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# Evaluation of the Fertility Status of Rice Fields in Giri Jaya Village, Nagrak District, Sukabumi Regency

Erlina Rahmayuni[1*], Elfarisna[1], Welly Herman[2], Elsa Lolita Putri[2], Kurniati[3]

[1]*Department of Agrotechnology, Faculty of Agriculture, University of Muhammadiyah Jakarta, Jl. KH. Ahmad Dahlan, Cireundeu, East Ciputat, South Jakarta, 15419, Indonesia*
[2]*Soil Science Department, Faculty of Agriculture, University of Bengkulu, Bengkulu, 38121, Indonesia*
[3]*Agroecotechnology Study Program, Faculty of Agriculture and Forestry, Sulawesi Barat University, Majene 22559, Indonesia*

*Corresponding Author : erlina.rahmayuni@umj.ac.id*

## ABSTRACT

*The research comprises three stages, which include: Field research, Laboratory research, encompassing the analysis of soil chemical properties. Data analysis, conducted both descriptively and quantitatively. Composite soil samples from rice fields were collected at three different elevations (top, middle, and bottom) at a depth of 1-20 cm in the surface layer of the rice field soil. Analysis of paddy soil samples involved measuring pH $H_2O$ using the electrometric method, total N, and cation exchange capacity (CEC) using the titrimetric method, potential $K_2O$ using the flame photometric method, potential $P_2O_5$ and organic C using the spectrophotometric method, K exchangeability and Na exchangeability using the flame photometric method, and Ca exchangeability and Mg exchangeability using the AAS method. Data obtained from soil analysis at different elevations were compared based on soil type for each observed parameter. The research results indicate that the evaluation of nutrient status is influenced by altitude. Land situated at lower elevations exhibits better soil fertility status, followed by land at the upper and middle elevations.*

*Keywords:* *altitude, Andisols, erosion, rice fields, soil fertility*

## INTRODUCTION

In Indonesia, rice fields consist of irrigated rice fields, rain-fed rice fields, tidal rice fields, and lowland rice fields, with an area of around 8.1 million ha. National rice production is 67.5% from irrigated rice fields and 27.5% from rain-fed rice fields, of which around 43% is on the island of Java such as in West Java Province (Hardiansyah *et al*., 2023 ; Wahyunto & Widiastuti, 2014). The area of rice fields in 2019 in West Java Province was around 928,218 ha of the area where Sukabumi Regency has the fifth largest area of rice fields in West Java, namely 56,783 ha (Kementrian Pertanian, 2020). One of the villages that relies on lowland rice in Sukabumi Regency is Giri Jaya Village which is located in Nagrak District. This village is one of the areas that relies on lowland rice farming as the main source of livelihood.

Rice production from rice fields has its challenges considering that rice fields on Java Island are increasingly narrow due to land conversion to non-agriculture. To meet food needs, and ensure food security and independence, the use of new technology to increase lowland rice production and productivity must be accompanied by improvements in cultivation techniques while still paying attention to environmental sustainability. Add to this, climate change, unpredictable rainfall patterns, and changes in agricultural practices, there is an urgent need to understand and monitor the fertility status of paddy fields in this region. Awareness of good soil fertility will not only increase agricultural productivity but will also help rural communities achieve economic prosperity and environmental sustainability.

Soil fertility is related to the soil's ability to provide nutrients to meet plant needs. Agricultural practices carried out by farmers can sometimes reduce soil fertility levels through harvesting, leaching and soil erosion. Management of agricultural land must be considered according to the characteristics and type of land use (Okorie *et al*., 2021). Rice field management plays a very important role as a key to successfully increasing rice production. Rice field management techniques, intensity of use of rice fields, and differences in soil parent materials can cause differences in soil physical and chemical properties. The problem of fulfilling food, especially in West Java Province, especially in the Sukabumi subdistrict, can be seen from the decline in the area of rice fields from 66,692 hectares in 2015 to 56,783 hectares in 2019 (Kementrian Pertanian, 2020) due to the widespread conversion of agricultural land to the industrial sector (Rahmayuni, 2023a ; Rahmayuni *et al*., 2023b). This is one of the obstacles in meeting the food needs, especially (rice products) for the community, which are increasing over time in line with the rate of population growth. Therefore, agricultural intensification is an effort to increase the productivity of rice fields by maximizing the potential of available rice fields by increasing soil fertility (Wulandari *et al*., 2023 ; Rahmayuni *et al*., 2023c).

