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Microbial decomposition of longan leaf: I. physico-chemical and biological changes during composting

Pattarin Kudreaung[1], Yupa Chromkaew[2], Kawiporn Chinachanta[2], Fapailin Chaiwan[2] and Arawan Shutsrirung[2,*]

[1]Philosophy Program in Soil Science and Natural Resources Management, Graduate School, Chiang Mai University, Chiang Mai, Thailand
[2]Department of Plant and Soil Sciences, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand
[*]Corresponding author: arawan.s@cmu.ac.th

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Abstract

Longan is an economic fruit crop of Northern Thailand. Incineration of longan residues from pruning is practiced, leading to environmental pollution. The more sustainable way is to convert the wastes into compost. In this study, therefore, composting of longan leaves was performed to monitor changes in physico-chemical and biological properties. There were three treatments including 1) longan leaves+cow dung (LC), 2) rice straw+cow dung (RC) and 3) longan leaves+rain tree leaves+cow dung (LRC). Our results indicated that, at day-120, adding rain tree leaves to longan leaves in LRC provided the lowest C:N ratio (24.2:1) while the highest one was found in LC (40.3:1). The high N applied treatments (LRC and LC) appeared to reach maturity germination index (GI) >80% earlier than that with low N content (RC). Humic acid concentration of RC and LC was around 4 times higher than their initial values, indicating high rate of humification process. The total N (TN) of all treatments tended to increase with composting time. The highest TN was recorded in LRC (2.7%) while RC gave the highest total P and K (0.25 and 2.99%, respectively). The bacterial population ranged from 2.2×10^6 to 2.6×10^8 colony forming unit (CFU)/g. The fungal population was low ($\approx 10^6$ CFU/g) at early stage of composting and afterwards the population increased to around 10^7 CFU/g. In contrast to bacteria and fungi, the number of actinomycetes was quite high ($\approx 10^8$ CFU/g). Bacteria, fungi and actinomycetes existing in the composts could be developed as a driving agent for rapid composting of longan leaves.

Keywords: Compost, Germination index, Humic acid, Longan leaves, Microorganisms

1. Introduction

In Thailand, crop residues have become one of the most important pollution problems due to open incineration of the residues on farm which is a common practice among Thai farmers for land clearing. The incineration of crop residues generates various greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), carbon monoxide (CO), nitrogen oxide (NO_X) and sulfur dioxide (SO_2), which has led to global warming so far. In addition to GHGs, the levels of particulate matter (PM) and smog is also increased [1,2]. Crop residue burning not only negatively affects soil biodiversity and fertility [3] but also reduces crop yield. Composting of crop residues and applying the output to agricultural land are a sustainable way to handle agricultural wastes because it can bring back plant nutrients and organic matter to the soils, improving soil structure, water holding capacity of soil and as well as soil microbial population. Composting is a natural biological process of decomposition and transformation of organic residues into humus and humic-like substances, carried out under controlled aerobic conditions (such as aeration, moisture content and C:N ratio). Bacteria, fungi and actinomycetes are the largest group of microorganisms involved in the composting process [4]. Besides these factors, chemical structure and the content of cellulose, hemicellulose and lignin of crop residues are also the key factors determining the decomposition rate of crop residues. In general, crop residues are consisted of cellulose (30-75%), lignin (15-40%) and hemicelluloses (7-25%) [5]. Some fruit tree leaves such as avocado, longan, mango and coffee leaves have a thick layer of waxy cuticle on their epidermis thus subjected to resistant to microbial decomposition process [6]. Cuticle is the outer skin of all aerial parts of plants and its thickness of leaves varies >100 times across species. Cuticle is composed of cutin, polysaccharides and waxes which make it difficult for decomposing by microbes [6].

Longan (*Dimocerpus longan* L.) is widely grown in the Northern part of Thailand, particularly in the upper provinces e.g. Chiang Mai, Lamphun, Chiang Rai and Lampang province [7]. It is Thailand's second-most exported fruit in terms of value after pineapple and ranked second in harvested area after mango with production area of approximately 160,000 hectares [7,8]. Heavy pruning of longan trees after harvest is a common practice of Thai farmers therefore, longan leaves are one of the most abundant agricultural wastes in the fruit orchard of the Northern part of Thailand. This organic material is difficult and expensive to collect, so the majority of the dry leaves are burned to ash after harvesting the longan fruit and tree pruning operations (between August and December). Open-air waste incineration has been used to eliminate any residues from the pruning and this causes considerable environmental pollution. More sustainable uses such as composting of pruning wastes from longan are increasingly important. However, recycling could be encouraged by the development of alternative composting methods and the implementation of local legislation to prevent incineration. Recently, attempts have been made to use longan leaves for compost production. However, due to low decomposition rate of the waxy leaves, the composting is not widely accepted. Although many studies have been carried out to investigate the decomposition of agricultural waste, but little is related to composting of longan leaves.

