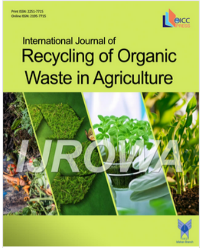

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Oil palm empty fruit bunch biochar fertilizer as a solution to increasing the fertility of peat soil for sustainable agriculture

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Abstract:
Purpose: Utilization of waste oil palm empty fruit bunches as an ameliorant in the form of biochar enriched with chicken manure and urea fertilizer to increase the fertility of immature (seedling) oil palm planted on peat soil which has poor soil physical, chemical, and biological characteristics.
Methods: Biochar material, namely empty fruit bunches, was subjected to conventional pyrolysis for 3, 4 and 5 hours at a temperature of 400°C. Then the biochar is weighed to get the desired proportion of biochar then sieved through a 60 mesh sieve.nd analyzed for pH, ash content, organic-C, total-N, total-P, total-K, as well as biochar functional groups using Fourier Transform Infrared Spectroscopy (FTIR), and structural analysis using Scanning Electron Microscopy (SEM). The implementation of the research consisted of 2 activities, namely 1) Planting oil palm seedlings in polybags by giving treatment according to the dose and 2) Chemical characterization of biochar, peat soil properties and growth and NPK uptake of oil palm seedlings.
Results: Bs1 treatment: (Biochar oil palm empty fruit bunches: chicken manure:urea by (280g:555g:90g) increased plant height to 213%, 36% number of leaves, 49.7% soil total N, 16.2% available P, and 35% available K compared to control.
Conclusion: Palm oil waste in the form of empty bunches of biochar, has special properties such as porous structure, relatively large surface area with various functional groups, hence it has the potential as an ameliorant to increase marginal soil fertility including peat and increase plant growth of oil palm seedlings.

Keywords: Oil palm waste; Biochar; Chicken manure; Marginal soil; Peat

1. Introduction

The use of peatlands for the cultivation of plantation crops, including for oil palm plantations cannot be avoided in line with population growth and socio-economic development as well as the need for food and energy based on both vegetable and non-fossil, both at the local, national and international levels (Rauf 2016). Like oil palm cultivation on mineral lands, oil palm cultivation on peatlands must also be oriented towards sustainable agricultural systems, which not only aim to achieve economic value but also to support welfare and social equity while ensuring the sustainability of natural resources and the environment (environmentally friendly) Rauf (2016) and Rauf et al. (2019). The main problems faced in developing smallholder oil palm plantations include low productivity because oil palms are mostly cultivated on peatlands with low soil fertility and relatively low nutrient inputs (Masganti and Widiyano 2019).

Cultivation of oil palm on peatlands can ensure environmental sustainability or prevent land degradation if it is carried out using cultivation techniques (agrotechnology) in relation to water management. For example, soil surface management, soil ameliorant management, and fertilization management (Rauf et al. 2019; Winarna 2016).

Oil palm empty fruit bunches are one of the most common types of solid waste produced by palm oil mills. However, so far it has only been used as animal feed and the amount is still very small. The development of the oil palm area in Indonesia in the period 1980 – 2016 tends to increase. If in 1980 Indonesia's oil palm area was 294.560 hectares, then in 2015 it reached 11.30 million hectares and was predicted to be 14.60 million hectares in 2019. The average growth during this period is 10.99% per year (Gapki 2019; Febriyanti et al. 2019). On the other hand, every 1 hectare of oil palm plantations will produce around 1.5 tons of oil palm empty fruit bunches (Febriyanti et al. 2019).

Based on these data, many empty fruit bunches are produced from palm oil mills into biomass waste. One technology that can be used to overcome this problem is pyrolysis technology. This technology has many advantages such as the product of bio-oil, biochar and the gas produced can be an alternative solution for controlling the impact of environmental pollution. The solid product of the thermochemical conversion of biomass is biochar. Compared to charcoal produced from non-renewable coal, biochar contains lower sulphur and is more environmentally friendly that makes it advantageous to use as alternative fuel sources and ameliorant (Chan and Xu 2009).

Biochar has special properties, such as a porous structure, relatively large surface area, contains functional groups and abundant mineral elements, can immobilize heavy metals, and provides benefits in loading fertilizer nutrients (Chen et al. 2008). The structure of biochar, which is significantly altered by the pyrolytic temperature, plays an important role in the absorption of various organic/inorganic contaminants. The quantitative contributions of adsorption and partitioning are determined by the relative fractions of carbonized and noncarbonized, and their surface properties (Chen et al. 2008). Lehmann explained that in contrast to other organic materials in soil, biochar is also able to absorb phosphate strongly even though it is an anion, however, the mechanism of this process is not yet fully understood (Lehmann 2007). These properties make biochar a unique substance, retain nutrients that are exchangeable and therefore available to plants in the soil, and are likely to increase crop yields while reducing environmental pollution by nutrients.

The role of biochar is as a vessel to bind nutrients around it, as a source of water, and as a home for soil microorganisms due to the large number of pore spaces. Soil that is given biochar will supply more nutrients (Barus et al. 2023).

