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THE EFFECT OF COMPOSTING APPLICATION ON SOIL PHYSICAL AND CHEMICAL PROPERTIES IN OIL PALM PLANTATIONS

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Abstract

The larger part of oil palm plantation locales have moo levels of physical and chemical ripeness in their soils. Fertilization can make strides the soil's physical and chemical ripeness. Experts are investigating beneficial agronomic methods, such as the composting of discarded fruit bunches as organic fertilizer for oil palm plants. As a result, the goal of this study was to see how compost application affected physical and chemical soil fertility in oil palm farms. The researchers did descriptive study by examining the land of oil palm farms that were employing POM waste compost as a consequence of the experiment or research. The observation concentrated on the soil's features. For the observation parameters with a significant influence, the data was statistically analyzed using the Least Significant Difference Test (LSD). The use of OPEFB waste compost in oil palm farms improves soil quality both physically and chemically. The soil density rose from 0.78 g/cm3 to 0.95 g/cm3 with the addition of OPEFB compost. The area employing OPEFB compost demonstrated marginally improved soil permeability, resulting in constant soil moisture conditions at the field capacity level. In terms of soil chemical characteristics, the addition of OPEFB compost might increase soil quality in terms of CEC, total N, total K, exchanged K, Na, Ca, Mg, and S.

Keywords: compost, oil palm, physics, chemistry, soil

INTRODUCTION

Soil preservation is an exertion to move forward and protect soil quality by constraining disintegration from water and wind, as well as over the top supplement and natural component exhaustion. Soil natural matter contributes to the arrangement of soil structures and impacts the physical, chemical, and natural properties of the soil. It is additionally basic for overseeing water circulation and decreasing soil disintegration and supplement filtering. Soil carbon conservation makes it more hydrologic ally economical and competent of giving a appropriate domestic for plants and other living creatures (Agus, 2013).

The larger part of oil palm manor districts has moo levels of physical and chemical richness in their soils. Fertilization can move forward the physical and chemical richness of the soil, which can boost the generation of oil palm plants, as oil palm could be a nutrient-consuming plant. Numerous components must be considered when fertilizing oil palm on farmers arrive, counting the number of supplements gotten by plants, supplements returned, supplements misplaced from the rhizosphere, supplements carried by collect, and the soil's capacity to deliver nutrients. The ability of the soil to supply supplements incorporates a exceptionally huge distinction and it depends on the sum of accessible supplements, the nearness of obsession and mobilization forms, and the accessibility of supplements to reach the rhizosphere of plants (Arsyad et al., 2012).

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Most oil palm farmers are unaware of the necessary and accurate fertilization methods for boosting the production of their oil palm farms, particularly in terms of raising the quantity of fresh fruit bunches. If intensive or traditional tillage farming systems on drylands continue for an extended period of time without soil conservation activities, production will rapidly fall. Finally, it will produce nutrient-deficient land. Experience has shown that if farmers treated the land appropriately, soil production could be maintained and increased (Arsyad et al., 2012).

Experts are currently investigating effective agronomic approaches, such as the composting of discarded fruit bunches as organic fertilizer for oil palm plants. This is an ongoing endeavor to lessen reliance on chemical fertilizers and shift toward healthy food production by encouraging recycling and the use of agricultural waste as organic fertilizer (Sundram et al., 2019).

If POM does not effectively manage its waste, palm oil waste might be one of the environmental contaminants. Industry may convert this waste into biological fertilizer or compost, which can boost crop production and soil fertility, and use it as an alternative source of renewable nutrition for sustainable oil palm plantations (Yi et al., 2019).

Composting natural squander could be a common strategy for changing strong squander into accommodating fertilizer. Natural trash, which comprises green squander, sewage slime, nourishment preparing squander, and palm oil process squander, makes up a sizable component of civil and agrarian garbage. In certain districts, composting has challenges such as terrible odors, leachate, bugs, and flies, but transportation will prevent low-value squander from being exchanged to distant better;a much better;a higher;a stronger;an improved">an improved composting area. Moreover, the failure to isolated and treat natural squander components in an unexpected way comes about in an expansive misfortune of follow components, minerals, and other imperative chemicals. Natural fertilizers are regularly arranged from a single common component and are as often as possible combined with inorganic fertilizers to suit the dietary requests of plants. Characteristic fertilizers can be decided from plant, animal, or other mineral sources, such as Cleanse Common item Bunch, palm bit expeller, palm oil pressing fiber, palm oil prepare exuding (POME), sawdust, rice straw and husks, and other agrarian waste. This sort of fertilizer depends on dampness and supportive life forms to break down the fertilizer component, subsequently conditioning the soil with a consistent discharge of natural matter (Sundram et al., 2019).

