Dokumen Bukti Proses Review:

The role of rice husk biochar and rice straw compost on the yield of rice (oryza sativa L.) in polybag

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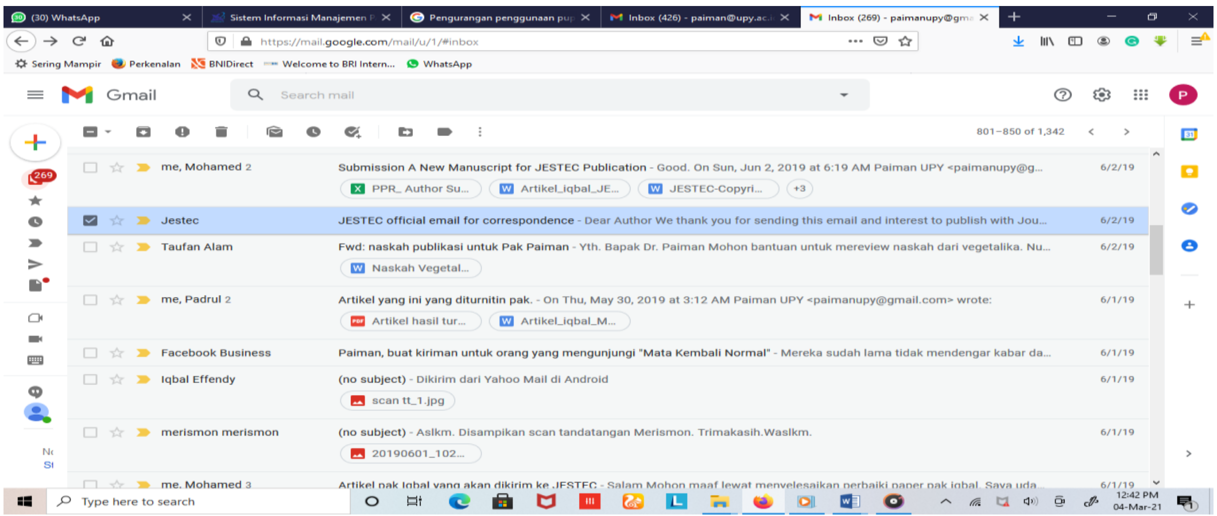

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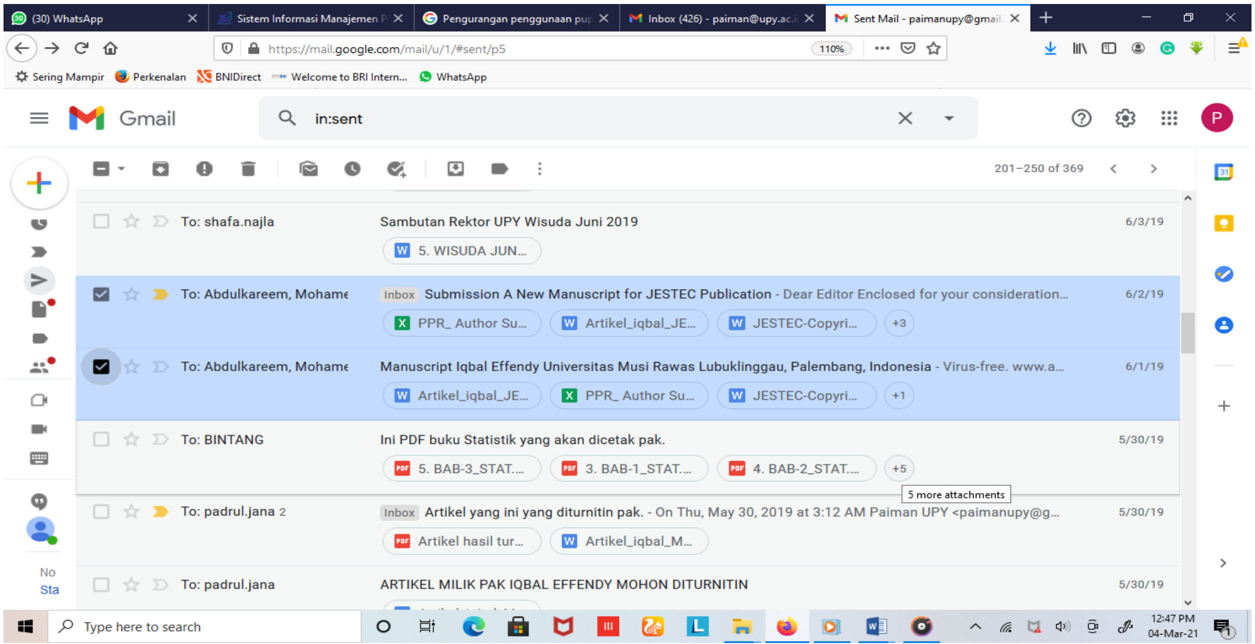

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Enclosed for your considerations is an original research article, entiled **"THE ROLE OF BIOCHAR HUSK AND RICE STRAW COMPOST TO PRODUCTION OF RICE (*Oryza sativa* L.) IN POLYBAG"** for publication in Journal of Engineering Science and Technology. This paper has not been published or accepted for publication previously, and is not under consideration by any other journal.
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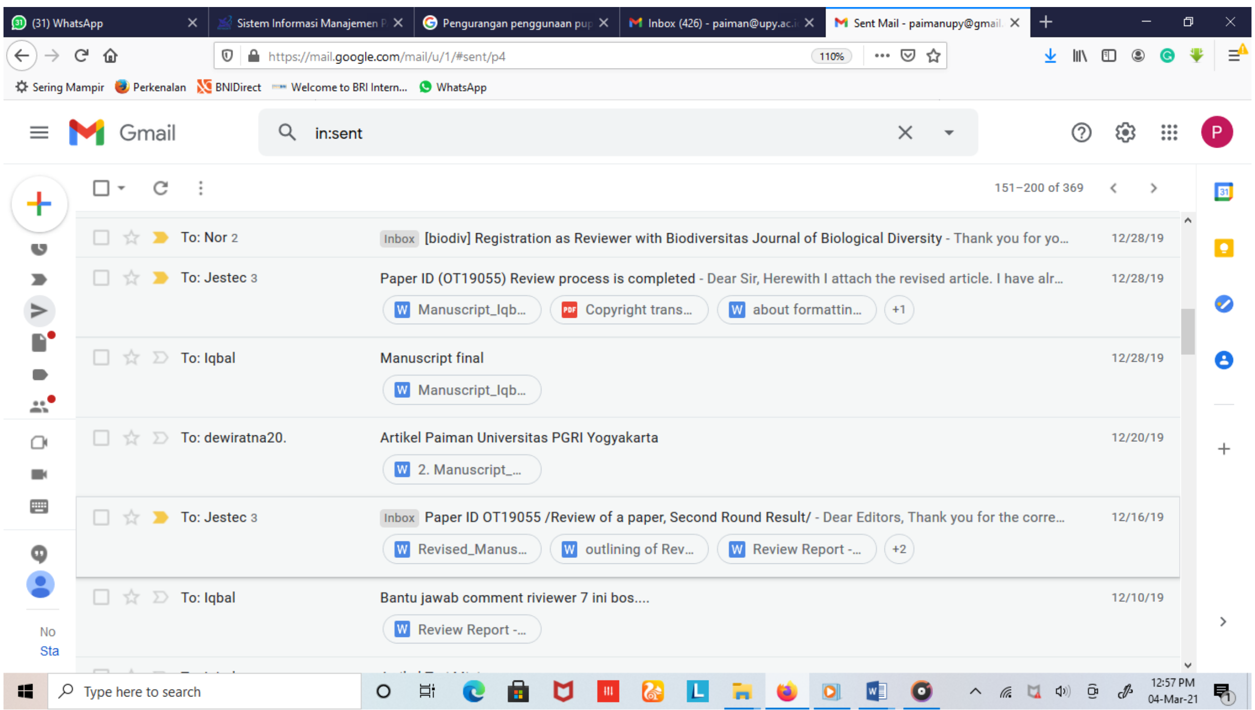

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THE ROLE OF RICE HUSK BIOCHAR AND RICE STRAW COMPOST ON THE YIELD OF RICE (*Oryza sativa* L.) IN POLYBAG

Abstract

Low rice productivity caused by a great deal of "off-farm" input in modern agriculture, declining soil health, and fertility status. Gradually recovery through soil amendment and organic fertilizer need to conduct. The research objective was to determine the role of rice husk biochar and rice straw compost on the yield of rice in a polybag. It was conducted at Air Lesing Village, Muara Beliti Sub-district, Musi Rawas District, South Sumatra Province having an elevation of 79 m mean sea level (MSL). The rice variety was used by Inpari Sidenuk. This research was arranged in a randomized completely block design (RCBD) factorial and three replications. The first factor was a dosage of rice husk biochar consisted of three levels, namely, 5; 10; and 15 t ha^{-1} (25; 50; and 75 g $polybag^{-1}$). The second factor was a dosage of rice straw compost consisted of three levels, namely, 5; 10; and 15 t ha^{-1} (25; 50; and 75 g $polybag^{-1}$). The data parameters were leaf chlorophyll, roots-canopies ratio, flowering age, harvest index, and rice yield ha^{-1}. Analysis of data was done by using analysis of variance (ANOVA) at 5% significance levels ($p < 0.05$). The difference between the average of the treatment was compared using the HSD test at 5% significance levels ($p < 0.05$). The results of the research showed that the dosage of rice husk biochar of 12.5 t ha^{-1} produced higher leaf chlorophyll content of rice. The treatment combination between the dosage of rice husk biochar and rice straw compost at 10:10 t ha^{-1} was produced a better rooting system (roots-canopies ratio). The dosage of rice husk biochar of 9.1 t ha^{-1} caused the rice flowering age was slowly. The treatment of rice straw compost at a dosage of 8.9 t ha^{-1} produced the highest rice yield ha^{-1}.

Keywords: Rice husk biochar, Rice straw compost, Rice, Inpari Sidenuk variety, Polybag.

1. Introduction

One cause of decreasing productivity of the rice field, especially on an irrigated rice field, is due to low organic matter besides imbalance soil nutrients as a result of improper fertilizing and monoculture cultivation.

Indonesia's rice production in 2018 reached 32,419,910 tonnes and the level of national rice consumption reached 29,568,496 tonnes so that Indonesia occurred a rice surplus of 2,851,414 tonnes [1]. Even the use of uncontrolled agrochemicals element can decrease the physical, chemical and biological quality of soil [2]. The most important aspects of applying biochar to the soil in the agriculture system were increasing plant yield and aboveground production through several mechanisms to promote plant productivity and yield [3].

