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Efficient recycling of organic wastes in arecanut (*Areca catechu*) and cocoa (*Theobroma cacao*) plantation through vermicomposting

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ABSTRACT

The possibility of converting available organic wastes in arecanut (*Areca catechu* L.) and cocoa (*Theobroma cacao* L.) gardens into vermicompost by using African night crawler (*Eudrilus eugeniae*) was studied during 1994-95. The result indicated that the organic wastes could be efficiently converted into vermicompost with a recovery of 74.65–87.75 % in a composting period of 3 months. Earthworm biomass doubled irrespective of organic waste used in a period of two months. Major nutrient (NPK) and micronutrient (Cu, Zn, Fe and Mn) contents were slightly higher in all the vermicompost samples than in normal compost. Vermicompost had lower C:N ratio and *p*H than normal compost irrespective of the source of organic waste. Microbial population was considerably higher in vermicompost than in normal compost. Economics of vermicompost production revealed that the profit of Rs 1.51–1.69 could be realized from 1 kg of the compost. Estimated cost of commercial vermicompost production showed that a profit of Rs 11 114/could be obtained from the vermicompost production from organic wastes available in 1 hectare of arecanut plantation.

Key words : arecanut, cocoa, vermicompost, normal compost, C : N ratio

Arecanut (*Areca catechu* L.) is an important commercial plantation crop grown in humid tropics of India. Cocoa (*Theobroma cacao* L.) a shade loving crop is an ideal mixed crop in arecanut garden (Bhat and Leela 1968, Bhat 1978). The area under arecanut cultivation in India is 2.54 lakh hectares (1995-96), while cocoa is cultivated in 14 100 ha. Arecanut is generally grown in laterite soils with acidic nature and low nutrient retention capacity. Continuous use of chemical fertilizers is assumed to be a major cause of deterioration of soil health. To maintain high productivity of both soil and crop, balanced use of mineral fertilizers and organic manures is indispensable. As mineral fertilizers are not in a position to meet the nutrient demand, extensive use of organic wastes is advisable. Available arecanut wastes have a potential to supply 5 260, 1 337 and 6 230 tonnes of nitrogen, phosphorous and potassium respectively to the agricultural system annually (Biddappa *et al.* 1996). Cocoa wastes could contribute 540, 72 and 244 tonnes of N, P and K respectively. However, these wastes are not put in to proper use.

Tiesson *et al.* (1994) pointed out that organic matter recycling is related to agricultural potential of soils. Direct recycling of these organic wastes do not meet the crop nutrient demand immediately. In this context, vermicomposting gained significance in organic matter recycling. Hence, a study was conducted to compare the efficacy of vermicomposting with normal composting.

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MATERIALS AND METHODS

This study was conducted for 2 years during 1994 and 1995 at the Regional Station of the Institute, Vittal. Hundred kilogram of each dried areca leaves, cocoa leaves and cocoa pod husk were chopped into pieces of 5–10 cm and filled in cement tanks of 1 m × 1 m × 0.75 m and covered with a thin layer of soil. The moisture level was maintained at 30–40% in the compost tank throughout the experimental period by frequent watering. After 30 days of incubation, the soil layer was removed and 1 kg of African night crawler (*Eudrilus eugeniae*) were released in to partially decomposed organic wastes and incubated for another 60 days. Normal compost was made in the same process without releasing the earthworms. Four sets of each method were maintained. The compost material was turned at weekly interval. Finally, all the organic wastes were converted in to fine granular, odourless vermicompost with in the period of 90 days. The vermicompost was air-dried in shade after separating the earthworms from the compost and sieved using 2 mm sieve.Percentage of vermicompost recovered and earthworm biomass were estimated. Nutrient analysis of base and composted materials was done using standard procedures

(Piper 1950, Jackson 1967). Bacteria, fungi and actinomycetes counts were enumerated using nutrient agar, Martin's Rose Bengal agar and Starch-casein agar respectively. Pikovskaya's medium was used to identify P-solubilizers. Economics of compost production was worked out with prevailing market rates.

RESULTS AND DISCUSSION

Recovery of compost and earthworm biomass production

Higher recovery of 87.75% of vermicompost was obtained with arecanut leaves than with cocoa leaves (74.65 %) (Table 1). The lower recovery per cent in cocoa may be due to more carbonaceous material in the base material resulting in higher release of carbon dioxide. The recovery of normal compost ranged from 73.5 (cocoa leaves) to 76.15 % (arecanut leaves). There was more than 2-fold increase in biomass production of earthworms (2.1–2.7 kg) over initial earthworm culture applied (1 kg) indicating the wide scope for converting large quantities of wastes into vermicompost in a short period.

