Journal of Spices and Aromatic Crops
Vol. 14 (1) : 15-20 (2005)

Indian Society for Spices

Evaluation of composted coir pith with chemical and biofertilizers on nutrient availability, yield and quality of black pepper (*Piper nigrum* L.)

V Srinivasan, S Hamza & A K Sadanandan

Indian Institute of Spices Research
Calicut – 673 012, Kerala, India.
E-mail: vsrinivasan@iisr.org

Received 02 July 2003; Revised 18 December 2004; Accepted 08 February 2005

Abstract

Composted coir pith was evaluated at Madikeri (Karnataka) under integrated plant nutrient management system to substitute chemical input of fertilizers for improving the yield and quality of black pepper (*Piper nigrum*). Application of composted coir pith (CC) @ 2.5 t ha^{-1} with full recommended dose of NPK (100:40:140 kg ha^{-1} of N, P_2O_5 and K_2O) yielded the highest (4.18 kg $vine^{-1}$) which was on par with 1.25 t ha^{-1} CC + full NPK, 2.5 t ha^{-1} CC + ½ NPK + *Azospirillum* sp., 1.25 t ha^{-1} CC + ½ NPK + *Azospirillum* sp. and 2.5 t ha^{-1} CC alone. The levels of composted coir pith application were on par with regard to quality (piperine and oleoresin contents) of black pepper. The highest benefit-cost ratio of 1.94 was recorded in the treatment with composted coir pith @ 1.25 t ha^{-1} + *Azospirillum* sp.

Key words: black pepper, composted coir pith, *Piper nigrum*, quality, yield.

Introduction

The productivity of black pepper (*Piper nigrum* L.) in India is the lowest when compared to other countries mainly due to improper management practices. The growth of black pepper vines is affected by various environmental factors like soil physico-chemical properties, water, climate, etc. Organic matter improves the physico-chemical characteristics of the soil by giving better aggregation, cation exchange capacity and water holding capacity and reduces soil erosion. The current boom in fertilizer prices, farm energy requirements and the growing preference for organically cultivated farm produce has necessitated the development of a programme for organic waste recycling in agriculture. Coir pith, a highly lignocellulose material is available in large quantities as a by-product of coconut coir industry and is a rich source of potash. About 7.5 million tonnes of coir pith is produced annually in India (Kamaraj 1994). Composted coir pith (CC) has been recommended for use as an amendment and can serve as a substitute for farmyard manure and other organic manures (Savithri & Khan 1994). However, information on the utilization and economics of CC as organic manure for black pepper is lacking. An experiment was therefore conducted with the objective of evaluating CC for sustaining soil nutrient availability, yield and quality of black pepper.

Materials and methods

The field experiment was conducted at M/s. Ashoka Plantations, Madikeri (Karnataka) during 1998-2001. The experimental design was of two factor randomized block design with a main factor of CC (marketed by Marson Bio Care Pvt. Ltd., Mumbai) at three levels (CC_0-0; CC_1-1.25 and CC_2-2.5 t ha^{-1}) and sub-factors of fertilizer combinations at four levels (F_0-No fertilizers; F_1-*Azospirillum* sp. alone @ 20 g $vine^{-1}$; F_2-½ recommended NPK fertilizers + *Azospirillum sp.*; F_3-full recommended NPK fertilizers @ 100:40:140 kg ha^{-1} of N, P_2O_5 and K_2O). Each treatment was replicated thrice with a plot size of six vines (at 3 m x 3 m spacing) per treatment. The soil of the experimental area was slightly acidic (pH 6.1) with organic carbon content of 2.1%. The soil was sandy loam with 7.1 mg kg^{-1} Bray P, 162 and 995 mg kg^{-1} exchangeable K and Ca, respectively. The initial micronutrient content of the soil was 44.0, 29.0, 0.9 and 3.8 mg kg^{-1} of Fe, Mn, Zn and Cu, respectively. The CC used in the study had a nutrient content of 1.2% N, 0.1% P_2O_5 and 1.3% K_2O with a C/N ratio of 12.5.

