The quality of compost made from mixture of *Mucuna bracteata* and oil palm empty fruit bunch

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Abstract. *Mucuna bracteata* and Oil Palm Empty Fruit Bunch (OPEFB) forages are large amount of palm oil plantation wastes, but they have not optimally utilized yet. This study analyzed the compost from forage of *M. bracteata* combined with OPEFB. The study used a complete non factorial randomized design with different treatment composition of *M. bracteata* and OPEFB as compost material, that is: 100% OPEFB, 75% OPEFB + 25% *M. bracteata*, 50% OPEFB + 50% *M. bracteata*, 25% OPEFB + 75% *M. bracteata*, and 100% *M. bracteata*. The results showed the differences of *M. bracteata* and OPEFB as forage composition were significantly affected the content of N, K, and compost yield but did not significantly affect the content of P and C/N ratio of compost. The average of compost C-organic content is 35.97-39.14%, N is 2.3-4.42%, P is 0.53-0.64%, K is 3.75-6.59%, C/N ratio is 8.9-17.9, and compost yield is 56-69%. The greater the composition of *M. bracteata*, the higher the N content of the compost, but K content is lower and vice versa. If the composting was using OPEFB and *M. bracteata* as the materials, it is suggested to use a composition of 75% OPEFB and 25% *M. bracteata*.

1. Introduction

Indonesia is the world's largest producer of palm oil. The production is reaching 48.68 million tons in 2018 [1] with 14.23 million hectares of oil palm plantations area [2]. In the operation of processing fresh fruit bunches into crude palm oil, a waste will produce in the form of empty fruit bunch, shells, mesocarp fibers, palm kernel cake and liquid waste [3]. Each waste is with an amount of 220 kg of the empty bunch, 670 kg of liquid waste, 120 kg of mesocarp fiber, 70 kg of shells, and 30 kg of palm kernel cake from each processing of one ton of fresh fruit bunches [4].

Empty bunches contain macro and micronutrients, on average there are 0.8% N; 0.07% P; 2.15% K; 0.14% Mg; 0.21% Ca; 0.33% Cl; 13 ppm B; 44 ppm Cu; 33 ppm Zn and 15 ppm Mn [5]. Due to its content, empty bunches have great potential to be used as a source of nutrients and organic matter to restore and maintain soil productivity [6]. Empty bunches are composed of compounds that are difficult to break down into simpler compounds, that are lignin 22.8%; cellulose 45.9% and hemicellulose 16.5% hence naturally it takes between 6-12 months for the empty bunches to decompose completely [4,7].

Besides waste from the processing of fresh fruit bunches from the Palm Oil Mill, waste in the form of forage such as *Mucuna bracteata* and fronds is also produced from the Plantation when maintaining palm oil plants. *Mucuna bracteata* is a fast-growing legume plant, a reliable weed competitor, has high N fixation ability, and not preferred by pests and ruminants. In standard technical culture, the area
covered by *M. bracteata* during the initial planting period can reach to 2-3 m month\(^{-1}\). A complete area closure achieved when entering the 2nd year with vegetation thickness ranging from 40-100 cm, and biomass ranging from 9-12 tons ha\(^{-1}\) dry weight [8]. Planting *M. bracteata* in entisol soils can increase soil organic matter content as much as 30.43% in a flat area and 53.33% in a hilly area and increase soil N total content as much as 27.27% in a flat area and 7.69% in a hilly area [9]. In ultisol soil, planting *M. bracteata* can increase 44.96% organic matter in a flat area and 59.15% in a sloping area, and increase the soil nitrogen content as much as 57.14% in a flat area and 91.7% in a sloping area [10].

The rapid growth of *M. bracteata* needs to be controlled, so that they do not become a competitor to the main crop. In Kebun Aneka Persada, Riau, *M. bracteata* is one of the dominant weeds (6.23%) [11].

Controlling *M. bracteata* in the manual system produce forage from plant parts; that are leaves, stalks and stems. Considering the characteristics of *M. bracteata* which is capable of producing organic matters equivalent to 263 kg of N-P-K-Mg with 45-56% N, means that *M. bracteata* has the potential to be used as compost raw material.

The increasing area of palm oil plantations in Indonesia is resulting in an increase in production from year to year. Based on this phenomena, more waste will be produced, and proper treatments are needed; hence, empty fruit bunches and forage of *M. bracteata* become more beneficial in increasing crop production and also have higher economic value. The application of composting technology is an alternative to handling waste. The aims of this research were to determine the quality of compost made from *M. bracteata* and OPEFB with different compositions, to compare the quality of compost, and to obtain the formula for the proper amount of *M. bracteata* and/or OPEFB material needed to make the required amount of compost.

