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Evaluation of Soil Fertility Status on Oil Palm Cultivation Land (*Elaeis guineensis* Jacq.) In Pulo Padang Village

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ABSTRACT

Declinen soil fertility on crop cultivation land has become a problem that must be considered. As an effort to rehabilitate these lands, it is very necessary to carry out appropriate actions. One way is to evaluate soil fertility by looking at the soil chemical characteristics of land that has been managed intensively. The aim of this research is to determine the chemical characteristics of the soil and the status of soil fertility on agricultural land in Pulo Padang Village, Rantau Utara District, Labuhanbatu Regency. The method used in this research was a survey method and soil sampling which was carried out by purposive sampling on oil palm plants which were composited, air-dried and chemical analysis of the soil was carried out in the laboratory. The results of research on soil chemical characteristics show a soil pH value of 5.0-5.2 with acid status, C-organic 1.42-1.67% (Low), Total Nitrogen 0.13-0.15% (low), P2O5 with a value of 283-400 mg/100g (Very High), P available 36.2-126.6 ppm (Very High), Base cations can be exchanged Ca^{2+}, Mg^{2+}, K^{+}, Na^{+} namely 7.19-8.13 cmol/kg (Medium), 3.22-3.93 cmol/kg (High), 0.17-0.30 cmol/ kg (Low), 0.08-0.22 cmol/kg (Very low), CEC 14.66cmol/kg (Very Low) and 21.98 cmol/kg (Medium), KB 57-73 % (Very High). The soil fertility status of agricultural land in Pulo Pandang Village, Rantau Utara District, Labuhanbatu Regency has a low fertility status, so management measures are needed to increase soil fertility.

Keywords: *Nutrient Status, Palm Oil, Purposive Sampling, Soil Fertility*

1. INTRODUCTION

One of the causes of critical land is intensive cultivation with the use of chemical fertilizers over a long period of time, thereby reducing the quality of agricultural land or decreasing soil fertility. Soil fertility is defined as a condition where chemical, physical and biological properties are at optimal conditions and are supported by environmental factors that influence plant growth (Harahap *et al.,* 2024). Soil fertility factors describe the condition of the soil in providing nutrients and are supported by environmental factors that are in optimal conditions or circumstances for plant growth. As land management is carried out intensively and over a long period of time, soil fertility decreases. To be able to improve soil fertility and maintain land sustainability and increase crop production, one of the efforts that needs to be taken as a first step in sustainable land management can be to evaluate soil fertility. The research results of Qishty *et al.,* (2023), stated that the level of nutrients in the replanting land for oil palm plants (*Elaeis guineensis* Jacq.) in Bakaran Batu Village, Rantau Selatan District was included in the low category so as to improve the soil fertility status at the research location for further planting, So efforts are needed in the form of liming and fertilizing as well as adding organic material so that the availability of nutrient elements for plants is more adequate. Soil fertility evaluation is defined as the process of diagnosing the status of nutrients in the soil and recommending fertilizer. The land in the Pulo Padang Village is a horticultural crop cultivation area that has been cultivated since the 1980. Over this long period of time, land quality has decreased. Apart from that, plant cultivation activities are carried out by applying inorganic fertilizers as an effort to increase production so that there has been a decrease in land quality which can be seen from the physical characteristics, namely the compaction of the soil. So far there have been many research results which state that there is an effect of applying chemical fertilizers on reducing physical fertility biology or chemistry (Harahap *et al.,* 2019). One of the uses of chemical fertilizers and pesticides is one of the factors causing a decrease in land productivity. Efforts to increase knowledge of the importance of organic fertilizers in improving soil have been carried out as a solution to improving and increasing soil fertility. However, in the application of organic fertilizers is necessary to know how much the characteristic value of the soil's chemical properties is. land that is experiencing a decline in quality, so that the basis for fertilization can be done by considering the chemical properties of the soil. Results of research by Resti *et al.,* (2024) in the study of several physical properties of soil in immature oil palm plantations (Tbm) on different slopes with different values Bulk Density value 1.30 – 1.51 g/cm3, Total Pore Space 0.17-0.58%, water content 0.20-0.27%, while the texture is dominantly clayey, and the structure is dominantly angular blocky. The physical properties of soil require a long time to change, because the physical properties of soil are difficult to change. To improve land quality or increase land productivity in Pulo Padang sub-district, one way that can be done is to evaluate the chemical properties of the soil on land in Pulo Padang sub-district. By evaluating soil fertility on land in Pulo Padang Village, it is hoped that it can provide an overview of the chemical characteristics of the soil and appropriate steps can be taken to improve soil fertility.

