

Effect of Biochar on Growth of Main Nursery Palm Oil Seedlings (*Elaeis guineensis* Jacq.) on Soil Chemical Properties in Vertisol Soil Planting Media

Erwin Junaidi Lubis^{1*}

¹Department of Agrotechnology, Faculty of Agriculture, University of Sumatera Utara, Medan, Indonesia

*Corresponding author: lubiserwinjunaidi@gmail.com

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ABSTRACT

Plant growth response of palm oil seedlings (*Elaeis guineensis* Jacq.) on D x P Yangambi varieties using biochar applications made from palm oil shells, rice husks, and corn cobs in the Main Nursery. This study aims to determine the effect of the application of several types of biochar on the growth of palm oil seedlings (main nursery) on soil chemical properties namely C-Organic, N-Total, Phosphorus Nutrients, Potassium Nutrients and Soil pH in Vertisol Soil Planting Media. This research was conducted at the Soil Laboratory Practice Farm of the Indonesian Institute of Palm Technology, Medan, North Sumatera. The research used Factorial Randomised Group Design (RGD) with 3 replications. The research was conducted for 4 months. The results showed a significant effect on the application of rice husk biochar, palm oil shells and palm oil cobs and the application of N.P.K.Mg 15.15.6.4 fertilizer at a fertilizer dose of 7.5 g.polybag⁻¹ on the parameters of plant height, stem circumference, number of leaf midribs, and biochar treatment can increase soil pH, Phosphorus nutrients, and Potassium nutrients.

Keywords: biochar, vertisol, rice husk, palm kernel shell, corn cob

INTRODUCTION

One type of soil that is widely used in agriculture as a place to do agricultural cultivation is Ultisol, Vertisol and Oxisol soil. Vertisol soil is a clay soil that contains clay and has the property of shrinking and expanding as the weather changes. The characteristics of vertisol soil are grey to black in colour. The high clay content in vertisol soils is >30%, and has a thick soil solum layer between 100 - 200 cm, soil texture is clayey to loamy, has soil

cracks reaching 25 cm wide and 60 cm deep when dry.

One of the factors that affect soil colour in vertisols is the presence of organic matter, parent material, and soil moisture. Moist or wet soil will look darker than dry soil.

Biochar is wood charcoal that has pores/porous and is commonly used as a soil

improver that can reduce CO₂ from the air or biochar is commonly called activated charcoal which is a solid material formed from carbonisation of biomass. Biochar can increase soil moisture and fertility on agricultural land (Warta Penelitian dan Pengembangan Pertanian, 2009).

In the long term, biochar will not disturb the Carbon-Nitrogen balance and can retain and can be utilised as nutrients and retain water to make it more available to plants (Kurniawan, 2019). When biochar as organic fertilizer is mixed with inorganic fertilizer, it can increase productivity and retention which will become nutrient availability for plants (Gani, 2009 *in* Kurniawan, 2019).

According to Tobing *et al.* (2007) that temperature will greatly affect and the determination of the right temperature will affect

the quality of charcoal. The high increase in total phosphorus (P-Total) (151%) would indicate that phosphorus did not evaporate or hydrolysed at the resulting temperature during charcoal production.

The use of biochar is expected to improve the chemical properties, physical properties and biological properties of vertisol soil. Leaching of nitrogen (N) nutrients will be reduced by the application of biochar into the growing medium, and nitrogen (N) will increase, and be available to plants. Biochar given to the soil will be able to increase plant growth and development and nutrient supply in the soil will be fulfilled (Glaser *et al.*, 2002 *in* Siahaan, 2019). This study was conducted to test the application of biochar on vertisol soil to see the effect on soil chemical properties on the growth of palm oil seedlings (*Elaeis guineensis* Jacq.) Main Nursery.

MATERIALS AND METHODS

The palm oil seedlings used are the D x P Yangambi variety with an age of 3 months taken at the PPKS Sei Pancur nursery, Tanjung Morawa, *Top Soil* with *Vertisol Soil* type from Tanjung Morawa, River Sand as a mixture of planting media, watering water, N.P.K.Mg 15.15.6.4 compound fertilizer as a research fertilizer, RP (*Rock Phosphate*) fertilizer as a rooting fertilizer.

This research was conducted for 4 months from July to November 2023. The research was conducted at the Soil Laboratory Practice Farm of the Institut Teknologi Sawit Indonesia, Medan, North Sumatra. The research used a Factorial Randomised Group Design (RGD) with a 3x3 combination of experimental treatments.

