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Analysis of Ground Cover Vegetation on Soil Chemical Properties at PT Cibaliung Tunggal Plantation, Cibaliung I Palm Oil Plantation, Rokan Hilir Regency, Riau Province

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Abstract

The productivity of oil palm (*Elaeis guineensis* Jacq.) is strongly influenced by the chemical fertility of the soil, which can be maintained or enhanced through the presence of ground cover vegetation. This study aims to analyze the effects of different types of ground cover vegetation on soil chemical properties in the Cibaliung I Estate Plantation of PT. Cibaliung Tunggal Plantation, Rokan Hilir, Riau. The research employed a survey method with purposive soil sampling at 0–30 cm depth across three distinct land conditions: areas covered with Nephrolepis biserrata, areas covered with Ottochloa nodosa, and open land without vegetation. Soil chemical properties tested in the Palm Oil Research Center (PPKS) laboratory included soil pH, total nitrogen (Total N), available phosphorus (Available P), and organic carbon (Organic C). Laboratory analysis revealed that ground cover vegetation significantly improves and maintains soil chemical quality compared to open land without vegetation. Areas covered with Nephrolepis biserrata exhibited the highest soil pH value of 5.4 (slightly acidic), attributed to its high biomass production, which suppresses leaching of soil bases, compared to more acidic land without vegetation (pH 4.6). Meanwhile, areas with Ottochloa nodosa were most effective at enhancing soil nutrient and organic matter fertility, recording the highest Total N value of 0.60% and the highest Available P concentration of 69.39 ppm, likely due to biomass decomposition and root-microenvironment activity. In contrast, open land without vegetation showed the lowest fertility, with a Total N value of only 0.08% and very low Available P (<0.01 ppm), resulting from high risks of surface erosion and nutrient leaching. This study concludes that the management and maintenance of ground cover vegetation such as Nephrolepis biserrata and Ottochloa nodosa are essential components of a sustainable soil conservation strategy in oil palm plantations. Ground cover vegetation plays a crucial role in maintaining and improving soil quality, thereby supporting sustainable oil palm plantation management.

Keywords: Land Without Vegetation, *Ottochloa nodosa, Nephrolepis biserrata*, Nitrogen, Soil pH

1. Introduction

Palm oil is a major plantation commodity that plays a vital role in the Indonesian economy. In 2024, Indonesia's palm oil production reached 45.44 million tons, a 3.5% decrease from 2023. The total area of oil palm plantations is approximately 16.01 million hectares, with Riau Province having the largest plantation area, followed by West Kalimantan, Central Kalimantan, East Kalimantan, and North Sumatra. These developments in palm oil production and exports demonstrate the importance of sustainable plantation management to maintain production stability and sustain its contribution to the national economy (Statistics, 2025).

Oil palm productivity is significantly influenced by soil fertility, including physical and chemical properties, and nutrient availability. Soil with good fertility supports optimal plant growth and sustainably increases oil palm production (Amu *et al.*, 2022). Conversely, decreased soil

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chemical fertility due to nutrient leaching and the absence of cover crops in open areas is a fundamental problem that triggers nutrient degradation. This condition directly contributes to reduced crop productivity, with macro implications for oil palm production. Managing soil chemical properties is a crucial aspect in maintaining oil palm plantation productivity. One effort to maintain soil chemical properties is through the use of cover crops, which have been shown to increase nutrient content and sustainably improve soil fertility (Haruna et al., 2025).

Ground cover vegetation is vegetation that grows on the soil surface and helps protect the soil from erosion, retain moisture, and increase soil organic matter. The presence of ground cover vegetation also improves the physical, chemical, and biological properties of soil through biomass decomposition, thereby increasing soil fertility and nutrient cycling (Quintarelli et al., 2022). In oil palm plantations, the diversity of ground cover vegetation types is thought to affect soil chemical properties differently. Hence, an analysis is necessary to determine the relationship between ground cover vegetation types and soil fertility conditions.

