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Analysis Of The Effect Of Leaf Litter Thickness On Soil Organic Carbon And Total Nitrogen In Coffee Plantations With Different Shade Plants In East Java, Indonesia

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Abstract

Each type of shade plant has different characteristics and number of leaves so that the aborted leaves will have different thicknesses. The difference in litter thickness will affect the quality of the soil, especially the organic carbon and nitrogen content in the soil. This study will examine the effect of leaf litter thickness on Soil Organic Carbon (SOC) and Total Nitrogen (TN) as well as soil pH levels in coffee plantations with different shade plants. The sampling method used the quadrant method and used the Spearman correlation test to determine the effect of leaf litter thickness on SOC and TN thickness and soil pH. This study found that each shade plant has a different effect on the amount of SOC, TN and pH. The thickness of leaf litter on the soil affects the amount of SOC and TN of the soil. The thickness of the litter affects the pH level of the soil on the surface because of leaf litter.

Keywords: Shade Plants, Litter leaves, SOC, TN, pH.

INTRODUCTION

Indonesia is one of the largest coffee producing countries in the world. According to World Markets and Trade 2021, Indonesia is ranked fourth as the largest coffee producing country in the world after Brazil, Vietnam, and Colombia (Usda, 2021; Slavova 2019). Coffee plantations in Indonesia are mostly cultivated on smallholder plantations which reach an average area of 999.17 thousand hectares while the rest are state-owned and private coffee plantations (Sarvina, 2021: Fitriani, 2021). The most widely cultivated type of coffee in plantations is Robusta coffee which reaches 81.9% with an average area of 1.04 million hectares so that Robusta coffee has a coffee production that dominates Arabica coffee, which is 75.4%. While the remaining Arabica coffee production is 24.6%. Coffee production from 2020 and 2021 shows production at 1,250 million tons and 1,258 tons (Plantation Directorate 2019). Based on the coffee production data, the increase in coffee production has not been significant, so an evaluation is needed to increase coffee production. Coffee production can be influenced by many factors, including cultivation factors such as coffee plantation management, coffee age, land area and amount of coffee, coffee shade plants, pests and diseases (Kudama, 2019). One of the important factors influencing coffee production is the management of coffee shade plants (Ayalew, 2018). According to research by Neto (2018), Shao (2014) that coffee shade plants have an effect on coffee production. Coffee plants that have a 50% shade of incoming light have higher coffee production compared to coffee plants that have less or more than 50% shade.

Coffee is cultivated in almost all provinces, but the largest coffee producers are in the provinces of South Sumatra, Lampung, East Java and South Sulawesi (Martauli 2018). According to Khusnul's research (2019) that coffee plantations in Indonesia have various shade plants, including Avocado (Persea americana), Banana (Musa paradisiaca), Lamtoro (Leucaena leucephala), Coconut (Cocos nucifera), Gamal (Gliricidia sepium) and Sengon. (Falacataria mollucana). Based on the data on the type of shade plant used, it is still not in accordance with the requirements for shade plants that can be used for coffee shade. According to Alemu (2015), Premono (2018) that plants that can be used for coffee shelters must comply with the requirements for coffee shade plants, including shaders having deep roots that can minimize soil mineral competition, maintain soil erosion and maintain soil moisture. The recommended shade plants are plants belonging to the Leguminosae family. Suitable shade plants belonging to the Leguminosae family include Falacataria mollucana, Leucaena leucephala and Gliricidia sepium.

Shade plants have the impact of different abiotic factors on coffee plantations according to the characteristics of the type of shade plants used. Abiotic factors that affect the form of air temperature, humidity, light intensity, soil pH, soil moisture, leaf litter on the soil (Khusnul, 2021). One of the factors that need to be investigated further is leaf litter on the soil. Each type of shade plant has different characteristics and number of leaves so that the aborted leaves will have different thicknesses. The difference in litter thickness will affect the quality of the soil, especially the organic carbon and nitrogen content in the soil. According to Zhou's research (2015) that the level of litter thickness (litter decomposition) affects the dynamics of soil dissolved organic carbon (DOC) and dissolved nitrogen (DN). The litter carbon mass controlled the DOC and the hemicellulose mass controlled the DN concentration. The analysis of the main components of litter decomposition showed that there was litter degradation which resulted in variations in DOC concentrations of 61.3% and DN concentrations of 71.2%. Another study according to Amorim (2022) that changes in soil organic carbon and soil fertility varies by tree species and fertilization, largely because each tree species has a distinctive leaf litter and different nutrient inputs. Based on several studies above that leaf litter on the soil produced by trees affects soil quality. Tree species also have different effects on soil quality because each tree species has distinctive leaves.

