



Effect of Different Raw Materials with Poultry Manure on Composting for Rubber Nursery Production

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Abstract

Currently, rubber nursery production in local areas of Myanmar requires composting methods and effective utilization of locally available waste materials in composting. As the quality of compost depends on the raw materials used, we conducted an experiment at the Perennial Crops Research and Development Center, Mawlamyine Township, Mon State, from March to May, 2019. Aiming to assess the output qualities, we studied five treatments: T1 (oil palm frond + poultry manure-PM), T2 (rice husk + PM), T3 (rice straw + PM), T4 (sawdust + PM), and T5 (yard waste + PM). The experimental design was a randomized complete block design with four replications. According to changes in temperature and pH, the local raw materials adding poultry manure were composted completely after eight weeks. Although the volume of all composts did not change after 8 weeks, some nutrient contents of tested composts with the bin method showed differently at 10 weeks. Composts from the yard waste, rice straw, and sawdust with proper C:N ratios had maximum N, P, and Ca, respectively. Wherein, rice husk compost contained the lowest N, P, K, Ca, and Mg with the maximum C:N. Thus, composts from yard waste, rice straw, and sawdust could be selected as a constituent of potting medium for raising the nursery seedlings. This study also suggested to compare the growth of nursery seedlings and to investigate further agronomic characters & micro-organisms application in rubber production.

Subject Areas

Agricultural Science

Keywords

C:N, Compost, Composting, Different Raw Materials, Nutrient Content

1. Introduction

Expanding the agricultural sector enlarges the disposal of agro-industrial waste in different ways. In many developing countries, removing this waste becomes a problem, and most scientists consider recycling these wastes as an effective way to control environmental pollution. Likely, rubber production in Myanmar requires recycling locally available waste materials as compost for nursery production [1].

Composting is the conversion process of raw organic materials like plant and animal residues into humus-stabilized forms [2]. In this process, locally available waste materials can reuse, and the nutrients contained in those residues can support living plants [3] [4]. Generally, rubber nursery production in Myanmar uses composts as a constituent of the growing medium. Practically, plant waste materials such as lawn clippings, hedges, trees, shrubs, by-products from municipal & domestic parks and gardens, husks, stubble, etc., are used for composting [5]. Under the appropriate composting processes, green garden wastes are excellent sources for growing media. The other waste materials such as clean cardboard, wood wastes, food processing wastes, domestic and commercial kitchen and catering wastes, manures, etc. can be used as compost also. However, materials such as sewage sludge, post-consumer wood waste contaminated with metal, glass, plastic, and potentially toxic preservative materials are not permitted as certified composts [6].

There are variously and widely applied composting methods for industries, namely open static piles, turned windrows & piles, aerated static piles, and in-vessel systems [7]. Different processing methods take one month to several months for composting [8]. The choice of composting technology relies on several local parameters, such as availability of organic waste disposal, the cost of raw materials, the location of the composting facility, the type of compost required by available markets, and environmental legislation [9].

Among different systems of composting, the in-vessel system has many advantages; it requires less space and provides better control for agitation, aeration, and mixing of the compost materials [10]. In-vessel systems, four methods are subdivided. These are the bin method, the rectangular agitated bed method, the silo method, and the rotating tube method [11]. In literature, composting period of an in-vessel composting system can last for 6 to 12 weeks. Among the in-vessel composting systems, the bin method is the simplest, and it can reduce labor requirements, weatherproofing, effective process control, faster composting, reducing land requirements, and qualify output [8].

In the composting process, compost is the end product, and the ratio of carbon and nitrogen (C:N) on the raw materials is a major influent factor [12]. For an effective composting process, raw materials should mix in the C:N ratio of 30:1. pH, moisture content, organic carbon, and electrical conductivity (EC) can also use as indicators for composting [13]. The standards of compost vary across countries. In India, the compost standard for C:N ratio is less than 20, that of pH ranges from 6.5 to 7.5, and total N, P₂O₅, and K₂O content are 0.8%, 0.4%, and

0.4% respectively [14]. Those composts (decaying organic matter) can mix with soils and apply as garden media and potting soils [15].

In Myanmar, Mon State mainly produce paddy, rubber, and oil palm, a large amount of disposal from those industries, such as rice husk, rubber sawdust, twigs and dry leaves from oil palm, etc. are locally available for composting [16]. Also, poultry manure (PM) is one of the locally available raw materials, and it has a C:N ratio of about 5 to 15 [17]. Poultry manure can support as a nitrogen (N) source for the decomposable microorganisms in composting. The addition of PM helps to increase soil moisture, nutrient holding capacity, and to reduce the composting time [18].

Currently, most of rubber nurseries located in Mon State, from where most seedlings are distributed over the country. For successive cultivation of rubber and yearly extension of rubber growing area in Myanmar, the requirement of rubber seedlings is increased [19]. Most rubber growers for nurseries usually use soil as a growing medium. However, loss of the upper soil layer in Mon state is a locally serious problem for growing medium. In addition, using compost in growing media is too costly and not readily available [20]. Local farmers in Mon state want to develop composting methods and effective use of locally available waste materials [1]. Therefore, we conducted this study to investigate the qualities of the different composts made from locally available raw materials in the rubber's nursery production.

