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Study Of Chemical Properties Of Soil On Gambir (*Uncarıa Gambir Roxb*) Land Based On Slope İn Nagari Siguntur, Koto XI Tarusan district, Pesisir Selatan regency, Indonesia

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ABSTRAC

Gambier plants (*Uncaria gambir.Roxb*) are the main plantation commodity in West Sumatra. However, cultivating gambier on steep slopes can cause changes in soil chemical properties. This research aims to examine the chemical properties of soil on gambier land based on slope class in Nagari Siguntur. This research was carried out from June to December 2022. The method used was a survey method with the Purposive Random Sampling technique. Soil samples taken were soil samples on 3 slopes and forest as a control (45%) at a depth of 0-30 cm with 3 replications. The analysis results show the soil pH value is between 3.98–4.47 with very acid criteria. Soil C-Organic content is between 0.86%-1.76% with very low to low criteria. The N-Total content is between 0.26%-0.32% with medium criteria. The P-Available content is between 2.15 ppm-13.54 ppm with very low to low criteria. CEC with a value of 14.39-17.02 cmol/kg with low to moderate criteria. And the exchangeable cations in gambier land are classified as very low criteria.

Keywords: Gambier plants, slope, soil chemical

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INTRODUCTION

Astronomically, Pesisir Selatan Regency is located at 100° 24’12.2” – 100° 28’40.1” East Longitude and 1° 1’38.9” – 1° 8’45.5” South Latitude. Geographically, Pesisir Selatan Regency is located on the west coast of Sumatra Island and has 15 districts with a total area of 6,049.33 km². Gambir is one of the important agricultural commodities because it has a relatively high economic value and is traded in the form of dried resin derived from the extract of Gambir leaves and twigs, which are processed and molded into cylindrical shapes. Gambir can be used as a raw material in the pharmaceutical, cosmetic, batik, paint, leather tanning, biopesticide, growth hormone, pigment industries, and as a food additive.

In Indonesia and India, Gambir is commonly used for betel chewing. In fact, India imports 68% of its Gambir from Indonesia for use as a betel chewing ingredient. With the growth of industrialized countries that produce goods requiring raw materials from Gambir, the demand for Gambir in industries is increasing. Therefore, the potential for Gambir export development remains significant. The market share for Gambir is still quite favorable as Indonesia only supplies 2.43% of the global demand (Denian, 2008). Gambir is used as a raw material for medicines and cosmetics, leather tanning, textile dyeing, paint, brewing, and as an ingredient in betel chewing mixtures (Bakhtiar, 1991 dan Suherdi, 1993).

In Koto XI Tarusan District, several nagaris extensively cultivate Gambir, one of which is Siguntur Nagari. According to the Pesisir Selatan Regency Agriculture and Plantation Office (2017), Siguntur Nagari has 822 ha of Gambir plantations with a production of 748.02 tons. Approximately ¼ of the Gambir production in Koto XI Tarusan District comes from Siguntur Nagari, with the demand for Gambir (Uncaria gambir Roxb) continuously increasing throughout the year (Yulnafatmawita dan Yasin, 2018). Gambir cultivation in Siguntur Nagari is generally conducted on moderately steep slopes (15 – 25%). Gambir is planted on slopes exceeding 60% (Winardi, 2011). This is due to the diverse topography of Siguntur and the growth requirements of Gambir, which needs well-drained soil conditions (not waterlogged). Another factor contributing to the low production of Gambir is planting on newly opened lands, which are generally located on critical land with steep slopes (>25%) and without the application of conservation farming techniques. The planting spacing used is irregular and does not follow contour lines. This cultivation system increases the risk of erosion and affects the soil's chemical properties (Ridwan, 2012).

