



## Improvement of Corn Plant Yield Through the Application of Biochar and Trichocompost from Rice Harvest Waste

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### Keywords:

Biochar; Paddy Straw; Rice Husk; Trichokompos; Ultisol

### ABSTRACT

*This research aimed to determine the optimal dosage of biochar and rice straw trichocompost for improving corn plant yield on Ultisol soil. The study was designed using a field experiment method with a Split Plot Design, consisting of two treatment factors. The first treatment factor was biochar with three levels: B0 = without biochar, B1 = 10 tons/ha, and B2 = 15 tons/ha. The second treatment factor was rice straw trichocompost with four levels: K0 = without trichocompost, K1 = 10 tons/ha, K2 = 15 tons/ha, and K3 = 20 tons/ha. The observed parameters for corn plant yield were cob length, cob diameter, dry weight of corn cobs, and dry weight of corn grains. The data collected from the observations were analyzed using an F-test at a significance level of 5%, followed by a Tukey test for further analysis. The results of the research indicated a significant effect of individual treatments of paddy straw biochar and rice straw trichocompost on corn plant yield, but there was no interaction between the treatments on corn yield in Ultisol soil. The optimal dosage of biochar for improving corn plant yield in Ultisol soil was found to be between 10 to 15 tons/ha. Meanwhile, the best dosage of rice straw trichocompost for enhancing corn plant yield in Ultisol soil was between 15 to 20 tons/ha.*

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## INTRODUCTION

Corn is a cereal crop that holds strategic and economic value and has the potential for development due to its position as a primary source of carbohydrates and proteins after rice, as well as a source of animal feed (Harahap et al., 2019). However, corn productivity, especially in West Kalimantan, tends to fluctuate. In 2022, corn productivity only reached 29.94 quintals/ha, while in 2020 and 2021, it reached 30.33 and 31.90 quintals/ha, respectively (BPS West Kalimantan Province, 2023). One of the reasons for low corn productivity in West Kalimantan is the limited cultivated area. Therefore, efforts are needed to increase corn production by expanding cultivation to marginal lands, including Ultisol soil.

Ultisol soil has the potential for agricultural development. This soil type is widespread in the West Kalimantan region, covering an area of 9.2 million hectares or 64.83% of the total area of West

Kalimantan, which is approximately 14.7 million hectares (Central Bureau of Statistics of West Kalimantan Province, 2017). Utilizing Ultisol soil for cultivation poses some challenges, such as low average pH (< 4.5), high Al saturation, limited availability of nutrients and organic matter, as well as low Cation Exchange Capacity (CEC) (Harahap et al., 2020). These issues can be addressed by improving soil fertility through the incorporation of organic materials into the soil. The addition of organic matter to the soil can act as a soil conditioner (ameliorant), improving the soil's chemical properties by providing macro and micronutrients, increasing the soil's Cation Exchange Capacity (CEC), and forming complex compounds with toxic metal ions (Al, Fe, Mn) (Pasang, Jayadi, & Rismaneswati, 2019). Besides enhancing soil chemical properties, organic matter is known to improve soil structure, increase soil temperature, enhance aggregate stability, increase water-holding capacity, reduce soil sensitivity to erosion, and act as an energy source for soil microorganisms (Panda, Jawang, & Lewu, 2021). Ameliorants can be applied using agricultural waste from the harvest. Rice husk and straw are waste materials abundantly available and have the potential to be utilized as ameliorants.

Using ameliorants aims to enhance soil fertility while increasing the soil's ability to retain water and nutrients present in biochar (Dariah et al., 2015). Biochar is a product derived from heating agricultural biomass waste without air or with limited air. Rice straw, containing lignin, has the potential to be used as raw material for biochar production (Wijitkosum, 2022).

Rice straw can be utilized to produce trichocompost, a type of organic fertilizer resulting from the fermentation of *Trichoderma* spp. Trichocompost serves as a source of plant nutrients and energy for soil microorganisms, improves water retention and drainage, enhances air circulation, and can suppress soil-borne pathogens (Yusman & Effendi, 2020). Research by Apzani, I Made, & Muhammad (2015) showed that the use of rice straw trichocompost with various *Trichoderma* spp. strains increased plant height, the number of tillers, and the dry weight of rice plants.