The CC, *Azospirillum* sp., full P and ½ of N and K were applied during June and the remaining N and K were applied in September-October on 5 year–old vines of Panniyur-1 variety trailed on silver oak trees. Soil, leaf and berry samples were collected, processed and analysed for major, secondary and micronutrients as per standard procedures (Jackson 1967). The berry samples were also analysed for quality parameters, oleoresin and piperine contents (ASTA 1968). The yield data was recorded and subjected to statistical analysis and economics of the treatments was also worked out.

Results and discussion

Soil nutrient availability

The pH of the soil varied from 6.3 to 6.7 and was not altered significantly due to the treatments. Organic carbon status varied from 2.08% to 2.61% and was significantly lowest (2.08%) in the control plot. The organic carbon content increased significantly due to application of CC, *Azospirillum* sp. and NPK. The addition of CC might have improved the soil physical conditions like porosity and water holding capacity and also served as a substrate for the proliferation of *Azospirillum* sp. and native microbial population, thereby improving the organic carbon status. Lourduraj *et al.* (1998) also observed improved physico-chemical properties like reduced bulk density, increased pore space and organic carbon due to incorporation of CC in the soil. Available P status varied from 15.9 to 40.0 mg kg^{-1}. CC, NPK and *Azospirillum* sp. application significantly increased the Bray P status of soil and was significantly the highest (40 mg kg^{-1}) in the treatment 2.5 t ha^{-1} CC + full NPK. Potassium availability varied from 468 to 982 mg kg^{-1} and was highest in the treatment combination of 2.5 t ha^{-1} CC + ½ NPK + *Azospirillum* sp. which was on par with recommended full dose of NPK combination. The increase in P and K status might be due to the contribution from applied P and K fertilizer sources in addition to CC (Table 1a). As CC contains appreciable amount of potassium, Savithri *et al.* (1993) also attempted to use it as K source in groundnut, sorghum, maize and finger millet in sandy and clay loam soils of Tamil Nadu. Utilization of CC as manure to improve potassium use efficiency of rice was also reported by Ammal & Durairajmuthiah (1996) where K fertilizer requirement of rice was reduced by 63.5% of the normal K required when K fertilizer was mixed with CC (Table 1a).

The availability of Ca was significantly the highest in the treatment 1.25 t ha^{-1} CC + ½ NPK + *Azospirillum* sp. and which was on par with other treatments except control, *Azospirillum* sp., ½ NPK + *Azospirillum* sp. and CC @ 1.25 t ha^{-1} alone. Mg availability varied from 304 to 356 mg kg^{-1} without any significant difference among the treatments. Fe and Mn availability varied from 31.0 to 36.3 mg kg^{-1} and 24.9 to 32.4 mg kg^{-1}, respectively (Table 1a). The effect of different levels of CC on soil availability of nutrients showed that an increase in dose from 0 to 2.5 t ha^{-1} significantly increased organic carbon status (2.24% to 2.56%), available Bray P (23.3 to 31.0 mg kg^{-1}), Ca (1350 to 1737 mg kg^{-1}) and

Mg (310 to 335 mg kg^{-1}). However, there was no significant difference in soil Zn and Cu availability in the soil due to different levels of CC application. Soil pH, availability of K and other micronutrients also did not alter significantly with increasing levels of CC application (Table 1b). Improved soil physico-chemical properties and uptake of nutrients by tomato (Baskar & Saravanan 1997) and arrowroot (Maheswarappa *et al.* 1999) was also reported due to incorporation of CC. The suitability of digested CC and biofertilizers as amendments in improving the physical, chemical and biological properties of tea soil and also the green leaf yield of tea was reported by Rajalingam & Kumar (2001). Combined NPK and biofertilizer application significantly increased soil organic carbon status (2.30%–2.51%), Bray P (21.6–30.4 mg kg^{-1}), available K (480–923 mg kg^{-1})

