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Utilization of microbial-assisted composting of the palm-press fiber as pre-nursery growing medium for oil palm seedlings

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Abstract. Oil palm fruit fiber (mesocarp) is waste generated mainly from palm oil manufacturing activities. Since it is organic in origin, they are rich in nutrient for the plant. Composting can be a suitable method for converting the fiber into compost that can be used as growing media. In this study, three types of composts were made by mixing the fiber with cow manure in ratios as follows: fiber compost I (3:1), fiber compost II (1:1) and fiber compost III (1:3) respectively and the chemical properties (pH, temperature and nutrient content) of them were determined. Their suitability as growing media was observed through growth performance of oil palm seedlings. They were grown in four types of growing media which were F0 = subsoil 100% (control), F1 = 90% fiber compost I : 10% subsoil, F2 = 90% fiber compost II : 10% subsoil, F3 = 90% fiber compost III : 10% subsoil. As results, initial pH of fiber compost I were lower than other composts but value eventually similar by the end of the study. The composting temperature which higher, in the beginning, were decreasing and were stable at the end of composting (week 6). The growth of oil palm seedlings was the greatest when grown in a mixture of 90% fiber compost II: 10% subsoil. Results of this study suggest a bright future for the use of fiber as growing media as indicated in chemical properties of fiber that can be improved through composting process and its positive effect as reflected in the growth of oil palm seedlings.

1. Introduction

Oil palm fruit fiber (mesocarp fiber) is one of the organic wastes produced by palm oil mill processing activities. The average fiber produced is 400 g per TBS (Fresh Fruit Bunches) [1]. Fiber is generally used as boiler fuel in palm oil processing plants [2] and [1] and also as an ingredient in making potassium fertilizer [1]. Potassium plays a role in the translocation of sugar in starch and protein formation, increasing plant resistance to pest and disease attacks, improving fruit size and quality in the generative period and adding sweetness to the fruit [3]. Fiber has content including Potassium (K) of 0.5%, Calcium (Ca) 0.5%, Chlorine (Cl) Carbon (C) of 42.7%, Nitrogen (N) of 0.8%, Phosphorus (P) of 0.1%, and Zinc (Zn) of 9.8% [4]. The nutrients content show that fiber can be used as compost material. Compost is a source of macro and micronutrients and in the long run, can improve pH and increase crop production. [5] mentioned that compost is a soil enhancer because organic matter available in composts can maintain and increase the fertility of the growing medium. Furthermore, [6] stated that the addition of nitrogen sources such as cow dung can accelerate the decomposition process. [4] in the results of his research concluded that mesocarp fibers composted for 50 days were able to meet good compost quality with a C/N ratio of 12.6 and could be used as fertilizer and soil enhancing material.

The type of growing media and the use of growing containers are some factors that can affect the growth of plant seeds. The use of a pot tray as growing media container has several advantages because it can save the use of growing media as a medium for plant growth and the pot tray can be used repeatedly. This shows that the use of pot tray in early nurseries can reduce plastic waste from polybags. [7] and [8] suggested that the use of pot tray in oil palm plantations in the South Sumatra region had several advantages, namely saving space, the number of growing media and labor in the nursery area. [9] stated that there was an adaptation process when the pot tray was first used in the early oil palm nursery, however the results of the study on the use of pot tray in Sabah, Malaysia showed that the seedling growth was as good as the use of poly bags and had been applied routinely in the early nursery process in the area [10]. In the research of [10] showed that the volume of growing media on pot tray use was only 10% compared to the use of growing media in polybag containers, and the use of fertilizer did not show a significant difference between 100%, 50%, and 0% fertilization. This shows that the growth period of oil palm seedlings in early nurseries can be filled with food reserves contained in the kernel. However, [10] in his research showed that the addition of organic matter to the growing medium can contribute to producing a good seedling growth in the early nursery.

The research on the application of growing media enriched with compost of palm fruit fiber waste, in the early nursery of oil palm seedling growth using pot tray containers needs to be done and to provide insight into the dynamics of the growth of oil palm seedlings in the early nursery using pot tray and obtain alternative solutions to environmental problems oil palm plantation. The purpose of this study was to analyze the dynamics of the physical and chemical properties of composted oil palm fruit fibers and the response of the growth of oil palm seedlings in pot tray containers with planting media enriched with oil palm fruit fiber compost.

