JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 7 NO. 1 January 2025

DOI :https://doi.org/10.36378/juatika.v7i1.4163
eissn 2656-1727
pissn 2684-785X
pages : 315 – 319

RESEARCH ARTICLE Open Access

Analysis of Soil Chemical Properties in Oil Palm Plantation Land Produces in Tebing Tinggi Pangkatan Village Sub-district of Pangkatan

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Abstract

Oil palm (*Elaeis guineensis*) is a commercially significant plantation crop, primarily due to its production of crude palm oil (CPO), which finds applications in the food, cosmetics, and biofuel sectors. The fertility of the land is closely linked to the soil's chemical characteristics, including pH, nitrogen (N), phosphorus (P), potassium (K), organic carbon content, and cation exchange capacity (CEC). This study employed a field survey methodology, utilizing purposive sampling for data collection. Findings indicate that the soil in oil palm plantations exhibits an acidic pH range of 4.87 to 5.22 and a low organic carbon content between 0.90% and 1.05%, factors that may influence nutrient availability. While nitrogen levels (1.03% to 1.07%) and phosphorus concentrations (41.22 to 42.33 ppm) are relatively high, potassium levels (0.54 to 0.63 meq/100g) are low, potentially hindering plant growth. The cation exchange capacity, measured at 15.66 to 16.87 meq/100g, is categorized as moderate, suggesting that while the soil can retain nutrients adequately, enhancements in potassium availability are necessary.

Keywords: Chemical Properties, Chemical Properties of Soil, Palm Oil, Land, Soil

1. Introduction

Oil palm (*Elaeis guineensis*) is a commercially significant crop known for producing crude palm oil (CPO), which serves many industries, including food, cosmetics, and biofuels. This species thrives best in tropical regions with adequate rainfall, warm temperatures, and nutrient-rich soils. Oil palm cultivation has emerged as a crucial component of the economies of major producing nations, particularly Indonesia and Malaysia, which dominate global palm oil output (Lestari, 2020). Nonetheless, the palm oil sector faces numerous challenges, particularly deforestation, land degradation, and conflicts over land use with indigenous communities. The extensive land clearing is frequently linked to biodiversity loss and heightened greenhouse gas emissions. Furthermore, inadequate land management practices can result in diminished soil fertility and environmental contamination due to the overuse of fertilizers and pesticides. Consequently, there is a pressing need for adopting more sustainable agricultural practices to ensure that oil palm production can continue to thrive without inflicting harm on the environment.

Soil represents the uppermost layer of the Earth's crust and is crucial for sustaining life, particularly as a medium for plant growth. It is composed of a combination of minerals, organic materials, water, and air, all of which influence its fertility and productivity. Beyond serving as a substrate for vegetation, soil plays vital roles in the water cycle, carbon sequestration, and providing a habitat for diverse microorganisms that contribute to the decomposition of organic matter and nutrient cycling (Walida et al., 2020). Nonetheless, soil is confronted with numerous challenges stemming from human activities and environmental shifts. Issues such as soil erosion, contamination from industrial and agricultural byproducts, and fertility decline due to overexploitation pose significant risks to soil sustainability. Furthermore, rapid urban development has led to the transformation of agricultural lands into urban areas and infrastructure, thereby diminishing the availability of arable land. Consequently,

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initiatives aimed at soil conservation, including reforestation, judicious fertilizer application, and adopting sustainable agricultural practices, are essential for preserving soil quality and functionality for future generations.

Soil chemical properties are one of the main factors determining agricultural land's fertility and productivity. These properties include soil pH, nutrient content such as nitrogen (N), phosphorus (P), potassium (K), and cation exchange capacity (CEC), which affect the soil's ability to store and provide nutrients for plants. Balanced soil chemical properties are essential to support plant growth because nutrients that are available in sufficient quantities and easily absorbed forms will increase the efficiency of fertilizer use and crop yields. However, soil chemical properties can be degraded due to less sustainable agricultural practices, such as excessive use of fertilizers and pesticides, soil erosion, and heavy metal pollution from industrial waste. Soil pH imbalance is also a common problem, where soil that is too acidic or alkaline can inhibit the availability of nutrients for plants. Therefore, good soil management, such as proper fertilization, crop rotation, and the use of organic matter, is essential to maintain the balance of soil chemical properties and support sustainable agriculture.

