropped and monocropped blocks. Recommended dose of compost *i.e.* 25 kg/palm/year along with neem cake @ 3.0 kg/palm/year were applied during pre-monsoon (June) and post-monsoon (September), respectively.

The crop was harvested eight months after planting. Observations on different growth (at 90, 150 and 210 DAP) and yield attributing parameters were recorded from five randomly selected plants per replication. Rhizome yield was taken on net plot basis at harvest and the projected yield was calculated on the basis of yield per plot, considering the 60 % area occupied by intercrop in the present investigation. Curcumin and oleoresin content of the fresh rhizome were estimated after harvest using air condensation and chromatographic column methods, respectively.

Results and Discussion

Vegetative growth

The data on growth characters (Table 1) revealed significant differences at all stages of growth. The maximum plant height (103.84 cm) was recorded in plant grown under recommended NPK (inorganic) at 90 DAP and 150 DAP (140.65 cm), but maximum height of 171.86 cm was observed with compost + *Azospirillum* + AM at 210 DAP. The plants raised with inorganic source of recommended NPK recorded maximum tiller at 90 DAP (2.25) and 150 DAP (2.95) followed by vermicompost + *Azospirillum* + AM at both stages of growth (2.04 and 2.75) but at 210 DAP, application of phosphocompost + *Azospirillum* + AM gave maximum tiller number (4.39) followed by vermicompost + *Azospirillum* + AM (4.12). Like plant height, plants grown under inorganic management produced maximum leaf at 90 DAP (12.32) and 150 DAP (18.34), but compost + *Azospirillum* + AM produced maximum number of leaves at 210 DAP (24.86).

Irrespective of kind of organic manure, the efficacy of AM was more as compared to *Azospirillum* and some additive effects of AM and *Azospirillum* were noticed. The height of plants increased at faster rate upto 180 days and thereafter decreased. This trend was in good agreement with the observation of Manohar Rao *et al.* (2005) in turmeric. The slow growth after 180 days may be attributed to the transportation of more photosynthates from source (leaves) to sink (rhizomes). Generally, in all root and tuber crops, as the under ground storage organ

Table 1. Effect of organic manures and microbial inoculants on vegetative growth of turmeric

Treatments	Plant height (cm)			No. of tillers/clump			No. of leaves/clump		
	90 DAP	150 DAP	210 DAP	90 DAP	150 DAP	210 DAP	90 DAP	150 DAP	210 DAP
C + *Azos*	84.58	124.43	154.40	1.66	2.52	3.78	9.23	17.05	21.50
C + AM	80.94	119.33	158.55	1.90	2.57	3.65	10.47	17.44	23.82
C + *Azos* + AM	95.28	137.76	171.86	2.00	2.65	3.85	10.66	18.24	24.86
VC + *Azos*	78.91	118.12	152.70	1.76	2.47	3.76	9.91	16.44	21.50
VC + AM	80.44	126.60	158.20	1.82	2.58	3.67	10.84	16.36	21.92
VC + *Azos* + AM	93.33	140.50	170.94	2.04	2.75	4.12	11.63	17.18	23.76
PC + *Azos*	76.23	115.96	140.87	1.37	2.11	3.34	10.49	17.18	21.23
PC + AM	75.92	119.05	146.82	1.58	2.30	3.41	9.11	16.91	21.11
PC + *Azos* + AM	78.37	120.72	149.63	1.71	2.64	4.39	9.64	16.84	21.44
MC + *Azos*	76.33	118.01	147.34	1.85	2.29	3.25	9.51	16.22	19.41
MC + AM	74.10	112.88	151.08	1.72	2.38	3.43	9.19	15.48	24.53
MC + *Azos* + AM	79.98	122.78	161.82	1.90	2.52	3.92	10.30	16.39	21.49
Recommended NPK	103.84	140.65	160.91	2.25	2.95	3.52	12.32	18.34	22.59
S.Em. (±)	1.979	1.882	2.665	0.121	0.173	0.067	0.229	0.513	1.573
C D (P = 0.05)	5.628	5.353	7.579	0.343	0.491	0.192	0.652	1.458	NS

DAP= Days After Planting, **C:** Compost, **VC:** Vermicompost, **PC:** Phosphocompost, **MC:** Mustard cake, ***Azos* :** *Azospirillum,* **AM :** Arbuscular mycorrhiza, **NS :** Not significant

increases in size, there will be a gradual decrease in the growth of above ground parts (Kawakami, 1978).