2. Material and Method

2.1. Material
This research was carried out at the Citra Widya Edukasi Oil Palm Polytechnic in Bekasi, West Java. Palm oil seedlings used in this study were obtained from PT Mekar Sari, Cileungsi, Bekasi, West Java, and Mesocarp Fiber obtained at PT Kertajaya, PTPN 8 Malimping Banten, West Java. Cow Dung was got in cow farming in Bekasi and bio activator Agrisimba were from PT Rekayasa Hayati, Bandung Institute of Technology. Pot Tray was obtained from PT. Megah Buana Pancarona, Tangerang, West Java.

2.2. Method

*2.2.1. Composting Mesocarp Fiber Establishment.*The composts made in this research consists of 3 types of variations in the mixture of the amount of fruit fiber of palm oil and cow dung, namely: (Fiber compost I) is a mixture of mesocarp fiber and cow dung in a ratio of 3: 1; (Fiber compost II) is a mixture of mesocarp fiber and cow dung in a ratio of 1: 1; and (Fiber compost III) is a mixture of mesocarp fiber and cow dung with a ratio of 1: 3.

At the beginning of the composting process, mesocarp fiber was boiled at 100^{o} C for 3 hours and then placed in a basket to remove boiled water. Mesocarp fiber is composted by the Takakura method using a plastic coated basket to place a bearing containing sawdust to maintain compost moisture (Figure 1.). In the composting process, commercial bio-activator (Agrisimba) was applied which was first activated by urea fertilizer and the composting process was carried out for 50 days.

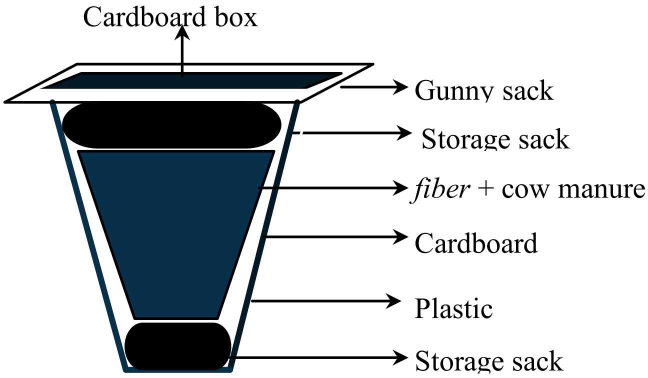

Figure 1. Composting container

2.2.2. Oil palm seedling growth in pot tray. This study used a Complete Randomized Block Design (RCBD) consisting of four treatments, namely: P1 = 100% Subsoil, P2 = 90% Compost fiber I: 10% Subsoil, P3 = 90% Compost fiber II: 10% Subsoil , and P4 = 90% Compost fiber III: 10% Subsoil.

The oil palm seedling was first soaked with an active ingredient fungicide in a concentration of 0.2% for 10 minutes and then put on a clean cloth to be planted in the soil media that has been prepared in pot trays. Each day, the plant was watering twice a day, morning and evening, and if there are weeds around the seedlings then hand-picking were done manually.

2.2.3. Determination of physicochemical Properties of compost and oil palm seedling growth. The temperature of compost was measured weekly at three different points in the middle layer of the compost pile by using a thermometer. The thermometer dipped into the pile for about five minutes before taking the reading. Compost samples (10 g) were collected from the interior of the compost pile. The samples were suspended in distilled water (100 ml) and the filtrate was used to measure the pH using pH meter.

2.2.4. Morphological and Physiological Observation. Observations made in this study include morphological and physiological parameters of oil palm seedlings, namely: (a). seedling height (cm), which is measured from the base of the stem to the highest leaf tip; (b). collar girth (cm), which is measured using a caliper run at a distance of 0.5 cm from the root neckline; (c). a number of leaves (strands), which is measured by counting all leaves that have opened perfectly; (d). leaf greeness was determined with a SPAD 502 instrument; (e). Leaf area was measured with a Leaf Area Meters; (f). plant biomass, that the measurements consist of root wet weight (gr), root dry weight (gr), shoot wet weight (gr) and shoot dry weight (gr).

Morphological parameter measurements were carried out one month after planting for 3 months, while physiological parameters were measured at the end of the study at 3 months old seedlings (3 MAP = Month After Planting). Compost and growing media analysis were carried out at the beginning of the study and at the end of the study at the Test Laboratory of the Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agricultural University.

2.2.5. Data Analysis. To determine the growth of the oil palm seedling, we used monthly data and at the three months after planting data to run an analysis of variance using the Statistical Analysis System (SAS, v.9.2) software.