This study has 2 factorials, Factor 1 Biochar with 3 experimental levels, experiment B₁ = Rice Husk 100 g.polybag⁻¹, B₂ = Palm Oil Shell 100 g.polybag⁻¹, B₃ = Corn Cob 100 g.polybag⁻¹. Factor 2 Compound fertilizer N.P.K.Mg 15.15.6.4 with 4 experimental levels, experiment M₁ = 2.5 g.polybag⁻¹, M₂ = 5 g.polybag⁻¹, M₃ = 7.5 g.polybag⁻¹, M₄ = 10 g.polybag⁻¹.

Research observations consisted of Biochar Analysis parameters (C-Organic (%) and N-Total (%)), Soil H₂O pH, N-Total (%), P₂O₅ - Available (ppm P), K₂O - Exchange (me.100 g soil⁻¹), C-Organic (%), Plant Height (cm), Stem Circumference (cm), and Number of Leaflets (leaflets).

RESULTS AND DISCUSSION

1. Biochar Analysis

Biochar analysis was conducted in the soil laboratory. Biochar analysis was conducted to determine the nutrient content of biochar before it was applied to vertisol soil. Biochar analysis

consists of rice husks, palm oil shells, and corn cobs. The following biochar analysis results on C-Organic and N-Total nutrients are presented in Table 1 as follows:

Table 1. Biochar Analysis (C-Organik and N-Total)

Biochar Type	Nutrient Parameters			
	C-Organic (%)		N-Total (%)	
Rice Husk	3,98	m	0,51	m
Palm Kernel Shell	4,48	h	0,55	h
Corn Cob	5,70	h	0,55	h

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High

From the results of laboratory analysis, it is shown that the analysis of biochar in rice husks, palm kernel shells, and corn cobs produced data and descriptions through the table of criteria for the suitability of soil nutrient levels (soil chemical properties). The results on rice husk biochar analysis for C-Organic nutrients have moderate

nutrient levels of 3.98%, while N-Total has moderate nutrient levels of 0.51%. In the analysis of biochar Palm Oil Shells and Corn Cob have high nutrient content criteria in the C-Organic nutrient criteria of 4.48% and 5.70%, while in N-Total it is 0.55% and 0.55%.

2. Plant Growth

The following table of plant growth of palm oil seedling (*Elaeis guineensis* Jacq.) Main Nursery is shown in Table 2 as follows:

Table 2. Average Plant Growth of Palm Oil Seedlings

Treatment		Average Plant Growth		
Biochar (100 g.polybag ⁻¹)	N.P.K.Mg 15.15.6.4 (g.polybag ⁻¹)	Plant Height (cm)	Stem Circumference (cm)	Number of Leaf Sheaths (Fronds)
Rice Husk	2,5	51,00 a	9,70 c	9,43 a
	5	51,50 a	9,73 c	9,90 b
	7,5	52,90 b	9,76 c	9,90 b
Palm Kernel Shell	2,5	51,90 a	8,90 a	10,00 c
	5	52,00 b	9,37 b	10,10 c
	7,5	52,00 b	9,80 d	10,18 c
Corn Cob	2,5	52,00 b	9,26 c	10,33 c
	5	52,20 b	9,34 b	10,50 d
	7,5	52,77 c	9,35 b	10,87 e

Total	471,27	85,21	91,21
Average	52,36	9,47	10,13

Description: Number followed by the same index in the same row or column showed no the significant difference according to the DMRT test (*Duncan's Multiple Range Test*) 95% confidence level ($\alpha = 0,05$)

From the results of testing the average plant growth during planting 4 months, the results of the application of biochar from rice husks, palm oil shells and corn cobs and a mixture of N.P.K.Mg 15.15.6.4 compound fertilizer at different levels, obtained better plant growth results at the N.P.K.Mg 15.15.6.4 fertilizer application level of 7.5 g.polybag⁻¹. At 100 g.polybag⁻¹ rice husk biochar and 7.5 g.polybag⁻¹ compound fertilizer for plant height parameters, is the highest at 52.90 cm, at a plant circumference of 9.76 cm, and at the number of leaf midribs of 9.90 midribs not significantly different from the fertilizer level of 5 g.polybag⁻¹ which is 9.90 midribs.

At 100 g.polybag⁻¹ palm oil shell biochar and 7.5 g.polybag⁻¹ compound fertilizer, the highest results were obtained in plant height which was 52.00 cm and not significantly different from the fertilizer is level of 5 g.polybag⁻¹ of 52.00 cm. The stem circumference was 9.80 cm, and the number of leaf midribs was 10.18 midribs.

At 100 g.polybag⁻¹ corn cob biochar and 7.5 g.polybag⁻¹ compound fertilizer, the highest results were obtained in plant height at 52.77 cm. The stem circumference was 9.35 cm but not significantly different from the level 5 g.polybag⁻¹ fertilizer at 9.34 cm. The number of leaf midribs was 10.87 midribs.

