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Analysis of Several Chemical Properties during The Incubation Period in the Agrotechnology Cultivation Land of Rantau Selatan District

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Abstract

Land management practices primarily influence soil fertility. The utilization of farmer group land at Agrowisata Beken Jaya in Kuantan Senggigi Regency has been ongoing for seven years, employing both inorganic and organic fertilization techniques that are inconsistent or tailored to specific conditions. Therefore, it is essential to assess the soil's current state and chemical properties to promote sustainable agriculture. This study employed a purposive random sampling method for soil collection at 15 drilling points, each at a depth of 20 cm. The parameters analyzed included pH, organic carbon (C-organic), total nitrogen (N-total), and the carbon-to-nitrogen (C/N) ratio. The research findings indicate that oil palm soil exhibits lower pH, organic carbon, and total nitrogen levels than shrub soil, with an average pH of 4.44 versus 4.63, C-organic 0.96% versus 1.19%, and N-total 1.05% versus 1.18%. The low C/N ratio (<10) observed in both soil types suggests rapid decomposition but indicates a low carbon content. This study aimed to determine the chemical characteristics of the soil in cultivated land, providing a foundation for future fertilization recommendations. The findings are particularly beneficial for the community and students, as they enhance understanding of the current state of soil fertility—reason: Improved clarity, vocabulary, and technical accuracy while maintaining the original meaning.

Keywords: Chemical Properties, Cultivated Land, Incubation, Soil, Soil Fertility

1. Introduction

Examining soil chemical properties is crucial for assessing soil fertility and enhancing agricultural productivity. Key chemical attributes significantly influence plant growth, including pH, organic matter content, total nitrogen, available phosphorus, and potassium (Lubis et al., 2024). A well-balanced nutrient profile in the soil enhances plants' nutrient uptake efficiency, thereby maximizing yield. By analyzing these chemical properties, farmers can make informed decisions regarding the selection, quantity, and application methods of fertilizers and implement effective soil management practices to sustain fertility. On a larger scale, sustainable soil management practices are essential to mitigate soil degradation caused by the overuse of fertilizers and chemicals (Syahrul et al., 2021). Nevertheless, the significance of understanding soil chemical properties is frequently overlooked in numerous agricultural settings. Farmers often apply fertilizers indiscriminately, neglecting the specific requirements of the soil, which can result in nutrient imbalances and deficiencies. Furthermore, factors such as climate change, soil degradation, and unsustainable agricultural practices are increasingly compromising soil quality, leading to a decline in the productivity of cultivated lands over time. Therefore, analyzing soil chemical properties is vital for early identification of these issues and formulating effective remedial strategies (Rahmadhani et al., 2024).

The cultivated land at the Faculty of Science and Technology, Labuhanbatu University, has the potential to be developed into an area for agricultural research and development. The land is sufficiently extensive to accommodate a diverse range of plant species, functioning simultaneously as an educational hub and a practical research facility for students. The land's topography is generally relatively flat, and there is adequate access to

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water, making it suitable for various plant cultivation practices. However, the soil conditions exhibit declining fertility, including a reduction in organic matter content, an imbalance in pH levels, and a potential decline in nutrient levels due to the intensity of land use without sustainable management practices. This cultivated land is experiencing productivity issues despite its favourable potential due to poor comprehension and soil fertility management. The absence of regular soil chemical analysis makes determining fertilizer requirements and management techniques less effective, ultimately leading to suboptimal harvest outcomes (Sari, 2020). Furthermore, environmental pressures, including alterations in weather patterns and suboptimal agricultural practices, also contribute to the deterioration of soil quality. If not addressed with haste, this situation can impede the advancement of agricultural development within the university setting and diminish the advantages of the land as a resource that bolsters research, education, and technological innovation (Risky Amelia, 2016).

