The Utilization of Agricultural Waste Biochar and Straw Compost Fertilizer on Paddy Plant Growth

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Abstract. The agricultural environment continues to be used for inappropriate technology, reduced agricultural land, insufficient inputs (chemical fertilizers and inorganic pesticides), and air. Rice is the most important food crop in Indonesia because almost all residents use rice as a staple food. Rice straw is a source of organic material that is available after harvesting rice with a large enough amounts but the use of rice straw has only been used in paddy fields. This research is a field experiment followed by laboratory research with the following stages: (a) analysis of soil samples before the research was conducted at the Soil Chemistry Laboratory, Faculty of Agriculture, Syiah Kuala University, (b) field experiments by planting Inpari 30 variety rice, biochar treatment and straw compost treated according to the combination of each plot treatment, and soil sample analysis at the end of the study to re-test the soil chemical properties after conducting research with biochar and straw compost. This research method uses factorial randomized block design (RBD) consisting of two factors, namely: Biochar and Straw Compost. The results of this study indicate that biochar space has an influence on plant growth, namely plant height and number of paddy tillers. Observations on rice growth were 28 day after planting (DAP), 35(DAP) and (DAP) to find out the effects of giving biochar and straw compost, it is necessary to conduct further research on the next planting season so that it can be recognized and applied to save the use of chemical fertilizers. The administration of biochar and straw compost affects plant growth, namely plant height and the number of tillers in each rice with higher yields. It would be even better by giving biochar and straw compost together with higher yields. Thus, it is hoped that further research will be carried out in the next rice planting season to see how much residue is giving biochar and straw compost to improve rice yields. The results of the variance analysis showed that plant height 28 HST was significantly affected by biochar treatment with a significance value of 0.033. The results of the variance analysis showed that plant height 35 HST was significantly affected by the treatment of straw compost with a significance value of 0.018. The results of the variance analysis showed that plant height of 45 DAP was significantly affected by the treatment of biochar with a significance value of 0.019 while the treatment of straw compost had a very significant effect on plant height 45 DAP with a significance value of 0.001. The results of the variance analysis showed that the numbers of tillers 28 DAP were significantly affected by the treatment of biochar with a significance value of 0.019 while the treatment of straw compost had a very significant effect on plant height 45 DAP with a significance value of 0.001. The results of the variance analysis showed that the numbers of tillers 28 DAP were significantly affected by the treatment of biochar with a significance value of 0.013. The results of the variance analysis showed that the number of tillers 35 DAP and 45 DAP all had no significant effect by the treatment of biochar, straw compost, and interaction of biochar and straw compost because at plant age 35 DAP and 45 DAP the significance values were above 0.05.
1. Introduction
Technology, reduced agricultural land, insufficient inputs (inorganic chemical fertilizers and pesticides), and water. Concerns about environmental pollution and degradation, the impact of the global economy, and food needs continue to increase, resulting in the agricultural environment continuing to experience changes in the future.

According to Fitri [1] each country has a goal to improve the development of the economy including Indonesia. Indonesia is an agricultural country with a large portion of its population living from the agricultural sector. Agriculture is a very important sector in Indonesia's economic growth where agriculture has a contribution to both the economy and the fulfillment of basic needs of the community. Agricultural development aims to provide food supply. One way to achieve this goal is by increasing production where increasing production is a prerequisite for meeting people's food needs especially rice. Rice is the most important food crop in Indonesia because almost all residents use rice as a staple food. Rice is also a strategic food commodity that has a considerable influence on economic stability especially the level of inflation, social stability and political stability.

Biochar contains high carbon (C) which is more than 30%. Biochar does not experience further weathering so that when applied in the soil it can last for a long time to millions of years [2]. Research using biochar with various age levels shows that biochar has greater adsorption properties over cations through surface oxidation than through adsorption by ordinary organic matter. Although the new biochar has a low adsorption capacity, the old ones show very high CEC [3]. Asai [4] in the 2007, rainy season has also tested the effect of biochar administration on soil properties and grain yield of upland rice in northern Laos. Biochar administration of 16 that -1 increases the hydraulic conductivity of the top soil. In soils with low P availability biochar can increase grain yield. Besides, the response to N fertilization increases with the addition of biochar. Rice straw is a source of organic material that is available after harvesting rice with a large enough amounts, but the use of rice straw has only been used in paddy fields only [5-9]. The provision of rice straw compost can increase C-organic and P-available Ultisol soil, plant height, plant dry weight, N uptake and P uptake on maize plants. The administration of rice husk ash can increase C-organic Ultisol soil and N uptake of corn crops. The interaction of compost and rice husk ash had a significant effect on all variables of growth and production of sweet potato which included variable stem length, number of branches, number of tuber leaves / plants, tuber weight or tuber and tuber starch content [10-13].