The utilization of rice plant waste as ameliorants can assist farmers in substituting chemical fertilizers and promote environmentally friendly farming practices that support the implementation of sustainable agriculture. Based on the above description, research is needed to study the application of biochar and trichocompost from rice plant waste on corn plants in Ultisol soil. The research aims to determine the optimal dosage of biochar and trichocompost for improving corn plant yield in Ultisol soil.

## METHOD

### Location and Time of Research

This research took place over 4 months on the agricultural land of Panca Bhakti University, Pontianak.

### Materials and Tools

The materials used were rice husk, rice straw, goat manure, and easily combustible materials such as paper, wood, and dried leaves for the burning process. Pure culture of *Trichoderma harzianum*, and maize seeds of BISI 18 variety were also used. The tools used included wire mesh, knife, scale, shovel, wire sieve, polybags (40 x 50 cm), watering can, and sprayer.

### Research Design

The research was designed using a field experiment method with a Split Plot Design. The design consisted of 2 factors: the first factor was the application of biochar as the main plot, with 3 levels: B0 = without biochar, B1 = 10 tons/ha, and B2 = 15 tons/ha. The second factor was the application of rice straw trichocompost as the sub-plot, with 4 levels: K0 = without trichocompost, K1 = 10 tons/ha, K2 = 15 tons/ha, and K3 = 20 tons/ha. There were a total of 12 treatment combinations with 4 replications, and each experimental unit consisted of 4 plants, resulting in a total of 192 plants.

## Research Implementation

### 1. Biochar Production

The production of rice husk biochar was carried out by creating a soil kiln using a semi-spherical pit with a diameter of 1.5 meters and a depth of 50 cm. For oxygen supply, a chimney made of wire mesh with a height of 100 cm and a diameter of 30 cm was used. Once the pit was prepared, the chimney was placed in the centre of the pit. Next, rice husks were placed in the pit, covering the chimney in the middle of the rice husks. The burning process was initiated through the chimney using easily combustible materials such as tree branches. When the rice husks turned black, they were stirred to ensure even burning. Once the rice husks were uniformly blackened, water was used to extinguish the fire. The resulting biochar was then left to dry.

### 2. Trichocompost Production

The production of rice straw trichocompost was carried out as follows: 75 kg of rice straw is cut into approximately 5 cm long pieces and then moistened with water. The activator ingredients consisted of: 1.5 kg of Urea, 1 kg of SP-36, 10 kg of goat manure, and 1 kg of pure culture of *Trichoderma harzianum* (functioning as a decomposer). All activator ingredients were thoroughly mixed. The rice straw and activator mixture were divided into four parts. In the first part, the cut rice straw was evenly spread on the floor surface, and then the activator ingredients were added on top. Next, the second part of the rice straw and activator was added on top of the first layer. This process was repeated to create four layers. The entire trichocompost layers were covered with a tarpaulin. During the composting process, the temperature was checked. If the temperature exceeded 40°C, the trichocompost pile was stirred. The composting process took place for 3 weeks. The readiness of the trichocompost was indicated by the complete decomposition of all components, a black colour, no odour, and no heat.

### 3. Preparation of Planting Medium, Soil Incubation, and Planting

The soil used as the planting medium was Ultisol soil. The soil was sieved and weighed to obtain a 10 kg portion, then placed into polybags. The application of biochar and trichocompost treatments was done by sprinkling the fertilizers and mixing them thoroughly into the soil according to the specified dosage. Afterwards, the soil was incubated for 3 weeks. Corn planting was conducted after the incubation period by making holes in the soil, each about 3 cm deep. Each polybag was then filled with two maize seeds.

### 4. Maintenance

Thinning was carried out two weeks after planting by selecting the healthiest plant. Thinning was also done for seeds that did not germinate or were affected by pests/diseases. Subsequently, maintenance was done by watering the plants daily. Pest and disease control measures were applied according to the specific pests and diseases that affect the plants. Weed control was performed manually by hand-pulling weeds.

### 5. Harvesting

The corn was harvested 100 days after planting (DAP). Corn that was ready for harvest is characterized by the cobs or kernels starting to dry, indicated by a black layer on the seed coat. The seeds were dry, hard, and shiny, and did not leave an indentation when pressed. The harvesting method involved twisting the corn cob until it breaks off along with its husk.