2. MATERIAL AND METHODS

2.1 Time and Place

The research was carried out on the community's oil palm plantation land in Pulo Padang Village, Rantau Utara District, Labuhanbatu Regency at a height of 32 meters above sea level in Figure 1. Research activities were carried out from December 2023-April 2024. Soil

analysis was carried out at the Socfindo Seed Production and Laboratories (SSPL) Laboratory. Taman Bangun Bandar PT. Socfin Indonesia North Sumatra. The research was carried out using a field survey method carried out in the oil palm plantation area of the Rantau Utara District, Labuhanbatu Regency. The research began with pre-research by taking soil samples. At the N : 98^0 22'43,22" E : 02^0 42' 54.21" coordinate point.

Figure 1. Map of research locations

2.2 Tools and Materials

The materials used in this research were intact soil samples at depths of 0-30 and 30-60 cm and disturbed soil samples taken as a composite. The tools used are GPS (Global Position System), abney level, sample ring, mineral soil drill, field knife, hoe, cutter, plywood or board, plastic bags, rubber bands, labels, stationery, camera, office software, Arc software - GIS, Avenza MAP application, and Munsel Color Chart book.

2.3 Research Methods

The method used in this research is a free grid measurement method at a semi-detailed survey level (observation frequency of 1 sample per 500 meters). Carrying out soil sampling at up to 5 sampling points with a distance of 100 meters in the field using a random method, spread over a predetermined area based on the base map as shown in Figure 2 (Rauf and Harahahap. 2019). Sampling was carried out using a random sampling method at predetermined points in each block, sampling was carried out from two depths, namely from a depth of 0-30 cm and from a depth of 30-60 cm, 5 samples each at the same two depths for content examination chemistry. explore soil properties with certain predetermined criteria, based on technical guidelines for soil fertility management, to evaluate instructions by the Ministry of Agriculture's Agricultural Research and Development Agency (2012).

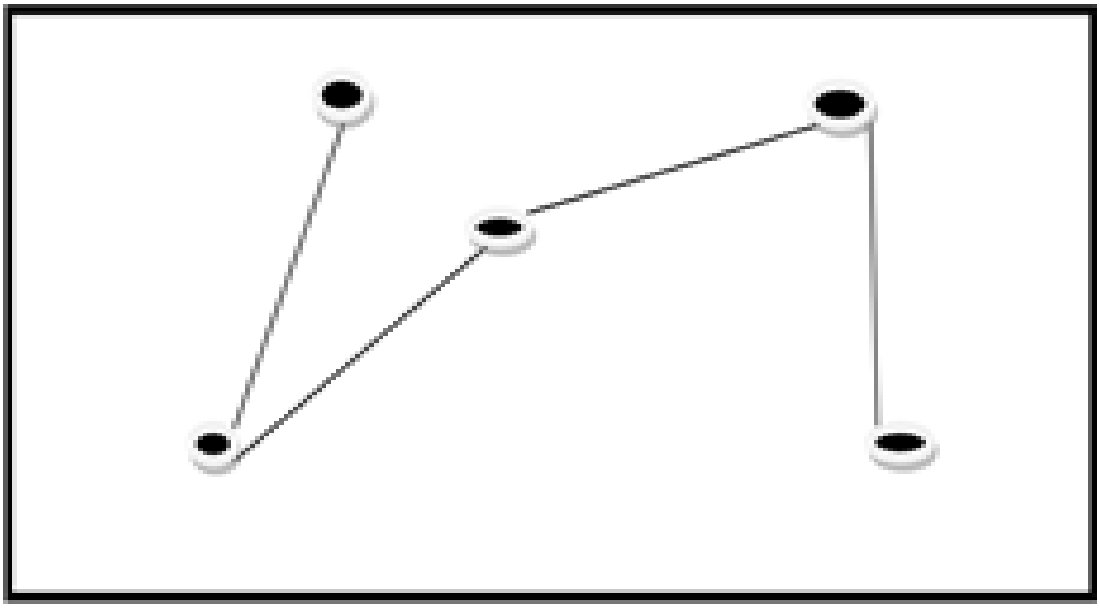

Figure 2. Taking soil sample points in the field

Soil samples were analyzed to determine the nutrient content, namely Nitrogen (N) Kjeldahl method in % units, Phosphorus (P) 25% HCl method in mg/100 units, Potassium (K) 25% HCl method in mg/100 units, C-Organic Walkey method and Black units %, soil pH. The results of the analysis are carried out tabulated to describe the chemical properties of the soil referring to the criteria of soil chemical properties, while the assessment of soil fertility status is based on a combination of several chemical properties of soil and the status of soil fertility.