According to research by Franklin (2019) that leaf litter on the soil will have an influence on soil organic matter, especially on the upper soil surface. Leaf litter on the soil produced on each type of coffee shade plant will definitely be different and can affect the quality of the soil in the coffee plantation. Soil quality will affect the fertility of coffee plants, especially on the absorption of soil nutrients which will have an impact on the development, growth, fertilization and production of coffee cherries. According to Ghimire (2018), soil not only functions in the production of food and fiber, but also plays a role in maintaining environmental quality which has an impact on the plants themselves, so it is important to increase the value of soil quality. Therefore, based on the explanation above, it is necessary to conduct research on the quality of the soil in coffee plantations with different types of shade plants. The research findings are expected to help community, private and state-owned coffee farmers to make decisions on the right use of coffee land in accordance with the shade plants used. This study will examine the effect of leaf litter thickness on soil organic carbon (SOC) and total nitrogen (TN) as well as soil pH levels in coffee plantations with different shade plants.

METHODOLOGY

Research Place

This research was conducted in the tip of East Java in the city of Jember which is located in the central part of Indonesia. This research site is

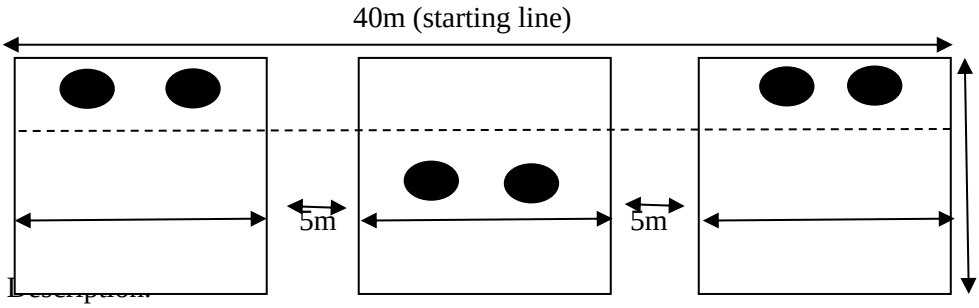
astronomically located between 6º27'29" - 7º14'35" East Longitude and 7º59'6" - 8º33'56" South Latitude and has an area of 3,293.34 Km2 (Nurdin, 2018). The research area is one of the largest coffee producers in Indonesia, so it has a lot of coffee plantations that are cultivated by the community, private sector and the state. Coffee plantations that are cultivated in this area use various types of shade plants. Sampling was carried out on three coffee plantations with shade plants Leucaena leucephala, Gliricidia sepium and Falacataria mollucana. The selection of this type of shade plant is based on shade plants that have appropriate requirements for coffee shade plants, namely the recommended shade plants, namely plants belonging to the Leguminosae family (Alemu (2015), Premono (2018). The following is Figure 1 coffee plantation soil sampling.

(a) (b) (c)

Figure 1. Coffee plantations where samples were taken
(a) Leucaena leucephala, (b) Gliricidia sepium, (c) Falacataria mollucana

Sampling method

Sampling was carried out on three coffee plantations with different shade plants, namely Leucaena leucephala, Gliricidia sepium and Falacataria mollucana. The three plantations have coffee plants that are 4-5 years old and are already producing. The sampling method was carried out using the quadrant method, namely the method of using plots. Determination of the first sampling by making a plot of three. The following Figure 2 is a plot determination technique using the quadrant method.



