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The Effect of Biochar from Oil Palm Empty Fruit Bunches (EFB) on the Efficiency of Urea Fertilizer in the Production of Chinese Cabbage (*Brassica rappa* var. *parachinesis* L.)

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Abstract. *This research study aims to determine proper composition of biochar, to find out the efficiency of fertilizer used, and to evaluate the effect of interaction between biochar and urea fertilizer used on the cultivation of green mustard. This study used Complete Randomized Design (CRD) consisting of 2 factors with factorial arrangement. The first factor was biochar dosage consisting of: control (without biochar), 5 tons/ha, 7.5 tons/ha, and 10 tons/ha. The second factor was urea dosage consisting of: control (without urea), 75 kg/ha, 125 kg/ha, and 200 kg/ha. All treatment combinations were replicated 3 times so there were 48 experimental units obtained. The parameters observed were: soil properties, biochar properties, plant height, leaf width, number of leaves, canopy area, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, total fresh weight, water consumption, water productivity, and fertilizer productivity.The addition of biochar is proven to increase the productivity of mustard plants. The use of urea fertilizer had no significant effect, presumably because of the low soil organic matter content. The interaction between biochar doses and urea fertilizer doses was not significant and only significant for the fertilizer productivity parameters. Research also revealed that the optimal dose of biochar for mustard greens is 5 tons/ha, giving an average yield of 88.25 g/plant and fertilizer productivity of 210.41%.*

Keywords: *Biochar, Dose, Green Mustard, Oil Palm Empty Fruit Bunch (OPEFB), Urea Fertilizer.*

1. Introduction

Agricultural wastes, that can be used as a solution to improve soil fertility, include rice husks, corn cobs, coconut shells, and empty oil palm bunches. Besides agricultural waste, livestock wastes can also be used as a solution to improve soil fertility. Agricultural and livestock wastes can be used as the raw materials to produce biochar which can be utilized to control pesticide residues and other chemical fertilizers.

Currently biochar is widely used as a soil enhancer that is able to provide and store organic carbon (C) in the soil. Biochar is a stable carbon produced from the pyrolysis process of organic materials. Biochar has been proven to be stable and effective as a carbon stock. In biochar, carbon is formed from the pyrolysis process so it is not easily degraded by microbial activity like other biomass containing low levels of carbon. The quality of biochar depends on the type of material and the characteristics of the materials used (Shenbagavalli, and Mahimairaja, 2012).

One of the potential raw materials for biochar production to improve soil quality is empty palm fruit bunches (OPEFB) because they are organic material and have fairly high nutrient content. Empty palm fruit bunches are the main waste from the palm oil processing industry, the percentage of which is 23% of fresh fruit bunches (Peni, 1995). Utilization of empty oil palm fruit bunches as a soil enhancer can usually be done by direct application as mulch or made into compost (Darmosarkoro and Winarna, 2007). However; if the soil enhancer was given in the form fo biochar, the the performance could be better because biochar is able to retain moisture so it helps plants in periods of drought, can act as a booster for plant growth, and absorbs nutrients so they are not easily leached which will ultimately affect on increased crop yields (Lehmann et al., 2003). Therefor, the use chemical fertilizers can be saved.

Saving of chemical fertilizers could be significant especially for leafy vegetables such as green mustard that need high dose of the fertilizer primarily nitrogen. The nitrogen fertilizer commonly used by farmers is urea. Erawan et al. (2013) report that green mustard needs at least 125 kg/ha of urea. But Sarif et al. (2015) find that the optimum dose of urea for green mustardis 200 kg/ha. The use of urea in green mustard cultivation could potentially be optimized when combined with biochar application.

Researches on the use of biochar to save chemical fertilizers and improve soil fertility have been done many people. Chhay, et al. (2013) and Sokchea, et al. (2015) report that application of biochar made from rice husk on green mustard cultivation give increasing yield as well as the nutritive values. The improved yield could be associated with the improved availability of nitrogen through the biochar absortion so decreasing nitrogen loss as reported by Coelho et al. (2018); Shi et al. (2019); and Dey and Mavi (2021) when they are appliying the nitrogen fertilizer combined with biochar. Materials used to produce biochar are mostly agricultural bimass such as raice husk, coconut shell, corn stalks, wood waste ect. The uses of OPEFB to produce biochar and its applications have been investigated extensively as well such as done by Idris et al. (2014), Ichriani et al. (2016), Bindu et al. (2019), Hidayat et al. (2021). However; the use of biochar made from OPEFB for co-application of urea on the green mustard cultivation has not been reported. This research study was aimed to investigate the effect of biochar made from OPEFB on the urea saving on green mustard cultivation.