### 6. Observation

The variables observed included parameters related to corn plant yield. The yield parameters included the length, diameter, weight of corn cobs and weight of dried corn kernels.

## Research Observations

The observed parameters were:

1. Length of corn cob (cm) The measurement of the cob length without the husk is done after harvesting by removing the husk from the cob. The length is measured from the base of the cob to

- the tip of the cob using a measuring tape.
2. Diameter of corn cob (cm) The measurement of the cob diameter is done on all sample plants after harvesting. The diameter is measured using a calliper.
  3. The dry weight of corn cob (g) The dry weight of the corn cob is measured after harvesting by weighing the cob without its husk.
  4. The dry weight of corn kernels (grams) The dry weight of the corn kernels is obtained by weighing all the seeds from each plant after they have been dried for one week.

### Statistical Analysis

The data obtained were analyzed using analysis of variance (ANOVA) at the 5% level of significance, and to determine the differences in the mean values between treatments, a Tukey test was conducted at the 5% level of significance ( $\alpha = 0.05$ ).

## RESULTS AND DISCUSSION

Based on the analysis of variance results, there was no interaction between the application of biochar and trichocompost on all observation parameters. The individual application of biochar significantly affected the length of the corn cob, the diameter of the corn cob, the dry weight of the corn cob, and the dry weight of the corn kernels. The individual application of trichocompost significantly affected the diameter of the corn cob, the dry weight of the corn cob, and the dry weight of the corn kernels. A summary of the analysis of variance results can be seen in Table 1.

Table 1  
Summary of Analysis of Variance: The Effect of Biochar on Corn Growth and Yield in Ultisol Soil

Application	Length of Corn Cob	Diameter of Corn Cob	Dry Weight of Corn Cob	Dry Weight of Corn Kernels	F Table 5%
Biochar	17.07*	24.78*	23.08*	15.82*	4.26
Trichocompost	0.61 <sup>tn</sup>	3.86*	6.89*	6.08*	2.96
Interaction	0.70 <sup>tn</sup>	0.62 <sup>tn</sup>	1.34 <sup>tn</sup>	1.68 <sup>tn</sup>	2.46

Note : \* : Significant; tn : No Significant Effect

Table 1 shows that there was a significant difference in the length of corn cobs between those treated with biochar and those without biochar. However, there was no significant difference in the length of corn cobs among plants that received different biochar treatments (Table 2). The application of 15 tons/ha of biochar resulted in the highest cob length, but it did not differ significantly from the application of 10 tons/ha of biochar. The use of biochar is believed to increase nutrient availability, ensuring an adequate supply of nutrients during corn cob formation. Biochar application can enhance soil fertility, especially for nutrients like N, P, and K, through improvements in soil physical properties, leading to better root growth and nutrient availability, ultimately promoting corn cob length (Herhandini, Suntari, & Citraresmini, 2021). The increased length of corn cobs can also be attributed to improved soil chemical properties, such as an increase in N and P content in the soil. According to Sirajuddin and Lasmini (2010), sufficient N during the generative phase can support cob formation. Supported by Hawalid (2019) who stated that N and P nutrients are continuously absorbed by the plant until corn approaches maturity, while K is needed during the formation of female corn flowers (silking). Additionally, P is more dominantly involved during the generative phase, especially in cob formation, in sweet corn. Plants lacking P nutrients may produce imperfect cobs, with small and often abnormal cob sizes.

There was a significant effect in the diameter of corn cobs between those treated with biochar and those without biochar (Table 3). However, there was no significant difference in the diameter of corn cobs among plants that received different biochar treatments (Table 3). The application of 15 tons/ha

of biochar resulted in the highest cob diameter, but it did not differ significantly from the application of 10 tons/ha of biochar. The increase in corn cob diameter is attributed to the nutrient retention capacity and availability provided by biochar compared to other organic materials such as compost or manure. This is especially true for nutrients like phosphorus (P), which are not readily retained by common organic materials. According to Luta et al. (2020), biochar plays a role in Cation Exchange Capacity (CEC), allowing it to bind soil cations that can be utilized by plant growth. Additionally, biochar has high and persistent nutrient absorption capabilities in the soil. The effect of biochar on plant productivity depends on the amount added. As shown in this study, an increase in the dosage of biochar can enhance the diameter of corn cobs.