The purpose of this research was to determine the effect of empty fruit bunches biochar enriched with chicken manure and urea (namely biokos fertilizer) on improving the chemical properties of peat soil and increasing the vegetative growth of oil palm plants. Biochar has advantages, including slow release (biochar is difficult to destroy and takes a long time to be decomposed by microbes) (Lehmann 2007). Biokos fertilizer was rich in NPK nutrients due to the provision of chicken manure compost. The raw materials were cheap by using agricultural waste and livestock, then after being processed into biochar and chicken manure compost, it turned into zero waste and benefitted the environment (Indrawati 2018).

Table 1. Characterization of functional clusters of biochar from oil palm empty fruit bunches with pyrolysis time of 3, 4 and 5 hours.

No	Oil palm empty fruit bunches 3 hours (peak cm^{-1})	%	Functional group	Oil palm empty fruit bunches 4 hours (peak cm^{-1})	%	Functional group	Oil palm empty fruit bunches 5 hours (peak cm^{-1})	%	Functional group
1	617.22	3.79	CX Chloride	678,94	4.14	CX Chloride	486.06	3.71	CX Chloride
2	717.52	4.40	CX Chloride	748.38	4.57	CX Chloride	570.93	4.35	CX Chloride
3	756.1	4.64	CX Chloride	1118.71	6.83	C-H Amine, protein	748.38	5.71	CX Chloride
4	879.54	5.40	-CH_3 bonding	1327.03	8.10 8.10	C-H Amine protein	871.82	6.65	-CH_3 bonding
5	1111	6.82	C-H Amine, protein	1581.63	9.65	group C=O amide, ketone	1064.71	8.11	N-H amine
6	1427.32	8.76	Salt from carboxylate acid	1705.07	10.40	group C=O amide, ketone	1435.04	10.94	carboxylates acid
7	1581.63	9.71	Amide group C=O amide ketone	2854.65	17.42	carboxylates acid	1581.63	12.06	group C=O amide, ketone
8	2854.65	17.52	carboxylates acid	2924.09	17.84	carboxylates acid	2931.80	22.35	carboxylates acid
9	2924.09	17.95	Caboxylates acid	3448.72	21.05	O-H, H bonding O-H, H bonding	3425.56	26.12	carboxylates acid
10	3425.58	21,02	O-H, H bonding						

Source: (Indrawati 2018).

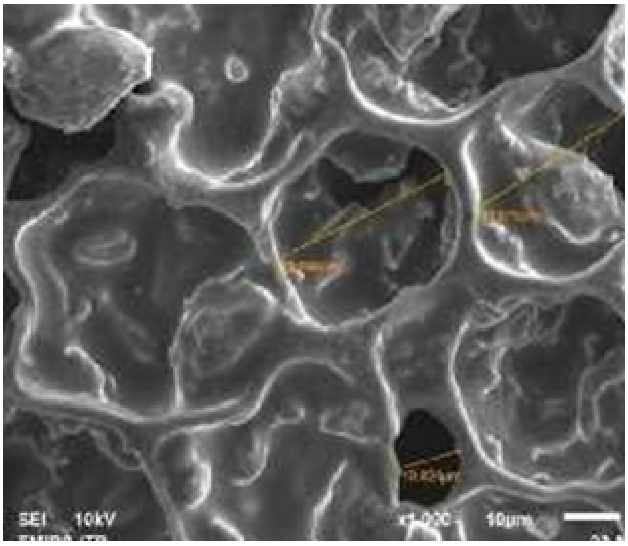

Figure 1. Structure of oil palm empty fruit bunches biochar pyrolyzed at 350°C for 3 hours.
T3 = (macro and micro pore size: 280 μm; 7.169 μm) (Indrawati 2018).

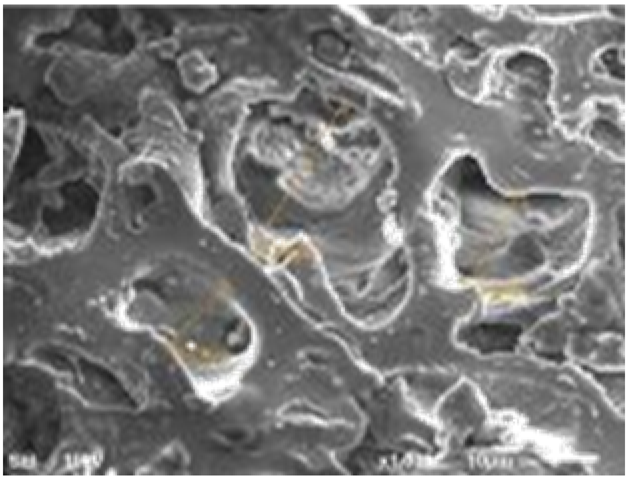

Figure 2. Structure of oil palm empty fruit bunches biochar pyrolyzed at 350 °C for 4 hours.
T4 = (macro and micro pore size: (33.899 μm: 31.079 μm; 10.824 μm) (Indrawati 2018).

2. Material and methods

The research was conducted on peat soil in the village of Rasau Jaya, Kubu Raya Regency, West Kalimantan Province, Indonesia, and at the Laboratory of Chemistry and Soil Fertility, Faculty of Agriculture, University of Tanjungpura, West Kalimantan. The research materials used were biochar empty palm oil bunches, chicken manure, Urea, peat soil, and the tools used were Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy FITR, pyrolysator (Retort), muffle, sieve, digital scales, atomic absorption spectrophotometry (AAS), pH meter, spectrophotometer, flamephotometer, cylinder chemicals, percolation, spray flasks, etc.