Hence, it is important to provide more data related to possibility and appropriate techniques of composting longan leaves and to better understand the decomposition processes. The aims of the present paper were therefore firstly to determine the changes in physical, chemical and biological properties in the longan leaves compost pile. Secondly, in the further study, compost microorganisms would be subjected to examine and develop as microbial product for rapid composting of longan leaves. The study was among the first attempts to investigate the decomposition rate of longan leaves in Thailand.

2. Materials and methods

2.1 Composting Materials

The materials used in this study were longan leaves, rice straw, rain tree leaves and cow dung. Longan leaves were obtained during longan tree pruning in farmers orchards in Chiang Mai, Lamphun and Lampang province. Rice straw and cow dung were purchased from a rice processing plant and farmers near the experimental location. Fallen rain tree leaves were collected around trees in Lampang province. All the composting materials were kept under shade in a screenhouse until use.

2.2 Composting experiment

In the present study, completely randomized design (CRD) was applied in this experiment with three replications in a screenhouse. Three treatments were conducted as follows;

Treatment 1: longan leaves+cow dung (LC) (10:2 w/w)
Treatment 2: rice straw+cow dung (RC) (10:2 w/w)
Treatment 3: longan leaves+rain tree leaves+cow dung (LRC) (5:5:2 w/w).

Ten kilograms of single or mixed materials were mixed with two kilograms of cow dung on a dry weight basis according to treatment. Water was added to each treatment until reach optimum moisture content (no water seeps out when the compost was squeezed; the water content was approximately under 40%). After that, mixing waste components were put in the plastic-net cabinet (80x80x100 cm) and allowed to decompose for 120 d.

2.3 Physico-chemical analysis of compost product

The samples of compost product from all treatments were collected for physico-chemical analysis at 0, 7, 14, 30, 60, 90 and 120 d after composting. All the samples were analyzed for temperature, acid-base characteristics (pH), organic matter content (%OM), carbon:nitrogen ratio (C:N ratio), germination index (GI), total nutrient contents; nitrogen (N), phosphorus (P) and potassium (K). The methods of analysis were as described by Department of Agricultural Extension (DOA) [9]. Humic acid was also determined by the method described by Jayaganesh and Senthurpandian [10].

2.4 Biological analysis of compost product

2.4.1 Enumeration of microorganisms

Dilution plate technique was adopted for enumeration of the microbial population (bacteria, actinomycetes and fungi) in the compost. Ten grams of each compost sample was added to 95 mL of sterile distilled water to get 10^{-1} dilution. Then, serial dilution was made from 10^{-2}-10^{-5} dilution. There were three replications for each compost sample; drop plate technique was used by dropping 0.01 mL of the desired dilution (10^{-4} dilution for fungi and actinomycetes, 10^{-5} and dilution for bacteria)

2.4.2 Culture Media

Egg Albumin agar: The medium contained (all in g/L), glucose 1.0, egg albumin 0.25, KH_2PO_4 0.5, $MgSO_4.7H_2O$ 0.2, $Fe_2(SO_4)_3.9H_2O$ 0.01 and agar 15. The pH of the medium was adjusted to 7.0 by HCl before autoclaving at 121˚C for 15 min. This culture media was used for bacterial counting.

Rose Bengal agar: The medium contained (all in g/L), glucose 1.0, peptone 5, K_2HPO_4 1.0, $MgSO_4.7H_20$ 0.5, Rose Bengal 0.035, agar 15. Streptomycin was added to warm agar medium (50-60 ˚C) prior to plating. This culture media was used for fungal counting.

Inhibitory Mold Broth-2 (IMB-2): The medium contained (all in g/L), D-glucose 5.0, starch soluble 5.0, beef extract 1.0, yeast extract 1.0, Nz-case 2.0 and $CaCO_3$ 1.0. For solid medium (Inhibitory Mold Agar-2 (IMA-2), agar 15 g was added. The pH of the medium was adjusted to 7.2 before autoclaving at 121˚C for 15 min. Antibiotics were added to warm agar medium (50-60 ˚C) prior to plating: trimethoprim 20 mg/L, naldixic 10 mg/L and heritage 10 mL/L. This culture media was used for actinomycetal counting.

2.5 Statistical analysis

The data of nutrient composition of compost product at day 120, were subjected to analysis of variance by Statistix 8.0 (Tallahassee, FL, USA). The differences among various treatment means were analyzed by one-way analysis of variance (ANOVA) to determine if they were different from one another. Differences between means were tested by LSD at a significance level of $p<0.05$.