Although various studies have shown that ground cover vegetation plays a role in increasing soil fertility and improving the physical, chemical, and biological properties of the soil, studies on the influence of different types of ground cover vegetation on soil chemical properties in oil palm plantations are still limited, especially in the specific conditions of plantation locations in Indonesia. Each type of ground cover vegetation has distinct growth characteristics, biomass production, and decomposition capacity, potentially affecting soil nutrient dynamics. Therefore, more specific research is needed to analyze the relationship between the type of ground cover vegetation and changes in soil chemical properties in oil palm plantations (Pangestu *et al.,* 2025).

In oil palm plantations, particularly at PT Cibaliung Tunggal Plantation Cibaliung I, the diverse topography and high rainfall make the land vulnerable to soil degradation, including erosion and reduced physical soil fertility. Therefore, an in-depth analysis is needed to determine the most effective types of ground cover vegetation for maintaining soil physical properties and ensuring long-term land productivity and sustainable oil palm plantation management.

Ottochloa nodosa plant (often known as crocodile nest grass or paitan suket) has a dual nature in agriculture. On the one hand, it is often categorized as a weed due to its massive growth. However, this grass has the potential to have a positive impact when properly managed as a cover crop or biomulch. According to Suryana et al. (2020), the selected plants from vegetation analysis results that can be used as ground cover are Ottochloa nodosa and Nephrolepis biser*rata.* The criteria for plants that can be used as ground cover are easy to propagate, non-competitive, fast-growing, produce many leaves, and tolerant of shade. Previous research by (Bagus Setyawan, 2018) recommended the use of *Mucuna bracteata* for Inceptisol soil and *Nephrolepis biserrata* for Spodosol soil because in Inceptisol soil, Mucuna bracteata treatment gave the best chemical property improvement results (pH 4.6; C-Organic 10.22%; N-Total 1.62%) and in Spodosol soil, Nephrolepis biserrata treatment gave the best improvement results (pH 5.5; C-Organic 6.80%; N-Total 0.86%). Meanwhile, my research provides new information that the combination of *Nephrolepis biserrata* (superior in stabilizing pH) and *Ottochloa nodosa* (very superior in significantly increasing Total N and Available P) is an excellent soil chemistry conservation strategy in oil palm plantations.

Ground cover plants such as *Nephrolepis biserrata* are common weeds found in oil palm plantations and have a high tolerance for shade, making them potentially useful as ground cover crops in productive areas. The use of ground cover plants combined with conservation techniques such as terraces has been shown to reduce surface runoff, increase water infiltration, and support oil palm growth (Sibarani *et al.*, 2024).

Replanting oil palm plantations is an effective strategy for maintaining and ensuring the sustainability of the oil palm plantation industry in the future. However, this replanting process is not without challenges, particularly related to the reuse of land previously planted with oil palms. Reusing used land can cause various problems, such as decreased productivity due to soil structure degradation and changes in soil physical, chemical, and biological properties resulting from previous oil palm cultivation. The level of oil palm productivity on a given plot of land is highly dependent on the nutrient conditions and fertility of the soil. Therefore, to ensure the success of replanting activities and support optimal production outcomes, a comprehensive evaluation of the soil's physical, chemical, and biological properties in the area to be replanted with oil palms is necessary (Qishty et al., 2023).

This study aims to analyze the differences in the chemical properties of soil pH, total nitrogen (N), available phosphorus (P), and organic C in areas with fern vegetation (*Nephrolepis biserata),* crocodile nest *(Ottchloa nodosa),* and without vegetation at PT Cibaliung Tunggal Plantation Cibaliung I with a depth of 0-30 cm.

2. Material and Methods

This research was conducted at PT Cibaliung Tunggal Plantation Cibaliung I, Pasir Putih Village, Balai Jaya District, Rokan Hilir Regency, Riau Province. Astronomically, this plantation area is located at 01°44´30´´ N - 01°47´15´´ N and 100°32´40´´ E - 100°36´10´´ E with an altitude ranging between 25–65 meters above sea level (m asl). The research lasted for ± 3 weeks.