According to Chiew and Rahman (2002), the application of empty fruit bunch compost of 37.5 tons/ha/year in oil palm plantations enhanced FFB yields considerably, as did the elements K, Ca, Mg, and exchangeable soil pH. Bakar et al. (2011) discovered that using EFB as mulch as a source of nutrients on oil palm land boosts soil fertility and sustains crop productivity over time. As a consequence, increasing the use of organic fertilizers not only helps to reduce environmental pollution produced by agriculture and animal husbandry, but it also helps to increase nutrient availability for plants and functions as a soil conditioner (Mishra & Dash, 2014). So also, compost application, concurring to Yi et al. (2019), can progress soil chemical properties such as pH, natural C, add up to N and P, open P, trade cations, and CEC whereas moreover upgrading FFB yields. In differentiate, inorganic fertilizers brought down soil pH, natural C, add up to N, and interchangeable K. and Ca. According to Rauf et al. (2020),

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composting abandoned fruit bunches in frond stacks and weeded circles in oil palm farms can improve soil fertility and help retain or store rainfall. As a result, the goal of this study was to see how compost application affected the physical and chemical qualities of soil in oil palm farms.

MATERIALS AND METHODS

2.1 Research Material

The materials used in Stage 3 Research are:

a. Compost from research results 2
b. Examples of oil palm plantation land
c. Oil Palm Plants
d. Soil analysis materials in the Laboratory

2.2 Research Tools

The tools used in Stage 3 Research are:

a. Hoe
b. Shovel
c. Ground drill
d. Traps box for soil monolith extraction
e. Laboratory Equipment

2.3 Research Methodology

The research was conducted at PT Eastern Sumatra Indonesia, Bukit Maraja Estate, and Simalungun Regency with sample analysis at the Socfindo Laboratory, Medan and the Laboratory of the Research and Development Center for Biotechnology and Agricultural Genetic Resources, Bogor and the Soil Biology Laboratory, Universitas Sumatera Utara, Medan.

1. The researchers conducted descriptive research by observing the land of oil palm plantations, which was using POM waste compost resulted from the research or experiment.
2. Soil characteristics observation was done by taking soil samples for analysis in the laboratory from:
   a) Soil that was not applied compost as a control (T0)
   b) Soil that has been composted once (2017 application) (T1) (12 Ton/Ha)
   c) Soil that has been composted twice (applications in 2017 and 2018) (T2) (24Ton/Ha)

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d) Soil that has been composted 3 times (applications in 2017, 2018, and 2019) (T3) (36 Tons/Ha)

e) Soil that has been composted 4 times (applications in 2017, 2018, 2019, and 2020) (T4) (48 Tons/Ha)

The observed soil depth consists of two layers, namely:

a) Topsoil (0-30 cm) (D1), and

b) Subsoil (30-60 cm) (D2)

Thus, the researchers designed stage 3 research as a Factorial Randomized Design (FRD), which is a combination of two factors of compost application intensity (T) and soil depth (D) with a combination of 10 units, namely:

T0D1 T1D1 T2D1 T3D1 T4D1

T0D2 T1D2 T2D2 T3D2 T4D2

To obtain 30 units of samples needs to repeat three times for the observation.

The object of the study is the oil palm plantations, which have the same planting year in 1996 (aged 24 years) with the application of 12 tons of compost per hectare by spreading the compost evenly on the soil surface of frond stacks.

2.3 Observation parameters on the soil are:

Soil Physical Characteristics consist of:

a. Bulk Density
b. Porosity
c. Water level
d. Soil Permeability

Soil Chemical Characteristics consist of:

a. pH of Water (H2O)
b. Cation-Exchange Capacity (CEC)
c. Exchange Base (K, Na, Ca, Mg)
d. Base Saturation
e. Nutrient P, S

2.4 Data analysis

the results were statistically produced by employing the least significant difference test (lsd) for the observation parameters that have a significant influence.

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RESULTS AND DISCUSSION

3.1 Soil Physical Characteristics

The variance analysis results on the effect of oil palm waste composting on soil physical parameters revealed that compost had a significant influence on soil density and porosity at soil depths of 0-30 and 30-60 cm, as well as a single effect of compost as shown in table 1. Meanwhile, the use of palm oil waste compost had no perceivable impact on soil water substance or porousness. With this pattern, the source of side income & main and principal in pattern-2 can still take place, but the other source is from Agro trident which is the main source of the family's mainstay. Of course, the synergistic partnership is no longer just about the technical side of adjusting the timber plantation & trident agribusiness among wood plants, but also related to the position of the company's citizens as a potential market for various agribusiness (agro trident) products.

Table 1: Physical Characteristics of Soil Comprises of Impacts of Giving Palm Oil Squander Compost

Treatment	Parameter			
	Density (cm/3)	Porosity (%)	Water Content (%)	Permeability(cm/hour)
D1	0.83a	68.52b	26.81	4.80
D2	0.92b	65.50a	23.62	4.65
LSD	0.07	2.51		
A0	0.78a	70.58c	30.63	4.71
A1	0.81ab	69.59bc	27.09	4.42
A2	0.89b	66.40ab	23.17	4.81
A3	0.94b	64.65a	24.96	4.89
A4	0.96b	63.84aa	20.21	4.80
LSD	0.11	3.97		

Note: numbers followed by the same letter notation in the same column are not significantly different in the 5% LSD test.