3. Results and discussion

3.1 Physico-chemical changes at different stages of composting

Composting is a bio-oxidative microbial degradation process that can be influenced by many factors, such as chemical structure of organic substrate(s), C:N ratio, size of raw materials, size of compost pile, moisture and aeration. These factors affect how long composting takes and how much heat is generated. In the present study, different types and mixture of raw materials of composting resulted in different properties during incubation period (120 d).

The temperature of compost piles in this study typically followed a pattern of rapid increase above 40 ˚C at early stage of composting and finally to ambient air temperature. The temperature of all treatments increased at early stage of the composting process due to microbial degradation of easily decomposable fractions. All the treatments gave the maximum-temperature of compost pile at day 14 after incubation. The rice straw compost (Treatment 2) gave higher maximum-temperature (45.3 ˚C) than longan leaves compost (42.7 ˚C) (Treatment 1) and longan leaves+rain tree leaves compost (40.3 ˚C) (Treatment 3) (Figure 1A). This phenomenon implied that longan leaves in the compost seemed to have the lowest amount of the easily decomposable fractions. The maximum temperature in the compost pile depends on several factors such as types of organic materials, size and height of compost pile. Under appropriate conditions (e.g. aeration, microbial activity) of mass compost production, the temperature can rise well above 80 ˚C. In general, maximum-temperature of the compost piles conducted in lab or experimental scale was around 28 to 65 ˚C [11-13]. Temperature determines the sanitation capacity of the process by microbial activity since high temperature (>83 ˚C for 3 d) destroy all the weed seeds [14] and some pathogens [15] in the compost pile. In the present study, after 14 d, the temperature of all the treatments gradually decreased and stabilized around 120 d and reached an ambient temperature suggesting that the active composting was completed.

The compost piles under this study were slightly acidic to alkaline range (6.7 to 8.7) (Figure 1B). The pH of rice straw compost (treatment 2) remained alkaline (8.1 to 8.7) throughout composting process while the pH of LC and LRC slightly decreased at 7 d and slightly increased at 14 d. In general, various types of organic acids are produced during microbial decomposition of organic matter thus causes an increase of acidity. The alkalinity of compost is due to the presence of low amount of short chain organic acids mainly lactic acid and acetic acid [16].

The transition from mesophilic to thermophilic stage during composting results in the more alkalinity of the pile [17]. After thermophilic stage, the pH of compost increased as the result of volatilization and microbial decomposition of organic acids, and the release of ammonia by microbial mineralization of organic nitrogen [18].