2.4 Stages of Research

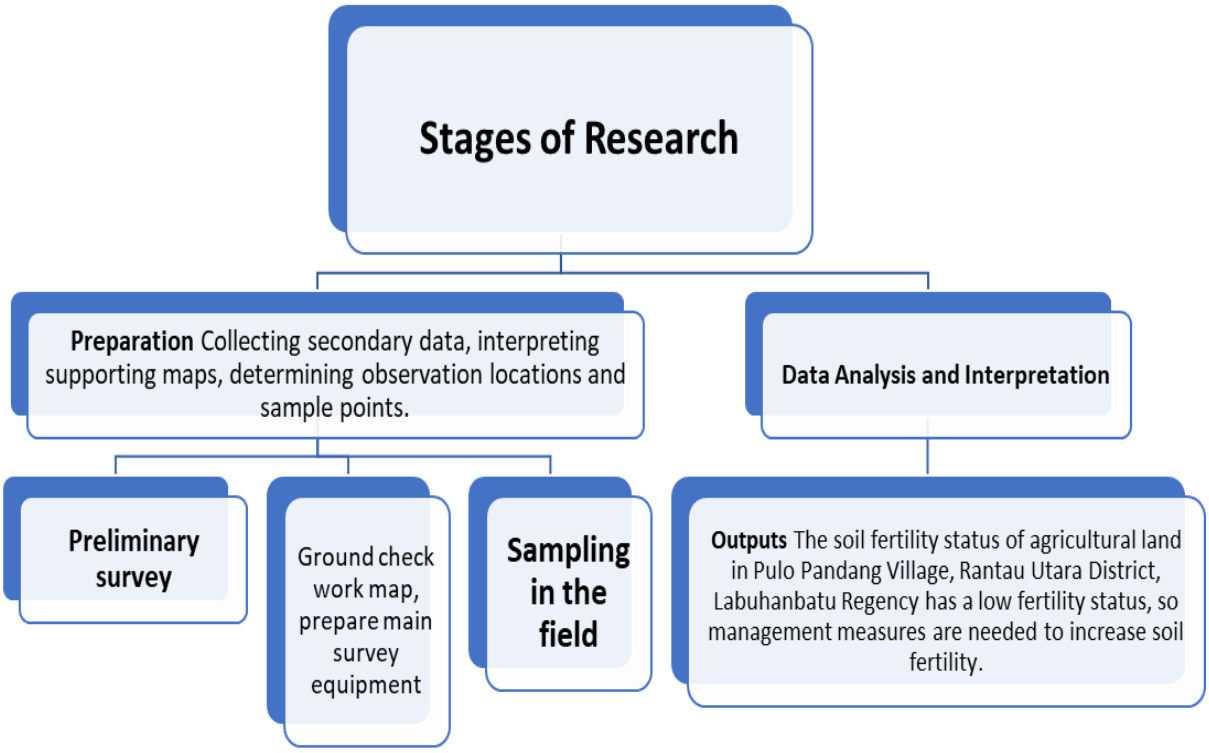

Figure 3. Research Flow Diagram

3. RESULT AND DISCUSSION

Plants need nutrients to grow well. The main source of nutrition for plants is soil which provides nutrients. The availability of nutrients in the soil is part of the chemical characteristics of the soil. Soil chemical properties are one of the soil properties that play a role in determining soil fertility. Analysis of soil chemical properties includes pH, Carbon (C-Organic), Nitrogen, P_2O_5, available P, exchangeable base cations, Cation Exchange Capacity, Base Saturation (%), Aluminum Saturation (%). The results of soil chemical analysis of soil chemical parameters can be seen in Table 1.