This is due to the enlargement in plant height growth of active meristem cells in plants, and Potassium and Calcium contained in plants play a role in accelerating plant growth. Biochar can also increase plant height and plant stem diameter. The presence of nutrients contained in biochar, so biochar is very useful in adding nutrients to plants so as to make plant growth and development faster (Singh and Fulekar, 2010).

According to Niswati (2013) explains that to support the vegetative growth of plants in seedlings,

N.P.K and other nutrients must be required in sufficient and balanced amounts.

In the observation of the stem circumference of palm oil seedlings, it can be seen that the effect of biochar application of 100 g.polybag⁻¹ will be able to make the growth of stem circumference greater and the effect of additional inorganic fertilizer N.P.K.Mg 15.15.6.4 as much as 7.5 g.polybag⁻¹ to the planting media. This proves that the application of biochar and inorganic fertilizer will be able to make better stem circumference growth and spur plant growth.

This causes that nitrogen nutrients that play a role in increasing plant development are better in both vertical and horizontal conditions. According to Mangoensoekarjo (2007), that the availability of phosphorus nutrients which function as strengthening stem growth, as well as potassium nutrients that are slightly available will result in less well-developed plant stems.

According to Lubis (2000) *in* Siahaan (2019), the element potassium (K) functions as a strengthening of plant stem stands and affects the circumference of the plant stem.

In the parameter of the number of midribs, the largest data was produced in the biochar application of 100 g.polybag⁻¹ and inorganic fertilizer application of the 7.5 g.polybag⁻¹. This indicates that the application of biochar organic fertilizer from rice husks, palm oil shells, and corn cobs will be able to increase the number of midribs on palm oil seedlings in the main nursery.

According to Lingga and Marsono (2001) *in* Kurniawan (2019), that in the formation of a lot of chlorophyll, there are elements used in the formation of chlorophyll and new cells. Apart from the photosynthesis process, nitrogen nutrients are

also needed in producing proteins and other materials.

Soil H₂O pH Value

Based on the soil analysis conducted in the soil laboratory, it is shown in Table 3 as follows:

Table 3. Soil H₂O pH Value

Treatment		Soil H ₂ O pH Value
Biochar (100 g.polybag ⁻¹)	N.P.K.Mg 15.15.6.4 (g.polybag ⁻¹)	
Rice Husk	2,5	5,10 a
	5	5,39 ab
	7,5	5,57 b
Palm Kernel Shell	2,5	5,15 a
	5	5,60 b
	7,5	5,99 c
Corn Cob	2,5	5,62 b
	5	5,88 c
	7,5	6,10 d

Description: Number followed by the same index in the same row or column showed no the significant difference according to the DMRT test (*Duncan's Multiple Range Test*) 95% confidence level ($\alpha = 0,05$)

From Table 3, the results of soil H₂O pH analysis obtained the lowest soil pH after biochar application was with a value of 5.10 and the criteria included acidic in the application of inorganic fertilizer of 2.5 g.polybag⁻¹ and rice husk biochar as much as 100 g.polybag⁻¹. While the highest was in the application of corn cob biochar as much as 100 g.polybag⁻¹ and inorganic fertilizer as much as 7.5 g.polybag⁻¹ with a pH value of 6.10 and including slightly acidic criteria. However, the application of palm kernel shell biochar is much higher than rice husk biochar.

It is also able to increase the pH value of low soil on palm kernel shell biochar. Biochar application will be able to raise the pH of low soil (Nurida, 2009).

According to Yamato *et al.* (2006); Novak *et al.* (2009) in Siahaan (2019) that the addition of biochar applications into the soil will be able to increase soil acidity (pH) and increase the Cation Exchange Capacity (CEC) of the soil where the increase in CEC will minimise the risk of leaching of nutrients such as K⁺ and NH₄⁺.

Soil Analysis Value

1. Soil C-Organic and N-Total Analysis

The following table of Soil C-Organic and Soil N-Total Analysis is Shown in Table 4 as follows:

Table 4. Soil C-Organic and Soil N-Total Analysis

Treatment		Analysis Value			
Biochar (100 g.polybag ⁻¹)	N.P.K.Mg 15.15.6.4 (g.polybag ⁻¹)	C-Organic Soil		Soil N-Total	
Rice Husk	2,5	3,21	m	0,32	m
	5	3,29	m	0,41	m
	7,5	3,31	m	0,52	h
Palm Kernel Shell	2,5	3,15	m	0,39	m
	5	3,49	m	0,48	m
	7,5	4,10	h	0,49	m
Corn Cob	2,5	3,15	m	0,37	m
	5	4,15	h	0,51	h
	7,5	4,37	h	0,53	h

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High

In the results of soil laboratory analysis, the results of the analysis in Table 4, namely the criteria of biochar and inorganic fertilizers on soil chemical properties. The application of biochar as much as 100 g.polybag⁻¹ and compound fertilizer as much as 7.5 g.polybag⁻¹ on the type of palm oil shell biochar into high criteria values, while corn cob biochar 100 g.polybag⁻¹ and inorganic fertilizer 7.5 g.polybag⁻¹ also produces high C-Organic criteria, the same as inorganic fertilizer 5 g.polybag⁻¹.