3. Results and Discussion

3.1. Mesocarp fiber compost chemical content

Organic materials, with various compositions used for composting, showed the results that different compositions produce different nutrient values. Before composting each material has a high C/N ratio. The C/N ratio of mesocarp fiber was 167.58% and cow dung was 129.47%. However, after composting for 50 days, the C/N ratio decreased by reaching the range of 22-36% (Table 1).

In fiber compost type I, it showed that the compost contains the highest amount of K compared to fiber compost type II and III. Fiber compost I was produced from a mixture of fiber and cow dung in a ratio of 3: 1. In line with the research conducted by [11] which states that to increase the K content, a material that has high fiber content, which can absorb water and prevent the loss of K, is added to the compost. The results of the analysis can be seen in Table 1.

Table 1. Chemical content of *fiber* composts.

Type of compost	C-org	N (%)	P (%)	K (%)	Mg (%)	C/N Ratio
Fiber compost I	45,02	2,04	1,13	2,89	0,31	22,02
Fiber compost II	47,64	2,01	0,94	2,05	0,3	23,71
Fiber compost III	51,02	1,42	0,62	1,3	0,25	36,01

The decrease in the C/N ratio is the outcome of the organic matter decomposition activities carried out by microorganisms from large particles into small. The higher the C / N ratio, the longer the process of degradation carried out by microorganisms. The content of Carbon and Nitrogen in organic matter will affect the composting process, this is due to microbes using C for energy and growth, while N, P, and K are important for protein synthesis and reproduction. One method to increase nutrient value, by utilizing mesocarp fiber and cow dung compost for alternative growing media and by adding the commercial bio-activators. The palm-press fiber consists of cellulose, hemicellulose, and lignin, which difficult and takes time for the degradation. Then, the addition of microbial in composting, which containing decomposer microorganisms, can speed up the composting process and also improve the quality of compost.

3.2. pH of compost

The initial pH value in the composting process is 7.35 - 8.59. The degree of acidity at the beginning of the composting process will decrease because of a number of microorganisms in composting transform organic matter into organic acids. Microorganisms of other types will convert organic acids that have been formed so that the material has a high and close neutral acidity. The pH value increases when the added organic material has decomposed completely (mature) and the mature organic material will release the mineral in the form of base cation [12]. The pH value of compost can be seen in Fig. 2.

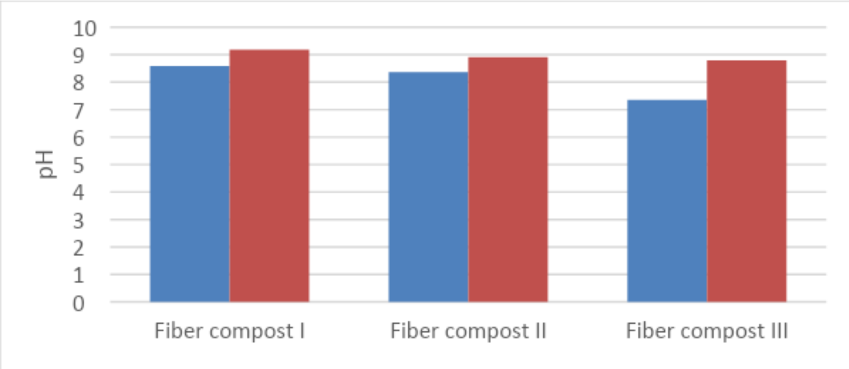

Figure 2. pH value in the beginning and at the end of composting

The degree of acidity needs to be controlled during the composting process. If the acidity level is too high or too much oxygen consumption will increase and will produce bad results for the environment. The degree of acidity that is too high will also cause the element N in the compost material to change to ammonia (NH_3) otherwise in an acidic state it will cause some microorganisms to die.

Too high a degree of acidity can be reduced by adding animal waste, urea, or N fertilizer. If the acidity level is too low it can be elevated by adding lime or kitchen ash to the compost material. In Figure 2 it can be seen that the final pH value reaches 8.8-9.19. [13] states that the pH value of the compost which changes from acid to base is due to nitrogen ionization in the form of ammonium (NH_4^+), nitrite (NO_2^-) and nitrate (NO_3^-) in the mineralization process.

3.3. Temperature of composts

The optimum temperature required for microorganisms to degrade organic matter is 35-55 °C, but each group of microorganisms has the optimum composting temperature which is an integration of various types of microorganisms involved. The results in this research showed that the highest composting temperature in the treatment was in the range 29°C-32°C. The compost temperature can be seen in Figure 3.