2. Materials and Methods

In this experiment, various composts obtained from locally available different raw materials were examined by using an in-vessel composting system and the bin method. The perforated bamboo baskets known as a conventional local design, were used as composting bins in this experiment. The diameter of the basket was 72 cm and it was 72 cm in height.

2.1. Collection and Preparation of Raw Materials

Composting is made by mixing the locally available raw materials with poultry manure (PM). The raw materials used in this experiment were oil palm frond (OPF), rice husk (RH), rice straw (RS), sawdust (SD), and yard waste (a mixture of grass and dry leaves, YW). All raw materials were by-products of agro-industrial wastes and collected from the paddy fields, rubber wood factories, and poultry farms near the Perennial Crops Research and Development Center-PCRDC, Mawlamyine. After collecting, OPF, RS, and YW were chopped and shredded into small pieces of less than 50 mm before composting [21]. Preparation of raw materials is an important factor because the greater surface area, the slower the decomposition rate.

2.2. Preparation for Composting

For composting, each of the collected raw materials of OPF, RH, RS, SD, and

YW were homogeneously mixed with PM to obtain a C:N ratio of 30:1. The amount of materials needed to mix was based on the C:N ratio of composting materials and calculated by using the following equations [11]:

$$C = X_C a + Y_C b \quad (1)$$

$$N = X_N a + Y_N b \quad (2)$$

where;

X_C = Carbon content of material X

Y_C = Carbon content of material Y

a = Mix content of material X

b = Mix content of material Y

X_N = Nitrogen content of material X

Y_N = Nitrogen content of material Y

C = Carbon content of mix

N = Nitrogen content of mix

2.3. Experimental Design and Treatments

The composting experiment was conducted at the Perennial Crops Research and Development Center (PCRDC), Mawlamyine Township, Mon State, from March to May during 2019. The experimental design was a randomized complete block design with four replications. The spacing was 1.7 m × 1.7 m. The total experimental plot was 20. The experiment contained five treatments:

T_1 = Oil palm frond (31.04 kg) + Poultry manure (22.96 kg)

T_2 = Rice husk (40.78 kg) + Poultry manure (13.22 kg)

T_3 = Rice straw (41.00 kg) + Poultry manure (13.00 kg)

T_4 = Sawdust (29.88 kg) + Poultry manure (24.12 kg)

T_5 = Yard waste (42.07 kg) + Poultry manure (11.93 kg)

2.4. Composting

While mixing the raw materials, water is usually added to maintain the moisture content about 50%. The moisture content of each material was calculated by using the following equation [22]:

$$M_n = \left((W_w - W_d) / W_w \right) \times 100 \quad (3)$$

In which:

M_n = Moisture content (%) of material n

W_w = Wet weight of the sample, and

W_d = Weight of the sample after drying

Firstly, the mixtures were placed in the perforated polythene bag, which was inserted into the bamboo basket and shown in **Plate 1(a)**. Perforated polythene bags were drilled with regular spacing of 32 holes (diameter in 5 mm) at the side of the bag for ventilation and 6 holes at the bottom for drainage. Then, the mixers were turned up and down for aeration at a weekly interval.



Plate 1. (a) Composting by using bamboo basket and (b) Measurement of temperature.

2.5. Data Collection

The daily temperature inside of the composts was monitored from three sampling points by using a thermometer, as shown in **Plate 1(b)**. The pH and volume reduction (%) were collected weekly. To identify the completion of composting, indicator $\text{pH} \geq 7.0$ was used [23]. Moreover, the stable volume showed one of the characteristics of well-compost. Then, the samples were air-dried, grounded, sieved with <5 mm mesh, and stored for analysis of the physico-chemical characteristics of the compost, such as bulk density, pH, EC, N, P, K, Ca, and Mg.

2.6. Analysis of Raw Materials and Composts

Before composting and ten weeks after composting, the different raw materials and output composts were analyzed for some characteristics such as pH, EC, organic carbon (OC), total nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) using respective methods [24] [25] [26] [27] [28].

2.7. Statistical Analysis

Analysis of Variance (ANOVA) was performed by the linear model procedure of Statistix (Version 8.0). Mean comparisons were done at the Least Significant Difference (LSD) at a 5% probability level of significance.

3. Results and Discussion

3.1. The Characteristics of Raw Materials

The collected raw materials before composting were sampled and analyzed for their characteristics. The characteristics of raw materials are shown in **Table 1**. The organic matter content of the composting materials varied from 31.26% to 135.04%. The OPF contained maximum organic matter content (135.04%) and that of PM showed the minimum (31.26%). The greatest C:N ratio (192.03) was observed in sawdust and was followed by oil palm frond (OPF), rice husk (RH),

Table 1. Some characteristics of raw materials used in this experiment.