The chemical properties of the soil in oil palm plantations greatly affect plant productivity because they determine the availability of nutrients needed for growth. Several important parameters in oil palm plantation soil include soil pH, organic carbon content, nitrogen (N), phosphorus (P), potassium (K), and cation exchange capacity (CEC). Fertile soil with a good balance of nutrients will support root development, leaf formation, and optimal fresh fruit bunch production. Therefore, periodically monitoring and managing soil chemical properties is important in oil palm cultivation. However, various problems often occur in the chemical properties of the soil in oil palm plantations, such as decreased fertility due to excessive use of chemical fertilizers, leaching of nutrients due to high rainfall, and increased soil acidity due to decomposition of organic matter that is not managed properly. In addition, environmentally unfriendly cultivation practices can cause the accumulation of chemical residues that can potentially damage the balance of the soil ecosystem. To overcome this problem, a sustainable soil management strategy is needed, such as using organic fertilizers, applying soil conservation techniques, and crop rotation to maintain the balance of soil chemical properties in the long term.

The researcher undertook a study titled "Analysis of Soil Chemical Properties on Oil Palm Plantation Land in Tebing Tinggi Pangkatan Village, Pangkatan District" to assess the soil fertility status in this region. The objective of this investigation is to evaluate various soil chemical parameters, including soil pH, nitrogen (N), phosphorus (P), potassium (K), organic carbon, and cation exchange capacity (CEC), all of which are critical for enhancing the growth and productivity of oil palm.

2. Material and Methods

2.1. Place and Time of Research

Research and soil sampling will be planned in January to February 2025 in Tebing Tinggi Pangkatan Village, Pangkatan District, Labuhanbatu Regency, North Sumatra Province. With coordinates 2 ° 8′2.4 ″ N and 100 ° 4′40.8 ″ E. With a height of 7 meters above sea level.

Figure 1. Map of Tebing Tinggi Pangkatan Village

2.2. Materials and Tools

Soil samples and other materials used to analyze soil chemical properties have been prepared in the laboratory. The tools used in this study are location maps, GPS (Global Positioning System), compasses, and mobile phones. The research tools in the field are hoes, shovels, plastic, labels, meters, 0.5 mm sieves, scales, and stationery.

2.3. Research Methods

This study was conducted using a field survey method (Walida et al ., 2020) on oil palm plantations owned by farmers in Tebing Tinggi Pangkatan village. This study will be planned by taking soil samples. The technique used is purposive sampling, a method based on subjective assessment or random selection of samples from a predetermined population. In conducting soil sampling, five sample points were taken with a distance of 30 meters between points in the field, using a random method spread over a predetermined area based on a location map.

2.4. Research Procedures

The research procedure is a method of sampling diagonally at predetermined points, such as on oil palm plantation land. Sampling can be seen in Figure 3.4 below. Sampling was carried out at two depths, namely 0-30 cm and 30-60 cm. At each depth, samples were taken at 5 points at the same two depths. The purpose of this sampling is to determine the chemical properties of the soil based on predetermined criteria.

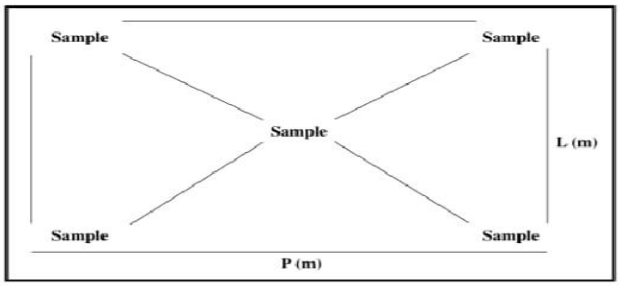

Figure 2. Soil Sampling Points

2.5. Preparation Stage

Taking care of research permits before researching community land in Tebing Tinggi Pangkatan village, Labuhanbatu district, North Sumatra province. Conducting literature studies on soil fertility status, parameters in determining soil fertility, and other things supporting this research. Collecting secondary data to support the implementation of this research. Secondary data used include slope data, and geology in the rubber plantation area of the Tebing Tinggi Pangkatan village which was studied covering an area of 1 hectare.

