Research Article

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Biofertilizers and inorganic fertilizers on growth and yield of turmeric grown as intercrop in arecanut plantation

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Abstract

A field experiment was conducted at Horticultural Research Station, Mondouri, BCKV, West Bengal during 2005-2006 to study the effects of *Azospirillum*, *Azotobacter*, Phosphate solubilizing bacteria (PSB) and Arbuscular mycorrhiza fungi (AMF) coupled with three levels (100, 75 and 50% of recommended rate) of inorganic NPK fertilizers on growth and yield of turmeric cv. Suguna grown as intercrop in six year old arecanut cv. Mohitnagar plantation. Among the biofertilizers, AMF (*Glomus fasciculatum*) was applied @ 65 kg ha^{-1} directly to the soil. The other three biofertilizers namely, *Azospirillum brasilense*, *Azotobacter chroococcum* and phosphate solubilizing bacteria (*Bacillus polymixa*) were incorporated through seed treatment @ 5 g kg^{-1} of seed rhizome along with *Acacia* gum as sticker. Healthy seed rhizomes were treated with *Trichoderma viridae* before planting and crop was mulched with paddy straw. Combined application of biofertilizers and inorganic fertilizers had beneficial effect on growth and yield of turmeric. Application of *Azospirillum* and AMF was superior to other treatments. Maximum plant height, number of tillers, number of leaves and weight of clump were observed in treatments NPK (75%) + *Azospirillum* + AMF. The same treatment also recorded maximum projected yield (34.44 t ha^{-1}) followed by NPK (75%) + *Azotobacter* + AMF (31.53 t ha^{-1}) as compared to 100% inorganic NPK alone (24.47 t ha^{-1}). The experimental results clearly indicate that NPK rate can be reduced to 75 per cent of the recommended rate if biofertilizers are also applied.

Keywords: Arecanut, biofertilizers, intercropping, Turmeric

Introduction

Turmeric (*Curcuma longa* L.) is one of the important spice crops in India. It is widely used in religious ceremonies and functions in South Asia. The demand for turmeric is increasing due to its wide utility as a spice, dye in textile industry, cosmetics and also by the drug industries particularly for the preparation of anti-cancer medicines. India accounts for 80 percent of the world production.

Continuous application of inorganic fertilizers has resulted in ecological imbalance with consequent ill effect to the soil. However, in recent years, biofertilizers has emerged as promising component of plant nutrient supply system. The micro-organisms involved contribute much towards improving the fertility status of the soil besides augmenting yield. Intercropping turmeric in arecanut plantation is profitable without hampering the performance of the main crop (Ray *et al.*, 2000). Hence, the experiment was designed with the objective to supplement the use of chemical fertilizers with biofertilizers.

Materials and Methods

The experiment was carried out in six year old arecanut (cv. Mohitnagar) plantation at Horticultural Research Station, Mondouri, BCKV during April 2005 to December 2006. The soil of the experimental plot was sandy clay loam with pH 6.8 and 0.50 per cent organic carbon. Available N, P and K in soil were 231.66, 17.09

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and 204.49 kg ha^{-1}, respectively. 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.

Three levels of inorganic fertilizers *i.e.*, 50, 75 and 100 per cent of recommended NPK and four biofertilizers namely *Azospirillum brasilense*, *Azotobacter chroococcum* and PSB (*Bacillus polymixa*) and AMF (*Glomus fasciculatum*) were included in this experiment. The PSB and AMF were included separately with *Azotobacter* and *Azospirillum* along with each level of inorganic fertilizers. Altogether there were 13 treatments including NPK (100%) alone *i.e.*, without biofertilizers.

Among the biofertilizers, AMF was applied @ 65 kg ha^{-1} directly to the soil. *Azospirillum, Azotobacter* and PSB were incorporated through seed treatment @ 5 g kg^{-1} seed rhizome. Compost and ash were applied basally @ 10 and 2 t ha^{-1}, respectively in all treatment combinations except NPK (100%).

The biofertilizers as per treatment schedule along with *Trichoderma viridae* @ 5 g kg^{-1} seed rhizome and *Acacia* gum (1 table spoon) as sticker were taken in water in a plastic tray and mixed thoroughly. Healthy seed rhizomes (30-35 g) were soaked in biofertilizers mixture for 30 minutes and stirred thoroughly 4-5 times to confirm uniform soaking. After soaking the rhizome bits were dried under shade in airy place.

The recommended rate of NPK for turmeric is 150:60:210 kg ha^{-1}. The fertilizers were applied in three split doses; 1/3rd of N and full dose of P as basal; whereas, each split of 1/3rd N and ½ K at 45 and 90 days after planting. Urea, single super phosphate and muriate of potash were used as inorganic sources of N, P and K, respectively.

Rhizomes of turmeric were planted to a depth of 3-4 cm, in the middle of April during both the years 2005 and 2006. Crops were mulched with paddy straw at the rate of 10 t ha^{-1} immediately after planting and 5 t ha^{-1} at 45 and 90 days after planting. Earthing up was done before second and third mulching. Three to four hand weedings were done. Irrigation was given as per requirement. Scheduled management practices for arecanut were followed.

