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Standardization of Composting Technique for Cocoa Leaf Waste

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ABSTRACT

The present investigation was conducted to standardize the protocol for composting of cocoa (*Theobroma cacao L.*) leaf wastes. Cocoa leaf litter is a important waste material from cocoa. Since these wastes are rich in lignin and cellulose, it takes long time for decomposition and hence add nutrients slowly to the soil. In order to decompose the waste quickly, the effectiveness of several decomposing agents, including micro organisms, in degrading the waste of cocoa and the performance of cocoa compost were studied. The treatments included Cocoa leaf waste + cow dung slurry (T1), Cocoa leaf waste + Earthworm(T2), Cocoa leaf waste + TNAU Biomineralizer (T3), Cocoa leaf waste + *Phanerochaete chrysosporium* (T4) and Cocoa leaf waste + *Pleurotus Sajor- Caju* (T5). Physiochemical properties such as changes in temperature, pH and EC were recorded. Among the different days and treatments, the highest temperature of 60.5°C was recorded in cocoa leaf waste inoculated with cow dung slurry (T_1) on 30^{th} day of composting, the lowest pH of 6.09 was recorded in the cocoa leaf waste inoculated with earthworm (T_2) on 120^{th} day of composting and the lowest EC of 0.52 dSm^{-1} was registered in cocoa leaf waste inoculated with *Phanerochaete chrysosporium* (T_4) on 120^{th} day of observation.

Key Words: Cocoa, Composting, Earthworm, Leaf Waste.

INTRODUCTION

Cocoa belongs to the genus *Theobroma*, a group of small trees which occurs in the wild in the Amazon basin and other tropical areas of South and Central America. There are over twenty Species under the genus *Theobroma* and among them *Theobroma cacao* is the only one widely cultivated species widely. Cocoa is the third important beverage crop next to coffee and tea and is the third highest traded commodity in the world after coffee and sugar and it is one of the most important tropical crops.

Continuous crop cultivation causes depletion of organic matter as well as other nutrient contents of the soil. Hence, to harvest crop yields, it becomes necessary to apply organic manures and inorganic fertilizers to enrich the soils. Well-decomposed organic manures have a greater potential to improve the soil's physical conditions in terms of water holding capacity, soil porosity, infiltration rate humus content, and also the microbial status of the soil besides adding nutrients to the soil. According to Phukon et al. (2021), integrating cocoa plants with coconut cultivation has been shown to enhance coconut yields. As a self-mulching plant, cocoa regularly sheds its substantial leaves, which serve as excellent mulch, helping to retain soil moisture and augment organic matter. This process also boosts microbial activities, including nitrogen fixation, phosphate solubilization, and the production of indole-3-acetic acid (IAA) by Aspergillus flavus and Aspergillus fumigatus in the soil. Therefore, intercropping with cocoa is highly advantageous for coconut farming.

Cocoa leaf litter is typically left in the field to facilitate nutrient recycling. As the leaves naturally decompose, they enrich the soil with nutrients, serve as mulch to retain soil moisture, suppress weed growth, and help preserve topsoil, particularly in hilly or sloped areas. Utilizing agro-waste such as cocoa leaf litter holds significant potential for enhancing soil productivity and crop yields by improving the soil's physical, chemical, and microbiological properties. Some farmers also use cocoa pod husks as animal feed. However,

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Table 1. Treatment details.

T_1	Cocoa leaf waste + cow dung slurry (100 kg leaf waste + 10 kg cow dung slurry)
T_2	Cocoa leaf waste + Earthworm (100 kg leaf waste + 500 g earthworm)
T_3	Cocoa leaf waste + TNAU Biomineralizer (100 kg leaf waste+500 g TNAU Biomineralizer)
T_4	Cocoa leaf waste + *Phanerochaete chrysosporium* (100 kg leaf waste+PC 5 %)
T_5	Cocoa leaf waste + *Pleurotus Sajor - Caju* (100 kg leaf waste+ *Pleurotus Sajor - Caju* 500g)

Table 2. Standard methods for physico-chemical analysis of cocoa leaf waste.

Parameters	Method	Reference
Temperature	Digital thermometer	Wang *et al* (2014)
pH	1: 2.5 solid waste: distilled water using pH meter	Tyl and Sadler (2017)
Electrical conductivity (EC)	1: 2.5 solid waste: distilled water using conductivity bridge	Bhat *et al* (2017)

there is a lack of research on standardized composting protocols for cocoa waste and the optimal application rates for using these composts as fertilizer for both cocoa seedlings and established plantations.

To boost soil fertility in intercropped cocoa plantations and accelerate the decomposition process, composting techniques for cocoa leaves and pods were employed using cow dung, earthworms, TNAU Bio mineralizer, *Phanerochaete chrysosporium*, and *Pleurotus sajor-caju.* This study aimed to standardize the composting methods for cocoa leaf litter.