The incubation period refers to a designated timeframe during which soil is subjected to specific treatments or left undisturbed to monitor alterations in its chemical characteristics. This phase is crucial in soil research as it elucidates the dynamics of nutrients, pH levels, organic matter content, and mineral composition under both controlled and natural conditions. The interactions among organic matter, microorganisms, and soil minerals throughout the incubation period can significantly influence nutrient availability for plant uptake (Siregar et al., 2017). For instance, the decomposition of organic matter can lead to elevated levels of nitrogen and phosphorus in the soil, while pH alterations may arise from the release of hydrogen ions during various chemical reactions. The incubation process is instrumental in understanding the soil's response to treatments, such as applying fertilizers or organic amendments, before its utilization for agricultural purposes (Haitami & Wahyudi, 2019).

A primary challenge encountered during the incubation period is the management of environmental variables, including temperature, humidity, and aeration, which profoundly impact the chemical processes occurring within the soil. An imbalance in these conditions can trigger undesirable chemical reactions, such as excessive soil acidification or nitrogen loss through volatilization. Furthermore, without appropriate treatment protocols, the incubation process may fail to accurately simulate real-world land conditions, thereby rendering the observations of soil chemical properties less representative. Additionally, the absence of precise baseline data regarding soil chemical properties before incubation often complicates the evaluation of the effectiveness of the treatments applied during this period. This underscores the necessity for meticulous planning and monitoring in soil incubation studies (Kusuma et al., 2016). In previous research conducted at the Labuhanbatu University Practice Land, the bulk density of Ultisol soil was studied at 1,060 grams/cm³, with organic matter identified as a significant influencing factor. This study is distinctive in that it concentrates on soil chemical characteristics, including pH, C-organic, and C/N ratio, and contrasts the impacts of oil palm vegetation and shrubs (Harahap et al., 2021).

In light of the aforementioned discussion, the researcher will undertake a study entitled "Analysis of Several Soil Chemical Properties during the Incubation Period in the Cultivation Land of the Faculty of Science and Technology, Labuhanbatu University". The objective of this study is to ascertain the chemical characteristics of the soil found in cultivated land, including pH, organic matter content, total nitrogen, available phosphorus, and potassium. The results of this analysis will provide a comprehensive understanding of soil fertility and the alterations in chemical properties that occur during the incubation period. The findings of this study will provide a foundation for the development of effective fertilization recommendations, aiming to enhance cultivated land's productivity in a sustainable and optimal manner.

2. Material and Methods

2.1. Research Site and Time

This research was conducted in Agrotechnology cultivation land domiciled with oil palm plants and shrubs at N 230548 ° and E 595859. With an altitude of 28 MDPL. This research was conducted from April to September 2024.

Figure 1. Location of soil sampling research

2.2. Research Tools and Materials

The tools used include a hoe and soil drill for soil sampling, a digital scale for weighing soil and additional materials, a Memmert brand drying oven with a capacity of 50 liters to remove soil moisture, a Hanna HI 98129 brand pH meter to measure soil acidity levels, and other devices such as a stainless steel spatula, a Tupperware brand transparent plastic container, and a Pyrex brand measuring cup with a capacity of 250 ml. The materials needed include soil samples, organic materials or ameliorants for treatment, distilled water for analysis, and standard chemical solutions for testing parameters such as cation exchange capacity (CEC) and nutrient levels. Fertilization is carried out in the practice area by providing chemical fertilizers that have N, P and K nutrients and factors that affect the addition of chemicals are also caused by the weathering of organic materials that occur so that they can affect the quality of soil pH and organic C in the soil.

2.3. Research Method

a. Survey Method

The survey method is a research approach used to systematically collect data from a group of respondents who are representative of a particular population, intending to understand their views, attitudes, behaviors, or characteristics towards a topic. This method usually involves using instruments such as questionnaires or structured interviews designed to obtain relevant information (Tewu et al., 2016).

b. Purposive Random Sampling Method

Soil sampling in this study was carried out using the purposive random sampling method, which combines the deliberate selection of points based on specific land characteristics, while maintaining random elements in the distribution of sampling points (Walida et al., 2020).

c. Observation Parameter

Soil pH Measurement

Soil pH is measured using a potentiometric method with a pH meter. Prepared soil (usually a mixture of soil and water) is measured using a pH meter to determine the soil's acidity level, which is an important indicator for understanding the chemical condition of the soil.