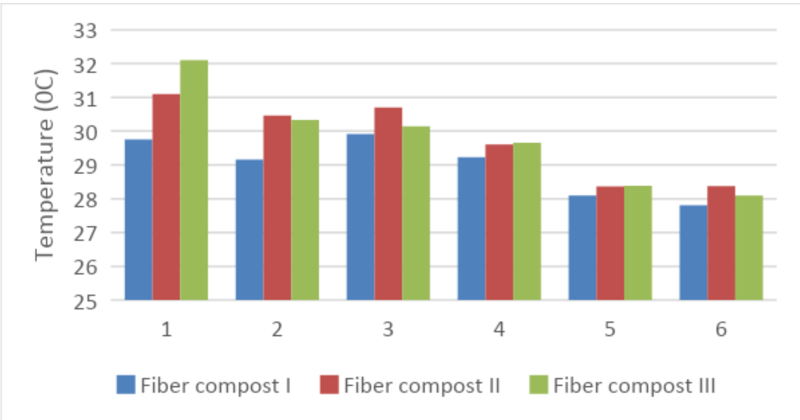

Figure 3. Temperature of compost

In this study the thermophilic phase, which is 40-60°C, is not reached and is estimated due to the process of microbial adaptation in the new composting environment and also the amount of compost available is insufficient to capture the heat generated from the microbial activity. [14] suggested that the thermophilic phase is a good phase for the degradation of hemicellulose, cellulose, lignin, and lipids. In the composting process there is a fairly rapid temperature increase during the first 3-5 days and the temperature is the best for the growth of microorganisms, in this temperature range microorganisms can grow three times compared to temperatures less than 55°C, besides that at the temperature of the enzyme the resulting one is also the most effective in breaking down organic matter. Decreasing in composting temperature could be explained by the decreasing of the composting pile due to the composting process itself. The material that was composted will shrink then it insufficient to trap heat in this study.

3.4. Seedling height (cm)
The setting of growing media with the combination of compost and subsoil in pot tray does not significantly affect the height of oil palm plants aged 1 and 2 months after planting (MAP). But at the third months, the height of oil palm plantations has a significant effect. The highest plant height was found in P3 treatment which is 90% Fiber II Compost: 10% Subsoil, not significantly different from P4 treatment, which is 90% Compost fiber III: 10% Subsoil. The lowest plant height was found in 100% P1 Sub soil treatment (Table 2).

At three months after planting, the plant height significantly different higher in P3, that is 90% Fiber II Compost: 10% Subsoil and P1 100%, than P1 and P2. This is because the seedlings at the 3 MAP have absorbed nutrients from growing media. The C/N ratio in P3 is relatively stable, and the standard C/N compost value is around 17-25 and can be said to be mature compost. The ratio of C/N ratio is an important indicator to determine the level of maturity, quality, and stability of compost. This is because mature compost can immobilize and release nitrogen and other important nutrients in the soil that can be used by the plants [15].

Tabel 2. The average of oil palm seedling height (cm) at 1, 2, 3 MAP

Growing Media Composition	Age (Month After Planting)		
	1	2	3
	---height (cm)---		
P1 100% *subsoil*	6.40[a]	12.40[a]	17.25[b]
P2 90% fiber compost I: 10% *subsoil*	6.00[a]	13.25[ab]	21.10[ab]
P3 90% fiber compost II: 10% *subsoil*	7.9[a]	16.82[ab]	25.85[a]
P4 90% fiber compost III: 10% *subsoil*	7.92[a]	17.15[b]	25.50[a]

Note. Means with the same letter within a column are not significantly different using LSD at $p < 0.05$.

In addition, potassium also plays a role in plant growth because the element of potassium helps carbohydrate metabolism and accelerates meristem tissue proliferation. [16] stated that high doses of organic fertilizer containing N, P, K, and S affected vegetative growth and crop production. Nitrogen is very necessary for the formation and growth of vegetative parts of oil palm plants such as plant height.