## 2. Materials and Methods

### 2.1 Materials

The materials used in this research are oil palm empty fruit bunches (OPEFB) and *M. bracteata*. The OPEB sample was taken from Adolina Palm Oil Mill, PT. Perkebunan Nusantara IV. The *M. bracteata* sampling was taken from Adolina plantation area by clearing *M. bracteata* plants that spread on each palm oil tree or covering the road. The inoculant of *Trichoderma sp* (population : 108) as an initial decomposer was taken from Laboratory of Soil Biology, Faculty of Agriculture, Universitas Sumatera Utara. NPK 15-15-15 fertilizer as a starter for microbial nutrition, water to moisturize compost material, chemical matters including K\(_2\)Cr\(_2\)O\(_7\), H\(_2\)SO\(_4\), H\(_3\)PO\(_4\), and others. The tools used in this research were machetes, scales, barrels/buckets, plastic, gunny and laboratory equipment for compost analysis in the laboratory. Materials collection and composting were carried out in March 2019.

### 2.2 Research Design

The research used a non-factorial Completely Randomized Design (CRD), as a treatment that is the difference in the composition of OPEFB and *M. bracteata* which arranged in 5 levels: P1 (OPEFB 100%); P2 (OPEFB 25% + *M. bracteata* 75%); P3 (OPEFB 50% + *M. bracteata* 50%); P4 (OPEFB 75% + *M. bracteata* 25%) and P5 (*M. bracteata* 100%). Each treatment carried out in 3 repetitions hence it obtained 15 experimental units.

### 2.3 Composting of *M. bracteata* and OPEFB

The empty fresh bunches was cut into eight parts, and *M. bracteata* was chopped with the size of ± 20 cm. Furthermore, 18 grams of 15-15-15 NPK fertilizer was dissolved in water and then poured evenly on the compost material; this action aims to provide food for microorganisms at the beginning of composting. As much as 100 mL of *Trichoderma sp* inoculant was applied into the composting. Then, the compost was evenly mixed and put into the barrels. One barrel contains 6 kg of material, with the ratio of ingredients as stated in the treatment. The compost materials were pressed until solidified and then covered [7,12]. The composting was done aerobically; compost turning was done every seven days and carried out for three months.
2.4 Compost Analysis
The analysis of N (Kjeldahl with Spectrophotometry), P (Dry Ashing-HNO₃ with Spectrophotometry), K (Dry Ashing – HCl with Atomic Absorption Spectrophotometry), C-organic (Walkley & Black with Spectrophotometry) were following Sulaeman (2012) [13]. The C/N ratio and compost yield are determined using 1 and 2, respectively [14].

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\text{C/N ratio} = \frac{\% \text{ of } C_{\text{organic}}}{\% \text{ of } N} \\
\text{Compost yield} = \frac{B}{A} \times 100\%
\]

where A is the initial weight of compost for each treatment, and B is the final weight of compost for each treatment.

2.5 Statistical Analysis
Observation data were analyzed with Analysis of variance (ANOVA) at 5% level. If F arithmetic > F table, then proceed with the Least Significant Difference test. The data were processed using SPSS 20 software.

3. Results and Discussion
Based on the results of data analysis (table 1) that the differences in the composition of empty bunches and *M.bracteata* as compost raw material were significantly different in observation parameters of N, K and compost yield, while P, C-organic and C/N ratio were not significantly different between P1, P2, P3, P4 and P5.

| Treatment                              | N (%) | P (%) | K (%) | C-organic (%) | C/N Ratio | Compost Yield (%) |
|----------------------------------------|-------|-------|-------|---------------|-----------|-------------------|
| P1 (OPEFB 100%)                        | 2.30 a| 0.53  | 6.09 d| 37.73         | 17.9      | 59 a              |
| P2 (OPEFB 25% + M. bracteata 75%)      | 2.83 c| 0.64  | 4.18 b| 38.42         | 14.3      | 66 b              |
| P3 (OPEFB 50% + M. bracteata 50%)      | 2.94 d| 0.63  | 4.88 c| 35.97         | 12.3      | 67 b              |
| P4 (OPEFB 75% + M. bracteata 25%)      | 2.62 b| 0.61  | 6.59 e| 37.72         | 14.4      | 56 a              |
| P5 (M. bracteata 100%)                 | 4.42 e| 0.6   | 3.75 a| 39.14         | 8.9       | 69 b              |
| Averages                               | 3.02  | 0.6   | 5.1   | 37.8          | 13.5      | 63                |