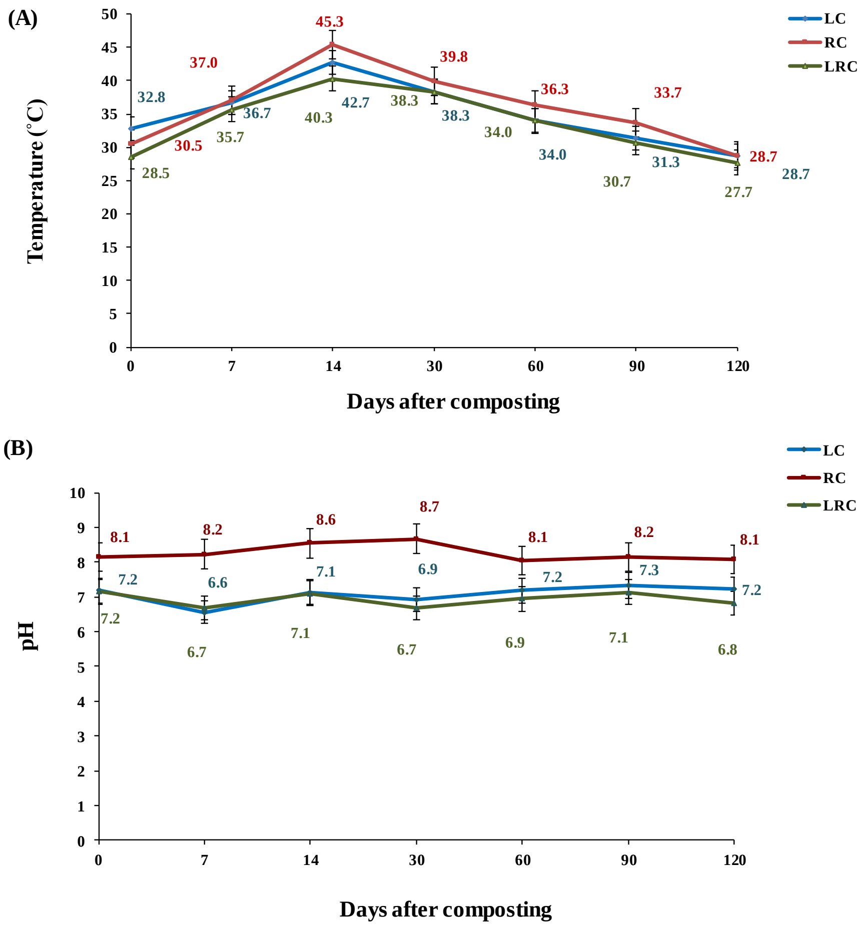

Figure 1 Changes in (A) temperature and (B) pH of compost product, at different stages of composting. The error bars represent the standard deviation of measurements for 3 compost samples. LC=longan leaves+cow dung; RC=rice straw+cow dung; LRC=longan leaves+rain tree leaves+cow dung.

On the average, weight losses for RC were around 50% of initial weight after 90 d of composting. Weight losses for treatments containing longan leaves were less than rice straw (data no shown). This result indicated that chemical composition of longan leaves was more difficult for microorganisms to degrade than that of rice straw. In addition, longan leaf also has waxy surface which is difficult for microorganisms to break down thus it would take longer time for composting process. The maximum weight loss of RC was associated with the higher mineralization of organic matter than that of LC (Figure 2A).

At the beginning of composting, similar organic matter content (OM) was recorded in compost which contained longan leaves (LC & LRC) (62%) while OM in RC was less than LC and LRC (57.9%). Due to microbial activity, OM of all the treatments decreased with time of incubation. The OM of LC and LRC maintained higher than that of RC from the beginning until day 30 of composting, then only OM of LRC which contained rain tree leaves (high nitrogen material) sharply decreased and exhibited lower OM content (26.08%) than that of RC (35.9%) at day 90 of composting. This phenomenon implied that high nitrogen material (rain tree leaves) could effectively accelerate decomposition of longan leaves. At the end of composting period (120 d), the highest OM content was observed in LC followed by RC and LRC, 40.3, 32 and 24.2%, respectively. In general, OM content decreased during microbial decomposition and the mature compost normally contain organic matter below 30%.

The carbon:nitrogen (C:N) ratio of compost is an important factor that determines the rate of organic matter decomposition. The higher an initial C:N ratio is, the slower process at the beginning of the decomposition becomes. So, it requires longer composting time [19]. The supplement of a nitrogen source such as manure and organic waste materials rich in nitrogen such as rain tree leaves could help accelerating the decomposition processes. In the present study, the addition of rain tree leaves (3.2% N) in longan leaves composts in Treatment

3 resulted in lower C:N ratio (14.4:1) when compared to C:N ratio of longan leaves alone in Treatment 1 (20.5:1) (Figure 2B). In general, the decomposition rate of composts with low initial C:N ratios was faster than in composts with high initial C:N ratio. In the present study, however, RC with initial C:N ratio of 23.4:1 exhibited faster decreased in OM than LC and LRC with the initial C:N ratio of 20.6:1 and 14.4:1, respectively. These results might be due to differences in chemical composition of the raw materials. After 120 d of composting, the C:N ratio of LC and RC was similar and decreased to 10.7:1 and 11.6:1, respectively. The lowest C:N ratio was obtained with LRC with value of 5:1. This might be due to high nitrogen content in rain tree leaves (Figure 2B).