Biochar material, namely empty fruit bunches, was subjected to conventional pyrolysis, which was carried out for 3, 4 and 5 hours at a temperature of 400°C. Then the biochar was weighed to obtain the desired percentage of biochar and then sieved through a 60-mesh sieve and analyzed for pH (1:20 biochar: water), ash content, organic- with Walkey and Black method, total-N by Kjeldhal method, total-P by Spectrophotometry, total-K by AAS, and biochar functional groups using FTIR as well as structural analysis using SEM. The implementation of the research consisted of 2 activities, namely 1. Peat soil properties and growth and NPK uptake of oil palm seedling and 2. Planting oil palm seedlings in polybags by giving treatment according to the dose.

The experiment used a completely randomized design consisting of 6 treatment factors with 3 replications, namely Biokos (a combination of tankos biochar, chicken manure and urea in 6 comparisons) namely Bs1 = (280g: 555g: 90g), Bs2 = (280g: 833g: 60g), Bs3 = (555g: 555g: 30g), Bs4 = (555g: 555g: 15g), Bs5 = (833g: 280g: 90g), Bs6 = (833g: 280g: 60g), and repeated 5 times so that there are 30 polybags. Polybags were then planted with one month old oil palm seedlings, measurement of growth parameters, namely plant height, number of leaves and stem diameter was carried out at every 1 month until the seedlings were 4 months old. At the end of the study, soil and plant tissue samples were taken for analyzing N, P and K content and uptake in the laboratory Data generated were analyzed with F test and DMRT at 5% confidence level (Gomez and Arturo 2007).

3. Result and discussion

3.1 Surface morphology

The pore structures of oil palm empty fruit bunches biochar were observed using Scanning Electron Microscope. The dried samples were spread on a conductive carbon-bond adhesive tape surface that was attached to a SEM stub and then gold-coated prior to analysis.

SEM is widely used to characterize the surface morphology and composition of biochar (composite), especially to detect macro pores and biochar channels. The macropores and channels in the highly porous structure of biochar enable it to store nutrients and soil microorganisms well, to retain nutrients, and to retain water during irrigation or rainy periods (Liu et al. 2019).

There are many pyrolysis process variables that affect the structural and physical characteristics of biochar, including heating rate, reaction pressure, time, and reaction vessel dimensions. In addition, pretreatment such as drying or chemical activation will affect the biochar structure (Chia et al. 2015). Lua et al. (2004) explained that the high treatment temperature during pyrolysis is considered to have the most significant effect on the structure of biochar. Figs. 1, 2 and 3 show the biochar structure of oil palm empty bunches pyrolyzed at 3, 4 and 5 hours, respectively.

For the surface pore morphology of oil palm empty fruit bunches biochar pyrolyzed at 400°C for 3 hours, the macro and micro pore sizes were smaller (5,280 μm; 7,169 μm), compared to oil palm empty fruit bunches biochar pyrolyzed for 4 hours (33,899 μm; 31,079 μm; 10,824 μm) and 5 hours (15,416 μm, 18,436 μm, 31,249 μm). Oil palm empty fruit bunches biochar pyrolyzed for 5 hours had larger

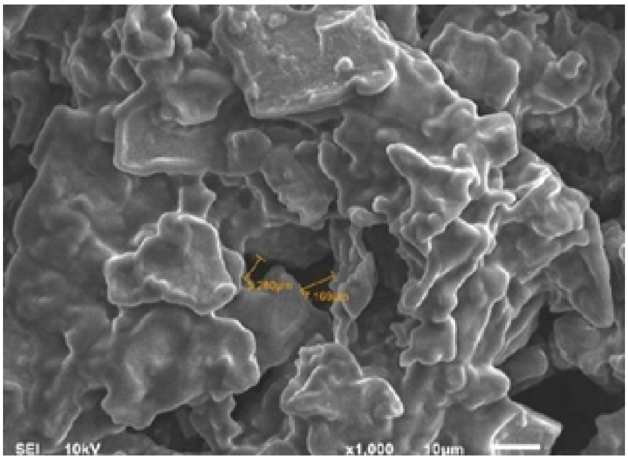

Figure 3. Structure of oil palm empty fruit bunches biochar pyrolyzed at 350- 450 °C for 5 hours by SEM T5 = (pore size: 15.416 µm, 18.436 µm, 31.249 µm))(Indrawati 2018).

macro and micropores, followed by oil palm empty fruit bunches biochar pyrolyzed for 4 hours and oil palm empty fruit bunches biochar pyrolyzed for 3 hours. Oil palm empty fruit bunches biochar (5 hours) had shown pore cracking and ashing. Therefore, the biochar of oil palm empty fruit bunches was chosen which was pyrolyzed at 400°C for 4 hours which had a large porosity, but was not easily crushed, had a surface area of 7,214 (m^2 g^{-1}) and a pore volume of 0.012 (cc g^{-1}). This is in accordance with the results of research by Hasan et al. (2016) that the manufacture of biochar by pyrolysis at a temperature of 400 – 450°C was better than over 500°C. Pyrolyses at a temperature of up to 450°C resulted in an increase in the number of pores, diameter and pore size, but at 500°C pyrolysis conditions for 3 hours, there was a decrease in the number of pores and the average pore size and pore diameter. This shows that the pyrolysis conditions higher than 450°C for 3 hours had a negative effect on biochar, especially an increase in the amount of liquid ash which caused clogged pores and decreases the number of pores and pore size, and there are also some pores that collapse due to pyrolysis to form ash.

