JPPIPA 10(4) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Changes in Soil Chemical Properties and Growth of Palm Oil (*Elaeis guineensis* Jacq) with Comparative Composition of Plant Media

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Received: February 4, 2024
Revised: April 8, 2024
Accepted: April 23, 2024
Published: April 30, 2024

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DOI: 10.29303/jppipa.v10i4.7161

Abstract: One of the benefits of Oil Palm Empty Fruit Bunches (OPEFB) waste can be processed into bokashi as a planting medium for oil palm nurseries. The research aims to: Determine changes in soil chemical properties due to the comparison of planting media, and obtain the best ratio of planting media to the best seedling growth in Main-Nursery. The research was conducted in Koto Panjang Ikur Koto Village, Koto Tangah District, Padang City. The study was conducted in January-April 2022. RAL design (completely randomized design) with 4 treatments and 6 replications. One experimental unit consist of 3 polybags of plants so there are 72 polybags of plants. Treatment: A = Control (Without Bokashi OPEFB), B = Topsoil: Bokashi OPEFB (1:3), C = Topsoil: Bokashi OPEFB (1:1), and D = Topsoil: Bokashi OPEFB (3:1). The results showed: Treatment B or Topsoil : Bokashi OPEFB (1:3) is the best, cause increase in soil chemical properties: pH 1.17 units; C-organic 1.98%; N-total 0.11%; P-available 4.01 ppm; K-dd 0.48 me/100g; Mg-dd 1.42 me/100g; and Ca-dd 2.67 me/100g. OPEFB bokashi application was significantly different to increase the plant height, not significant to wet weight and dry weight of the plant.

Keywords: Compost; Fertilization; Growing media

Introduction

Ultisol is a type of soil that is very widely distributed in Indonesia. The decomposition process of organic matter in Ultisol soil takes place quickly, causing the organic matter content to be low. Organic matter, as one of the building blocks of soil, plays an important role in improving, maintaining or improving the physical, chemical and biological properties of mineral soil. This affects the level of plant productivity, including oil palm plantations on Ultisol soil.

Oil palm (*Elaeis guineensis* Jacq) is a plantation crop that has an important function in aspects of Indonesian agriculture (Ariyanti *et al.*, 2023). The area of oil palm plantations is always increasing, so more and more quality seeds are needed for large production. The nursery system consists of 2 sessions, namely: pre-nursery aged 0-3 months and main nursery aged 4-12 months. To get quality seeds, good planting media and care are needed, one of which is by providing fertilizer. Fertilization aims to improve the quality and health of the soil (Tioner *et al*., 2021).

Fertilization can be done using inorganic and organic fertilizers. Inorganic fertilizers that are used for a long time can cause an imbalance in several aspects of nutrients in the soil, the soil structure becomes damaged, and there is little microbiology in the soil.The concept of balanced fertilization, the use of organic fertilizer is multifunctional, including adding essential nutrients, improving productivity and soil quality on land which is often given inorganic fertilizer, increases carbon reserves and reduces the effects of climate change (Wihardjaka & Harsanti. 2021), which can then increase soil microorganisms which are very useful in improving the environment (Syawal *et al*., 2017). Plant residues and animal waste are types of organic material that can be

How to Cite:
Murnita, M., Desi, Y., & Meriati, M. (2024). Changes in Soil Chemical Properties and Growth of Palm Oil (Elaeis guineensis Jacq) with Comparative Composition of Plant Media. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 1633–1639. https://doi.org/10.29303/jppipa.v10i4.7161

used as bokashi and are very useful for increasing nutrients in the soil (Sadeli *et al*., 2022)

Among the materials for making bokashi that are still abundant in oil palm plantations is EFB. Where with an oil palm plantation area of ± 13,000 ha, the annual harvest can be around ± 159,000 tons, so that EFB can reach ± 36,000 tons/year (Gustomo, 2017). The area and fruit production are increasing every year (Ichriani *et al.*, 2016; Hasibuan *et al.*, 2023). Palm fruit creates palm waste (Gusrawaldi *et al*., 2020). Waste is everything resulting, from production operations (Syamsuddin & Rivai, 2023). This process creates a lot of waste (Praevia & Widayar, 2022). Generally, there are three types of mustard oil factory waste, namely solid waste (eg EFB), liquid and gas (Tan *et al*., 2019). This increase will of course lead to an increase in the number of EFB produced.

