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Nutrient availability and soil fertility status in Raja Uncak paddy fields, Kapuas Hulu district, Indonesia

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ABSTRACT

This study examines the nutrient availability and soil fertility status in Raja Uncak rice fields, a traditional farming system in Kapuas Hulu regency, west Kalimantan, Indonesia. Soil samples were collected from 6 Raja Uncak fields and analyzed for physical and chemical properties. Results indicate that Raja Uncak soils are predominantly acidic (pH 4.42–4.83) with high – very high organic matter content (3.94% and 11.33%). Base saturatin were found to be limiting factors, while potassium (K) levels were generally adequate. The study provides insights into the unique soil characteristics of Raja Uncak systems and suggests potential strategies for sustainable soil management in these traditional agroecosystems.

Keywords: fertility, Kapuas Hulu, nutrient, paddy, soil.

INTRODUCTION

The raja uncak rice farming system, integral to cultural heritage of Kapuas Hulu regency in west Kalimantan, Indonesia exemplifies a compelling convergence of agricultural methodology, ecological adaptation, and indigenous wisdom (Intan et al., 2024). Traditional agricultural cultivation practices have been passed down from generation to generation, serving as the basis for food security and local cultural identity (Hatta et al., 2021). The resilience of this traditional agricultural system continues amidst the advancement of modern agriculture (Xu et al., 2024). Global attention tends to increase on indigenous agricultural practices to gain knowledge about sustainable food production systems (Stanly et al., 2024). The Raja Uncak rice cultivation system is an important research topic and requires an integrated multidisciplinary approach. A comprehensive study of this system is not only important academically and scientifically but can open strategic insights and combine anthropogenic aspects and ecological principles in a symbiotic manner (Lan, 2024). Further in-depth research is expected to encourage the development of an integrative concept to support agricultural development, especially a sustainable rice cultivation system.

The development of the Raja Uncak rice cultivation system has a vital role in improving the economy of the people of Kapuas Hulu regency and the ecosystem in the border areas of Indonesia and Malaysia. However, information about this is still very rare in various scientific publications, especially those discussing the status of soil fertility and the availability of nutrients in it. as stated by Cavanagro (2022) that soil fertility status is an important component in optimizing plant growth and yields. The scarcity of scientific information regarding the availability of nutrients and soil fertility status in the Raja Uncak rice cultivation system is a challenge and opportunity for researchers to develop a technique for preserving and increasing crop yields. As stated by Hou et al. (2020) understanding soil conditions in an agricultural cultivation system can reveal new knowledge to formulate agricultural cultivation system policies on a larger and more sustainable scale. In addition, a more detailed understanding of the availability of nutrients in the Raja Uncak rice cultivation system will provide a more precise direction in increasing crop yields by maintaining the continuity of cultivation and ecology that will encourage progress in the field of agroecology. This is in accordance with Muhie's statement (2022) that by properly combining indigenous agricultural techniques and scientific knowledge, it will produce environmentally friendly and economically sustainable plant cultivation techniques.

The application of scientific principles in the Raja Uncak rice cultivation system, in addition to aiming for development, also aims to anticipate the socio-economic dynamics and environmental damage that is currently occurring. To overcome this, a comprehensive analysis of the status of soil fertility and the availability of nutrients in the soil is needed so that the main factors that influence soil productivity can be identified (Rpnham and Messiga, 2024). Furthermore, Srivastav et al. (2021) explained that a holistic understanding of soil aspects can be a strong foundation for formulating a preservation strategy for indigenous agricultural cultivation systems from the negative impacts of climate anomalies and the decline in the quality of the agricultural environment.

The cultivation system in Raja Uncak, in addition to containing the cultural values of the local community, is also closely related to spiritual beliefs, social structures and environmental sustainability. As explained by Kamakaula (2024) that the combination of agricultural cultivation systems with cultural values and the social order of the community creates a unique and distinctive perspective for studying the relationship between local cultural systems and agro-ecosystem dynamics, especially in soil components. The study of the availability of nutrients in the soil and the various factors that influence it as a basis for determining soil fertility is an important aspect in revealing the role of indigenous practices in sustainable rice field management. In accordance with this, Agnoletti and Santoro (2022) stated that an agricultural cultivation system that is studied in an integrated manner by including aspects of soil fertility and biodiversity can be used to design a sustainable agricultural concept that combines cultural, social and environmental aspects comprehensively.