2.1. Tools and Materials

Tools used: notebook, knife, pencil/marker, documentation tools, plastic sample clips, hoe, digital scales, and equipment for analysis activities in the laboratory, according to the method for each observation variable. The materials used were mineral soil samples taken from land covered with Ottochloa nodosa vegetation. *Nephrolepis biserrata,* and without vegetation in the plantation of PT Cibaliung Tunggal Plantation Cibaliung I Planting Years 1889 and 1990.

This research was conducted from February 27 to March 17 using a 2-stage survey method. The first stage was a preliminary survey conducted on February 27 - March 4, and the second stage was a main survey conducted on March 5 - 10. In the first stage, the preliminary survey determined the research location and secondary data. The second stage of the main survey was to determine the soil sampling blocks and points. The soil samples obtained were analyzed at the Palm Oil Research Center (PPKS) Laboratory from March 3 - 17, 2026. Soil sampling was carried out by purposive sampling (intentional) at points that were overgrown with ground cover vegetation such as Ottchloa nodosa and Nephrolepis biserrata, as well as at points without vegetation. Soil samples taken from the field will then be analyzed at the Palm Oil Research Center (PPKS) Laboratory, followed by Data analysis and thesis. Observation parameters include soil pH, soil chemistry, total nitrogen (N), available phosphorus (P), and organic carbon. The implementation of the research includes several stages, namely:

2.1.1. Preparation & Determining Research Area

Research preparation is the initial step before conducting the research. This preparation involves obtaining legal permits and determining the land used for sampling: mineral soil in an oil palm plantation with ground cover vegetation of *Ottochloa nodosa and Nephrolepis biserrata,* and no vegetation.

2.1.2. Soil Sampling & Laboratory Analysis

Soil sampling was carried out using a hoe to dig the soil and a meter to measure the depth of 0- 30 cm. Soil sampling was carried out by purposive sampling (intentionally) at points where *Ottochloa nodosa, Nephrolepis biserrata,* and no vegetation had grown. Then, the soil surface was cleaned of vegetation. Determination of sample points was carried out at 3 locations with different ground cover vegetation categories: the area with Nephrolepis biserrata fern vegetation, the area with Ottochloa nodosa crocodile nest vegetation, and the area without vegetation. At each vegetation location, samples were collected at a depth of 0- 30 cm, yielding 3 sample points and depth data. Soil samples collected in the field were analyzed at the Palm Oil Research Center (PPKS) Laboratory for data analysis and thesis preparation. The observed parameters analyzed included soil pH, soil chemistry, total Nitrogen (N), available Phosphorus (P), and organic C.

2.2. Research flowchart

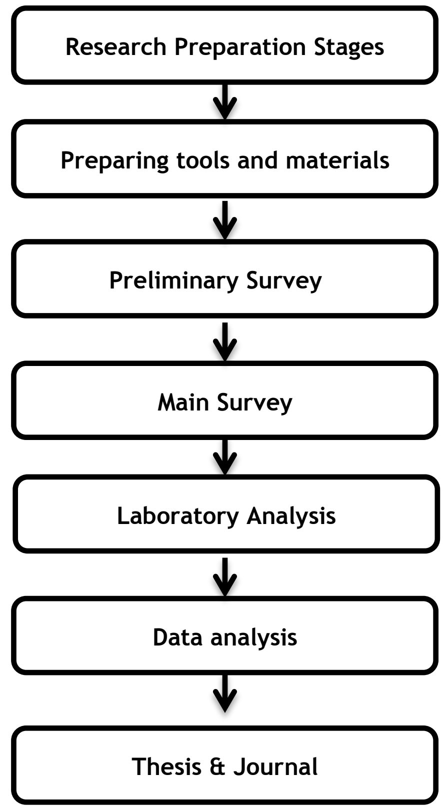

Figure 1. Research flow diagram

2.3. Observation Parameters

2.3.1. Soil pH

pH observation follows AOAC (1990) and uses a pH meter; direct measurements are made when taking soil samples. Before the measurement is carried out, the pH meter must be standardized first using a pH 7.0 or pH 4.0 buffer solution. Next, measurements are taken on the sample solution and left for a while until a stable reading is obtained. The working procedure in soil pH analysis is as follows: weigh the soil that has been taken, then take 10 g of filtered soil (passing a 0.5 mm sieve) put into a shaker bottle, then add 50 ml of H2O and shake for 30 minutes on a shaker, then let it stand for 5 minutes and then measure using a pH meter (Sulaeman *et al.,* 2005).