From the structure read through SEM, it can be said that the physical properties of good quality biochar have a particle size of less than 0.5 mm (up to 50 mm) and a highly developed total surface area to be indicated as a great removal technology (Sadaka et al. 2014). Besides having low levels of water, ash, and volatile residue (Sadaka et al. 2014), biochar has a high C content to provide a C framework for adsorption purposes. In addition, high C content in biochar is positively correlated with high surface area (Kim et al. 2015), pore size, and C stability as characteristics of good biochar (Hameed et al. 2020; Yan et al. 2020).

3.2 Functional group

Identification and interpretation of functional groups of oil palm empty fruit bunches biochar using Infrared Spectroscopy can be seen in Fig. 4. Functional groups that were read from biochar pyrolysis temperature of 350°C can be divided into aliphatic groups (> 2000 cm^{-1}), aromatic groups ($900 - 2000$ cm^{-1}) and inorganic groups (< 900 cm^{-1}). Identification of biochar functional groups was carried out based on the absorption of infrared rays due to the vibration of each functional group at a certain wavelength (Artz et al. 2008).

The results of the FTIR analysis of oil palm empty fruit bunches biochar which were pyrolyzed for 3, 4 and 5 hours can be seen in the Fig 4.

Fourier-transformed infrared spectroscopy (FTIR) is an instrument that uses spectroscopic principles. The spectroscopy used is infrared spectroscopy, which is equipped with a Fourier transform for the detection and analysis of the spectrum results. Infrared spectroscopy is useful for the identification of organic compounds because of its very complex spectrum consisting of many peaks. The use of Fourier-transformed infrared spectroscopy (FTIR) is better known as a simpler and faster approach method in observing changes in functional groups of organic components (Janu et al. 2021). The interpretation of the functional groups can be seen in Table 1.

The longer the pyrolysis process, the lesser the functional groups, with 3 hours of functional groups totaling 10 groups and dominated by inorganic groups (4 types), then aromatic groups (3 types) and aliphatic groups (3 types). Dispersed and readable inorganic groups at four peaks: 617.22 cm^{-1}, 717.52 cm^{-1}, 756.1 cm^{-1} indicated the presence of CX chloride group, and were characterized as inorganic chlorine compounds, 879.54 cm^{-1}, showed the presence of CH_3 bending binding characterized as lignin. Aromatic groups scattered and readable at three peaks: 1111 cm^{-1}, 1427.32 cm^{-1} and 1581.63 cm^{-1} indicated the presence of CH amine, a salt of carboxylic acid and a series of C=O amide groups, characterized as proteins, salts of carboxylic acids (humic acid structure) and aliphatic carboxylic acids. The aliphatic groups were scattered and read at three peaks: 2854.65 cm^{-1} and 2924.58 cm^{-1} indicated the presence of a carboxylic acid group and were characterized as wax/fat/wax, 3425.58 cm^{-1} indicated the presence of HOH bonds and were characterized as cellulose.

Biochar resulted from the breakdown of organic matter undergoing chemical decomposition to a stable form of carbon through pyrolysis in an oxygen-limited environment, usually at temperatures of 350–600°C (Weyers and Spokas 2011). Pyrolysis is the thermal degradation of biomass under pressure in the absence of reacting gases (Indrawati 2018; Lehmann 2007). The highly recalcitrant aromatic nature of biochar can remain stable in soil for hundreds to thousands of years.

From the results of the FTIR analysis, it was found that in oil palm empty fruit bunches biochar which was pyrolyzed for 4 hours, there were 9 types of functional groups with 3 aliphatic groups, 4 types of aromatic groups and 2 inorganic groups. Aromatic groups scattered and readable at four peaks: 1118.71 cm^{-1}, 1327.03 cm^{-1} indicated the presence of CH amine and characterized as protein, 1581.63 cm^{-1} and 1705.07 cm^{-1}, indicating the presence of a series of groups. C=O amide, ketone, were characterized as a protein. The aliphatic groups were scattered and read at three peaks: 2854.65 cm^{-1} and 2924.09 cm^{-1} indicated the presence of a carboxylic acid group and were characterized as

