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24 The Role of Rot Fungi in Composting Process of Empty Fruit Bunches of Oil Palm

Sukriming Sapareng¹, Ambo Ala², Tutik Kuswinanti³, Burhanuddin Rasyid⁴

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¹Post Graduate Program of Hasanuddin University, Makassar, Faculty of Agriculture, Andi Djemma Palopo University, South Sulawesi, Indonesia

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²Department of Agronomy, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia

³Department of Plant Pests and Diseases, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia

⁴Department of Soil Science, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia

*Corresponding author.

Abstract

Empty Fruit Bunches of Oil Palm cannot be readily decomposed as they are still in complex elemental form, therefore must be degraded first, yet natural degradation processes takes a very long time, hence the use of fungi can accelerate the degradation process by various enzymes they produced. Rot fungi possess the ligninolytic capability i.e., producing enzyme that degrade lignin. The materials used in this study include EFB of oil palm, bran, and dolomite lime. Ingredients were mixed evenly and then inoculated with 3 different rot fungi. Treatment 1: without rot fungi (control), treatment 2: *Trichoderma* sp., treatment 3: *Pleurotus ostreatus*, and treatment 4: *Tramella* sp. Composting process was done on the vessel with dimension of 200 × 100 × 80 cm. Compost was covered with a tarpaulin, mixed and reversed thoroughly every 2 weeks and placed under the shade for 12 weeks to accelerate decomposition. The results showed that the inoculation of the rot fungus accelerate the composting process, improve the physical and chemical properties and contribute to the nutrient content of the compost. This study showed that the quality of the compost with different parameters such as temperature, pH and the ratio C: N was good. Temperature was increased in all treatments after three weeks and then decreased gradually until the stage of maturity of compost. The inoculation treatment with *Trichoderma* sp had better quality than other treatments. C/N ratio and pH of mature compost was 18.68 and 6.1. It was concluded that inoculation of *Trichoderma* sp is potential for EFB decomposition.

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Keywords

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Ligninolytic fungi
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Introduction

Bunches of oil palm empty (EFB) cannot directly decompose because they are still in complex

elemental form, so they must be degraded first and degradation processes naturally take a very long time, for the fungus was used to accelerate the degradation process. Ligninolytic rot fungus has the ability to

produce enzymes that degrade lignin (Goyal et al., 2005). The main components of the oil palm waste are cellulose, hemicellulose and lignin. EFB is composed of cellulose (24-65%), hemicellulose (21-34%) and lignin (14-31%) (Khalil et al., 2007; Kavitha et al., 2013; Chang, 2014).

According to Goyal et al. (2005), the fungus is actively involved in the decomposition of cellulose, hemicellulose and lignin in the organic material. The composting process can be accelerated approximately one month with the inoculation of the cellulolytic fungus such as *Aspergillus* and *Trichoderma* (Amira et al., 2011; Siddiquee et al., 2016), because of its ability to produce enzymes that degrade cellulose, hemicellulose and lignin (Saili et al., 2014).

Widiastuti et al. (2008) concluded several groups of white rot fungi from the class *Basidiomycetes* are able to degrade lignin because ligninolytic produce enzymes such as laccase (Lac), lignin peroxidase (Li-P), and Mn-peroxidase (Mn-P). De-polymerization of lignin using a variety of fungi often produce low molecular weight aromatic compounds such as guaiacol, coniferil alcohol, *p*-kumarat, ferulic, protocatekueat, *p*-hidroksibenzoat and vanilat (Masai et al., 2007).

Composting is an aerobic process where microorganisms transform organic substrate into carbon dioxide, water, minerals and organic material in controlled conditions, especially moisture and aeration (Bernal et al., 2009; Kala et al., 2009). The main objective is to produce quality humus as much as possible. In the decaying process, physical and chemical changes occurred on the remains of plants and animals become mature organic matter. The response of plants is a key indicator of the quality of the compost.