2. Research Methodology
This research is a field experiment followed by laboratory research with the following stages:

i. Analysis of soil samples before the research was conducted at the Soil Chemistry Laboratory, Faculty of Agriculture, Syiah Kuala University
ii. Field experiments by planting Inpari 30 variety rice, biochar treatment and straw compost treated according to the combination of each plot treatment, and soil sample analysis at the end of the study to re-test the soil chemical properties after conducting research with biochar and straw compost.

This research method uses factorial randomized block design (RBD) consisting of two factors, namely: Biochar and Straw Compost.

i. Biochar Factors: The biochar factor consists of 4 different doses: treatment without biochar, biochar 5 tons / ha, biochar 10 tons / ha, and biochar 15 tons / ha.
ii. Straw Compost Factors: These consists of 3 different measures, namely treatment without biochar, compost 10 tons / ha and compost 20 tons / ha. From the table, 12 combinations of treatments were repeated (3) times, becoming 36 unit test units.
2.1 Data analysis. This can be analyzing by using the statistical models for factorial randomized block design (RBD) are as equation (1) follows:

\[ Y_{ijk} = \mu + K_k + F_i + B_j + (FB)_{ij} + \epsilon_{ijk} \]  

Where \( Y_{ijk} \) is the observation value in the experimental group to those who received a combination of \( ij \) treatment (level \( i \) of biochar administration factor and \( j \)-level of straw compost), \( \mu \) the average value (mean) of hope. Next, \( K_k \) is the value of observing the influence of the group. \( F_i \) is the value of observing the effect of straw composting on the level of \( i \) whereas \( F_j \) is a value of observing the effect of biochar administration on the \( j \)-level. \( (FB)_{ij} \) is the value of interaction observation of giving straw compost at level \( i \) and giving biochar at level \( j \) and \( \epsilon_{ijk} \) is a randomized effect of experiment on the experimental group that received a combination of biochar treatment at the level and the provision of straw compost at the level of.

2.2 Data Collection Methods and Procedures

2.2.1 Preliminary Analysis of Soil Examples. Soil collection was carried out in a composite manner, each composite consisting of 5 sample points taken diagonally at a depth of 0-20 cm (using a drill). Analysis of initial soil samples prior to the study, was carried out on soil chemical properties.

2.2.2 Soil Processing. The first treatment carried out three weeks before planting using a rotary with a depth of 20-25 cm. The second treatment is done one week before planting with rotary.

2.2.3 Planting Preparation. Before planting rice seeds, the experimental plot with a size of 5 m x 5 m was made beforehand, this plot was made before NPK fertilizer was applied (15:15:15). To prevent fertilizer seepage between treatment plots, each treatment plot is separated from one treatment to another by using a dike. The water channel is made on the edge of the plot in such a way that the entrance water gate is separated by the exit gate.

2.2.4 Rice Nursery. Seed treatment is carried out by means of seeds soaked in salt water (5 liters) of 3% salt for 30 minutes; the seeds that float are discarded and then soaked with fresh water for 12 hours, then pressed 2 x 24 hours. Nursery area of 5.0% of planted area.

2.2.5 Planting. After the soil is processed to a suitable condition for rice cultivation, the Legowo 2: 1 system is planted with a distance of 20 cm x 40 cm x 20 cm, which is the distance according to the path 20.0 cm and distance by row 20.0 cm. Each hole is planted with 2 new rice stems removed from the nursery. The age of rice planting is carried out 15 days after seedling (DAS). Then, plant simultaneously in one day from all experimental plots.

2.2.6 Provision of Biochar, Compost Straw and Fertilization. The biochar treatment is given at the time of final soil treatment, dried, sprinkled and immediately immersed in the soil evenly on the 20 cm processing layer. Biochar and straw compost are given at the earliest before planting. NPK Basic Fertilization is given according to the results of balanced fertilizer recommendations using PUTS carried out with regard to fertilizer time and dosage, a week after planting. Then given additional Urea fertilizer at 30 days after planting (DAP) and 45 DAP.