2.6. Research Implementation

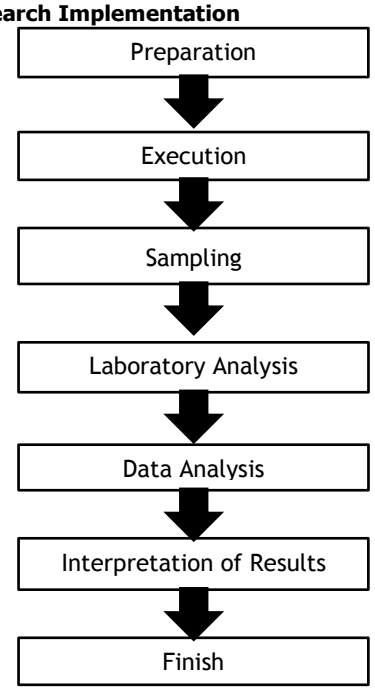

Figure 3. Research Flow Diagram

2.7. Observation parameters

These observation parameters are used to see the chemical properties of the soil such as soil pH using the pH meter method, C-organic using the Walkley and Black method, KTK using the Leaching method, Nitrogen using the Kjeldahi method, Phospor using the Hcl method. Potassium using the HCl method.

2.8. Data analysis

The data obtained from the study were analyzed descriptively in the Laboratory. The primary data includes the chemical properties of the soil. Data analysis was done using Microsoft Excel software to describe the results of laboratory tests.

3. Results and Discussion

Research on the chemical properties of soil in Tebing Tinggi Pangkatan Village needs to be conducted to determine the level of fertility and suitability of the land for plant growth. The main obstacles often faced are the decline in soil quality due to the continuous use of chemical fertilizers, erosion, or lack of organic matter in the soil. These factors can cause pH imbalance, low nutrient content, and decreased cation exchange capacity, affecting plant productivity. Therefore, analysis of the chemical properties of the soil is important to determine the right land management strategy to increase agricultural yields sustainably. The results based on the results of laboratory tests of soil chemical properties samples are presented in Table 1.

The analysis of the chemical properties of soil in oil palm cultivation within Tebing Tinggi Pangkatan Village, located in Pangkatan District, reveals that the soil pH varies between 4.87 and 5.22, signifying acidic conditions. Such acidity may hinder the availability of essential nutrients, particularly phosphorus (P) and potassium (K), as these elements can become immobilized in forms that are less accessible to plants. Furthermore, the organic carbon content is relatively low, ranging from 0.90% to 1.05%, which suggests a limited presence of organic matter in the soil. This organic carbon deficiency can adversely affect water retention and nutrient availability over time. Therefore, it is imperative to incorporate organic materials, such as compost or manure, to enhance soil fertility.

The nitrogen (N) concentration in the soil is between 1.03% and 1.07%, suggesting an adequate supply of nitrogen to facilitate the growth of oil palm plants. The total phosphorus (P) levels are recorded at 41.22 to 42.33 ppm, which is considered relatively high and sufficient for promoting root development and overall plant growth. In contrast, the total potassium (K) content is measured at 0.54 to 0.63 meq/100g, indicating a relatively low level that may pose a limitation to the production of oil palm fruits. The cation exchange capacity (CEC) ranges from 15.66 to 16.87 meq/100g, reflecting a moderate capacity of the soil to retain and supply nutrients. To enhance soil quality, it is recommended to undertake measures such as liming to mitigate acidity and the application of potassium fertilizers to ensure that oil palm plants receive the necessary nutrients.

Table 1. Results of Laboratory Analysis of Soil Physical Properties

Sample	Soil pH	C_Organic	N_ Total	P_Total	K_Total	KTK
I	4.87	0.95	1.07	41.22	0.63	15.66
II	5.22	1.05	1.03	42.33	0.58	16.34
III	5.06	0.9	1.06	42.11	0.54	16.87