2.3.2. Total Nitrogen

A total of 500 mg of soil (passing a 0.5 mm sieve) was put into a 25 ml Kjeldahl flask. After that, 1.9 g of Se, CuSO4 and Na2SO4, 5 ml of concentrated H2SO4 and 5 drops of liquid paraffin were added to the flask, then heat the flask in a smoke chamber with low heat until a bright colored liquid (blue green) was obtained then approximately 50 ml of distilled water and 5 ml of 50%

NaOH was added. Distillation was carried out in a 125 ml Erlenmeyer flask containing 10 ml of 4% H3BO4 and 5 drops of Conway indicator. Finally, the distillation titration with 0.01 N HCl was carried out until a color change from green to reddish occurred (Sulaeman et al., 2005).

2.3.3. Available Phosphorus

The soil sample, weighing up to 2.5 g, was sieved to < 2 mm, then added to a Bray and Kurt I extract of 25 ml and shaken for 5 minutes. Filter, and if the solution is cloudy, return to the original filter (filtering process: maximum 5 minutes). Pipette 2 ml of clear extract into a test tube. The sample and standard series were each added 10 mL of phosphate dye reagent, shaken, and left for 30 minutes. The absorbance was measured at 693 nm using a spectrophotometer (Sulaeman *et al.*, 2005).

2.3.4. C – Organic

A total of 0.5 g of soil sample measuring <0.5 mm was put into a 100 ml measuring flask. Add 5 ml of 1 N K2Cr2O7, then shake. Add 7.5 ml of concentrated H2SO4, shaken and let stand for 30 minutes, then diluted with deionized water, let cool and evaporate, adding indicator add 3 – 5 drops of ferroin indicator (or according to the volume specifications in the technical instructions) after that titrate the solution with Ferro Ammonium Sulfate (FAS) until the color changes from bright green to brick red (the end point of the titration) (Sulaeman *et al.*, 2005).

3. Results and Discussion

Analysis of soil chemical properties, particularly soil pH, is the entry point for plant uptake of chemical elements. The pH value affects the solubility of macro- and micro-nutrients and the activity of soil microorganisms, which play a role in the mineralization of organic matter. In oil palm plantations, the optimal soil pH ranges from 4.5 to 6.5, where nutrients are relatively available to plants (Amu *et al.*, 2022).

Soil with a pH too low can increase the solubility of toxic aluminum and iron, and inhibit phosphorus uptake by plant roots. Conversely, a pH that is too high makes some micronutrients unavailable. Other research shows that managing organic matter and ground cover vegetation can help stabilize soil pH in oil palm plantation ecosystems (Pratama *et al.*, 2023).

Table 1. Laboratory Analysis Results of $_{\text{Soil}}$ pH (H_2O)

	Vegetation		
Depth	***N. biserrata***	***O. nodosa***	**T. Vegetation**
0 – 30 cm	5.4 H_2O	4.7 H_2O	4.6 H_2O

Description: is a marker of the results of *the pH value of the soil* from various vegetation on the chemical properties of the soil. (Source: PPKS Laboratory)

Table 1 shows that vegetation types and non-vegetation have values of 4.6–5.4. The table data analysis results above also show a striking difference between land with ground cover vegetation and open land without ground cover vegetation on the surface. In land without vegetation, the soil pH tends to be lower and acidic, 4.6 H2O. Areas with *Nephrolepis biserrata vegetation* have the highest pH, namely 5.4, which is practically on the threshold of the "Somewhat Acidic" category (5.6 – 6.5). In contrast, areas with Ottochloa nodosa (4.7) and areas without vegetation (4.6) exhibit a stronger acidity, approaching the "Very Acidic" category. In line with research (Bagus Setyawan, 2018), ground cover plants in Inceptisol soil have a pH value ranging from 4.4-4.6, and Spodosol pH values range from 4.7 - 5.5 while without vegetation, the pH is 4.4. Soil pH increases in areas containing *Mucuna bracteata* and *Nephrolepis biserrata* due to increased soil organic matter through the input of plant biomass cover over time. The growth of plant biomass lowers soil temperature and increases the population of soil microorganisms.

