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The contents availability of N, P, K, and Mg in empty fruit composting of oil palms with symbiont bacteria from rhinoceros beetle larvae (*Oryctes rhinoceros*) (Coleoptera: Scarabidae)

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Abstract

The using of palm oil waste had not been optimal lately. It could be seen in oil empty fruit bunches (EFB). It was placed along the oil palm plantations. The condition was not only the trigger of air pollution but also could invite rhinoceros beetle pests (*Oryctes rhinoceros*) to lay their eggs and carry out reproductive activities due to availability organic matter of the trees. Oil palm plants required large amounts of macro nutrients, especially potassium. However, the potassium nutrient was found in EFB was too slow available because of its relatively long breakdown. That was the reason why it was needed a method of using EFB waste into a capable of high use value product, environmentally friendly, and could give a lot of benefits to oil palm farmers. The purpose of this study was to determine the availability of nutrient content in EFB composting by the using of symbiont bacteria from larvae *O. rhinoceros*. The research was experimentally conducted a factorial randomized block design (RBD) with 2 factors, namely the type of bacteria and the time of decomposition. The composting stage was carried out by coarsely chopping the EFB then 75 ml of bacterial culture was applied to 1 kg of EFB. Analysis, results indicated C/N ratio (35.56% and 36.97%) and high K content (1.64% and 1.48%). The EFB composting method is achievable in 6 weeks with activators of *Bacillus stratospphericus* and *Bacillus siamensis*.

1. Introduction

Oil palm plantations in Indonesia increases every year. This is one way to increase Crude Palm Oil (CPO) production in the country. The total area of Indonesian oil palm plantation in 2019 was 14,724,600 ha and in 2018 which was previously 14,326,300 ha. (Badan Pusat Statistik, 2020). This affected the quantity of waste produced. Meanwhile, in oil palm plantations, Empty Fruit Bunches (EFB) are the largest waste produced. When processing fresh fruit bunches (FFB) in palm oil mill (POM) with a capacity of 100 tons/hour produces 22 -23% EFB or 220-230 kg of EFB (Fuadi and Pranoto, 2016). Meanwhile, large amount of EFB causes problems not only for the environment but also humans. Apart from the pungent odor, it also reduces the beauty of the environment when placed carelessly. Therefore, there is need to carry out proper management in order to form a product having high economic value, such as compost.

Aside ensuring environmental conservation, compost also reduces the use of chemical fertilizers. Yunindanova *et al*. (2013) showed that decomposition of EFB for 8 weeks increased the N-total value by 1.34%, and P, K as well as Mg by 0.08%, 0.24%, 0.25% respectively with C/N ratio (35.16%) raising soil pH, CEC, and tomato production in ultisol. This was in line with Hayat and Andayani (2014) which stated that the compost contains N, P, and K around 3.62%, 0.94%, and 0.62%. Furthermore, Fauzana *et al*. (2019) stated that EFB is capable of becoming an organic material which increases C-organic, N-total, and alter soil pH.

EFB is a potential source for cellulosic biomass which affects the abundance of rhinoceros beetle (*Oryctes rhinoceros*). This is due to the weathering of organic matter present (Fauzana *et al*., 2018). Susanto *et al*. (2011) stated that the presence of *O. rhinoceros* was the main pest in the area for replanting oil palms. However, the feces resulting from the defecation (kolarhino) of *O. rhinoceros* larvae that eat EFB become one of the organic fertilizers. Kolarhino contains C (25.71%), N (1.50%), P (8.69%), K (0.31%) and Mg (4.47%) (Pulungan *et al*., 2018).

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Handoko *et al.* (2017) stated that the application of EFB creates the breeding ground for *O. rhinoceros*. However, these beetles also have benefits in composting activities. Sari *et al.* (2016) stated that microbes in the *O. rhinoceros* larvae intestines such as cellulotic and hemicellulotic bacteria produces hydrolytic enzymes.

Empty Fruit Bunches (EFB) also contain high lignocellulose hence, it naturally takes about 12-18 months to become a compost (Hatta *et al*., 2014). However, the process is being accelerated using bio-activator (inoculant) (Wei *et al*., 2004). Marheni dan Lubis (2019) stated that there were bacterial species in the 3rd instar larva of *O. rhinoceros*, including *Achromobacter sp.* and *Bacillus sp.* which is being used as composting activator.

Only few studies have examined the relationship between symbiont bacteria types from *O. rhinoceros* larvae and decomposition time. Therefore, research is needed to observe the different nutrient content in the resulting EFB compost.