Description:
: Coffee Plant
---:-Location of Shade Plants

Figure 2. Sample plot for sampling

After making the plots, soil samples were taken in each plot and the three were mixed. This was done on three coffee plantations that have different shade plants. Soil samples taken were only the soil on the top, namely the 0-15cm plow layer to measure SOC, TN and soil pH. Soil samples taken about 500 g of the excavated layer mixture were then put into plastic bags, labeled and transported to the laboratory for further analysis. Soil samples were analyzed for indicators of certain chemical properties. Soil chemical properties were determined as follows: SOC using the Walkley and Black method (SNI 19-7030-2004), TN using the

Kjeldahl method (SNI 19-7030-2004) and soil pH (SNI 2803:2010).

Assessment Method

The assessment method was developed by NARC (1993), this assessment is used as a category to determine SOC and TN. The following is Table 1 and Table 2 for the determination of SOC, TN and pH categories.

Table 1. Category Determination of SOC

Range (%)	Category
<0,5	Low
0,5-1	Mod Low
1,1-2	Moderate
2,1-4	Mod High
>4	High

Table 2. Category Determination of TN

Range (%)	Category
<0,05	Low
0,05-0,09	Mod Low
0,10-0,15	Moderate
0,16-0,20	Mod High
>0,2	High

Table 3. Category Determination of pH

pH	Kategori
<4.5	Strongly Acidic
4,5-5,5	Moderately Acidic
5,6-6,5	Weakly Acidic
6,6-7,5	Near;y Neutral
>7,5	Alkaline

Statistical Analysis

Data analysis to find the relationship between leaf litter levels in the soil with SOC, TN and pH using statistical software IBM SPSS version 23.0 and Microsoft Excel 2010. Spearman correlation test which will be used to test the relationship between leaf litter levels in soil with SOC and TN.

RESULTS

This study revealed the SOC, TN and pH values of the three coffee plantations with different shade plants and the effect of leaf litter on the soil produced by shade plants on SOC, TN and pH. The following table shows the results of observations of leaf litter thickness on soil, SOC and TN test values in coffee plantations with three different coffee shade plants, namely Leucaena leucephala (LL), Gliricidia sepium (GS) and Falacataria mollucana (FM).

Table 1. Test Results SOC and TN

Shade Plant	Litter	SOC	TN

	Average Thickness (cm)	Category	Average Test Results(%)	Category	Average Test Results(%)	Category
LL	2,5	Little Thick	2,546	Moderate High	0,119	Moderate
GS	1,5	Thin	1,766	Moderate	0,010	Low
FM	1,2	Very Thin	1,751	Moderate	0,036	Low

The thickness of the litter found in observations on each shade plant has a different thickness of litter. Leucaena leucephala litter thickness of 2.5 cm which is included in the slightly thick category, Gliricidia sepium has a litter thickness of 1.5 cm which is included in the thin category and Falacataria mollucana has a litter thickness of 1.2 cm which is included in the very thin category. Based on the results of observations of the thickness of the litter above, Leucaena leucephala has the highest litter thickness of 2.5 cm.

The SOC found in each shade plant has a different value. SOC Leucaena leucephala has an average value of 2.546% with a close to high category, while Gliricidia sepium has an SOC value of 1.766% which has almost the same value as the SOC value of Falacataria mollucana with an average of 1.751%, both of which are in the medium category. Leucaena leucephala had the highest SOC value when compared to the other two shade plants. Meanwhile, TN was found in each shade plant, namely Leucaena leucephala which had an average TN of 0.119% which was included in the medium category, Gliricidia sepium had an average TN of 0.10% in the low category and Falacataria mollucana had an average TN of 0.36%. Based on the test results, the highest TN value is Leucaena leucephala, 0.119%, which has a relatively higher value than the other two shade plants. In Figure 1 is a graph of the results of litter thickness, SOC and TN test values on the three coffee shade plants.