The higher the slope, the more the soil's chemical properties deteriorate (Yulia, 2021). Based on research, the soil pH value on slopes of 0-8% is 5.75, while on upper slopes of 25-45%, the pH decreases to 4.76. The decrease in soil pH on steep slopes (25-45%) is likely due to soil erosion caused by water, leading to soil being eroded and base cations being carried away, leaving less fertile soil and resulting in leaching into the lower layers. In general, the best physical and chemical soil properties are found at the lower slope positions, as they have high soil organic matter and clay content (Sefano et al., 2024)

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MATERIALS AND METHODS

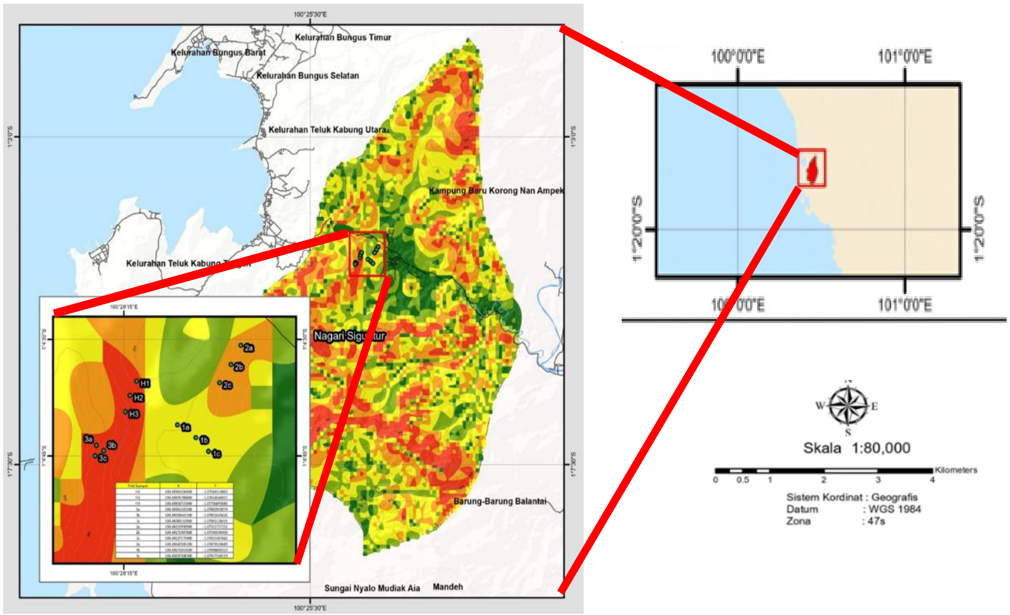

Fig. 1. Soil Sempling in Nagari Siguntur

This study was conducted using the survey method. Soil sampling was carried out using Purposive Random Sampling. Soil samples were taken based on three slope classes: <15%, 15-25%, 25-45%, with forest as the control (Figure 1). The soil samples collected were disturbed soil samples. Soil sampling was carried out at a depth of 0-30 cm based on slope classes, with three repetitions and forest as the control. The soil analysis conducted to observe soil chemical properties included pH (1:5) (Electrometric), Organic Carbon (OC) (Walkley and Black), Nitrogen (TN) (Kjeldahl), Available Phosphorus (Av.P) (Bray II), Cation Exchange Capacity (CEC) (Leaching with NH4OAc pH 7 1M), Determination of Exchangeable Aluminum (Al-exch) (Volumetric), and Base Saturation (Leaching with NH4OAc pH 7 1N). To determine the effect of slope on soil chemical properties in Kenagarian Siguntur, it is necessary to process the data on soil chemical properties in the gambir plantation. Data processing is done by calculating the average results of soil chemical analysis in the laboratory, then comparing the laboratory analysis results with the soil chemical properties criteria.

RESULTS AND DISCUSSION

A. General Conditions of the Research Area

Nagari Siguntur, is located in Koto XI Tarusan Subdistrict, Pesisir Selatan Regency, Indonesia, is one of the village that produces gambir. Land use in Nagari Siguntur, includes settlements, secondary forests, dry fields, and rice fields. From interviews conducted with gambir farmers, it was found that fertilization is done only

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once at the beginning of the planting period. Land clearing is done by cutting and burning, followed by planting. Gambir is fertilized with manure. The gambir plantations in the study area have slopes that are moderately steep (15-25%), steep (25-45%), and very steep (>45%). The land with slopes of (0-8%) and (8-15%) is not planted with gambir because these slopes are used for community settlements. Therefore, soil samples were taken only from three slopes, with the forest as a control (8-15%).

