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The Effects of Biochar and Chicken Manure Application on Red Ginger (*Zingiber Officinale Rosc*.) Growth and Yield of Semi Paludiculture in Tropical Peatlands

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Abstract

The research was conducted to determine the influence of growth and yield of red ginger plants by applying the combination of biochar palm oil and chicken manure in a semi-paludiculture planting system on peatland. The design used in this study is the Completely Randomized Design (CRD) with 4x4 factors and with a three repetitions factor. The first treatment factors are oil palm shell biochar with control treatment, 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1} and the second factor is chicken manure with control treatment, 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1}. The research was conducted in Tanjung Taruna Village, Jabiren Raya Sub-district, Pulang Pisau Regency. The research was conducted from December 2018 until April 2019. The results showed that the interaction occurred in both factors, on the plant variable's height and the highest yield from the introduction of chicken manure 10 t ha^{-1} and the biochar 15 t ha^{-1}. The interaction of biochar palm oil shells on growth and yield of ginger plants only occur in plant variable height and the samplings at 8, 10, and 14 weeks after planting. While the chicken manure has real effect on ginger plants' growth and yield in all observation variables.

Keywords: biochar, chicken manure, red ginger, semi-paludiculture.

INTRODUCTION

Red ginger (*Zingiber officinale* Rosc.) is a spice plant traded in the world and exported in the form of fresh ginger, dried ginger, processed ginger, and essential oil (Rapelia, 2012). The more rapid activities of the modern, traditional medicine industry and other industries that have sprung up using ginger as raw material have caused the demand for this commodity to tend to increase from year to year (Pribadi, 2009). The survey results from the Ministry of Agriculture (2008) in 7 (seven) main provinces for the development of the traditional medicine industry show that the volume of ginger needs for the industry reaches more than 47,000 tons per year and does not include the needs of the traditional medicine industry so that Indonesia still imports ginger from China. Indonesia has the largest peatlands among tropical countries, namely ± 21 million ha, which are spread mainly in Sumatra, Kalimantan, and Papua, which can develop red ginger. However, due to the very high variability in land quality, both in terms of peat thickness, maturity, and fertility, not all peatlands are suitable for agricultural use. Central Kalimantan contains ± 3 million ha of peatlands, or about 13.5% of all peatlands in Indonesia, with an average thickness of 3 meters (Konsorsium Central Kalimantan Peatlands Project, 2008). Utilization of peat land for agricultural land is quite difficult and requires proper handling to not damage the peat itself.

Therefore, the use of peat in semi-paludiculture is one solution. Paludiculture is defined as the sustainable production of biomass in wet or wetted peat conditions (Wichtmann and Joosten, 2007), and at least three things are related, namely the benefits of paludicultural ecosystem services, the hydrological conditions of peatlands, and the selection of vegetation for planting, especially in tropical areas (Tan *et al*., 2021). Semi-paludiculture is a technique of modifying the environment by not changing and or destroying land conditions but can be used for cultivation. Semi-paludiculture has the principle of reducing the level of peat damage and increasing the potential yield of plants cultivated on peat soil, with improved media, including the use of biochar and manure. Biochar or black carbon can overcome some limitations and provide additional options for soil management. Biochar is more effective at holding nutrient availability for plants than other organic materials such as leaf litter, compost, or manure. Biochar can also withstand P, which cannot be retained by ordinary organic matter (Jambi Agricultural Technology Research Institute, 2015). One of the agricultural wastes that can be processed into biochar is oil palm shell. The potential of oil palm shells as biochar for soil improvement is quite large, given the large production and area of oil palm plantations in Central Kalimantan. The area of oil palm land in Central Kalimantan is 1,142,004 ha, with 3,572,982 tonnes in 2015 (Directorate General of Plantation, 2016). While manure has natural properties and does not damage the soil, it provides macro and micro elements. It also increases the soil's ability to hold water, increase soil microbiological activity and cation exchange capacity and improve soil structure. Chicken manure contributes to nutrients that can meet plant growth because chicken manure contains higher nutrients than other manure. Besides, chicken manure has a reasonably good effect on peat soil fertility because it contains complete nutrients (macro and micro), and the microorganisms in it can break down peat so that nutrients in peat such as P are easily available to plants (Yuliana *et al.*, 2015). This research aimed to study the interaction between biochar and chicken manure and its effect on the growth and yield of ginger by semi-paludiculture in peat soils.