Using EFB with certain materials will produce various types of products such as compost, activated carbon, liquid smoke, charcoal briquettes, and others (Windiastuti *et al*., 2022;). Explained that EFB are oil palm biomass that can be processed to form organic material (Januari & Agustina, 2022). EFB contains 55,75% cellulosa, 28,93% hemicellulose, 15,32% lignin (Hidayah & Wusko, 2020), but EFB contain obtain cellulose (24–65%), hemicellulose (21–34%) and lignin (14–31%) Chang (2014). Variations in lignin, cellulose and hemicellulose content are caused by many factors, including plant age, harvest time, etc (Joni *et al*., 2019).

This condition causes the EFB decomposition process to take a long time. This can be assisted by MOL (Local Microorganisms) until it becomes compost in a shorter time. Compost decomposition using Banana weevil MOL decomposer has pH, C/N ratio, total Nitrogen, Phosphorus, and higher Potassium compared to compost using EM4 decomposer (Kesumaningrat, 2019). The results of the TKKS bokashi analysis are Nitrogen 1.40%; Total phosphorus 0.96%; Potassium 0.41%; Carbon-organic 19.81%; acidity 7.8; and C/N ratio 14.15. These results prove that EFB bokashi is categorized as quality compost (Agung *et al*., 2019). EFB can be processed at one time to produce 15 tons of fertilizer, thereby reducing the difference in usage costs between IDR fertilizer and organic EFB fertilizer. 8,403,360 (Hidayat *et al*., 2022). The specialty of EFB compost is that it stores large amounts of potassium, without accumulation or chemicals, increases the nutrients found in the soil, and is able to improve its physical, chemical and biological properties (Kesumaningwati, 2015).

Studies that have been carried out include: bokashi EFB (Asih *et al*., 2019), bokashi EFB with rice husk charcoal (Harahap *et al*., 2020), bokashi EFB combined with dolomite (Amri, *et al.*, 2018), Bokashi EFB added NPK (16:16:16) (Aminullah *et al*., 2017; Halim *et al*., 2019), Bokashi EFB and given biological fertilizer (Hidayat & Astarina, 2016), Bokashi EFB and NPKMg (Syukri *et al*., 2019).

However, research has never been conducted on bokashi EFB combined with topsoil from Ultisol soil. So far, oil palm nurseries use fertile soil imported from other areas, while the locations that will be used as oil palm plantations are classified as less fertile, such as Ultisol. Therefore, research will be carried out to increase soil fertility in nurseries by adding inorganic fertilizer.

Based on the previous matter, the author conducted research entitled Changes in Soil Chemical Properties and Growth of Oil Palm Seedlings (*Elaeis guineensis* Jacq) in Main-Nursery with Comparison of Planting Media Composition. The objectives of this research are: Determine changes in soil chemistry due to the comparison of the composition of planting media, and to compare the composition of planting media for optimal growth of oil palm seedlings in the Main-Nursery.

Method

Time and Place

The research was carried out from January 2022 to April 2022 in Koto Panjang Ikur Koto Village, Koto Tangah District, Padang, West Sumatra Province.

Materials and Tools

The materials needed for the research are DXP Simalungun oil palm seeds aged 3.5 months; poly bag measuring 40 x 50 cm; topsoil, bokashi EFB, NPK fertilizer 16:16:16, Dithane M-45 80 WP, Sevin 85 SP. The tools used were calipers, rulers, knives, hoes, machetes, measuring tape, raffia rope, large analytical scales, sprays, writing instruments and cameras.

This experiment used a Completely Randomized Design (CRD), with 4 treatments and 6 replications (24 experimental units).

Experimental Design

This experiment used a Completely Randomized Design (CRD), 4 treatments and 6 replications (24 experimental units). Each experimental unit consisted of 3 plant polybags (72 plant polybags). All plants in the experimental unit were observed. The comparison treatment for the composition of planting media are:

A = Control (Without TKKS bokashi)
B = Topsoil planting media: Bokashi EFB (1 : 3)
C = Topsoil planting media: Bokashi EFB (1 : 1)
D = Topsoil planting media: Bokashi EFB (3 : 1)

The observed data was analyzed statistically using variance (F test), followed by Duncan's New Multiple Range Test (DNMRT) with a significance level of 5%.