The crop was harvested eight months after planting. Observations on plant height, tiller and leaf number (at 60, 120 and 180 DAP) and yield attributing parameters (at harvest) 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 per cent area occupied by intercrop in the present investigation.

Results and Discussion

The combination of biofertilizers along with inorganic fertilizers performed better over application of

Table 1. Effect of graded doses of fertilizers and biofertilizers on vegetative growth of turmeric (Mean of 2 years)

Treatments	Plant height (cm)			No. of tillers/clump			No. of leaves/clump		
	60 DAP	120 DAP	180 DAP	60 DAP	120 DAP	180 DAP	60 DAP	120 DAP	180 DAP
NPK (100%) + Azot. +AMF	71.28	120.05	164.76	1.40	2.10	3.65	7.15	16.12	24.56
NPK (100%) + Azot.+PSB	69.97	116.74	157.35	1.54	2.38	3.91	7.48	15.83	22.74
NPK (100%) + Azos.+ AMF	82.16	128.27	178.95	1.71	2.89	3.81	8.07	17.19	25.12
NPK (100%) + Azos.+PSB	75.36	119.52	161.60	1.62	2.79	3.19	6.97	14.92	23.45
NPK (75%) + Azot.+ AMF	73.85	123.92	167.82	1.60	2.35	3.25	7.00	16.78	24.72
NPK (75%) + Azot.+PSB	69.19	120.47	163.35	1.62	2.53	3.61	7.63	18.30	23.66
NPK (75%) + Azos.+ AMF	77.12	136.92	181.54	1.79	2.94	4.14	8.70	17.85	26.16
NPK (75%) + Azos. +PSB	73.85	119.42	158.06	1.61	2.68	3.08	8.45	15.93	22.28
NPK (50%) + Azot. + AMF	70.80	112.94	154.25	1.45	2.01	4.26	6.98	15.16	23.65
NPK (50%) + Azot. +PSB	72.32	116.80	157.69	1.48	1.94	3.34	6.54	14.40	21.05
NPK (50%) + Azos.+ AMF	75.07	117.76	161.52	1.54	2.11	3.51	7.74	14.11	22.75
NPK (50%) + Azos. +PSB	74.52	112.02	152.85	1.46	2.03	3.52	6.46	13.18	22.14
NPK (100%)	71.27	129.60	169.58	1.91	2.70	4.10	7.53	14.46	21.35
S.Em. (±)	1.226	0.713	1.621	0.112	0.091	0.128	0.328	0.155	0.614
CD (P = 0.05)	3.487	2.027	4.611	NS	0.257	0.364	0.928	0.440	1.738

Azot. : Azotobacter, Azos : Azospirillum, PSB : Phosphate solubilizing bacteria; AMF : Arbuscular mycorrhiza fungi, DAP : Days after planting, NS : Non-significant

100 per cent inorganic fertilizers (Table 1). The maximum plant height at 180 days after planting (DAP) was recorded with NPK (75%) + *Azospirillum* + AMF (181.54 cm), which was at par with NPK (100%) + *Azospirillum* + AMF (178.95 cm). The plants raised with NPK (50%) + *Azotobacter* + AMF exhibited maximum number of tillers per clump (4.26), followed by NPK (75%) + *Azospirillum* + AMF (4.14). Application of NPK (75%) + *Azospirillum* + AMF and NPK (100%) + *Azospirillum* + AMF occupied first and second position for production of 26.16 and 25.12 number of leaves per clump, respectively followed by NPK (75%) + *Azotobacter* + AMF (24.72). The minimum number of leaves (21.05) was observed in the treatment NPK (50%) + *Azotobacter* + PSB combination.

Maximum weight of clump (372.58 g), length of clump (20.24 cm), number of both primary (7.38) and secondary fingers (15.58), weight (164.35 g) and length (6.74 cm) of secondary finger and yield (34.44 t ha^{-1})

Table 2. Effect of graded doses of fertilizers and biofertilizers on clump and primary finger of turmeric (Mean of 2 years)

Treatments	Clump / plant			Primary fingers / plant			
	Weight (g)	Length (cm)	Breadth (cm)	Number	Weight (g)	Length (cm)	Breadth (cm)
NPK (100%) + Azot. + AMF	301.62	19.12	14.26	6.43	162.75	7.42	2.51
NPK (100%) + Azot. +PSB	285.10	18.36	13.29	5.13	152.84	6.15	1.65
NPK (100%) + Azos. + AMF	316.45	19.46	14.75	7.02	171.20	7.58	2.31
NPK (100%) + Azos. +PSB	269.50	17.94	14.37	6.09	145.80	6.48	1.72
NPK (75%) + Azot. + AMF	338.40	19.35	15.42	5.74	192.25	7.96	2.43
NPK (75%) + Azot. +PSB	312.64	18.75	13.86	5.97	154.16	6.46	2.14
NPK (75%) + Azos. + AMF	372.58	20.24	15.38	7.38	175.28	7.10	2.37
NPK (75%) + Azos. +PSB	302.12	17.56	13.58	6.35	165.17	7.24	2.30
NPK (50%) + Azot. + AMF	290.75	17.15	14.25	5.31	105.35	5.95	1.74
NPK (50%) + Azot. +PSB	238.36	16.82	14.73	4.82	126.33	6.15	1.95
NPK (50%) + Azos.+ AMF	263.56	18.22	14.30	5.55	145.71	6.84	2.36
NPK (50%) + Azos. +PSB	251.62	16.91	14.69	5.20	114.02	5.93	1.82
NPK (100%)	272.84	17.92	13.85	5.91	138.46	6.54	2.28
S.Em. (±)	2.382	0.440	1.126	0.035	1.074	0.102	0.027
C. D. (P = 0.05)	6.775	1.247	NS	0.100	3.055	0.292	0.078