Table 1a. Effect of different levels and combination of coir pith compost, NPK and *Azospirillum* sp. on soil nutrient availability in black pepper garden

Treatment	pH	OC (%)	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
			(mg kg^{-1})								
CC_0F_0	6.6	2.08	197	15.9	468	1078	309	32.8	27.2	2.0	27.9
CC_0F_1	6.3	2.15	216	22.8	569	1214	304	36.3	28.9	2.1	27.1
CC_0F_2	6.4	2.42	238	27.9	839	1478	306	34.6	29.6	2.2	31.5
CC_0F_3	6.4	2.32	218	26.4	948	1621	322	31.3	31.4	2.1	30.4
CC_1F_0	6.6	2.27	247	22.9	481	1523	338	33.9	31.7	2.2	29.6
CC_1F_1	6.6	2.42	251	24.7	617	1613	347	33.7	29.7	2.2	34.6
CC_1F_2	6.7	2.57	249	23.7	689	1810	331	31.5	30.2	1.9	30.2
CC_1F_3	6.5	2.36	259	25.2	858	1752	313	31.3	24.9	1.7	31.8
CC_2F_0	6.5	2.54	259	26.1	492	1649	356	35.1	29.2	1.9	31.0
CC_2F_1	6.5	2.61	243	25.1	422	1728	354	31.0	29.6	2.0	25.3
CC_2F_2	6.5	2.54	227	33.3	982	1774	315	35.1	28.6	2.3	28.1
CC_2F_3	6.5	2.56	248	40.0	962	1798	316	35.6	32.4	2.3	29.3
CD (P=0.05)	NS	0.13	22	5.6	113	200	NS	3.2	2.5	0.2	NS

CC_0=0, CC_1=1.25 and CC_2=2.5 t ha^{-1} of composted coir pith; F_0=No fertilizers; F_1=*Azospirillum* sp. alone @ 20 g $vine^{-1}$; F_2=½ recommended NPK + *Azospirillum* sp.; F_3=NPK @ 100:40:140 kg ha^{-1} of N, P_2O_5 and K_2O

Table 1b. Effect of different levels of composted coir pith on soil availability of nutrients in black pepper garden (mean of 3 years)

Composted coir pith levels	pH	OC (%)	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
			(mg kg^{-1})								
CC_0	6.39	2.24	217	23.3	706	1350	310	34	29	2.1	29
CC_1	6.56	2.39	252	24.1	662	1680	331	33	29	2.0	32
CC_2	6.50	2.56	244	31.0	715	1737	335	34	30	2.1	28
CD (P=0.05)	NS	0.08	11	2.8	NS	100	18	NS	NS	NS	NS

CC_0=0, CC_1=1.25 and CC_2=2.5 t ha^{-1} of composted coir pith

Table 1c. Effect of different combinations of NPK and *Azospirillum* sp. on soil availability of nutrients in black pepper garden (mean of 3 years)

Fertilizer levels	pH	OC (%)	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
			(mg kg^{-1})								
F_0	6.60	2.30	234	21.6	480	1420	334	33.9	29.4	2.0	29.2
F_1	6.50	2.39	237	24.2	536	1518	333	33.7	29.4	2.1	29.0
F_2	6.47	2.51	238	28.3	837	1687	317	33.7	29.5	2.1	29.9
F_3	6.51	2.40	242	30.4	923	1724	317	32.7	29.6	2.0	30.5
CD (P=0.05)	NS	0.09	NS	3.3	65	116	NS	NS	NS	NS	NS

F_0=No fertilizers; F_1=*Azospirillum* sp. alone @ 20 g $vine^{-1}$; F_2=½ recommended NPK + *Azospirillum*; F_3=NPK @ 100:40:140 kg ha^{-1} of N, P_2O_5 and K_2O

and Ca (1420–1724 mg kg^{-1}). However, there was no significant difference in soil pH, availability of Mg and micronutrients due to NPK and *Azospirillum* sp. applications (Table 1c).