Implementation

The nursery land is cleaned, then leveled with a hoe. Fill the polybags according to the treatment (capacity 10 kg per polybag), water the polybags until they are saturated (incubate for 2 weeks). Transfer the seedlings to polybags at the age of 3 months. Before transplanting, the seeds are sprayed with Dithane M-45 80 WP (dose 2 g/liter of water), then labels and stakes are attached according to the treatment. Water the plants twice a day (morning and evening) using gembor. Weeding every time there are weeds by pulling out the weeds in the polybag and around the polybag area.

The fertilizer given is NPK 16: 16: 16 at 10 g/plant a week after transplanting. Fertilizer is sprinkled around the plant, 10 cm from the base of the stem and covered with soil. Pest and disease control is carried out every time a pest or disease appears. To control fungus, Dithane M- 45 WP is used at a dose of 2 grams/liter of water.

Observed Variables

The variables observed in the chemical properties of the soil and bokhasi EFB as well as palms seeds (Figure 1).

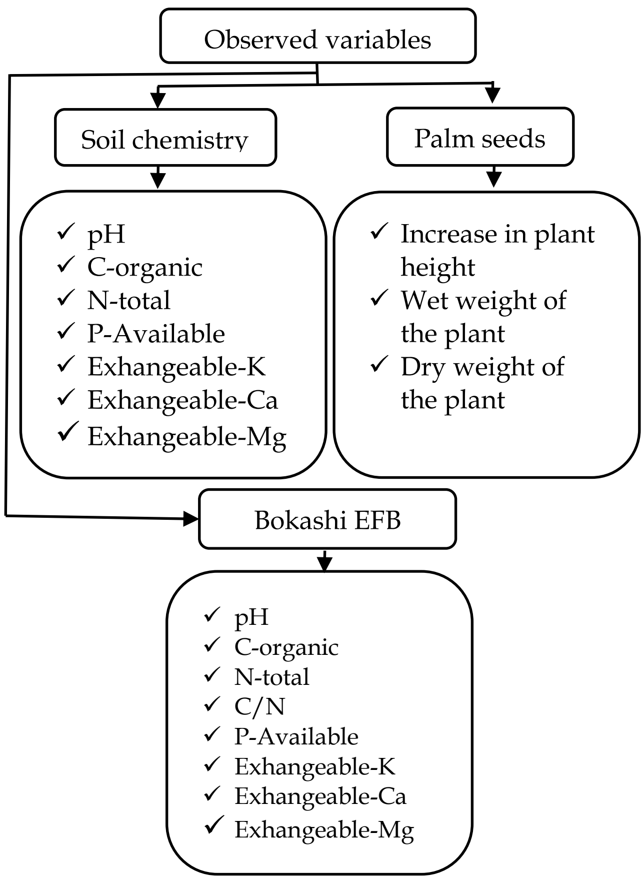

Figure 1. Variables observed in research

Result and Discussion

Initial Soil Chemical Properties and Bokashi of Palm Oil Empty Bunch

The results of analysis of soil chemical properties at the Bogor Soil Research Laboratory show very low soil fertility, which is characterized by very acidic soil pH (4.39), C-organic, N-total, C/N ratio, P-available, Exhangeable-K, and Exhangeable-Mg at low criteria respectively: 1.99%; 0.19%; C/N 10.47; 6.19 ppm; 0.28 me/100 g; 0.56 me/100 g; while Exhangeable-Ca is in very low criteria, namely 1.29 me/100 g. This is related to soil-forming factors, especially climate, namely humid tropical areas (high temperatures and rain). During soil formation, high temperatures cause active processes of mineral weathering and decomposition of organic matter. High rainfall can result in the loss of basic nutrients (K, Na, Ca, and Mg). Hardjowiguno (2007) explained that there are several obstacles to Ultisol, such as acid soil reaction (pH), high aluminum content, and low nutrient content. The results of research conducted by Oksana *et al*. (2012) showed that the H_2O pH value of Ultisol soil in forest areas was 4.49, the KCl pH was 3.71, the total nitrogen content was 0.028%, and the organic carbon content was 1.87%. Continuous soil washing results in low nutrient buffer capacity.

