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RESEARCH ARTICLE

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Analysis of Peat Soil Characteristics (Histosol) at Several Maturity Levels in Oil Palm (*Elaeis guineensis* Jacq.) Plantations in Lubuk Sakat Village, Kampar

Patra Anjara Ginting[1], Wawan[1], Fifi Puspita[1], Cynthia Bernadetta Silalahi[1,*], Asri Cahyati Zebua[1]

Abstract

Agricultural development on peatlands requires a careful and thoughtful approach. Therefore, conducting an inventory of their characteristics is essential for ensuring proper utilization and effective planning. This study aims to analyze the characteristics of peat soils in Lubuk Sakat Village, Kampar, Riau, which are planted with oil palm at various maturity stages, covering a potential peatland area of approximately 800 hectares. The research was conducted using observational and descriptive methods, with purposive sampling employed at peatlands of fibric, hemic, and sapric maturity stages. The observed soil characteristics included pH, organic carbon (C-Organic), available phosphorus (P-Available), and cation exchange capacity (CEC). In addition to these chemical properties, the soil microbial population was also assessed. The results revealed that soil pH, C-Organic, and CEC were similar across the three maturity stages, while P-Available was higher in sapric and hemic peat compared to fibric peat. The microbial population was found to be highest in sapric peat, followed by hemic peat, and lowest in fibric peat. These findings are expected to provide a solid foundation for managing fertilization and improving oil palm productivity on peatlands with similar characteristics.

Keywords: Oil Palm, Peat, Peat Maturity, Soil Biological Properties, Soil Chemical Properties

1. Introduction

Oil palm (Elaeis guineensis Jacq.) is a superior plantation commodity that plays a vital role in Indonesia's socioeconomic development. The increasing population and high demand for agricultural products have led to the increased use of marginal land, including peatlands.(Rizky Alviodinasyari et al., 2015). According to Ditjen Pengendalian Pencemaran Dan Kerusakan Lingkungan Kementerian Lingkungan Hidup dan Kehutanan (2017), the distribution of peatlands in Indonesia spans approximately 24.6 million hectares across Sumatra, Kalimantan, and Papua. Riau Province is one of the provinces with the largest peatland area, at approximately 4.04 million hectares, or approximately 56.1% of the total peatland area in Sumatra.(Wahyunto et al., 2013)

Peatlands have great potential for agricultural development; however, they also face several constraints, including physical, chemical, and ecological aspects, which can impair plant productivity (Supriyanto et al., 2022). According to the regulation of the Minister of Agriculture Number 14/Permentan/PL/110/2/2009 of 2009 concerning Guidelines for the Utilization of Peatlands for Oil Palm Cultivation, the criteria for peatlands that can be used for oil palm cultivation are peat with a thickness of less than 3 meters with maturity of sapric peat (mature) and hemic peat (semi-mature) while fibric peat (raw) is prohibited.

Macro- and micro-nutrient content differ depending on the level of peat maturity. Fibric peat is characterized by a high fiber content (>66%) and a bulk density (<0.1 g/cm3). Generally, the N, P, and K nutrient content in fibric peat tends to be low, and the pH is acidic (Dania Ayushinta et al., 2021). Hemic peat has a fiber content of between 33-66% and a bulk density of around 0.1-0.19 g/cm3. The N, P, and K nutrient content is slightly higher when compared to fibric peat. The fibre content in sapric peat is less than 33%, and the bulk density is greater than or equal to 0.2 g/cm^3. In this peat, the macro nutrient content, especially N, P, and K, is relatively high because the organic matter has

*Correspondence: cynthiabernadetta@gmail.com
1) Universitas Riau - Kampus Bina Widya Km. 12.5 Simpang Baru, Pekanbaru 28293, Indonesia

been significantly decomposed so that the nutrients are readily available to plants (Sabiham & Sukarman, 2012)

Research results (Afrianti et al., 2023)indicate that peat soil exhibits high soil porosity, regardless of whether it has been planted with oil palm or not. Research results (Yuningsih et al., 2) stated that the peat soil is 10R 3/4 (dark brown) with a pH range of 3.17–3.56 and a high organic carbon content (19.13%–23.95%). Previous research has focused on the general physical and chemical characteristics of peat soil, whereas this study also analyses the chemical and biological characteristics of peat soil at various levels of maturity.

This study aims to analyze the characteristics of peat soil in Lubuk Sakat Village, where oil palm is planted at different stages of maturity. Therefore, the results are expected to contribute to technical recommendations for appropriate fertilization to increase oil palm productivity and maintain nutrient availability on marginal land with similar characteristics.

2. Material and Methods

2.1. Time and Place

This research was conducted at PT. Central Lubuk Sawit, Lubuk Sakat Village, Siak Hulu District, Kampar Regency, Riau Province, from January 2025 – June 2025, with an area of 477 Ha, with an altitude of 10 – 22 meters above sea level, with coordinates of 0020'27" North Latitude and 101025'52" East Longitude. Chemical analysis of the peat soil was conducted at the Central Plantation Services Laboratory, located at Jalan Soekarno Hatta No. 488, Pekanbaru. Biological analysis of the soil was conducted at the Microbiology Laboratory – Central Plantation Services in Sungai Pagar, Kampar.