In the results of soil N-Total analysis, the results of rice husk biochar 100 g.polybag⁻¹ and inorganic fertilizer 7.5 g.polybag⁻¹ were found to be high criteria values. Likewise, the 100 g.polybag⁻¹ corn cob biochar and the 7.5 g.polybag⁻¹ inorganic fertilizer became high criteria values, not different from the application of a 5 g.polybag⁻¹ inorganic fertilizer which produced high criteria values.

It is suspected that the C-Organic in palm kernel shell and corn cob biochar in the application of inorganic fertilizer is appropriate in the soil and used by plants. According to Nuryani and Havlin *et*

al. (2005) in Siahaan (2019), that organic matter applied to the soil will undergo a decomposition process by bacteria in the soil, thereby increasing carbon (C) levels in the soil and the presence of dry matter produced by biochar in the form of nitrogen (N), hydrogen (H), and other mineral elements.

Biochar is an organic material that can increase heterotrophic microbes which are useful as amino acid digesters into ammonium through the process of amonitisation, as well as microorganisms have a role as a penitritic and convert ammonium into nitrate so that it can be used for plants.

According to Hale *et al.* (2013) and Siahaan (2019) that most of the N-Total in acidic soils is in the form of organic compounds so that when there is a mineralization process by N-Organic compound will turn into NH₄ – N (N – Ammonium) and NO₃ – N (N – Nitrat) which can be absorbed by plants and biochar is able to retain Nitrogen and Phosphor so that it is not easily lost or hyrolysed into the air and is available to plants.

2. Soil P₂O₅ - Available and K₂O - Exchange Analysis

The following table of Soil P₂O₅ - Available and Soil K₂O - Exchange Analysis is Shown in Table 5 as follows:

Table 5. Soil P₂O₅ – Available and K₂O – Exchange Analysis

Treatment		Analysis Value			
Biochar (100 g.polybag ⁻¹)	N.P.K.Mg 15.15.6.4 (g.polybag ⁻¹)	P ₂ O ₅ - Soil Available		K ₂ O – Soil Exchange	
Rice Husk	2,5	39,10	h	0,98	h
	5	39,35	h	1,21	vh
	7,5	40,20	h	2,11	vh
Palm Kernel Shell	2,5	40,20	h	1,39	vh
	5	40,90	h	2,45	vh
	7,5	43,00	vh	2,98	vh
Corn Cob	2,5	41,15	vh	0,97	h
	5	42,00	vh	3,11	vh
	7,5	42,15	vh	5,77	vh

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High

Based on Table 5, the results of P₂O₅ – Available soil with high and very high criteria. The results of the K₂O – Exchange analysis test also produced high to very high criteria. This is due to the ability of palm oil seedlings in absorbs the phosphorus nutrients given into the soil has been well absorbed by the plants so that it has formed new cells.

This is conveyed according to Oguntude *et al.* (2004) in Kurniawan (2019), that phosphorus (P) plays a role in cell formation so that it will be easily absorbed in plants, and what if the P nutrients levels are lacking will inhibit plant growth..

According to Cheng *et al.* (2006) in Kurniawan (2019) and Lubis (2020) that biochar

will be able to increase the availability of phosphorus (P) in the soil and increase the formation of compounds so that phosphorus (P) will not easily dissolve, and biochar is different from other organic materials, biochar can absorb phosphorus (P) nutrients more strongly.

The provision of biochar has a significant effect on soil chemical properties, one of which is on soil exchange knockout in Vertisol soil. The effect given is as a soil improver, organic biochar contains potassium (K) nutrients that can improve the availability of K nutrients that are lacking and available in plant growth. Potassium contained in biochar can be in the soil solution and so it is easily absorbed by plants, and not easily washed away (Widiowati *et al.*, 2012).

CONCLUSION

The application of biochar of rice husk, palm kernel shells, and corn cobs and mixed application of inorganic fertilizer N.P.K.Mg 15.15.6.4 gave a significant effect on the growth of main nursery palm oil seedlings and vertisol soil the application of biochar and inorganic fertilizer also increased the soil pH by 6.10.

This indicates the need for biochar application in other soil types and in horticultural crops and the difference in biochar applied must be different too

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