The different between biochar and charcoal is that biochar is used as a soil amendment, whereas charcoal is used as fuel. Biochar can be produced from several biomass matters and it is used for soil improvement effort such as carbon sequestration for reducing carbon emission from the soil [4-8]. Biochar can increase soil C-organic, improve soil structure, increase cation exchange capacity (CEC) and water holding capacity (WHC) of soils [9-10]. According to Yamato et al. [11] and Jiang et al. [12], biochar application was capable to increase soil power of hydrogen (pH), Ca content, base saturation, CEC and decrease Al^{+++} saturation. In addition, biochar can improve physical soil properties, improving soil biological health by inducing the growth of beneficial organisms as well as decreasing soil born diseases [13-15].

The rice plants treated in rice straw compost (10 t/ha) and rice husk biochar (10 t/ha) along with chemical fertilizer had higher of leaf area, number of tillers and roots per plant, dry weights of shoots, roots per plant, number of grains and filled grains, and filled grain weight per panicle than comparing chemical fertilizer alone [16]. Rice straw compost has several benefits such as supplying nutrients, improving soil structure, improving soil texture, increasing soil porosity and aeration as well as adding microorganisms composition within soil [17]. The raw material for rice straw compost is also available in abundant quantity, obtained easy and cheap [18]. Nutrients from organic fertilizers were an important role in roots development. Rice field on soil having sufficient nutrients will produce optimum roots development. The availability of balance and sufficient nutrients will determine better growth and development of the plant, whereas insufficiency and excessive availability of one or more nutrients in the soil will result in the symptom of less optimum growth of plant [19].

There were different soil properties effects and crop responses of biochar application due to different sources and processes of biochar such as different pyrolysis temperature, particle size and rate and time of application to the stage of crop growth and development. The finer particle size of biochar able to increase soil enzyme activity [5]. Different effects of biochar produced at different temperatures varied in their effect on nitrogen uptake on the *Eruca sativa* plant, and on the growth of lettuce [20]. The effect of rice husk biochar and rice straw compost on growth and yield of rice could be measured by the indicator of leaf chlorophyll, flowering age, roots-shoots ratio, rice yield ha^{-1}, and harvest index.

Chlorophyll is an important photosynthetic pigment to the plant, largely determining photosynthetic capacity and hence plant growth [21]. Rice flowers after a lengthy vegetative growth. During the vegetative growth period, flowering is inhibited by several independent pathways. After sufficient vegetative growth, flowering signals are produced in the leaves due to reduced expression of the inhibitors [22]. The root-canopy ratio (defined as dry weight of root biomass divided by dry weight of shoot biomass) depends upon partitioning of photosynthate which may be influenced by environmental stimuli. Exposure of plant canopies to high CO_2 concentration often stimulates the growth of both roots and shoots [23]. High grain nitrogen (N) concentration in crops may require to translocate more N from the vegetative tissues, cause faster plant senescence, alter sink-source balance during grain filling, and ultimately lower grain yield. Sink-source relationships during rice grain filling were associated with grain N concentration [24]. Harvest index is the ratio of grain yield and the total above-ground biomass which indicates the efficiency of the plant to assimilate partition to the economic parts (example: rice grain). Higher the harvest index means the plant is capable to deposit assimilates having economic importance from the source (leaf, leaf sheath, stem, flag leaf) to the panicle (sink) especially grain in case of cereals [25].

Based on the above description, the objective of these works here was to study the role of rice husk biochar and rice straw compost in improving soil properties to increase the yield of rice. It is necessary to conduct the role of rice husk biochar and rice straw compost on the rice yield.

2. Materials and Methods

2.1. Research areas

This study was conducted at Air Lesing Village, Muara Beliti Sub-district, Musi Rawas District with an elevation of 79 m from MSL. It was conducted from December 2016 up to March 2017 followed by laboratory analysis at the Faculty of Agriculture, Universitas Musi Rawas, Palembang, Indonesia.

2.2. Biochar and compost processing

Biochar characterization was done using simple pyrolysis apparatus made from the modified drum as a biochar reactor, fresh rice husk from rice milling put in the reactor. Starting burning from the bottom of the reactor for 5 hours with the average temperature in the reactor 225 ^{o}C and after 5 hours will change to biochar.

Rice straw compost was made by mixing straw that colonized approximately 3-5 cm as many as 20 kg with effective microorganism-4 (EM-4) (as stater) of 100 ml, the rice brand of 1 kg, brown sugar of 0.5 kg and enough water. The mixture was placed in a chamber and closed using plastic tarp incubated for 21 days.

2.3. Experimental design

This research was arranged in a randomized completely block design (RCBD) factorial and three replications. The first factor was a dosage of rice husk biochar consisted of three levels, namely, 5; 10; and 15 t ha^{-1} (25; 50; and 75 g polybag^{-1}). The second factor was a dosage of rice straw compost consisted of three levels, namely, 5; 10; and 15 t ha^{-1} (25; 50; and 75 g polybag^{-1}). There were 27 treatment combinations and each treatment combination consisted of 6 samples, then 162 polybags were needed.

2.4. Soil and rice variety

The soil used in this study was mineral soil of yellowish-red podsolic with soil bulk density of 1.1 kg m^{-3}, pH of 5.0 and low fertility. The soil used for the research was rainfed soil and the former rice field.

The rice variety was used by Inpari Sidenuk. The variety description was the commodity of lowland rice, plant age of 103 days, productive tillers of 15 panicles, the grain number panicle^{-1} of 175-200 grain, and rice yield potential of 9.1 t ha^{-1} grain dry weight.

2.5. Research procedures

The soil weight of 10 kg was mixed evenly with husk rice biochar (5; 10; and 15 t ha^{-1} or 25; 50; and 75 g polybag^{-1}) and rice straw compost (5; 10; and 15 t ha^{-1} or 25; 50; and 75 g polybag^{-1}) base on the treatment within 162 polybags and incubated during 14 days. After that, the polybags were arranged in blocks suitable with treatment randomization within a plastic canvas tub to control the height of irrigation water.

Two rice seedlings of Inpari Sidenuk variety having the age of 15 days after sowing (DAS) was transplanting into each polybag with a plant spacing of 25 cm x 25 cm, as commonly practiced by local farmers. This research required as many as 324 seedlings or 162 clumps of rice plants. The rice population per hectare is 160,000 clumps.

Inorganic fertilizers applied were consisted of urea fertilizer at a dosage of 200 kg ha^{-1} [26], with three times application. Dosage of each application at age of 14; 28; and 42 days after planting (DAP) were 66.7 kg ha^{-1} (0.42 g polybag^{-1}). SP-36 fertilizer at a dosage of 150 kg ha^{-1} (0.94 g polybag^{-1}) and KCl at a dosage of 100 kg ha^{-1} (0.63 g polybag^{-1}) which were applied one time during the rice plant age of 14 DAP. Agronomic effort or action was done as usual.

2.6. Data Parameter

The parameter observed in this research included the leaf chlorophyll, roots-canopies ratio, flowering age, harvest index, and rice yield ha^{-1}.

Leaf chlorophyll can be as indicator growth of rice plants. In this research, leaf chlorophyll at 85 DAP, because the days were peak the grain filling. The measurement of leaf chlorophyll was using chlorophyll meter-SPAD 200. In this study only observed the greenness of the leaves of rice plants.

The roots-canopies ratio is the ratio between roots dry weight and canopies (shoots) dry weight with the following formula.

$$\text{Root-canopy ratio} = \frac{\text{roots dry weight}}{\text{canopies dry weight}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Flowering age is observed when the rice gets started the first flower appears from DAP. The observation was conducted in each treatment until all of the rice plants in the polybag had flowered.

Rice yield was evaluated by measuring grain production on the polybag (clumps^{-1}). The moisture percentage of grains was determined by moisture meter and final grain yield was adjusted at 14% moisture level. Rice yield ha^{-1} was converted from grain yield clumps^{-1} x population of rice plants ha^{-1}. In this research that plant spacing (a distance of rice stem between clumps in the polybag) used 25 x 25 cm, then the population of rice plant ha^{-1} was 160.000 clumps.

$$\text{Grain yield ha}^{-1} = \text{grain yield clumps}^{-1} \times \text{population of rice ha}^{-1} \ \ldots\ldots (2)$$

Harvest index (HI) was computed by dividing economic yield with the biological yield with the following formula.

$$\text{HI} = \frac{\text{economic yield (grain yield)}}{\text{biological yield (grain yield + straw yield)}} \quad \ldots\ldots\ldots\ldots (3)$$

2.7. Statistical analysis

The analysis of data was done by using analysis of variance at 5% significance levels ($p < 0.05$). The difference between the average of the treatment was compared using the HSD test at 5% significance levels ($p < 0.05$) [27].

3. Results and Discussion

3.1. Leaf Chlorophyll

The results of ANOVA showed that treatment interaction had no significant effect on the leaf chlorophyll content. Rice husk biochar treatment had a significant effect on the leaf chlorophyll content, whereas rice straw compost treatment had no significant. Results of the HSD test at 5% significance levels on the leaf chlorophyll content could be seen in Table 1.

Based on Table 4 showed that the application of rice husk biochar was capable to increase leaf chlorophyll content of rice. There was no different effect between the application of rice husk biochar at a dosage of 10 and 15 t ha^{-1}, but both treatments were significantly different than a dosage of 5 t ha^{-1}. Biochar application at a dosage of 10 and 15 t ha^{-1} can increase leaf chlorophyll content of 23.73, and 23.76 units. respectively. Biochar application at a dosage of 5 t ha^{-1} produced lower leaf chlorophyll content (16.44 units). The effect of rice husk biochar on chlorophyll content has obtained the equation of quadratic regression: $y = 1.89 + 3.636\,x - 0.145\,x^2$. Base on the equation of quadratic regression, the optimum dosage of rice husk biochar is 12.5 t ha^{-1} and the maximum leaf chlorophyll content is 24.65 units.

Biochar application basically can improve soil physical properties such as increasing soil pH. This is in accordance with the study results by Chan et al. [8], which showed that biochar application was capable to increase N absorption and other nutrients in which this nitrogen element is highly needed for leaf chlorophyll development. This was also in accordance with the study results by Fellet et al. [28] and Uchimiya et al. [10], which showed that biochar application will result in increasing of soil pH in line with increasing application dosage, increasing of CEC and WHC. Increasing soil pH will increase soil capacity in the absorption process and cation release which subsequently will increase nutrients absorption by roots crop such as nitrogen. According to Lu et al. [29] and Glaser et al. [30], the increase of CEC of soil was due to negative charge which originates from the carboxylate acid group.

Table 1. The effect of rice husk biochar and rice straw compost treatments on chlorophyll content (units) after harvest.

Rice husk biochar (t ha^{-1})	Rice straw compost (t ha^{-1})			Average
	5	10	15	
5	16.56	13.01	19.74	16.44 a
10	18.01	25.00	28.18	23.73 b
15	26.26	22.67	22.36	23.76 b
Average	20.28 p	20.23 p	23.42 p	(-)
HSD at 5% levels for rice husk biochar treatment = 7.65				

Remarks: Numbers followed by the same characters on rows or columns are not significantly different based on HSD at 5% significant levels ($p < 0.05$). (-) = No significant interaction.