MATERIALS AND METHODS

The research was carried out in December 2018-April 2019. In the village of Tanjung Taruna, District Jabiren Raya, District Pulang Pisau, Province of Central Kalimantan. The material used in this research is a sack with a capacity of 50 kg, oil palm shell biochar, manure broiler, dolomite, Urea, SP36, KCl, Dhitane M-45, Grow Quick, peat soil, and seeds of red ginger.

The design applied in this study was a completely randomized design (CRD) with a 4x4 factor pattern with 3 (three) replications. The first factor is biochar with control treatment, 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1}. The second factor was chicken manure with control treatment, 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1}, so 16 treatment combinations were obtained and 3 replications so that a total of 48 experimental units were obtained.

Maintenance is carried out by several methods, including:

a. Watering is done in the nursery and after planting in the field, the plants are watered in early April because of the low rainfall intensity;
b. Embroidering is done to replace plants that do not grow or plants that grow stunted. Stitching is done when the plants are 3 weeks after planting. Insert plants come from the same seeds that have been prepared in advance;
c. Humping is done by making a mound of soil around the plant. Filling begins 3 weeks after transplanting when clumps have formed, so that the rhizome is always covered with soil. Another goal is that drainage will always be maintained. Weeding is done manually by pulling out weeds that grow around the sacks;
d. Fertilization is done by applying SP36 fertilizer at planting time, Urea fertilizer when the plants are 4 weeks old after planting and KCl fertilizer is given when the plants are 10 WAP, with a dose of Urea 300 kg ha^{-1}, SP36 200 kg ha^{-1}, KCl 200 kg ha^{-1};
e. Pest and disease control is carried out by spraying the fungicide Dithane M-45;
f. Harvesting is done when the ginger plant is four months after planting by washing the ginger and drying it.

Observational variables, the observed variables are as follows:

a. Plant height (cm), measurements are taken from the base of the stem to the tip of the longest leaf and performed at the age of 6, 8, 10, 12, 14 and 16 weeks after planting with intervals of 2 weeks. Measurement of plant height is carried out using a measuring device.
b. Number of tillers (stems), observations are made by counting the total number of tillers in the sack. Performed at the age of 6, 8, 10, 12, 14 and 16 weeks after planting with intervals of 2 weeks.
c. Fresh Weight of Rhizome (g), the calculation of fresh weight of ginger rhizome is done at the end of the

observation by weighing the amount of ginger that has been dried.

d. Plant dry weight (g), the measurement of plant dry weight was carried out by means of oven samples at 70 ° C for 48 hours, then weighed. Samples were taken at harvest time.

Data analysis, the results of the observations were analyzed using the F test (analysis of variance) at the 5% confidence level. If there is a difference between treatments, then a further test is carried out using the mean Honest Significant Difference (HSD) test at the 5% level.

RESULTS AND DISCUSSION

Plant Height

The effect of biochar and chicken manure is presented in Table 1. Based on Table 1, it appears that the provision of oil palm shell biochar with chicken manure can significantly increase the height of ginger plants at all ages of observation. The lowest plant height was obtained in the control treatment while increasing the chicken manure and biochar dose was followed by an increase in plant height. This happens because of the function of chicken manure, which increases plants' absorption capacity in binding nutrients, which can increase soil fertility. Therefore, the roots will more easily absorb the nutrients contained in the soil. Widiowati (2004) states that nutrients absorbed by plant roots are used to increase plant height growth.

Meanwhile, oil palm shell biochar acts as an ameliorant to increase soil pH and has high water retention capacity (Ardiyani *et al*, 2015). Asie *et al*. (2013) stated that Application chicken manure increased the growth and yield of ginger on plant height variables, a number of tillers, leaf area, and fresh ginger rhizome weight. There is a very significant effect on plant height because chicken manure can improve soil physical, chemical and biological properties to maintain, improve and increase soil fertility. Setyamidjaja (1986) in Afandi (2018) states that poultry fed with protein and mineral feed will produce manure that is high in nitrogen and mineral content. The results of Bella & Pradika's research (2018) state that the use of oil palm shell biochar also shows an increase in the height of the red ginger plant. This is because biochar releases nutrients slowly to plants. So that nutrients will remain available for up to one growing season without having to provide them intensively. The same thing was reported by Putri *et al*. (2017) that Application biochar can increase soil pH, Corganic, total N, P-available, K exchange, flowering age, plant height, canopy dry weight, and N and P uptake. Solaiman & Anwar (2015) state that biochar's alkalinity is one of the factors that biochar has potential as lime. In addition, biochar can also bind C-organic in the soil to remain stable and not easily decomposed by microorganisms.