Parameter	OPF	RH	RS	SD	YW	PM
BD ($\text{kg}\cdot\text{m}^{-3}$)	194.75	144.84	116.11	198.70	154.41	372.48
OM (%)	135.04	61.17	97.99	122.49	75.08	31.26
N (%)	0.78	0.38	1.11	0.37	0.75	3.08
P (%)	0.14	0.07	0.48	0.01	0.19	2.07
K (%)	0.54	0.36	1.18	0.06	0.55	1.24
Ca (%)	1.51	0.11	0.35	0.38	0.61	6.55
Mg (%)	0.12	0.04	0.09	0.07	0.11	0.70
C:N ratio	100.42	93.37	51.21	192.03	58.07	5.89

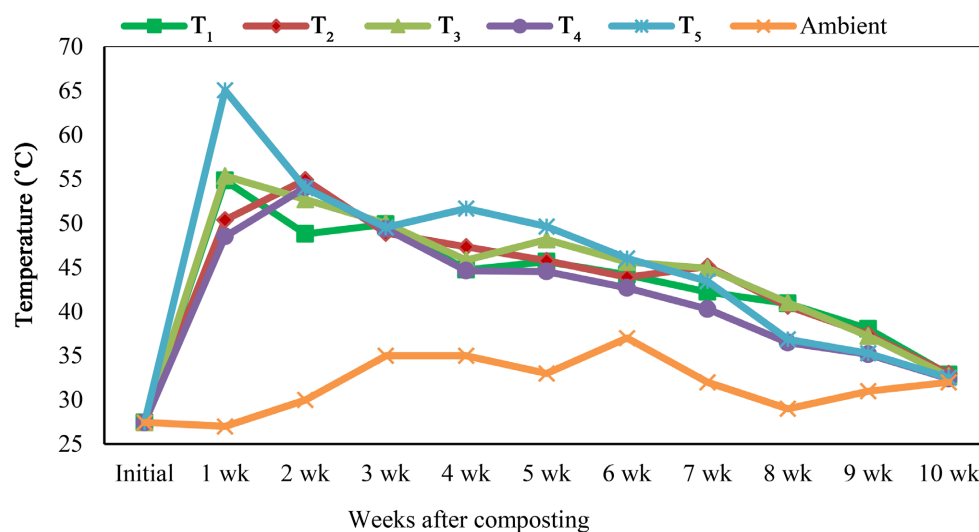
OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure, BD—Bulk density, OM—Organic matter, N—Nitrogen, P—Phosphorus, K—Potassium, Ca—Calcium, Mg—Magnesium, C:N ratio—Carbon: Nitrogen ratio.

yard waste (YW), rice straw (RS), and poultry manure (PM) with 100.42, 93.37, 58.07, 51.21, and 5.89, respectively. The highest value of total N content (3.08%) was observed in PM and the lowest was found in sawdust with 0.37%. According to the analysis results, the highest P, K, Ca, and Mg content were observed in PM with values of 2.07%, 1.24%, 6.55%, and 0.70%, respectively. Among the different raw materials, PM had the highest value of bulk density ($372.48 \text{ kg}\cdot\text{m}^{-3}$). The bulk densities of OPF, SD, YW, RH, and RS were $194.75 \text{ kg}\cdot\text{m}^{-3}$, $198.7 \text{ kg}\cdot\text{m}^{-3}$, $154.41 \text{ kg}\cdot\text{m}^{-3}$, $144.84 \text{ kg}\cdot\text{m}^{-3}$, and $116.11 \text{ kg}\cdot\text{m}^{-3}$, respectively.

3.2. Changes in Temperature by Using Different Raw Materials during Composting

Changes in temperature of the different composts' piles were shown in **Figure 1**. In composting, the initial temperature of all composts with PM was kept near the ambient temperature 27°C (81°F). Then, all treatments rose from ambient to higher levels within 24 hours of composting. However, the increase in temperature of the different raw mixtures varied at different composting stages was shown in **Table 2**. Such a drastic increase in temperature was due to the rapid decomposition of organic raw materials accompanied by various microbial activities [29].

Among the treatments, T_5 (YW + PM) reached the thermophilic stage (40°C to 70°C) within a short period. For T_4 (SD + PM), T_2 (RH + PM), T_1 (OPF + PM), and T_3 (RS + PM), the thermophilic stage started at 3 (days after composting, DAC) and continued through 35 DAC, 39 DAC, 40 DAC, and 50 DAC, respectively. And then the temperature gradually decreases to the ambient temperature at 70 DAC. The temperatures of this thermophilic stage assumed as the most effective and efficient for composting [30]. In the active thermophilic stage of all treatments, a temperature of above 55°C is sufficient to kill pathogens and



T₁ = OPF + PM, T₂ = RH + PM, T₃ = RS + PM, T₄ = SD + PM, T₅ = YW + PM, Ambient = Ambient temperature. OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure.

Figure 1. Changes in weekly temperature by different raw materials used during composting compared with ambient temperature.

Table 2. ANOVA of changes in weekly temperature (°C) due to the effect of different raw materials with poultry manure on composting.