3.2. Roots-Canopies Ratio

The results of ANOVA showed that there was a significant interaction between rice straw compost and rice husk biochar treatments on the roots-canopies ratio. The results of the HSD test on the roots-canopies ratio are presented in Table 2.

The roots-canopies ratio is a parameter that compares the root dry weight divided by canopies dry weight of the crop. The higher value of this parameter shows a better growth and development of roots crop as a result of applied treatment. This ratio indicates that the application of rice straw compost and rice husk biochar certainly increase the canopies dry weight which is higher than root the dry weight.

Based on Table 2 showed that treatment combination of rice straw compost and rice husk biochar with the respective magnitude of 10 t ha^{-1} as well as rice straw compost and rice husk biochar with the respective magnitude of 10 t ha^{-1} had produced the highest roots-canopies ratio because these treatments are capable to improve soil physical properties. The treatment combination between rice husk biochar and rice straw compost at 10:10 t ha^{-1} was produced a better rooting system.

The results of the regression analysis from the effect of rice husk biochar on the roots-canopies ratio in three levels dosage of rice straw compost were followed. In a dosage of 5 t ha^{-1} was obtained an equation of quadratic regression: $y = -0.25 + 0.092\,x - 0.004\,x^2$, the optimum dosage of is 11.5 t ha^{-1} (or 52.3 g polybag^{-1}) and the maximum roots-canopies ratio is 0.28. In a dosage of 10 t ha^{-1} rice straw compost was obtained an equation of quadratic regression: $y = -0.86 + 0.255\,x - 0.0122\,x^2$, the optimum is 10.5 t ha^{-1} (or 47.7 g polybag^{-1}) and the maximum roots-canopies ratio is 0.47. The equation of quadratic regression in a dosage of 15 t ha^{-1} is $y = -0.15 + 0.068\,x - 0.002\,x^2$, the optimum dosage is 17.0 t ha^{-1} (or 77.3 g polybag^{-1}) and the maximum roots-canopies ratio is 0.43. According to Lakitan et al. [5], during the vegetative growth phase, applying biochar significantly increased the shoots (canopies) and roots dry weight.

The soil used in this study was red-yellowish podsolic soil as one of the ordos from eight ordos of acid organic mineral soil, namely, Ultisol based on USDA classification [31]. This soil type has clay up to sandy texture, agglomerate, low fertility level, low base saturation and relatively acid pH due to podsolization.

Table 2. The interaction effect between rice husk biochar and rice straw compost on the root-canopy ratio.

Rice husk biochar (t ha^{-1})	Rice straw compost (t ha^{-1})			Average
	5	10	15	
5	0.11 a	0.11 a	0.14 a	0.12

10	0.27 ab	0.47 b	0.33 ab	0.36
15	0.23 ab	0.22 ab	0.42 b	0.29
Average	0.20	0.27	0.30	(+)
HSD at 5% levels for treatment interaction biochar and compost = 0.21				

Remarks: Numbers followed by the same characters on combination treatments are not significantly different based on the HSD test at 5% significant levels ($p < 0.05$). (+) = Significant interaction.

3.3. Flowering Age

Based on the results of ANOVA showed that the interaction of both treatments had no significant effect on the flowering age of the plant. The application of rice husk biochar had a significant effect on the flowering age, whereas rice straw compost treatment had no significant effect on the flowering age of the plant (Table 3).

The application of rice husk biochar of 15 t ha^{-1} is capable to accelerate rice crop flowering (59.56 days) compared to the application of rice husk biochar of 10 t ha^{-1} (66.11 days), and 5 t ha^{-1} (63.11 days) respectively. Table 1 showed that the application of rice husk biochar with magnitude 15 t ha^{-1} was significantly different than the other treatments. The effect of rice husk biochar on the flowering age has obtained the equation of quadratic regression: $y = 50.56 + 3.465\,x - 0.191\,x^2$, the optimum dosage of rice husk biochar is 9.1 t ha^{-1} (or 41.3 g $polybag^{-1}$) and flowering age is slowly by 66.3 days. According to Kartika [32], flowering and fruiting strongly affected the yield of the crop.

Biochar application basically can improve soil physical properties such as increasing soil pH. The increase of soil pH results in a "favorable" environment for root's crop development because pH value near neutral condition results in optimum availability of nutrients which facilitate higher phosphate absorption in addition to other nutrients. Phosphate element is highly needed for roots development as the nutrient source for a crop that substitutes inorganic fertilizer role and can be categorized as a chemical function, although this function has not yet properly implemented by rice straw compost and rice husk biochar. The research by Fellet et al [28], that using garden waste biochar could increase pH along with the increased dosage of biochar.

The pH of soil before treatment is 5.0 and after treatment the pH 6.1. Soil pH has related to the availability of nutrients in the soil that were ready to be absorbed by plants. An increase in pH to 6.1 caused soil nutrients more available so that causing faster plant growth and flowering age.

Table 3. The effect of rice husk biochar and rice straw compost on the flowering age (days).

Rice husk biochar (t ha^{-1})	Rice straw compost (t ha^{-1})			Average
	5	10	15	
5	59.00	66.33	64.11	63.11 b
10	66.67	66.67	65.00	66.11 b
15	63.00	57.67	58.00	59.56 a
Average	62.89 p	63.56 p	62.33 p	(-)
HSD at 5% levels for rice husk biochar treatment = 3.19				

Remarks: Numbers followed by the same characters on rows or columns are not significantly different based on the HSD test at 5% significant levels ($p < 0.05$). (-) = No significant interaction.

3.4. Harvest Index

Results of ANOVA showed that interaction had no significant effect on the harvest index. Rice husk biochar treatment had a significant effect on the harvest index, whereas rice straw compost treatment had no significant. The results of the HSD test on the harvest index was shown in Table 4.

The application of rice husk biochar can increase harvest index. The dosage of rice husk biochar at 15 t ha^{-1} produced the harvest index of 0.81 higher than rice husk biochar at a dosage of 10 and 5 t ha^{-1} of 0.74 and 0.65, respectively. This showed that higher application dosage of rice husk biochar given the yield in higher dry rice harvest (economic yield) in relation to the total dry weight of rice (biological yield). The effect of rice husk biochar on harvest index has obtained an equation of quadratic regression: $y = 0.54 + 0.024\,x + 0.0004\,x^2$, the optimum dosage is 30 t ha^{-1} and the maximum harvest index is 0.9. The increase in harvest index suitable with the increasing biochar dosage.

It was suitable for the results of the research Lakitan et al. [5], there were know by increasing rice yield components, namely, numbers of tillers, productive tillers, number of grains with a higher rate of biochar application.

The increase of harvest yield in the form of dry rice is due to the increase of phosphate nutrient availability which has a determinant role in rice seed filling process and this is also in accordance to statement by Goyal et al. [33], which showed that increase a soil pH is due to compounding of organic acids with aluminum and iron ions within soil solution through chelation process which indirectly increases phosphate availability. This statement was also supported by research results from Verheijen et al. [34], which showed that fulvate acid originates from the decomposition of organic matter has a higher role in phosphate element release in the soil solution.

The effect of rice husk biochar which can release nutrients in slow fashion will determine nutrients availability during the plant growth period which is shown by the harvest index. This is in accordance to a study result by Ismaid et al. [35], which showed that the application of biochar can improve soil structure.

Table 4. The effect of rice husk biochar and rice straw compost treatments on the harvest index.

Rice husk biochar (t ha^{-1})	Rice straw compost (t ha^{-1})			Average
	5	10	15	
5	0.59	0,62	0.74	0.65 a
10	0,72	0.77	0.71	0.74 ab
15	0,80	0,83	0.81	0.81 b
Average	0,70 p	0.74 p	0.75 p	(-)
HSD at 5% levels for rice husk biochar treatment = 0.15				

Remarks: Numbers followed by the same characters on rows or columns are not significantly different based on the HSD test at 5% significant levels ($p < 0.05$). (-) = No significant interaction.

3.5. Rice Yield per Hectare

Based on the results of ANOVA showed that interaction between rice husk biochar and rice straw compost had no significant effect on rice production per hectare. Rice husk biochar treatment had no significant effect on rice production per hectare, but rice straw compost treatment had a significant. Results of the HSD test on rice production per hectare are shown in Table 5.

The application of rice straw compost at a dosage of 10 t ha^{-1} produced the highest rice yield in dry rice with magnitude 7.56 t ha^{-1} and it was significantly different from than application of rice straw compost at a dosage of 15 t ha^{-1}, but not significantly different with a dosage of 5 t ha^{-1}. Rice yield will be lower if the application of dosage is higher than a dosage of 10 t ha^{-1}. The effect of rice straw compost on crop production has obtained an equation of quadratic regression: $y = 2.67 + 1.111\,x - 0.0622\,x^2$, the optimum dosage is 8.9 t ha^{-1} (or 40.6 g polybag^{-1}) and the maximum rice yield is 7.63 t ha^{-1}. According Halim et al. [36], compost-treated rice plants showed the best reading in increasing the soil pH and plant performance including the highest reading of photosynthetic rate, WUE, number of tillers, number of panicles, size of panicles, number of grains per panicle, percentage of filled grains, and 1000 grain weight. This lead to the conclusion that the best treatment for soil amendment used for rice plant cultivation in acid sulfate soil is compost, followed by biochar.

The application of inorganic fertilizer in the form of rice straw compost is a management effort to improve soil fertility through the improvement of the physical, chemical and biological properties of the soil. Therefore, the application of rice husk biochar can have functioned as a soil amendment, whereas the application of rice straw compost will improve rice growth by supplying some nutrients while functioning to improve the physical, chemical, and biological properties of the soil [30].

The increase in the grain yield was due to an improvement in the soil chemical properties and nutrients enhancement. Finally, the co-application of the highest rate of rice straw biochar, RSB (0.9%) and compost (3%) is recommended to obtain the appropriate rate of rice grain yield in calcareous sandy soil [29]. Another study showed that biochar can increase soil humidity and fertility and organic fertilizer originate from the decomposed rice straw had very high potential in terms of nutrients [33].

The nutrients that originate from organic fertilizer also have an important role in root development. Optimal crop production highly depends on the photosynthesis process which occurred after flowering, that is the higher the photosynthate available in leaf and trunks during the seed filling process, the higher rice production. A low carbohydrate synthesis rate causes a decrease of plant matter dry weight, where plant dry matter is one of the plant's indicators on the photosynthesis rate. It is in line with Phonguodume et al. [37] who stated that light intensity levels can have a significant effect on photosynthesis rates, which are directly related to a plant's ability to grow. According to Sukarto et al. [38], the rate of photosynthesis must be supported by the sufficient availability of nutrients. Applying biochar increased soil organic content and available N, P, and K.