Leaf nutrient composition

Application of different levels and combination of CC, NPK and *Azospirillum* sp. significantly increased the leaf N status from 2.07% to 2.30%, K from 1.10% to 1.67%, Ca from 2.3% to 3.4%, Mg from 0.40% to 0.48%, Fe from 92 mg kg^{-1} to 148 mg kg^{-1} and Mn from 310 mg kg^{-1} to 646 mg kg^{-1}. However, there was no significant difference in leaf P, Zn and Cu status due to CC, NPK and *Azospirillum* sp. application. Different levels of CC application did not influence leaf nutrient composition and the nutrient concentrations were on par except that of Mn and Cu. Application of full dose of NPK significantly increased leaf N, Ca, Mg and Mn concentrations whereas leaf P, K, Fe, Zn and Cu contents remained unaffected (Table 2).

Yield and quality

Application of different levels and combination of CC, NPK and biofertilizers significantly influenced the yield of black pepper. Only the first and third year yield were considered for mean as the second year yield was very low due to the alternate bearing nature of the crop at the experimental location. The maximum mean yield (4.18 kg vine^{-1}) was recorded for the treatment where 2.5 t ha^{-1} CC + full recommended NPK was applied which was 21% higher than recommended NPK and 114% higher than absolute control. The treatments 2.5 t ha^{-1} CC + full NPK, 1.25 t ha^{-1} CC + full NPK, 2.5 t ha^{-1} CC + ½ NPK + *Azospirillum* sp., 1.25 t ha^{-1} CC + ½ NPK + *Azospirillum* sp. and 2.5 t ha^{-1} CC alone were statistically on par with regard to yield. Application of CC @ 2.5 t ha^{-1} produced maximum yield (3.71 kg vine^{-1}), which was 25% higher than no CC application and was on par with 1.25 t ha^{-1} of CC application (Table 3). Use of CC in increasing the yield (10%–30%) of number of crops namely, sorghum, pearl millet, maize and cotton under rainfed condition was reported by Anabayan (1988) and Veerabadran (1991). Promising results were also obtained by application of CC in sugarcane (Sundersingh *et al.* 1991) and on growth of cardamom (Moorthy *et al.*1998) also. CC charged with garden weeds, *Gliricidia* sp., rock phosphate and micronutrients along with 50% recommended fertilizer increased the dry matter yield significantly over recommended practice in maize (Rao *et al.* 2001). Among the combinations of NPK and *Azospirillum* sp., maximum yield (3.83 kg vine^{-1}) was recorded for the treatment NPK alone which was on par with ½ NPK + *Azospirillum* sp. application; NPK application resulted in 35% more yield over control.

Table 2. Effect of different levels and combination of coir pith compost, NPK and *Azospirillum* sp. on leaf nutrient composition of black pepper

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
	(%)					(mg kg^{-1})			
CC_0F_0	2.07	0.14	1.40	2.30	0.40	97	310	23	563
CC_0F_1	2.00	0.13	1.10	2.40	0.47	97	424	20	487
CC_0F_2	2.10	0.17	1.43	2.63	0.44	101	470	29	628
CC_0F_3	2.30	0.14	1.67	2.67	0.42	94	383	20	403
CC_1F_0	2.13	0.14	1.27	2.43	0.42	92	341	24	610
CC_1F_1	2.03	0.12	1.33	2.93	0.45	104	343	24	603
CC_1F_2	2.13	0.14	1.10	3.00	0.44	116	360	19	580
CC_1F_3	2.20	0.14	1.17	3.10	0.48	114	412	22	577
CC_2F_0	2.03	0.16	1.23	2.80	0.45	103	443	21	607
CC_2F_1	2.10	0.15	1.13	3.13	0.45	105	626	29	664
CC_2F_2	2.17	0.14	1.27	2.87	0.44	135	408	24	620
CC_2F_3	2.27	0.13	1.23	3.40	0.48	148	646	21	500
CD (P=0.05)	0.18	0.05	0.26	0.69	0.05	44	121	NS	NS

