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Applying Biochar and Oil Palm Seeds' Resistance to Drought Stress

Sri Suryanti[1]*, Andre Wibowo[2] Retni Mardu Hartati[1]
[1]Institut Pertanian Stiper, Jl. Nangka II, Krodan, Maguwoharjo, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia
[2]PT. Dhanistha Surya Nusantara, Jl. Lingkar Luar Barat, Kembangan Utara, Kec. Kembangan, Kota Jakarta Barat, Daerah Khusus Ibukota Jakarta 11610
*Email: ntie@instiperjogja.ac.id

ABSTRACT

Biochar is a soil enhancer because it contains macronutrients and has a high water-holding capacity. Research on the application of biochar and resistance of oil palm seedlings to drought stress was conducted to determine the dosing effect of oil palm shell biochar and watering intervals on the growth of pre-nursery oil palm seedlings under drought stress. The research was conducted in Sialang Godang Village, Bandar Petalangan District, Pelalawan District, Riau Province. The study was conducted in April 2021 – July 2021. The research used a completely randomized design (CRD) with two factors. The first factor was using biochar doses of 5 levels, namely 0 g, 50 g, 100 g, 150 g, and 200 g. The second factor was the watering interval which consisted of 3 groups, i.e.,, watering once a day, every two days, and every three days. Observational data were analyzed using an analysis of variance, and if there was a significant difference, it was continued with the Duncan Multiple Range Test at the 5% level. The results showed that giving biochar at a dose of 200 grams of oil palm shells and watering once every two days significantly increased the fresh weight of roots while providing biochar at a dose of 50 grams of biochar/polybag and watering once every three days significantly increased the dry weight of roots. Watering once every three days significantly increased the number of secondary and tertiary roots, while treatment without biochar and 50 gram/polybag biochar significantly increased the width of stomatal openings. There was a positive correlation between soil moisture content and the number of stomata (r = 0.26), the width of the opening of the stomata, and the dry weight of the roots (r = 0.25).
Keywords*: Biochar, resistance, drought, seedling, oil palm*

1. INTRODUCTION

Seed quality will affect crop production. Oil palm nurseries are the first link in the oil palm plantation supply chain, followed by plantations producing fresh fruit bunches (FFB), mills producing crude palm oil (CPO), and palm kernel. As a result, the quality of the seeds will impact crop productivity.

In oil palm nurseries, the selection of planting material must be examined. Topsoil can be used as a planting medium because of its loose texture and high nutrient content from organic matter from previous plants' degradation. Oil palm is a plant with shallow roots vulnerable to drought stress. Drought is caused by high levels of transpiration and restricted groundwater supply during the dry season (Maryani, 2012).

According to estimates, oil palm farms create 36.5 tonnes of biomass per hectare per year, showing an abundance of this waste. This garbage is high in carbon and can be utilized to make biochar (Mohamed & Yusup, 2021)

The palm oil mill (PKS), with a capacity of 30 tons of FFB/hour, produces 2.7 tons of palm shells each hour, resulting in 32.4 tons of shells per day if the PKS processes it for 12 hours per day. Because they include hemicellulose, cellulose, and lignin, oil palm shells have the potential to be converted into biochar (Sasmita and Septianda, 2022).

Furthermore, (Nurida, 2014) claimed that using biochar might increase soil chemical qualities (pH, cation exchange capacity, total-N, available-P, and Aldd) as well as soil physical properties (bulk density, porosity, and soil's ability to hold water). Improving the quality of the earth's chemical and biological qualities impacts the availability of nutrients and water due to biochar's ability to retain nutrients and water. Biochar is a pyrolysis-derived organic soil additive that can improve soil's physical, chemical, and biological qualities, similar to the organic matter in general. Biochar has the advantage of being resistant to decomposition, so the positive effect of adding biochar to the ground is permanent because it can last long enough in the ground. Applying biochar to the soil also increases the carbon stocks of terrestrial ecosystems because the organic matter that can be converted into carbon biochar will remain stored in the soil (Wijaya et al., 2018). Applying biochar can significantly reduce soil density and increase the porosity of ultisol soils (Rusdi et al., 2020), reducing the negative impact of drought stress by increasing the efficiency of water use (Zhang et al., 2020).

According to (Santi, 2020), 150 grams of biochar can increase seedling height (33.3%), number of leaves (36.2%), stem diameter (28.9%), leaf length and width (22.6 and 33.3). %), dry weight of oil palm seeds, especially the root (65.2%), cation exchange capacity (17.2%), and C-organic (26.9%).

2. MATERIAL AND METHODS

The research was conducted in Sialang Godang Village, Bandar Petalangan District, Pelalawan Regency, Riau with an altitude of 54 masl at coordinates 0.1235 South Latitude and 102.1291 East Longitude. The study was conducted from April to July 2021 using a completely randomized design (CRD) with two factors. The first factor is using biochar doses of 5 levels, 0 g, 50 g, 100 g, 150 g, and 200 g. The second factor was the

watering interval which consisted of 3 levels, i.e. watering once a day, every 2 days and every 3 days. Observational data were analyzed using the variance test; if there was a significant difference, it was continued with the DMRT test at the 5% level.