Treatments	Weeks after composting									
	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th
T ₁ —OPF + PM	54.8 ^b	48.8 ^d	49.9	44.7 ^d	45.7 ^c	44.2 ^b	42.2 ^c	40.9 ^a	38.0 ^a	32.9 ^{ab}
T ₂ —RH + PM	50.4 ^c	54.9 ^a	48.9	47.3 ^b	45.8 ^c	43.9 ^b	45.1 ^a	40.6 ^a	37.4 ^b	33.0 ^a
T ₃ —RS + PM	55.4 ^b	52.7 ^c	50.0	45.8 ^c	48.2 ^b	45.6 ^a	44.9 ^a	41.0 ^a	37.2 ^b	32.7 ^{bc}
T ₄ —SD + PM	48.5 ^d	54.1 ^{ab}	49.4	44.6 ^d	44.5 ^d	42.7 ^c	40.3 ^d	36.5 ^b	35.2 ^c	32.4 ^d
T ₅ —YW + PM	65.1 ^a	54.0 ^b	49.5	51.7 ^a	49.6 ^a	46.0 ^a	43.4 ^b	36.9 ^b	35.3 ^c	32.5 ^{cd}
LSD _{0.05}	0.565	0.936	1.153	0.823	0.538	0.605	0.616	0.735	0.487	0.271
Pr > F	<0.001	<0.001	0.291	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
CV (%)	0.67	1.15	1.51	1.14	0.75	0.88	0.93	1.22	0.86	0.54

In a column, means having the same letter are not significantly different at the 5% level. OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure. ANOVA—Analysis of Variance.

weed seeds. In this experiment, T₁ (OPF + PM) reached 55°C at 16 DAC and was maintained the similar temperature for three days. T₂ (RH + PM), T₃ (RS + PM), T₄ (SD + PM), and T₅ (YW + PM) reached 55°C at 9 DAC, 6 DAC, 15 DAC, and 5 DAC and maintained until 14 DAC, 9 DAC, 18 DAC, and 13 DAC, respectively. Compared to maintaining a temperature at 55°C for two days, all treatments were sufficient for maximum sanitation [31]. During composting, changes in the temperature at the thermophilic stage were significantly different

due to different raw material used (Table 1) but for the different composting process, our results were as similar as [32].

3.3. Changes in pH by Using Different Raw Materials during Composting

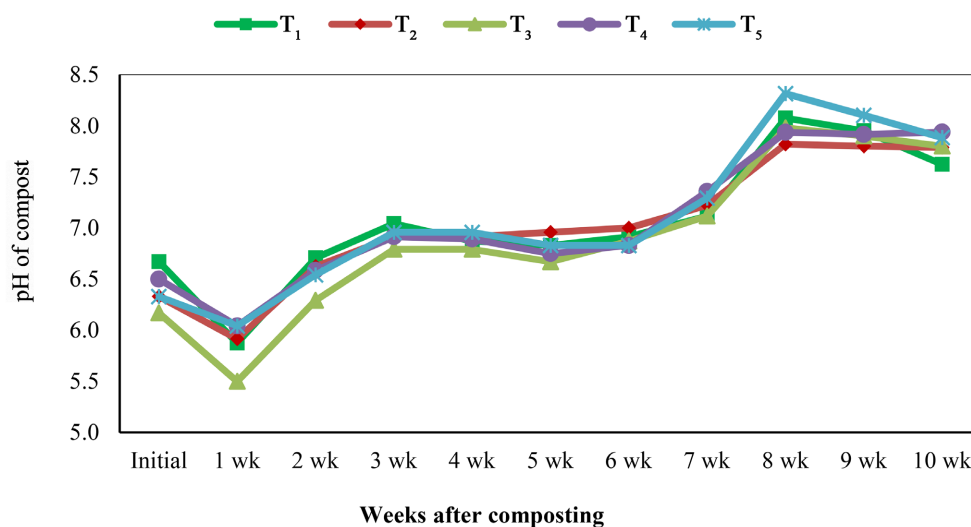
The initial pH of the different raw material mixtures varied from 6.17 to 6.67 and the suitable pH for composting different organic wastes has a range of 5 to 12 [33]. Changes in pH from initial to 10 weeks after composting (WAC) are shown in Figure 2. All treatments showed decreasing trends of changes in pH within a week. The reason was due to the decomposition of organic matter by microbial activities and production of organic acids [34]. Then, the pH of all treatments reached neutral after 3 weeks of composting.

This increase in pH to neutral is caused by the conversion of organic acids to CO_2 with the help of microbial activities during the composting process [35]. Ten weeks after composting, the pH of all treatments reached above 7. The pH range of 6.9 to 8.3 indicated the end of composting and the end-product recognized as the standard compost [36] [37] [38]. These pH values were significantly different among the treatments. Maximum pH value (7.94) was observed in sawdust compost, T_4 (SD + PM) at ten weeks after composting (WAC). That of minimum (7.6) occurred in T_1 (YW + PM)-OPF compost.

3.4. Physico-Chemical Properties of the Different Composts

3.4.1. Volume Reduction (%)

Table 3 shows the volume reduction (%) by using different raw materials during composting. The volume reduction was one of the advantages of composting output [23]. All treatments showed a sharply decrease in volume from 1 WAC to 4 WAC. It was related to the thermophilic temperature range (above 45°C) and



T_1 = OPF + PM, T_2 = RH + PM, T_3 = RS + PM, T_4 = SD + PM, T_5 = YW + PM. OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure.

Figure 2. Changes in weekly pH due to the effect of different raw materials used during composting.

this temperature ensured effective and efficient for composting. Then, the volume reduction (%) was slightly decreased until 8 weeks. This condition was also related to slowly decrease in temperature change and that caused low rate in decomposition of organic matter. At 10 weeks after composting, there was no significant difference among the treatments. However, the lowest volume reduction was observed in T1 (OPF + PM) at zero percent. The highest reduction of 0.91% occurred in T3 (RS + PM). However, the total reduction percent varied with different raw materials from 58.86% to 22.18% as shown in **Table 4**. Similarly, it was observed by [20] and the actual reduction of the different composts could

Table 3. ANOVA of volume reduction (%) in weekly interval due to the effect of different raw materials with PM on composting.