Yield

Maximum clump weight of 326.15 g (Table 2) was observed with vermicompost + *Azospirillum* + AM, followed by compost + *Azospirillum* + AM (302.80 g) and recommended NPK (284.28 g) as compared to minimum weight of clump (194.53 g) in plants grown with mustard cake + *Azospirillum*. The single inoculation of *Azospirillum* in combination with compost and phosphocompost gave comparatively higher clump weight but combined inoculation of biofertilizers with vermicompost and compost were superior. Irrespective of source of manures, the co-inoculation of biofertilizers was proved effective in the production of higher clump weight.

Maximum yield per plot (11.51 kg/2.25 m^2) was associated with vermicompost + *Azospirillum* + AM treatment, followed by compost + *Azospirillum* + AM (10.49 kg/2.25 m^2) and vermicompost + AM (9.57 kg/ 2.25 m^2). The lowest yield per plot was recorded in mustard cake + *Azospirillum* (6.80 kg/2.25 m^2) combination.

Table 2. Effect of organic manures and microbial inoculants on yield and quality of turmeric

Treatments	Weight of clump (g)	Yield per plot (kg/2.25 m^2)	Projected yield (t/ha)	Curcumin (%)	Oleoresin (%)
C + *Azos*	256.16	8.80	22.06	6.17	10.72
C + AM	232.45	8.03	20.12	6.13	10.58
C + *Azos* + AM	302.80	10.49	26.93	6.71	10.83
VC + *Azos*	237.20	8.29	23.59	6.08	10.56
VC + AM	275.62	9.57	24.75	5.75	10.38
VC + *Azos* + AM	326.15	11.51	28.94	6.46	11.10
PC + *Azos*	242.31	8.37	24.01	5.69	9.81
PC + AM	225.26	7.90	22.66	5.54	10.05
PC + *Azos* + AM	259.17	8.95	24.56	5.85	10.25
MC + *Azos*	194.53	6.80	17.10	5.95	10.33
MC + AM	219.72	7.60	20.00	5.95	10.18
MC + *Azos* + AM	246.57	8.45	23.28	6.02	10.07
Recommended NPK	284.28	9.44	24.11	6.19	10.29
S.Em. (±)	3.875	0.370	1.070	0.046	0.054
C D (P = 0.05)	11.020	1.048	3.028	0.131	0.155

C: Compost, **VC:** Vermicompost, **PC:** Phosphocompost, **MC:** Mustard cake, ***Azos*:** *Azospirillum,* **AM:** Arbuscular mycorrhiza

A same pattern of influence of different treatment combinations on yield was noticed in respect of projected yield per hectare. The highest per hectare yield (28.94 t/ha) was recorded with vermicompost + *Azospirillum* + AM, followed by compost + *Azospirillum* + AM (26.93 t/ha) and vermicompost + AM (24.75 t/ha) as compared to the lowest yield (17.10 t/ha) with mustard cake + *Azospirillum*. The co-inoculation of *Azospirillum* and AM performed better with vermicompost and compost, as compared to phosphocompost and mustard cake.

Turmeric responds well to the application of organics and biofertilizers (Srinivasan *et al*., 2000). In turmeric, 10 % yield increase was reported with the inoculation of *Azospirillum* (Santhanakrishnan and Balashanmugam, 1993). Application of vermicompost at 10 t /ha increased the rhizome yield from 6.7 % - 25.5% (Vadiraj *et al*., 1998). The mycorrhizal inoculation is advantageous in improving plant growth and plants inoculated with different spices of VAM fungi recorded a significant increase in growth compared to uninoculated plants (Kumar, 2004).