There is a tendency for the application of organic fertilizer that has been decomposed to effectively increase rice growth and yield [39]. The application of rice straw compost is capable to increase crop yield. Optimum benefit for production depends on sufficient nutrients supply during crop growth [40].

Nutrients content of N, P, and K within rice straw compost is relatively high with a low C/N ratio so that they can be directly used as organic fertilizer that has a role as a nutrients source for the crop. It is expected that the application of rice straw compost can improve the physical, chemical and biological properties of soil that can be obtained from inorganic fertilizer application. The effect of organic fertilizer application into the soil, especially rice straw compost, areas granulator (improving soil structure), source of macro and micronutrients, increasing WHC of soil, increasing soil capability to retain nutrients (CEC of soil become high) and as an energy source for soil microorganisms [41].

Table 5. Effect of rice husk biochar and rice straw compost treatments on the rice yield (t ha^{-1}).

Rice husk biochar (t ha^{-1})	Rice straw compost (t ha^{-1})			Average
	5	10	15	
5	5.91	7.21	3.95	5.69 a
10	7.07	7.00	6.30	6.79 a
15	7.04	8.46	5.77	7.09 a
Average	6.67 pq	7.56 q	5.34 p	(-)
HSD at 5% levels for rice husk biochar treatment = 1.59				

Remarks: Numbers followed by the same characters on rows or columns are not significantly different based on the HSD test at 5% significant levels ($p < 0.05$). (-) = No significant interaction.

4. Conclusion

Based on the literature review and the discussion above, the following conclutions from this research is given below.

- The dosage of rice husk biochar of 12.5 t ha^{-1} produced higher leaf chlorophyll content of rice.
- The treatment combination between the dosage of rice husk biochar and rice straw compost at 10:10 t ha^{-1} was produced a better rooting system (root-canopy ratio) of rice.
- The dosage of rice husk biochar of 9.1 t ha^{-1} caused the rice flowering age was slowly.
- The treatment of rice straw compost at a dosage of 8.9 t ha^{-1} produced the highest rice yield ha^{-1}.
- For the next and longer-term research, it should be investigated a higher dosage of biochar and or using different sources of biochar since it showed that the higher dosage of rice husk biochar and rice straw compost, the higher yield obtained.

Nomenclatures

C	Carbon
Ca	Calcium
KCl	Kalium Chloride
N. P. K	Nitrogen; Phosphate; and Kalium
SP-36	Superphosphate, 36 percent P_2O_5

Greek Symbols

Al^{+++}	Alumunium Three Valency
C/N	Carbon and Nitrogen Ratio

pH	Power of Hydrogen
Abbreviations	
ANOVA	Analysis of Variance
CEC	Cation Exchange Capacity
DAS	Days After Sowing
DAP	Days After Planting
EM-4	Effective Microorganism – 4
HI	Harvest Index
HSD	Honestly Significant Different
MSL	Mean Sea Level
P	Probabilty
RCBD	Randomized Completely Block Design
RSB	Rice Straw Biochar
SPAD	Soil Plant Analysis Development
USDA	United States Departement of Agriculture
WHC	Water Holding Capacity

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Paper ID OT19055 /A progress of Review Process/

Jestec <Jestec@taylors.edu.my>   Fri, Aug 9, 2019 at 3:12 PM
To: Paiman UPY <paimanupy@gmail.com>

Dear Author

This email is to confirm that your paper is currently undergoing the

þ 1st ¨ 2nd ¨ 3rd round of the review process.

Thank you for your patience.

Best regards

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Paper ID OT19055 /Review of a paper, First Round Result with Rejection/

Jestec <Jestec@taylors.edu.my>   Sun, Sep 15, 2019 at 8:48 AM
To: Paiman UPY <paimanupy@gmail.com>

Dear Author

The first round of the review process has been completed.

6 reviewers have reviewed your paper.

4 accepted with minor corrections 2 accepted with major modifications, but 1 rejected your work

The Review panel decision is to conditionally accept the paper with **Major Corrections**.

This is to give you opportunity to improve the quality of your paper to be up to a journal article level.

Attached herewith, please find six reviewers' reports.

Please notice the following:

1- Address all the concerns/recommendations of the reviewers

2- All additions/corrections are to be highlighted in red color in the revised paper.

3- Send an outlining as one file (refer to the attachment) how did you address each reviewers' concern/recommendations.

4- In order to complete the review process on time, we highly appreciate it if we can receive the revised paper within **five weeks** from today.

Best regards

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To: Paiman UPY <paimanupy@gmail.com>

Sun, Nov 10, 2019 at 8:29 AM

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This email is to confirm that your paper is currently undergoing the

¨ 1st þ 2nd ¨ 3rd round of the review process.

Meanwhile, we received two more review reports as attached.

At the moment, please no need to revised the paper until you receive the results of the second round

Thank you for your patience.

Best regards

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OUTLINING HOW THE ISSUES ARE ADDRESSED

Title of paper:	**The role of rice husk biochar and rice straw compost on the yield of rice (*Oryza sativa* L.) in polybag**

1. Address all the concerns/recommendations of the reviewers.
2. All amendments made are to be highlighted in red color in the revised paper.

Reviewer # 1

Final Recommendation	**Accepted without modification**	**Accepted with minor corrections**	**Accepted with major modification**	**Rejected**
Please tick	☐	☑	☐	☐

Comments	**Addressed (Y/N)**	**Reply/Action taken**
• Please check the spelling errors of some words throughout the manuscript. eg: inbalance	Y	Done
• A brief of research background may be included on abstract (at the first sentence before the aims)	Y	We have added in abstract
• Please include 5 keywords on abstract	Y	Done
• Please put the reference of this statement "National rice demand was 79.141 million tonnes with rice consumption 134 kg capita^{-1}, whereas national rice production was 77 million tonnes so that Indonesia still need to import rice."	Y	We have change citations: [1]
• The authors should highlight the research gap (what has not been studied / explore) on Introduction and can be stated on the last paragraph of Introduction. For example : "……..*has not been explored. Therefore*, it is necessary to conduct the study related to the effect of the application of rice husk biochar and rice straw compost on growth and production of the rice crop."	Y	The statement related to the effect was exchanged with the word "optimization". And in the last sentence, we have added: especially variety of Inpari Sidenuk

• The authors may put the recommendations for future works on Conclusion	Y	We have added recommendations in conclusions

(Please add more rows if needed)

Reviewer # 2				
Final Recommendation	**Accepted without modification**	**Accepted with minor corrections**	**Accepted with major modification**	**Rejected**
Please tick	☐	☐	☑	☐

Comments	**Addressed (Y/N)**	**Reply/Action taken**
• The importance of the treatment application is not clearly explained	Y	We have corrected, so this treatment application enough cleary.
• No novelty of this study because a lot of similar experiments had been conducted elsewhere	N	The statement the previous researcher stated that biochar is very dependent on the manufacturing process, especially temperature and materials, but the plant response indicator will also determine the local environmental conditions.
• Some of the literature reviews were older than 2010?	Y	We have been added some new literature reviews 2010 above and now there were 67.6%
• More detail of methodology used should be included in Methodology Section, such as how and when to apply the fertilizer and treatment, no detail methods on the observed parameters	Y	We have added materials and methods.
• Some of the results were not been discussed deeply, very surface explanations, no comparison made with previous studies	Y	Done

Comments	Addressed (Y/N)	Reply/Action taken
• No recommendations for future work or application of the findings	Y	We have added in the conclusion
• There is a need to improve the English for this manuscript	Y	We have consulted this paper to a native English speaker.

(Please add more rows if needed)

Reviewer # 3

Final Recommendation	Accepted without modification	Accepted with minor corrections	Accepted with major modification	Rejected
Please tick	☐	☑	☐	☐

Comments	**Addressed (Y/N)**	**Reply/Action taken**
• The title of the manuscript does not suit well with the content of the paper. Despite the authors studying the effect of compositing biochar and rice straw compost for rice production, the author did not really discuss in depth on 'the role' of the respective compound. There are no detail characterisation for biochar and compost used in this study reported in this work, or cited in the previous work done by the author. In the manuscript, the authors mainly focus on determining the optimum dosage of rice husk biochar and rice straw compost for rice yield. Suggest the authors to change the title to "optimization of rice husk biochar and rice straw compost on the rice production in polybag".	Y	We have exchanged the title to "optimization of rice husk biochar and rice straw compost on the rice yield in polybag".
• At the end of introduction section, include a statement of objective for this study	Y	We have included in the last paragraph of the introduction.
• In the results and discussion, it is suggested to include visual results of the grown rice in polybag and provide some discussion on the physical appearance.	N	We could not display visual results of the grown rice polybag, because we have only visuals results of the grown rice in polybags as a whole.

• Page 6, 2nd paragraph, “Application of rice straw compost is capable to increase crop yield and this is in accordance to statement by Anonymous [28]”. Restructure the sentence to avoid the use of anonymous in the text.	Y	Done
• Add reference “Application of Biochar and Compost for Enhancement of Rice (*Oryza Sativa* L.) Grain Yield in Calcareous Sandy Soil” by Sadegh-Zadeh et al. 2018 to the manuscript.	Y	Done

(Please add more rows if needed)

Reviewer # 4

Final Recommendation	**Accepted without modification**	**Accepted with minor corrections**	**Accepted with major modification**	**Rejected**
Please tick	☐	☑	☐	☐

Comments	**Addressed (Y/N)**	**Reply/Action taken**
• Title: Rice <u>production</u> should be replaced by <u>yield</u>	Y	We change the title to **Optimization of rice husk biochar and rice straw compost on the rice yield in polybag**
• Abstract: research design is recommended to use the term randomized block design (RBD), and added arranged factorial, information added on the names of rice varieties and the dose of an organic fertilizer used for each polybag	Y	We have changed to a randomized completely block design (RCBD) with factorial. The rice variety was used by Inpari Sidenuk. Dosage of organic fertilizer were 25; 50; 75 g polybag^{-1}
• Introduction: a. add information on the characteristics of soil in your location at the beginning of the last paragraph. b. explain the location of the soil used for the study and the soil's fertility status.	Y	a. We have added in subheading 2.4 on the materials and methods. b. We have added in subheading 2.4 on the materials and methods.

c. change CRD to RBD with factorial. d. Suggested writing order for variables ie : leaf chlorophyll (chlorophyll meter-SPAD... ??), root-shoot ratio, flowering root, harvest index, and specifically for rice production (because using the conversion value should add the formula used).		c. We have changed CRD to RCBD in subheading 2.3 on the materials and methods d. We have fixed in subheading 2.6 on the materials and methods
• Result and Discussion a. Preferably, the results and discussion are sorted in the order of biological processes (as suggested in point 3d). b. in the third alinia, please explain why the combination of rice straw and low-dose biochar (5: 5) flowering age is faster one day than the combination (15:15)...	Y	a. Done b. We are not discussing the effect of treatment combination because the interaction is not significant. We only discussed the treatment of rice husk biochar that significant effects.
• Conclusion Preferably, it is explained why the combination dose of biochar-rice straw (10:10) was chosen as the best treatment combination, and not the combination chosen (15:10).	Y	We were chosen combination rice husk biochar-rice straw compost (10:10 t ha^{-1}) because of the optimum dosage of rice husk biochar at 9.1 t ha^{-1} on the earlier flowering and the optimum dosage of rice straw compost at 8.93 t ha^{-1} had produced the highest rice yield ha^{-1}.