MATERIALS AND METHODS

Experiment on composting of cocoa waste which included cocoa leaf waste was conducted during August 2015 to June 2016 in farmer's cocoa plantation at VSR Farm, Sethumadai and Cocoa Nursery, Pollachi, Coimbatore district. Cocoa waste was collected from 13 years old cocoa crop. Cocoa leaf litter is an important waste material from cocoa. Since these wastes are rich in lignin and cellulose, it takes a long time for decomposition and hence add nutrient slowly to the soil. In order to decompose the waste quickly, the effectiveness of several decomposting agents which includes micro organisms in degrading the waste of cocoa and the performance of cocoa compost were studied.

Treatment details

Experimental Design : RBD

Number of treatments : 5

Replication : 4

The plant waste material comprising of cocoa leaves were collected from 13-year-old cocoa crop fields and used for composting. Samples were drawn from compost heaps at thirty days intervals with different treatments and analyzing the sample by the method. Compost samples of cocoa leaf waste were air-dried, powdered, sieved, and analysed for physicochemical properties *viz.,* temperature, moisture, pH, EC by following the standard methods as given below.

RESULTS AND DISCUSSION

The temperature fluctuations play a crucial role in indicating microbial activity and the progress of composting. Typically, the ideal temperature range for composting falls between 40°C and 65°C, as noted by Verma et al. (2014). Temperatures exceeding 55°C are necessary to eliminate pathogenic microorganisms. However, if the temperature surpasses the tolerance threshold of thermophilic decomposers, it can adversely affect the composting process.

Table 3. Changes in temperature during composting of cocoa leaf waste.

Treatment	Temperatures (^{0}C)				
	Sampling periods (Days)				
	30	60	90	120	Mean
T_1	60.5	41.9	34.5	25.4	40.57
T_2	57.9	49.0	35.2	24.9	41.75
T_3	55.8	50.9	36.4	26.9	42.50
T_4	59.1	51.2	39.2	28.1	44.40
T_5	58.6	53.6	37.5	22.0	42.92
Mean	58.38	49.32	36.56	25.46	
SE(d)	0.73	0.71	0.50	0.42	
CD(0.05%)	1.60 **	1.55 **	1.09 **	0.92 **	
**- Highly Significant					

Table 4. Changes in pH values during composting of cocoa leaf waste

Treatment	pH				
	Sampling periods (Days)				
	30	60	90	120	Mean
T_1	7.74	7.14	6.75	6.12	6.94
T_2	7.54	7.09	6.67	6.09	6.85
T_3	7.26	7.15	6.81	6.24	6.87
T_4	7.31	7.1	6.72	6.13	6.82
T_5	7.50	7.06	6.60	6.12	6.82
Mean	7.47	7.11	6.71	6.14	
SE(d)	0.07				
CD(0.05%)	0.15 **	NS	NS	NS	
NS- Non Significant, ** Highly Significant					

Microbial activity diminishes rapidly when temperatures exceed 63°C, leading to suboptimal conditions for various thermophiles, with activity reaching minimal levels at 72°C. According to Sapkota and Poudel (2019), the temperature range of 52°C to 60°C is most conducive to effective decomposition.

In the present investigation, the temperature of cocoa leaf waste after 30 days of compositing ranged from 55.80°C to 60.50°C and then gradually decreased at the final stage (22.0°C to 26.9°C). The average temperature mean of decomposition ranged from 40.57°C to 44.40°C in different treatments. The temperature of cocoa pod husk wastes ranged between 44.40 to 38.50°C after 120 days of composting. The temperature during the initial stages of composting rose rapidly, maintaining levels above 55°C for approximately 20 days before gradually declining. However, throughout the treatment period, temperatures remained above 40°C for 30 days, indicating an extended thermophilic phase (T>40°C), crucial for organic material decomposition, as noted by Tang et al. (2007). The elevated temperature observed within composting waste heaps is attributed to microbial activity, where heat is generated through microbial respiration and accumulates within the pile, as discussed by Tiquia

Table 5. Changes in EC values during composting of cocoa leaf waste.

Treatment	Electrical conductivity (dSm^{-1}) Sampling periods (Days)				
	30	60	90	120	Mean
T_1	1.98	1.86	1.24	0.67	1.44
T_2	1.90	1.35	0.85	0.72	1.21
T_3	1.74	1.58	1.29	0.91	1.38
T_4	1.33	1.12	0.74	0.52	0.93
T_5	1.46	1.23	0.78	0.60	1.02
Mean	1.68	1.43	0.98	0.68	
SE(d)	0.020	0.026	0.010	0.013	
CD (0.05%)	0.043 **	0.056 **	0.023 **	0.029 **	

**- Highly Significant

and Tam (2000). Thermophiles possess cell membranes composed of saturated fatty acids, creating a hydrophobic environment that enables them to thrive at high temperatures by maintaining cell rigidity, as explained by Herbert and Sharp (1992). In this study, the highest recorded temperature initially reached 60.5°C. Microbial activity was notably higher during the middle stages of decomposition across all treatments due to the favorable temperatures observed during this phase.