In Nagari Siguntur, the soil is not cultivated according to the contour, and there is no terracing on sloping land. The community only uses a monoculture cropping pattern. During the field survey, many gambir plants over 50 years old were found. Farmers only utilize the waste from the extraction process as fertilizer or organic matter, but its application is not evenly distributed across the slopes. The waste is only applied on slopes of 15-25% and >45%, with more being applied on slopes >45% because the gambir extraction site is located on that slope. Weeding is still done manually and traditionally. The appearance of the gambir plantations in the study area is shown in Figure 2.

Fig. 2. Gambir Land in Nagari Siguntur

B. Soil Analysis Results

1. pH and Al-Exchantable

Following are the results of pH and Al-Exch analysis on Gambir Land Based on Slope in Nagari Siguntur shown in Figure 3.

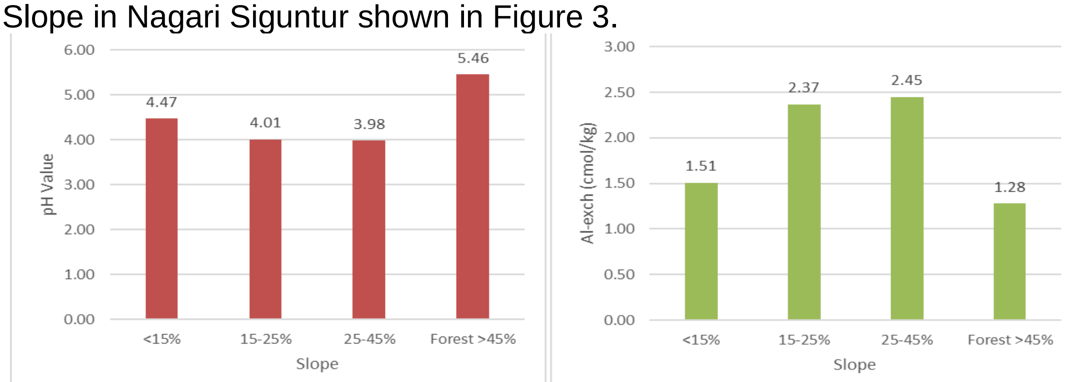

Fig. 3. pH and Al-exchantable in study area

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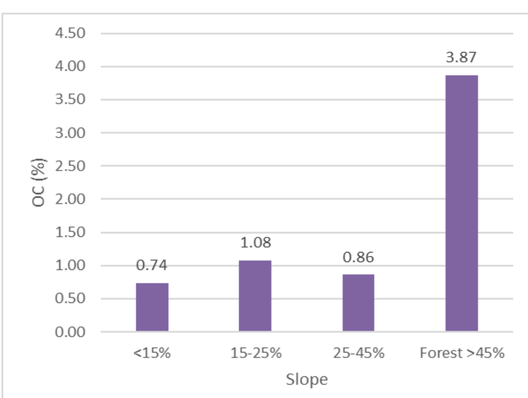
Based on Figure 3, the highest soil pH is found on slopes <15% with a value of 4.47, while the lowest soil pH is found on gambir land with a slope of 25-45% with a value of 3.98. This is due to the minimal surface runoff, which leads to the accumulation of organic matter on the upper slopes, as organic matter in the soil affects the soil pH. One factor that influences soil pH is the content of organic matter in the soil. This is in line that organic matter in the soil is a source of organic colloids that can bind Al and Fe [8]. The more water content in the soil, the greater the reaction of releasing H+ ions, causing the soil to become more acidic. In the forest land used as a control in this study, the soil pH has a value of 5.46, which is due to the higher content of organic matter compared to the gambir land. The forest has a high organic matter content derived from litter, and the cycle of organic matter return on forest land also occurs continuously.