Determination of C-organic

The organic carbon content of the soil was determined by the Walkley and Black method, which employs potassium dichromate oxidation in the soil to convert organic carbon to carbon dioxide. Following the oxidation process, the organic C content was calculated based on the amount of potassium dichromate that had been reduced.

N-total analysis

The soil's total nitrogen content was determined by the Kjeldahl method, which entails the digestion of the soil sample with sulfuric acid and the use of a catalyst to convert nitrogen to ammonium. Subsequently, the resulting ammonium is titrated with a standard solution, thereby enabling the calculation of the total nitrogen content in the soil sample.

C/N Ratio Calculation

The C/N ratio is calculated by comparing the organic C content obtained using the Walkley and Black method with the total N content obtained using the Kjeldahl method. This ratio indicates the balance between carbon and nitrogen in the soil, which is important for the decomposition process of organic matter.

d. Implementation of research

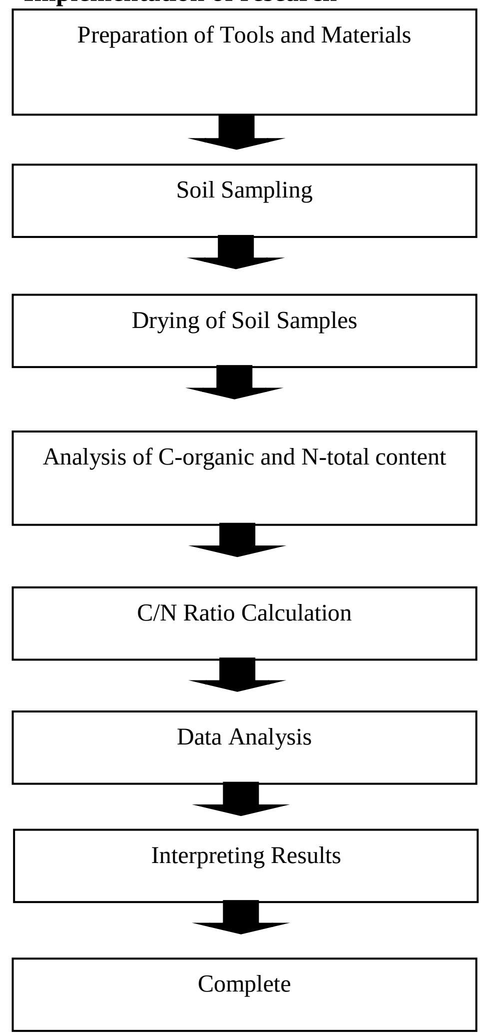

Figure 2. Research flow diagram

3. Results and Discussion

From the results of soil sampling in 2 different areas in the Labuhanbatu University agrotechnology research area and research has been conducted in the physics and soil conservation laboratory at the University of North Sumatra, which aims to determine soil pH, organic C, total N, and C/N, the data is presented in the table according to each soil parameter as follows:

3.1. Soil pH

Based on the results of laboratory tests conducted in the physics and soil conservation laboratory at the University of North Sumatra, the soil pH parameters obtained are presented in Table 1. Laboratory results showed variations in soil pH values in two vegetation types: oil palm and shrubs. In oil palm land, the pH value ranged from 4.30 to 4.60, with an average of around 4.44. This pH value indicates that the soil in oil palm land tends to be acidic, which may be caused by the intensity of using nitrogen-based fertilizers or the lack of organic matter that can neutralize acidity.

Table 1. Soil pH laboratory test results

Vegetation	Soil pH				
	1	2	3	4	5
Oil Palm	4,50	4,60	4,30	4,30	4,50
Brush	4,40	4,80	4,75	4,60	4,60