Table 1. Results of Soil Chemical Analysis on Palm Oil Cultivation Land in Pulo Padang Village, Rantau Utara District, Labuhanbatu Regency

No	Soil Properties	L1	L1 state	L2	L2 state
1	pH (H2O)	5.2	Sour	5.43	Sour
2	Carbon (%)	1.7	Low	1.45	Low
3	Total Nitrogen (%)	0.15	Low	0.13	Low
4	C/N	11.13	Currently	11.12	Currently
5	P_2O_5 HCL (mg/100g)	283	Very high	400	Very high
6	P available (ppm)	126.6	Very high	36.2	Very high
	Base cations can be exchanged				
	Ca++ (cmol/kg)	7.19	Currently	8.13	Currently
	Mg++ (cmol/kg)	3.22	Tall	3.93	Tall
	K+ (cmol/kg)	0.17	Low	0.3	Low
	Na+ (cmol/kg)	0.08	Very low	0.22	Very low
7	Cation Exchange Capacity (cmol/kg)	14.66	Low	21.98	Currently
8	Base Saturation (%)	73	Tall	57	Currently
9	Aluminum Saturation (%)	2.09	Very low	1.55	Very low

Source: Laboratory Analysis Results andAgricultural Research and Development Agency, Ministry of Agriculture (2012)

Results Table 1. Soil pH is an important factor that influences plant growth and determines soil fertility because pH has an important role in determining whether or not nutrients can be absorbed by plants. The results of pH analysis from land in Aek Paing Village have pH values ranging from 5.0-5.2 and include acid criteria. Several factors cause soil acidity, namely the presence of aluminum content, calcium and magnesium deficiency and manganese poisoning. From these three factors, the results of calcium analysis show moderate criteria so it is thought to have a correlation between the acidity of soil pH on land in Pulo Padang Village, while organic matter has an important role. as a provider of nutrients for plants either directly or indirectly. Organic matter in the soil is available in the form of C-organic. The organic C content from the analysis results is in the low criteria with values of 1.42% and 1.67%. This low organic matter content can be caused because the land that has been used is intensively cultivated land, thereby reducing the value of C-organic content. C-organic is an indicator in determining soil fertility so if it has a low value it can be one of the causes of low soil fertility (Rauf *et al.,* 2020). Efforts to improve organic C on agricultural land that has experienced a decrease in C content and soil fertility can be done by adding organic fertilizer to the soil. Providing organic fertilizer can increase crop production. Increasing the application of cow dung bokhasi fertilizer has an influence on changes in soil organic C content. Nitrogen is a nutrient that has an important role, especially for plant vegetative growth (Rahmawaty *et al.,*2020). The results of soil analysis show that the total nitrogen contained in

the soil on land in Aek Paing Village has a low status with values of 0.13 and 0.15%. Nitrogen is an element that is easily lost due to leaching. Inorganic nitrogen compounds are easily lost in water. Nitrogen is an element that plants need in greater quantities, especially for vegetative growth and is easily lost so nitrogen is usually the main concern regarding its availability in the soil. The results of the analysis of available P are at very high status with availability values of 126.6 ppm (L1) and 26.2 ppm (L2). The high availability of P shows that the soil on plant cultivation land in Aek Paing Village has very high P availability for plant growth. The availability of P in the soil is greatly influenced by various factors including high clay content, soil pH, and P fertilization. The availability of P in the soil in high quantities provides nutrients for plant growth. Sources of P in soil for plants come from organic materials and fertilizer application.Exchangeable base cations consisting of Ca2+, Mg2+, K+, and Na+ have an important role in determining soil base saturation. The results of the analysis of exchangeable base cations show that Ca2+ has a medium status with a value of 7.19 cmol/kg and 8.13 cmol/kg, Mg2+ has a high status with a value of 3.22 cmol/kg and 3.92 cmol/kg, K+ has a status low with values of 0.17 cmol/kg and 0.30 cmol/kg, and Na+ has a very low status with values of 0.08 cmol/kg and 0.22 cmol/kg (Table 1). The low base cation content can be caused because tropical land tends to have high rainfall, causing these bases to be easily leached (Widyantari *et al.,*2015). BMKG rainfall data in the Labuhanbatu area throughout 2022 shows light to heavy rainfall, so this could be a factor in the high level of leaching of exchangeable bases. Apart from that, the low availability of basic cations can be caused by factors being transported by plants at the same time as harvest and the absence of additions through fertilization. In the analysis results, Mg2+ has a high status and Ca2+ has a medium status, because the factors that influence the availability of Mg2+ are soil texture, where if the texture is finer it will increase the availability of Mg2+ and if the texture is coarse it will have a lower Mg2+ content, as well as the deficiency of Mg2+ in acidic sand-textured soils. Cation Exchange Capacity has an important role in determining soil fertility. The cation exchange capacity (CEC) value will determine how much nutrients the plant absorbs. The results of the cation exchange capacity analysis show that the status is low with a value of 14.66 cmol/kg for Land 1 (L1) and the medium status is 21.98 cmol/kg for Land 2 (L2). Factors that influence the magnitude of the CEC value in the soil are soil pH, amount of clay and amount of organic matter, base saturation. The low CEC value from the analysis results has a correlation with the acidic pH analysis results and low organic C content. High and low CEC is determined by soil pH, clay content or texture, type of clay minerals, soil organic C content and fertilizer action. Cation exchange capacity will increase in line with the higher clay content and soil organic matter (Husni, *et al.,* 2016). This statement correlates with research results which show that soil organic matter in the analysis results shows a low status. Low cation exchange capacity influences soil fertility because it is always related to the availability of nutrients in the soil for plant growth, so that if the CEC is low it indicates that the condition of the nutrients in the soil is low. The results of soil chemical analysis show that the Base Saturation (KB) value is high with a value of 73% (L1) and 57% (L2) with medium status. Base saturation is an important indicator in determining soil fertility.Soil with base saturation ≥ 80% is considered very fertile, soil with medium soil fertility if the base saturation value is between 80-50% and ≤ 50 has low soil fertility (Lubis and Siregar 2019). so that the base saturation value on land in Aek Paing shows the level Moderate