Table 2  
 Tukey Test on the Effect of Single Factor Biochar on the Length of Corn Cobs

Application	Length of Corn Cobs (cm)
B0 = without biochar	19.21 a
B1 = 10 ton/ha	20.49 b
B2 = 15 ton/ha	20.98 b

Note: The numbers accompanied by the same letters in the same column indicate non-significant differences in the Tukey test at the 5% level of significance.

Table 3  
 Tukey Test on the Effect of Single Factor Biochar on the Diameter of Corn Cobs

Application	Diameter of Corn Cobs (cm)
B0 = without biochar	11.08 a
B1 = 10 ton/ha	12.82 b
B2 = 15 ton/ha	13.36 b

Note: The numbers accompanied by the same letters in the same column indicate non-significant differences in the Tukey test at the 5% level of significance.

The application of 20 tons/ha of rice straw trichocompost resulted in the highest diameter of corn cobs compared to the treatment without biochar (Table 4). However, the application of 20 tons/ha of trichocompost did not differ significantly from the treatments of 10 tons/ha and 15 tons/ha of trichocompost. The increase in corn cob diameter can be attributed to the nutrient content present in the trichocompost, especially phosphorus (P). According to Mulyanti, Usman, and Wahyudi (2015), phosphorus can enhance fruit formation, and its availability as a component of ATP ensures an adequate energy supply for growth, facilitating the formation of assimilates and their transportation to storage sites, thus leading to the production of larger cobs. Phosphorus plays a crucial role in the cob development, and potassium is also essential for cob filling, ensuring that the cob is fully packed with kernels.

Table 4  
 Tukey Test on the Effect of Single Factor Trichocompost on the Diameter of Corn Cobs

Application	Diameter of Corn Cobs (cm)
K0 = Without Trichocompost	11,60 a
K1 = 10 ton/ha	12,39 ab
K2 = 15 ton/ha	12,61 ab
K3 = 20 ton/ha	13,10 b

Note: The numbers accompanied by the same letters in the same column indicate non-significant differences in the Tukey test at the 5% level of significance.

The application of 15 tons/ha of biochar (B2) resulted in the highest dry weight of corn cobs compared to the treatment without biochar (B0) (Table 5). However, the application of 15 tons/ha of biochar (B2) did not differ significantly from the treatment of 10 tons/ha of biochar. The increased yield of corn plants can be attributed to the improvement in soil physical, chemical, and biological properties, leading to enhanced soil fertility.

The improvement in soil physical and biological properties supports root development in the soil, which in turn enhances nutrient uptake in corn plants. Biochar from rice straw contains micro-pores that can serve as a habitat for the growth of microorganisms, reducing competition among them and ultimately increasing soil biological activity. Higher soil microorganism activity can improve nutrient availability in the soil, leading to better nutrient uptake by plants and increasing crop yield (Mangunsong, Soemarsono, & Zudri, 2019).

Table 5  
 Tukey Test on the Effect of Single Factor Biochar on the Dry Weight of Corn Cobs

Application	Dry Weight of Corn Cobs (gram)
B0 = Without biochar	18,63 a
B1 = 10 ton/ha	31,52 b
B2 = 15 ton/ha	33,25 b

Note: The numbers accompanied by the same letters in the same column indicate non-significant differences in the Tukey test at the 5% level of significance.

The application of 20 tons/ha of trichocompost (K3) showed a significant difference compared to the treatment without trichocompost (K0) in terms of the dry weight of corn cobs (Table 6). However, the application of 20 tons/ha of trichocompost (K3) did not show a significant difference compared to the treatments of 10 tons/ha of trichocompost (K1) and 15 tons/ha of trichocompost (K2). The nutrients phosphorus (P) and potassium (K) present in the trichocompost play a role in cob formation (Anjani, Sjojfan, & Puspita, 2016). In particular, phosphorus influences cob and seed size development, while potassium is involved in accelerating nutrient translocation to enhance cob quality. When sufficient phosphorus is available, cob development improves. Trichocompost provides essential macro and micronutrients, contains humic acids, increases soil cation exchange capacity, enhances soil microorganism activity, and can help improve soil pH. The findings of this study are consistent with Situmeang et al. (2016) who reported that the best growth response of corn plants was obtained with the application of 20 tons/ha of compost fertilizer.