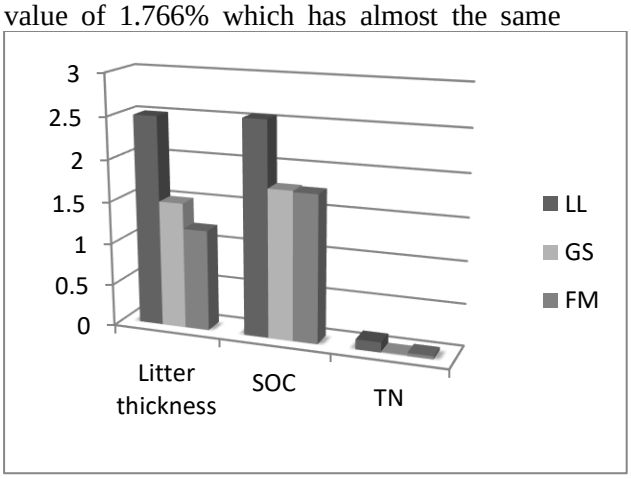


Figure 1. Litter thickness, SOC and TN
Leucaena leucephala (LL), Gliricidia sepium (GS) dan Falacataria mollucana (FM)

If the highest SOC value is associated with litter, it is based on observations that shade plants with the highest litter thickness will have higher SOC values. Meanwhile, the highest TN value was associated with litter, based on observations that shade plants with the highest litter thickness would have higher TN values. The following table shows the correlation between litter thickness and SOC and TN . values.

Table 2 Correlation of litter thickness with SOC and TN

SOC		TN	
Sig	**Correlation Coefficient**	**Sig**	**Correlation Coefficient**
0,000	0,960	0,001	0,918

Correlation of litter thickness with SOC and TN based on Table 2 seen from the significance, strength of the relationship and the direction of the relationship. The significance of litter thickness with SOC and TN has the same value, namely 0.000 < 0.050, which means that there is a relationship between litter thickness with SOC and TN. When the two have a relationship, it is necessary to know how strong their relationship is. The strength of the relationship between litter thickness and SOC and TN got values of 0.960 and 0.918, which means that the strength of the relationship is very strong. The direction of the relationship of litter thickness with SOC and TN has a positive relationship. Based on the results of the statistical analysis, litter thickness greatly influences the SOC and TN values. The following table shows the results of pH tests from coffee plantations in the shade plants Leucaena leucephala (LL), Gliricidia sepium (GS) and Falacataria mollucana (FM).

Table 3. Test Results pH

Shade Plant	Litter Thickness (cm)	Category	Average Test Results pH	Category
LL	2,5	Little Thick	6,85	Neary Neutral
GS	1,5	Thin	6,08	Weakly Acidic
FM	1,2	Very Thin	5,85	Weakly Acidic
Sig			0.001	
Correlation Coefficient			0,889	

The pH value found from each shade plant has a relatively different pH value. The shade plant Leucaena leucephala has an average pH value of 6.85 which is included in the near neutral category. The shade plant Gliricidia sepium has an average pH value of 6.08 which is included in the weak acid category. The shade plant Falacataria mollucana has an average pH value of 5.85 which is included in the weak acid category. Based on the results of the pH test of the three shade plants, Leucaena leucephala had the highest pH value of the other shade plants.
Correlation of litter thickness with pH based on Table 3 seen from the significance, strength of the relationship and the direction of the relationship. The significance of litter thickness with pH has the same value, namely 0.001 < 0.050, which means that there is a relationship between litter thickness and pH. When the two have a relationship, it is necessary to know how strong the relationship is. The strength of the relationship between litter thickness and pH got a value of 0.889 which means that the strength of the relationship is very strong. The direction of the relationship of litter thickness with pH has a positive relationship. Based on the results of the statistical analysis that the thickness of the litter greatly affects the pH value of the soil on the surface.