Treatments	Weeks after composting									
	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th
T ₁ —OPF + PM	10.56 ^b	6.11	5.56 ^c	9.17 ^b	1.39 ^{ab}	0.83 ^{ab}	0.00 ^c	1.67	8.89 ^a	0.00
T ₂ —RH + PM	3.92 ^c	9.31	8.09 ^{bc}	3.43 ^c	1.96 ^a	1.23 ^a	3.68 ^a	1.23	6.13 ^b	0.49
T ₃ —RS + PM	14.77 ^a	5.91	13.86 ^a	17.27 ^a	0.00 ^b	0.45 ^{ab}	0.91 ^b	1.14	3.64 ^c	0.91
T ₄ —SD + PM	10.48 ^b	6.45	0.81 ^d	1.61 ^c	0.00 ^b	0.00 ^b	0.00 ^c	2.42	0.00 ^d	0.40
T ₅ —YW + PM	17.96 ^a	10.91	8.86 ^b	9.32 ^b	0.00 ^b	1.36 ^a	0.00 ^c	2.73	2.95 ^c	0.23
LSD _{0.05}	4.015	4.671	2.662	3.418	1.551	0.916	0.841	1.281	2.365	0.967
Pr > F	<0.001	0.131	<0.001	<0.001	0.041	0.039	<0.001	0.066	<0.001	0.376
CV (%)	22.59	39.18	23.24	27.19	150.23	76.66	59.54	45.3	35.52	154.68

In a column, means having the same letter are not significantly different at the 5% level. OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure ANOVA—Analysis of Variance.

Table 4. Total volume reduction (%) in weekly interval of the effect of different raw materials with PM on composting.

Treatments	Weeks after composting									
	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th
T ₁ —OPF + PM	10.56 ^b	16.67 ^c	22.22 ^c	31.39 ^c	32.78 ^c	33.61 ^b	33.61 ^c	35.28 ^c	44.17 ^c	44.17 ^c
T ₂ —RH + PM	3.92 ^c	13.24 ^d	21.32 ^c	24.76 ^d	26.72 ^d	27.94 ^c	31.62 ^c	32.84 ^c	38.97 ^d	39.46 ^d
T ₃ —RS + PM	14.77 ^a	20.68 ^b	34.55 ^b	51.82 ^a	51.82 ^a	52.27 ^a	53.18 ^a	54.32 ^a	57.96 ^a	58.86 ^a
T ₄ —SD + PM	10.48 ^b	16.94 ^c	17.74 ^d	19.36 ^e	19.36 ^e	19.36 ^d	19.36 ^d	21.77 ^d	21.77 ^e	22.18 ^e
T ₅ —YW + PM	17.96 ^a	28.86 ^a	37.73 ^a	47.05 ^b	47.05 ^b	48.41 ^a	48.64 ^b	51.14 ^b	54.09 ^b	54.32 ^b
LSD _{0.05}	4.015	3.165	1.545	3.601	4.337	3.922	3.650	2.863	1.134	1.489
Pr > F	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CV (%)	22.59	10.66	3.75	6.70	7.92	7.01	6.35	4.76	1.70	2.21

In a column, means having the same letter are not significantly different at the 5% level. OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure.

vary with the different materials used, weather conditions, and the size of the reduction prior to composting. In this study, maximum reduction (58.86%) found in T₃ (RS + PM) and that of minimum (22.18%) was in T₄ (SD + PM). In the observation of [30], manure could reduce the compost's volume by 30 to 50%.

3.4.2. Weight Reduction

At the end of decomposition (10 WAC), weight losses from all treatments were significantly different ($P < 0.01$) at (in **Table 5**). Maximum reduction (44.18%) occurred in T₃ (RS + PM) and that of minimum (31.13%) was in T₄ (SD + PM). Similar finding was observed by [39].

3.4.3. Bulk Density

In **Table 5**, there was a significant difference among different composts at 10 WAC ($P < 0.01$). Among different treatments, T₃ (RS + PM) had the maximum value of bulk density (442.56 kg·m⁻³) and that T₂ (RH + PM) had the minimum (296.23 kg·m⁻³). All values from these treatments were under the standard rate of compost of less than 1000 kg·m⁻³ [14].

3.4.4. Electrical Conductivity (EC)

Among the treatments, EC of T₁ (OPF + PM) was the maximum value (2.33 dS·m⁻¹). That of minimum (1.53 dS·m⁻¹) was observed in T₃ (RS + PM) and T₅ (YW + PM) (in **Table 5**). All results in this study reached the standard EC value (<3.5) [36]. As the end product of EC values were related to different salt contents, higher contents of K, Ca, and Mg in T₃ were the reason of maximum EC value (in **Table 5**).

Table 5. Weight reduction (%), bulk density (BD), electrical conductivity (EC), organic matter (OM), nitrogen (N) and carbon: nitrogen ratio (C:N) of different composts of the effect of different raw materials with poultry manure on composting.