2.3 Maintenance

Maintenance of rice plants includes; control of plant pest organisms (OPT), weed control and water regulation. To prevent pest attacks pesticides are used. Weed control is done manually by removing weeds by pulling them by hand. Weed weeding is done when monitoring weed growth, usually when the rice is 25 DAP.
3. Result and Discussion

3.1 Products from Research

Before weaving rice, the product made in this study is first made. The activities that have been carried out in this study are as follows:

3.1.1 Making Biochar

The making of biochar is done using a tool in the form of a modified drum for the combustion using a little oxygen or the pyrolysis process and is assisted by using fan angina to speed up the process of cooking into biochar husk charcoal. So, this can be shown in figure 1 below:

![Figure 1. Making of biochar from rice husk](image)

3.1.2 Making Prebiotic Decomposer

The making of the prebiotic decomposer is done by using waste around the research location with the aim of being easily available and easy to use by farmers at relatively low prices compared to having to buy on the market. The prebiotic decomposer making materials use coconut water, fish head or fish waste remnants decayed straw, decomposed sawdust, palm sugar residual production and palm oil bunch waste. The production of prebiotic has been done 100% to speed up the process of making straw compost and this composer can be visualized in figure 2.
3.1.3 Making Straw Compost

Making straw compost is done by mixing 50% of the basic ingredients of straw from the total straw compost material and this can show in figure 3 until figure 7. The other supporting materials are rice husk, husk ash, water hyacinth, sawdust, prebiotic decomposer and water. The manufacturing process is carried out with each layer of material and given every layer of water and prebiotic decomposer. At this time the manufacturing process is ongoing 50% waiting for the reversal process and perfect decomposition process.
Figure 4. Place for paddy nursery in the fields

Figure 5. Planting paddy after giving biochar and straw compost
Figure 6. Observation of paddy plant growth

Figure 7. Plant paddy 28 days after planting
After that, this plant result can be tabulated as in table 1.

| No | treatment combinations | Replication I (cm) | Replication II (cm) | Replication III (cm) | Average (cm) |
|----|-------------------------|--------------------|---------------------|----------------------|--------------|
| 1  | B₀ K₀                   | 54.10              | 54.57               | 57.41                | 55.36        |
| 2  | B₀ K₁                   | 62.77              | 55.55               | 56.10                | 58.14        |
| 3  | B₀ K₂                   | 58.58              | 56.62               | 63.20                | 59.47        |
| 4  | B₁ K₀                   | 59.79              | 55.03               | 60.34                | 58.39        |
| 5  | B₁ K₁                   | 62.37              | 54.58               | 58.00                | 58.32        |
| 6  | B₁ K₂                   | 59.68              | 58.57               | 62.44                | 60.23        |
| 7  | B₂ K₀                   | 55.42              | 52.88               | 59.66                | 55.99        |
| 8  | B₂ K₁                   | 56.78              | 57.23               | 60.48                | 58.16        |
| 9  | B₂ K₂                   | 56.63              | 57.54               | 58.24                | 57.47        |
| 10 | B₃ K₀                   | 60.18              | 54.40               | 59.16                | 57.91        |
| 11 | B₃ K₁                   | 59.07              | 59.74               | 61.39                | 60.07        |
| 12 | B₃ K₂                   | 63.05              | 59.35               | 64.43                | 62.28        |

Table 1 shows that the highest value of plant height in the treatment of biochar as much as 15 tons ha⁻¹ and the provision of straw compost as much as 20 tons ha⁻¹ were given together with an average plant height of 62.28 cm. After that the high plant height was followed by the treatment of 5 tons ha⁻¹ of biochar and 20 tons ha⁻¹ of straw compost together with an average plant height of 60.23 cm. The average value of plant height without the administration of 55.36 cm of biochar and straw compost was the control that had not been carried out at the research site. This can show in figure 8 and the results tabulated in table 2.