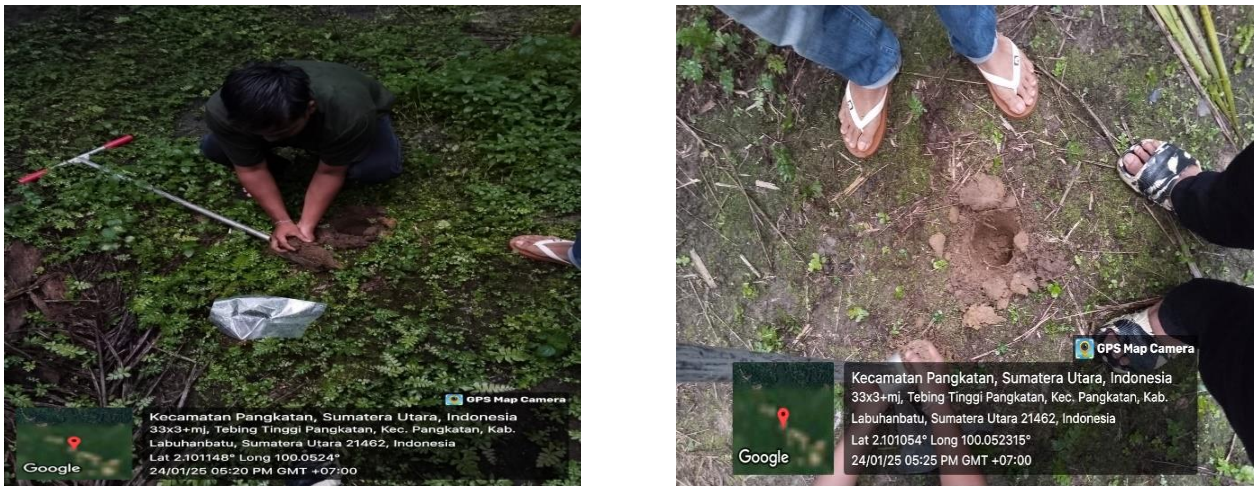

Figure 4. Soil sampling image

The analysis of the chemical properties of soil in oil palm cultivation within Tebing Tinggi Pangkatan Village, located in Pangkatan District, reveals that the soil pH ranges from 4.87 to 5.22, indicating an acidic environment. Elevated acidity levels in the soil can hinder the availability of crucial nutrients, particularly phosphorus (P) and potassium (K), as these elements tend to bind with soil minerals, rendering them less accessible to plant roots. Additionally, high acidity can enhance the solubility of aluminum (Al) and iron (Fe), which, at elevated concentrations, can be detrimental to plant health. Consequently, applying lime, specifically dolomite or agricultural lime ($CaCO_3$), is recommended to raise the soil pH to a more favorable level for the growth of oil palm.

The organic carbon content ranging from 0.90% to 1.05% indicates that the soil has low organic matter. Organic carbon is important in improving soil structure, increasing water-holding capacity, and providing an energy source for soil microorganisms that help the decomposition process and release nutrients. The low organic matter content is likely caused by minimal provision of organic fertilizers, less than optimal management of palm oil waste, and rapid decomposition of organic matter in tropical environments. To overcome this problem, using organic fertilizers such as compost, green manure, or fermented empty oil palm bunches can be a solution to increase the organic carbon content of the soil.

The soil's total nitrogen (N) content, ranging from 1.03% to 1.07%, indicates that the soil still has sufficient nitrogen availability to support the growth of oil palm plants. Nitrogen plays a role in leaf formation and photosynthesis, which is essential for plant growth. However, the total phosphorus (P) ranging from 41.22 to 42.33 ppm indicates quite high availability, although its effectiveness in acidic soils can be reduced due to fixation by aluminum and iron. Therefore, its plant utilization may not be optimal despite the high P content. To increase the efficiency of phosphorus absorption, applying ameliorants such as agricultural lime can help reduce soil acidity and increase phosphorus availability for plant roots.

The main problem that needs attention is the low total potassium (K) content, which ranges from 0.54 to 0.63 meq/100g. Potassium is an important nutrient that plays a role in fruit formation and plant resistance to environmental stress, so potassium deficiency can inhibit oil palm fruit production. Factors causing low potassium content can come from nutrient leaching due to high rainfall, unbalanced fertilization, or high potassium uptake by plants without being returned as fertilizer. To overcome this problem, potassium fertilization with the right dose using KCl fertilizer or potassium-based organic fertilizers, such as empty oil palm bunch ash, must be applied to increase potassium availability in the soil and support optimal oil palm productivity. This study's results align with (Baihaki et al ., 2020). There is a difference in the content of soil chemical properties observed in forest land in oil palm plantations by 60%. Namely pH, C-organic, P-available, Al-dd, Fe, and KB, and there was no difference in the N-total, P-total, K-dd, and CEC content. The difference in soil chemical properties between forest land and oil palm plantations is influenced by agro-climatic conditions such as high rainfall and acidic soil types, which cause nutrient leaching and increased Al and Fe content in plantation land.

