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Study of Lerak *(Sapindus Rarak)* Biochar Application for Andosol Agricultural Soil Remediation

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Abstract. Andosol is a type of soil that has a high nutrient content and is suitable for agricultural land. However, the use of pesticides in farming to increase and protect production from physical defects can cause a decrease in andosol soil quality. This study aims to determine whether the application of lerak biochar can improve the quality of andosol soil on the parameters of pH, organic carbon and total nitrogen based on the Soil Quality Standard of the Indonesian Agricultural Environmental Research Institute in 2009. The experiment was carried out by applying 0.805 g of biochar to 2 kg of andosol soil that already add by urea, KCl, insecticides and fungicides in standard dosages. The results showed that the quality of the andosol soil increased from the acidic category to slightly acidic in the pH category (6.01). The medium category became high for organic carbon (4.85%) and the medium category became high for total nitrogen (0.58%). This statement is evidenced by the results of the t-test which shows that there is no difference between the average value of each parameter and the respective standards. This means that the value meets the existing standard category.

Keywords: Andosol Soil, Lerak Biochar, pH, Total Nitrogen, Organic Carbon

1. Introduction

Based on data released by the Ministry of Environment and Forestry (MoEF) in 2018 in Indonesia there were 14,000,000 hectares of critical land. [1] One of the causes of soil damage is the agricultural sector which is not environmentally friendly. The agricultural sector is one of the backbones of the Indonesian economy. Agriculture and vegetable plantations are the main food commodities with production demands that continue to increase in line with the increase in population and industrial development. This encourages farmers to increase the use of inorganic fertilizers at each harvest season to get abundant yields with good products. Fertilizer applications tend to be uncontrolled and cause problems with the nutrient content in the soil. [2]

Agricultural areas in Indonesia are dominated by andosol soil types. Andosol soil is a blackish brown soil type, has a variety of characteristics, has low to high soil productivity and is suitable for agriculture. [3] Although andosol soils are suitable for agriculture, intensive application of inorganic fertilizers for a long period of time can cause residue accumulation in the andosol soil because plants generally cannot absorb 100% of chemical fertilizers. The remnants of chemical fertilizers left in the soil, when exposed

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to water will bind to the soil, so the soil will stick together and hard. Besides being hard, the soil also becomes acidic or has a low pH. This condition makes nutrient-forming organisms in the andosol soil die or their population decreases.[4] Therefore, it is necessary to make efforts to fix the problem of nutrient availability in andosol soil sample, one of which is the use of organic matter.

Currently, there is a technology called biochar. Biochar is a solid organic material such as carbon that is conserved from solid organic through incomplete combustion or limited oxygen supply. Biochar provides a habitat for soil microbes and is resistant to their attack. Generally, biochar persists in the soil for a relatively long time maintaining a balance of carbon-nitrogen. Biochar can retain the water and nutrients more available to plants. [5] Biochar, which is now known, is generally made from solid organic materials that are difficult to decompose, such as corn cobs, coconut shells, felt,wood and others.[6]

In this study, the author tries to find an alternative raw material using lerak fruit. Lerak *(Sapindus rarak)* is a plant known for its fruits which can be used as traditional detergents, but the saponins in lerak also have the potential as insecticides and pesticides (biopesticide). [7] So that motion has the potential tobe used as a good alternative raw material for biochar. In its application as an agricultural soil remediation agent, lerak biochar is applied togetherwith farmers' organic and inorganic fertilizers with appropriate doses to increase productivity and the availability of nutrients for plants.[8] The authors wanted to find out whether the application of lerak biochar can improved andosol agricultural soil quality on several biochemical properties (pH, total nitrogen, organic carbon). The study was conducted on real agricultural soils of the andosol order with acid pH, low organic carbon and low total nitrogen content due to intensive fertilization.

2. Research Method

2.1. Time and Place

The experiment period was conducted on June - July 2021 at Banjarnegara, Central Java. The result of this experiment was analyze at laboratory scale in Laboratory of Soil and Land Resources, Jendral Soedirman University, Purwokerto, Central Java.