Treatments	Wt. reduction (%)	BD (kg·m ⁻³)	EC (dS·m ⁻¹)	OM (%)	N (%)	C:N ratio
T ₁ —OPF + PM	34.03 ^b	381.12 ^b	2.33 ^a	58.27 ^c	2.36 ^b	14.39 ^b
T ₂ —RH + PM	34.42 ^b	296.23 ^c	1.68 ^{bc}	51.02 ^{ab}	1.51 ^c	19.67 ^a
T ₃ —RS + PM	44.18 ^a	442.56 ^a	1.53 ^c	59.08 ^{bc}	2.45 ^b	14.07 ^b
T ₄ —SD + PM	31.13 ^c	438.08 ^a	1.82 ^b	58.17 ^c	2.28 ^b	14.84 ^b
T ₅ —YW + PM	43.46 ^a	401.96 ^b	1.53 ^c	60.58 ^a	2.66 ^a	13.21 ^c
LSD _{0.05}	1.230	33.337	0.194	1.769	0.174	0.790
Pr > F	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CV (%)	2.13	5.52	7.07	5.45	4.87	3.42

In a column, means having the same letter are not significantly different at the 5% level. OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure.

3.4.5. Organic Matter

At 10 WAC, the organic matter contents of all composts were highly significant ($P < 0.01$) in **Table 5**. The largest amount of OM (60.58%) observed in T_5 (YW + PM), then followed by T_3 (RS + PM), T_1 (OPF + PM), T_4 (SD + PM) and T_2 (RH + PM) with values of 59.08%, 58.27%, 58.17% and 51.02% respectively. Due to the recommended value ($\geq 35\%$), all composts were in the range [36]. When compared to the reduction percentage before and after composting, the greatest loss of OM (35.9%) occurred in T_1 (OPF + PM) and T_2 (RH + PM) lost at least (5.25%) as shown in **Table 6**.

3.4.6. Some Nutritional Contents and Their Variations

Some nutritional contents such as total nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) and their variations (differences before & after composting) were shown in **Tables 5-7**.

Table 6. Variation of physico-chemical properties of different composts as affected by different raw materials with PM on composting over the initial stage of mixture of raw materials.

Particulars	Variation as % of initial stage				
	T_1 —OPF + PM	T_2 —RH + PM	T_3 —RS + PM	T_4 —SD + PM	T_5 —YW + PM
OM	-35.90	-5.25	-27.88	-28.83	-7.36
N	33.95	44.71	54.75	43.99	111.11
P	37.16	0.59	205.71	42.37	275.54
K	80.69	118.93	93.58	158.45	134.32
Ca	-0.39	39.83	177.72	75.51	168.68
Mg	131.97	219.12	269.38	176.29	481.88

OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure OM—Organic matter, N—Nitrogen, P—Phosphorus, K—Potassium, Ca—Calcium, Mg—Magnesium.

Table 7. Total P, K, Ca and Mg of different composts at 10 WAC.

Treatments	P (%)	K (%)	Ca (%)	Mg (%)
T_1 —OPF + PM	1.32 ^c	1.52 ^b	3.64 ^b	0.85 ^c
T_2 —RH + PM	0.56 ^d	1.28 ^c	2.36 ^c	0.65 ^d
T_3 —RS + PM	2.63 ^a	2.32 ^a	5.10 ^a	0.89 ^{bc}
T_4 —SD + PM	1.33 ^c	1.53 ^b	5.51 ^a	0.97 ^b
T_5 —YW + PM	2.28 ^b	1.64 ^b	5.16 ^a	1.40 ^a
LSD _{0.05}	0.018	0.140	0.589	0.081
Pr>F	0.000	0.000	0.000	0.000
CV (%)	0.72	5.46	8.78	5.50

In a column, means having the same letter are not significantly different at the 5% level. OPF—Oil palm frond, RH—Rice husk, RS—Rice straw, SD—Sawdust, YW—Yard waste, PM—Poultry manure P—Phosphorus, K—Potassium, Ca—Calcium, Mg—Magnesium.

Nitrogen content (N) in different composts was highly significant at $P < 0.01$ (**Table 5**). Maximum content of N (2.66%) showed in T₅ (YW + PM) which variation was increased to 111.11% (**Table 6**). The minimum N content (1.51%) was in T₂ (RH + PM) and this value occurred under the standard rate of N ($\geq 1.0\%$) for compost [36]. The reason was that available nutrients released during composting [34]. Statistically, T₃ (RS + PM) showed the significant difference in P, K, Ca contents among the treatments at $P < 0.01$. Wherein T₂ had the lowest contents in all measured nutrients. Other three composts showed the proper amount of nutrients (**Table 7**). When compared in increment of P, T₅ (YW + PM) showed the maximum value of 275.54%. In the increment of Ca & Mg, T₃ (RS + PM) showed the largest 177.72% and 269.38%. In potassium, the largest increase occurred in T₄ (SD + PM) (in **Table 6**).