Quality

Maximum curcumin content (6.71 %) was recorded with compost + *Azospirillum* + AM followed by vermicompost + *Azospirillum* + AM (6.46 %) as compared to lowest curcumin with phosphocompost + AM (5.54 %). The pooled data also exhibited that rhizomes from turmeric grown with vermicompost + *Azospirillum* + AM had highest oleoresin content (11.10 %) followed by compost + *Azospirillum* + AM (10.83 %), compost + *Azospirillum* (10.72 %) and compost + AM (10.58 %). The plants grown with combination of phosphocompost + *Azospirillum* yielded rhizomes with minimum oleoresin content (9.81 %).

The positive influence of biofertilizers on various growth and yield parameters observed in the present study may be attributed to enhanced uptake of nutrients by the plants (Borea, 1991). *Azospirillum* aid in increased plant growth due to their nitrogen fixing capacity and also they are known to help in synthesis of growth promoting substances like IAA and GA (Jackson and Brown, 1966). VAM fungi increases the plant growth by increasing the uptake of P and other minor elements like Zn, Cu and Mn (Borea, 1991). Further, VA mycorrhizae are known to influence the water uptake (Tinker, 1975).

The possible explanation for the beneficial effect of vermicompost may be due to accumulation of mobile substances in earthworm casts as reported by many workers (Lunt and Jacobson, 1994). Earth worms are reported to excrete plant growth promoting substances into castes (Nielson, 1965). Biswas *et al*. (1971) reported that the application of organic manures improved the soil aggregates resulting in favorable pore geometry, which in turn increased the soil porosity thereby paving the way for good development of rhizomes under the soil.

Among the different treatment combinations, combined application of biofertilizers had influenced both the growth, yield and quality parameters at different combination of organic manures. It may be due to synergistic interaction effect of co-inoculations of biofertilizers. The improvement in growth because of biofertilizers application singly or in combination has been reported by many workers (Mohan *et al.,* 2004; Sreekala and Jayachandran, 2006). Application of organic manures incurred nutrient availability, improved physical conditions of the soil, and increased the yield (Sadanandan and Hamza, 1998). Kale *et al.* (1992) observed that vermicompost application enhanced the activity of beneficial microbes like N_2 fixers and colonization by mycorrhizal fungi and hence play a significant role in N_2 fixation and phosphate mobilization leading to better uptake by the plant. Thus the increased availability of nutrients and uptake by the plants would have resulted in better growth and yield in plots treated with vermicompost.

The quality characters such as curcumin and oleoresin content were significantly differed due to organic and biofertilizer combination treatments. The beneficial effect of vermicompost on curcumin and oleoresin was reported by Manohar Rao *et al*. (2005). They recorded higher curcumin (2.31 %) and oleoresin (7.40 %) with vermicompost @ 1.0 t/ha alone, as compared to recommended fertilizer dose with 1.70 % curcumin and 5.28 % of oleoresin respectively. Higher curcumin content in turmeric with organic amendments was also reported by Rao and Swamy (1978).

Among the different treatment combinations tried, the most effective treatment was vermicompost + *Azospirillum* + Arbuscular mycorrhiza followed by compost + *Azospirillum* + Arbuscular mycorrhiza for maximising the yield of turmeric grown as inter crop in arecanut garden.

References

Anonymous, 2003. *Export of organic products from India: Prospects and Challenges. Occasional Paper No.97*. Export Import Bank of India, Mumbai

Biswas, T.D., Jain, B.L. and Mondal, S.C.1971. Cumulative effect of different levels of manures on the physical properties of soil. *J. Indian Soc. Soil Sci*. **19**: 31-37.

Boaea, J.M.1991. Vesicular arbuscular mycorrhizae as modifiers of soil fertility. *Adv. In Soil Sci*. **15**:2 31.

ITC. 2004. Marketing Manual and Web Dictionary for organic spices, Harbs and Essential Oils. International Trade Centre (UNCTAD/WTO), Geneva.

Jackson, K.M. and Brown, M.E. 1966. Behaviour of *Azotobacter chroococcum* introduced into the plant rhizosphere. *Ann. Inst. Pasteur*, Paris. **3**: 108-12.

Jena, M.K., Das, P.K. and Pattanaik, A.K. 1999. Integrated effect of microbial inoculants and fertilizer nitrogen on N-use efficiency and rhizome yield of turmeric. *Orissa J. Hort.,* **27** (2):10-16.