(Please add more rows if needed)

Reviewer # 5

Final Recommendation	Accepted without modification	Accepted with minor corrections	Accepted with major modification	Rejected
Please tick	☐	☑	☐	☐

Comments	Addressed (Y/N)	Reply/Action taken

• The amount of work in this study is acceptable. However, some amendments are needed to be made by the authors. Please refer to the corrections/suggestions in the text (track changes and comments).	Y	We have already revised the suggested corrections
• Use ‘rice husk biochar’ instead of ‘biochar husk’.	Y	We have already revised to ‘rice husk biochar’ in the title
• Use ‘on’ instead of ‘for’.	Y	We have already revised to ‘on’ in the title
• Add introduction of the research in the abstract.	Y	We have added the introduction of the research in the abstract
• Use ‘rice’ instead of ‘paddy field rice’.	Y	We have already revised to ‘rice’ in the abstract
• Use ‘in’ instead of ‘within’.	Y	We have already revised to ‘in’ in the abstract
• Include the statistical analysis used.	Y	We have added the statistical analysis used in the abstract.
• Cause	Y	The word has already revised to ‘causes’ (prular) in the introduction
• Inbalance	Y	We have already revised to ‘imbalance’ in the introduction
• Add subheadings in Materials and Methods section.	Y	We have already added subheadings in the materials and methods section
• Include the parameters used in this study.	Y	Done
• Include the statistical analysis used.	Y	We have included the statistical analysis used in the materials and methods section.
• Add the citation used in the discussion part.	Y	We have added references […].

• Rrice	Y	We have already revised to 'rice' in the first paragraph of point of 3.3
• Include prospect for future research to strengthen the findings.	Y	Done

(Please add more rows if needed)

Reviewer # 6

Final Recommendation	Accepted without modification	Accepted with minor corrections	Accepted with major modification	Rejected
Please tick	☐	☐	☑	☑

Comments	Addressed (Y/N)	Reply/Action taken
• English language used in this manuscript is very weak. Can the authors get this manuscript to be proof read by a colleague that is a native English speaker or perhaps with the help of professional English editing?	Y	We have consulted this paper to native English speakers.
• Abstract – Include 1-2 sentences what is the motivation leading to this research.	Y	Low rice productivity cause by agreat deal of "off-farm" input in modern agriculture, declining soil wealthy and fertility status. Gradually recovery through soil amendment and organic fertilizer need to conduct.
• Introduction – Why suddenly compare biochar with charcoal?	Y	We have removed the sentence because it was not relevant
• Introduction – Example of a glaring badly constructed sentences, "Applying chemical fertilizer alone, incorporation of rice straw (1.0 t ha-1) and rice husk biochar (1.0 t ha-1) along with chemical fertilizer is possible to increase the grain weight per panicle for better yield under local conditions and promoting the plant growth"….starting with applying chemical	Y	We have been revised to: The rice plants treated in rice straw compost (10 t/ha) and rice husk biochar (10 t/ha) along with chemical fertilizer had higher of leaf area, number of tillers and

fertilizer…..then along with chemical fertilizer……???		roots per plant, dry weights of shoots, roots per plant, number of grains and filled grains, and filled grain weight per panicle than comparing chemical fertilizer alone.
• Introduction – So which is supposed to play the role of organic nutrients? Rice husk Biochar or rice straw compost or both? The problem statement is NOT clear in the Introduction.	Y	They both have a role in supplying organic nutrients. This has been explained that biochar can function as supplying organic nutrient (Ferizal 2011) and compost too (Hardiatmi, 2006)
• Materials and methods – Generally NOT properly described… Composition of the soil used? Composition of the rice husk biochar and rice straw compost? • Where are both obtained from? • Self synthesized? If yes, need to describe the procedure. • What is CRD? • Please do not assume everyone knows the abbreviation. What is DAP? • I do not understand, is inorganic fertilizer still being applied to the paddy plants? • Where is your control?	Y	• Composition of the soil used, rice husk biochar and rice straw compost were listed in the beginning paragraph of subheading 2.5 of materials and methods. • Yes, self synthesized. We have added work procedures of processing rice husk biochar and rice straw compost in subheading 2.2 of materials and methods. CRD replaced RCBD it was as environmental design. • DAP is abbreviation from days after planting (this is a common term). • Yes, inorganic fertilizer still being applied to rice plants and listed in the last paragraph of the subheading of 2.5 of materials and methods. • We do not use control plants.
• Results and Discussion – Needs significant improvement.. I will just use the Flowering age as example. Need to explain why no interaction between both treatments and also have to explain why rice straw compost had no	Y	• The pH of soil before treatment is 5.0. and pH average after treatment of 6.1. pH measurement using a pH tester.

significant effect on flowering age. Do not only explain the treatment that has effect. As for effect of biochar, authors stated that application of biochar is favorable to alter the pH of the soil for faster flowering. Did the authors measure the pH which can be easily done? Many misleading interpretation of results, for example, "Application of rice husk biochar with magnitude 15 t ha-1 is capable to accelerate rice crop flowering compared to the application of rice husk biochar with magnitudes 10 and 5 t ha-1, respectively". Looking at Table 1, maybe true for compost 10 and 15 t ha-1, but for compost 5 t ha-1, 5 t ha-1 of rice husk biochar has the shortest flowering time at 59 days. How was the regression equation derived? It was stated, "….and obtained optimum dosage of rice husk biochar was 9.1 t ha-1."….this totally contradicts the statement "Application of rice husk biochar with magnitude 15 t ha-1 is capable to accelerate rice crop flowering compared to the application of rice husk biochar with magnitudes 10 and 5 t ha-1, respectively". At one hand the authors said 15 t ha-1 can accelerate flowering as compared to 10 and 5 t ha-1, but the optimum is at 9.1. PLEASE re-look into all other parameters.		• We have added this paragraph in results and discussion: Soil pH have related to the availability of nutrients in the soil that were ready to be absorbed by plants. An increase in pH to 6.1 caused soil nutrients more available so that causing faster plant growth and flowering age. • Rice husk biochar was a significant effect on flowering age but rice straw compost was not. We only explained that significant effect. We only analyzed the regression in the treatment of rice husk biochar that significant effect on flowering age. The effect of rice husk biochar on flowering age was obtained equation regression $y = 50.56 + 3.465\,x - 0.191\,x^2$ and obtained optimum dosage of rice husk biochar was 9.1 t ha^{-1} (41.3 g $polybag^{-1}$).

(Please add more rows if needed)

Reviewer # 7				
Final Recommendation	**Accepted without modification**	**Accepted with minor corrections**	**Accepted with major modification**	**Rejected**
Please tick	☐	☐	☑	☐

Comments	**Addressed (Y/N)**	**Reply/Action taken**

• In the introduction, the research scope/research objectives should be clearly described/elaborated at the end of the introduction with substantial narration of research gap/ research problem to motivate this study.	Y	We have been written in the end paragraph of the introduction.
• Authors need to clearly state the factors contribute to the production of paddy field rice, and justify with reasons of selecting rice husk biochar and rice straw compost in this study.	Y	The factors contributed to the rice yield were soil pH, soil organic matter, available nutrients, etc. We know that both rice husk biochar and rice straw compost improvement the soil properties and increased the growth and yield of rice.
• The background regarding the factors other than dosage should be included as well. Why did author choose only the dosage? Please justify. The ranges selected for both of the dosages should be justified as well.	Y	Actually, a lot of effects of rice husk biochar and rice straw compost on the soil properties and response of the plant which applicated by biochar and compost. In this study, we are stressing on dosage. The previous research also used the level of 5; 10; and 15 t ha^{-1}.
• Justify the ranges used in this study for both of the factors are 10 times higher as compared to the cited references [15-18], "incorporation of rice straw (1.0 t ha^{-1}) and rice husk biochar (1.0 t ha^{-1}) along with chemical fertilizer"	Y	We have been revised to: The right one is in the dosage of rice straw compost (10 t ha^{-1}) and rice husk biochar (10 t ha^{-1})
• Rice straw compost, rice husk biochar and chemical fertilizer, justify among these 3 factors, which one is the major factor? The research gap needs to be highlighted and the novelty of this research should be elaborated.	N	This research used two factors only, but chemical fertilizer was not a treatment factor. Both factors were very important to study to look at the effect of treatment interaction. The statement the previous researcher stated that biochar is very dependent on the manufacturing process, especially temperature and materials, but the plant response indicator will also determine the local

		environmental conditions. The research used a specific variety of Inpari Sidenuk that treated by nuclear radiation.
• Authors need to include the background of quality analysis such as flowering age, root-canopy ratio, rice production per hectare, leaf chlorophyll and harvest index in the introduction.	Y	We had added in the 8th paragraph of the introduction.
• This research was arranged in the CRD. Authors need to discuss what is CRD, show the design of CRD in Table form. Is this a common practice/ procedure? • Authors need to provide citation for this. “Inorganic fertilizers applied were consisted of urea fertilizer at a dosage of 200 kg ha^{-1} with three times application, SP-36 fertilizer at dosage of 150 kg ha^{-1} and KCl at a dosage of 100 kg ha^{-1} which were applied one time during rice crop age of 14 DAP.”	Y	• This research, actually used RCBD, instead of CRD. Because the research was conducted in the heterogenous site. • We have been added the reference in [26] in materials and methods. The dosage of fertilizer application in South Sumatra based on Regulation of Permentan (Indonesia), No.40/Permentan/OT.140/4/2007. The recommended in the soil of low productivity of < 5 t ha^{-1} was needed Urea of 200 kg ha^{-1}, and TSP 145.7 kg ha^{-1}.
• Authors need to include the material and methods (design and equations) of quantifying flowering age, Root-Canopy Ratio, Rice Production per Hectare, Leaf Chlorophyll, Harvest Index	Y	We have been written in a sub-heading of 2.6 about data parameters with clearly in the materials and methods.
• Applied to 3.1 to 3.5, the discussion must be supported with data/ trend. Authors need to justify the data/trend and relate to scientific background/ mechanism instead of merely reporting the data. The discussion of the trend in missing. All the discussion should be cited as well to find the similar trend and to relate the potential reasoning to support the findings in this study.	Y	We have been added supported reference in the sub-heading 3.1 of [8], 3.2 of [5], 3.3 of [32], 3.4 of [5] and 3.5 of [36] in the discussion.