On the other hand, the challenge of meeting global food needs in line with efforts to mitigate ecological damage makes the study of traditional agricultural systems such as Raja Uncak rice cultivation a source of new perspectives. Sanz et al. (2023) stated that the synergy between agroecological production systems, biodiversity conservation, low input use, and adaptation to local conditions can create a model of sustainable agriculture economically, socially, and ecologically. Integrated research to examine the level of soil fertility in Raja Uncak rice fields through a scientific approach is considered crucial in increasing the effectiveness of its management. As expressed by Wijerathna and Pathirana (2022), the integration of local wisdom with modern agricultural systems has the potential to produce effective and efficient strategies in responding to global food security challenges. Furthermore, Marchetti et al. (2020) stated that this hybridization of traditional and scientific knowledge can form a framework for local culture-based solutions to strengthen the sustainability of agricultural cultivation systems in a more environmentally friendly global context.

One of the parameters that can be used as an indicator of the sustainability of agricultural cultivation systems is the analysis of soil fertility status, which is the result of the interaction of various processes that occur in an ecosystem. As stated by Wittwer et al. (2021) that agricultural systems can play a multifunctional role in local ecosystems such as soil conservation, water management and biodiversity conservation. Furthermore, Telo da Gama (2023) stated that an agricultural cultivation system can be evaluated through an assessment of soil fertility status by utilizing the concept of agricultural ecosystem services. This knowledge is not only relevant for the development of the Raja Uncak rice cultivation system but is also useful as a scientific basis in formulating a development policy that leads to improving the welfare of local communities. In line with that, Viana et al. (2022) added that indigenous agricultural systems can play a role in sustainable development while providing a technique/method for managing adaptive and sustainable land resources.

A comprehensive study of the availability of nutrients in the soil and the level of soil fertility, as well as the factors that influence it in the Raja

Uncak rice cultivation system can provide information on indigenous rice cultivation practices that have been passed down from generation to generation over a very long period of time. Additionally, it can offer detailed scientific insights into the relationship between traditional (indigenous) agricultural systems and scientific knowledge in cultural preservation and natural resource management.

MATERIALS AND METHODS

The research location includes the Raja Uncak rice cultivation area spread across six villages, which are administratively included in the Putussibau Selatan district, Kapuas Hulu regency, west Kalimantan province, Indonesia. The study site is situated at coordinates (1°4′N 112°45′E) and includes the villages of Melapi, Suka Maju, Urang Unsa, Sayut, Ingko Tambe, and Kedami Hulu (Figure 1), located 1–3 km from the Kapuas River. The land slope ranges from 0–3%, with flat to gently undulating topography, and the soil types are typic Dystrudepts and Fluvaquentic Endoaquepts (Husnain et al., 2024).

The research period was from February to August 2024 with the implementation method using surveys and interviews to determine the research location, soil sampling points and land attribute data. Other secondary data were obtained by interviewing agricultural extension officers, farmers and land owners. Raja Uncak rice cultivation is carried out conventionally without fertilization with chemical fertilizers with an average production of three tons per hectare.

Planting is carried out annually from August to September, while harvesting is carried out from February to March. The farming technique uses no-till methods without fertilizer application. Harvesting involves selective removal of the upper rice stalks, while the lower stalks are retained in the field to function as organic fertilizer for the next planting season.

Soil sampling used a stratified random sampling methodology to ensure a comprehensive and representative characterization of soil fertility across the research locations. A systematic sampling method was used to assess spatial variability and ruduce potential sampling bias in the agricultural landscape of each village. Core soil samples were taken from the topsoil at each designated sampling point, focusing on the 0–30 cm depth interval using a standard soil auger.

The selected depth range aimed to cover the primary root zone, and the most active soil biological and biogeochemical processes related to agricultural productivity. The soil sampling process to agricultural productivity. The soil sampling process adhered to strict pedological protocols to ensure sample integrity and reduce environmental contamination. Core were systematically collected from each sampling location on represent a range of micro-spatial positions, addressing potential local heterogeneity in soil composition and characteristics. Individual cores were thoroughly homogenized using a standard mixing procedure, producing composite samples that accurately represent the overall fertility status and soil properties of the agricultural land.