2. Materials and methods

This research was conducted between June until October 2020 at the Laboratory of Plant Diseases, Universitas Sumatera Utara. The materials used include empty oil palm bunches which have been coarsely chopped, NA and NB media, alcohol, cotton, and bacterial symbiont intestinal isolates of *O. rhinoceros*, obtained from the Disease Laboratory, based on Sijabat *et al.* (2018).

This research was experimentally conducted a factorial randomized block design (RBD) with 2 factors, such as type of bacteria and time of decomposition. The type of bacteria was namely *Bacillus siamensis* and *Bacillus stratosphericu*s. Meanwhile, the second was time of decomposition EFB in 6 and 9 weeks. Bacterial propagation was performed on NA media by scratching and harvesting after 18 - 24 hrs. Thereafter, it was placed into NB and stirred using a shaker. Hence, the density was calculated using a spectrophotometer. Coarsely chopped EFB were placed in a bucket and doused with 75 ml of bacterial culture for every 1 kg. Meanwhile, the bucket tips were covered with black plastic to prevent contamination. Composting was carried out for 6 and 9 weeks. The parameters observed include organic C, N, P, K, Mg, pH, moisture and C/N ratio (Sijabat *et al*., 2018; Maysaroh, 2018).

3. Results and discussion

The acidity level is one of the critical factors in microorganism growth. Based on Table 1 and 2, EFB composting carried out for 6 and 9 weeks shows the pH ranges from 7.6 - 7.88 and 6.57 - 6.65 respectively.

The nine weeks EFB compost indicated a lower pH compared to six weeks. According to Benito *et al.* (2012), bacteria form acids which reduces pH. Furthermore, microorganisms begin to convert inorganic nitrogen into ammonium which rapidly increases pH hence, compost becomes alkaline. In addition, some ammonium is converted to nitrates which are denitrified by bacteria therefore, the compost becomes neutral. Meanwhile, Putra *et al.* (2018) reported that the pH value was close to neutral (6.8 - 7.2) due to decomposing microorganisms which convert nitrogen into ammonia.

The ratio between carbon and nitrogen (C/N) ratio determines the compost quality and maturity. Besides from Table 1, the 6 weeks composting had a ratio C/N of 35.56% - 36.97% while 9 weeks from Table 2, had a ratio of 8.33% - 11.77%. The longer the composting duration, the smaller the C/N ratio (Surtinah, 2013). When this ratio is high, it indicates that decompose of the compost material has not completely. Soil C/N ratio around 13 - 20 which is the final value (Indrasti and Elia, 2004). Based on these results, EFB composting is achievable in 6 weeks although, the C/N ratio is quite high due to its incomplete decomposition. Notwithstanding, the microbes still obtained enough Carbon (C) as the energy source and Nitrogen (N) for protein synthesis. Veronika *et al.* (2019) stated that the greater the deficiency of the Carbon Nitrogen ratio, the better the composting process, although with more time.

The compost C/N ratio decreased with increasing incubation time and also determine the degrading ability of the organic matter and the compost maturity. Meanwhile, the organic matter quality is determined not only by the concentration of lignin and low polyphenols but also by large amount of N. In cell formation, microorganism obtain energy and growth from carbon and nutrients from nitrogen. The ratio values are 20: 1 to 35: 1 hence, too large (>40) or too small (<20) values interferes with this biological process. EFB processing takes time because it contains lignin and cellulose compounds which are difficult to decompose. Lignin is a phenyl propane polymer in vascular plants, therefore the plants become stiffer and bind to cell wall fibers (Setyorini *et al*., 2006).

Based on Table 1 and Table 2, the C-organic value after 6 and 9 weeks ranged from 24.13% to 29.58% and 16.17% - 25.34% respectively. The C-organic value in the 9 weeks EFB compost was lower due to the release of C molecules in form of CO_2 during the process. Widiastuti *et al.* (2015) reported a decrease in carbon contents caused by microbes' respiration to form CO_2.

Meanwhile, Mirwan (2015) stated that the decomposition process and the maturity while of the compost are indicators of C-organic, carbon is an energy source for microbes. This microorganism uses carbon as a constituent of the cells by releasing CO_2 and producing other compounds as a result of decomposition. Furthermore, C-organic is a biological buffer for balancing nutrients and other properties to improve the soil physically, chemically, and biologically. When the C -organic value is low, the nutrient resistance is also low. Therefore, fertilization is inefficient (Veronika *et al.*, 2019).