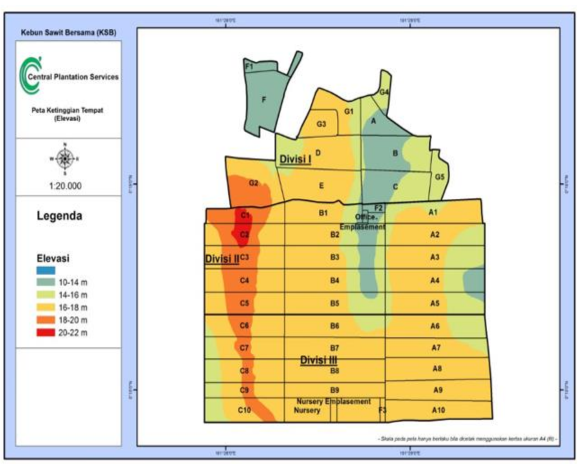

Figure 1. Research Map Site

2.2. Tools and Materials

The tools used in this research included peat soil drills (Eijkelkamp), hoes, meters, plastic bags, labels, stationery, cameras, and laboratory equipment for analyzing the soil's chemical and biological properties.

The materials used in this study included soil samples with varying levels of maturity, chemicals for testing the chemical properties of the soil, PDA (Potato Dextrose Agar) media, and NA (Nutrient Agar) media for isolating fungi and bacteria.

2.3. Research Methods

The method used in this study is an observational and descriptive approach, where soil sampling was conducted using a purposive sampling method in peatlands planted with oil palms at various stages of maturity. Soil sampling was conducted using a grid method at each maturity level, with a grid spacing of 100-200 m. At each level of peat maturity (fibric, hemic, and sapric), five soil samples were taken and then homogenized (Rauf and Harahap, 2019). Soil samples were taken at a depth of 0–40 cm.

The data obtained were analyzed both descriptively and inferentially using Microsoft Excel software version 2017.

2.4. Research Chart

The flow of this research is illustrated in Figure 2.

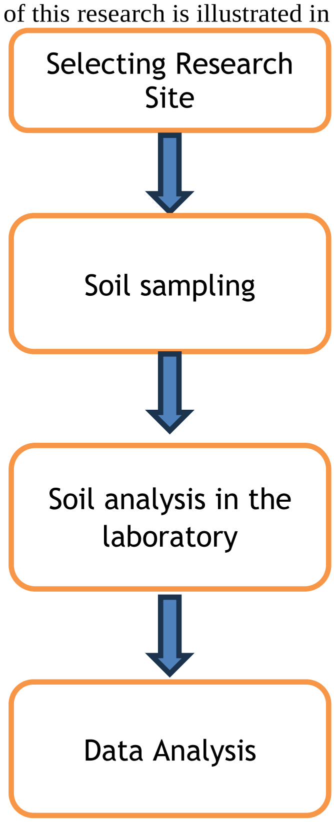

Figure 2. Research flow diagram

3. Results and Discussion

3.1. Chemical Properties of Soil

3.1.1. Peat Soil pH

The average pH values of peat soil at different levels of maturity are presented in Table 1. Based on data from Table 1, the pH value of peat soil ranges between 3.6 and 4, indicating that it is classified as very acidic (Balai

Penelitian Tanah, 2009).

The acidic pH of peat is attributed to the hydrolysis of organic acids produced during the decomposition process, which is dominated by fulvic and humic acids (Dania Ayushinta et al., 2021). Organic acids influence the low pH in peat soil. Decomposed organic matter has reactive groups, including Carboxylate (COOH) and Phenolate (C_6H_4OH), which dominate the exchange complex and act as weak acids, thus producing large amounts of H+ ions.

Table 1. Average pH value of peat soil at different levels of maturity

Treatment	pH	Criteria
Fibric	3.6	Very Sour
Hemic	3.9	Very Sour
Saprik	4	Very Sour

Peat soil pH increases with increasing peat maturity (fibric-sapric). This finding suggests further decomposition of organic material, leading to relatively less acidic soil conditions (PAGE et al., 2011).

3.1.2. C-Organic

The average C-organic value in peat soil at different levels of maturity is presented in Table 2. Based on data from Table 2, the C-Organic value in peat soil ranges from 48.86% to 52.40%. The C-Organic content in peat soil is classified as very high according to the criteria for assessing soil chemical properties (Balai Penelitian Tanah, 2009).

Table 2. Average C-Organic value of peat soil at different levels of maturity

Treatment	C-Organic (%)	Criteria
Fibric	52.40	Very high
Hemic	50.36	Very high
Saprik	48.86	Very high

The accumulation of incompletely decomposed organic matter is a primary cause of the high organic carbon content in peat soils. This high accumulation of organic matter and its slow decomposition rate maintain a high organic carbon content in peat soils (Page & Banks, 2007), with organic carbon content in Indonesian tropical peat soils reaching 40–60% of the soil's dry weight.