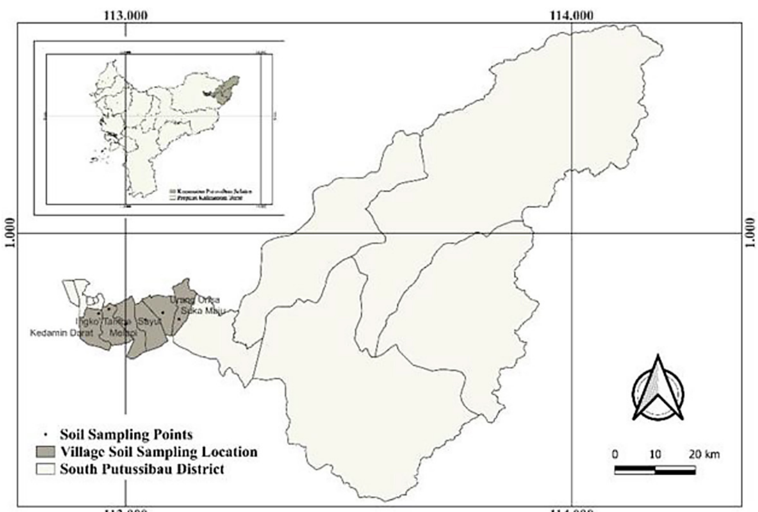

Figure 1. Location of soil sampling in Raja Uncak rice cultivation land

This study used a composite sampling technique that effectively captures the spatial complexity of soil properties, facilitating a comprehensive understanding of soil fertility parameters across the varied agricultural landscapes in the study area. Composite soil samples were sent to the soil chemistry and fertility laboratory, departement of soil science, faculty of agriculture, Tanjungpura University for analysis. Further parameters were determined: soil pH was determined through a 1:2.5 soil-water suspension using a pH meter. Cation exchange capacity (CEC) was assessed using the ammonium acetate extaction method. Base saturation (%) is determined by proportion of CEC occupied by base cations, specifically calsium (Ca^{+2}), magnesium (Mg^{+2}), potassium (K^{+}), and sodium (Na^{+}). Total nitrogen (N-total) is analyzed by Kjeldahl digestion, followed by titration or spectrophotometry. Available phosphorus (P-available) is determined by the Bray I method, followed by colorimetric analysis. Exchangeable potassium (K-exchangeable) is quantified through ammonium acetate extraction, subsequently analyzed via atomic absorption spectrometry. Total potassium (K-total) is determined through acid digestion and subsequent analysis using atomic absorption spectrometry. Organic carbon (C-organic) was analyzed utilising the Walkley-Black method. A soil analysis was conducted according to the standardized technical protocols for the chemical examination of soil, plant, water and fertilizer substrates as specified by Eviati et al. (2003).

Descriptive statistics were utilized to summarize the soil data. Criteria for soil properties derived from soil analysis result as outlined by Eviati et al. (2023). Soil fertility ratings were determined according to established criteria for each parameter (Soil Researcher Cener, 1995). Correlation analysis was conducted to evaluate the relationships among various soil parameters. All data analysis were conducted using the r-statistical program.

RESULT AND DISCUSSION

Soil nutrient availability

Table 1 provides an analysis of soil fertility parameters in Raja Uncak rice fields across six villages in Putussibau Selatan District. this study emphasized three important soil components: organic carbon (C-organic), total nitrogen (N-total), and available phosphorus (P-available). These parameters serve as important indicators of soil fertility, which have a direct impact on crop productivity. The data indicates a consistent pattern of elevated nutrient levels across most locations, implying that Raja Uncak fields typically exhibit superior soil fertility. This finding is important because of the traditional nature of the Raja Uncak system, suggesting that this long-standing practice has effectively preserved, and perhaps improved, the nutrient status of the soil over generations.

Organic carbon content, an important indicator of soil organic matter, exhibits significantly elevated levels in five of the six villages, with values between 3.94% and 11.33%. The values classified as "very high" markedly surpass the standard levels observed in numerous agricultural soils. The exception is Ingko Tambe village, where the organic carbon content is high at 3.94%. This consistently high organic matter content across most sites suggests that the Raja Uncak system effectively preserves and potentially accumulates soil organic matter. Such high levels of organic carbon are associated with numerous benefits, including improved soil structure, enhanced water retention capacity, increased nutrient holding capacity, and support for diverse soil microbial communities (Hartmann and Six 2023). These factors contribute to the system's resilience and sustained productivity.