(Please add more rows if needed)

Reviewer # 8

Final Recommendation	Accepted without modification	Accepted with minor corrections	Accepted with major modification	Rejected
Please tick	☐	☑	☐	☐

Comments	Addressed (Y/N)	Reply/Action taken
• One of the causes for decreasing (in first alinea of introduction)	Y	We change to One cause of decreasing (in the first paragraph of introduction)
• The different between biochar and charcoal is that biochar is used ……	N	We have not added a comma after that in the sentence, because it was right.
• Nutrients from organic fertilizers, also has important ….	Y	We have been deleted **also** and **has** in this sentence in the 6th paragraph of the introduction.
• You must tell first about MSL Abbreviation (in materials and method)	N	We have been told first MSL abbreviation in the abstract
• …… which indirectly increases phosphate **availably ility** (in sub-heading of 3.5. Harvest index)	Y	We have been revised another word to …… which indirectly increases phosphate **availability.**

Gmail

Paiman UPY <paimanupy@gmail.com>

Paper ID OT19055 /A progress of Review Process/ /2 more review reports/

Paiman UPY <paimanupy@gmail.com> Sun, Nov 10, 2019 at 10:27 AM
To: Jestec <Jestec@taylors.edu.my>

Thank you for the update.

[Quoted text hidden]

https://mail.google.com/mail/u/0/#search/jestec/FMfcgxwGCGxBpTgFQhGpnlGPVSMDBfdB

Gmail Paiman UPY <paimanupy@gmail.com>

Paper ID OT19055 /Review of a paper, Second Round Result/

Jestec <Jestec@taylors.edu.my> Mon, Dec 9, 2019 at 7:57 PM
To: Paiman UPY <paimanupy@gmail.com>

Dear Author

The second round of the review process has been completed.

6 reviewers reviewed your revised paper, only Reviewer # 6 commented:

I can accept the technical revisions, but I think the English language can still be significantly improved. Reading the first few lines in the Abstract can easily reflect that.

We however, received, two more review report for your action to check and revise your paper accordingly.

Attached herewith, please find one/two/three/four/five/six reviewers' reports.

Please notice the following:

1- Acknowledge the receipt of this email
2- Address all the concerns/recommendations of the reviewers
3- All additions/corrections are to be highlighted in red color in the revised paper.
4- Send a separate outlining how did you address each reviewers' concern/recommendations.

Best Regards

JESTEC Editor

http://jestec.taylors.edu.my

3 attachments

Review Report - 8.docx
47K

Review Report - 7.docx
42K

Review Report - 8 Reviewed Manuscript.docx
84K

Gmail Paiman UPY <paimanupy@gmail.com>

Paper ID OT19055 /Review of a paper, Second Round Result/

Paiman UPY <paimanupy@gmail.com> Tue, Dec 10, 2019 at 8:51 AM
To: Jestec <Jestec@taylors.edu.my>

Received, thank you.

[Quoted text hidden]

6. Submit Revision: 16 Desember 2019

Gmail — Paiman UPY <paimanupy@gmail.com>

Paper ID OT19055 /Review of a paper, Second Round Result/

Paiman UPY <paimanupy@gmail.com> — Mon, Dec 16, 2019 at 7:34 AM
To: Jestec <Jestec@taylors.edu.my>

Dear Editors,

Thank you for the correction. I have already revised the two items. Herewith I attach the required files.

Best Regards
[Quoted text hidden]

2 attachments

Revised_Manuscript_Iqbal Effendy (Des_2019).docx
90K

outlining of Review Report_v3 (Des_2019).docx
72K

Manuscript Final:

THE ROLE OF RICE HUSK BIOCHAR AND RICE STRAW COMPOST ON THE YIELD OF RICE (*Oryza sativa* L.) IN POLYBAG

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Abstract

Low rice productivity caused by a great deal of "off-farm" input in modern agriculture, declining soil health, and fertility status. Gradually recovery through soil amendment and organic fertilizer need to conduct. The research objective was to determine the role of rice husk biochar and rice straw compost on the yield of rice in polybag. It was conducted at Air Lesing Village, Muara Beliti Sub-district, Musi Rawas District, South Sumatra Province having an elevation of 79 m above sea level (ASL). The rice variety of Inpari Sidenuk was used in this research. This research was arranged in a randomized completely block design (RCBD) factorial and three times replications. The first factor was a dosage of rice husk biochar consisted of three levels, namely, 5; 10; and 15 tons ha^{-1} (25; 50; and 75 g polybag^{-1}). The second factor was a dosage of rice straw compost consisted of three levels, namely, 5; 10; and 15 tons ha^{-1} (25; 50; and 75 g polybag^{-1}). The data parameters were leaf chlorophyll, roots-canopies ratio, flowering age, harvest index, and rice yield per hectare. Analysis of data was done by using analysis of variance (ANOVA) at 5% significance levels ($p < 0.05$). The difference between the averages of the treatment was compared using the HSD test at 5% significance levels ($p < 0.05$). The results of the research showed that the dosage of rice husk biochar of 12.5 tons ha^{-1} produced higher leaf chlorophyll content of rice. The treatment combination between the dosage of rice husk biochar and rice straw compost at 10:10 tons ha^{-1} was produced a better rooting system (roots-canopies ratio). The dosage of rice husk biochar of 9.1 tons ha^{-1} caused the rice flowering age was slowly. The rice husk biochar was no direct effect on the rice yield, but the role of rice straw compost at a dosage of 8.9 tons ha^{-1} produced the highest rice yield per hectare.

Keywords: Rice husk biochar, Rice straw compost, Rice, Inpari Sidenuk variety, Polybag.

1. Introduction

One cause of decreasing productivity of the rice field, especially on an irrigated rice field, is due to low organic matter besides imbalance soil nutrients because of improper fertilizing and monoculture cultivation.

Indonesia's rice production in 2018 reached 32,419,910 tons and the level of national rice consumption reached 29,568,496 tons so that Indonesia occurred a rice surplus of 2,851,414 tons [1]. Even the use of uncontrolled agrochemicals element can decrease the physical, chemical and biological quality of soil [2]. The most important aspects of applying biochar to the soil in the agriculture system were increasing plant yield and aboveground production through several mechanisms to promote plant productivity and yield [3].

The different between biochar and charcoal is that biochar is used as a soil amendment, whereas charcoal is used as fuel. Biochar could be produced from several biomass matters and it is used for soil improvement effort such as carbon sequestration for reducing carbon emission from the soil [4-8]. Biochar can increase soil C-organic, improve soil structure, increase cation exchange capacity (CEC) and available water capacity (AWC) of soils [9-10]. According to Yamato et al. [11] and Jiang et al. [12], biochar application was capable to increase soil power of hydrogen (pH), Ca content, base saturation, CEC and decrease Al^{+++} saturation. In addition, biochar can improve physical soil properties, improving soil biological health by inducing the growth of beneficial organisms as well as decreasing soil-borne diseases [13-15].

The rice plants treated in rice straw compost (10 tons ha^{-1}) and rice husk biochar (10 tons ha^{-1}) along with chemical fertilizer had higher of leaf area, number of tillers and roots per plant, dry weights of shoots, roots per plant, number of grains and filled grains, and filled grain weight per panicle than comparing chemical fertilizer alone [16]. Rice straw compost has several benefits such as supplying nutrients, improving soil structure, improving soil texture, increasing soil porosity and aeration as well as adding microorganisms composition within soil [17]. The raw material for rice straw compost is also available in abundant quantity, obtained easy and cheap [18]. Nutrients from organic fertilizers were an important role in roots development. Rice field on soil having sufficient nutrients will produce optimum roots development. The availability of balance and sufficient nutrients will determine better growth and development of the plant, whereas insufficiency and excessive availability of one or more nutrients in the soil will result in the symptom of less optimum growth of plant [19].

There were different soil properties effects and crop responses of biochar application due to different sources and processes of biochar such as different pyrolysis temperature, particle size and rate and time of application to the stage of crop growth and development. The finer particle size of biochar able to increase soil enzyme activity [5]. Different effects of biochar produced at different temperatures varied in their effect on nitrogen uptake on the *Eruca sativa* plant and on the growth of lettuce [20]. The effect of rice husk biochar and rice straw compost on the growth and yield of rice could be measured by the parameters of leaf chlorophyll, flowering age, roots-shoots ratio, rice yield ha^{-1}, and harvest index.

Chlorophyll is an important photosynthetic pigment to the plant, largely determining photosynthetic capacity and hence plant growth [21]. Rice flowers after a lengthy vegetative growth. During the vegetative growth period, several independent pathways inhibit the flowering. After sufficient vegetative growth, flowering signals are produced in the leaves due to reduced expression of the inhibitors [22]. The root-canopy ratio (defined as dry weight of root biomass divided by dry weight of shoot biomass) depends upon partitioning of photosynthetic which may be influenced by environmental stimuli. Exposure of plant canopies to high CO_2 concentration often stimulates the growth of both roots and shoots [23]. High grain nitrogen (N) concentration in crops may require translocating more N from the vegetative tissues, causing faster plant senescence, altering sink-source balance during grain filling, and ultimately lowering grain yield. Sink-source relationships during rice grain filling were associated with grain N concentration [24]. Harvest index is the ratio of grain yield and the total aboveground biomass, which indicates the efficiency of the plant to assimilate partition to the economic parts (example: rice grain). Higher the harvest index means the plant is capable to deposit assimilates having economic importance from the source (leaf, leaf sheath, stem, and flag leaf) to the panicle (sink) especially grain in case of cereals [25].

Based on the description above, the objective of these works here was to study the role of rice husk biochar and rice straw compost in improving soil properties to increase the rice yield. It is necessary to conduct the research on the role of rice husk biochar and rice straw compost on the rice yield in the polybag.

2. Materials and Methods

2.1. Research areas

This study was conducted at Air Lesing Village, Muara Beliti Sub-district, Musi Rawas District with an elevation of 79 m ASL. It was conducted from December 2016 up to March 2017 followed by laboratory analysis at the Faculty of Agriculture, Universitas Musi Rawas, Palembang, Indonesia.

2.2. Biochar and compost processing

Biochar characterization was done using simple pyrolysis apparatus made from the modified drum as a biochar reactor, fresh rice husk from rice milling put in the reactor. Starting burning from the bottom of the reactor for 5 hours with the average temperature in the reactor 225 ^{o}C and after 5 hours will change to biochar.

Rice straw compost was made by mixing straw that colonized approximately 3-5 cm as many as 20 kg with effective microorganism-4 (EM-4) (as starter) of 100 ml, the rice brand of 1 kg, brown sugar of 0.5 kg and enough water. The mixture of media was entered in a chamber, and then was closed using plastic tarp and it has was incubated for 21 days.

