Paper 20200917 (3)

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Journal of Engineering Science and Technology
Vol. 15, No. 4 (2020) 2135 - 2148

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

Lowrice 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 mabove 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 15tons 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 15tons 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: Polybag, Rice husk biochar, Rice Impari Sidenuk variety, Rice straw compost.

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. Burning starts from the bottom of the reactor for 5 hours with the average temperature in the reactor 225°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 been 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).

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

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 25×25 cm, then the population of rice plant per hectare was 160.000 clumps.

Grain yield ha^{-1} = grain yield clumps^{-1}× population of rice ha^{-1}................. ....(2)

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

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

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. Leafchlorophyll

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 increase leaf chlorophyll content of rice. There was no different effect between the application of rice husk biochar at a dosage of 10and15 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 tonsha^{-1} can increase leaf chlorophyll content of23.73, and 23.76 units, respectively. Biochar application at a dosage of 5 tonsha^{-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. [9], 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	16.44a
10	18.01	25.00	28.18	23.73b
15	26.26	22.67	22.36	23.76b
Average	20.28p	20.23p	23.42p	(-)
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 tonsha^{-1} is capable to accelerate rice crop flowering (59.56 days) compared to the application of rice husk biochar of 10tonsha^{-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 et al. [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 "favourable" 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}) 5	10	15	Average
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 and Basri [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	0.65a
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}.Riceyield 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 led 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 originates 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}) 5	10	15	Average
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	6.67pq	7.56q	5.34p	(-)
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.

Acknowledgments

The researchers would like to express gratitude to the head of the physiological laboratory, Faculty of Agriculture, Universitas Musi Rawas who has kindly provided all analytical facilities in this study and thanks to Mrs. Arwita Sari for her assistance and deep cooperation in this research.

Nomenclatures

Ca	Calcium, meq/100 g
CO_2	Carbon dioxide, ppm,
C-organic	Carbon organic,%
K	Potassium, meq/100.g
KCl	Potassium chloride fertilizer, kg ha^{-1}
N	Nitrogen %
P	Phosphate, ppm
p	Probability
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
ASL	Above Sea Level
AWC	Available Water Capacity
CEC	Cation Exchange Capacity
DAP	Day After Planting

DAS	Day After Sowing
EM4	Effective Microorganism-4
HI	Harvest Index
HSD	Honestly Significance Difference
Ph	Power of Hydrogen
RCBD	Randomized Completely Block Design
RSB	Rice Straw Biochar
USDA	United States Department of Agriculture

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