Soil fertility status is one of the determinants of stability and increased agricultural production. Soil can be defined as fertile if the plants planted can grow well so that the plants planted grow well and have high production throughout the year (Agustian & Simanjuntak, 2018) (Hermita *et al*., 2019). Agricultural intensification can be carried out by evaluating the soil fertility status in the specific location of the rice fields that will be cultivated so that the nutrient status of the soil can be known. Soil has different levels of fertility because many factors influence the level of soil fertility (Gusmini *et al*., 2024) (Rahmayuni & Gustia, 2023). Evaluation of paddy soil fertility is a process of assessing the problems of nutrient content in the soil, namely the elements N, P, K, Ca, and Mg. Parameters for assessing soil fertility include cation exchange capacity (CEC), base saturation (BS), organic C, and total soil P and K levels according to technical instructions for evaluating soil fertility. The current recommendations for fertilizing paddy fields are general for all regions in Indonesia without considering the nutrient status of paddy fields and the adequacy of location-specific plant nutrients (Adrinal *et al*., 2024 ; Budi *et al*., 2024; Matondang & Nurhayati, 2022).

Therefore, research to evaluate the fertility status of rice fields in Giri Jaya Village, Nagrak District, Sukabumi Regency is very important to carry out. The research aims to examine the fertility status of rice fields located at different altitudes in Giri Village, Ngarak District, Sukabumi Regency.

## MATERIALS AND METHODS

The research was conducted from July to October 2023 in Giri Jaya Village, Nagrak District, Sukabumi Regency. The research location is depicted in Figure 1.

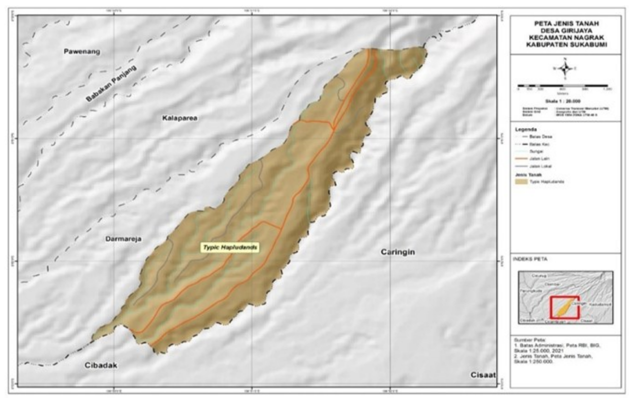


Figure 1. Research location

The research location is depicted in Figure 1. Soil analysis was carried out in the Soil Chemistry laboratory, Faculty of Agriculture, Bogor Agricultural Institute (IPB). The research includes three stages consisting of: 1. Field research, 2. Laboratory research including analysis of soil chemical properties, and 3. Data analysis was carried out descriptively and quantitatively. Rice field soil samples for observation were taken compositely at three different heights (upper, middle, and bottom) at a depth of 1-20 cm in the surface layer of rice field soil. Analysis of paddy soil samples includes analysis of pH $H_2O$ using the electrometric method, total N and cation exchange capacity (CEC) using the titrimetric method, potential $K_2O$ using the flamephotometric method, potential $P_2O_5$ and organic C using the spectrophotometric method, K *exchangeability* and Na *exchangeability* using the flamephotometric method and Ca-exchangeable and Mg- exchangeable using the AAS method. Data from soil analysis at different heights were compared based on soil type for each observation parameter.

## RESULTS AND DISCUSSION

The research was carried out using the method of taking soil samples from locations representing rice fields at various heights in Giri Jaya Village.

Samples are analyzed to measure nutrient content. The results of the analysis are presented as follows:

*pH value, N-total, C-organic, and C/N ratio of paddy soil*

Figure 2 shows data on pH $H_2O$, total N content, organic C content, and C/N ratio for three types of soil in different elevations. This data can be used to analyze the physical and chemical characteristics of each type of soil.