The research results (Sari et al., 2022) also stated that the C-organic content in peat soil is relatively high, especially in peat soil with a raw maturity (fibric) of 6.07%.

3.1.3. P-Availability

The average P-Available value in peat soil at various levels of maturity is presented in Table 3. Based on the data from Table 3, the Available P value in peat soil ranges from 43.6 to 88.5 mg/100g^{-1}, as assessed by the criteria for evaluating soil chemical properties (Balai Penelitian Tanah, 2009). The Available P content in this soil is classified as moderate to very high.

Table 3. Average P-Available values of peat soil at different levels of maturity

Treatment	P-Available (mg.100g $^{-1}$)	Criteria
Fibric	43.6	Currently
Hemic	88.5	Very high
Saprik	50.7	Tall

The available P content in peat soil is determined by the degree of peat decomposition. Raw (fibric) peat has a lower P content compared to hemic and sapric peat. (Servais et al., 2019) The level of phosphate dissolution in the soil is very low compared to other nutrients, resulting in a significant accumulation of this essential element.

The availability of phosphate in the soil is also influenced by pH, soil aeration, temperature and organic matter content (W. Darmosarkoro et al., 2001).

3.1.4. Cation Exchange Capacity (CEC)

The average value of Cation Exchange Capacity in peat soil at different levels of maturity is presented in Table 4. Based on the data from Table 4, the CEC value in peat soil ranges from 58.1 to 65.4 meq/100g^{-1}, which falls within the criteria for assessing the chemical properties of the soil (Balai Penelitian Tanah, 2009). The CEC content in this soil is classified as very high.

Table 4. Average CEC values of peat soil at different levels of maturity

Treatment	KTK (meq/100 g^{-1})	Criteria
Fibric	58.5	Very high
Hemic	65.4	Very high
Saprik	58.1	Very high

The high CEC value is due to the very high organic carbon content. This result is consistent with the literature (Mukhlis et al., 2011), which states that the CEC value is influenced by the content of organic matter, some of which is humus, acting as a soil colloid. Therefore, the higher the soil organic matter content, the higher the CEC value. According to Iwan Sasli's (2011) research, the ongoing decomposition process produces humic compounds that can improve the soil's cation exchange capacity (CEC).

3.2. Soil Biological Properties

3.2.1. Total Plate Count (TPC) of Bacteria and Fungi

The average Total Plate Count (TPC) values for Bacteria and Total Plate Count (TPC) for Fungi in peat soil at different levels of maturity can be seen in Table 5.

The total microbial population of the peat soil, as measured by bacterial total plate count (Bacterial TPC) and fungal total plate count (Fungal TPC), showed variations between observation points. The total bacterial population ranged from 2.74 × 10^4 to 4.96 × 10^4 CFU/mL, and the total fungal population ranged from 2.00 × 10^5 to 2.30 × 10^5 CFU/mL. The high bacterial and fungal populations were due to the high organic matter content. According to A. S. Hanafiah et al. (2005), increasing organic matter in the soil enhances microbial activity and population, particularly those related to the decomposition and mineralization of organic matter. The greater the organic matter content, the greater the increase in organic carbon in the soil. Meanwhile, sapric peat has a low organic carbon content, presumably because it has undergone advanced decomposition, resulting in low microbial activity that decomposes organic matter.

Table 5. Average TPC values of bacteria and TPC of fungi in peat soil at different levels of maturity

Treatment	TPC Bacteria (104 ^{CFU}/mL)	TPC Fungus (105 ^{CFU}/mL)
Fibric	2.74	2
Hemic	3.52	2.2
Saprik	4.96	2.3

The lower bacterial population compared to fungi is due to the fact that peat soil has a low pH, which is less favourable for the growth of most bacteria, but is ideal for fungal growth (Maipa Dia Pati et al., 2016).

a b c

Figure 3. Peat soil (a) Sapric; (b) Hemic; (c) Fibric

4. Conclusion

Peat soil in oil palm plantations in Lubuk Sakat Village, Kampar, Riau, at various maturity levels (fibric, hemic, and sapric), exhibits a highly acidic pH range of 3.6 to 4.0, a very high organic carbon (C-Organic) content of 48.86% to 52.40%, available phosphorus (P-Available) levels ranging from 43.6 mg/100g to 88.5 mg/100g, and cation exchange capacity (CEC) ranging from 58.1 me/100g to 65.4 me/100g. The microbial content in the peat soil of Lubuk Sakat Village varies between 2.74 x 10^4 CFU/mL and 4.96 x 10^4 CFU/mL (TPC Bacteria) and from 2.0 x 10^5 CFU/mL to 2.3 x 10^5 CFU/mL for other microbial populations. Based on the results of this study, these findings can serve as a technical reference for fertilization and plantation management practices aimed at enhancing oil palm productivity on peatlands at various maturity levels in Lubuk Sakat Village, Kampar Regency, Riau.

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