In general, the criteria for soil density in the two treatments of soil depth (0-30 and 30-60 cm) as well as the effect of compost are low criteria. It is due to the more application of palm oil, and then the soil will have the more organic substance. Organic substance in the soil acts as a ground binder of soil particles so that soil aggregation is good, soil pore space increases and bulk density decreases.

This is in accordance with the research results of Sollins & Gregg's (2017) that the presence of organic substance caused microbial activity to increase. When organic substance remains stored in the soil, it will cause the formation of a crumblier soil structure with a more stable density to support the development of plant roots. Using waste from POM can create a good environment for soil biota activity in decomposing organic matter. To increase the population of soil microorganisms, including fungi and bacteria, needs organic matter addition. Soil

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microorganisms used organic matter as a constituent of the organism and its source of energy.

This research proved that the input of organic matter from POM compost sources significantly increased the microbial population, consisting of groups of bacterial cellulose and decomposing fungi. Fungal hyphae or mycelia are able to unite soil grains into aggregates, while bacteria function as a binder that unite the aggregates as well as nourish the soil (Liang et al., 2019). Likewise, higher aggregate stability can reduce the soil bulk density, thereby increasing the percentage of pore space and higher water binding capacity (Kallenbach et al., 2016). **Table 2.** The Interaction Effect of Compost Application at Soil Depth on Soil Physical Properties

Parameter	**Depth**	**Compost**				
		A0	**A1**	**A2**	**A3**	**A4**
Porosity	D1	76.45^{bB}	68.42^{aA}	63.48^{aA}	68.92^{bA}	65.34^{aA}
	D2	64.72^{aA}	70.77^{aB}	69.32^{bB}	60.38^{aA}	62.33^{aA}
	LSD	5.61				
Density	D1	0.63^{aA}	0.84^{aB}	0.97^{bB}	0.82^{aA}	0.92^{aA}
	D2	0.94^{bB}	0.78^{aA}	0.81^{aA}	1.05^{bB}	1.00^{aA}
	LSD	0.15				
Water Content	D1	38.09^{bB}	26.52^{aA}	16.79^{aA}	31.09^{bB}	21.55^{aA}
	D2	23.17^{aA}	27.67^{aA}	29.56^{bA}	18.82^{aA}	18.88^{aA}
	LSD	11.38				
Permeability	D1	5.17	4.37	4.96	5.21	4.31
	D2	4.25	4.47	4.65	4.57	5.29

Note: numbers taken after by the same letter documentation within the same column and push are not essentially distinctive within the 5% LSD test. Examined lowercase documentation on a level plane and vertically in capitalized notation.

Soil porosity brought about from the combination of composting medicines at two soil profundities (0-30 and 30-60 cm) were diverse from each other. At a soil profundity of 0-30 cm, the control treatment had 76.45% of the most elevated soil porosity, whereas the least soil pore space within the treatment of giving 2 times of compost (A2) was 63.48%. The layout of soil pore space was taken very seriously inside the compost treatment once (A1=12 tons/ha), which formed 70.77 percent of soil pores. Whereas the control treatment produced the maximum pore space at a depth of 0-30 cm, it produced 64.72 percent at this depth, which was still less than the compost treatment two times (A2=24 tons/ha). The increase in porosity corresponds to a decrease in the thickness of the soil material. So that the sum of a soil mass in a soil volume is able to decide the amount of pore space within the soil. This can be in agreement with the investigate of Glaser et al., (2002) that the impact caused by natural matter was not all the same, but varied based on each characteristic of the compost. Natural matter application is additionally able to supply unused living space for soil organisms so that it can influence the arrangement of soil pores which comes about in expanded soil porosity (Rauf et al., 2020). The thickness at two soil profundities appeared a propensity to extend after composting. At a soil profundity of 0-30 cm, the control treatment had a soil thickness of 0.63

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g/cm3, at that point after giving the tried dosage compost with (2, 4, 6 and 8 tons/ha) the thickness expanded, where the 4 tons/ha measurements (A2) expanded up to 0.97 g/cm3; higher than other compost medications. In the interim, at a soil profundity of 30-60cm, the soil thickness was higher and altogether diverse from that of a profundity of 0-30 cm, with the most noteworthy value of 1.05 g/cm3 within the compost treatment of 6 tons/ha. Usually in agreement with the inquire about conducted by Verheijen et al. (2010) which expressed that the application of natural matter might move forward the thickness of mineral soil contents by the instrument of expanding the soil surface region, subsequently expanding the pore space within the soil. Concurring to Masulili et al., (2010) the application of natural matter can deliver a conducive soil bulk thickness to the advancement of plant roots and result the permeable soil, subsequently expanding the pore space within the soil. When applied to the soil, it'll cause a noteworthy impact on making strides the thickness and expanding the pore volume of the soil.