The materials used are DxP Yangambi oil palm seeds, topsoil, oil palm shells, NPK fertilizer, forest wood, paranet, insect nets, UV plastic, polybags, and water. Biochar is made using oil palm shells which are burned using the drum kiln method in low oxygen conditions (pyrolysis)..

Parameters of agronomic observations included seedling height, number of leaves, stem diameter, leaf area, length of primary roots, number of primary roots, number of secondary roots, number of tertiary roots, root volume, root fresh weight, root dry weight, soil moisture content, shoot dry weight. , the number of stomata and the width of the stomata opening.`

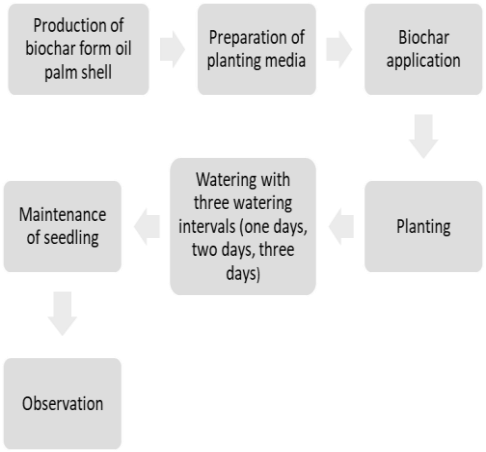

Figure 1. Research Flowchart

3. RESULT AND DISCUSSION

On seedling height, number of leaves, stem diameter, leaf area, length of primary roots, number of primary roots, number of secondary roots, number of tertiary roots, shoot dry weight, number of stomata, and stomata opening width, there was no significant interaction between biochar dosage and watering interval.

Table 1. The effect of watering intervals on several agronomic parameters

Parameter	Watering intervals		
	1 Day	2 Days	3 Days
Seedling height (cm)	25.64 a	26.60 a	25.71 a
Number of leaves	3.57 a	3.60 a	3.73 a
Stem diameter(mm)	6.11 a	6.46 a	6.27 a
Leaf area (cm2)	27.16 a	29.55 a	28.72 a
Primary root length(cm)	25.03 a	25.36 a	26.29 a
Number of primary roots	2.47 a	2.67 a	2.60 a
Number of secondary roots	29.20 b	32.07 ab	35.20 a
Number of tertiary roots	73.80 b	82.07 b	104.53 a
Root volume(ml)	1.41 a	1.53 a	1.49 a
Soil moisture content (%)	24.85 a	22.43 a	20.91 a
Canopy dry weight (grams)	7.17 a	7.15 a	7.19 a
Number of stomata	23.13 a	22.87 a	21.13 a
Stomatal opening width	0.65 a	0.64 a	0.57 a

Note: Different letters in the row indicate that there is a significant difference based on the results of the DMRT test at the 5% level

The three-day watering interval produced the greatest number of secondary and tertiary roots (Table 1). It is hypothesized that the once-every-three-

days watering interval causes drought stress in oil palm seedlings. This is indicated by a decrease in soil moisture content after every three days watering intervals. Secondary and tertiary roots have an exceptional

capacity for water absorption. Under drought stress conditions, the roots increase their ability to absorb water by producing more secondary and tertiary roots. This is a morphological response of plants to ensure their survival under conditions of drought duress. (Laoli et al., 2023). One of the mechanisms of plant adaptation to drought stress is to maintain high water status by developing roots, thereby increasing the ability of plants to absorb water. Watering once every 3 days causes the number of stomata to tend to decrease and the width of the stomata openings to be smaller. According to (Pirasteh-Anosheh et al., 2016), closing of the stomata is the first reaction to drought stress.

Table 2. Effect of biochar on several agronomic parameters

Parameter	Biochar Dosage (grams)				
	Control	50	100	150	200
Seedling height (cm)	26.93 p	25.59 p	26.31 p	25.33 p	25.76 p
Number of leaves	3.72 p	3.56 p	3.67 p	3.50 p	3.72 p
Stem diameter(mm)	6.73 p	6.12 p	6.13 p	6.10 p	6.32 p
Leaf area (cm2)	31.02 p	27.39 p	28.61 p	26.87 p	28.50 p
Primary root length(cm)	28.10 p	24.02 p	26.79 p	24.10 p	24.79 p
Number of primary roots	2.78 p	2.67 p	2.33 p	2.56 p	2.56 p
Number of secondary roots	35.22 p	33.00 p	29.78 p	34.00 p	28.78 p
Number of tertiary roots	99.22 p	89.78 p	80.78 p	85.78 p	78.44 p
Root volume(ml)	1.57 p	1.44 p	1.46 p	1.52 p	1.41 p
Soil moisture content (%)	20.74 p	22.03 p	22.35 p	23.96 p	24.56 p
Canopy dry weight (grams)	0.96 p	0.83 p	0.88 p	0.82 p	0.87 p
Number of stomata	20.89 p	23.11 p	21.33 p	22.56 p	24.00 p
Stomatal opening width	0.73 p	0.65 pq	0.62 q	0.50 r	0.48 r