3.5. Collar girth (cm)
Different composition of growing media, the combination of compost and subsoil, in the pot tray, give no significant effect on the collar girth of oil palm plants at 1 month after planting (MAP). At 1 MAP, the highest plant collar girth was found in P1 which growing media composition is 100% Subsoil, while the lowest collar girth was in P2 which the composition of growing media is 90% fiber compost III: 10% Subsoil, P3 is 90% fiber compost II: 10% Subsoil, and P4 that is 90% fiber compost I: 10% Subsoil, gets the same value. At 2-3 BST collar diameter of the plants has no significant effect. The highest collar girth plant was found in P3 with the composition of growing media is 90% fiber compost 10% Sub soil at 3 MAP. While the lowest collar girth is in growing media P1 which is 100% Sub soil. The average collar girth of plants at 1-3 MAP was shown in Table 3.

Table 3. The average of collar girth (cm) of oil palm seedling at 1, 2, 3 MAP

Growing Media Composition	Age (Month After Planting)		
	1	2	3
	--collar girth (cm)--		
P1 100%	0.207[b]	0.300[a]	0.450[a]
P2 90% fiber compost I: 10% *subsoil*	0.200[b]	0.400[a]	0.540[a]
P3 90% fiber compost II: 10%	0.200[b]	0.395[a]	0.545[a]
P4 90% fiber compost III: 10% *subsoil*	0.200[a]	0.421[a]	0.522[a]

Note. Means with the same letter within a column are not significantly different using LSD at $p < 0.05$.

According to [17], the availability of nutrients in growing media that can be absorbed by plants is one factor that can affect plant growth. [18], states that potassium functions to accelerate the growth of meristem tissue. Plants will not be able to metabolize these important process if less nitrogen is available in plants. Potassium plays a role in increasing the collar girth of plant, especially in its role as a network that connects the roots and leaves in the transpiration process [19]. Nutrients contained in the growing medium cannot be separated from the increase in diameter of the plant from the role of P and K nutrients. The availability of potassium elements supports the formation of carbohydrates and translocation of starch to the collar girth of the oil palm seedling. The stem will support palm oil seedlings and facilitate the process of transporting nutrients from root to shoot. According to [20], potassium serves to increase growth and strengthen the robustness of the stem.

3.6. Number of leaves and leaf area

Variety of growing media composition does not significantly affect the number of leaves of oil palm seedling plant at 1-3 MAP. The number of oil palm leaves can be seen in Table 4. The average growth of the highest number of leaves at 3 MAP is P3 which grown the media of 90% fiber compost II: 10% subsoil (3.75 strands) and P4 which grown in the media of 90% fiber compost III: 10% subsoil (3.50 strands). While The lowest number of strands is in P1, grown in 100% Sub soil (3.00 strands).

Table 4. The number of leaves of oil palm seedling grown in a different composition of growing media.

Composition of Growing Media	Age (Month After Planting)		
	1	2	3
	--number of leaves (strand)--		
P1 100% *subsoil*	1.00[a]	3.00[a]	3.00[b]
P2 90% fiber compost I: 10% *sub soil*	1.00[a]	2.75[b]	3.25[ab]
P3 90% fiber compost II: 10% *sub soil*	1.25[a]	3.25[ab]	3.75[a]
P4 90% fiber compost 10% *subsoil*	1.50[a]	3.50[a]	3.50[ab]

Note. Means with the same letter within a column are not significantly different using LSD at $p < 0.05$.

Table 5. The average of the leaf area of oil palm seedling growing in different combination of fiber compost and subsoil at 3 MAP

Composition of Growing Media	Age (a month after planting)
	3
	--leaf area (cm^2)-
P1 100% *subsoil*	19
P2 90% fiber compost I: 10% *subsoil*	28.75
P3 90% fiber compost II: 10% *subsoil*	28.96
P4 90% fiber compost III: 10% *subsoil*	18.5

According to [21], the function of nitrogen is in the formation of chlorophyll cells, where chlorophyll is useful in the photosynthesis process so that the energy required for cell division, enlargement and elongation is formed. According to the standard of growth of oil palm seedlings, the number of leaves of 7 months old oil palm seedlings is around 10.5 strands, whereas from the results of the research the number of seed leaves in the treatment of biogas wastewater at a dose of 150 ml/plant is close to the growing standard of 10.25 strands. Generally, in the pre-nursery stage, one leaf per month is produced until the seedling is 6 months old. In this stage is called the four-leaf stage [22]. Furthermore, [23] explain that nutrients that most influence the growth and development of leaves are nitrogen. The nitrogen content contained in plants will be used by plants in cell division.