CC_0=0, CC_1=1.25 and CC_2=2.5 t ha^{-1} of composted coir pith; F_0=No fertilizers; F_1=*Azospirillum* sp. alone @ 20 g vine^{-1}; F_2= ½ recommended NPK + *Azospirillum* sp.; F_3=NPK @ 100:40:140 kg ha^{-1} of N, P_2O_5 and K_2O

Table 3. Effect of different levels and combinations of coir pith compost, NPK and *Azospirillum* sp. on yield in black pepper

Treatment	Yield (kg vine^{-1}) (I year)			Yield (kg vine^{-1}) (III year)			Mean yield (kg vine^{-1})			Mean of F
	CC_0	CC_1	CC_2	CC_0	CC_1	CC_2	CC_0	CC_1	CC_2	
F_0	2.33	2.35	3.66	1.57	2.97	4.07	1.95	2.66	3.86	2.82
F_1	2.63	3.31	2.28	3.47	4.17	3.83	3.05	3.76	3.06	3.28
F_2	3.04	3.03	3.02	3.70	3.97	4.47	3.37	3.50	3.74	3.54
F_3	3.62	3.83	3.43	3.00	3.87	4.93	3.46	3.85	4.18	3.83
Mean of CC							2.96	3.44	3.71	
CD (P=0.05) CC x F=0.93; CC=0.46; F=0.54										

CC_0=0, CC_1=1.25 and CC_2=2.5 t ha^{-1} of composted coir pith; F_0=No fertilizers; F_1=*Azospirillum* sp. alone @ 20 g vine^{-1}; F_2=½ recommended NPK + *Azospirillum* sp.; F_3=NPK @ 100:40:140 kg ha^{-1} of N, P_2O_5 and K_2O

The quality of black pepper namely, oleoresin and piperine also increased due to application of CC, NPK and *Azospirillum* sp. (Table 4). Maximum oleoresin content (9.45%) was recorded in the treatment 2.5 t ha^{-1} CC + ½ NPK+ *Azospirillum* sp. which was on par with 1.25 t ha^{-1} CC + NPK. There was no significant difference in oleoresin and piperine content due to levels of CC application. Regarding oleoresin production, there was no significant difference due to NPK and biofertilizer application. A similar trend was observed by Subbaraj & Ramaswami (1995) on oil yield of groundnut.

Economics

Application of CC @ 1.25 t ha^{-1} resulted in a benefit-cost (BC) ratio of 1.79 with a net return of Rs. 42,630 followed by CC @ 2.5 t ha^{-1} (1.76). The cost of cultivation per hectare was Rs. 51,300 at 1.25 t ha^{-1} CC and Rs. 56,302 at 2.5 t ha^{-1} CC levels. On integrating with fertilizers, CC @ 1.25 t ha^{-1} + *Azospirillum* sp. application recorded the highest BC ratio of 1.94 with a net return of Rs. 43,995 followed by 1.25 t ha^{-1} CC + full NPK (1.91). The application of recommended dose of NPK alone recorded a BC ratio of 1.89. Hence, for higher yield and fertility buildup in black pepper gardens, CC can be recommended @ 1.25 t ha^{-1} integrating with ½ the recommended fertilizer dose and *Azospirillum* sp. @ 20 g vine^{-1}.

Acknowledgement

The authors gratefully acknowledge M/s. Marson Bio Care, Mumbai for providing financial support and the Director, Indian Institute of Spices Research, Calicut, for providing the necessary facilities to carry out this investigation.