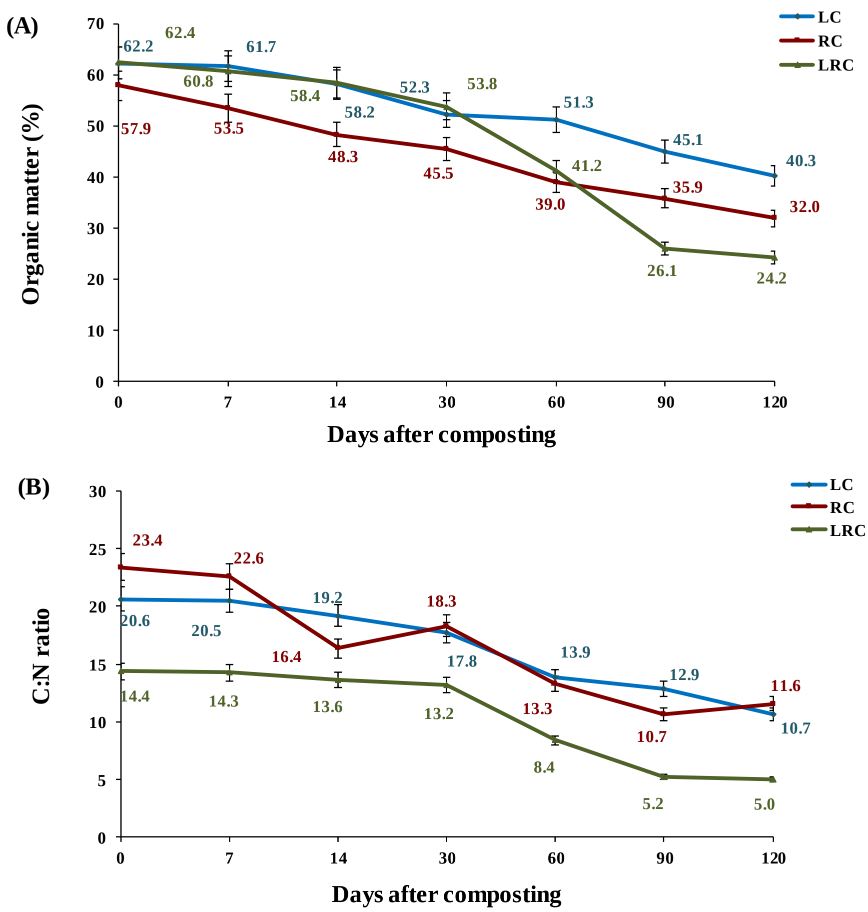

Figure 2 Changes in (A) organic matter and (B) C:N ratio of compost product, at different stages of composting. The error bars represent the standard deviation of measurements for 3 compost samples. LC=longan leaves+cow dung; RC=rice straw+cow dung; LRC=longan leaves+rain tree leaves+cow dung.

During the active composting stage (immature/unstabilized compost), various intermediate substances are produced as a result of microbial activity. These substances are collectively called phytotoxins such as heavy metals, phenolic compounds, ethylene, free ammonia, excess salts and organic acids. Phytotoxins in immature compost particularly short-chain organic acids can limit seed germination and root development [20-22]. Germination index (GI) is one of the most important criteria to evaluate the maturity of compost. The compost is considered to be matured and non-toxic to plant when GI value is greater than 80%. In this study, the GI value of Treatment 1 and 3 was similar throughout the period of incubation with the initial values of around 38.7 and 43.9%, respectively while that of Treatment 2 was lower than 20% (Figure 3A). The GI of all the treatments gradually increased until day 30 of incubation. After this, the GI values of all the treatments sharply increased and reached the value higher than 80% around 90 d of incubation. LRC gave the highest GI values throughout the composting period and appeared to be matured faster than LC and RC. It was interesting to note that the GI value of RC was much lower than LC and LRC during 30 d of composting indicating more phytotoxins were produced. It was found that the GI values (compost maturity) varied greatly with the types of organic materials [23].

Maturity of compost is achieved by mineralization (degradation of organic molecules to inorganic substances) and humification (degradation and synthesis of stable organic molecules: humic substances). Humic substances are heterogeneous organic macromolecules, consisting of humic acids (HAs), fulvic acids (FAs), and humins, according to solubility in aqueous solution [24,25]. Humic acids have shown to have various advantages to soil properties, increase nutrient availability and enhance plant growth [26]. Humic acids are the major extractable component of humic substances [27]. The amount of HAs produced during composting can be used as an indicator for compost quality [25]. In this study, HAs were analyzed in three different composts at all stage of the composting processes. The percentage of HA concentration extracted from the RC, LC and LRC was approximately doubled at day 14 (99.83%), 14 (97.38%) and 60 (102.2%) after composting, respectively. This indicated that the humification process of RC and LC appeared to occur more rapidly than that of LRC at all stage of composting time (Figure 3B). At the end of composting time (120 d), the HA concentration of RC and LC was around 4 times higher than their initial values while the HA concentration of LRC gave around 2.4 times higher than its initial value. This phenomenon implied that composting enables humic acid synthesis of various organic wastes within a short period of time and could be used as one of the quality indices of compost. The synthesis process was found to have positive correlation with the composting time but negative correlation with C:N ratio (Figure 2B & 3B).