Although the initial C:N ratios of all treatments were the same as 30:1, those of the final products from different composts at 10 WAC were significantly different at $P < 0.01$ (**Table 5**). C:N ratios of four composts except T₂ (RH + PM) were lower than 15 which was described as the maturity index [40]. Among them, T₅ (YW + PM) provided the lowest C:N ratio of 13.2. The reason for lower C:N ratios after composting was that microorganisms utilized carbon as an energy source and as a basic building block, and they were making up about 50% of the mass of microbial cells during composting [30]. The reason of high C:N ratio in T₂ (RH + PM) was that RH contained high content of silica and lignin. It was difficult to degraded [41].

4. Conclusion

The present study conducted to fulfill one of the demands for local growers in the rubber nursery production in Mon State. According to changes in temperature and pH, the local raw materials adding poultry manure were composted completely after eight weeks. Although the volume of all composts did not change after 8 weeks, some nutrient contents of tested composts with the bin method showed differently at 10 weeks. Composts from the yard waste, rice straw, and sawdust with proper C:N ratios had maximum P, K, and Ca, respectively. Wherein, rice husk compost contained the lowest N, P, K, Ca, and Mg with the maximum C:N. Thus, composts from yard waste, rice straw, and sawdust could be selected as a constituent of potting medium for raising the nursery seedlings. This study also suggested to compare the growth of nursery seedlings and to investigate further agronomic characters & micro-organisms application in rubber production.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Soe, K.H., Ngwe, K., Soe, Y.M., Win, K.K. and Oo, A.N. (2022) Assessment of Farmer's Practices on the Rubber Nursery Management Using Growing Medium and Varietal Selection in Mon State. <https://doi.org/10.4236/as.2022.133021>
- [2] Liu, G., Simonne, E.H., Morgan, K.T., Hochmuth, G.J., Ozores-Hampton, M., Agehara, S., Dittmar, P.J., *et al.* (2016) Fertilizer Management for Vegetable Production in Florida. In: *Vegetable Production Handbook of Florida*, Vol. 17, IFAS Extension, University of Florida, 3-10.
- [3] Goyal, S., Singh, D., Suneja, S. and Kapoor, K.K. (2009) Effect of Rice Straw Compost on Soil Microbiological Properties and Yield of Rice. *Indian Journal of Agricultural Research*, **43**, 263-268.
- [4] Wilkinson, K.M., Landis, T.D., Haase, D.L., Daley, B.F. and Dumroese, R.K. (2014) Tropical Nursery Manual: A Guide to Starting and Operating a Nursery for Native and Traditional Plants. Agriculture Handbook 732. US Department of Agriculture, Forest Service, Washington DC, 376 p.
- [5] Munjuga, M.R., Gachuri, A.N., Ofori, D.A., Mpanda, M.M., Muriuki, J.K., Jamnadas, R.H. and Mowo, J.G. (2013) Nursery Management, Tree Propagation and Marketing: A Training Manual for Smallholder Farmers and Nursery Operators. World Agroforestry Centre, Nairobi.
- [6] Waste and Resources Action Programme (2014) Guidelines for the Specification of Quality Compost for Use in Growing Media. Waste and Resources Action Programme.
- [7] Hubbe, M.A., Nazhad, M. and Sánchez, C. (2010) Composting as a Way to Convert Cellulosic Biomass and Organic Waste into High-Value Soil Amendments: A Review. *BioResources*, **5**, 2808-2854. <https://doi.org/10.15376/biores.5.4.2808-2854>
- [8] Misra, R.V. and Roy, R.N. (2002) On-Farm Composting Methods. UN-FAO, Rome.
- [9] Border, D. (2002) Processes and Plant for Waste Composting and Other Aerobic Treatment. Environment Agency, R&D Technical Report P1-311/TR.
- [10] Kim, J.D., Park, J.S., In, B.H., Kim, D. and Namkoong, W. (2008) Evaluation of Pilot-Scale In-Vessel Composting for Food Waste Treatment. *Journal of Hazardous Materials*, **154**, 272-277. <https://doi.org/10.1016/j.jhazmat.2007.10.023>
- [11] Graves, R.E. and Hattermer, G.M. (2000) Chapter 2 Composting. Part 637 Environmental Engineering National Engineering Handbook. United States Department of Agriculture. Natural Resources Conservation Service. 210-VI-NEH.
- [12] United Nations Conference on Trade and Development (2003) United Nations Conference on Trade and Development—Organic Fruit and Vegetables from the Tropics.
- [13] Vargas, D.C., Monedero, M.S., Urpilainen, S.T., Kamilaki, A. and Stentiford, E.I. (2005) Assessing the Stability and Maturity of Compost at Large-Scale Plants. *Ingeniería*, **9**, 25-30.
- [14] The Fertilizer Association of India, New Delhi (1985) The Fertilizer (Control) Or-

der.