The pH value ranged from 6.82 (T_5 consisting of cocoa leaf waste inoculated with *Phanerochaete chrysosporium* and with *Pleurotus sajor- caju)* to 6.94 (T_1 consisting of cocoa leaf waste inoculated with cow dung slurry). The pH value ranged from 7.35 (T_5 containing cocoa pod husk waste inoculated with *Phanerochaete chrysosporium* and with *Pleurotus sajor- caju)* to 7.48 (T_1 consists of cocoa pod husk waste inoculated with cow dung slurry). In general, a pH of 6.7–9.0 supports good microbial activity during composting (Meng et al., 2019). The ideal pH range for composting typically falls between 5.5 and 8.0. While pH is not usually a critical factor for composting because most materials naturally fall within this range, it becomes significant in managing nitrogen losses due to ammonia volatilization, especially when pH exceeds 7.5.

The EC value ranged from 0.93 dSm^{-1} (T_5 consist of cocoa leaf waste inoculated with *Phanerochaete chrysosporium*) to 1.44 dSm^{-1} (T_1 consist of cocoa leaf waste inoculated with cow dung slurry). The EC valued from ranged from 1.25 dSm^{-1} in T_5 consist of cocoa pod husk waste inoculated with *Phanerochaete chrysosporium* to 1.44 dSm^{-1} in T_1 consist of cocoa pod husk waste inoculated with cow dung slurry. During the later stages of composting, the electrical conductivity (EC) of the compost may decrease due to the volatilization of ammonia and the precipitation of mineral salts, as observed by Wong et al. (2017).

CONCLUSION

The temperature of the compost was recorded as high at the 30th day, thereafter temperature decreased gradually in both cocoa leaves. Towards the final stage of composting, occurring on the 120th day, all treatments involving cocoa leaf waste compost exhibited slightly lower temperatures, indicating a decline in microbial activity compared to the initial stages of the composting process. The highest temperature of 60.5°C was recorded on the 30th day of composting. The decrease in temperature towards the end of composting is advantageous for utilizing the compost as manure. Initially, during the 30th day of composting, the pH of cocoa leaf waste compost was slightly above neutral (pH 7.74) across all treatments, gradually decreasing thereafter. By the 120th day of composting, all treatments showed pH levels almost reaching neutral (pH 7.0), which is conducive for utilizing the compost as manure. The electrical conductivity (EC) of cocoa leaf waste compost gradually decreased from the 30th to the 120th day of composting. Among the treatments, the lowest EC (0.93 dSm^-1) was observed in cocoa leaf waste inoculated with Phanerochaete chrysosporium, while the highest EC (1.44 dSm^-1) was recorded in cocoa leaf waste with cow dung slurry.

REFERENCES

Bhat S A, Singh J and Vig A P (2017). Instrumental characterization of organic wastes for evaluation of vermicompost maturity. *J Analyt Sci and Technol* **8**:1-2.

Herbert R and Sharp R (1992). *Molecular Biology and Biotechnology of Extremophiles*. Chapman and Hall, New York, p. 17.

Meng X, Liu B, Zhang H, Wu J, Yuan X and Cui Z. (2019). Co-composting of the biogas residues and spent mushroom substrate: Physicochemical properties and maturity assessment. *Bioresource Technol* ***276***, 281-287.

Phukon R M, Nath J C, Sumitha S, Maheswarappa H P and Elain Apshara S. (2021). Early evaluation of cocoa (*Theobroma cacao* L.) clones as intercrop in coconut gardens under red river region of Assam state, India. *J Plantation Crops* **49**(2): 77-82

Sapkota P, Poudel L. (2019). Heat exchanger for bio-digester under thermophilic range. *J Adv College of Eng and Manage* **13**(5):79-88.

Tang J C, Shibata A, Zhou Q and Katayama A (2007). Effect of temperature on reaction rate and microbial community in composting of cattle manure with rice straw. *J Biosci and Bioengineer* **104**(4):321-8.

Tiquia S M, Wan H C and Tam N F. (2002). Microbial population dynamics and enzyme activities during composting. *Compost Sci and Utilization* **10**(2):150-61.

Tyl C and Sadler G D (2017). pH and titratable acidity. In: Nielsen, S.S. (eds) Food Analysis. Food Science Text Series. Springer, Cham. https://doi.org/10.1007/978-3-319-45776-5_22

Verma R, Maurya B R, Meena V S, Regar K L, Kumar L O, Jat M M and Deewan P (2014). Studies on temperature fluctuation and moisture changes in different methods of composting. *Trends in Biosci* **7**:4085-9.

Wang G, Wang W, Li K and Liu H (2014). A digital thermometer with fast response and high precision. *In 7th International Conference on Biomedical Engineering and Informatics*. (pp. 504-510). IEEE.

Wang Q, Wang S and Huang Y (2008). Comparisons of litterfall, litter decomposition and nutrient return in a monoculture Cunninghamia lanceolata and a mixed stand in southern China. *Forest Ecol and Manage* 255(3-4):1210-8.

Wong J W, Wang X and Selvam A (2017). Improving compost quality by controlling nitrogen loss during composting. *In Current Developments in Biotechnology and Bioengineering*. (pp. 59-82). Elsevier.

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