Shafawati and Siddiquee (2013) stated the level of maturity of the compost can be seen from the primary and secondary criteria. C/N ratio, temperature, moisture content, color, and material structures are all secondary criteria; while the primary criteria is the growth of plants that are affected by the application of the compost. Compost also improves plant growth at very low cost (Gaiind and Nain, 2007). In this study, EFB composted using four potential-rot fungus strain. The purpose of this study was to test the physico-chemical changes such as temperature, pH, and the C:N ratio during the composting process inoculated with the four-rot fungi.

18 Materials and methods

Procurement of compost materials

Materials used in this study include EFB, bran, and dolomite lime with the composition of 5: 1: 0.05. EFB derived from palm oil mill Luwu Unit 1, Village Burau Lagego District of Luwu Timur, Indonesia. Bran collected from rice milling factory in the village of Pattimang, Malangke. Dolomite lime was purchased from the farm shop. EFB were chopped small of 5-10 cm in dimension to accelerate the composting process. Ingredients are mixed evenly and then inoculated with the rot fungus in accordance with the four treatments.

Treatment 1 (K0): No-rot fungus (control), treatment 2 (K1): The fungus *Trichoderma* sp., Treatment 3 (K2): Fungus *Pleurotus* sp, and Treatment 4 (K3): Fungus *Tramella* sp. Rot fungus comes from the collection of Research and Development Centre of Agricultural Biotechnology, University of Hasanuddin. Composting was performed on the vessel measuring 200 × 100 × 80 cm (L × W × H) with holes on the sides and bottom of the tub to provide aeration and water discharge during composting. Compost were covered with a tarpaulin and mixed and reversed thoroughly every 2 weeks, and placed in the shade to 12 weeks to accelerate decomposition.

Methods and data analysis

The temperature is measured every week during the composting process according to the procedures of Erwan et al. (2012). Temperatures were measured at three different places, namely the upper, middle and lower part of the compost using a thermometer. Thermometer inserted for five minutes into the compost. Compost pH was measured every week during the composting period, approximately 10 g of compost were put in a 500 mL beaker and add 50 mL of sterile water, then shaken for 30 minutes (Jeong and Kim, 2001).

Total Organic Carbon (TOC) was determined in accordance with the method of combustion. One gram of compost is placed in a container and put in a furnace at 350°C for one hour. Then the temperature was raised to 550 °C and left to stand for 4 hrs. The remaining ash is weighed, and organic C was calculated from the weight loss of material during incineration (Kala et al., 2009). The total Kjeldahl Nitrogen (TKN) compost was determined using the Kjeldahl method.

Results

Temperature analysis

Temperature difference during the composting process is illustrated in Fig. 1. Initial temperature of all treatments around was 25°C-36°C, while the

ambient temperature is 30°C. Compost temperature has increased sharply in the first three weeks, then decrease gradually until the final stages of composting. The highest recorded temperature was 50°C for the treatment of K0 (without fungi), 53°C for K1 (*Trichoderma* sp.), 55°C for K2 (*Pleurotus* sp.), and 59°C for K3 (*Tramella* sp.).

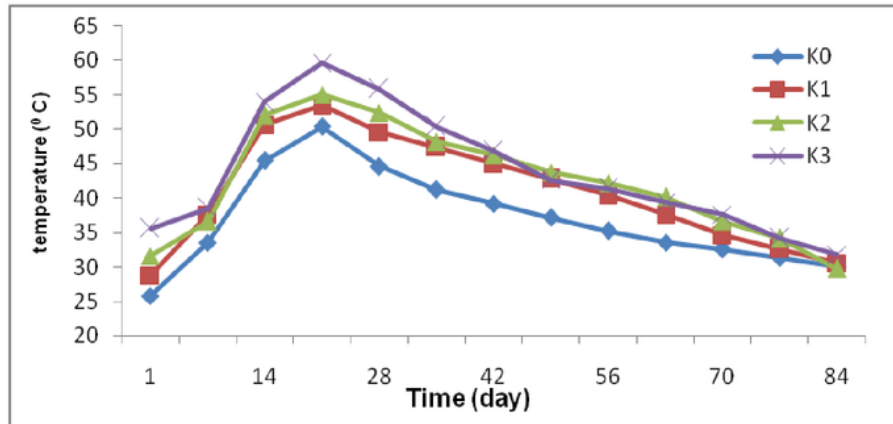


Fig. 1: Changes in the treatment temperature compost EFB K0 (control = No-rot fungus), K1 (*Trichoderma* sp.), K2 (*Pleurotus* sp.) and K3 (*Tramella* sp.).