2 Materials and Methods

This research was conducted from September to October 2019 at the Integrated Field Laboratory, Faculty of Agriculture, University of Lampung. The materials used are soil, OPEFB, mustard greens, urea, and water. The supporting tools in this study were small barrels, polybags, rulers, sitting scales, analytical scales, cameras, notebooks, measuring cups, sprayers, and shovels. This study used a completely randomized design (CRD) in factorial arrangement, with the first factor being the dose of biochar and the second factor being the dose of urea fertilizer. Biochar dosage factors are: B1 (without biochar), B2 (biochar 5 tons/ha), B3 (biochar 7.5 tons/ha), B4 (biochar 10 tons/ha). The dosage factors for urea fertilizer are: P1 (without urea fertilizer), P2 (75 kg/ha urea), P3 (125 kg/ha urea), P4 (200 kg/ha urea). Each of the treatment combination was carried out using polybag of 20 cm x 25 cm filled with initial soil of 3 kg, and replicated three times.

Implementation of this research began with the production of OPEFB biochar, preparation of planting media, measurement of field capacity of planting media, seeding, fertilizing, planting, maintenance, and harvesting. Parameters observed were soil properties, biochar properties, plant growth, and productivity. Growth parameters observed in this study included plant height, number of leaves, leaf width, leaf color, canopy area. Observations at harvest included total fresh weight, top fresh weight, root fresh weight, total plant dry weight, shoot dry weight, root shoot weight, crop water productivity, and fertilizer productivity. Furthermore, the data set was analyzed by using analysis of variance (ANOVA) and followed by LSD at 5% of significancy.

3 Results and Discussion

3.1 Soil properties

The results of soil analysis (Table 1) showed that the soil used in the study had very low total N content (0.01%), very low total P (388.24 ppm), very low organic C (0.23%)), very low K (0.235 mg/100gr), very low CEC (4.36 me/100gr), and moderate pH (4.87). Soil texture is classified as "clay" with a composition of 12.96% sand, 78.32% clay and 8.72% dust.

The soil characteristics are in accordance with the characteristics of ultisol soil which has low nutrients. The nutrient content in Ultisols is generally low due to intensive alkaline leaching, while the organic matter content is low because the decomposition process is fast and some are carried away by erosion. In Ultisols that have a kandic horizon, their natural fertility depends only on the organic matter in the top layer. The dominance of kaolinite in this soil does not contribute to the cation exchange capacity of the soil, so the cation exchange capacity only depends on the content (Prasetyo, 2006).

Table 1. Physical and chemical properties of the soil used as a planting medium

Parameters	Values	Category
N-total (%)	0,01	Very low
P-total (ppm)	388,24	Very low
C-organic (%)	0,23	Very low
Potassium (mg/100gr)	0,235	Very low
CEC (me/100gr)	4,36	Very low
pH	4,87	Moderate
Texture	(%)	
Sand	12,96	
Clay	78,32	Clay
Dust	8,72	

3.2 Biochar Properties

The biochar characteristics of oil palm empty fruit bunches are presented in Table 2. The biochar of oil palm empty fruit bunches has a C/N ratio of 22.72. When compared to oil palm empty fruit bunches, the C/N ratio has decreased after being made into biochar so the decomposition process can take place more quickly. Compared to the soil, biochar contains higher C-organic. In addition, biochar also contains N, P, K which is higher than that contained in the soil of the planting medium. Thus, biochar can be expected to be a suitable soil amendment. This is in accordance with that reported by Mawardiana et al. (2013) who stated that applying biochar to the soil has the potential to increase soil C-organic levels, water retention, and nutrients in the soil.