Based on Figure 3, the highest Al-exch is found on slopes of 25-45% with a value of 2.45 cmol/kg, while the lowest is found on slopes <15% with a value of 1.51 cmol/kg. The high value of Al-exch is influenced by high rainfall and temperature, leading to a very intensive chemical weathering process, causing the loss of soil bases, and most of the colloids are dominated by H and Al ions. As a result, acidic soil is formed with low base saturation and high aluminum saturation. This is also supported that high rainfall leads to the leaching of bases such as Ca, Mg, Na, and K, which are easily carried away by surface runoff, resulting in high Al content [14]. The content of exchangeable Al (Al-dd) in the soil is related to soil pH and available P. This is in line that in acidic soils, P is bound by Al and forms Al-P and Fe-P compounds that are relatively insoluble, so P cannot be absorbed by plants [10]. Additionally, acidic soil pH is caused by colloids dominated by acidic cations such as Al3+. If Al3+ remains in the soil continuously, it will contribute a large amount of H+ ions to the soil, increasing soil acidity. In general, acidic pH is caused by high exchangeable Al content, high leaching of bases, and low organic matter content. The higher the clay fraction content in a soil, the higher the aluminum saturation [16].

2. Organic Carbon and Total Nitrogen

Following are the results of the analysis of total organic carbon and nitrogen on Gambir Land based on slope in Nagari Siguntur, shown in Figure 4.



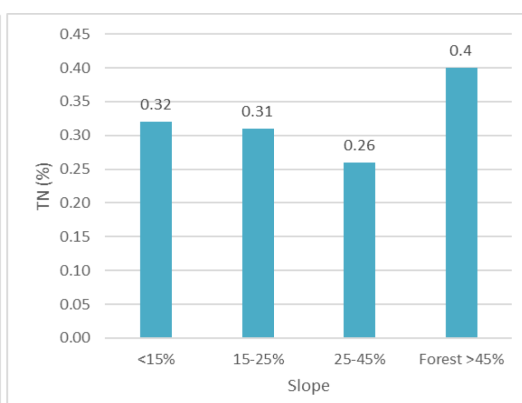


Fig. 4. OC and TN in study area

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Based on Figure 4, the highest organic carbon (C-Organic) content is found on slopes <15% with a value of 1.76%, while the lowest is on slopes of 25-45% with a value of 0.86%. The organic carbon content decreases with increasing slope percentage, which is due to the steepness of the slope causing the kinetic energy of surface runoff to be high, leading to greater energy for detaching and transporting the topsoil, which is rich in organic matter, down to lower slope areas. In the forest land used as a control in this study, the C-Organic content is 3.87%, attributed to the presence of large canopies that can reduce surface runoff, preventing rainwater from directly hitting the soil surface, thus maintaining the organic matter content in the soil. Additionally, forests are stable ecosystems where organic matter is continuously returned, making the forest soil fertile. This is consistent that organic matter plays a crucial role in soil fertility [5]. Organic matter can chelate acidity-causing elements such as Al and Fe, thereby reducing their concentrations in the soil and increasing the pH [13]. Organic matter content in soil plays an important role in determining the success of crop cultivation because organic matter can enhance the chemical, physical, and biological fertility of the soil [7].

Based on Figure 4, the highest total nitrogen (N-Total) content is found on slopes <15% with a value of 0.32%, while the lowest is on slopes of 25-45% with a value of 0.26%. This is likely related to the higher C-Organic content on slopes <15% compared to slopes of 25-45%. The N-Total content in soil is influenced by the organic matter content, which is related to the C-Organic in the soil. This is consistent that the N-Total content in soil is directly proportional to the organic matter content, meaning that any factor affecting soil organic matter content also affects N-Total levels [4]. The soil's ability to provide nitrogen is determined by the organic matter content [2]. N-Total tends to be higher in the upper slopes compared to the lower slopes, likely due to the decomposition of organic matter from plant and animal residues in the upper layers. Organic matter in soil contains protein (organic N), which during decomposition by microorganisms is broken down into amino acids, then into ammonium (NH_4) and nitrate (NO_3), which are soluble in the soil [9]. The bacteria involved in this decomposition process are nitrifying bacteria [9].