Changes in pH

Compost pH values of all treatments are presented in Fig. 2. The pH values ranged from 5.4 to 7.8 at the

beginning of composting. All treatments have fluctuating pH values and tend to be more acidic. At the end of the composting process, the pH value of each treatment K0 = 5.3, K1 = 6.1, K2 = 6.4, and K3 = 6.9.

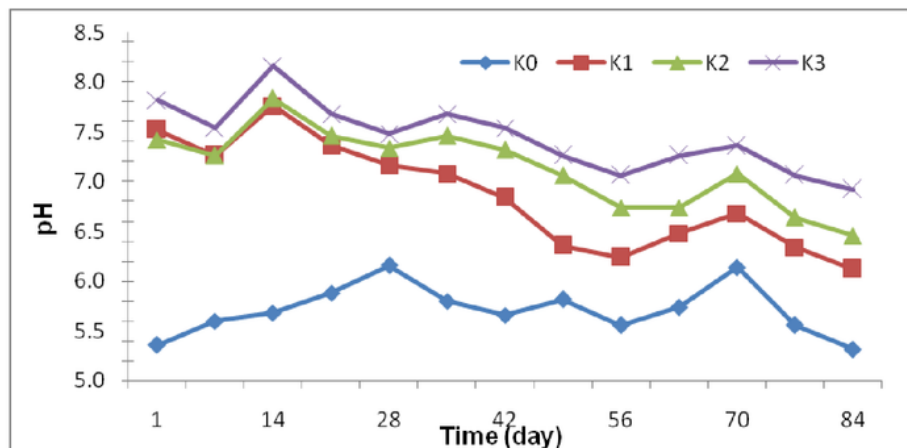


Fig. 2: Changes in pH Compost Treatment EFB on K0 (control = No-rot fungus), K1 (*Trichoderma* sp), K2 (*Pleurotus* sp) and K3 (*Tramella* sp).

The ratio of carbon and nitrogen (C/N)

Changes in C:N ratio of EFB compost of all treatments shown in Table 1. The highest ratio of C: N obtained by

compost without fungus (control) i.e. 34.58, followed by compost treatment with *Tramella* sp. (22.52), compost with *Pleurotus* sp. (21.54) and compost with *Trichoderma* sp. (18.68) (see Table 1).

Table 1. Changes in EFB compost C:N ratio during trial.

Treatment	Observation time (days)			
	0	28	56	84
K0 (without rot fungus)	40.24	39.22	36.38	34.58
K1 (<i>Trichoderma sp</i>)	40.24	27.38	22.09	18.68
K2 (<i>Pleurotus sp</i>)	40.24	32.81	24.38	21.54
K3 (<i>Tramella sp</i>)	40.24	34.34	26.68	22.52

Discussion

Analysis of temperature

Temperature is one of the most important parameters in the composting process. Rise and fall of temperature during the composting process could be due to the levels of growth, metabolism and types of organisms in the compost (Tiquia and Tam, 2002). The results showed that the values are in the range of thermophilic temperatures ranging from 40 to 65°C (Bernal et al., 2009). In this study, all treatments except K0 (without inoculation of the fungus) reaches a temperature of 55°C which is required to kill pathogenic microorganisms (Kala et al., 2009). This is due to the metabolic heat as result of rot fungi activity and high closure in the compost materials (EFB). Siddiquee et al. (2016), reported that the addition of *Trichoderma sp* accelerate degradation and improve the physical properties of compost such as water-holding capacity, aeration and texture.