Within the parameter of soil water substance at a soil profundity of 0-30 cm, the control treatment soil was able to tie more water than the compost treatment (38.09%), but it was not essentially distinctive from the soil water substance within the A3 compost treatment (36 tons/ha), which was 31.09%. At a soil profundity of 30-60 cm, the sum of accessible water capacity was lower than at a soil profundity of 0-30, and the A2 compost treatment (24 tons/ha) seem tie water up to 29.56%, essentially distinctive from the control treatment and the expansion of other compost. In parallel with the regard of soil porosity, utilizing the A0D1 treatment made the foremost lifted regard. Since the porosity of the soil is higher, it can besides increase the water substance of the soil. Dharma & Puja (2019) clarified that soil porosity can be a put to store water inside the soil so the more vital the porosity of the soil is, the more vital the capacity of the soil to store water and the more essential the soil water substance as well.

One of the variables that influence the accessibility of water within the soil is soil surface. Soil surface enormously influences the soil capacity to hold water (Aslam et al., 2014). The ultisol at the research location has a dusty clay surface with a dominant clay composition and limited water retention ability, indicating that the soil has a lower capacity to store water. According to Sutono and Nurida (2012), palm oil waste has the ability to absorb water tall up to > 50% of volume, but it isn't matched with the capacity to keep it since it loses water extremely quickly. This condition ensures that the use of biochar has no significant effect on the availability of ultisols. Furthermore, the distribution of pore measure throughout the soil influences water accessibility inside the soil. Table 2 appears that the composting treatment and the soil profundity don't essentially influence the esteem of soil porousness. In any case, the soil permeability esteem within the treatment concentrated of A3 OPEFB compost application was the most elevated, which was 4.89 cm/hour whereas the least soil penetrability within the A1 treatment was 4.42 cm/hour. Concurring to the Soil Inquire about Institute (1979), the classification of soil porousness for all medications is within the medium category. The size of the soil porosity impacts the moderate or quick rate of soil penetrability, at whatever point the porosity is more prominent, at that point the rate of soil porousness is additionally more prominent, so that water and certain substances move rapidly (Bintoro et al., 2017). Agreeing to Arifin (2011), the dissemination of soil pores impacts the soil penetrability. In case large scale pores overwhelm the pore estimate conveyance of a soil, at that point the soil has the

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capacity to pass expansive water and discuss. By and large, the application of natural matter from OPEFB squander has an impact to extend soil porousness. In parallel with the investigate conducted by Nurida & Rachman (2012), the application of natural matter may decrease porousness. It is since water does not vanish rapidly from the rhizosphere, so that water maintenance moreover increments. Soil depth did not have a statistically significant influence on the physical qualities of the soil studied, according to research. However, when the soil depth is 0.30 cm, the average porosity, permeability, and water content of the soil is highest. On the contrary, the soil bulk density and particles had the lowest mean compared to the soil depth of 3060 cm. Surya et al. (2017) explained that fertilizer application can result in the highest levels of organic matter in topsoil, but can be reduced in subsoil. This was due to the accumulation of concentrated organic matter present only in the top layer. According to the findings of Nelvia & Maysarah (2018), the average bulk density increased from 030 cm to 3060 cm in depth, which increased the depth of the soil. As a result, the deeper the soil, the lesser the organic matter level. These speeds up the compaction process and improves the physical qualities of the soil.

3.2 Soil Chemical Characteristics

Table 3: Soil Chemical Characteristics

Treatment	Parameter										
	pH	CEC	N	P tot	P av	K tot	K exch	Na	Ca	Mg	S
D1	4.77a	21.04a	0.17b	0.44a	165.28b	0.24a	1.33a	0.06a	0.60b	0.89b	2.41a
D2	4.70a	20.44a	0.08a	0.44a	147.02a	0.22a	1.25a	0.08b	0.39a	0.58a	2.44a
LSD	0.07	1.35	0.01	0.03	14.76	0.04	0.30	0.01	0.02	0.06	0.18
A0	4.70b	21.83c	0.11a	0.54c	172.61b	0.22b	1.06b	0.06a	0.53c	0.69b	2.79b
A1	4.95c	22.94d	0.12a	0.54c	151.82a	0.12a	0.42a	0.10c	0.38b	0.41a	2.32a
A2	4.58a	15.93a	0.11a	0.45b	149.16a	0.23b	1.21b	0.08b	0.32a	0.66b	2.08a
A3	4.73b	19.07b	0.15b	0.40b	149.07a	0.29c	2.19c	0.07a	0.64d	0.99c	2.77b
A4	4.72b	23.95d	0.12a	0.27a	158.10a	0.28bc	1.59b	0.07a	0.61d	0.92c	2.16a
LSD	0.11	2.13	0.02	0.05		0.06	0.48	0.01	0.02	0.09	0.29

Note: numbers taken after by the same letter documentation within the same column and push are not altogether distinctive within the 5% LSD test.