The data in Table 1 and Table 2 shows that the N value at 6 and 9 weeks ranged between 0.66% - 0.80% and 1.94% - 2.15% respectively. This value was higher than the standard compost quality base on SNI 19-7030-2004, where the N content is >0.40%. The N value in the 9 weeks compost was higher than in 6 because the longer the incubation time, the more the N value (Widiastuti *et al.*, 2015). The C content decreases with longer incubation time because it is used by microorganisms as a source of food while nitrogen increases due to the decomposition action of microorganisms which produces ammonia and nitrogen (Sari *et al.*, 2018).

Based on Table 1 and Table 2, the P-value for 6 and 9 weeks were 0.12% - 0.16% and 0.16% respectively. This value correlate with the standard compost quality base on SNI 19-7030-2004, which is > 0.10%. The P-value is related to the N content therefore, the greater the nitrogen, the higher the microorganisms that break down Phosphorus hence, the P content also increases Hidayati *et al.* (2011). Furthermore, Syukri *et al.* (2019) stated that the organic materials contained in the EFB compost forms organic compounds, therefore it reduces the presence and release of P in available form. Microorganisms are able to remove organic acids such as citric, glutamate, succinic, and glycosate which chelates Fe, Al, Ca, and Mg. Therefore, the bound phosphorus

Table 1. The results of the EFB composting analysis for 6 weeks

Type of bacteria	Decomposition time	Parameter	Results
Bacillus siamensis	6 weeks	c-organic	29.58%
		N	0.80%
		P	0.12%
		K	1.48%
		Mg	0.30%
		pH	7.6
		moisture	75.7
		ratio C/N	36.97
Bacillus stratosphericus	6 weeks	c-organic	24.13%
		N	0.66%
		P	0.16%
		K	1.64%
		Mg	0.37%
		pH	7.8
		moisture	78.49
		ratio C/N	35.56

Table 2. The results of the EFB composting analysis for 9 weeks

Type of bacteria	Decomposition time	Parameter	Results
Bacillus siamensis	9 weeks	c-organic	25.34%
		N	2.15%
		P	0.16%
		K	0.30%
		Mg	0.35%
		pH	6.57
		moisture	80.68
		ratio C/N	11.77
Bacillus stratosphericus	9 weeks	c-organic	16.17%
		N	1.94%
		P	0.16%
		K	0.28%
		Mg	0.34%
		pH	6.6
		moisture	77.52
		ratio C/N	8.33

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becomes soluble and available (Boraste *et al*., 2009).

From Table 1 and Table 2, the K value in the 6 and 9 weeks EFB compost ranged from 1.64% - 1.48% and 0.28% - 0.30% respectively. This value correlates with the compost quality base on SNI 19-7030-2004, which is >0.20%. The high content of K especially in EFB 6 compost reduce the use of potassium (K) fertilizer on plants. This element increases plant growth and production. Solihin *et al.* (2019) showed that potassium application to inceptisol soils was able to increase the growth sweet corn and its yield.

The Mg content for 6 and 9 weeks ranged from 0.30% - 0.37% and 0.34% - 0.35% respectively. Based on SNI 19-7030-2004, this value was in relate with the compost quality standard, which is < 0.60%. Magnesium (Mg) play a role in the formation of leaf chlorophyll. In addition, the element is present in chloroplasts (10%) and as an activator of several enzymes (Wirawan *et al*., 2016).

Moisture was in the range of 75.70% - 80.68%. Meanwhile, the increased humidity during composting indicates the metabolic activity of microorganisms and oxygen supply. Widiastuti *et al.* (2015) explained that the aerobic compost water content for bacterial growth fluctuates between 50% -70% and tends to increase up to 80%. In addition, the optimum humidity is at 40.0 - 60.0% (Indriani, 2000). When the humidity is below 40%, the microbial activities decrease meanwhile, when the humidity is greater than 60%, anaerobic fermentation occurs, resulting in an unpleasant odour (Sari *et al*., 2018).

4. Conclusion

Composting is achievable in 6 weeks using bacterial isolates of *Bacillus stratosphere* and *Bacillus siamensis* with C/N ratio values of 35.56% and 36.97%. Despite the high C/N ratio due to incomplete decomposition, microbes are able to obtain enough Carbon (C) is used as an energy source and Nitrogen (N) is used for protein synthesis. Base on SNI 19-7030-2004 showed that the high K values (1.64% and 1.48%) correlates with the compost quality standards, which indicates that there is no decrease in potassium levels with 6 weeks composting.

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