Table 6  
 Tukey Test on the Effect of Single Factor Trichocompost on the Dry Weight of Corn Cobs

Application	Dry Weight of Corn Cobs (gram)
K0 = Without Trichocompost	19,39 a
K1 = 10 ton/ha	29,69 b
K2 = 15 ton/ha	31,39 b
K3 = 20 ton/ha	30,72 b

Note: The numbers accompanied by the same letters in the same column indicate non-significant differences in the Tukey test at the 5% level of significance.

The application of rice straw biochar at a dose of 15 tons/ha resulted in the highest dry weight of corn kernels (*pipilan kering*) and showed a significant difference compared to the treatment without biochar (Table 7). However, there was no significant difference in the treatment with a biochar application of 10 tons/ha. This is attributed to the water retention capacity of biochar, where water is crucial for the growth and yield of corn (Ling Li et al., 2021). The yield of corn kernels is significantly influenced by the amount of water supplied during the flowering phase. Water deficiency can lead to decreased

yields. Several studies have shown that water deficiency during the three weeks after tassel emergence can reduce yields by up to 30%, while water deficiency during the flowering stage can reduce the number of formed kernels (Amaru et al., 2013).

Table 7  
 TUKEY test on the Effect of Single Factor Biochar on the Dry Weight of Corn Kernels

Application	Dry Weight of Corn Kernels (gram)
B0 = Without biochar	11,96 a
B1 = 10 ton/ha	22,88 b
B2 = 15 ton/ha	23,15

Note: The numbers accompanied by the same letters in the same column indicate non-significant differences in the Tukey test at the 5% level of significance.

The application of trichocompost at a dose of 15 tons/ha resulted in the highest dry weight of corn kernels (*pipilan kering*) and showed a significant difference compared to the treatment without trichocompost (Table 8). However, the application of trichocompost at a dose of 15 tons/ha did not show a significant difference compared to the treatments of 10 tons/ha and 20 tons/ha of trichocompost. This indicates that the application of trichocompost has a positive effect on the yield of corn plants, especially at a dose of 15 tons/ha. The addition of trichocompost from rice straw can improve soil structure, balance soil aggregation levels, enhance microorganism activity, and improve the soil's water-holding capacity (Masulili, Suryani, & Sutikarini, 2022). Moreover, the addition of trichocompost provides a supply of nutrients for the growth and yield of corn plants. According to Pranata (2011), phosphorus (P) influences cob and seed size development, while potassium (K) plays a role in accelerating nutrient translocation to enhance cob quality. Supported by Sari (2011), higher levels of potassium lead to more complete seed formation and filling.

Table 8  
 Tukey Test on the Effect of Single Factor Trichocompost on the Dry Weight of Corn Kernels

Application	Dry Weight of Corn Kernels (gram)
K0 = Without Trichocompost	13,75 a
K1 = 10 ton/ha	19,44 ab
K2 = 15 ton/ha	22,53 b
K3 = 20 ton/ha	21,58 ab

Note: The numbers accompanied by the same letters in the same column indicate non-significant differences in the Tukey test at the 5% level of significance.

## CONCLUSIONS

The application of biochar alone significantly affected the length of corn cobs. However, the application of trichocompost and the interaction between both treatments did not show a significant effect on the length of corn cobs. Both biochar and trichocompost applied individually had a significant effect on the diameter, dry weight of corn cobs, and dry weight of corn kernels. However, the interaction between the two treatments did not show a significant effect on the diameter, dry weight of corn cobs, and dry weight of corn kernels. The application of both biochar and trichocompost had a positive impact on increasing corn yield compared to without their application. The optimal dosage of biochar for improving corn plant yield in Ultisol soil was found to be between 10 to 15 tons/ha. Meanwhile, the best dosage of rice straw trichocompost for enhancing corn plant yield in Ultisol soil was between 15 to 20 tons/ha.

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