

# Characteristics of latosol soil after application of rice husk biochar in Bogor Regency, Indonesia

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**Abstract.** Latosol soil is one of the predominant soil types in the Bogor region, but it is characterized by low nutrient content. One approach to improving soil conditions is the use of biochar as a soil amendment. Biochar, being rich in carbon, has the potential to enhance soil quality. This study aimed to examine the characteristics of soil after the application of rice husk biochar. The application of rice husk biochar was found to influence the characteristics of latosol soil. Higher biochar doses resulted in increased soil electrical conductivity and total carbon content, with the highest values recorded at a treatment level of 125 tons/ha, reaching 335.7  $\mu$ S/cm and 4.71%, respectively. In this study, the addition of biochar had no effects on soil pH and total nitrogen content. Additionally, silicon content in the soil was enhanced by the application of rice husk biochar. Overall, the application of rice husk biochar can improve the quality of latosol soil in Bogor Regency.

## 1 Introduction

Agricultural land degradation, particularly the decline in soil fertility due to intensive agricultural practices, is a pressing global issue [1, 2, 3]. This phenomenon is further exacerbated by the excessive use of chemical fertilizers, as in Bogor Regency, Indonesia [4, 5]. The dominance of Latosol soils in this region, whose characteristics are susceptible to degradation due to high rainfall and improper management, further complicates the problem. Previous studies by Suratman et al. [6] have shown that Latosol soils in Bogor Regency have

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a crucial role in supporting agricultural activities. But also face serious challenges in maintaining their productivity [7].

Latosols are formed through strong weathering and laterization in tropical climates, with strong leaching of alkali and alkaline earth metals [8]. Yang et al. [9] observed that latosols are very deficient in phosphorus and potassium, and overall soil fertility is quite low. High acidity, leaching, weathering, low fertility, and high exchangeable aluminum content are common characteristics in more than 60% of soils, where Latosols and Argisols are the dominant soil types [10]. The challenge faced by these soils is their low fertility, which often requires improvement through the application of organic matter and other ameliorants [7]. One of the ameliorants that is currently being widely developed is biochar.

Biochar is a carbon-rich material produced through the pyrolysis of biomass with limited oxygen. Biochar also plays an important role in increasing soil fertility, by increasing the availability of nutrients and the stability of organic matter in the soil. In addition, biochar can improve water retention in the soil, making it very useful for agricultural land in dry areas or with low rainfall [11]. Biochar applied to the soil can increase the Cation Exchange Capacity (CEC) and pH by up to 40%. The high availability of nutrients is the result of increased nutrition and nutrient retention obtained from the addition of biochar [12].

Biochar is beneficial for latosols to improve soil structure and increase total soil carbon [13]. Through incubation experiments in tropical latosols, biochar showed its ability to increase soil pH, cation exchange capacity, and urease activity, but had no impact on acid phosphatase activity [14].

On the other hand, some farmers burn rice residues as a cheaper and more convenient option for managing rice waste [15]. Meanwhile, rice husks are a highly potential raw material for producing biochar. The application of rice husk biochar on sandy soils has been shown to improve soil quality and act as a liming agent to increase soil pH [16]. However, information regarding the application of rice husk biochar on latosol soil in Bogor Regency remains limited. Therefore, the objective of this study was to assess the post-application effects of rice husk biochar by analyzing changes in the chemical characteristics of latosol soil in Bogor Regency. This research provides insights into how biochar interacts with latosol soil in tropical agriculture and offers practical recommendations for soil management in Bogor and similar regions.

## 2 Method

This study was conducted in the greenhouse facility of the National Research and Innovation Agency (BRIN) at the Soekarno Science and Technology Park, Cibinong District, Bogor Regency, West Java Province, from January 2024 to May 2024.

The materials used in the study included latosol soil obtained from Cibinong District and rice husk biochar. The latosol soil was air-dried, ground, and sieved using a 2 mm mesh, while the rice husk biochar was finely ground and sieved through a 250-micrometer (60-mesh) sieve. The experiment employed a single-factor treatment design, which was the application dose of biochar. The treatment levels were as follows: B0: Control, B1: 25 tons/ha, B2: 50 tons/ha, B3: 75 tons/ha, B4: 100 tons/ha, and B5: 125 tons/ha. Each treatment was replicated three times.

Soil samples with the respective biochar treatments were incubated for four months under field capacity (moist) conditions. After incubation, the soil was air-dried and sieved using a 350-micrometer mesh. The sieved samples were then subjected to further analysis.