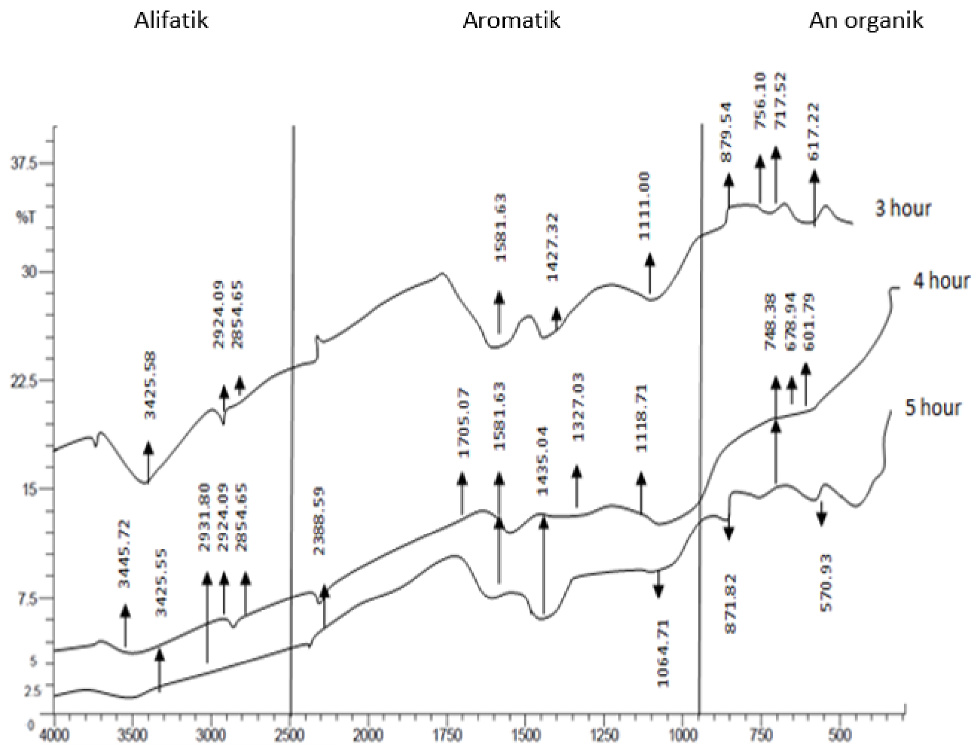

Figure 4. Functional Group of Oil palm empty fruit bunches Biochar (Indrawati 2018).

wax/fat/wax, 3448.72 cm^{-1} indicated the presence of HOH bonds and were characterized as cellulose. These groups play a role in the binding of nutrients and water in the soil. The biochar produced which contains aromatic structures is mostly a preferred precursor as it provides porous C matrix which assist in enhancing the surface area and sorption capability to produce activated carbon (Lehmann 2007).

The main chemical difference between biochar and other organic materials was the greater ratio of aromatic carbon to aliphatic carbon, especially the presence of fused aromatic rings compared to other aromatic structures (Schmidt and Noack 2000). These fused aromatic rings are present in various forms, such as amorphous carbon containing a higher number of aromatic rings at lower pyrolysis temperatures and turbostratic carbon at higher temperatures (Keiluweit et al. 2010). Most biochars contain a thicker aromatic ring with fewer functional groups, which makes biochar resistant to decomposition (Cheng et al. 2006; Yadav et al. 2017).

3.3 Chemical properties of peat after treatment

The chemical properties observed after treatment included N, P, K and soil pH. The chemical characteristics of peat soils in Indonesia are very diverse and are determined by the mineral content, thickness, types of peat constituent plants, types of minerals in the substratum (at the bottom of the peat), and the level of peat decomposition. Peat is soil that

Table 2. Effect of treatments on nutrient availability of N, P, K on Peat soil after 1 month incubation.

Treatments (T:C:U)	Parameter			
	pH	Total N (%)	Av P (μg/g)	Av K Cmol (+)/kg
Bs1= (280g : 555g : 90g)	6.00 a	2.5 a	424.77 a	8.07 a
Bs2= (280g : 833g: 60g)	6.01 a	2.3 a	416.80 a	7.43 b
Bs3= (555g: 555g: 30g)	6.05 a	2.06 ab	359.68 ab	5.95 c
Bs4= (555g: 555g: 15g)	6.04 a	1.79 b	259.09 c	5.88 c
Bs5= (833g: 280g: 90g)	6.00 a	2.21 a	245.76 d	5.10 c
Bs6= (833g: 280g: 60g)	6.02 a	2.16 ab	247.42 d	4.83 d
F Table 5%	0.01	< 0.01	< 0.01	< 0.01
F count		ns	29.99*	894.96*

Source = Data analysis, 2021; Description * = significant effect; T: tankos (Oil palm empty fruit bunch biochar), C: chicken manure, U: urea.

Table 3. Effect of treatments on oil palm plant height in peat soil up to 3 months of treatments.

Treatments (T:C:U)	Plant Height(cm)		
Month	1	2	3
Bs1= (280g: 555g: 90g)	31.85 a	27.35 a	37.8 a
Bs2= (280g: 833g: 60g)	28.75 ab	22.4 a	34.4 a
Bs3= (555g: 555g: 30g)	27.85 ab	26.0 a	36.7 a
Bs4= (555g: 555g: 15g)	28.45 ab	22.8 a	31.1 a
Bs5= (833g: 280g: 90g)	23.65 ab	22.9 a	30.2 a
Bs6= (833g: 280g: 60g)	20.75 b	23.6 a	24.9 b
F Table 5%	1.55	0.16	3.59
F count	0.19 ns	0.24	0.073*

Source = Data analysis, 2021; Description * = significant effect; T: tankos (Oil palm empty fruit bunch biochar), C: chicken manure, U: urea.

is poor in macro and micronutrients and has an acidic pH (Agus and Subiksa 2008; Masganti and Widiyano 2019). After treatment, there was an increase in soil pH and the availability of nutrients. The chemical properties of peat after treatment with biochar, chicken manure and enriched with urea can be seen in Table 2.