- [15] Marr, C.W., Carey, T., Cloyd, R. and Kennelly, M. (2010) Garden Guide, Kansas State University.
- [16] Department of Agriculture, Mon State (2021) Annual Report, Department of Agriculture, Ministry of Agriculture, Livestock and Irrigation, Myanmar.
- [17] Cooperband, L. (2002) The Art and Science of Composting. Center for Integrated Agricultural Systems, Madison.
- [18] McCall, W.W. (1980) Chicken Manure.
- [19] Department of Agriculture, Mon State (2020) Annual Report, Department of Agriculture, Ministry of Agriculture, Livestock and Irrigation.
- [20] Miller, J.H. and Jones, N. (1995) Organic and Compost-Based Growing Media for Tree Seedling Nurseries (Vol. 264). World Bank Publications.
- [21] Dalzell, H.W., Dalzell, H.E., Biddlestone, A.J., Gray, K.R. and Thurairajan, K. (1987) Soil Management: Compost Production and Use in Tropical and Subtropical Environments (No. 56). Food and Agriculture Organization, Rome.
- [22] Trautmann, N. and Richards, T. (1996) Moisture Content. Cornell Composting. Science and Engineering. Cornell Waste Management Institute, Ithaca.
- [23] Jann, G.J., Howard, D.H. and Salle, A.J. (1959) Method for the Determination of Completion of Composting. *Applied Microbiology*, **7**, 271-275.
<https://doi.org/10.1128/am.7.5.271-275.1959>
- [24] Hoffmann, G. (1991) Book of Methods. Volume 1, The Analysis of Soils.
- [25] Sánchez-Monedero, M.A., Roig, A., Paredes, C. and Bernal, M.P. (2001) Nitrogen Transformation during Organic Waste Composting by the Rutgers System and Its Effects on pH, EC and Maturity of the Composting Mixtures. *Bioresource Technology*, **78**, 301-308. [https://doi.org/10.1016/S0960-8524\(01\)00031-1](https://doi.org/10.1016/S0960-8524(01)00031-1)
- [26] Walkey, A. and Black, I.A. (1947) A Critical Examination of a Rapid Method for Determining Organic Carbon in Soils-Effect of Variations in Digestion Conditions and of Inorganic Soil Constituents. *Soil Science*, **63**, 251-264.
<https://doi.org/10.1097/00010694-194704000-00001>
- [27] Yang, S.S. (1991) Reduce Waste Production with Modified Kjeldahl Method for Nitrogen Measurement. *Journal of the Biomass Energy Society of China*, **10**, 147-155.
- [28] Rashid, A. (1986) Mapping Zinc Fertility of Using Indicator Plants and Soil Analyses (Seed, Geostatistics, Hawaii, Colorado). University of Hawai'i, Manoa.
- [29] Sarkar, P. and Chourasia, R. (2017) Bioconversion of Organic Solid Wastes into Biofortified Compost Using A Microbial Consortium. *International Journal of Recycling of Organic Waste in Agriculture*, **6**, 321-334.
<https://doi.org/10.1007/s40093-017-0180-8>
- [30] Chen, L., de Haro Marti, M., Moore, A. and Falen, C. (2011) The Composting Process. *Dairy Manure Compost Production and Use in Idaho*, **2**, 513-532.
- [31] Stentiford, E.I. (1996) Composting Control: Principles and Practice. In: *The Science of Composting*, Springer, Dordrecht, 49-59.
https://doi.org/10.1007/978-94-009-1569-5_6
- [32] Qasim, W., Lee, M.H., Moon, B.E., Okyere, F.G., Khan, F., Nafees, M. and Kim, H.T. (2018) Composting of Chicken Manure with a Mixture of Sawdust and Wood Shavings under Forced Aeration in a Closed Reactor System. *International Journal of Recycling of Organic Waste in Agriculture*, **7**, 261-267.
<https://doi.org/10.1007/s40093-018-0212-z>

- [33] Wilson, G.B. (1989) Combining Raw Materials for Composting. *BioCycle*, **30**, 82-85.
- [34] Iqbal, M.K., Nadeem, A., Khan, R.A. and Hussnain, A. (2012) Comparative Study of Different Techniques of Composting and Their Stability Evaluation in Municipal Solid Waste. *Journal of the Chemical Society of Pakistan*, **34**, 273.
- [35] Seo, J.Y., Heo, J.S., Kim, T.H., Joo, W.H. and Crohn, D.M. (2004) Effect of Vermiculite Addition on Compost Produced from Korean Food Wastes. *Waste Management*, **24**, 981-987. <https://doi.org/10.1016/j.wasman.2004.08.002>
- [36] Compost, T.A.S. (2005) TAS9503-2005. National Bureau of Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperative, Bangkok.
- [37] Na Mona, B. (2003) Compost Testing and Analysis Service Interpretation of Results. Bord na Mona, Newbridge Co., Kildare.
- [38] Hoitink, H.A.J. and Poole, H.A. (1980) Factors Affecting Quality of [Tree Bark] Composts for Utilization in Container Media. *HortScience*, **15**, 171-173.
- [39] Poincelot, R.P. (1975) The Biochemistry and Methodology of Composting. The Connecticut Agricultural Experiment Station, Bulletins, 754, 1-18.
- [40] van der Wurff, A.W., Fuchs, J.G., Raviv, M. and Termorshuizen, A. (2016) Handbook for Composting and Compost Use in Organic Horticulture. BioGreenhouse.
- [41] Thiyageshwari, S., Gayathri, P., Krishnamoorthy, R., Anandham, R. and Paul, D. (2018) Exploration of Rice Husk Compost as an Alternate Organic Manure to Enhance the Productivity of Blackgram in Typic Haplustalf and Typic Rhodustalf. *International Journal of Environmental Research and Public Health*, **15**, 358. <https://doi.org/10.3390/ijerph15020358>