DISCUSSION

This study revealed that each shade plant has a different litter thickness. The highest litter thickness was owned by coffee plantations which had shade plants Leucaena leucephala with a litter thickness of 2.5%. This is because each shade plant will produce different leaf litter according to the characteristics and the number of leaves that are aborted. As in Babl's research (2019) that the thickness of leaf litter

produced by trees has different properties and thicknesses according to the characteristics of the leaves on the tree. The thickness of the resulting litter will have different impacts on the soil such as soil moisture, soil microorganisms, carbon allocation and can reduce drought. In a study by Lozano-baez (2021) conducting research on several coffee plantations with 15 different shade plants to see shade plants benefiting the soil, getting the results that shade plants benefit the hydrophilic attributes of the soil due to the presence of shade and leaf litter produced from shade plants. Leaf litter on each shade plant is different, thus affecting the hydrophilic level of the soil. In addition, research by Pinheiro (2022) found that leaf litter produced by shade has a different mass and has an effect on grass cover and biomass. The increase in ground leaf litter has an effect on the decrease in above-ground biomass. Based on several studies above, it is in line with the results of observations of the thickness of the litter in the three shade plants. The three shade plants produced different litter thicknesses according to the characteristics of these plants.

The SOC and TN values found in the three shade plants had different test values. Leucaena leucephala had the highest SOC and TN values when compared to the other two shade plants, respectively, with an SOC value of 2.546% in the close to high category and a TN value of 0.119% in the medium category. In Frouz's research (2017) that the litter layer will affect the amount of SOC and TN in the soil. This can happen because the presence of litter will affect the activity of soil microbes or soil fauna. Meanwhile soil fauna will affect the amount of SOC and TN that enter the soil and determine the rate of soil decomposition, so that the quality and volume of litter will affect the condition of fauna and fauna will affect the amount of SOC and TN in the soil. Another study by Jilkova (2020) that the decomposition of leaf litter will affect microbial respiration and will affect the carbon organik and nitrogen conditions of the soil. Leaf litter is a source of soil carbon organik and nitrogen, so the high and low levels of carbon organik and nitrogen are influenced by the amount and decomposition of litter and the microbes in it. In addition, Zhou's (2015) study found that litter carbon organik mass controlled and hemicellulose mass controlled nitrogen. Litter decomposition is the main factor controlling the dynamics of soil surface carbon organik and nitrogen. Based on this explanation, it is in accordance with the results of the study that the thickness of the litter affects the amount of SOC and TN of the soil. The highest litter thickness will have a higher SOC value. Meanwhile, the highest TN value was associated with litter. In line with the statistical correlation results, litter thickness greatly influences the SOC and TN values with a very strong and significant relationship.

The pH values found in the shade plants Leucaena leucephala, Gliricidia sepium and Falacataria mollucana had different pH levels, respectively, the average pH was 6.85, 6.08 and 5.85. The pH test results from the three shade plants Leucaena leucephala, had the highest pH value of the other shade plants, Leucaena leucephala also had the highest litter thickness of 2.5cm. Based on the test results, litter also affects soil pH, especially the top or surface soil. When viewed from the statistical calculation of the correlation between litter thickness and pH levels of each shade plant, both of them have a very strong correlation in a positive direction, so that litter thickness has a positive effect on pH levels. Tao's research (2019) revealed that leaf litter has an effect on the pH level of the surface soil. This is because the leaves have a leaf pH which when the leaves are decomposed it will affect the pH level of the soil. Leaf pH levels vary according to the content of basic cations and organic acids contained in the leaves. Leaf pH levels are also influenced by the level of leaf photosynthesis. Another study by Hassan (2021) found that soil exposed to Ficus retusa L. leaf litter showed lower pH but increased EC, which means that leaf litter on Ficus retusa L plants had phenolic compounds and minerals released from litter residue. Based on other studies above that each plant has different characteristics and content of leaf compounds, so that it can affect the pH level of the surface soil. In line with the results of this study, the pH levels of each shade plant were different. The highest and best pH level of

the shade plant Leucaena leucephala which means that the leaves on this shade plant have a positive effect on pH because the pH can be close to neutral.

CONCLUSION

From the results, data analysis and changes, it can be concluded that the thickness of leaf litter on the soil affects the amount of SOC and TN of the soil. Each shade plant has a different effect on the amount of SOC and TN, this is due to the difference in litter thickness in each different shade plant. Likewise with pH, the thickness of the litter affects the pH level of the soil on the surface because leaf litter has different compounds that will affect the pH level of the soil. Recommendations for further research are in-depth testing of the compounds in each leaf litter produced by the three shade plants.

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