Addition of biochar to acidic soil has shown an increase in soil pH. Thus, biochar possesses a liming effect on soil. Narzari et al. (2015) suggested that the increase in the soil pH suppresses the activity of enzyme(s) involved in the conversions of nitrite to nitrous oxide thereby increasing nitrogen availability in the soil.

The effect of Biokos fertilizer on soil total N, available P and available K showed that treatment Bs1 gave the highest value compared to other treatments and was significantly different, while the available pH and P were not significantly different. Provision of urea as recommended (90g) in combination with 280g oil palm empty fruit bunches biochar and 555g chicken manure gave the highest total soil N, because urea as a source of N was added to chicken manure which was rich in N, P and K nutrients. The addition of biochar in the soil resulted in an increase in CEC which in turn reduced the loss of nutrients through leaching (Lehmann 2007). Since biochar had a high CEC, it had the capacity to retain nutrients present in the soil, thereby increasing the efficiency of using soil nutrients that would otherwise be washed away by rainfall (Narzari et al. 2015). The value of total N, available P, and available K for peat soil was very high because the bulk density (volume weight) of peat was very low. When converted in weight/weight, the value was 0.25 of that value.

With its large surface area, biochar helped in increasing water holding capacity, cation exchange capacity (CEC), microbial activity (act as its habitat) and also reduced leaching of nutrient by providing nutrient binding sites. This reduced the total fertilizer requirement of biochar-amended

Table 4. Effect of treatments on number of leaves of palm plants up to 3 months.

Treatments (T:C:U)	Sum of leaves of oil palm plants		
Month	1	2	3
Bs1= (280g: 555g: 90g)	2.0 a	4.7 a	6.7 a
Bs2= (280g: 833g: 60g)	2.0 a	4.0 a	6.0 a
Bs3= (555g: 555g: 30g)	2.0 a	4.6 a	6.7 a
Bs4= (555g: 555g: 15g)	2.0 a	4.3 a	6.6 a
Bs5= (833g: 280g: 90g)	2.0 a	3.9 ab	5.9 ab
Bs6= (833g: 280g: 60g)	2.0 a	3.8 b	5.6 b
F Table 5%	0.54	0.37	0.34
F count	0.193 ns	1.4*	1.15*

Source = Data analysis, 2021; Description * = significant effect; T: tankos (Oil palm empty fruit bunch biochar), C: chicken manure, U: urea.

Table 5. Effect of treatments on number of leaves of palm plants up to 3 months.

Treatments (T:C:U)	Oil palm stem diameter(cm)		
Month	1	2	3
Bs1= (280g: 555g: 90g)	5.1 a	6.7 a	7.7 a
Bs2= (280g: 833g: 60g)	5.3 a	6.1 a	7.0 a
Bs3= (555g: 555g: 30g)	5.2 a	6.6 a	7.7 a
Bs4= (555g: 555g: 15g)	5.1 a	6.3 a	7.6 a
Bs5= (833g: 280g: 90g)	5.1 a	6.4 a	6.9 a
Bs6= (833g: 280g: 60g)	5.1 a	6.5 a	7.6 a
F Table 5%	0.44	0.37	0.54
F count	0.193 ns	0.41 ns	0.15 ns

Source = Data analysis, 2021; Description * = significant effect; T: tankos (Oil palm empty fruit bunch biochar), C: chicken manure, U: urea

soil and thereby reduced the environmental pollution caused by the leaching of inorganic fertilizer (Narzari et al. 2015).

3.4 Oil palm plant height

Oil palm is generally cultivated on tropical soils that have low chemical fertility and varying physical properties (Winarna 2016; Febriyanti et al. 2019). In general, oil palm productivity is influenced by environmental factors, genetics and cultivation techniques (Yudistina et al. 2010). The results showed that treatment Bs1 with a dose of 90 g urea produced the highest plants, however, increasing the dose of biochar did not significantly increase the plant height. The results of this study is in line with the results of previous research (Febriyanti et al. 2019; Sholeh et al. 2016) which reported that the application of nitrogen fertilizer increased and accelerated the growth of “lady palm” (Rhapis excels) plant seedlings. Goh and Hardter, and Sholeh et al. showed that nitrogen fertilization was the main driving force for the rapid vegetative growth of oil palm (Goh and Härdter 2000; Sholeh et al. 2016). Observation of the height of oil palm seedlings in months 1, 2, 3 can be seen in Table 3.