Table 3 shows that the strength of OPEFB compost application can increase soil pH from control 4.70 (acidic) to A1 4.95 (acidic). On the other hand, A3 and A4 did not differ significantly from A0, but the soil pH increased slightly by 0.04. On the other hand, the treatment of soil sampling depth was not statistically tested, but the soil pH was slightly higher at D1, 4.78 (acidic) than at D2, 4.71 (acidic).

This suggests that adding compost had a considerable impact on pH. The maximum pH (2 ton / ha) of composted soil treated once a year is 4.95, while the lowest pH (4 ton / ha) of composted soil treated twice a year is. It was 4.58. Compared to soil pH standards, the pH obtained from this study was in the acidic category. When the pH of the soil increases as a consequence of the application of OPEFB compost, the findings of this study are consistent with those of

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Harahap et al (2020). Pane et al. (2014) discovered the usage of organic materials in acidic soils like B. Red dirt can be used to increase the pH of the soil. This statement supports the findings. In general, soil organic matter is important for carbon and nutrient cycling, as well as pH fluctuations in the soil (Wang et al., 2013).

The addition of organic matter to the soil through the use of palm oil waste compost can elevate the pH. As organic matter decomposes in compost, the amount of OH ions grows, which lowers or neutralizes the activity of H + ions. Organic acids cannot be hydrolyzed because they bind or chelate to Al3 + and Fe2 +. Wibowo et al. (2017) discovered that using palm oil waste compost without the addition of compound fertilizers raised the pH of the soil.

Researchers have offered a number of explanations for the rise in soil pH induced by the addition of organic matter and plant detritus. According to Yan and Schubert (2000) and Mokolobate and Haynes (2002), ash alkalinity (level of organic anions) effects soil pH. Other studies (Pocknee and Sumner, 1997; Marschner and Noble, 2000; Xu and Coventry, 2003; LI et al., 2008) have more directly linked soil pH rise with plant material addition to compound mineralization. It is one of the alkaline cations.

Table 3 further demonstrates that adding compost has a considerable influence on the CEC value. The maximum compost dose (4 times / 48-ton hectares applied) increased the greatest CEC content by 23.95 me / 100g. Increased soil organic C content released from compost material caused high CEC values in A4 treatment. According to Bakar et al. (2011), organic matter, especially humus, is a major component involved in the continued development of negative soil charges while increasing CEC.

After applying palm oil waste compost, the total soil nitrogen content at a depth of 0.30 cm was 0.17%. It was higher, significantly different from the total N content of the 3060 cm layer, which was 0.08%. Regarding the effect of composting palm oil waste, when compost was added three times and treated (A3 = 6 tons), the total N value of the soil became 0.15%. It was very different from all treatments. This means that this is the most effective treatment for increasing the total N content of the soil.

From 2017 to 2020, the application of OPEFB compost increased the total N content in the 0–30 cm soil layer (Table 3). Despite this, the total N value remained low. The concentration of N minerals in both soil layers (0–30 and 30-60 cm) was fairly low, most likely owing to plant absorption and leaching, whereas the top layer had the greatest overall N concentration (0.17 percent). The presence of total N in the soil was unaffected by the addition of total N to the soil as a consequence of the usage of oil palm compost. Sianturi et al. (2018) also published different results, claiming that empty fruit bunch compost could yield 0.23 percent of total soil N. In general, the value of N-total generated by this investigation was lower than the results of Harahap et alresearch's (2015). The study, titled The Use of Several Sources and Doses of Organic Activators to Increase the Rate of Decomposition of Empty Fruit Bunch Compost, revealed that incubating the compost for 5 weeks yielded a total value of 2.07 percent. Nitrogen will be fixed by microbes involved in decomposition, although this is reliant on the availability of carbon.

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Based on the examination of soil chemical characteristics, the six treatments met the low criterion, and there was no increase compared to before the treatment. The low total N value may be due to plant and soil microbial uptake or leaching of N nutrients following fertilizer treatment. Furthermore, the C/N ratio created was connected to the low amounts of total N produced in this composting. If the availability of carbon is restricted (low C/N ratio), there aren't enough carbon molecules for microorganisms to use as an energy source to bind all of the free nitrogen. In this scenario, the amount of free nitrogen released NH_3 gas. As a result, when there is more carbon available (high C/N ratio), the amount of nitrogen is very limited.

There was no significant variation in the total P content of the soil at the two depths of compost placement (0.44 percent). Meanwhile, the effect of composting produced significantly different results across all treatments. The research revealed that the control treatment and composting 1 time (A1=12 tons) contributed the most to total P (0.54 percent), followed by treatments A2, A3, and A4, which contributed 0.45, 0.40, and 0.27 percent, respectively. P concentration was discovered at various soil depths, and the addition of compost produced radically different effects. The availability of P content was larger at 0-30 cm soil depth than at 30-60 cm soil depth. Furthermore, the control fertilizer application had more accessible P than all composting intensities combined. This study's findings also demonstrated that putting empty fruit bunch compost and husk charcoal to the soil might provide P nutrients in the range of 149-172.6 me/100 g soil. This is congruent with the findings of Haitami and Wahyudi (2019), who proposed that using empty fruit bunch compost might provide P nutrients to the soil. This is also similar with the position of Harahap et al., (2020), who asserted that the presence of organic matter in the soil might make the element of P available, either directly through mineralization or indirectly through treatment to release the P fixed.