In table 5 it showed that the average of total leaf area is found in P3 that seedling was grown in 90% fiber compost 10% subsoil (28.96 mm), and the smallest average value is P4 which the seedling grown in 90% fiber compost III: 10% subsoil (18.50 mm). According to [24], the number of leaves determines the photosynthesis results, where the photosynthesis results will affect the growth and development of plants, one of which is the development of leaves. Furthermore, [25] added that nitrogen and phosphorus nutrients play an important role in the activation of potassium which affects the development of meristem tissue, then the length and width of the leaf.

3.7. Leaf greenness

The results showed that the highest number of leaf greenness was found in P4 in oil palm seedling grown in 90% fiber compost III: 10% subsoil (53.18unit), then the lowest leaf greenness was found in P1 which seedling in 100% subsoil (40.43 units) as shown in Table 6. Oil palm seedling grown in growing media contain fiber compost has a significant effect on leaf greenness, this is because the plants in the P4 growing media get enough nitrogen nutrients. [26] states that the growth of roots, stems, and leaves occurs quickly if sufficient nutrient is available for the process of forming the organ in sufficient condition.

Table 6. The average of oil palm seedling leaf greenness grown in a different composition of growing media at 3 MAP.

Composition of growing media	Age (a month after planting)
	3
	--leaf greeness--
P1 100% *sub soil*	40.43[b]
P2 90% fiber compost I: 10% *subsoil*	50.27[a]
P3 90% fiber compost II: 10% *subsoil*	50.18[a]
P4 90% fiber compost III: 10% *subsoil*	53.18[a]

Note. Means with the same letter within a column are not significantly different using LSD at $p < 0.05$.

The amount of chlorophyll content in the leaves can be seen from the greenish leaves, the more greenness of the leaves indicate the more chlorophyll content in the leaf. Greenish leaves are one of the factors to determine the element of nitrogen in the leaves. Nitrogen nutrients absorbed by plants can stimulate plant growth and encourage the formation of chlorophyll so that the leaves of the plant will become green which functions for the photosynthesis process of plants. The presence of abundant green substances in plants will be easier to carry out photosynthesis.

3.8. Biomass
The composition of the combination of fiber compost and subsoil as growing media was not significantly related to the root wet weight, shoot wet weight, and root dry weight. The highest plant seedling biomass was found in P3 which the composition was 90% fiber compost II: 10% subsoil, whereas the lowest biomass was found in P1 which the growing media is 100% subsoil. The effect of various compost growing media on plant biomass was shown in table 7.

Tabel 7. The average of the wet and dry root and shoot weight of oil palm seedling grown in a different composition of growing media at 3 MAP.

Composition of growing media	Age (three months after planting)			
	Root wet weight	Shoot wet weight	Root dry weight	Shoot dry weight
	----- (g) -----			
P1 100% *subsoil*	0.71	2.44^{b}	0.15	0.39^{c}
P2 90% fiber compost I: 10% *subsoil*	0.71	3.57^{ab}	0.35	0.72^{ab}
P3 90% fiber compost II: 10% *subsoil*	1.22	5.25^{a}	0.22	0.83^{a}
P4 90% fiber compost III: 10% *subsoil*	1.07	4.35^{ab}	0.14	0.58^{bc}

Note. Means with the same letter within a column are not significantly different using LSD at $p < 0.05$.

In Table 7 it is known that the highest biomass yield is oil palm seedling grown in growing media namely P3 and the lowest is in growing media namely P1. [25] said that organic matter is very important for supporting the physical and chemical properties of the soil. Its role not only increases aggregate but can improve the upper soil structure. The [27] research result on oil palm seedlings could significantly produce higher dry weight compared to inorganic fertilizers and without inorganic or organic fertilizers. The high and low weight of dry weight plants depends on the amount or minimum of nutrient uptake that takes place during the plant growth process. Furthermore, [28] suggested that the high element of potassium can increase the dry weight of corn plants. Nitrogen, phosphorus, and potassium nutrients are the most needed nutrients in photosynthesis as constituents of compounds in plants that will be converted to form plant organs such as leaves, stems, and roots. According to [29], the value of the root-shoot ratio shows how much photosynthesis values accumulate in plant parts.

4. Conclusions
This present study shows that composting increase the added value of the waste of palm press fiber (mesocarp fiber). In the application of 90% fiber compost II and 10% subsoil provides nutrient availability for supporting the oil palm growth. Compost application stimulated the performance of oil palm seedling and improve soil quality. The use of solid fibrous waste compost as a growing medium

would play an important role in sustainable crop production technology. Further study should target a thorough and nuanced analysis of seedling growth in the main nursery.

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