Total nitrogen levels in the Raja Uncak fields are equally impressive, with all sites falling into either the "very high" categories. Suka Maju village exhibits the highest N-total at 1.11%, whereas the other villages display values ranging from 0.55% to 0.91%. Elevated nitrogen levels are essential for plant growth and development, especially for rice, a crop that requires significant nitrogen (Xie et al., 2025). The consistently elevated nitrogen levels observed at all sites suggest that the Raja Uncak system effectively regulates the nitrogen cycle, likely through methods that rudece nitrogen losses and enhance biological nitrogen fixation. Nitrogen management in Raja Uncak paddy fields involves harvesting only the rice panicles, while the rice straw is left on the soil surface until it decomposes, thereby serving as a source of soil organic matter. The very high levels of soil organic matter (Table 1) are one of the primary sources of nitrogen nutrients in the soil.

Table 1. Content of c-organic, n-total and p-available in Raja Uncak rice fields

Location	C-organic (%)		N-total (%)		P-available (ppm)		P-total (mg/100g)		K-total (mg/100g)	
Melapi	8.97±0.02	VH	0.79±0.02	VH	18.12 ± 3.57	VH	29.75 ± 1.48	M	27.03 ± 0.78	M
Suka Maju	11.33±0.66	VH	1.11±0.13	VH	11.70 ± 1.48	H	33.38 ± 1.42	M	20.63 ± 0.66	M
Urang Unsa	6.22±0.11	VH	0.61±0.04	VH	13.03 ± 0.73	H	37.98 ± 2.47	M	22.84 ± 0.86	M
Sayut	7.85±0.93	VH	1.07±0.02	VH	19.67 ± 1.71	VH	42.07 ± 2.15	H	30.85 ± 1.47	M
Ingko Tambe	3.94±0.44	H	0.55±0.01	VH	15.15 ± 1.52	VH	50.30 ± 2.44	H	26.38 ± 2.34	M
Kedamin Hulu	8.91±0.78	VH	0.91±0.04	VH	13.53 ± 0.87	H	26.69 ± 4.26	M	37.84 ± 0.49	M

Note: Data is presented as mean ± standard error (n=4). Description: M = moderate, H = high, VH = very high. Results of chemical laboratory analysis and soil fertility, 2024.

Raja Uncak rice field soil has very high available P content in all research locations with a value of 11.70–19.67 ppm. The very high available P content is beneficial because in general the available P content in soils in tropical areas is very low, making it a limiting factor for plant growth. The high available P content is likely due to the high organic matter content in Raja Uncak rice field soil, which can help dissolve phosphorus in the soil (Voltr et al., 2021). The high organic C, nitrogen and phosphorus content indicates that the soil conditions in Raja Uncak Rice Fields are balanced and will play an important role in the long term to increase the productivity of the Raja Uncak rice cultivation system.

Table 2 shows that the base cations such as K^+, Ca^{2+} and Mg^{2+} in the Padi Raja Uncak paddy soil are included in the very low to high category. The data shows that there are variations in the content of base cations in the soil with the research location. This difference is thought to be due to the influence of soil parent material, topography and agricultural practices. The results of the exchangeable potassium (K-dd) analysis showed that there was significant variation between research locations. Paddy soils in the Raja Uncak rice cultivation area of Ingko Tambe village, and Urang Unsa village had K-dd levels that were included in the low criteria with values between 0.35 and 0.21.40 cmol(+) kg^{-1}, while Sayut village and Melapi showed medium levels of 0.53 and 0.52 cmol(+) kg^{-1}, respectively. Low K-dd levels will have implications for various metabolic processes of rice plants, this is due to the important role of potassium in the photosynthesis process, enzyme activity and resistance to environmental stress that does not support plant growth (Johnson et al., 2021). Low levels of K elements can be replaced by providing several materials in the form of organic fertilizers or composts that are rich in K elements, such as organic fertilizers from rice straw and empty oil palm signs (Anyaoha et al., 2018; Selvarajh and Ch'ng, 2021). Both of these materials are abundant around the Raja Uncak rice cultivation area and have not been widely utilized.

