Recycling of leaf litters on cocoa (Theobroma cacao L.) plantation

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Abstract
Field experiment was carried out to standardize the protocol for effective decomposing of cocoa wastes, which includes both leaf litters and pod husk. For these, the experiment comprise of five treatments: cowdung slurry, earthworms, TNAU Biomineralizer, Phanerochaete chrysosporium and Pleurotus sajor-caju. Data on temperature, pH, electrical conductivity (EC), organic carbon, total nitrogen, carbon: nitrogen ratio, total phosphorus and total potassium were analyzed. The experiment was laid out in a Randomized Block Design (RBD) with four replications. The cocoa waste imposed with chrysosporium and Pleurotus sajor-caju showed the rapid decomposition rate than compared with other treatments used in the experiment. The nutrient content of N, P, K were found to be more in the treatment with TNAU Biomineralizer followed by Phanerochaete chrysosporium and Pleurotus sajor-caju.

Keywords: Cocoa waste, cocoa pod husk, cocoa leaf, cocoa waste compost

Introduction
Cocoa, the most important tropical crops belongs to the genus Theobroma a group of small trees that occurs as wild in the Amazon basin and other tropical areas of South and Central America. Cocoa is the third important beverage crop next to coffee and tea, which ranks third highest traded commodity in the world after coffee and sugar. The fruit of the cocoa is an important commodity because of the economic value of its beans. Commercial cultivation of cocoa started in India during 1970. This crop is widely grown as intercrop crop in coconut and arecanut gardens in India. Generally, agro-wastes are converted into composts or farmyard manure before being used in crop production to improve soil fertility. Enrichments in composting improve nutritive value; augment disease suppressive activity and beneficial microbial populations in the composts. Addition of organic matter to soil not only provide plant available nutrients on its decomposition but also offer an energy (carbon) source to the soil ecosystem and build soil fertility and structure in the long run.

Litterfall and litter decomposition and subsequent nutrient release represent major biological pathways for element transfer from vegetation to soils, and play an important role in regulating nutrient cycling, and in maintaining soil fertility in forest and agro-ecosystems (Yang et al., 2003) [21]. For the majority of farmers, fertility of soils under cocoa plantations is maintained through the recycling of nutrients through leaf fall and decomposition of leaf litter (ISSER 2004; Appiah et al., 2006) [2]. A number of factors influence the decomposition process. These comprise: (1) microclimate, mainly temperature and humidity, (2) litter quality, (3) soil nutrient content and (4) the qualitative and quantitative compositions of decomposer communities (Anderson and Swift, 1983) [1]. These factors interact to determine decomposition rates.

The present study is aimed for the generation of nutrient- enriched composts using cocoa leaf litter. However, under normal condition it will take longer time for decomposition. The present investigation was done with the objective to hasten the decomposition process and for obtaining enriched compost from cocoa leaf litter.

Materials and Methods
Field experiment were carried out at VSR farms, Pollachi, Coimbatore district during 2015-2016. Main materials used were cocoa leaf, cocoa pod husk, cowdung slurry, earthworms, TNAU Biomineralizer, Phanerochaete chrysosporium and Pleurotus sajor-caju.
The cocoa pod husk collected from the processing yard after beans were extracted and dried leaves were collected from the field were used as substrates or raw material for composting process. Composting method used for the experiment was aerobic composting. The treatment details were, T1 (Cocoa leaf waste + cow dung slurry), T2 (Cocoa leaf waste + Earthworm), T3 (Cocoa leaf waste + TNAU Biomineralizer), T4 (Cocoa leaf waste + Phanerochaete chrysosporium) and T5 (Cocoa leaf waste + Pleurotus Sajo- Caju) and the similar treatments were followed in case of composting of cocoa pod husk. The CPH was chopped into smaller pieces before composting to reduce the particle size. The temperature, pH and EC of each pile was monitored for four weeks interval until the end of the composting with the use of digital thermometer. The mixtures were turned every fortnight and watered. The organic materials were composted for four months after which they were allowed to cure for two weeks, shredded and bagged for use. At maturity of the composts, samples were randomly taken from each compost type, milled, sieved through a 2 mm sieve and subjected to chemical analysis.

The following analyses were carried out at the end of each of the incubation period. pH and EC were determined in water (1:2 soils: water ratio) and measured in digital meter (Jackson, 1973) [15]. Organic carbon was determined by the method of chromic acid wet digestion (Walkely and Black, 1934). Mineralized total Nitrogen was determined by Kjedahl method (Bremner and Mulvaney, 1982) [6]. mineralized available P was extracted from the incubation samples using Bray P method (Olser et al., 1954) and mineralized K was extracted with 1N ammonium acetate at neutral pH and the amount of K were determined using flame photometer (Jackson, 1973) [15]. The data obtained from the above experiments were analysed using Randomized block design (RBD) as suggested by Panse and Sukhatme (1961) [17]. The critical difference was worked out at five per cent probability level and the result were interpreted.