Table 2. Characteristics of oil palm empty fruit bunch biochar

Parameters	Values
C-organic (%)	28,86
N-total (%)	1,27
P-total (%)	0,28
K-total (%)	0,76
S-total (%)	0,21
Ash (%)	25,42
C/N	22,72
C/P	103,07
C/S	137,43

3.3 Observation data

Table 3. The results of the least significant difference (LSD) test for various observation parameters at the 5% level for the treatment of biochar doses

Treatment	Plant Height (cm)	Leaf width (cm)	Nember of leaves (sheet)	Canopy ares (cm²)	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)	Total fresh weight (g)	Water consumption (ml)	Water Productivyty (kg/m³)
B1	5,51 b	1,75 b	5,09 b	12,03 b	1,436 c	0,11 c	0,48 c	0,302 b	1,92 b	3766,83 b	0,24 b
B2	11,27 a	4,49 a	8,51 a	140,33 a	26,83 b	2,73 ab	61,42 a	21,27 a	88,25 a	5549,17 a	16,05 a
B3	11,3 a	4,84 a	8,90 a	160,30 a	40,17 a	3,29 a	54,25 ab	20,83 a	94,42 a	5427,33 a	16,12 a
B4	10,87 a	4,60 a	7,99 a	142,75 a	30,75 b	2,50 b	39,08 b	13,56 a	69,83 a	5327,25 a	13,05 a

3.3.1 Plant Profile

Observation of plant profile consisting of several variables, namely: plant height, leaf width, number of leaves, and leaf canopy area. The test of variance on the variables of plant height, leaf width, number of leaves, and leaf canopy area showed that the biochar addition was significant at the 5% level, while the urea factor was not significant nor the interaction effect. The results of the least significant difference test of these variables can be seen in Table 3 which shows that the addition of biochar gave better growth rates and significantly different as compared to control (B1) on the average. One of the factors disrupting plant growth is due to a lack of nutrients for the growth process of mustard plants. Lack of nitrogen in plants will result in stunted growth, easily fallen leaves, yellowish leaf color, and various other physical changes. This is in line with the fact that sufficient nitrogen and potassium nutrients play a role in strengthening the plant body so the leaves do not fall easily (Istarofah and Salamah, 2017).

If the plant lacks nutrients, plant growth is stunted, the leaves turn pale yellow. This situation causes plant proteins, fats and carbohydrates to become less formed, so that it can interfere with metabolic processes, especially the formation of new cells in plant meristematic tissues, which in turn inhibits the process of plant growth and development (Lingga and Marsono, 2007). Lingga and Marsono (2007), suggested that the main role of nitrogen for plants is to stimulate overall growth, especially stems, branches and leaves.

One week after transplanting (WAP), the B1 treatment plants (without biochar) began to turn yellow on the edges of the leaves (symptoms of nitrogen deficiency) and some experienced discoloration on the veins turning purple (symptoms of P deficiency). Entering week 2, several leaves of the B1 treatment plants experienced yellowing to brown on the edges of the leaves (symptoms of K deficiency). At 3 – 5 WAP some leaves of P1 treatment plants (without urea fertilizer) changed color to pale green to yellowish (a common symptom of N deficiency). At 6 WAP the color of the leaves in the same treatment still experienced pale green to yellowish, leaf loss, and purple stems. One of the reasons is that the soil used as the planting medium has a low fertility level. There are practically no reserves of N nutrients, so N deficiency in some organs of the plant will soon be visible very quickly (Wulansari, 2015). The nitrogen content in biochar is higher than the nitrogen content in the soil used as a planting medium, so biochar addition can help provide nitrogen for plants.

3.3.2 Plant Yield

The results of the analysis of variance on the variables of fresh, dry, fresh, and fresh weight showed that the effect of the biochar dosage factor was very significant at the 1% level, but the effect of urea dose was not significant nor the interaction effect.

The results of the least significant difference test of these variables (Table 3) showed that the treatment with the addition of biochar gave significantly higher plant yields compared to the control (B1). This is in line with the opinion that to achieve optimal plant fresh weight, plants still need a lot of energy and nutrients so that an increase in the number and size of cells can be optimal (Lahadassy et al., 2007). These results indicate that the addition of biochar to soils that have low nutrient content can help increase the availability of nutrients and improve soil pH so that the process of growth and development of mustard plants is better.