The lowest value of 4.30 was found in samples 3 and 4, while the highest value of 4.60 was in sample 2. This condition indicates the possibility of heterogeneity in the distribution of nutrients or land use in the area. In shrub vegetation, the soil pH tends to be higher than oil palm land, ranging from 4.40 to 4.80, with an average of 4.63. The highest value was found in sample 2, with a pH of 4.80, while the lowest was 4.40 in the first sample. This increase in pH is likely due to the high content of natural organic matter from leaves and decomposed shrub residues. In addition, shrubs do not receive chemical fertilizer input, which can usually increase soil acidity. This difference indicates that the type of vegetation and land management significantly affect soil acidity levels. This study is different from (Harahap et al., 2021), which showed that the application of durian skin compost, Tithonia diversifolia, and empty oil palm bunches significantly increased the pH of Ultisol soil. The combination of durian skin compost with chicken manure also increased soil pH. The main difference with this study is the focus on the effect of vegetation type on soil pH, whereas this study compared soil pH between oil palm and shrub lands. In addition, this study assessed the effect of vegetation on overall soil chemical properties, not just soil pH (Harahap et al., 2021). Research (Rosalina & Maipauw, 2019) stated that soil chemical characteristics vary based on vegetation type, with paddy fields having higher pH, organic C, and available P values than garden and dry land soils. Meanwhile, garden soil showed higher total N, available P, and extra Al levels than other vegetation. Overall, the observed soil chemical properties values included pH (5-6), organic C (0.11%), available P (23 ppm P2O5), total N (0.25%), and extra Al (1.5 me/100 g), indicating that different vegetation and soil management had a significant impact on soil chemical properties (Rosalina & Maipauw, 2019).

3.2. C organic (%)

Based on observations of laboratory results in the physics and soil conservation laboratory at the University of North Sumatra, the organic c results are presented in Table 2. Laboratory results showed that the organic C content in oil palm plantations varied, with values ranging from 0.54 to 1.36. The lowest value of 0.54 was found in sample 4, which was likely due to low input of natural organic matter such as leaves or decomposed plant residues.

Table 2. Organic C laboratory test results

Vegetation	C organic (%)				
	1	2	3	4	5
Oil Palm	0.95	1,05	0,90	0.54	1,36
Brush	1,46	1,52	1,11	0,88	0,98

In contrast, the highest value of 1.36 was found in sample 5, which may indicate an area with higher organic matter accumulation. In general, the average organic C content in oil palm plantations tends to be low, which may be caused by intensive land management practices, such as weeding that reduces sources of organic matter or the decomposition process accelerated by environmental conditions. Meanwhile, the organic C content in shrub lands tends to be higher than in oil palm plantations, with values ranging from 0.88 to 1.52. The highest value of 1.52 was found in sample 2, likely due to high decomposition of shrub residues and accumulation of organic matter from natural vegetation. The lowest value of 0.88 was found in sample 4, possibly due to less supportive environmental conditions, such as flooding or lower microorganism activity. The average C-organic content in shrub land is higher than oil palm, indicating that natural vegetation is more effective in maintaining or increasing soil organic matter through natural processes without human intervention. This study is different from Ginting et al. (2023) in Wawolahumbuti Village, Pondidaha District, Konawe Regency, assessing the status of C-organic and N-total in oil palm development land. The results showed that the soil C-organic content was at a very low to low status, with values ranging from 0.87% to 1.57%. This decrease in C-organic content may be caused by intensive land management practices, such as weeding, which reduces sources of organic matter, or the decomposition process accelerated by environmental conditions (Ginting et al., 2023). Research conducted by Pratiwi et al. 2013 showed that soil processing and bagasse mulching did not significantly affect the content of soil organic C in the second year of sugarcane plantations. In addition, no significant correlation was found between organic C and the content of microorganism carbon biomass (C-Mic) in the soil. These results indicate that the treatment did not directly increase the content of soil organic C, likely caused by a suboptimal organic decomposition process or soil properties that are not responsive to the treatment under certain conditions (Pratiwi et al., 2013).

3.3. N total (%)

Based on observations of laboratory results carried out in the physics and soil conservation laboratory at the University of North Sumatra, the total N results are presented in Table 3.

Laboratory results showed that the total nitrogen (N) content in oil palm plantations was relatively uniform, ranging from 1.02 to 1.07. The lowest value of 1.02 was found in sample 5, while the highest value of 1.07 was seen in samples 1 and 4.