The chemical properties of the soil were analyzed as follows: pH was measured using a HORIBA LAQUAtwin pH11 meter. Electrical conductivity was determined using a HORIBA LAQUAtwin EC11 meter. Total soil carbon and total soil nitrogen were analyzed using a Leco CHN 628 analyzer. Elemental composition was analyzed using X-ray

fluorescence (XRF) with a Bruker S2 PUMA instrument. The analysis results were averaged and discussed descriptively.

### 3 Results and Discussion

#### 3.1 Results

The application of biochar at varying doses on latosol soil demonstrated diverse effects. In this study, the addition of biochar did not show a significant influence on soil pH. As illustrated in Figure 1, the pH values across all treatments generally fell within the same range and remained in the acidic category.

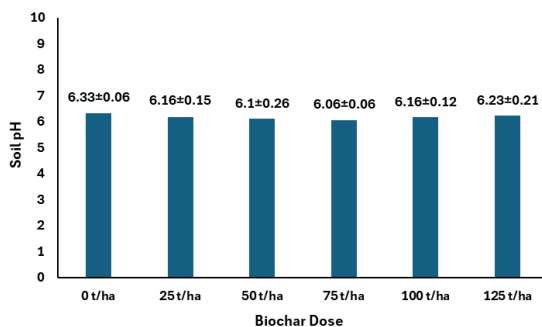


Fig. 1. Soil pH condition after applying biochar.

Fig. 2 illustrates that the application of biochar at various doses has differing effects on electrical conductivity (EC). The highest EC value was observed in the B5 treatment (125 tons/ha), reaching 335.66  $\mu\text{S}/\text{cm}$ , while the lowest was recorded in the B1 treatment (control), at 136  $\mu\text{S}/\text{cm}$ . This indicates that EC values increase with higher levels of biochar application. According to Chintala et al. [17], untreated acidic soils exhibit an electrical conductivity (EC) of approximately 92.8  $\mu\text{S}/\text{cm}$ . This value increased to 130  $\mu\text{S}/\text{cm}$  following the application of 104 tons/ha of corn stover biochar and further increased to 240  $\mu\text{S}/\text{cm}$  with an application of 156 tons/ha.

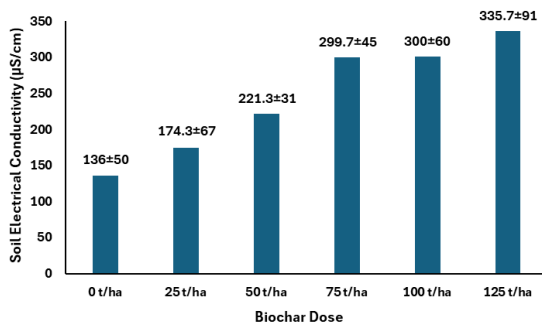
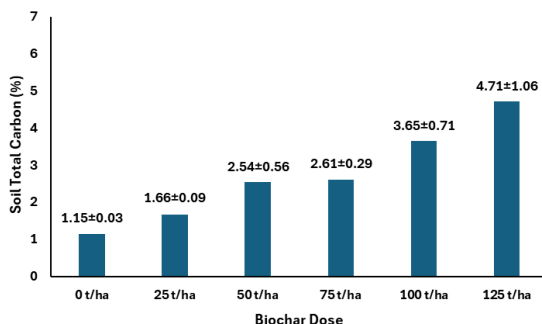


Fig. 2. Soil electrical conductivity condition after applying biochar.

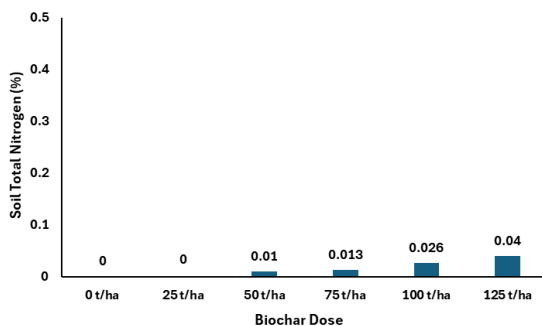
Figure 3 shows that the application of biochar influences the total carbon content in the soil. The highest total carbon content was observed in the B5 treatment (125 tons/ha), reaching 4.71%, while the lowest was recorded in the B0 treatment (control) at 1.15%. This indicates that the total carbon content increases with higher levels of biochar application.

This finding aligns with the study by Wu et al. [13], which reported that the addition of biochar to soil can enhance the total carbon content.