2.2. Research design

This research is a field research with 1 control, 1 treatment compositions and 1 repetitions. So that there are 3 samples are obtained which are presented in the following table:

Table 1. Research design

Sample	Code	Spacing
Control	C	Urea 4.025 g KCl 1.543 g /pot Fungicide 0.123 g/pot Insecticide 3.36 g/pot
Fertilizer mix with Lerak Biochar	B1	Urea 4.025 g KCl 1.543 g /pot Fungicide 0.123 g/pot Insecticide 3.36 g/pot Lerak Biochar 0.805 g/pot
Fertilizer mix with Lerak Biochar	B2	

Th research uses 4 type of fertilizer, this kind of fertilizer is accordingly to fertilizer that commonly uses by Dieng farmers. [9] The treatment dose was based on recommendations from the Agricultural Environmental Research Institute, 2018. [10]

2.3. Soil sample preparations

The soil sample used was andosol soil originating from Dieng agricultural area, taken a two different points, namely at coordinates 7.202584185 109.85363211E and 7.188630195 109.88309496E on Pekasiran and Kepakisan, Batur, Dieng, Banjarnegara, Central Java. [11] Soil was taken at a depth of 0-20 cm from the soil surface. The soil used in laboratory research to check soil characteristics is 0.5 kg air dry weight, while for planting celery plants as much as 6 kg air dry weight. Then the soil was applied to the treatment by mixing the soil with lerak biochar according to the treatment dose.

2.4. Initial soil analysis

The soil used in this research is soil of the order andosol. Initial soil analysis was carried out to determine the nutrient content (pH, total nitrogen, organic carbon) of the soil before the treatment was applied. All soil criteria in this study were adjusted to the criteria based on the Soil Research Institute (2009).[12]

Table 2. Characterization of Andosol Soil Sample

Parameter	Values	Criteria
Organic Carbon (%)	2.143	Low
Total Nitrogen (%)	0.236	Low
pH	5.24	Acid

The results of the data analysis above come from Laboratory of Soil and Land Resources, Jendral Soedirman University, Purwokerto, Central Java. The results of the basic soil analysis (Table 1) showed that several criteria (pH, total nitrogen, organic carbon) were different from the general andosol soil conditions. Andsol soil in general has slightly acidic to neutral soil pH and high content of organic carbon and total nitrogen.[13]

2.5. Preparation of lerak (Sapindus Rarak) biochar

Lerak biochar is produced through a pyrolysis process using the Soil Pit method overnight at a temperature up to 200 degrees celsius. Soil pit is a traditional way of making biochar by using a 4-sided hole as a kiln. The traditional method is relatively simple and easy to practice. [6]

2.6. Lerak (Sapindus rarak) biochar analysis

The basic analysis was carried out to determine the characteristics of the lerak biochar used as a treatment in the study. The quality of lerak biochar is adjusted to the biochar standardization quality set by International Biochar Initiative (IBI). The laboratory result shows that lerak biochar have organic carbon and total nitrogen values 29.485% and 0.336% respectively. But for the pH it is have a value which were 6.22.

2.7. Preparation of celery seeds, planting and maintenance

The plant used is celery. Planting was carried out in pots containing the initial andosol soil sample. Each planting hole contains 5 celery seeds to anticipate the seeds that fail to grow. At first week after planting fertilizer and lerak biochar were applied according to the treatment dose. The maintenance of celery is carried out by watering and weeding the surrounding weeds. The experiment time was set for 30 days, following the conditions applied in the minimum biochar implementation which is 30-60 days.[14]

2.8. Observation parameters (Variables)

The parameters chosen for this experiment are pH, organic carbon and total nitrogen. Soil observations included analysis of pH H_2O 1:5 with Electrometry method, organic carbon with Kjeldahl method, and total nitrogen with Spectrophotometry method which was carried out on initial andosol soil samples and soil that had been treated with lerak biochar for 30 days.[15]

2.9. Data analysis

Data analysis was performed using Microsoft Excel. This study uses a two-sample variance test at 5% level to prove that each of the main parameters experienced an increase in soil quality after the addition of lerak biochar according to the Soil Quality Standard of the Agricultural Environmental Research Institute Indonesia in 2009. For the t-test, the null hypothesis is that the mean of all populations is the same (in this case it meets the expected standard ($P > 0.05$)

3. Result and Discussion

3.1 Soil Quality Result

3.1.1 pH

The application of lerak biochar has a significant effect on increasing andosol soil pH close to normal. The initial pH was 5.24 which is categorize in acid condition. After 30 days of experiments, the pH of soil sample with lerak biochar tratment has increase in value. The quality ofpH average value after treatments is 6.01 and categorized in slightly acid condition. The quality meets the quality standard of pH soil for celery which is 5.8-6.7.[16] The increase in pH occurred because biochar was able to increase the concentration of OH^- ions in the soil. The increase in pH occurs through several mechanisms, including (1) oxidation of organic acids in the decomposition process to produce OH^- ions; (2) decarboxylation of organic acids using H^+ ions; (3) Inorganic ammonification which produces OH^- ions; and (4) Al^{+3} binding by organic acids.[17]