Table 4. Effect of different combinations of coir pith compost, NPK and *Azospirillum* sp. on piperine and oleoresin contents in black pepper (mean of 3 years)

Treatment	Oleoresin (%)			Piperine (%)			Mean of F	
	CC_0	CC_1	CC_2	CC_0	CC_1	CC_2	Oleoresin (%)	Piperine (%)
F_0	8.77	8.64	8.77	6.94	6.63	6.56	8.73	6.71
F_1	9.22	8.72	8.76	6.96	6.98	6.65	8.90	6.87
F_2	9.00	9.21	9.45	6.98	6.16	6.71	9.22	6.62
F_3	9.08	9.44	8.84	6.74	6.18	6.92	9.12	6.61
Mean of CC	9.03	9.00	9.12	6.91	6.49	6.71		
CD (P=0.05)	CC x F=0.21; CC= NS; F=NS			CC x F=0.15; CC=NS; F=0.08				

CC_0=0, CC_1=1.25 and CC_2=2.5 t ha^{-1} of composted coir pith; F_0=No fertilizers; F_1=*Azospirillum* sp. alone @ 20 g vine^{-1}; F_2= ½ recommended NPK + *Azospirillum* sp.; F_3=NPK @ 100:40:140 kg ha^{-1} of N, P_2O_5 and K_2O

References

Ammal U B & Durairajmuthiah N 1996 Utilization of coir pith as manure for rice and potassium use efficiency. J Indian Soc. Soil Sci. 44 : 445-447.

Anabayan K 1988 Evaluation of enriched farmyard manure and coir pith compost for N and moisture management in rainfed sorghum. M Sc (Ag) Thesis, Tamil Nadu Agricultural University, Coimbatore.

ASTA 1968 Official Analytical Methods. 2nd Edn. American Spice Trade Association, New York.

Baskar M & Saravanan A 1997 Effect of coir pith based potting mix and methods of fertilizer application on tomato. Madras Agric. J. 84 : 476-480.

Jackson M L 1967 Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Kamaraj C M 1994 Exportable coir products in Tamil Nadu. Coconut Wealth 1 (6) : 6-8.

Lourduraj A C, Rajagopal A & Meyyazhagan N 1998 Effect of irrigation regimes, organic and inorganic manures on physico-chemical characteristics of soil, yield and quality attributes of groundnut. Agric. Sci. Digest, Karnal. 18 : 129-132

Maheswarappa H P, Nanjappa H V & Hegde M R 1999 Influence of organic manures on yield of arrowroot, soil physico-chemical and biological properties when grown as intercrop in coconut garden. Ann. Agric. Res. 20 : 318-323.

Moorthy V K, Moorthy A K & Rao K B 1998 Effect of compost on growth of cardamom. In: Sadanandan A K, Krishnamurthy K S, Kandiannan K & Korikanthimath V S (Eds.). Water and Nutrient Management for Sustainable Production and Quality of Spices: Proceedings of the National Seminar, Madikeri (pp. 85-88). Indian Society for Spices, Calicut.

Rajalingam, G V & Kumar, N 2001 Effect of digested coir pith compost (DCC) and bio fertilizers on green leaf yield of tea. South Indian Hort. 49 : 142-144

Rao P S, Devi L S & Datta A 2001 Quality of coir dust composts and their effect on the dry matter yield of maize. J. Trop. Agric. 39 : 24-27.

Savithri P & Hameed Khan H 1994 Characteristics of coconut coir pith and its utilization in agriculture. J. Plantn. Crops 22 : 1-18

Savithri P, Murugappan V & Nagarajan R 1993 Possibility of economizing potassium fertilization by composted coir pith application. Fert. News 38 : 39-40.

Subbaraj D & Ramaswami P P 1995 Influence of organic amendments on groundnut pod and oil yields in Theri soils (Typic Ustipsamments). Int. Arachis Newslett. 95 : 81-82.

Sundersingh S D, Ramiah S, Purushothaman S & Rajagopal A 1991 Effect of irrigation regimes, methods of irrigation and coir pith application on sugarcane yield. In: Proceedings of Seminar on Utilization of Coir Pith in Agriculture, 20 November 1991, Coimbatore (pp. 65-72). Tamil Nadu Agricultural University, Coimbatore.

Veerabadran V 1991 Coir pith application and yield of rainfed millets in red soil. In: Proceedings of Seminar on Utilization of Coir Pith in Agriculture, 20 November 1991, Coimbatore (pp. 91-99). Tamil Nadu Agricultural University, Coimbatore.