Table 1 Recovery of compost and biomass production of earthworms (average data of 2 years)

Organic source	Initial weight of earth-worms (kg)	Weight of the dried organic wastes (kg)	Recovery of normal compost (kg)	Recovery of vermi-compost (kg)	Weight of earth-worms
Areca leaves	1	100	76.15	87.75	2.4
Cocoa leaves	1	100	73.50	74.65	2.7

Organic carbon

The mean organic carbon content of the base materials decreased from initial value of 47.1% to 24.4–28.0% after composting for cocoa dried leaves (Table 2). In case of arecanut wastes, the organic carbon content was reduced from an initial value of 44.2 % to 33.1-33.7 % after composting. The slow decomposition of arecanut wastes due to wide C:N ratio (62.25) might have resulted in more organic carbon accumulation compared to cocoa wastes with narrow C:N ratio (37.00). This might be also due to the fact that dicot crops tend to supply more N and monocot crops tend to supply more organic carbon.

Nutrient composition

The vermicompost produced from cocoa and areca leaves showed much variation in the nutrient composition. Normal composting and vermicomposting have increased the nitrogen content considerably over substrates used (Table 2). The nitrogen content has increased to 1.65% in vermicompost from dried cocoa leaves with a nitrogen content of 1.27%. Similarly, there was an increase in the nitrogen content of vermicompost (1.38 %) produced from areca leaves which had 0.71% nitrogen. This increase in nitrogen content in composted material can be attributed to the enhanced microbial activity which causes transformation of the soluble N in to microbial protein thereby preventing N loss. Alawdeen and Ismail (1986) observed that the protein content of earthworm tissue is high and yield nitrate nitrogen on decomposition. Further, enzymes and hormones excreted by earthworms would have contributed to higher nitrogen content in vermicompost. The presence of enzymes and plant growth hormones like cytokinins and auxins in the vermicompost has been reported earlier (Neilson 1965, Krishnamurthy and Vajranabhaiah 1986, Bhawalkar 1989).

Vermicomposting from arecanut leaves increased the phosphorus content (0.35 %) compared to normal composting (0.08 %) and dried areca leaves (0.08 %). The increase in P content might be due to higher concentration of phosphorus in earthworm casts (Watanabe 1975). Gaur *et al.* (1991) also reported an appreciable increase in total N and phosphorus in vermicompost from rice straw and plant twigs. Phosphorus content (0.17–0.19 %) did not vary much in case of cocoa leaves and composted materials. Potassium content did not vary much in composted materials and organic sources.

Table 2 Nutrient composition in organic source, vermicompost and normal compost (average data of 2 years)

Nutrients	Cocoa leaves			Areca leaves		
	Dried leaves	Normal compost	Vermicompost	Dried leaves	Normal compost	Vermicompost
Organic carbon (%)	47.10	28.0	24.4	44.20	33.7	33.1
N (%)	1.27	1.29	1.65	0.71	1.01	1.38
P (%)	0.17	0.19	0.19	0.08	0.08	0.35
K (%)	0.27	0.27	0.32	0.94	0.96	0.98
C:N ratio	37.00	21.90	14.78	62.25	33.36	23.18
Cu (ppm)	32.66	70.54	83.60	100.59	120.18	120.18
Fe (ppm)	1 157.41	2 580.0	2 593.0	1 745.61	2 397.00	2 561.00
Zn (ppm)	228.39	354.7	367.7	307.08	346.30	395.68
Mn (ppm)	363.1	546.41	679.84	81.73	172.79	241.68
Moisture (%)		29.35	29.94		31.26	31.82
*p*H		8.0	7.5		8.1	7.3

Table 3 Microbial population in vermicompost and normal compost (average data of 2 years)

Organic source	Microbial population /g sample			
	Bacterial (10^6)	Fungi (10^4)	Actinomycetes (10^6)	P-solubilizers (10^4)
Arecanut leaves				
Normal compost	24.10 ± 5.4	23.07±5.4	5.64 ± 3.8	13.84 ± 4.8
Vermicompost	30.76 ± 4.8	30.76±4.8	6.28± 2.76	16.25 ± 3.2
Cocoa leaves				
Normal compost	16.82 ± 3.2	6.15± 2.70	3.58 ± 1.8	12.81 ± 3.8
Vermicompost	17.43 ± 1.2	6.28±1.73	6.15 ± 2.6	15.89 ± 4.0