In general, temperatures of all treatments varied. After three weeks, the temperature began to fluctuate, although were still above the ambient temperature. Fluctuating temperatures achieved in the first 21 days of composting for biodegradation of EFB by rot fungi. After eight weeks, the compost temperature approaching the temperature of the environment; biodegradation of EFB almost completed and the process is beginning to stabilize. This occurs because environmental conditions favor the occurrence of biodegradation by rot fungi and affect changes in physical-chemical characteristics of compost (Wei et al., 2016).

Changes in pH

Changes in pH due to acid formation during decomposition of EFB are by rot fungi. In the first week, all fungi inoculation treatment showed a small decrease in pH. Thereafter, the pH in all fungi inoculation treatment increased in the second week. The increase was caused by the decomposition of organic matter, degradation of acid compounds, such as carboxylic and

phenolic, and mineralization of organic compounds such as proteins, amino acids, ammonia and peptides (Ng et al., 2001; Xu et al., 2006; Isaac et al., 2014; Wei et al., 2016).

The pH of compost at the end of composting is more acidic than the initial composting. This is due to nitrification which lowers the pH of the compost. pH decreased significantly when the compost is mixed with *T. reesei* (Ind and Nain, 2007) and *Trichoderma sp.* (Siddiquee et al., 2016). The optimum pH for compost is 6.5–8.0 (Said-Pullicino et al., 2007). During the composting process, organic matter is digested by microorganisms that cause a decrease in the pH value in the first week. After that, the pH value increases significantly at the stage of decomposition. The increase was caused by an increase in ammonia (Gajalakshmi and Abbasi, 2008; Petric et al., 2009).

The ratio of carbon and nitrogen (C/N)

Ratio of C/N explains part of C per unit of N needed by microorganisms. C/N ratio is the main parameter when using compost as fertilizer on soil, because if the value of C/N ratio is high, then it can inhibit decomposition and nitrogen availability in the soil. The composting process will lower the C/N ratio by converting organic C to CO₂, and the loss of nitrogen in the form of NH₃ (Isaac et al., 2014). A decrease in the ratio of C/N during the composting process occurred for all treatments (Table 1). C/N ratio decreased in all treatments for the mineralization of organic material by microorganisms (Kala et al., 2009). At the end of the experiment, C/N ratio decreased to 34.58, 18.68, 21.54 and 22.52 for the treatments, K0, K1, K2 and K3 respectively.

C/N ratio 17.00 obtained in combination EFB compost, liquid waste and wheat flour that were inoculated with *P. chrysosporium*, *T. harzianum* and *A. niger* (Siddiqui et al., 2008). But the C/N ratio as high as 59.30 obtained in the olives compost inoculated by *Trichoderma harzianum* and *Phanerochaete chrysosporium* (Haddadin et al., 2009). Mature compost has a C / N ratio of less than or equal to 25 (Oreopoulou and Russ

2007), less than 30 (Chai et al., 2013). Nagasaki et al. (1992) proposed a C / N ratio for composting should be in the range of 16 to 21. The results showed the C/N ratio of all treatments except K0 (without inoculation of the fungus) is within the optimum range (≤ 25).

Conclusions

This research showed beneficial results that EFB waste could be converted into valuable product within a relatively short time. EFB composting process only takes 28 days and continue to improve with time. The results showed that the inoculation of the rot fungus accelerate the composting process, improve the physical and chemical properties and contribute to the nutrient content of the compost. This study shows the quality of the compost with different parameters such as temperature, pH and the ratio C: N. High temperatures in all treatments after three weeks and then decreased gradually until the stage of maturity of compost. The fungus inoculation treatment of *Trichoderma sp* had better quality than other treatments. C:N ratio and pH of mature compost is 18.68 and 6.1 respectively. It can be concluded that inoculation of *Trichoderma sp* could be a potential as EFB bio decomposer.

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Conflict of interest statement

Authors declare that they have no conflict of interest.

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