The results of the EFB bokashi analysis showed that the C-organic content was 18.91%; N-total 1.75%; P-available 0.74%; K 3.57%, Ca 0.40% and Mg 0.39%. The advantage of KKSS which is used as compost is that it has a high potassium content, does not require starter culture additions and chemicals, can add nutrients to the soil, and improves the physical, chemical and biological properties of the soil.

pH, C-organic and Macro Nutrient Values After Treatment

The results of the analysis of pH, C-organics and soil macro nutrients after treatment are in Table 1. Table 1 shows the pH value of the soil as slightly acidic criteria with Topsoil: Bokashi EFB 1:3 planting media (treatment B), the pH value increased by 1.17 units from the original land. The research results obtained were higher than those obtained by Haitami & Wahyudi (2019), namely that the pH increased by 0.70 units with the application of 30 tonnes/ha of Palm Oil Empty Bunch Compost Plus (KOTAKPLUS) on ultisol soil.

It is suspected that EFB bokashi contains organic material which makes the soil pH slightly acidic. The application of organic material to acid soil (Ultisol) can increase soil pH (Pane *et al*., 2014). In general, soil organic matter plays an important role in the carbon and nutrient cycles and changes in soil pH (Wang *et al*., 2013).

Table 1 shows that the total N value based on soil chemical properties criteria (BPT, 2009) for the three treatments is in the medium criteria and the control is in the low criteria. This condition occurs because the C-Organic content becomes CO_2 through the evaporation process. This is balanced by an increase in N content due to a continuous decrease in organic C content (Nurrahma & Melati, 2013). This increase in N content is the result of the decomposition of organic matter by microorganisms that produce ammonia and N (Yu *et al*., 2019).

The highest P-available was in treatment B, including medium criteria (8.25 ppm) and the lowest was in treatment A (6.44 ppm). From the results of this research, it can be seen that if the planting medium is Topsoil: Bokashi EFB (1:3) it can contribute 2.04 ppm of P nutrients. This situation is caused by the availability of P in the soil, due to the presence of organic material, either directly or through a mineralization process, or through processing that allows the release of fixed phosphorus (Harahap *et al*., 2020). Another possibility is that because the P content depends on the N content in organic fertilizer, the proliferation of P-degrading microorganisms increases, so that the P content in bokashi also increases. In contrast, the less N is produced, the less P is produced (Ali *et al*., 2019).

In the control treatment, the K-dd and Mg-dd values were low standards, while the Ca-dd values were very low standards. However, after treatment, the standards rose from low to high (Table 1). So in the Topsoil planting medium: Bokashi EFB (1 : 3) there

Table 1. Values of pH, C-organic, and macro nutrients after treatment

Treatment	Value of soil chemical properties						
	pH (H_2O)	C-organic (%)	N-total (%)	P-availab (ppm	Exchangeable K (me/100 g)	Exchangeable Mg (me/100g)	Exchangeable Ca (me/100 g)
A	4.41 m	2.01 s	0.20 r	6.24 r	0.29 r	0.58 r	1.31 sr
B	5.58 am	3.99 t	0.31 s	10.25s	0.77 t	2.00 s	3.98 r
C	4.82 m	2.40 s	0.25 s	8.65 s	0.51 s	1.24 s	3.46 r
D	4.77 m	2.37 s	0.22 s	7.12 r	0.47 s	0.85 r	2.99 r

Information: m = sour, am = slightly sour st = very high, t = high, s = medium, r = low and sr = very low

was an increase in Exchangeable-K, Exchangeable-Mg and Exchangeable-Ca respectively: 0.48 mg/100 g; 1.42 mg/100 g; and 2.67 mg/100g.

The change in criteria is believed to be caused by the elements K, Mg and Ca contributed by EFB bokashi. The K content in the EFB bokashi used is 3.57%, Ca is around 0.40% and the Mg content is 0.39%. Furthermore, changes in the K value, because microorganisms in organic fertilizer are very important in handling the K content. The K factor in organic fertilizer raw materials plays a role as a microbial metabolism and catalyst (Dewilda *et al*., 2019). Microorganisms create K compounds through metabolic processes, which utilize free potassium ions in organic materials. Not only that, microorganisms undergo a decomposition process which breaks down carbon chains into complexes, causing potassium levels to increase (Mirawati & Winarsih, 2019).