Table 1. Average of red ginger plant height (cm clump^{-1}) at age 6, 8, 10, 12, 14 and 16 WAP

Age	Chicken Manure (ton ha^{-1})	Biochar (ton ha^{-1})			
		0	5	10	15
6 WAP	0	21.17 a	25.50 a	22.17 a	22.50 a
	5	52.33 de	40.17 b	46.50 bcd	49.17 cde
	10	51.50 de	54.50 e	53.50 de	54.83 e
	15	40.83 b	44.23 bc	41.17 b	40.50 b
	BNJ α 0.05 = 7.23				
8 WAP	0	26.43 a	27.83 a	27.00 a	26.67 a
	5	61.03 cde	47.57 b	58.50 cde	56.33 cd
	10	61.93 de	63.50 e	60.83 cde	62.07 de
	15	59.60 cde	59.50 cde	58.83 cde	55.33 c
	BNJ α 0.05 = 6.00				
10 WAP	0	28.33 a	30.50 a	30.17 a	30.50 a
	5	65.17 cd	51.17 b	62.83 cd	63.27 cd
	10	68.50 d	68.50 d	69.57 d	66.00 d
	15	66.27 d	65.50 cd	66.33 d	58.50 c

	BNJ α 0.05 = 7.35				
12 WAP	0	30.17 a	32.50 a	32.33 a	33.07 a
	5	72.33 cd	57.83 b	70.10 cd	70.67 cd
	10	71.63 cd	74.53 d	75.33 d	74.83 d
	15	70.00 cd	70.00 cd	71.17 cd	62.50 bc
	BNJ α 0.05 = 10.91				
14 WAP	0	36.50 a	40.33 a	40.83 a	40.27 a
	5	78.67 c	65.17 b	82.50 c	77.73 bc
	10	80.27 c	83.17 c	82.17 c	83.17 c
	15	76.83 bc	76.83 bc	81.50 c	71.67 bc
	BNJ α 0.05 = 12.62				
16 WAP	0	40.50 a	43.83 a	41.73 a	41.77 a
	5	81.80 bc	68.17 b	85.17 c	80.50 bc
	10	83.50 c	86.50 c	85.60 c	86.90 c
	15	82.50 bc	80.33 bc	86.67 c	75.67 bc
	BNJ α 0.05 = 14.47				

Note: The numbers followed by the same letters in the row and column and the same age show no significant difference in the 5% BNJ test

Number of Tillers

The effect of treatment on the number of tillers is presented in Table 2. Based on Table 2, the results of the average number of tillers of ginger at the age of 8, 10 and 14 WAP (weeks after planting), there was an interaction effect between chicken manure and biochar, while the provision of oil palm shell biochar to plants aged 6 , 12 and 16 WAP did not have a significant effect on the number of red ginger tillers. This is thought to be due to the high rainfall at the time of the study so that the growing medium for ginger plants was flooded. Stagnant water affects physiological and biochemical processes such as respiration, soil permeability, absorption of water and nutrients, and N embedding. Besides, it can cause death to roots due to root rot. Subbaiah *et al*. (2000) in Rahman (2016) stated that waterlogged plants resulted in decreased root growth caused by an increase in the hormone ethylene under hypoxic/anoxic conditions. This also triggers tissue death in the plant roots and allows the process of root tip death. Besides, the water holding capacity of biochar is quite large so that the infiltration power of the planting medium will decrease when it is inundated. The administration of biochar is thought not to have a direct effect on red ginger plants, Mawardiani *et al*. (2013) stated that land that contains biochar, its nutrients are released slowly so that it can be used optimally by plants. Saputra *et al*. (2016) reinforced this statement, which states that Application biochar with a combination of inorganic fertilizers will be more efficient if it uses a long or gradual time. The use of chicken manure had a significant effect on the number of tillers of ginger at 6, 8, 10, 12, 14 and 16 WAP. It was proven that Application chicken manure could increase the number of tillers of red ginger plants. Yuliana *et al*. (2015) stated that providing sufficient nutrients will increase the number of polybag^{-1} tillers to increase the number of rhizome tillers, which can increase the production of fresh rhizomes. Based on the test for the average number of red ginger tillers, the provision of chicken manure increased the number of tillers. This is presumably because chicken manure can provide sufficient nutrients for the growth and development of ginger rhizomes.