3. CEC and Available Phospor

Following are the results of the CEC and available phospor on the Gambir Land based on slope in Nagari Siguntur shown in Figure 5.

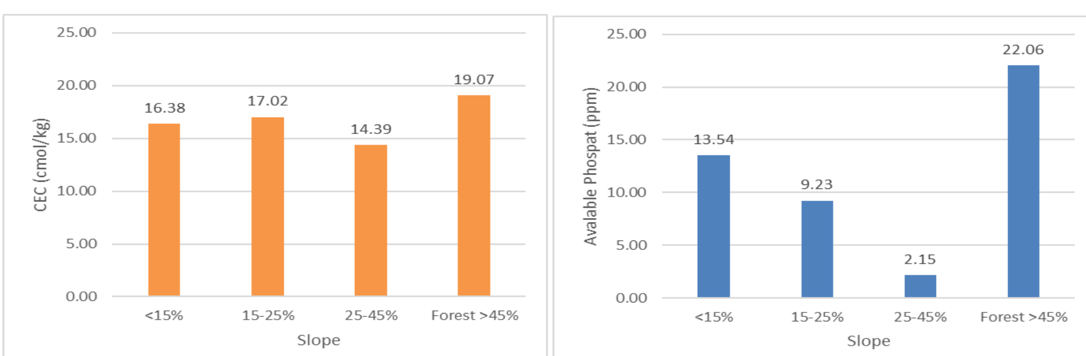

Fig. 5. CEC and Available Phospor in study area

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Based on Figure 5, the highest Cation Exchange Capacity (CEC) is found on slopes <15% with a value of 16.38 cmol/kg, while the lowest is on slopes of 25-45% with a value of 14.39 cmol/kg. The high or low CEC value is influenced by the organic matter content in the soil. This is consistent that the higher the organic matter content in the soil, the higher the soil CEC, and conversely, the lower the organic matter content in the soil, the lower the soil CEC [15]. The high CEC value is due to the decomposition of organic matter, which produces humus, thereby increasing CEC. Organic matter in soil has a higher cation exchange capacity than clay colloids. The higher the organic matter content in the soil, the higher the soil CEC. Soil with low CEC stores fewer nutrients but easily releases them into the soil solution, making them readily available to plants [14]. Besides the organic matter content, soil CEC is also influenced by soil pH. If the soil pH is low, the base saturation (BS) in the soil will also be low, causing soil cations to be dominated by acid cations such as Al and H. If there is an abundance of acid cations, especially Al, it can lead to toxicity in plants. This is consistent that the decrease in soil CEC value is caused by the soil pH value; the more acidic the soil, the lower the CEC value [8]. This occurs because CEC has variable charges that depend on soil pH. As soil pH becomes more acidic, the soil loses its ability to store nutrients, leading to a decrease in CEC.

Based on Figure 5, the highest available phosphorus (P-Available) is found on slopes <15% with a value of 13.54 ppm, while the lowest is on slopes of 25-45% with a value of 2.15 ppm. The highest P-Available content is found on the upper slopes, while the lowest is on the lower slopes. The low P-Available content on the lower slopes is due to the transport of clay particles from the upper slopes along with rainwater. This is also that one of the factors affecting P retention in soil is clay content; the higher the clay content, the higher the P retention in the soil [4]. Soil pH is another factor affecting P-Available content. If the soil pH is low or acidic, the availability of P-Available in the soil is also low. Phosphorus reacts with iron and aluminum ions to form iron phosphate and aluminum phosphate, which are insoluble in water and therefore cannot be utilized by plants in acidic soils. In the forest land used as a control in this study, the P-Available content is 22.06 ppm. This is due to the vegetation that protects the soil surface, which can supply nutrients such as leaf litter, twigs, and other decomposed materials, which are sources of soil organic matter. In contrast, the low vegetation density in gambier fields results in high organic matter leaching due to rainwater.