**Fig. 3.** Soil total carbon condition after applying biochar.

Based on Fig. 4, there is an indication of nitrogen content in the soil. Nitrogen in the soil was starting detected with the application of biochar at a dosage of 50 tons/ha. Although the detected nitrogen concentration is very low, its presence suggests that biochar may influence nitrogen levels in the soil. Furthermore, the nitrogen content increases with higher biochar dosages, indicating potential for biochar to affect soil nitrogen. Over the long term, the application of biochar is expected to enhance nitrogen content in the soil.



**Fig. 4.** Soil total nitrogen condition after applying biochar.

**Table 1.** Element content of soil.

No	Element (Oxide form)	B0 (Control)	B5 (125 ton/ha)
		Percentage (%)	
1	SiO <sub>2</sub>	37.553	40.251
2	Al <sub>2</sub> O <sub>3</sub>	35.665	34.040
3	Fe <sub>2</sub> O <sub>3</sub>	20.577	19.668
4	MgO	1.075	1.034
5	P <sub>2</sub> O <sub>5</sub>	0.915	0.900
6	SO <sub>3</sub>	0.445	0.349
7	Cl	0.197	0.247
8	K <sub>2</sub> O	0.121	0.169
9	CaO	0.416	0.434
10	MnO	0.529	0.493

Table 1 compares the elemental composition of soil without biochar application (control) and soil treated with biochar at a dosage of 125 tons/ha. The elemental analysis, conducted using X-ray fluorescence (XRF), provides data in terms of percentage composition rather

than absolute concentrations. As shown in Table 1, at least 10 dominant elements were detected, namely SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, MgO, P<sub>2</sub>O<sub>5</sub>, SO<sub>3</sub>, Cl, K<sub>2</sub>O, CaO, and MnO.

The table highlights that SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, and Fe<sub>2</sub>O<sub>3</sub> are the primary components in the analyzed samples. Following biochar application, changes in elemental percentages were observed, with an increase in SiO<sub>2</sub> and a decrease in Al<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub>. This alteration is likely attributable to the addition of biochar to the soil, as rice husk biochar predominantly contains Si as its major component.

### 3.2 Discussion

In this study, biochar did not significantly influence soil pH. This may be attributed to the pH characteristics of the biochar itself, as the applied biochar did not exhibit high alkalinity due to its production at relatively low temperatures. Consequently, when applied to the soil, it did not alter the soil pH. The alkalinity of biochar generally increases with higher pyrolysis temperatures. However, the biochar used in this study was produced using traditional methods, which likely involved low-temperature combustion processes [18].

Furthermore, the application of biochar appears to influence soil electrical conductivity (EC). Soluble salts in the soil are directly proportional to EC; thus, changes in EC values can be used to predict variations in soil salinity [19]. Upon the application of biochar, soil EC values increased significantly, which can be attributed to the soluble ash content in biochar, thereby enhancing soil base saturation [20]. These findings align with research conducted by Fernandes et al. [21], which demonstrated that biochar application affects soil electrical conductivity, with EC values increasing as the biochar dosage applied to the soil rises.

Biochar is a carbon-rich material produced through the pyrolysis of organic matter under low-oxygen conditions. Its high carbon content and fire-resistant properties enable it to persist in the soil for extended periods, effectively enhancing the overall soil carbon storage. According to Hidayat et al. [22] the carbon content of rice husk biochar pyrolyzed at 250°C reached 38.11%. Incorporating biochar into soil can subsequently increase the soil's carbon content. In terms of total soil nitrogen content, an increase was observed following the application of biochar; however, the nitrogen content remained very low. This can be attributed to the nitrogen content in the biochar itself. According to Hidayat et al. [22], the nitrogen content in rice husk biochar pyrolyzed at 250°C was only 0.68%. This low nitrogen content results in a minimal impact on the soil nitrogen levels.

The silica content in soil treated with 125 tons/ha of biochar showed an increase, likely due to the high silica content in rice husk biochar. According to Hidayat et al. [22], the percentage of silica (Si) in rice husk biochar pyrolyzed at 250°C reached 85.35%. Furthermore, the application of biochar resulted in a slight reduction in the percentages of aluminum (Al) and iron (Fe) in the soil. This indicates a positive response to soil conditions.

### 4 Conclusion

The application of rice husk biochar can influence the characteristics of latosol soil. Increasing biochar dosage resulted in higher soil electrical conductivity and total soil carbon. In this study, the addition of biochar showed low impact on soil pH and total nitrogen content. Furthermore, the silicon element content was raised by applying rice husk biochar. By applying rice husk biochar can improve the soil quality.

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