Table 2. Number of tiller of red ginger on 6, 8, 10, 12, 14 and 16 WAP.

Ages	Chicken Manure (ton ha^{-1})	Biochar (ton ha^{-1})				Average
		0	5	10	15	
6 WAP	0	4.33	3.33	2.33	2.00	3.00 a
	5	3.00	4.33	4.00	4.33	3.92 a
	10	4.67	3.67	6.00	4.67	4.75 b
	15	4.67	5.00	3.67	4.67	4.50 b
	Average	4.17	4.08	4.00	3.92	
	HSD α 0.05 = 1.26					
8 WAP	0	5.33 ab	4.67 a	6.33 abc	4.67 a	5.25
	5	5.33 ab	9.00 cde	8.33 bcde	6.67 abcd	7.33
	10	11.67 e	6.67 abcd	9.00 cde	10.33 e	9.42
	15	10.00 de	8.67 bcde	10.00 de	9.67 cde	9.58
	Average	8.08	7.25	8.42	7.83	
	HSD α 0.05 = 3.53					
10 WAP	0	6.33 ab	6.00 a	9.33 abcde	8.00 abc	7.42
	5	9.00 abcd	14.33 def	15.00 def	15.33 ef	13.42
	10	14.67 def	10.33 abcde	12.00 abcdef	15.33 ef	13.08
	15	16.67 f	14.00 cdef	12.33 abcdef	12.67 cdef	13.92
	Average	11.67	11.17	12.17	12.83	
	HSD α 0.05 = 6.28					
12 WAP	0	7.33	7.33	10.67	9.33	8.67 a
	5	13.00	20.33	22.33	22.00	19.42 b
	10	18.33	21.00	18.00	24.33	20.42 b
	15	23.67	20.67	20.33	16.67	20.33 b
	Average	15.58	17.33	17.83	18.08	
	HSD α 0.05 = 4.45			4.45		
14 WAP	0	11.00 a	11.33 a	18.00 ab	17.00 ab	14.33
	5	20.00 abc	24.67 abc	28.00 bc	28.67 bc	25.33
	10	27.00 bc	29.67 bc	24.00 abc	29.67 bc	27.58
	15	33.33 c	26.67 abc	26.67 abc	18.00 ab	26.17
	Average	22.83	23.08	24.17	23.33	
	HSD α 0.05 = 14.95					
16 WAP	0	12.33	14.33	21.67	18.67	16.75 a
	5	23.67	29.33	31.00	32.67	29.17 b
	10	28.67	31.67	27.33	32.33	30.00 b
	15	35.67	30.67	29.67	30.00	31.50 b
	Average	25.08	26.50	27.42	28.42	
	HSD α 0.05 = 7.04					

Note: The numbers followed by the same letters in the same row and column and the same age show no significant difference in the 5% HSD test

Fresh Rhizome Weight (g)

The effect of treatment on fresh rhizome weight is presented in Table 3. The results of the average test of ginger rhizome fresh weight showed that the dose of chicken manure had a significant effect on the yield of ginger. The results of the analysis of the nutrient content of chicken manure showed that the elements N, P and K were higher than biochar. Application of chicken manure with a dose of 10 t ha^{-1} was significantly different from chicken manure treatment at a dose of 15 t ha^{-1}.5 t ha^{-1} and without Application chicken manure (control). The heaviest average fresh weight of ginger $clump^{-1}$ was in the provision of chicken manure at a dose of 10 t ha^{-1} with an average weight of 131.31 g $clump^{-1}$ followed by 5 t ha^{-1} treatment with an average weight of 97.02 g $clump^{-1}$ was then followed by a treatment dose of 15 t ha^{-1} with an average weight of 92.87 g $clump^{-1}$ and without treatment with an average weight of 33.91 g $clump^{-1}$. This shows that chicken manure can supply sufficient nutrients for red ginger plants. Yuliana *et al*. (2015) stated that Application chicken manure can increase the growth and yield of ginger, this is following the results of his research which showed that Application chicken manure increased the wet weight of the rhizomes, with a difference of 28.18% higher than the wet weight of rhizomes with fertilizer. cowshed. Likewise the research results of Marlina *et al*. (2015) Application chicken manure at a dose of 10 t ha^{-1} was able to increase the amount of dry weight of pods, percentage of pods, weight of seeds evenly produced in plots of peanut plants. Phosphorus is absorbed by plants in the form of $H2PO_4$ and HPO_4^{2-}, which is very important in the energy transfer process in plants, regulates the processes of photosynthesis, respiration and cell division, and affects the ripening period of seeds and fruits. Potassium is absorbed by plants in the form of K^+ cations, which play a role in forming and transferring carbohydrates in plants (Handayanto *et al*., 2016). With good photosynthesis and balanced with the translocation of photosynthate to a large part of the rhizome, it will cause the rhizome's fresh weight to increase. Misnadeh *et al*. (2019) stated that Application chicken manure fertilizer at a dose of 2.80 kg $plot^{-1}$ equivalent to 20 t ha^{-1} can increase the growth and yield of ginger on alluvial soil.