Table 3. Total N laboratory test results

Vegetation	N Total (%)				
	1	2	3	4	5
Oil Palm	1,07	1,03	1,06	1,07	1,02
Brush	1,13	1,17	1,15	1,21	1,22

The average total N content in oil palm plantations was quite stable, which may be influenced by the regular application of nitrogen fertilizers in plantation management. However, small fluctuations in these values may be caused by differences in microhabitats or varying microorganism activities in certain areas. The total N content in shrublands showed higher variations than oil palm plantations, with values ranging from 1.13 to 1.22. The highest value of 1.22 was found in sample 5, possibly due to the high decomposition of organic matter from shrub residues. The lowest value of 1.13 was found in sample 1, which may be associated with natural variations in the distribution of organic matter and microorganism activities. Generally, the average total N content in shrub land is higher than in oil palm, indicating that natural ecosystems with shrub vegetation contribute more to nitrogen accumulation in the soil. This study differs from studies that found that the total nitrogen (N-total) content in oil palm development land ranged from 0.11% to 0.24%, with low to moderate status. This difference may be caused by variations in soil conditions, land management practices, and environmental factors between the two research locations (Ginting et al., 2023). The results showed that the soil's total nitrogen (N-total) content was higher in oil palm plantation land planted with ground cover plants than land without ground cover plants. Ground-cover plants contributed the greatest to increasing total soil nitrogen, while land without ground cover plants had the lowest total nitrogen content. This indicates that the presence of ground cover plants can effectively increase the total nitrogen content in the soil in oil palm plantation land (TM Alfarizi & Munawar Khalil, 2023).

3.4. C/N Ratio

Based on observations of laboratory results conducted in the physics and soil conservation laboratory at the University of North Sumatra, the C/N results are presented in Table 4. Based on laboratory data, the C/N ratio in oil palm vegetation showed low variation, ranging from 0.50 to 1.33.

Table 4. C/N ratio laboratory test results

Vegetation	C/N				
	1	2	3	4	5
Oil Palm	0,88	1,01	0,84	0,50	1,33
Brush	1,29	1,29	0,96	0,72	0,80

All values are below the ideal ratio threshold (10–30), indicating that organic matter in this soil decomposes quickly, but the carbon content is relatively low compared to nitrogen. For example, the sample at point 4 has a C/N ratio of 0.50, indicating a very low carbon content, so decomposition occurs too quickly, potentially resulting in carbon-poor soil. The highest value at point 5 (C/N 1.33) indicates slightly better conditions than the other points but is still far from the ideal range, affecting soil quality in the long term. Meanwhile, the C/N ratio in shrub vegetation is slightly higher than in oil palm, with values ranging from 0.72 to 1.29. However, all values remain in the low category (<10). Point 4 has a C/N ratio of 0.72, indicating conditions of organic matter that are easily decomposed, but the carbon content is still very low. On the other hand, points 1 and 2 have a C/N value of 1.29, the highest ratio for shrubs, reflecting slightly more carbon than the other points but still far from the ideal ratio. The low C/N ratio in both vegetations indicates the need for additional organic matter management, such as compost or other organic matter, to improve soil quality in the study area. This study differs from studies that found higher C/N ratios in oil palm and shrub lands, approaching or within the ideal range. This difference may be due to variations in land management practices, vegetation types, and environmental conditions between study sites (Dirra, 2022). According to Qadafi et al. 2021 A high C/N ratio indicates that the decomposition rate has not increased. The higher the C/N ratio, the lower the level of decomposition that occurs (Bintuni, 2023).

4. Conclusion

The study's findings indicated that the soil in oil palm and shrub samples exhibited distinct characteristics. The pH of oil palm soil exhibited a range of 4.30–4.60 (with an average of 4.44), which was lower than that observed in shrubs, which ranged from 4.40–4.80 (with an average of 4.63). Furthermore, the C-organic content of oil palm (0.54–1.36, average 0.96) was also lower than that of shrubs (0.88–1.52, average 1.19). The total nitrogen content of the oil palm ranged from 1.02 to 1.07 (with an average of 1.05), which was lower than that of the shrubs, which ranged from 1.13 to 1.22 (with an average of 1.18). The C/N ratio in both vegetation was low (less than 10), indicating rapid decomposition but low carbon content.

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