![Plant Height (cm)](image)

**Figure 8.** Plant paddy 28 days after planting
Table 2: Average number of tillers from 12 treatment combinations.

| No | treatment combinations | Replication I | Replication II | Replication III | Average (tillers) |
|----|------------------------|---------------|----------------|-----------------|------------------|
| 1  | B₀ K₀                  | 15.30         | 15.40          | 15.73           | 15.48            |
| 2  | B₀ K₁                  | 16.07         | 15.70          | 16.13           | 15.97            |
| 3  | B₀ K₂                  | 17.33         | 15.10          | 17.40           | 16.61            |
| 4  | B₁ K₀                  | 16.57         | 16.93          | 17.20           | 16.90            |
| 5  | B₁ K₁                  | 16.93         | 17.43          | 16.83           | 17.06            |
| 6  | B₁ K₂                  | 15.20         | 15.33          | 19.43           | 16.65            |
| 7  | B₂ K₀                  | 17.00         | 16.50          | 18.97           | 17.49            |
| 8  | B₂ K₁                  | 17.33         | 16.70          | 19.30           | 17.78            |
| 9  | B₂ K₂                  | 17.30         | 16.40          | 19.90           | 17.87            |
| 10 | B₃ K₀                  | 16.93         | 14.73          | 19.83           | 17.16            |
| 11 | B₃ K₁                  | 18.03         | 20.00          | 17.50           | 18.51            |
| 12 | B₃ K₂                  | 17.83         | 19.13          | 18.70           | 18.55            |

Table 2 shows that the highest value of number of tillers in the treatment of biochar as much as 15 tons ha⁻¹ and the provision of straw compost as much as 20 tons ha⁻¹ was given together with an average of number of tillers of 18.55 tillers. After that the high of number of tillers was followed by the treatment of 15 tons ha⁻¹ of biochar and 10 tons ha⁻¹ of straw compost together with an average plant height of 18.55 cm. The average value of number of tillers without the administration of 15.48 tillers of biochar and straw compost was the control that had not been carried out at the research site. So, it can picture as figure 9 while table 3 until table 9 results for tests of between-subjects effects according to the tillers and so on.
| Source                   | Type III Sum of Squares | df | Mean Square | F   | Sig.  |
|--------------------------|-------------------------|----|-------------|-----|-------|
| Corrected Model          | 184,874\(^a\)           | 13 | 14,221      | 1,534 | .182  |
| Intercept                | 83508,477               | 1  | 83508,477   | 9009,846 | .000  |
| Replication              | 36,386                  | 2  | 18,193      | 1,963 | .164  |
| Biochar                  | 96,785                  | 3  | 32,262      | 3,481 | .033  |
| Straw Compost            | 32,105                  | 2  | 16,053      | 1,732 | .200  |
| Biochar * Straw Compost  | 19,598                  | 6  | 3,266       | .352 | .901  |
| Error                    | 203,909                 | 22 | 9,269       |      |       |
| Corrected Total          | 388,783                 | 35 |             |      |       |

\(^a\) R Squared = .476 (Adjusted R Squared = .166)

| Source                   | Type III Sum of Squares | df | Mean Square | F   | Sig.  |
|--------------------------|-------------------------|----|-------------|-----|-------|
| Corrected Model          | 171,115\(^a\)           | 13 | 13,163      | 2,141 | 056   |
| Intercept                | 119965,250              | 1  | 119965,250  | 19517,462 | 000   |
| Replication              | 25,802                  | 2  | 12,901      | 2,099 | 146   |
| Biochar                  | 39,152                  | 3  | 13,051      | 2,123 | 126   |
| Straw Compost            | 59,760                  | 2  | 29,880      | 4,861 | 018   |
| Biochar * Straw Compost  | 46,402                  | 6  | 7,734       | 1,258 | 316   |
| Error                    | 135,224                 | 22 | 6,147       |      |       |
| Corrected Total          | 306,340                 | 35 |             |      |       |

\(^a\) R Squared = .559 (Adjusted R Squared = .298)
### Table 5. Dependent Variable: Plant Height 45 DAP

| Source                      | Type III Sum of Squares | df  | Mean Square | F    | Sig. |
|-----------------------------|-------------------------|-----|-------------|------|------|
| Corrected Model             | 577,702<sup>a</sup>     | 13  | 44,439      | 12,917 | 000  |
| Intercept                   | 174160,156              | 1   | 174160,156  | 50624,886 | 000  |
| Replication                 | 415,890                 | 2   | 207,945     | 60,446 | 000  |
| Biochar                     | 41,922                  | 3   | 13,974      | 4,062 | 019  |
| Straw Compost               | 75,305                  | 2   | 37,653      | 10,945 | 001  |
| Biochar * Straw Compost     | 44,584                  | 6   | 7,431       | 2,160 | 087  |
| Error                       | 75,685                  | 22  | 3,440       |       |      |
| Total                       | 174813,543              | 36  |             |       |      |
| Corrected Total             | 653,387                 | 35  |             |       |      |