Result and Discussion

All the composts appeared to be granular and dark grey in colour at 120 days of composting. Although colour and odour are the simplest criteria to evaluate the maturity and stability of the compost but for confirmation some physical, chemical and biological parameters were also studied.

Temperature

Changes in temperature at various stages of decomposition of different composting mixtures are shown in table 1. Temperature of all the composts reached maximum (55.8 C – 60.50 C and 56.90 C – 62.0 C) at 30 days of composting in cocoa leaf and pod husk respectively and it reflected the rapid initiation of composting process and it decreased gradually but remained in thermophilic range (>40 0 C) up to 60 days. It further decreased and reached ambient level between 90 and 120 days of composting in all the treatments and Maximum days of highest temperature was noted in cocoa waste (both leaf and pod husk) treated with Phanerochaete chrysosporium (T3) and Pleurotus Sajo-caju (T5). In general, temperature decreased after each turning indicating decrease in easily decomposable organic matter. Therefore, turning of pile, maintenance of moisture at optimum level and addition of easily available carbon sources are necessary to enhance microbial activity during composting (Tiquia et al., 1997) [19]. The compost indicates a good degree of stability when temperature during composting approaches the ambient level (Satisha and Devaranj, 2007) [18]. All the composts attained ambient temperature at 120 days indicating compost stability.

pH

The pH is a good indicator to determine the maturity of compost. The initial pH ranged between 7.26 to 7.74 for various treatments in cocoa leaf waste and 7.68 to 7.90 in cocoa pod husk. In cocoa leaf waste, T1 recorded highest pH 7.74 at 30 days of study and T3 recorded lowest pH 7.26. In cocoa pod husk, T1 recorded highest pH 7.68 at 30 days of study and T3 recorded lowest pH 7.90 (Table 1). The compost pH is a good indicator of compost maturity. During the initial days of composting, it descends slightly to maintain high pH and later decreases as the material gradually decomposes and stabilities, finally staying between 6.00 and 7.00 (Cardenas and Wang 1980). The pH values were significantly (>P<0.05) decreased with the increase of days in all the treatments.

Organic Carbon

The organic carbon loss increased with composting time in all the composts due to greater availability of easily biodegradable substances to microbes (Benito et al., 2003) [3]. Highest losses of organic matter were observed during first 60 days of composting in all the composts which slowed down thereafter. Maximum losses (31.56% and 21.10 %) of organic matter were observed in cocoa waste treated with Phanerochaetes chrysosporium (T3) followed by Pleurotus sajor-caju (32.32% and 21.80 %) (T5), earthworms (32.78% and 22.80%) (T2), TNAU Biomineralizer (32.87 % and 24.60%) (T4) and cow dung slurry (34. 12 % and 25.50 %) compost (T1). This fact indicates that the addition of fungal culture enhanced the decomposition rate of organic matter. The organic matter loss >42% may be accepted as an index value for mature compost. The initial nitrogen content varied between 1.27% and 1.57% in cocoa leaf waste and 0.45% to 0.76% in cocoa pod husk respectively. It was significantly increased (>P<0.05) and attained maximum value on the 120th day. The statement of Gaur (1982) [13] that the macro and micro nutrients were increased during composting due to the loss of organic carbon content as CO2. The breakdown of complex organic compounds into simpler compounds due to bio-degradation and conversion of carbon into CO2 and other by products increased the total nitrogen content in the final matured compost in case of all the five treatments (Table 2).

Total Nitrogen

The nutrient nitrogen is required for the growth and development of plants and the compost manure obtained from the treatment T1 had a total nitrogen content of 2.21% and 1.87% showing that the bacteria played an effective role in the decomposition process while compared to the total nitrogen content of the samples taken from the other four treatments (Table 2).

Carbon/Nitrogen ratio

As the C:N ratio is widely used as an indicator of compost maturity (Bernal et al., 1998) [5]. The C:N ratio of all the compost mixtures decreased substantially till 120 days, and stabilized thereafter. As the decomposition progressed due to losses of carbon mainly as carbon dioxide, the carbon content of the compostable material decreased with time and N content per unit material increased which resulted in the decrease of C:N ratio. The cocoa waste composts showed more rapid decrease in C:N ratio than the farm waste compost. Addition of agro-industrial wastes as organic
additives might have helped in increasing biological activity. At 120 days of composting, highest C:N ratio (17.15 and 15.27) was recorded in cowdung slurry (T₁) followed by earthworm (T₂) (16.23 and 13.49), TNAU Biominerlizer (T₃) (14.87 and 13.16), Phanerochaete chrysosporium (T₄) (15.51 and 12.60) and Pleurotus sajor-caju (T₅) (14.68 and 11.79) respectively in both cocoa leaf and pod husk. Previous researchers reported that a C:N ratio below 20 was assumed to be indicative of maturity compost (Golueke, 1981) [10], and a ratio of 15 or less is preferable (Morel et al., 1985; Bernal et al., 2009) [16, 4]. By considering this criterion, and Phanerochaete chrysosporium (T₄), Pleurotus sajor-caju (T₅) and TNAU Biominerlizer (T₃) composts showed their maturity at 120 days (Table 2).