Note: Different letters in the row indicate that there is a significant difference based on the results of the DMRT test at the 5% level

The analysis of variance on the width of the stomatal openings revealed that the treatment without biochar resulted in a substantially wider stomatal opening width than the treatments with 100, 150, and 200 grams of biochar/polybag (Table 2). Under drought stress conditions, plants reduce transpiration by narrowing their stomata and opening/closing their stomata. This is consistent with the theory (Riski, 2021) that stomata will close to reduce the transpiration rate under drought duress. In addition, biochar application increases soil potassium (K) levels because biochar charcoal is rich in potassium. Opening and closing of stomata are affected by the accumulation of potassium ions (Jasmi, 2016). Deficiency and excess of element K can

inhibit the growth of plants and roots (Xu et al., 2020).

The correlation test results between the moisture content and the number of stomata showed a positive correlation (r = 0.26), meaning that the higher moisture content value is also directly proportional to the increasing number of stomata.

The correlation test between the width of the stomatal openings and the dry weight of the roots revealed a positive correlation (r = 0.25), indicating that the width of the stomata openings did not decrease as the dry weight of the roots increased. With healthy root development, plants are better able to absorb water, thereby preventing drought duress.

Table 3. Effect of watering intervals and doses of biochar on root fresh weight

Watering Interval	Biochar Dosage (grams) Average					Average
	Control	50	100	150	200	
1 Day	1.08 ab	0.75 bc	0.94 abc	0.96 abc	0.50 c	0.93
2 Days	1.05 ab	0.72 bc	0.87 abc	0.91 abc	1.28 a	0.89
3 Days	1.03 ab	1.08 ab	1.03 ab	0.75 bc	0.79 abc	0.97
Average	1.05	0.85	0.94	0.87	0.86	+

Note: Different letters in the row indicate that there is a significant difference based on the results of the DMRT test at the 5% level
(+) : There is real interaction

Giving 200 grams of biochar/polybag with watering intervals every 2 days gave the best root fresh weight (Table 3). This shows that in this treatment combination, the plants did not experience drought stress, moisture content data support this. Giving 200 grams of biochar with watering once every 2 days was not significantly different from the control treatment (watering every day). This happens because the addition of 200 grams of biochar/polybag causes the soil to have a great ability to hold water, so the growth and development of plant roots is high.

Table 4. Effect of watering intervals and doses of biochar on root dry weight

Watering Interval	Biochar Dosage (grams) Average					Average
	Control	50	100	150	200	
1 Day	0.24 abcde	0.15 de	0.18 bcde	0.21 abcde	0.12 e	0.19
2 Days	0.27 abcd	0.17 bcde	0.20 abcde	0.17 cde	0.29 ab	0.20
3 Days	0.28 abc	0.31 a	0.18 bcde	0.16 de	0.21 abcde	0.23
Average	0.26	0.21	0.19	0.18	0.21	+

Note: Different letters in the row indicate that there is a significant difference based on the results of the DMRT test at the 5% level
(+) : There is real interaction

The root dry weight analysis revealed a significant relationship between the dose of biochar and the irrigation interval, with the best results (Table 4) obtained by administering 50 grams of biochar per polybag with watering intervals every three days. It is hypothesized that the provision of biochar at a rate of 50 grams of biochar per polybag with watering intervals every three days can provide sufficient water availability through its mechanism of water retention, allowing the supplied water to remain in the soil pores for plant requirements. In this study, biochar functions primarily as a soil enhancer. Plants under water duress will produce more roots than those with sufficient water needs. Under conditions of drought stress, roots serve an essential role in plant growth (Kang et al., 2021). Good root development will increase a plant's ability to assimilate nutrients, resulting in increased plant growth. Therefore, plant dry weight is an indicator of nutrient absorption from the sowing medium. According to (Neoriky et al., 2017), the quantity of nutrient uptake by plants has a significant impact on photosynthetic outcomes and photosynthate transfer, particularly dry weight.

4. CONCLUSION

1. Biochar dose of 50 grams/polybag and watering interval once every 3 days significantly increases root dry weight in pre-nursery oil palm seedlings.
2. The dose of biochar did not significantly affect the growth of oil palm seedlings in the pre-nursery treatment without biochar, and 50 gram/polybag biochar significantly increased the width of the stomata opening.
3. Watering intervals did not significantly affect the growth of oil palm seedlings in the pre-nursery, but watering intervals of once every 3 days significantly increased the number of secondary and tertiary roots.

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