Note: the number followed by the same letter in the same column indicate no significant difference in the Least Significance Different test of 5% level
3.1 Compost N Content
Statistically, the differences in the composition of OPEFB and *M. bracteata* have a very significant effect on N content of compost. Based on the LSD test, compost N content was significantly different between P1, P2, P3, P4 and P5. The highest N content was in the treatment of P5 (*M. bracteata* 100%), which was 4.42% and the lowest was in P1 (100% OPEFB). This is following the characteristics of each ingredient. *M. bracteata* can produce high organic matter, around 45-56% N in the closed area and 75-83% N in the open area [8], while the N content in OPEFB is only 0.80% [4]. The quality of compost is influenced by the type and quality of the basic ingredients and the quality of the composting process [7]. In compost with combined materials of OPEFB and *M. bracteata*, the highest N was resulted in P3 treatment (OPEFB 50% + *M. bracteata* 50%), that was 2.94%. When compare P3 with P5 treatments, N content in P5 was higher than N content in P3 treatments. Based on SNI (Indonesian National Standard) Standards 19-7030-2004, compost N contents in all treatments meet SNI Standards. Besides that, Barker (1997) who stated that to report compost as having fertilizing capabilities and for it to be used in agriculture the total N content must be over 1% dry weight [15]. Nitrogen is the main macro nutrient needed by plants. It is used for the synthesis of cellular material, amino acids, and proteins and is continuously recycled through the microbe’s bodies [16].

3.2 Compost P Content
Statistically, differences in the composition of OPEFB and *M. bracteata* did not have significant effect on compost P content. The compost material used, both OPEFB and *M. bracteata* is not a high P-producing material. P content in OPEFB is 0.22% [4] and P content in *Mucuna* sp is 0.2% [7]. P content in OPEFB and *M. bracteata* have the same value, this causes the P content of compost was not significantly different between compost with 100% OPEFB material, 100% *M. bracteata* or a combination of both compositions. However, compost P contents have met SNI Standards 19-7030-2004.

Phosphorus is an essential element for the metabolism of living organisms because it is a component of nucleic acids, the phospholipids that compose cellular membranes, ATP and ADP molecules and intermediate compounds of respiration and photosynthesis [17]. The P content in compost is quantified as total P, but within this total neither the quantities nor the P species that are available are entirely clear. Compost application in intensive cropping system soils often exceeds P uptake owing to an accumulation of P species which are unavailable or not readily available. It has been determined that high levels of total P in soil amended with compost increased fixed-form P with Fe, Al and Ca [18].

3.3 Compost K Content
Statistically, the differences in the composition of OPEFB and *M. bracteata* have a very significant effect on the K content of compost. Based on the LSD test, compost K contents were significantly different between P1, P2, P3, P4 and P5. The highest K content of compost was at P4 (75% OPEFB + 25% *M. bracteata*), higher than the compost K content at P1 (100% OPEFB). The K content of compost at P4 was 6.59% and the K content of compost at P1 was 6.09%, there was a difference of 0.5%. The K content in OPEFB is 2.90% [4] and the K content in *Mucuna* sp is 1.90% [7]. The composition of 75% OPEFB and 25% OPEFB is the best in producing compost with high K content. Referring to SNI Standards 19-7030-2004, compost K content has fulfilled SNI standards. Gaur [19] stated that the ratio of C-organic : N : P : K content in decomposed materials is equivalent to 30 : 1 : 0.1 : 0.5. It will affect the duration of composting [19].

3.4 Compost C-Organic Content
Statistically, the differences in the composition of OPEFB and *M. bracteata* did not have significant effect on compost C-organic contents. The compost C-organic contents produced were around 35.97 - 39.14%. This does not meet the standards when referring to SNI 19-7030-2004 standards. Microbes remodel organic matter require carbon as an energy source for growth [7]. *M. bracteata* is a producer...
of high organic matter. The organic material produced by *M. bracteata* is higher than weed-free and naturals [20].

### 3.5 Compost C/N ratio

Statistically, differences in the composition of OPEFB and *M. bracteata* did not have significant effect on the compost C/N ratio. The resulting compost C/N ratio is around 8.9-17.92. The compost C/N ratio is resulted from the comparison of C and N values. The higher the value of N will produce a lower C/N ratio. In this research the highest N content was at P5 at 4.42%, thus the lowest C/N ratio was generated at P5, even though C-organic was still relatively high > 30%.

### 3.6 Compost yield

Statistically, differences in the composition of OPEFB and *M. bracteata* significantly affect compost yield. Based on the LSD test, P1 and P4 are significantly different from P2, P3 and P5 but P1 is not significantly different from P4, and also P2 is not significantly different from P3 and P5. The highest compost yield was in P5 (100% *M. bracteata*) and the lowest was in P4 (OPEFB 7% + *M. bracteata* 25%). Compost yield is the percentage of compost produced from several composted materials, the greater the composition of *M. bracteata*, the greater the compost yield. Compost yield measurements can be used in determining the amount of material needed to produce compost.

### 4. Conclusion

The differences in the composition of OPEFB and *M. bracteata* had a significant effect on the content of N, K, and compost yield. The greater the composition of *M. bracteata*, the higher the N content of the compost, but K content is lower and vice versa. If the composting was using OPEFB and *M. bracteata* as the materials, it is suggested to use a composition of 75% OPEFB and 25% *M. bracteata*.

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