Plant growth requires macronutrients such as N, P and K in greater quantities than other elements. Nitrogen is an element that plays an important role in spurring the high growth of plants. According to Sholeh et al. (2016), the elements of nitrogen and water can increase plant height growth, if it occurs. Nitrogen deficiency can cause stunted growth. Plant height growth occurs in meristems and internodes. Segment lengthens as a result of an increase in the number of cells and is mainly due to the expansion of plant cells. Linga and Marsono stated that the addition of nitrogen can stimulate vegetative growth, namely branches, stems, and leaves which are components of amino acids, proteins and form protoplasm of cells that function in stimulating plant height growth (Sholeh et al. 2016).

3.5 The number of leaves

The leaf sheath is the organ of photosynthesis and transpiration in oil palm plants that greatly affects the growth of

Figure 5. Oil palm seedlings aged 3 months.

Table 6. Growth standards of oil palm seedlings in nursery.
Source: (Adnan et al. 2015)

Age (month)	Plant height (cm)	Stem diameter (cm)	Sum of leaves (blade)
4. 5	26.00 ± 1.3	1.30 ± 0.02	5.00 ± 0.2
6	39.90 ± 1.1	1.84 ± 0.02	8.60 ± 0.2
7	52.20 ± 1.4	2.70 ± 0.12	10.8 ± 0.3
8	64.30 ± 0.6	3.56 ± 0.04	11.0 ± 0.0
9	88.30 ± 2.5	4.50 ± 0.15	13.3 ± 0.3
10	101.9 ± 5.1	5.96 ± 0.33	15.8 ± 0.1
11	44.10 ± 3.9	5.84 ± 0.14	15.6 ± 0.3
12	126.90 ± 7.0	6.02 ± 0.24	15.8 ± 0.4

this plant. The number of leaves per month was not significantly different between treatments, but the Bs1 treatment with 90g N fertilizer composition showed an insignificant increase in the number of leaves after 3 months of observation. The number of leaves for months 1, 2 and 3 can be seen in Table 4.

The effect of Biokos fertilizer addition on the number of leaves of oil palm plants in the first month was not significantly different between treatments, as well as in the second and third months, but there was an increase in the number of leaves each month. Treatment Bs1 gave the highest number of leaves compared to other treatments. High organic C content in biochar was suitable as an ameliorant in order to improve long-term soil fertility. The higher surface area is considered as the cause of the increased negative charge on the surface of biochar. Such ameliorant characteristics when applied to the soil are expected to increase the adsorption complex, water retention, release of cations and anions in peat, which in turn increases the availability of nutrients for plants (Narzari et al. 2015; Indrawati et al. 2017).

3.6 Palm oil stem diameter

The size of the diameter of the oil palm trunk and the age of the plant affects several aspects of the productivity of the oil palm plant itself such as affecting the number of leaves, the number of harvests per week, the age of the plant to bear fruit for the first time, the weight of the stalk, and the number of midribs per tree (Yudistina et al. 2010). The stem diameter of oil palm seedlings up to the age of 3 months in various treatments can be seen in Table 5.

The effect of Biokos fertilizer addition in month 1 was not significantly different between treatments, as well as in months 2 and 3, but it was seen that there was an increase in stem diameter each month. Bs1 treatment showed the highest stem diameter compared to other treatments. Biochar additions to soils improved the soil quality by rapid nutrient cycling in soil organic matter, microbial biomass, and better colonization of Arbuscular mycorrhiza of roots (Narzari et al. 2015). In this research, it increased the availability of nutrients for crops through the retention of nutrients in peat soil, which had lower CEC values and a better supply of fixed P to the plants. These findings support the research results of scientists who have reported that the application of biochar in soil that has a significant effect on net primary crop production, grain yield, and dry matter production (Chen et al. 2008; Chan and Xu 2009; Spokas et al. 2009). Purakayastha clearly explained that the application of biochar made from wheat straw (1.9 t/ha) together with the recommended dose of NPK 180: 80: 80 kg ha^{-1} significantly increased maize yield in Inceptisosl (Pu-

Table 7. N, P, K uptake of oil palm seedlings after treatments.

Treatments (T:C:U)	N uptake ($mg.plant^{-1}$)	P uptake ($mg.plant^{-1}$)	K uptake ($mg.plant^{-1}$)
Bs1= (280g: 555g: 90g)	454.23 a	159.9 a	211.2 a
Bs2= (280g: 833g: 60g)	294.23 b	145.56 b	197.62 b
Bs3= (555g: 555g: 30g)	238.62 c	129.18 c	196.3 b
Bs4= (555g: 555g: 15g)	248.3 d	139.79 d	174.17 c
Bs5= (833g: 280g: 90g)	180.91 e	115.55 e	168.11 d
Bs6= (833g: 280g: 60g)	70.76 f	38.43 f	63.055 e
F Table 5%	2.77	2.77	2.77
F count	9.77*	16.63*	8.83*

Source = Data analysis, 2021; Description * = significant effect; T: oil palm empty fruit bunches (Oil palm empty fruit bunch bio-char), C: chicken manure, U: urea rakayastha 2010). From Tables 2, 3, 4, and 5, it can be seen that treatment Bs1, with the composition of oil palm empty fruit bunches biochar: chicken manure: urea (280g: 555g: 90g) increased the soil total N, available P, and available K and gave the highest value on vegetative growth of oil palm including plant height, number of leaves and stem diameter. In Indonesia, there are standards for oil palm growth as can be seen in Table 6.