<sup>a</sup> R Squared = .884 (Adjusted R Squared = .816)

### Table 6. Dependent Variable: Number of tillers 28 DAP

| Source                      | Type III Sum of Squares | df  | Mean Square | F    | Sig. |
|-----------------------------|-------------------------|-----|-------------|------|------|
| Corrected Model             | 38,058<sup>a</sup>     | 13  | 2,928       | 2,109 | 059  |
| Intercept                   | 5083,690                | 1   | 5083,690    | 3663,121 | 000  |
| Replication                 | 10,715                  | 2   | 5,357       | 3,860 | 037  |
| Biochar                     | 18,677                  | 3   | 6,226       | 4,486 | 013  |
| Straw Compost               | 1,312                   | 2   | .656        | 473   | 630  |
| Biochar * Straw Compost     | 7,355                   | 6   | 1,226       | 883   | 523  |
| Error                       | 30,532                  | 22  | 1,388       |       |      |
| Total                       | 5152,280                | 36  |             |       |      |
| Corrected Total             | 68,590                  | 35  |             |       |      |

<sup>a</sup> R Squared = .555 (Adjusted R Squared = .292)
Table 7: Dependent Variable: Number of tillers 35 DAP

| Source               | Type III Sum of Squares | df | Mean Square | F     | Sig. |
|----------------------|-------------------------|----|-------------|-------|------|
| Corrected Model      | 30,939a                 | 13 | 2,380       | 812   | 644  |
| Intercept            | 10096,900               | 1  | 10096,900   | 3443,311 | 000  |
| Replication          | 20,169                  | 2  | 10,084      | 3,439 | 050  |
| Biochar              | 7,536                   | 3  | 2,512       | 857   | 478  |
| Straw Compost        | 751                     | 2  | 375         | 128   | 881  |
| Biochar * Straw Compost | 2,483                | 6  | 414         | 141   | 989  |
| Error                | 64,511                  | 22 | 2,932       |       |      |
| Total                | 10192,350               | 36 |             |       |      |
| Corrected Total      | 95,450                  | 35 |             |       |      |

a. R Squared = .324 (Adjusted R Squared = .075)

Table 8: Dependent Variable: Number of tillers 45 HST

| Source               | Type III Sum of Squares | df | Mean Square | F     | Sig. |
|----------------------|-------------------------|----|-------------|-------|------|
| Corrected Model      | 198,817a                | 13 | 15,294      | 2,040 | 068  |
| Intercept            | 17897,980               | 1  | 17897,980   | 2387,949 | 000  |
| Replication          | 143,674                 | 2  | 71,837      | 9,584 | 001  |
| Biochar              | 26,381                  | 3  | 8,794       | 1,173 | 343  |
| Straw Compost        | 10,704                  | 2  | 5,352       | 714   | 501  |
| Biochar * Straw Compost | 18,058               | 6  | 3,010       | 402   | 870  |
| Error                | 164,893                 | 22 | 7,495       |       |      |
| Total                | 18261,690               | 36 |             |       |      |
| Corrected Total      | 363,710                 | 35 |             |       |      |

a. R Squared = .547 (Adjusted R Squared = .279)

4. Conclusion
This study can be concluded as follows;

i. Preparation of prebiotic decomposers in the form of liquid requires ingredients containing nitrogen, phosphorus, potassium and other elements by using bacterial decomposers to accelerate the decomposition process.
ii. The composition of straw compost requires other ingredients besides straw, namely husk ash, sawdust and prebiotic decomposers, water hyacinth. So that the elements needed by plants can be fulfilled.
iii. The administration of biochar and straw compost affects plant growth, namely plant height and the number of tillers in each rice with higher yields. It would be even better by giving biochar...
and straw compost together with higher yields. Thus, it is hoped that further research will be carried out in the next rice planting season to see how much residue is giving biochar and straw compost to improve rice yields.

iv. The results of the variance analysis showed that plant height of 45 HST was significantly affected by the treatment of biochar with a significance value of 0.019, while the treatment of straw compost had a very significant effect on plant height 45 HST with a significance value of 0.001. The results of the variance analysis showed that the number of tillers 28 HST was significantly affected by the treatment of biochar with a significance value of 0.013. The results of the variance analysis showed that the number of tillers 35 HST and 45 HST all had no significant effect by the treatment of biochar, straw compost, and interaction of biochar and straw compost because at plant age 35 HST and 45 HST the significance values were above 0.05.

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