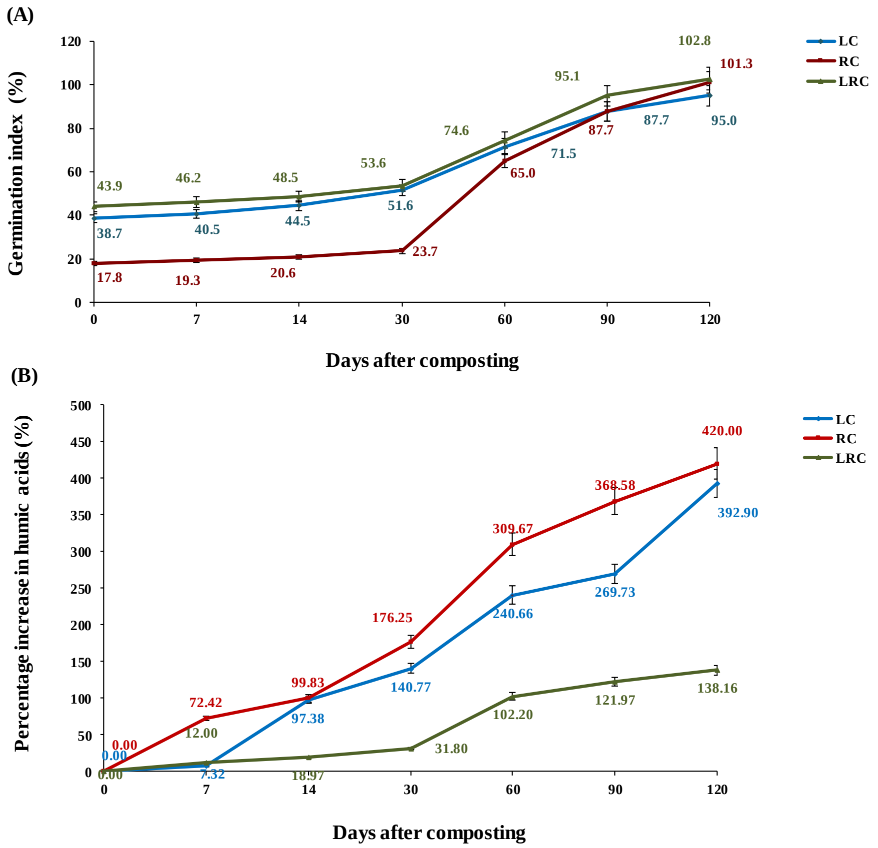

Figure 3 Changes in (A) germination index and (B) percentage increase in humic acid content of compost product, at different stages of composting. The error bars represent the standard deviation of measurements for 3 compost samples. LC=longan leaves+cow dung; RC=rice straw+cow dung; LRC=longan leaves+rain tree leaves+cow dung.

Although LRC gave the lowest percentage increase in humic acid content (Figure 3B) but this treatment gave the highest concentration of humic acid (% of dry matter: ODM) from the beginning (27.7% ODM) to the end of composting time (65.9% ODM) as compared to RC and LC (Figure 4A). The humic acid content of RC was quite low at the beginning (12.0%). However, due to rapid humification process of RC, its humic acid content achieved 62.4% ODM and was as high as that of LRC at the end of composting time. The humic acid content of LC was the lowest among three input materials at all stage of composting with values range from 9.2 (0 d) to 45.1 (120 d). This phenomenon might be due to that longan leaves in LC was hard to degrade compared to raw material in RC and LRC (Figure 2A & 4A). Humic substances contained around 5 to 9% of nitrogen and 48 to 54% of carbon [25]. Therefore, the nitrogen and carbon content in the input material(s) seemed to be important for humic acid synthesis. In the present study, it appeared that the highest nitrogen content in LRC gave the highest humic acid content (Figure 4A & 4B). Although LC showed slightly higher value of TN than RC, RC gave higher value of humic acid content at all period of incubation. This phenomenon might be due to that RC was more rapidly degraded than LC (Figure 2A & 2B) and could perform humification more rapidly (Figure 3B). Compost with high humic substances showed a high potential to use as soil quality improvement since they play a vital role in soil physiochemical and biological properties improvement including environmental recovery through phytoremediation [28].

Total nitrogen (TN) mineralized during incubation period was analyzed. The results indicated that nitrogen dynamic during composting of different organic residue and mixture, was different. The initial total N (TN) of LC was 1.7% and the value was maintained around 1.7 to 1.8% up to 30 d, afterwards the value increased to 2.2% and maintained at this value until the end of composting period (120 d) (Figure 4B). In contrast to LC, the TN of RC slightly fluctuated with values of 1.2 to 2.0%. The TN of LRC appeared to increase after 30 d of incubation and reached the maximum values of 3.0% at 90 d. Similar results have been reported in other studies [29,30]. They found that the TN increased with composting time and reached the maximum value at 60 d after incubation. The increase in TN might be due to loss of total dry weight. In addition, the activity of N_2-fixing bacteria which normally occurred at the end of composting also contributed to a TN increase [31]. However, a decrease amount of TN can occur during composting due to leaching of nitrate and ammonia volatilization which can be avoided by retaining optimum moisture and preventing leaching during the composting period [29].