From the standard table of growth of oil palm seedlings (Table 6) it can be seen that the plant height, stem diameter, and number of leaf midribs of oil palm seedlings met the standards, so it can be said that the treatment of oil palm empty fruit bunches fertilizer (biochar, chicken drum fertilizer enriched with urea) increased the availability of N, P, K in the soil which further increased the growth of oil palm seedlings. Fig. 5 shows the growth of oil palm seedlings at the age of 3 months.

3.7 N, P and K uptake of the upper part of the plant

Oil palm empty fruit bunch biomass which is processed into biochar is one of the strategies to achieve sustainable oil palm plantations. Harsono et al. stated that the results of the Life Cycle Analysis (LCA) of EFB biochar showed a positive energy balance of around 25% (Harsono et al. 2013). Several studies on agricultural land that have been given biochar provide benefits such as maintaining nutrients and cations, reducing soil acidity, reducing soil absorption of toxins, improving soil structure, using nutrients efficiently, maintaining water holding capacity and reducing non-CO_2 compounds and greenhouse gases CH_4, N_2O) (Kookana et al. 2011).

The results of this research are in line with those studies which show the benefits of biochar from oil palm empty fruit bunches. The nutrient uptake of oil palm seedlings treated with biochar increased significantly. Observations of N, P and K uptake of the upper part of the plant can be seen in Table 7.

Biokos fertilizer with the ratio of biochar: chicken manure: urea (280g: 555g: 90g) showed the most significant results in increasing N, P and K uptakes of oil palm seedling plant tissue at the age of 3 months. The larger proportion of chicken manure and urea was influenced by the biochar factor which plays a role in increasing nutrient uptake from chicken manure and urea. This is in accordance with the opinion of Rosmarkam and Yuwono that chicken manure in the mineralization process releases complete plant nutrients such as N, P and K (Rosmarkam and Yuwana 2002). The biochar also plays a role in providing nutrients, because of the presence of functional groups that are positively- and negatively-charged, so it can capture positively- and negatively-charged nutrients as well. Biochar is a home for microorganisms because there are many macro and micro pores in it so that microorganisms can decompose organic N into available N for plants (Indrawati 2018). The more doses of chicken manure and urea biochar given, the higher the N uptake value in plants. The addition of organic matter in the form of biochar oil palm empty fruit bunches and chicken manure had an effect on increasing total soil N, and then decomposed and produced amino acids which were then hydrolyzed into ammonium (NH_4^+) and nitrate (NO_3^- thus adding organic matter means increasing N levels. -total soil which directly also increased the N uptake in plants.

For the available P parameter, treatment Bs1 (biochar: chicken manure: urea (280g: 555g: 90g) was significantly different from all treatments, and also gave the highest available P value, this could be due to the increased availability of available P in the soil sourced from chicken manure and the addition of increased urea. One of the benefits of giving biochar is that it can reduce leaching because there are pores and functional groups on the surface, so that the more biochar given, the more available these nutrients are to plants (Indrawati 2018).

According to Hasan et al. (2016), plant P uptake was largely determined by root contact with P nutrients, P concentration in soil solution and plant capacity. They stated that the nutrient P absorbed by plant roots depends on the amount and availability of P and the plant's ability to absorb P in the soil. According to Atiyeh et al. (2002), the decomposition of organic matter can increase the availability of phosphate through its decomposition by forming humic P which was easily taken up by plants.

Treatment Bs1 gave a significantly different effect on all treatments and also gave the highest available K value. Potassium is a mobile element in plants, both in cells, in plant tissues, as well as in xylem and phloem. In the soil, the total K content s higher but only a small part is available to plants. Potassium has a valence of one and is absorbed in the form of K^+ ions. The availability of K in the soil can be influenced by several factors such as soil pH.

The increase in K uptake was thought to be due to the ability of biochar oil palm empty fruit bunches of chicken manure to increase the uptake of essential nutrients and increase plant growth. The role of organic matter on soil chemical properties is to increase the cation exchange capacity so that it can affect nutrient uptake by plants. Provision of chicken manure and biochar oil palm empty fruit bunches contributes K, and this is able to have a positive influence in increasing soil support for leaching or protecting K nutrients (Ichriani et al. 2016).

4. Conclusion

The application of Biokos fertilizer with a combination of treatment Bs1 = (280g tankos biochar: 555g chicken manure: 90g urea) increased the soil total N, available P and available K, resulting in the highest value on vegetative growth of oil palm plants including plant height, number of leaves and stem diameter, the increase in plant height reached 213%, leaf number 36%, 49.7% soil total N, 16.12% available P and 35% available K compared to control. This combination was also shown to increase the N, P, K uptake of oil palm seedlings at the age of 3 months. Palm oil waste in the form of empty bunches of biochar, had special properties such as porous structure, relatively large surface area, functional groups, has the potential as an ameliorant to increase marginal soil fertility including peat, and increase plant growth of oil palm seedlings. So, this reduces the total fertilizer requirement of biochar-amended soil and thereby reduces environmental pollution caused by the leaching of inorganic fertilizer. It also plays a vital role in increasing crop productivity.

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Compliance with ethical standards
Conflict of interest: The authors declare that there are no conflicts of interest associated with this study.

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