Furthermore, Syukri et al. (2019) said that the increase in available P value produced might be attributed to the influence of the fertilizer used, namely OPEFB compost. Organic compounds are formed in the soil by the organic matter included in OPEFB compost. These organic chemicals will combine to produce Al complex compounds, allowing them to decrease, bind, and release the availability of P. According to Mokolobate and Haynes (2002), organic matter decomposition increases the availability of P because organic molecules chelate Al. As a result, Al-dd and Al absorption of P decreased. The total Kalium parameter has no significant impact on soil depth, with a value of 0.24 percent at a depth of 0-30 cm and 0.22 percent at a depth of 30-60 cm. The compost application, on the other hand, had a significant impact on the total K content of the soil, with A3 and A4 treatments having the greatest values, followed by A2, A0, and A1. Similarly, a single application of palm oil waste compost had a significant impact on available K levels, with the A3 treatment yielding the most available K (2.19 me/100g) and the A1 treatment producing the least available K (0.45 me/100g). The Na content of the soil treated with oil palm waste compost exhibited substantial changes at each depth. Na was 0.06 me/100g at a soil depth of 0-30 cm and rose to 0.08 me/100g at a depth of 30-60 cm. Similarly, the direct effect of compost treatment varies greatly between composting applications. The lowest Na levels were reported in A0 at 0.06 me/100g, then rose in treatments A3 and A4, followed by A2, and the highest in A1 at 0.07, 0.08, and 0.1 me/100g, respectively. The researchers discovered the same findings for the Ca parameter, which had varying values at various soil

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depths. At a depth of 0-30 cm, it was 0.6 me/100g, while at a depth of 30-60 cm, it was 0.39 me/100g. Furthermore, the impact of adding different dosages of palm oil waste compost generated a considerably varied effect. The application of compost three times (36 tons = A3) supplied the most Ca (0.64 me/100g), while A2 contributed the least Ca (0.32 me/100g) two times. The rise in Ca levels might be attributed to the Mg and Ca elements provided by fertilization treatment, particularly OPEFB compost. OPEFB compost is an organic fertilizer rich in nutrients such as Mg and Ca. According to Darnoko and Sutarta (2006), the Mg level in EFB compost ranges from 0.8 to 1 percent, whereas the Ca content ranges from 1-2 percent.

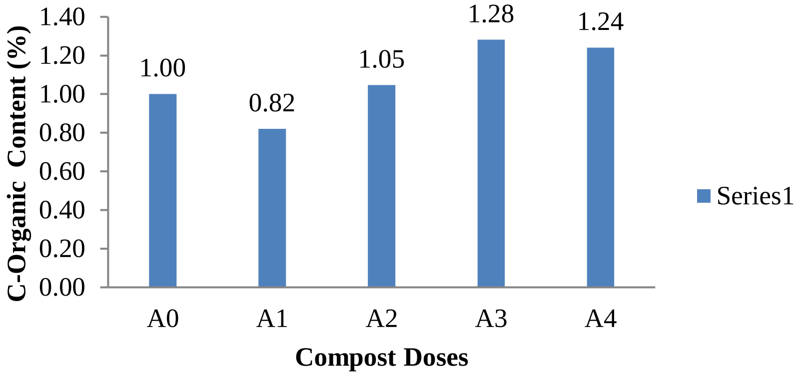

Figure 1: Conditions of soil C-organic contents due to OPEFB compost treatment

Figure 1 also depicts C-Organic content differences in the treatment of OPEFB compost. In this study, the application of OPEFB compost three times (36 tons = A3) resulted in the maximum contribution of organic C of 1.28 percent, whereas the treatment of A1 (12 tons/ha) resulted in the lowest contribution of 0.82 percent. This suggests that the continual treatment of OPEFB from 2017 to 2020, particularly at A3 levels, has considerably contributed to an increase in soil organic C-organisms. The increase in C-organic content in the research soil samples was caused by the use of empty fruit bunches as organic fertilizers with a high C-organic content. When compared to the original circumstances before treatment, the application of organic matter from empty oil palm fruit bunches (OPEFB) for 30 days of incubation improved the C-organic content of the soil. Regarding these findings, in their review study on long-term vegetation management in connection to C and N accumulation, Dungait et al. (2012) said that, in a given climate, the quantity of C-organic deposited in aerobic agricultural soils appears to be more connected to the amount of C than the kind of organic matter.

The impact of fertilizer application, particularly OPEFB compost, might explain the increase in the requirements for the value of C-organic. The organic materials in the OPEFB compost will decompose in the soil for an extended period of time. The organic matter content will stay in the soil as a carbon source during the breakdown process. In their investigation, Syukri et al. (2019) discovered that the addition of OPEFB compost had no significant influence on raising levels of organic C in a short period of time.