Nephrolepis biserrata vegetation had the highest pH among the treatments. This finding is thought to be due to its ability to produce a high biomass and evenly cover the soil surface, thereby suppressing erosion and leaching of soil bases. Furthermore, litter from cover crops can increase organic matter content and the activity of soil microorganisms, which are involved in nutrient mineralization. Research by Asbur and Ariyanti found that the use of cover crops in oil palm plantations can increase soil organic matter content and improve soil quality compared to land without cover vegetation (Asbur, Y., Ariyanti, 2017).

The results of this study indicate that the use of ground cover vegetation improves soil chemistry in oil palm plantations. Ground cover vegetation not only functions as soil and water conservation but also helps maintain soil pH stability, thus supporting nutrient availability for oil palm plants. Therefore, the presence of ground cover vegetation, such as Nephrolepis biserrata, needs to be maintained as part of sustainable land management in oil palm plantations.

Analysis of soil chemical properties, especially total nitrogen, is essential for macronutrient requirements in plant growth and development. In soil, nitrogen is a key component of chlorophyll, proteins, amino acids, enzymes, and nucleic acids, thus playing a significant role in photosynthesis and plant vegetative growth. Nitrogen in the soil is available in organic and inorganic forms, especially as ammonium (NH_4^+) and nitrate (NO_3^-), which can be absorbed directly by plant roots. The use of ground cover plants can increase soil nitrogen content through the addition of biomass and the decomposition of litter (Adli et al., 2025).

Table 2. Laboratory Analysis Results Total Nitrogen (%)

Depth	vegetation		
	N. biserrata	***O. nodosa***	**T. Vegetation**
0 – 30 cm	0.10%	0.60%	0.08%

Description: is a marker of the total nitrogen value resulting from various vegetation types on the chemical properties of the soil. (Source: PPKS Laboratory)

Table 2 shows that vegetation types and those without vegetation have values ranging from 0.08 to 0.60%. The analysis table data above also shows a striking difference between land with ground cover vegetation and open land without ground cover. In land without vegetation, total N tends to be lower, at 0.08%. Areas with *Otochloa nodosa vegetation* show the highest total N value, at 0.60%.

Areas with cover crops have higher total N content than oil palm plantations without cover crops, as cover crops are a source of soil N after decomposition. Furthermore, the low N content in oil palm plantations without cover crops may be due to evaporation, drainage, and erosion, as the cover crops are no longer present. Total N content in oil palm plantations with vegetation is higher than in those without vegetation.

Analysis of soil chemical properties, especially available phosphorus. According to Hardjowigeno (Bagus Setyawan, 2018), P elements in the soil are absorbed by plants in the form of H2PO4 and HPO4 ions. Available P improves soil quality by stimulating root growth, especially the roots of seeds and young plants. Phosphorus also functions as a raw material for the formation of certain proteins, helps assimilation, accelerates flowering, ripening of seeds and fruits, and strengthens stems so that they do not fall easily. Quantitatively, in oil palm commodities in Inceptisol soils, P availability ranges from 11.20 ppm to 18.50 ppm in areas with various ground cover plants. On the other hand, areas without vegetation in this study showed very critical conditions with available P values <0.01 ppm due to high nutrient leaching, in line with standard findings that open mineral soils without cover in oil palm plantations generally experience a drastic decrease in P availability to below the critical threshold (<5 ppm).

Table 3. Laboratory Analysis Results Available Phosphorus (ppm)

Depth	Vegetation		
	N. biserrata	***O. nodosa***	**T. Vegetation**
0 – 30 cm	3.63 ppm	69.39 ppm	<0.01 ppm

Description: is a marker of the results of the available phosphorus value from various vegetation on the chemical properties of the soil. (Source: PPKS Laboratory)

Table 3 shows that, based on the results of laboratory analysis of available Phosphorus content at a depth of 30 cm, there were quite significant differences among the types of ground cover vegetation. The highest available Phosphorus value was obtained in *Otochloa nodosa vegetation* at 69.39 ppm, followed by Nephrolepis biserrata at 3.63 ppm. In comparison, land without vegetation showed a very low available P value of <0.01 ppm. The difference in value indicates that ground cover vegetation affects the availability of phosphorus in the soil.