2.3. Experimental design

This research was arranged in a randomized completely block design (RCBD) factorial and three replications. The first factor was a dosage of rice husk biochar consisted of three levels, namely, 5; 10; and 15 tons ha^{-1} (25; 50; and 75 g $polybag^{-1}$). The second factor was a dosage of rice straw compost consisted of three levels, namely, 5; 10; and 15 tons ha^{-1} (25; 50; and 75 g $polybag^{-1}$). There were 27 treatment combinations and each treatment combination consisted of six samples, then 162 polybags were needed.

2.4. Soil and rice variety

The soil used in this study was mineral soil of yellowish-red podsolic with soil bulk density of 1.1 kg m^{-3}, pH of 5.0, and low fertility. The soil used for the research was rainfed soil and the former rice field.

The rice variety of Inpari Sidenuk was used in this research. The variety description was the commodity of lowland rice, plant age of 103 days, productive tillers of 15 panicles, the grain number $panicle^{-1}$ of 175-200 grain, and rice yield potential of 9.1 tons ha^{-1} grain dry weight.

2.5. Research procedures

The soil weight of 10 kg was mixed evenly with husk rice biochar (5; 10; and 15 tons ha^{-1} or 25; 50; and 75 g $polybag^{-1}$) and rice straw compost (5; 10; and 15 tons ha^{-1} or 25; 50; and 75 g $polybag^{-1}$) base on the treatment within 162 polybags and incubated during 14 days. After that, the polybags were arranged in blocks suitable with treatment randomization within a plastic canvas tub to control the height of irrigation water.

Two rice seedlings of Inpari Sidenuk variety having the age of 15 days after sowing (DAS) was transplanting into each polybag with a plant spacing of 25 cm x 25 cm, as commonly practiced by local farmers. This research required as many as 324 seedlings or 162 clumps of rice plants. The rice population per hectare is 160,000 clumps.

Inorganic fertilizers applied were consisted of urea fertilizer at a dosage of 200 kg ha^{-1} [26], with three times application. Dosage of each application at age of 14; 28; and 42 days after planting (DAP) were 66.7 kg ha^{-1} (0.42 g $polybag^{-1}$). SP-36 fertilizer at a dosage of 150 kg ha^{-1} (0.94 g $polybag^{-1}$) and KCl fertilizer at a dosage of 100 kg ha^{-1} (0.63 g $polybag^{-1}$) which were applied one time during the rice plant age of 14 DAP. Agronomic effort or action was done as usual.

2.6. Data parameter

The parameter observed in this research included the leaf chlorophyll, roots-canopies ratio, flowering age, harvest index, and rice yield ha^{-1}.

Leaf chlorophyll can be as indicator growth of rice plants. In this research, leaf chlorophyll at 85 DAP, because the days were peak the grain filling. The measurement of leaf chlorophyll content used CCM-200 plus Chlorophyll Content Meter. In this study only observed the greenness of the leaves of rice plants.

The dry weight of roots and canopies were measured using the Ohaus PA214 Pioneer Analytical Balance. The roots-canopies ratio is the ratio between roots dry weight and canopies dry weight with the following formula is given by Eq. (1).

$$\text{Roots-canopies ratio} = \frac{\text{roots dry weight}}{\text{canopies dry weight}} \quad (1)$$

Flowering age is observed when the rice gets started the first flower appears from DAP. The observation was conducted in each treatment until all of the rice plants in the polybag had flowered.

Grain dry weight (g clumps^{-1}) was measured using the Ohaus PA214 Pioneer Analytical Balance. Rice yield was evaluated by measuring grain yield on the polybag. The moisture percentage of grains was determined by grain moisture meter LSD-1G and final grain yield was adjusted at 14% moisture level. Rice yield ha^{-1} was calculated based on a formula as shown in Eq. (2). In research that plant spacing (a distance of rice stem between clumps in the polybag) used 25 x 25 cm, then the population of rice plant per hectare was 160.000 clumps.

$$\text{Grain yield ha}^{-1} = \text{grain yield clumps}^{-1} \text{ x population of rice ha}^{-1} \quad (2)$$

Harvest index (HI) was computed by dividing economic yield with the biological yield with the following formula as shown in Eq. (3)

$$\text{HI} = \frac{\text{economic yield (grain yield)}}{\text{biological yield (grain yield + straw yield)}} \quad (3)$$

2.7. Statistical analysis

The analysis of data was done by using ANOVA at 5% significance levels ($p < 0.05$). The difference between the average of the treatment was compared using the HSD test at 5% significance levels ($p < 0.05$) [27].

To find the optimal dosage of rice husk biochar and rice straw compost on the growth and yield of rice used equation of quadratic function is given by Eq. (4).

$$y = a + b\,x + c\,x^2 \quad (4)$$

Where y is an independent variable, x is a dependent variable, and a, b, and c represents the coefficients.

The value of optimal dosage ($x_{optimum}$) could be obtained base on the first derivate ($y' = 0$) from the equation of quadratic function, then the Eq. (4) changes into the formula as shown in Eq. (5).

$$y' = b\,x + 2c\,x \rightarrow x_{optimum} = -\frac{b}{2c} \quad (5)$$

3. Results and Discussion

3.1. Leaf chlorophyll

The results of ANOVA showed that treatment interaction had no significant effect on the leaf chlorophyll content. Rice husk biochar treatment had a significant effect on the leaf chlorophyll content, whereas rice straw compost treatment had no significant. Results of the HSD test at 5% significance levels ($p < 0.05$) on the leaf chlorophyll content could be seen in Table 1.

Based on Table 1 showed that the application of rice husk biochar was capable to increase leaf chlorophyll content of rice. There was no different effect between the application of rice husk biochar at a dosage of 10 and 15 tons ha^{-1}, but both treatments were significantly different than a dosage of 5 tons ha^{-1}. Biochar application at a dosage of 10 and 15 tons ha^{-1} can increase leaf chlorophyll content of 23.73, and 23.76 units, respectively. Biochar application at a dosage of 5 tons ha^{-1} produced lower leaf chlorophyll content (16.44 units). The effect of rice husk biochar on chlorophyll content has obtained the equation of quadratic function $y = 1.89 + 3.636\,x - 0.145\,x^2$. Base on the equation of quadratic regression, the optimum dosage of rice husk biochar is 12.5 tons ha^{-1} and the maximum leaf chlorophyll content is 24.65 units.

Biochar application basically can improve soil physical properties such as increasing soil pH. This is in accordance with the study results by Chan et al. [8], which showed that biochar application was capable to increase N absorption and other nutrients in which this nitrogen element is highly needed for leaf chlorophyll development. This was also in accordance with the study results by Fellet et al. [28] and Uchimiya et al. [10], which showed that biochar application will result in increasing of soil pH in line with increasing application dosage, increasing of CEC and AWC. Increasing soil pH will increase soil capacity in the absorption process and cation release which subsequently will increase nutrients absorption by roots crop such as nitrogen. According to Lu et al. [29] and Glaser et al. [30], the increase of CEC of soil was due to negative charge, which originates from the carboxylate acid group.

Table 1. The effect of rice husk biochar and rice straw compost treatments on chlorophyll content (units) after harvest.

Rice husk biochar (tons ha^{-1})	Rice straw compost (tons ha^{-1})			Average
	5	10	15	
5	16.56	13.01	19.74	16.44 a
10	18.01	25.00	28.18	23.73 b
15	26.26	22.67	22.36	23.76 b
Average	20.28 p	20.23 p	23.42 p	(-)
HSD at 5% levels for rice husk biochar treatment = 7.65				

Remarks: Numbers followed by the same characters on rows or columns are not significantly different based on HSD at 5% significant levels ($p < 0.05$). (-) = No significant interaction.

3.2. Roots-canopies ratio

The results of ANOVA showed that there was a significant interaction between rice straw compost and rice husk biochar treatments on the roots-canopies ratio. The results of the HSD test at 5% significance levels ($p < 0.05$) on the roots-canopies ratio are presented in Table 2.

The roots-canopies ratio is a parameter that compares the root dry weight divided by canopies dry weight of the crop. The higher value of this parameter shows a better growth and development of roots crop as a result of applied treatment. This ratio indicates that the application of rice straw compost and rice husk biochar certainly increase the canopies dry weight which is higher than root the dry weight.

Based on Table 2 showed that treatment combination of rice straw compost and rice husk biochar with the respective magnitude of 10 tons ha^{-1} as well as rice straw compost and rice husk biochar with the respective magnitude of 10 tons ha^{-1} had produced the highest roots-canopies ratio because these treatments are capable to improve soil physical properties. The treatment combination between rice husk biochar and rice straw compost at 10:10 tons ha^{-1} was produced a better rooting system.

The results of the regression analysis from the effect of rice husk biochar on the roots-canopies ratio in three levels dosage of rice straw compost were followed. In a dosage of 5 tons ha^{-1} was obtained an equation of quadratic regression function $y = -0.25 + 0.092\,x - 0.004\,x^2$, the optimum dosage of is 11.5 tons ha^{-1} (or 52.3 g $polybag^{-1}$) and the maximum roots-canopies ratio is 0.28. In a dosage of 10 tons ha^{-1} rice straw compost was obtained an equation of quadratic function $y = -0.86 + 0.255\,x - 0.0122\,x^2$, the optimum is 10.5 tons ha^{-1} (or 47.7 g $polybag^{-1}$) and the maximum roots-canopies ratio is 0.47. The equation of quadratic function in a dosage of 15 tons ha^{-1} is $y = -0.15 + 0.068\,x - 0.002\,x^2$, the optimum dosage is 17.0 tons ha^{-1} (or 77.3 g $polybag^{-1}$) and the maximum roots-canopies ratio is 0.43. According to Lakitan et al. [5], during the vegetative growth phase, applying biochar significantly increased the shoots (canopies) and roots dry weight.

The soil used in this study was red-yellowish podsolic soil as one of the ordos from eight ordos of acid organic mineral soil, namely, Ultisol based on USDA classification [31]. This soil type has clay up to sandy texture, agglomerate, low fertility level, low base saturation and relatively acid pH due to podsolization.

Table 2. The interaction effect between rice husk biochar and rice straw compost on the root-canopy ratio.

Rice husk biochar (tons ha^{-1})	Rice straw compost (tons ha^{-1})			Average
	5	10	15	
5	0.11 a	0.11 a	0.14 a	0.12
10	0.27 ab	0.47 b	0.33 ab	0.36
15	0.23 ab	0.22 ab	0.42 b	0.29
Average	0.20	0.27	0.30	(+)
HSD at 5% levels for treatment interaction biochar and compost = 0.21				

Remarks: Numbers followed by the same characters on combination treatments are not significantly different based on the HSD test at 5% significant levels ($p < 0.05$). (+) = Significant interaction.

3.3. Flowering age

Based on the results of ANOVA showed that the interaction of both treatments had no significant effect on the flowering age of the plant. The application of rice husk biochar had a significant effect on the flowering age, whereas rice straw compost treatment had no significant effect on the flowering age of the plant (Table 3).