fertility. In conditions of high base saturation, the soil will be able to release exchangeable bases such as Calcium, Magnesium, Potassium and Sodium, whereas the lower the base saturation value, the lower the release of bases.

3.1 Evaluation of Soil Fertility Status on Oil Palm Cultivation Land in Pulo Padang Subdistrict

Soil fertility is an important factor in determining plant production because soil fertility describes how the physical, chemical and biological properties of the soil influence the availability of nutrients for plant growth. The results of soil fertility evaluation on palm oil cultivation land in Aek Paing Village are determined based on technical instructions for soil fertility evaluation (Pinatih *et al.,* 2015), determining the values of Cation Exchange Capacity (CEC), Base Saturation (KB), P2O5, K2O, and C-Organic then the results Soil fertility status can be seen in Table 2.

Table 2. Soil Fertility Status on Palm Oil Cultivation Land in Pulo Padang Village, Rantau Utara District, Labuhanbatu Regency

No	Soil Indicator	L1 value	L1 state	L2 value	L2 state
1	CEC (cmol/kg)	14.66	R	21.98	S
2	KB (%)	73	ST	57	Q
3	P2O5 (mg/100g)	283	ST	400	ST
4	K2O (mg/100g)	16	R	21	S
5	C-Organic (%)	1.67	R	1.42	R
	Soil Fertility Status		Low		Low

Note: ST = Very High; S = Medium; R= Low

Evaluation results of soil fertility status on palm oil cultivation land in Pulo Padang Village based on indicators of Kaion Exchange Capacity, Base Saturation, P2O5, K2O, COrganic indicate Low soil fertility status (Table 2). The C-organic factor has a low status because farmers still do not use organic fertilizer in plant cultivation activities (Ariska *et al.,* 2022) The availability of organic matter (C-organic) in the soil determines soil fertility and productivity because it indicates the activity of soil microorganisms (Harahap and Yana 2020). Therefore, to increase soil fertility, fertilization measures from organic materials are needed to increase the availability of macro and micro nutrients. In actions or efforts to increase soil fertility, it is also necessary to carry out irrigation actions to increase soil pH so that it can have a correlation relationship to increase the Cation Exchange Capacity of the soil. Another action that can be taken to improve or increase soil fertility can be done by applying organic fertilizer. Several research results have proven that the application of organic materials can improve the physical, chemical and biological properties of soil (Harahap *et al.,* 2018). Application of organic fertilizer to the soil can improve soil pH. The application of organic fertilizer can improve soil pH. There is an interaction between chicken manure and egg shells on available P, available Ca and soil organic C.

4. CONCLUSION

Chemical characteristics of soil on agricultural land in Pulo Padang Village, Rantau Utara District, Labuhanbatu Regency are soil pH value with acid status, low organic C, low Total Nitrogen, very high P_2O_5, very high available P, base cations can exchange Ca^{2+}, Mg^{2+} , K^{+}, Na^{+} namely Medium, High, Low, Very low, Very Low CEC, medium to high CEC. Soil fertility status is low so management measures are needed to increase soil fertility.

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