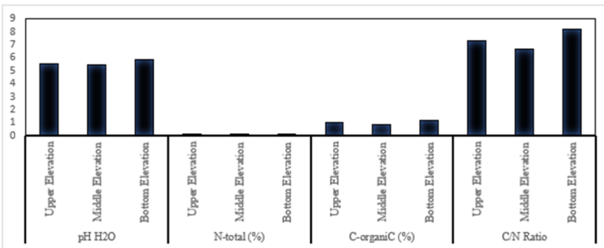


Figure 2. pH value, N-total, C-organic and C/N ratio of paddy soil

The pH values of the three soil types range from 5.42 to 5.85, indicating an acidity level that falls within the acidic to slightly acidic range. The altitude from which soil samples were collected has an impact on the pH values, with soil taken from lower elevations exhibiting higher pH values compared to the middle and upper positions. This is consistent with the findings of previous research conducted by Setiawan *et al*. (2014), which stated that hillsides tend to have lower pH values compared to hilltops and valleys. The lower pH values on hillsides can be attributed to their increased exposure to direct rainfall, leading to erosion of the topsoil layer and its transportation along with rainwater to lower layers (Budi *et al*., 2024 ; Rahmayuni, *et al*., 2023b). Simultaneously, this erosion process results in the leaching of nutrients, such as soil base cations. Additionally, rainwater often carries acidic properties that can dissolve into the soil, further contributing to its acidity. According to Aytenew (2015) and Emiru & Gebrekidan (2013) states that the lowest pH values in many soils are in areas with moderate slope gradients. Loss of soil cations due to runoff and erosion. The low pH value is due to increasing the activity of H+ ions in the soil solution and making the pH even lower.

The total nitrogen (N) content in all three types of paddy field soil is relatively low, with values ranging from 0.13% to 0.14%. The highest total N content is observed in the top and bottom soils. This disparity can be explained by the influence of organic material decomposition, which predominantly occurs at the top and bottom soil positions. The results of research Ezeaku & Iwuanyanwu (2013) state that the highest soil organic matter is usually found in the upper position and this is where the weathering and oxidation processes occur at the greatest rate, which can cause low total N content in the lower position.

However, the organic carbon (C-organic) content in the middle and lower soil positions is notably low, with the middle position falling into the category of very low. In accordance with research conducted by Gou *et al*. (2015), the organic matter content of rice field soil is lower at the bottom positions compared to slope. The values of total N and organic C are also related to the C/N ratio, which signifies the balance between organic carbon and nitrogen in the soil. The C/N value for paddy fields in the bottom position is classified as medium, while paddy fields in the top and middle elevations are categorized as low.

Organic carbon plays a crucial role in determining the soil's capacity to support plant growth. A decrease in organic carbon levels within soil organic matter can lead to a reduction in the soil's ability to support plant productivity. This decline in organic matter levels can serve as an indicator for assessing soil fertility and is often indicative of common soil degradation. The utilization of agricultural land on slopes is associated with high erosion in the research area, as evidenced by the low C-organic content in the soil, especially on steep slopes and on lands with less dense canopy coverage (Septianugraha & Suriadikusumah, 2014).

*Alkaline content of paddy soil*

The content of various cations in the soil, including calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na), is analyzed to assess the nutrient content in each soil type.

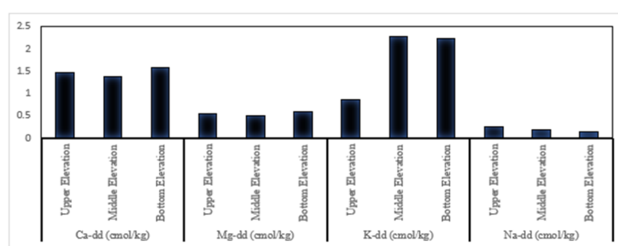


Figure 3. Base Content (Ca-, Mg-, K-, and Na-) of Paddy Soil

The exchangeable base content, on average, is low at the research location. However, in the paddy fields at lower elevations, it is significantly higher compared to the middle and upper positions. This phenomenon is attributed to the soil erosion process, which tends to be more significant on slopes than on the top and bottom of the slope. Soil erosion also transports topsoil particles rich in bases such as Ca-dd, Mg *exchangeability*, K *exchangeability*, and Na *exchangeability*. This aligns with the results of the soil pH analysis at the research location, where the soil pH value is higher at the bottom of the slope than at the middle and top slope positions.

### *$P_2O_5$ and $K_2O$ content of paddy soil*

The highest $P_2O_5$ content is observed in the soil at the upper position. According to Figure 4, the $P_2O_5$ content in all three soil types is notably high. This is believed to be due to the strong binding of P content in the soil by aluminum, making it challenging to dissolve and less accessible for plant uptake. Sembiring *et al*. (2013) explained that the predominant issue with Andisols is the high phosphate retention value (>85%), rendering phosphorus unavailable to plants. Most of the phosphate is tightly bound by soil clay colloids, limiting its availability to plants, necessitating the use of substantial amounts of P fertilizer to meet plant requirements. Phosphorus tends to be fixed in the form of Al-P, Fe-P, and Ca-P, this causes the solubility of P to be low. Fixed P will be difficult to dissolve and available to plants will be low (Jayadi & Majid, 2023). The $P_2O_5$ content in paddy field soil at the lower position is higher than in the slope and upper positions. This suggests that the increased $P_2O_5$ content in the slope position serves as a reservoir for locations susceptible to erosion and soil loss on slopes.