The application of rice husk biochar of 15 tons ha^{-1} is capable to accelerate rice crop flowering (59.56 days) compared to the application of rice husk biochar of 10 tons ha^{-1} (66.11 days), and 5 tons ha^{-1} (63.11 days) respectively. Table 1 showed that the application of rice husk biochar with magnitude 15 tons ha^{-1} was significantly different than the other treatments. The effect of rice husk biochar on the flowering age has obtained the equation of quadratic function $y = 50.56 + 3.465\,x - 0.191\,x^2$, the optimum dosage of rice husk biochar is 9.1 tons ha^{-1} (or 41.3 g $polybag^{-1}$) and flowering age is slowly by 66.3 days. According to Kartika [32], flowering and fruiting strongly affected the yield of the crop.

Biochar application basically can improve soil physical properties such as increasing soil pH. The increase of soil pH results in a “favorable” environment for root’s crop development because pH value near neutral condition results in optimum availability of nutrients which facilitate higher phosphate absorption in addition to other nutrients. Phosphate element is highly needed for roots development as the nutrient source for a crop that substitutes inorganic fertilizer role and can be categorized as a chemical function, although this function has not yet properly implemented by rice straw compost and rice husk biochar. The research by Fellet et al [28], that using garden waste biochar could increase pH along with the increased dosage of biochar.

The pH of soil before treatment is 5.0 and after treatment the pH of 6.1. Soil pH has related to the availability of nutrients in the soil that were ready to be absorbed by plants. An increase in pH to 6.1 caused soil nutrients more available so that causing faster plant growth and flowering age.

Table 3. The effect of rice husk biochar and rice straw compost on the flowering age (days).

Rice husk biochar (tons ha^{-1})	Rice straw compost (tons ha^{-1})			Average
	5	10	15	
5	59.00	66.33	64.11	63.11 b
10	66.67	66.67	65.00	66.11 b

15	63.00	57.67	58.00	59.56 a
Average	62.89 p	63.56 p	62.33 p	(-)
HSD at 5% levels for rice husk biochar treatment = 3.19				

Remarks: Numbers followed by the same characters on rows or columns are not significantly different based on the HSD test at 5% significant levels ($p < 0.05$). (-) = No significant interaction.

3.4. Harvest index

Results of ANOVA showed that interaction had no significant effect on the harvest index. Rice husk biochar treatment had a significant effect on the harvest index, whereas rice straw compost treatment had no significant. The results of the HSD test on the harvest index was shown in Table 4.

The application of rice husk biochar can increase harvest index. The dosage of rice husk biochar at 15 tons ha^{-1} produced the harvest index of 0.81 higher than rice husk biochar at a dosage of 10 and 5 tons ha^{-1} (0.74 and 0.65, respectively). This showed that higher application dosage of rice husk biochar given the yield in higher dry rice harvest (economic yield) in relation to the total dry weight of rice (biological yield). The effect of rice husk biochar on harvest index has obtained an equation of quadratic function $y = 0.54 + 0.024\,x + 0.0004\,x^2$, the optimum dosage is 30 tons ha^{-1} and the maximum harvest index is 0.9. The increase in harvest index suitable with the increasing biochar dosage. It was suitable for the results of the research Lakitan et al. [5], there were know by increasing rice yield components, namely, numbers of tillers, productive tillers, number of grains with a higher rate of biochar application.

The increase of harvest yield in the form of dry rice is due to the increase of phosphate nutrient availability which has a determinant role in rice seed filling process and this is also in accordance to statement by Goyal et al. [33], which showed that increase a soil pH is due to compounding of organic acids with aluminum and iron ions within soil solution through chelation process which indirectly increases phosphate availability. This statement was also supported by research results from Verheijen et al. [34], which showed that fulvate acid originates from the decomposition of organic matter has a higher role in phosphate element release in the soil solution.

The effect of rice husk biochar which can release nutrients in slow fashion will determine nutrients availability during the plant growth period which is shown by the harvest index. This is in accordance to a study result by Ismaid et al. [35], which showed that the application of biochar could improve soil structure.

Table 4. The effect of rice husk biochar and rice straw compost treatments on the harvest index.

Rice husk biochar (tons ha^{-1})	Rice straw compost (tons ha^{-1})			Average
	5	10	15	
5	0.59	0,62	0.74	0.65 a
10	0,72	0.77	0.71	0.74 ab
15	0,80	0,83	0.81	0.81 b
Average	0,70 p	0.74 p	0.75 p	(-)
HSD at 5% levels for rice husk biochar treatment = 0.15				

Remarks: Numbers followed by the same characters on rows or columns are not significantly different based on the HSD test at 5% significance levels ($p < 0.05$). (-) = No significant interaction.

3.5. Rice yield per hectare

Based on the results of ANOVA showed that interaction between rice husk biochar and rice straw compost had no significant effect on rice production per hectare. Rice husk biochar treatment had no significant effect on rice production per hectare, but rice straw compost treatment had a significant. Results of the HSD test on rice production per hectare are shown in Table 5.

The application of rice straw compost at a dosage of 10 tons ha^{-1} produced the highest rice yield in dry rice with magnitude 7.56 tons ha^{-1} and it was significantly different from than application of rice straw compost at a dosage of 15 tons ha^{-1}, but not significantly different with a dosage of 5 tons ha^{-1}. Rice yield will be lower if the application of dosage is higher than a dosage of 10 tons ha^{-1}. The effect of rice straw compost on crop production has obtained an equation of quadratic function $y = 2.67 + 1.111\ x - 0.0622\ x^2$, the optimum dosage is 8.9 tons ha^{-1} (or 40.6 g $polybag^{-1}$) and the maximum rice yield is 7.63 tons ha^{-1}. According Halim et al. [36], compost-treated rice plants showed the best reading in increasing the soil pH and plant performance including the highest reading of photosynthetic rate, WUE, number of tillers, number of panicles, size of panicles, number of grains per panicle, percentage of filled grains, and 1000 grain weight. This lead to the conclusion that the best treatment for soil amendment used for rice plant cultivation in acid sulfate soil is compost, and followed by biochar.

The application of inorganic fertilizer in the form of rice straw compost is a management effort to improve soil fertility through the improvement of the physical, chemical and biological properties of the soil. Therefore, the application of rice husk biochar can have functioned as a soil amendment, whereas the application of rice straw compost will improve rice growth by supplying some nutrients while functioning to improve the physical, chemical, and biological properties of the soil [30].

The increase in the grain yield was due to an improvement in the soil chemical properties and nutrients enhancement. Finally, the co-application of the highest rate of rice straw biochar, RSB (0.9%) and compost (3%) is recommended to obtain the appropriate rate of rice grain yield in calcareous sandy soil [29]. Another study showed that biochar can increase soil humidity and fertility and organic fertilizer originate from the decomposed rice straw had very high potential in terms of nutrients [33].

The nutrients that originate from organic fertilizer also have an important role in root development. Optimal crop production highly depends on the photosynthesis process which occurred after flowering, that is the higher the photosynthate available in leaf and trunks during the seed filling process, the higher rice production. A low carbohydrate synthesis rate causes a decrease of plant matter dry weight, where plant dry matter is one of the plant's indicators on the photosynthesis rate. It is in line with Phonguodume et al. [37] who stated that light intensity levels could have a significant effect on photosynthesis rates, which are directly related to a plant's ability to grow. According to Sukarto et al. [38], the rate of photosynthesis must be support by the sufficient availability of nutrients. Applying biochar increased soil organic content and available N, P, and K.

There is a tendency for the application of organic fertilizer that has been decomposed to effectively increase rice growth and yield [39]. The application of rice straw compost is capable to increase crop yield. Optimum benefit for production depends on sufficient nutrients supply during crop growth [40].

Nutrients content of N, P, and K within rice straw compost is relatively high with a low C/N ratio so that they can be directly used as organic fertilizer that has a role as a nutrients source for the crop. It is expected that the application of rice straw compost can improve the physical, chemical and biological properties of soil that can be obtained from inorganic fertilizer application. The effect of organic fertilizer application into the soil, especially rice straw compost, areas granulator (improving soil structure), source of macro and micronutrients, increasing AWC of soil, increasing soil capability to retain nutrients (CEC of soil become high) and as an energy source for soil microorganisms [41].

Table 5. Effect of rice husk biochar and rice straw compost treatments on the rice yield (tons ha^{-1}).

Rice husk biochar (tons ha^{-1})	Rice straw compost (tons ha^{-1})			Average
	5	10	15	
5	5.91	7.21	3.95	5.69 a
10	7.07	7.00	6.30	6.79 a
15	7.04	8.46	5.77	7.09 a
Average	6.67 pq	7.56 q	5.34 p	(-)
HSD at 5% levels for rice husk biochar treatment = 1.59				

Remarks: Numbers followed by the same characters on rows or columns are not significantly different based on the HSD test at 5% significance levels ($p < 0.05$). (-) = No significant interaction.

4. Conclusions

Based on the literature review and the discussion above, the following conclusions from this research are given below.

- The dosage of rice husk biochar of 12.5 tons ha^{-1} produced higher leaf chlorophyll content of rice.
- The treatment combination between the dosage of rice husk biochar and rice straw compost at 10:10 tons ha^{-1} was produced a better rooting system (root-canopy ratio) of rice.
- The dosage of rice husk biochar of 9.1 tons ha^{-1} caused the rice flowering age was slowly.
- The rice husk biochar was no direct effect on the rice yield, but the role of rice straw compost at a dosage of 8.9 tons ha^{-1} produced the highest rice yield per hectare.
- For the next and longer-term research, it should be investigated using different sources of biochar since it showed that the higher dosage of rice husk biochar and rice straw compost, the higher yield obtained.

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Nomenclatures

Ca	Calcium, meq/100 g
N	Nitrogen, %
CO_2	Carbon dioxide, ppm
C-organic	Carbon organic, %
P	Phosphate, ppm
K	Potassium, meq/100 g
KCl	Potassium chloride fertilizer, kg ha^{-1}
SP-36	Superphosphate-36 (36% P_2O_5), kg ha^{-1}
Urea	Nitrogen fertilizer, kg ha^{-1}

Greek Symbols

Al^{+++}	Aluminium three valency, meq/100 g
°C	Degree of Celsius, °C
C/N	Ratio of carbon and nitrogen

Abbreviations

ANOVA	Analysis of Variance
CEC	Cation Exchange Capacity
DAS	Days After Sowing
DAP	Days After Planting
EM-4	Effective Microorganism-4
HI	Harvest Index
HSD	Honestly Significance Different
ASL	Above Sea Level
P	Probability
Ph	Power of Hydrogen

RCBD	Randomized Completely Block Design
RSB	Rice Straw Biochar
USDA	United States Department of Agriculture
AWC	Available Water Capacity

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