3.1.2 Organic Carbon (%)

The initial organic carbon value was 2.143% which is categorize in low condition. After 30 days of experiments, the organic carbon value of soil sample with lerak biochar treatment has increase in value. The quality of organic carbon average value after treatments is 4.851% and categorized in high condition. This condition indicates that the andosol soil has improved in terms of organic carbon quality. The increasing of organic carbon value, it is based on the fact that biochar contains a high carbon content. Carbon is a food source for soil microorganisms so that the presence of organic carbon in the soil will stimulate activities as well as reactions that require the help of microorganisms. This is because biochar is dominated by C-stable compounds which can reduce C loss due to decomposition by soil microorganisms. [18]

3.1.3 Total Nitrogen (%)

The initial total nitrogen value was 0.236% which is categorize in low condition. But after treatment, the total nitrogen value of andosol soil sample with lerak biochar treatment has increase in value. The quality of total nitrogen average value after treatments is 0.5755% and categorized in high condition. The ability of biochar to increase soil moisture and pH stimulates the process of N mineralization and nitrification which causes plant uptake to increase. [19] The surface oxide on biochar is also effective in absorbing NH^{4+} and NO^{3-}. Biochar can increase CEC and good absorption capacity so that it can affect the function of the soil to retain nutrients. [20]

Table 3. Soil Quality (Experimental Result)

Parameter	Control	Criteria[c]	B1[a]	B2[b]	Average (B1:B2)	Criteria[c]
pH	5.25	Acid	6.16	5.89	6.01	Slightly Acid
Organic Carbon (%)	2.989	Medium	5.100	4.602	4.851	High
Total Nitrogen (%)	0.341	Medium	0.6	0.551	0.575	High

[a] Fertilizer mix with lerak biochar treatment 1.
[b] Fertilizer mix with lerak biochar repetition.
[c] Soil Quality Standard of the Agricultural Environmental Research Institute in 2009.

3.2 T-test result

3.2.1 pH

The t-test on the pH parameters compared with slightly acid standard showed that there was no significant difference between variable 1 and variable 2 ($P > 0.05$), meaning it was true that the addition of lerak biochar in andosol soil samples increased the quality of pH in andosol soil to slightly acid.

Table 4. t-test pH Result

Means			P one tail *(Alpha= 0.05, df=2*
Variable 1 (Lerak biochar treatment)	Variable 2 (Soil Quality Standard)		
	Value	Standard Criteria	
6.01	6	Slightly Acid	0.476[a]
6.01	5	Acid	0.011[b]

[a] $p > 0.05$ (no significant difference) between treatment and standard.
[b] $p < 0.05$ (significant difference) between treatment and standard.

3.2.2 Organic Carbon (%)

Both data of medium and low standard shows that the value of ($P < 0.05$) means that there is a significant difference between the organic carbon value with medium standard, and the organic carbon value with low standard. This indicates that the organic carbon value does not meet the medium and low standard but meets the high standard. This t-test result shows that the addition of lerak biochar can improve the andosol soil quality in the parameter organic carbon from low (initial sample) to high.

Table 5. t-test Organic Carbon Result

Means (%)			P one tail *(Alpha= 0.05, df=2*
Variable 1 (Lerak biochar treatment)	Variable 2 (Soil Quality Standard)		
	Value	Standard Criteria	
4.851	4.2	High	0.06[a]
4.851	2.7	Medium	0.0065[b]
4.851	1.5	Low	0.0027[b]

[a] $p > 0.05$ (no significant difference) between treatment and standard.
[b] $p < 0.05$ (significant difference) between treatment and standard.

3.2.3 Total Nitrogen (%)

The data of medium and low standard shows that the value of ($P < 0.05$) means that there is a significant difference between the total nitrogen value with medium standard and total nitrogen with low standard. This indicates that the total nitrogen value does not meet the medium and low standard but meets the high standard. This t-test result shows that the addition of lerak biochar can improve the andosol soil quality, in parameter total nitrogen from low (initial sample) to high.

Table 6. t-test Total Nitrogen Result

Means (%)			P one tail *(Alpha= 0.05, df=2*
Variable 1 (Lerak biochar treatment)	Variable 2 (Soil Quality Standard)		
	Value	Standard Criteria	
0.5755	0.63	High	0.07[a]
0.5755	0.35	Medium	0.0057[b]
0.5755	0.15	Low	0.001[b]

[a] $p > 0.05$ (no significant difference) between treatment and standard.
[b] $p < 0.05$ (significant difference) between treatment and standard.

4. Conclusion

In conclusion, the lerak biochar application can improve the andosol soil quality in 30 days become slightly acid category for pH (6.01), high category for organic carbon (4.85%) and high category for total nitrogen (0.58%) based on Soil Quality Standard of the Agricultural Environmental Research Institute Indonesia in 2009 and proven by the t-test result.

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