4. Cation Exchantable and Base Saturation

Following are the results of the Cation exchanable and Base saturation on the Gambir Land based on slope in Nagari Siguntur shown in Figure 5.

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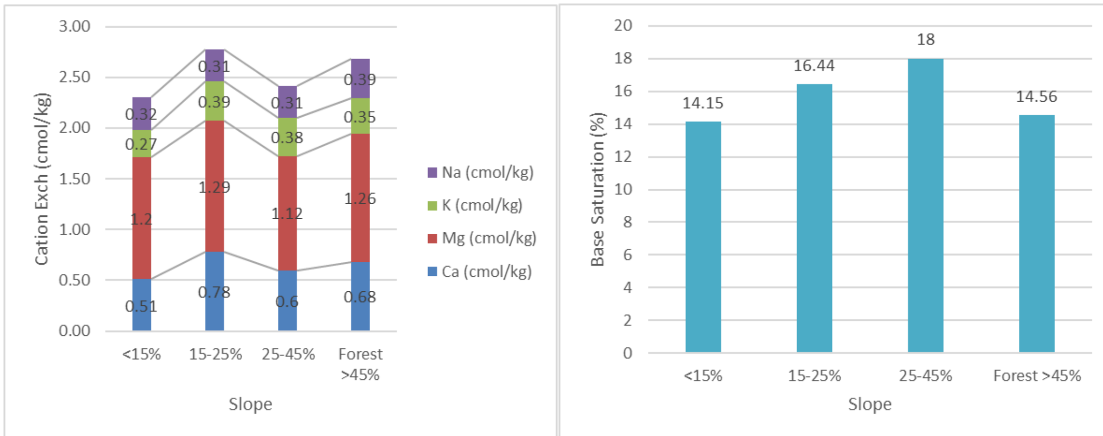

Fig. 6. Cation-exch and Base saturaion in study area

Based on Figure 6, the base saturation in gambier fields according to the slope in Nagari Siguntur ranges between 14.15% and 18%, classified as very low. The low levels of Ca, Mg, K, and Na in the soil are related to the soil pH. Generally, at low pH, base saturation is also lower, while at higher pH, base saturation tends to be higher. In soils with low base saturation, most of the soil adsorption complex is filled with acidic cations such as Al+ and H+. Soils with an excess of acidic cations can become toxic to plants [6].Low base saturation and acidic soil reactions usually indicate low soil fertility because they reduce the availability of nutrients [12]. This is consistent that the low levels of exchangeable cations (Ca, Mg, K, and Na) in the soil are due to the dominance of low-activity clay colloids [13]. Another factor influencing the low levels of exchangeable bases is the organic matter content in the soil. The low levels of exchangeable bases are caused by the low organic matter content in the soil [14]. As humus or organic colloids, which are sources of negative charges in the soil, decrease, the amount of positive charges or exchangeable cations in the soil also decreases.

CONCLUSION

Based on the research conducted on several chemical properties of gambier (*Uncaria gambir* Roxb.) plantation soils according to slope gradients in Nagari Siguntur, Koto XI Tarusan District, Pesisir Selatan Regency, it can be concluded that in gambier plantations across three slope classes moderately steep (<15%), steep (25-45%), and very steep (>45%) there is a decline in chemical properties with increasing slope percentage. This decline includes soil pH, available phosphorus (Av.P), organic carbon (OC), total nitrogen (TN), cation exchange capacity (CEC), and exchangeable cations at a depth of 0-30 cm. Soil pH values range from 4.47 to 3.98 units, categorizing them as very acidic. The C-organic content is considered very low, ranging from 1.76% to 0.86%. N-total ranges between 0.32% and 0.26%, falling into low to medium criteria. Available phosphorus varies from 13.54 ppm to 2.15 ppm, classified as very low to medium. CEC values are categorized as low to medium, ranging from 17.02 cmol/kg to 14.39 cmol/kg. Additionally, the exchangeable bases in the gambier plantations are classified as low.

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