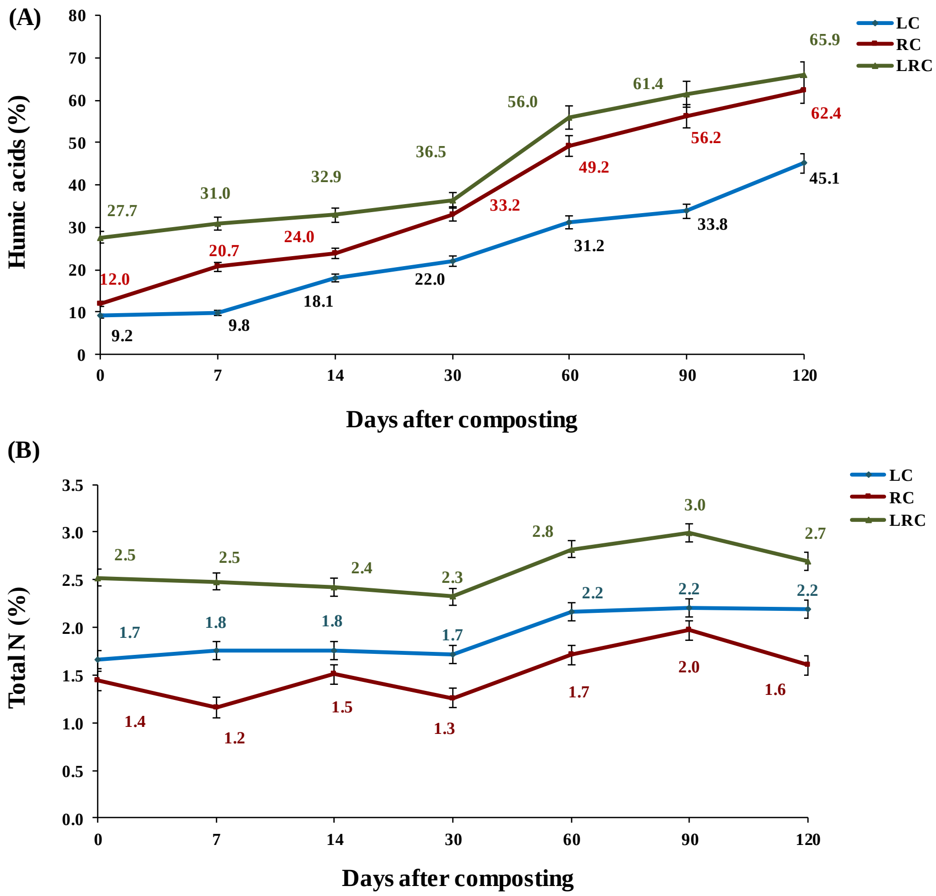

Figure 4 Changes in (A) humic acid content and (B) total nitrogen (N), of compost product, at different stages of composting. The error bars represent the standard deviation of measurements for 3 compost samples. LC=longan leaves+cow dung; RC=rice straw+cow dung; LRC=longan leaves+rain tree leaves+cow dung.

At the end of composting period (120 d), LRC gave significantly higher TN value (2.69%) than that of LC and RC. However, RC exhibited significantly higher total P (TP) (0.25%) and total K (TK) (2.99%) values than those of LC and LRC. (Table 1). Jusoh et al. [29] found that the K value increased to 55% in the C1 compost compared to 17% in C2 compost. Jiang-Ming [30] reported that the final TP and TK contents in several composts increased by 33.0-75.8% and 32.5-66.1%, respectively compared with the initial values. In the present study, the highest TK values was obtained in RC with the highest value of 3.32%, which represented around 4 times higher than those of LC and LRC. Rice straw in compost might help to prevent the loss of K since it can absorb moisture and maintain its structural integrity and porosity [31]. The increases in TP and TK might be due to the concentration effect arising from a higher rate of carbon loss (total mass of compost pile was reduced). That occurred when organic matter was decomposed or mineralized into CO_2 or CH_4.

Table 1 Nutrient composition of compost products at 120 d after composting.

Treatments	Total amount (%)		
	N	P	K
Longan leaves+cow dung	2.19[b]	0.19[b]	0.74[b]
Rice straw+cow dung	1.60[c]	0.25[a]	2.99[a]
Longan leaves+rain tree leafs+cow dung	2.69[a]	0.17[b]	0.77[b]
CV (%)	4.27	6.76	15.30

Values are means of three replications. Means with the same letter are not significantly different ($p < 0.05$).