Azot. : Azotobacter, Azos. : Azospirillum, PSB : Phosphate solubilizing bacteria; AMF : Arbuscular mycorrhiza fungi, DAP : Days after planting, NS : Non-significant

Table 3. Effect of graded doses of fertilizers and biofertilizers on secondary finger and yield of turmeric (Mean of 2 years)

Treatments	Secondary fingers / plant				Yield (t ha^{-1})
	Number	Weight (g)	Length (cm)	Breadth (cm)	
NPK (100%) + Azot. + AMF	10.45	102.45	5.62	1.84	27.48
NPK (100%) + Azot.+PSB	8.72	98.31	4.96	1.78	26.33
NPK (100%) + Azos. + AMF	10.35	116.24	5.74	1.93	29.37
NPK (100%) + Azos. +PSB	9.26	84.75	4.85	1.68	25.19
NPK (75%) + Azot. + AMF	11.74	112.30	5.58	1.85	31.53
NPK (75%) + Azot. +PSB	12.45	119.75	5.72	1.67	28.81
NPK (75%) + Azos. + AMF	15.58	164.35	6.74	2.16	34.44
NPK (75%) + Azos. +PSB	9.58	94.70	5.32	1.64	27.85
NPK (50%) + Azot. + AMF	14.16	152.53	6.33	2.28	26.61
NPK (50%) + Azot. +PSB	9.21	83.25	4.75	2.65	22.48
NPK (50%) + Azos. + AMF	8.76	77.50	5.12	1.83	24.53
NPK (50%) + Azos. +PSB	13.62	131.42	6.14	2.03	23.25
NPK (100%)	9.63	96.25	5.23	1.85	24.47
S.Em. (±)	0.308	1.128	0.510	0.033	0.633
CD (P = 0.05)	0.876	3.208	NS	0.093	1.801

Azot : Azotobacter, Azos : Azospirillum, PSB : Phosphate solubilizing bacteria; AMF : Arbuscular mycorrhiza fungi, DAP : Days after planting, NS : Non-significant

were observed in plants raised with NPK (75%) + *Azospirillum* + AMF combination. The plants raised with NPK (75%) + *Azotobacter* + AMF produced the clump with maximum weight of primary finger (192.25 g) and length of primary finger (7.96 cm). Maximum breadth of clump (15.42 cm) and maximum breadth of primary finger (2.15 cm) were observed in plants raised from NPK (75%) + *Azotobacter* + AMF and NPK (100%) + *Azotobacter* + AMF respectively. The experimental results clearly indicate that saving of 25 per cent inorganic NPK through biofertilizers is possible.

Results of the study showed that combined application of biofertilizers and inorganic fertilizers had beneficial effect on yield and yield attributing characters. The increase in yield was largely due to the cumulative effect of plant growth characters. These findings are in good agreement with the observations of earlier workers on turmeric (Jena *et al.*, 1999; Reddy *et al.*, 2003 and Mohan *et al.*, 2004). Jena *et al.* (1999) observed a yield increase of 15.2-30.5 per cent with biofertilizers in combination of inorganic and also obtained higher increase with 30 kg N as compared to 60 kg N. The better efficiency of *Azospirillum* as compared to *Azotobacter* was reported by Mohan *et al.* (2004). The good response of AMF in turmeric cv. Suguna was also reported by Reddy *et al.* (2003).

Dhanapal *et al.* (1978) reported that *Azospirillum* produced bio-active substances having similar effect of growth regulators besides N-fixation. The higher efficiency of *Azospirillum* + AMF as compared to other biofertilizer combinations was also reported by Tilak (1995). He observed that plants inoculated with both AMF and *Azospirillum* produced more grain yield than singly inoculated plants in pearl millet. The turmeric rhizome treated with *Trichoderma* produces plant hormones and enzymes and thereby promotes plant growth and yield (Sivaprasad, 2002).

The present findings are also in good agreement with the observations of Gowda *et al.* (2002) who observed improved growth, yield and quality of chilli with 75 per cent nitrogen, phosphorus plus 100 per cent potassium in addition to the inoculation of *Azotobacter*, *Azospirillum*, PSB and AMF. Application of bio-fertilizers along with reduced levels of chemical fertilizers has beneficial effects compared to the application of recommended NPK.

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