Table 3. Fresh Weight of Ginger Plant Rhizome per Clump.

Chicken Manure (ton ha^{-1})	Biochar (ton ha^{-1}) 0	5	10	15	Average
0	13.27	31.40	34.83	56.13	33.91 a
5	91.77	95.47	83.77	117.07	97.02 b
10	129.77	163.60	126.87	105.00	131.31 c
15	109.43	88.87	82.27	90.90	92.87 b
Average	86.06	94.83	81.93	92.28	
HSD α 0.05 = 30.17					

Note: The numbers followed by the same letter in the same column show no significant difference in the 5% HSD test

Plant Dry Weight

The effect of application of chicken manure and biochar fertilizers on the dry weight of plants is presented in Table 4. Application chicken manure at a dose of 15 t ha^{-1} gives the heaviest average yield of dry plant weight, namely 41.25 g, followed by 10 t ha^{-1} with weight. an average of 40.80 g, followed by treatment of 5 tons ha^{-1} with an average weight of 36.98 g and without treatment with an average weight of 10.25 g. Plant dry weight shows the amount of biomass that plants can absorb, so the better the plant growth, the higher the dry weight.

The application of chicken manure 15 t ha^{-1}, 10 t ha^{-1}, and 5 t ha^{-1} was not significantly different, but significantly different from the dry weight of ginger plants that were not given chicken manure. Plant growth and development are strongly influenced by macro nutrients that are needed by plants, especially nitrogen, phosphorus and potassium which are very important for plant vegetative development. In the vegetative growth process of ginger, N, P and K in chicken manure greatly affect the plant's dry weight, where the nutrient content of chicken manure is greater than that of biochar and peat soil. Research results from Taufik Atmaja *et al*. (2017) stated that Application chicken manure can increase the canopy and root dry weight of ginger plants, this is because chicken manure is able to supply P and N nutrients which play an important role in plant metabolism which includes cell division and development, energy transport, signal transduction, Macromolecular biosynthesis, photosynthesis and plant respiration. Alim *et al*. (2017) stated that the photosynthesis process in plants affects the plant's total dry weight. This statement is reinforced by Desiana *et al*. (2013), namely plant dry weight is the result of carbohydrate accumulation which is the result of photosynthetic activities, so that if the physiological processes that occur in plants go well and are supported by the application of efficient fertilization, it can increase plant dry weight.

Table 4. Dry Weight of Red Ginger per Plant Clump.

Chicken Manure (ton ha^{-1})	Biochar (ton ha^{-1})				Average
	0	5	10	15	
0	5.41	7.40	12.27	15.90	10.25 a
5	41.63	41.97	26.85	37.48	36.98 b
10	39.50	34.12	37.32	52.26	40.80 b
15	47.94	37.06	49.58	30.40	41.25 b
Average	33.62	30.14	31.51	34.01	
HSD α = 0.05= 16.40					

Note: The numbers followed by the same letters in the same row and column and the same age show no significant difference in the 5% HSD test.

CONCLUSION

The interaction between biochar and chicken manure gave a different effect on the observation phase for each ginger plant growth variable. Biochar affected the growth and yield of ginger on the variable plant height and number of tillers at 8, 10 and 14 WAP. The chicken manure application significantly affected the growth and yield of ginger on all treatment variables, with optimal results obtained from the provision of chicken manure at a dose of 10 t ha^{-1}.

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