Different research studies (Rauf et al ., 2020) showed that adding biochar significantly reduced bulk density and increased the porosity of Ultisol soil.

4. Conclusion

The analysis of the chemical properties of soil in oil palm cultivation within Tebing Tinggi Pangkatan Village, located in Pangkatan District, reveals several key characteristics. The soil exhibits an acidic pH range of 4.87 to 5.22, alongside a low organic carbon content varying from 0.90% to 1.05%. Notably, nitrogen levels are relatively high, ranging from 1.03% to 1.07%, as are phosphorus levels, which fall between 41.22 and 42.33 ppm. Conversely, potassium content is low, measuring between 0.54 and 0.63 meq/100g, potentially hindering plant growth. The Cation Exchange Capacity, recorded at 15.66 to 16.87 meq/100g, suggests a moderate capacity for nutrient retention within the soil. Effective management practices are essential to enhance soil quality, including applying lime to mitigate acidity and incorporating organic matter and potassium fertilizers to boost nutrient availability for oil palm cultivation.

References

Baihaki, A., Zuraida, Z., & Ilyas, I. (2020). Perbandingan sifat kimia pada tanah hutan dan kebun kelapa sawit (*Elaeis guineensis* Jacq.) di Kecamatan Beutong Kabupaten Nagan Raya. *Jurnal Ilmiah Mahasiswa Pertanian, 4*(2), 434–445. https://doi.org/10.17969/jimfp.v4i2.11007

Lestari, W. (2020). Pengaruh ketinggian perangkap feromon dalam mengendalikan kumbang tanduk (*Oryctes rhinoceros* L.) di perkebunan PT Herfinta. *Jurnal Agroplasma, 7*(2), 80–84. https://doi.org/10.36987/agroplasma.v7i2.1846

Lubis, A. M. S., Fitra, H. S., Kamsia, S. D., & Hilwa, W. (2024). Evaluation of soil fertility status on oil palm cultivation land (*Elaeis guineensis* Jacq.) in Pulo Padang Village. *Jurnal Agronomi Tanaman Tropika (Juatika, 6)*(2). https://doi.org/10.36378/juatika.v6i2.3592

Pa, S. K., Peku Jawang, U., & Hubi Ndapamuri, M. (2023). Analisis status kesuburan tanah pada lahan di PT. Sumba Moelti Agriculture. *Sandalwood Journal of Agribusiness and Agrotechnology, 1*(1), 19. https://doi.org/10.58300/jts.v1i1.483

Rauf, A., Supriadi, S., Harahap, F. S., & Wicaksono, M. (2020). Karakteristik sifat fisika tanah Ultisol akibat pemberian biochar berbahan baku sisa tanaman kelapa sawit. *Jurnal Solum, 17*(2), 21–28. https://doi.org/10.25077/jsolum.17.2.21-28.2020

Syahrul, Thaha, A. R., & Toana, M. R. C. (2021). Analisis beberapa sifat kimia tanah pada berbagai tipe penggunaan lahan di Desa Tolai Barat Kecamatan Torue Kabupaten Parigi Moutong. *Agrotekbis: E-Jurnal Ilmu Pertanian, 9*(5), 1287–1297.

Syofiani, R., Diana Putri, S., & Karjunita, N. (2020). Karakteristik sifat tanah sebagai faktor penentu potensi pertanian di Nagari Silokek Kawasan Geopark Nasional. *Jurnal Agrium, 17*(1). https://doi.org/10.29103/agrium.v17i1.2349

Taufiq, M., Siswoyo, H., & Wws, A. (2013). Terhadap keseimbangan air hutan (studi kasus Sub DAS Landak, DAS Kapuas). *Jurnal Teknik Pengairan, 4,* 47–52.

Tewu, R. W. G., Theffie, K. L., & Pioh, D. D. (2016). Kajian sifat fisik dan kimia tanah pada tanah berpasir di Desa Noongan Kecamatan Langowan Barat. *Cocos, 7*(2), 1–8.

Walida, H., Harahap, F. S., Ritongah, Z., Yani, P., & Yana, R. F. (2020). Evaluasi status hara bahan organik terhadap sifat kimia tanah di lahan miring kelapa sawit. *Ziraa'ah Majalah Ilmiah Pertanian, 45*(3), 234. https://doi.org/10.31602/zmip.v45i3.3429