3.2 Microbial population dynamic in compost product during 120 d of composting

In the process of composting, microorganisms break down organic matter and produce carbon dioxide, water, heat, and humus. Microorganisms use the carbon of the relatively stable organic end product for energy, and nitrogen for protein. They play the main role in the process as they are responsible for the degradation of organic matter [32]. The present study contained considerable population of bacteria, actinomycetes and fungi. The population of bacteria, actinomycetes and fungi presented in the different compost treatments are provided in Table 2. The compost samples in the present study contained considerable population of bacteria, fungi and actinomycetes. The bacterial population during 120 d of incubation ranged from $2.2x10^6$ to $2.6x10^8$ CFU/g of dry compost matter. On the average, the population of bacteria of RC and LRC was higher than those of LC, particularly at 30 d after incubation with the highest number of $2.2x10^8$ and $2.6x10^8$ CFU/g, respectively. The bacterial number of all treatments reached the highest number around 30 d after incubation, afterward the number appeared to decrease to around 10^6 CFU/g at 60 d of incubation. However, the population increased to around 10^7 CFU/g at the end of composting time. The lowest number of fungi was observed for all treatments; LC, RC and LRC at day 7 of incubation with values of $1.3x10^6$, $1.37x10^6$ and $1.5x10^6$ CFU/g, respectively. After that, the fungal population appeared to increase to around 10^7 CFU/g, excepting that at day 90. The results were in accordance with that of Balasundaran [5] who found that the fungal population was quite low ($\approx 10^6$ CFU/g) at early stage of composting. In contrast to bacteria and fungi, the number of actinomycetes was quite high at the early stage (0 to 30 d) with values around 10^8 CFU/g (Table 2). The population of actinomycetes showed a slightly decrease to around 0.5×10^8 CFU/g for LC and LRC, and 1.5×10^7 for RC. In the present study, it was interesting to note that, on the average, the population of actinomycetes was higher than those of bacteria and fungi at all sampling time. Their population still tended to increase in the later stages of composting. In general, actinomycetes are responsible for hard degradable organic materials. It appeared that high population of actinomycetes at early stage of composting might be due to high portion of hard degradable substances (lignin, cutin and waxes) contained in longan and rain tree leaves. Waxy leaves of several plants such as tea, rain tree and eucalyptus contained quite high portion of lignin (39 to 55%). Balasundaran [5] reported that the bacterial number was highest when compared to fungal and actinomycetal population in all organic wastes except tea waste compost. In tea waste compost, actinomycetes population was the highest followed by fungal and bacterial population. The fungi showed the lowest number of colonies in all the four types of samples.

Table 2 Changes in microbial population of compost product during of composting.

Treatments	Days	Microbial population (CFU/g)		
		Bacteria	Fungi	Actinomycetes
Longan leaves+cow dung	7	$1.6x10^7$	$1.3x10^6$	$1.5x10^8$
	14	$1.9x10^7$	$7.2x10^6$	$1.5x10^8$
	30	$1.7x10^7$	$1.7x10^7$	$6.7x10^7$
	60	$4.5x10^6$	$2.7x10^7$	$5.8x10^7$
	90	$2.2x10^6$	$2.2x10^6$	$6.0x10^7$
	120	$1.4x10^7$	$1.4x10^7$	$3.1x10^7$
Rice straw+cow dung	7	$4.5x10^7$	$1.37x10^6$	$1.4x10^8$
	14	$2.2x10^7$	$7.4x10^6$	$0.9x10^8$
	30	$2.2x10^8$	$4.6x10^7$	$6.7x10^7$
	60	$3.6x10^6$	$1.8x10^7$	$1.1x10^7$
	90	$2.8x10^7$	$5.4x10^6$	$2.8x10^7$
	120	$1.6x10^7$	$1.2x10^7$	$1.3x10^7$
Longan leaves+rain tree leaves+cow dung	7	$4.3x10^7$	$1.5x10^6$	$1.2x10^8$
	14	$2.2x10^7$	$5.2x10^6$	$1.3x10^8$
	30	$2.6x10^8$	$5.6x10^6$	$1.3x10^8$
	60	$5.6x10^6$	$1.9x10^7$	$4.6x10^7$
	90	$2.0x10^7$	$4.1x10^6$	$6.2x10^7$
	120	$1.5x10^7$	$1.1x10^7$	$4.5x10^7$

4. Conclusion

Composting, as one of the most efficient approaches to treat organic waste, had been proven to significantly reduce the volume of wastes in the country. In addition, composting products can also provide nutrients which are suitable for agriculture and can be used as organic fertilizer to replace a chemical one. Composting of three different compost compositions including LC, RC, LRC revealed that changes in physico-chemical and biological properties differed among different types of organic wastes. The maturity compost from longan leaves could be obtained after 60 d of composting with the GI values greater than 80%. The N contents of all treatments increased and reached a high value of around 2 or greater than 2%. Addition of rain tree leaves (high N material) to longan leaves in the compost provided the lowest C:N ratio, the highest contents of nitrogen and humic acid. The high population of bacteria, fungi and actinomycetes were obtained during composting. On the average, the population of actinomycetes was higher than that of bacteria and fungi at all periods of incubation. Their population still tended to increase in later stages of composting.

5. Acknowledgement

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