The highest $K_2O$ content is found in the lower position of the soil. One possible explanation is that potassium (K) in the soil has accumulated in the subsoil layers over time. This accumulation may result from various processes, such as groundwater percolation carrying potassium from upper soil layers to lower ones or the deposition of potassium-rich organic matter in the lower layers. This contradicts the findings of research reported by Gau *et al*. (2015), where the highest K content was more frequently found in rice fields situated on slopes.

Figure 4 shows that exchangeable potassium in the middle and lower positions is higher than in the upper position. According to the results of research conducted by Khan *et al*. (2013) it is stated that the K value is higher on lower slopes compared to upper slopes, this is caused by a combination of fertilization with organic and organic fertilizers.Figure 4. $P_2O_5$ and $K_2O$ content of rice field soil

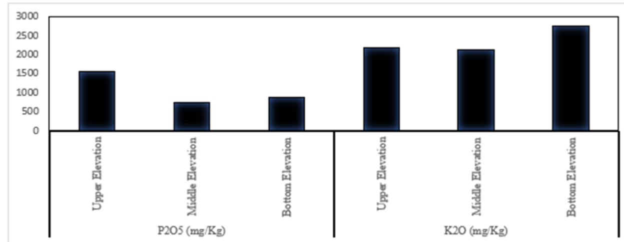


Figure 4. $P_2O_5$ and $K_2O$ content of rice field soil

### *Cation Exchange Capacity (CEC) and Base Saturation (BS) of paddy soil*

The Cation Exchange Capacity (CEC) and Base Saturation (BS) in the three different soil types exhibit medium CEC values, while KB values are low. Cation exchange capacity quantifies the soil's capacity to retain and release cation ions essential for plant growth, such as calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), potassium ($K^+$), and sodium ($Na^+$). Base saturation indicates the proportion of the CEC filled with base ions, typically $Ca^{2+}$ and $Mg^{2+}$. The following is an analysis of the data.

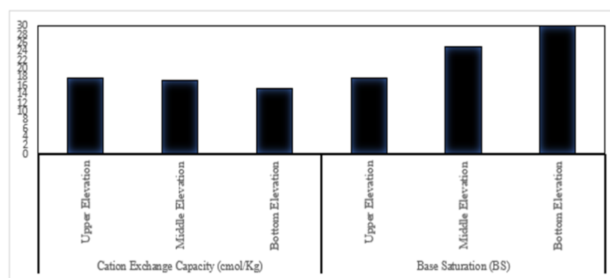


Figure 5. Cation Exchange Capacity (CEC) and Base Saturation (BS) of paddy soil

Higher CEC values were observed in soil at the top and middle positions, indicating that this soil possesses a greater ability to retain essential cations for plants. Regarding the KB value, it can be noted that soil at the lower position exhibits a higher value, signifying the extent to which the CEC is saturated with base ions such as $Ca^{2+}$ and $Mg^{2+}$ (Saosang *et al*., 2022 ; Zainudin & Kesumaningwati, 2021) The high CEC value of soil significantly influences its fertility level, as the cation exchange capacity of soil with abundant charge is dependent on pH and can vary with pH fluctuations. This capacity is also influenced by the dominant clay fraction.

The combination of high CEC and high BS is advantageous for plants since it indicates that the soil has a robust capacity to retain vital cations like $Ca^{2+}$ and $Mg^{2+}$, which are essential for plant growth. Nevertheless, it is crucial to bear in mind that aside from CEC and BS, other factors such as pH, nutrient content, and soil texture also contribute to determining soil quality for agricultural purposes. Pinatih *et al*. (2015) stated that the number of base cations and soil pH determine the relative value of base saturation.

## CONCLUSION

The evaluation of the fertility status of paddy fields conducted in Giri Jaya Village, Nagrak District, Sukabumi Regency, revealed that the assessment of nutrient status was influenced by altitude. Soil in lower elevations exhibited a superior soil fertility status, followed by soil in the upper and middle elevations.

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