Joshi, M. and Prabhakarsetty, T.K. 2005. *Sustainability through Organic Farming*. Kalyani Publishers, pp. 119-314.

Kale. R.O., Mallesh, B.C., Bano, K. and Basvaraj, D.J. 1992. Influence of vermicompost application on the available micronutrients and selected microbial population in a paddy field. *Soil Biol. Biochem.* **24**: 1317-1320.

Kawakami, K.1978. Physiology of yield of underground storage organs. In : *Crop Physiology* (Eds. Gupta, U.S.), Oxford and IBH Publ. Co., New Delhi, pp. 269-301.

Kumar, G.S. 2004. Association of VAM fungi in some spices and condiments. *J. Ecobiology*.**16** (2): 113-118.

Manohar Rao, A., Venkata Rao, P., Narayana Reddy, Y. and Reddy, M.S.N. 2005. Effect of organic and inorganic manorial combination on growth, yield and quality of turmeric (*Curcuma longa* L.). *J. Plantn. Crops* **33** (3): 198-205.

Mohan, E., Melenta, E.R., Guruprasa3d, T.R., Herle, P. S., Gowda, N.A.J. and Naik, C.M. 2004.Effect of graded levels of nitrogen and biofertilizers on growth, yield and quality in turmeric (*Curcuma domestica* Val.) cv. D K Local. *Env. Eco.*, **22** (3): 715-719.

Nybe, E.V., Raj, N.M. and Peter, K.V. 2007. *Spices*. New India Publishing Agency, New Delhi, p.104.

Rajan, K.M. and Singh, R.S. 1973. Effect of organic amendments of soil on plant growth, yield and incidence of soft rot of ginger. In. *Proc. Nat. Sym. Plantn. Crops (*Suppl.): 102-106.

Rao, D.V.R. and Swamy, G.S.1978. Effect of graded doses of farm yard manure on growth and yield of turmeric variety, Mydukur. *J. Res. APAU.* **5**:8-12.

Rao, R.M., Reddy, R.K.V. and Pubrayudu. 1975. Promising turmeric types of Andhra Pradesh. *Indian Spices* **12**(2):2-5.

Reddy, T.Y. and Reddi, G.H.S. 2002. *Principles of Agronomy*. Kalyani Publishers, pp. 200-253.

Ray, A.K., Srinivasa Reddy, D.V. and Sairam, C.V. 2000. Performance of areca based high density multispecies cropping system under different levels of fertilizers. *J. Plantn. Crops* **28**(2): 110-16

Sadanandan, A. K. and Hamza, S. 1998. Effect of organic farming on nutrient uptake, yield and quality of ginger. pp. 84- 89. In: *Water and Nutrient Management for Sustainable Production of Quality Spices*. Sadanandan, A.K., Krishnamurthy, K.S.,Kadiannan, K.and Korikanithimath, V.S. (Eds.) 5-6 October, 1997, Madikeri, Karnataka.

SanthanaKrishnan, P. and Balashanmngam, S. 1993. *Paper presented in All India Tuber Crops Meet at TNAU*, Feb, 1993, Coimbatore.

Singh, R.K., Bhalerao, M.M. and Reddy, M.J.M. 1986. Costs and returns of intercrops in arecanut. *Indian Cocoa, Arecanut and Spices J.* **9**(4):99.

Sreekala, G.S. and Jayachandran, B.K. 2006. Effect of organic manures and microbial inoculants on nutrient uptake, yield and nutrient status of soil in ginger intercropped coconut garden. *J. Plantn. Crops* **34** (1): 25-31.

Srinivasan, V., Sadanandan, A.K. and Hamza, S. 2000. An IPNU approach in spices with special emphasis on coir compost. pp.1363-1365. In: *Int. Conf. on Managing Natural Resources for Sust. Agril. Prod. in the 21st Century*. Feb.14-18, 2000, New Delhi.

Tinker, P.B.1975. Effect of VA mycorrhiza on higher plants. pp. 325-349. In: 29th *Sym. Expt. Biol*. Cambridge Univ. Press. London.

Vadiraj, B.A., Siddagangaiah and Potti, S.N.1998. Effect of vermicompost on the growth and yield of turmeric. *South Indian Hort*. **46**: 176-179.