Increase in Height, Wet and Dry Weight of Plants

The results of observations of the increase in height, fresh weight and dry weight of oil palm seedlings by comparing Bokashi EFB and Topsoil after statistical analysis showed that the effect was significantly different, but the difference between fresh weight and dry weight of the plants was not significant. The average plant height, fresh and dry weight of oil palm seedlings can be shown in Table 2.

Table 2. Average Increase in Height, Fresh and Dry Weight of Oil Palm Seedlings

Treatment	Observed parameters		
	Plant height (cm)	Plant fresh weight (g)	Plant dry weight (g)
A	22.29 b	69.10	23.72
B	26.47 a	71.49	24.93
C	23.26 b	69.71	23.99
D	22.69 b	69.49	23.84
	KK= 27.61%	3.44	4.71

Numbers in the same column followed by the same lower-case letters are not significantly different according to the DNMRT test at the 5% level

Table 2 shows that giving EFB bokashi had a significantly different effect on plant height, where treatment B was significantly different from the other treatments. In Topsoil planting media: Bokashi EFB (1:3) or treatment B showed better results compared to other treatments. This is because the nutrient content contributed by EFB bokashi to the planting medium, the availability of macro nutrients is much better when compared to other treatments (Table 1).

The research results show that the more the EFB bokashi is added, the taller and bigger the plants become and this is accompanied by an increase in the dry weight of the plants. This is due to the more bokashi that is given to the planting medium, so that it continues to provide a lot of nutrients for the plants, so that the plants get taller. This is proven by increasing the dose of bokashi EFB causing an increase in the availability of N, P, K, Ca, Mg, for plants (Table 1). Lingga & Marsono (2013) explain that the nutritional element nitrogen is amino acids, proteins and components of cell protoplasm that stimulate plant growth. Phosphorus plays a role in cell division at the growing point, thus affecting plant production. Plants that receive the maximum nutrients nitrogen, phosphorus, potassium and magnesium can increase chlorophyll. Increased chlorophyll increases photosynthetic activity resulting in more photosynthesis. The process of photosynthesis in oil palm seeds continues to become more efficient so that the photosynthate produced will also increase which will later be used for vegetative development, such as increasing the height of oil palm seedlings. Apart from that, the nutrient content of EFB bokashi is N: 1.75%, P: 0.74% and K: 3.57%. This NPK nutrient can increase the growth of oil palm seedlings (Loan *et al*., 2019; Thi *et al*., 2019; Kopaei *et al*., 2021a)

Although EFB composting is a useful solution in the agricultural sector, it must be recognized for its positive response to develop community behavior. Various studies have discussed the social aspects that influence composting activities. Several main aspects that support an activity are: subjective norms, attitudes and behavioral control based on the theory of planned behavior (Loan *et al*., 2019; Thi *et al*., 2019; Kopaei *et al*., 2021). Based on the research results, what has a significant effect ($p<0.05$) on the behavior of making compost at home is subjective norms and behavioral control, while what has an insignificant effect ($p>0.05$) is attitude (Afla *et al*., 2023).

Conclusion

The results showed: Treatment B or Topsoil : Bokashi OPEFB (1:3) is the best, cause increase in soil chemical properties: pH 1.17 units; C-organic 1.98%; N-total 0.11%; P-available 4.01 ppm; K-dd 0.48 me/100g; Mg-dd 1.42 me/100g; and Ca-dd 2.67 me/100g. OPEFB bokashi application was significantly different to increase the plant height, not significant to wet weight and dry weight of the plant.

Acknowledgments

The researcher would like to thank all parties who have helped make this research process smooth, especially the Chair of the LPPM, Ekasakti University and the Dean of the Faculty of Agriculture, Ekasakti University.

Author Contribution

Conceptualization (M, M); methodology (M, YD, M); validation (M); formal analysis (M, M); investigation (M, YD); resources (M); data curation (M,M) writing-original draf preparation (M,YD); writing-review and editing (M, YD); visualization (M, M). All research members carried out each stage cooperatively until this article was completed. All authors have approved the version of the manuscript to be published

Funding

This research received no external funding.

Conflicts of Interest

No conflicts of interest

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