3.3.3 Plant Productivity

Observation of plant productivity consists of several variables, namely: water consumption, water productivity, and fertilizer productivity. The results of the test of variance on the variables of water consumption and water productivity showed that the effect of biochar dose was significant at the 1% level, while the effect of urea dose was not significant even at the 5% level and the interaction between the two factors was not significant either. The results of the least significant difference test of the variables of water consumption and water productivity (Table 3) show that the application of biochar succeeded in significantly increasing water consumption and water productivity. Increased water consumption is related to plant health. The higher water consumption indicates higher crop yields which in turn increase water productivity. However, the opposite can happen because of excessive water supply, productivity does not increase. Increasing crop production using less water can be done by applying the concept of crop water productivity (CWP) through an irrigation system (Prabowo and Wiyono, 2006).

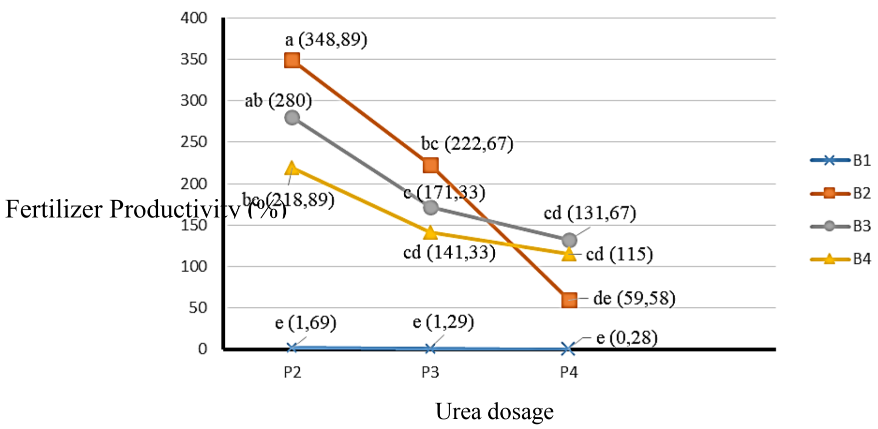

Figure 1. The least significant difference test for the interaction effect between the biochar and the urea on fertilizer productivity

The least significant difference test for the effect of the interaction between biochar and urea on the productivity of green mustard is presented in Figure 1. The data shows that the best fertilizer productivity was produced from the treatment combination of 5 tons/ha of biochar and 75 kg/ha of urea (B2P2). The treatment combination that is equally good is biochar of 7.5 tonnes/ha and urea of 75 kg/ha (B3P2). Fertilizer productivity can be used as one of the parameters in the production of mustard because the application of fertilizer as one of the efforts to add macronutrients for plants can be optimized. Besides being inefficient, applying too much fertilizer can cause plant poisoning.

Several factors such as low nutrient content, pH, and soil organic matter (table 1) are thought to have caused the effect of urea fertilizer doses to be insignificant. The low organic matter content and the acidic pH of 4.87 causes the activity of soil microorganisms to be inactive so the CEC becomes low. The content of soil organic matter affects the population and activity of soil microorganisms (Dermiyati et al., 2017). In addition, mustard plants are also not very tolerant of low pH so without the addition of biochar, many mustard plants experience poor growth. Meanwhile, with the addition of biochar, mustard greens growth is slightly better. Unfortunately, the low soil organic matter causes the addition of nitrogen fertilizers to lower soil pH (Foth, 1995).

4. Conclusions

The addition of biochar is proven to increase the productivity of mustard plants. The use of urea fertilizer had no significant effect, presumably because of the low soil organic matter content. The interaction between biochar doses and urea fertilizer doses was not significant and only significant for the fertilizer productivity parameters. Research also revealed that the optimal dose of biochar for mustard greens is 5 tons/ha, giving an average yield of 88.25 g/plant and fertilizer productivity of 210.41%.

The results showed that using a population of 250,000 plants with a spacing of 25 cm x 25 cm resulted in a low amount of fertilizer given, and it is advisable to continue the research with a smaller population size and wider spacing so the fertilizer dose per plant becomes higher.

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