The availability of phosphorus in areas where *Otochloa nodosa grows* is thought to be the result of the accumulation of organic matter derived from the plant's biomass. The decomposition of this organic matter produces organic ligands that are effective in releasing phosphate fixation in the soil. In addition to chemical factors, the root structure of *Otochloa nodosa* creates a microenvironment that supports the activity of microorganisms in transforming organic phosphorus into inorganic forms that plants can absorb. The very significant increase in available P values in *Otochloa nodosa vegetation* (69.39 ppm) is in line with quantitative findings by (Bagus Setyawan, 2018) in Inceptisol oil palm land, which noted that the presence of ground cover vegetation can boost P availability to reach a high range (>20 ppm) compared to open land without vegetation management which often leaves P content below the critical limit (<5 ppm) due to strong Al and Fe fixation.

Meanwhile, *Nephrolepis biserrata vegetation* also showed higher available phosphorus content compared to land without vegetation. This result indicates that ground cover vegetation can retain nutrients in the soil and reduce nutrient loss from erosion and leaching. Research by Satriawan *et al. (*2021) explains that Nephrolepis biserrata has potential as a ground cover crop in oil palm plantations because it can increase organic matter content and contribute N, P, and K nutrients through the decomposition of plant biomass.

Analysis of soil chemical properties, especially C – Organic According to Tornquist in (Bagus Setyawan, 2018) c-organic is the key to soil fertility because it increases the ability of the soil to bind and absorb nutrients and water for plants, reduces nutrient leaching, increases the ability of the soil to retain water and the stability of the soil structure and as a source of energy for soil biota. Soil C-organic is a biological soil buffer that can balance nutrients in the soil and provide nutrients for plants efficiently.

Table 4. Laboratory Analysis Results C – Organic %

	Vegetation		
Depth	***N. biserrata***	***O. nodosa***	**T. Vegetation**
0 – 30 cm	0.72%	7.29%	0.70%

Description: It is a marker of the results of the available organic C value from various vegetation on the chemical properties of the soil. (Source: PPKS Laboratory)

It can be seen that the organic carbon value without vegetation is the lowest, compared to that with Neprolepis biserrata and Otochloa nodosa vegetation. The low organic carbon content in unvegetated land is caused by the low organic matter content in the form of humus derived from vegetation growing above it, or by surface erosion.

The low organic carbon content in unvegetated land is thought to be due to minimal input of organic matter into the soil and to high topsoil loss from surface erosion. Soil without vegetation cover is more susceptible to nutrient leaching and soil structure degradation, leading to lower organic matter content. Research on soil organic carbon in oil palm plantations indicates that low organic matter content can lead to decreased soil quality and fertility (Farrasati *et al.*, 2020).

Furthermore, the presence of ground cover vegetation, such as Nephrolepis biserrata and Otochloa nodosa, can maintain soil moisture and increase the accumulation of organic matter from decaying leaves and plant roots. This vegetation is commonly found in oil palm plantations and has potential as ground cover because it grows well in shaded conditions *(Suryana et al.,* 2020).

4. Conclusion

Research conducted at the Cibaliung I Estate Plantation of PT. Cibaliung Tunggal Plantation has demonstrated that ground cover vegetation significantly enhances the chemical quality of soil in oil palm plantations compared to land without vegetation. Two primary advantages were identified: Nephrolepis biserrata excels at increasing soil pH, thereby creating optimal conditions for nutrient availability; Otochloa nodosa exhibits the highest effectiveness in increasing total nitrogen, available phosphorus, and organic carbon content through efficient biomass decomposition. In contrast, the absence of vegetation accelerates nutrient loss due to erosion and leaching. Therefore, the use of these two vegetation types is a vital strategy for maintaining soil fertility and ensuring the sustainability of oil palm plantations.

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