Total Phosphorus
The observations made on total phosphorus during decomposition of cocoa waste showed that there had been gradual increase in total phosphorus from the initiation of study till completion and it was significant at P≤0.05 level. The initial concentration of phosphorus varied between 0.55% in T₁ and 0.73% T₄ were observed in cocoa leaf waste. Similarly, concentration of phosphorus varied between 0.43% in T₁ and 0.66% T₄ were observed in cocoa pod husk after 30 days of composting. The change in phosphorus content during the course of decomposition process is agreeable with the findings (Elango et al., 2009) [10]. The highest concentration of total phosphorus (0.99% in cocoa leaf waste) and (1.21% in cocoa pod husk) in the compost obtained from the treatment T₃ (TNAU Biominerlizer) had shown that this has highest efficiency in bringing the decomposition of cocoa leaf waste and mineralization of organic phosphorus when compared to other treatments used for composting (Table 3).

Table 1: Changes in temperature and pH values during composting of cocoa leaf litter

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sampling periods (Days)</th>
<th>Sampling periods (Days)</th>
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<tbody>
<tr>
<td></td>
<td>30 60 90 120</td>
<td>30 60 90 120</td>
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<tr>
<td>T₁</td>
<td>60.5 41.9 34.5 25.4</td>
<td>7.74 7.14 6.75 6.12</td>
</tr>
<tr>
<td>T₂</td>
<td>57.9 49.0 35.2 24.9</td>
<td>7.54 7.09 6.67 6.09</td>
</tr>
<tr>
<td>T₃</td>
<td>55.8 50.9 36.4 26.9</td>
<td>7.26 7.15 6.81 6.24</td>
</tr>
<tr>
<td>T₄</td>
<td>59.1 51.2 39.2 28.1</td>
<td>7.31 7.11 6.72 6.13</td>
</tr>
<tr>
<td>T₅</td>
<td>58.6 53.6 37.5 22.0</td>
<td>7.50 7.06 6.60 6.12</td>
</tr>
</tbody>
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Table 2: Changes in organic carbon content, total nitrogen and C:N ratio during composting of cocoa leaf litter

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>30 60 90 120</td>
<td>30 60 90 120</td>
<td></td>
</tr>
<tr>
<td>T₁</td>
<td>38.64 35.94 35.56 34.12</td>
<td>1.36 1.43 1.67 1.99</td>
<td>28.41 25.13 21.29 17.15</td>
</tr>
<tr>
<td>T₂</td>
<td>38.12 35.79 35.45 32.78</td>
<td>1.27 1.49 1.78 2.02</td>
<td>30.02 24.02 19.92 16.23</td>
</tr>
<tr>
<td>T₃</td>
<td>38.47 36.98 33.45 32.87</td>
<td>1.57 1.7 2.05 2.21</td>
<td>24.50 21.75 16.32 14.87</td>
</tr>
<tr>
<td>T₄</td>
<td>36.76 34.94 33.29 31.56</td>
<td>1.45 1.68 1.98 2.15</td>
<td>25.35 20.80 16.81 14.68</td>
</tr>
<tr>
<td>T₅</td>
<td>37.21 35.98 33.68 32.26</td>
<td>1.39 1.56 1.84 2.08</td>
<td>26.81 23.06 18.30 15.51</td>
</tr>
</tbody>
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Table 3: Changes in total phosphorus and total potassium contents during composting of cocoa leaf litter

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sampling periods (Days)</th>
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<tbody>
<tr>
<td></td>
<td>30 60 90 120</td>
<td>30 60 90 120</td>
</tr>
<tr>
<td>T₁</td>
<td>0.55 0.58 0.62 0.64</td>
<td>0.31 0.45 0.70 0.95</td>
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<tr>
<td>T₂</td>
<td>0.59 0.60 0.66 0.69</td>
<td>0.20 0.47 0.81 1.19</td>
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<tr>
<td>T₃</td>
<td>0.63 0.68 0.93 0.99</td>
<td>0.37 0.59 0.96 1.10</td>
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<tr>
<td>T₄</td>
<td>0.73 0.86 0.92 0.96</td>
<td>0.23 0.51 0.89 1.20</td>
</tr>
<tr>
<td>T₅</td>
<td>0.60 0.63 0.71 0.75</td>
<td>0.27 0.53 0.85 1.07</td>
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</table>

Conclusion
The decomposition of cocoa wastes (both leaf and pod husk) helps to produce large quantity of good quality compost, which can be effectively used in field as a fertilizer, thereby the pressure on chemical fertilizers for various farming activities can be reduced and good quality of products free from chemical residues can be produced. Out of various organisms used for decomposing cocoa wastes and application of those composts in crop production had shown that promising results could be obtained from the application of compost produced by Phanerochaete chrysosporium and Pleurotus sajor-caju.

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References