Table 4 Economics of vermicompost (VC) and normal compost (NC) production

	Item	Areca leaves		Cocoa leaves	
		VC	NC	VC	NC
A	*Expenditure (Rs)*				
	Labour cost for collection wastes (100 kg), cutting and filling (8 man hr @ Rs 7.5/man hr)	60.0	60.0	60.0	60.0
	Cost of earthworms (1000 no.)	10		10	
	Labour cost for watering, drying and sieving (8.5 man hr)	67.5	67.5	67.5	67.5
	Total of A	137.5	127.5	137.5	127.5
B	*Cost of production*				
	Cost of production of vermicompost / normal compost from 100 kg wastes	137.5	127.5	137.5	127.5
	Returns from the compost vermicompost @ Rs 3/ kg and normal compost @ Rs 1.5/ kg based on recovery	262.5	114.2	223.5	110.2
	Returns from the earthworms multiplied @ Rs /1000 no.	24		27	
	Total returns	286.5	114.2	250.55	110.2
	Net profit (B-A)	149.0		113.05	
	Cost of production of 1 kg of vermicompost	1.57	1.67	1.84	1.73
	Returns from 1 kg of vermicompost/normal compost and earthworms multiplied	3.26	1.50	3.35	1.50
	Net profit	1.69		1.51	

Potassium content ranged between 0.27–0.32% in composted material of cocoa leaves. While, the potassium content increased slightly (0.96–0.98%) in composted materials produced from areca leaves. Vermicomposting has been found to increase the phosphorus content from an initial value of 0.19–0.26 % and potassium content from 0.12 to 0.18% (Gangadhar and Andanigowda 1995).

C:N ratio

Vermicomposting of both areca and cocoa leaves has narrowed down the C:N ratio substantially over normal composting (Table 2). The C:N ratio has come down to 23.98 in vermicompost and 33.36 in normal compost from the initial level of 62.25 in dried areca leaves. Similarly, vermicomposting reduced the C:N ratio to 14.78 over the C:N ratio of dried cocoa leaves (37.00). The lower C:N ratio ensures immediate release of nutrients when applied to the soil. Gaur *et al.* (1991) reported significant narrowing down of C:N ratio in vermicompost produced from rice straw. The concentration of micronutrients such as Cu, Fe, Zn and Mn was increased appreciably in composted materials of both arecanut and cocoa compared to their concentration in base materials. The composition of micronutrients was slightly higher in vermicompost than in normal compost of both organic sources. It can be observed that the *p*H of the vermicompost was near to neutral (7.3–7.5) compared to normal compost (8.0– 8.1). Recycling of organic wastes after composting to arecanut plantation would be helpful in improving the soil health and acidic nature of the soils in arecanut tract.

Microbial population

The most beneficial influence of earthworms is stimulation of microbial activity in castings (Parle 1963, Nowak 1975). Microbial population was considerably higher in vermicompost samples than in normal compost indicating the favourable influence of earthworms on microbial activity (Table 3). However, the microbial population was less in compost samples of cocoa wastes compared to compost samples of arecanut. This might be due to high polyphenol content in cocoa. Numbers of bacteria and fungi were particularly high reaching 24–30 millions each/ g of sample in composted material produced from arecanut compared to cocoa samples. Bacteria and fungi accounted for 75% of the total microbial population. Actinomycetes population was lower than other microbes both in normal and vermicompost samples. The population of P-solubilizers was more in vermicompost than in normal compost both in case of cocoa and arecanut.

Economic analysis

On working out the economics of compost production, it can be noticed that a net profit ranging from Rs 1.51–1.69 could be obtained from 1 kg of vermicompost produced (Table 4). A net profit of Rs 11 114 could be realized from vermicompost production of available wastes from one hectare of arecanut with a minimum investment of Rs 4 569 on labour input and earthworms. This would be an additional income to areca growers. The fertililizer dose for arecanut was standardised at 100 g N : 40 g P_2O_5 : 140 g K_2O per palm per year (Abdul Khader 1990). One hectare will accommodate 1 300 palms. In case of recycling, vermicompost produced from organic wastes of 1 hectare of arecanut plantation could meet 50% of N, 32.5% of P and 26% of K requirement besides supplying considerable organic matter and micronutrients. Thus, the vermicomposting is an efficient method of organic waste recycling and the nitrogen content and concentration of micronutrients could be enhanced considerably through this method.

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