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Table 4: The Interaction Effect of Compost Application at Soil Depth on Soil Chemical Properties

Parameter	Depth	Compost				
		A0	**A1**	**A2**	**A3**	**A4**
pH	D1	4.88^{bB}	4.94^{cA}	4.55^{aA}	4.67^{aA}	4.79^{aA}
	D2	4.53^{aA}	4.96^{cA}	4.60^{aA}	4.80^{bA}	4.64^{aA}
	LSD	0.16				
Total N	D1	0.14^{bA}	0.14^{bA}	0.16^{bA}	0.22^{bB}	0.18^{bA}
	D2	0.08^{aA}	0.09^{aA}	0.07^{aA}	0.07^{aA}	0.07^{aA}
	LSD	0.04				
Total P	D1	0.56^{dA}	0.54^{cdA}	0.47^{cA}	0.37^{bA}	0.27^{aA}
	D2	0.51^{aA}	0.54^{aA}	0.43^{aA}	0.43^{aA}	0.27^{aA}
	LSD	0.08				
Available P	D1	167.21^{aA}	159.17^{aA}	163.06^{aA}	175.23^{aB}	161.73^{aA}
	D2	178.00^{aA}	144.47^{aA}	135.25^{aA}	122.91^{aA}	154.47^{aA}
	LSD	33.02				
CEC	D1	21.41^{bA}	23.01^{bA}	21.55^{bB}	16.44^{aA}	22.82^{bA}
	D2	22.25^{bA}	22.86^{bA}	10.31^{aA}	21.71^{bB}	25.08^{bcA}
	LSD	3.01				
Total K	D1	0.20^{aA}	0.13^{aA}	0.28^{bB}	0.31^{aB}	0.27^{aA}
	D2	0.24^{aB}	0.12^{aA}	0.17^{aA}	0.28^{aB}	0.29^{aB}
	LSD	0.08				
Exchange K	D1	0.73^{aA}	0.56^{aA}	1.64^{bB}	2.32^{cA}	1.42^{bA}
	D2	1.39^{aA}	0.28^{aA}	0.79^{aA}	2.06^{aA}	1.76^{aA}
	LSD	0.68				
Na	D1	0.06^{aA}	0.07^{aA}	0.05^{aA}	0.07^{aA}	0.06^{aA}
	D2	0.06^{aA}	0.12^{bB}	0.10^{bB}	0.06^{aA}	0.07^{aA}
	LSD	0.03				
Ca	D1	0.48^{bA}	0.43^{aB}	0.46^{aB}	0.81^{cB}	0.83^{cB}
	D2	0.58^{eB}	0.32^{bA}	0.19^{aA}	0.47^{dA}	0.39^{cA}
	LSD	0.05				
Mg	D1	0.51^{aA}	0.55^{aB}	0.98^{bB}	1.27^{dB}	1.14^{cB}
	D2	0.87^{cB}	0.27^{aA}	0.34^{aA}	0.70^{bA}	0.70^{bA}
	LSD	0.13				
S	D1	2.71^{bcA}	2.37^{bA}	1.80^{aA}	2.81^{cA}	2.37^{bB}
	D2	2.86^{cA}	2.27^{aA}	2.37^{bcB}	2.73^{bcA}	1.96^{aA}
	LSD	0.41				

Note: numbers taken after by the same letter documentation within the same column and push are not essentially distinctive within the 5% LSD test. Studied evenly for lowercase documentations, and vertically for capitalized documentation.

According to the findings of statistical testing, the interaction between POM compost dosage and soil depth had a significant influence on all soil chemistry indicators (Table 4). In terms of soil pH characteristics, a single application of POM compost (12 tonnes / ha) at a depth of 060 cm (A1D1) raised soil pH, while it remained in the acidic range (4,944.96). When 6 ton/ha of POM compost was treated at a soil depth of 0.30 cm (A3D1), there was a significant difference

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in total soil N content of 0.22 percent, which was the greatest compared to other treatment combinations. Without compost treatment, however, the greatest total P intake (0.56) was obtained at a depth of 0.30 cm, which was not statistically different from the total P content of 12 tonnes / ha (A1) POM compost. With a p-value of 0.54, the rest had a significant impact when compared to the other treatments. The application of POM compost had no significant effect on available P, while the available P content at a depth of 30 cm (D1) was at a depth of 3060 cm (D2) at a treatment dosage of 6. It differed greatly from the available P content of. Tons / hectares (A3). The relationship between OPEFB compost application and soil depth had a substantial influence on soil CEC levels at the research location. CEC levels with a compost intensity of 8 tons/ha at a depth of 30-60 cm yielded 25.08 me/100 g of soil, which was significantly greater than other treatment combinations, according to the table. The A3D1 treatment had the highest total K soil concentration of 0.31 percent (compost application intensity 6 tons/ha at a depth of 0-30 cm). This illustrates that the higher the intensity of compost treatment, the higher the soil's total Kalium concentration. The kalium nutrient content in empty fruit bunch compost is so high that it affects the total K nutrients in the soil. Compost's high potassium concentration is obtained from the original material, EFB, which is unquestionably high in potassium content (Yunindanova et al., 2013). According to Surya and Suyono (2013), microorganisms use just a little amount of potassium for metabolic activities throughout the composting process, therefore the possibility of potassium in fertilizers stays as high as that of phosphate. The analytical findings indicated that the soil depth factor had no significant influence on soil potassium nutrients. However, the mean K-dd and K total soil values were 2.32 me/100g higher at a soil depth of 0-30 cm than at a depth of 30-60 cm by 0.31 percent. When OPEFB compost was applied to the top layer of soil, it resulted in a larger accumulation at a depth of 0-30 cm, indicating that there is more soil potassium nutrient. According to Holilullah et al. (2015), the top soil has a depth of 0-30 cm and includes more organic matter than other depths. Muharam and Saefudin (2016) discovered that the K-dd soil was 3.21 cmol/kg at a depth of 0-30 cm and reduced 2.79 cmol/kg at a depth of 30-70 cm. Murtinah and Komara (2019) found the same thing: the lowest K content was in the 30-60 cm soil depth class, owing to a drop in nutrient concentration at that level.

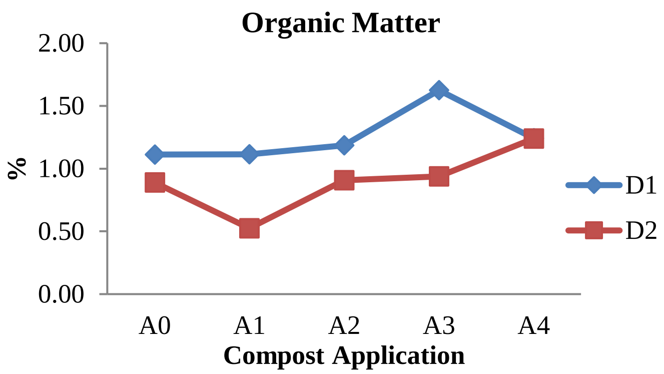

Figure 2: Organic C content (%) on the interaction effect of POM compost application and soil depth

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Figure 2 shows that D1 had the greatest Organic C content with a value of 1.26 percent (low) compared to D2, which had just 0.90 percent (very low). Although the intensity of OPEFB compost application was not statistically assessed, Organic C levels increased from 1.00 percent (very low) in the control to 1.05 percent (low) in A2, 1.28 percent (low) on A3, and 1.24 percent (low) on A4.

When compared to other EFB compost application intensity treatments, the A3 treatment had the greatest amounts of organic C, exchangeable K, exchangeable Ca, exchangeable Mg, and soil base saturation. Since the application of EFB compost of 12 tons/ha/year for three consecutive years beginning in 2017, 2018, and 2019, the accumulated 36 tons/ha and was incubated for four years, three years, and two years, respectively. As a result, the organic matter in the OPEFB compost has had adequate incubation time to decompose. It has the greatest organic C in A3 with a value of 1.28 percent, although it is still classified as low.

According to Mukhlis (2011), the greater the CEC of the soil, the more organic matter is given. However, for EFB compost to yield organic C, exchangeable K, exchangeable Ca, and exchangeable Mg, an incubation duration of 4 years, 3 years, 2 years, and less than 1 year is required. Because the application of OPEFB compost in 2020 did not get sufficient incubation, the OPEFB compost delivered in 2020 did not degrade entirely. It resulted in Organic C, K, Ca, and Mg not being fully accessible, resulting in Organic C content soil, exchangeable K, exchangeable Ca, and exchangeable Mg in A4 being somewhat lower than in A3.

Soil organic C content decreased from 1.00 percent (low) on A0 to 0.82 percent (very low) on A1. This occurred due to the application of EFB only once in A1 as much as 12 tons/ha/year in 2017, resulting in a four-year incubation period. Because of the extended incubation time, the organic C from the breakdown of EFB compost in A1 has vanished. Soil organic C loss can occur as a result of it evaporating into CO2, being devoured by microbes, and being leached. According to Diara (2017), if no input is supplied to improve soil C-Organic levels, soil C-Organic would be lost over time. Soil C-Organic loss can occur as a result of CO2 mineralization and erosion.

CONCLUSIONS

The use of OPEFB waste compost in oil palm farms improves soil quality physically, chemically, and biologically. OPEFB compost raised soil density from 0.78 g/cm3 to 0.95 g/cm3, resulting in a more appropriate density level. Soil permeability was also somewhat higher at the OPEFB compost treatment position, resulting in constant soil moisture conditions at the field capacity level.

In terms of soil chemical characteristics, adding EFB compost can really increase soil quality in terms of CEC, total N, total K, exchanged K, Na, Ca, Mg, and S. Meanwhile, the addition of EFB compost had no effect on soil pH, total P, or accessible P.

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