Analysis of exchangeable calcium (Ca-dd) levels throughout the Raja Uncak rice planting area in six villages was classified as very low - low. Soil planted with Raja Uncak rice in Melapi, Sayut, and Urang Unsa villages had very low Ca-dd levels ranging from 1.16 to 1.78 cmol(+)kg^{-1}. The remaining three villages, Ingko Tambe Suka maju, and Kedamin Hulu, fare slightly better but still fall within the low category with 2.11, 2.50 and 2.73 cmol(+)kg^{-1}, respectively. These consistently low calcium levels could have implications for soil structure, pH buffering, and overall plant health. Calcium plays a critical role in cell wall formation and root development, and its deficiency could potentially limit crop productivity (Jing ea al., 2024). The uniformly low Ca levels across all sites suggest that this might be a systemic issue in Raja Uncak fields, possibly related to the parent material of the soils or long-term nutrient extraction without adequate replenishment (Prietzel et al., 2021).

Exchangeable magnesium (Mg) levels exhibit the greatest variability among the three cations analyzed. Three villages, namely Urang Unsa and Sayut, exhibit low magnesium levels, which range from 0.53 to 0.85 cmol(+)kg^{-1}. Melapi, Suka Maju dan Ingko Tambe village showed moderate magnesium level of 1.08, 1.25 and 1.33 cmol (+) kg^{-1}, refrectively. Differences in exchangeable Mg content at the research location indicate that there are several factors that influence it, such as soil type, microtopography or management system. Variations in Mg availability reflect that locations with low Mg content (Melapi, Suka Maju

Table 2. Cation nutrient content in Raja Uncak rice fields

Location	K-exch		Ca-exch		Mg-exch	
	cmol(+)kg^{-1}					
Melapi	0.52±0.06	M	1.16±0.06	VL	1.25±0.26	M
Suka Maju	1.40±0.06	VH	2.50±0.50	L	1.33±0.28	M
Urang Unsa	0.21±0.02	L	1.77±0.25	VL	0.53±0.05	L
Sayut	0.53±0.01	M	1.78±0.35	VL	0.85±0.04	L
Ingko Tambe	0.35±0.05	L	2.11±0.06	L	1.08±0.07	M
Kedamin Hulu	0.65±0.04	H	2.73±0.16	L	4.05±0.24	H

Note: Data is presented as mean ± standard error (n = 4). Description: VR – very low, L = low, M = moderate, H = high. Results of chemical laboratory analysis and soil fertility, 2024.

and Urang Unsa) need to be given Mg in the form of fertilizer or dolomite containing Mg and can also increase soil pH. Adequate supply of Mg is important to note because Mg plays a role in chlorophyll synthesis and several plant enzymatic processes (Ahmed et al., 2023).

Soil chemistry properties

The pH, CEC and base saturation values in the Raja Uncak rice field soil can be seen in Table 3. These three chemical properties of the soil are very important for knowing the availability of nutrients and soil fertility status which will provide detailed insight into the characteristics, opportunities and challenges in the Raja Uncak rice cultivation system. The pH value or soil acidity level affects the availability of nutrients in the soil, the data in Table 3 shows that the soil pH value ranges from 4.42–4.83 with the criteria of very acidic to acidic. High acidity in all research locations is feared to cause problems in the availability of nutrients for plant growth. Barrow and Hartemink, (2023) stated that acidic pH will reduce the availability of nutrients in the soil, especially phosphorus, calcium and magnesium. High soil acidity can increase the solubility of potentially toxic elements such as alumunium, which can inhibit root growth and nutrient uptake (Rahman et al., 2018). The characteristics of consistently acidic soils suggest that pH management should be a primary concern in initiatives aimed at improving soil fertility and crop productivity in the Raja Uncak system.

Cation exchange capacity quantifies the soil's capacity to retain and exchange positively charged ions (cations), which are vital for plant nutrition. The CEC values in the Raja Uncak fields exhibit notable variability. Kedamin Hulu and Suka Maju villages demosrate elevated CEC levels of 40.96 and 49.24 cmol(+)kg^{-1}, respectively, indicating superior nutrient retention capacity. The other villages showed low - high CEC levels, between 15.22 and 38.75 cmol(+)kg^{-1}. High CEC is usually associated with soils that are rich in clay or contain large amounts of organic matter (Rabot et al., 2024). The high CEC in Kedamin Hulu and Suka Maju suggest that these locations may have better nutrient retention capacity, which may reduce nutrient leaching under acidic conditions. However, the moderate CEC level observed in the other villages, although less remarkable, indicates satisfactory nutrient retention capacity.

Base saturation indicates the fraction of soil CEC occupied by base cations (Ca^{+2}, Mg^{+2}, K^{+}, Na^{+}) compared to acid cations (H^{+} and Al^{+3}). The BS values in all Raja Uncak locations were very low - low. Four villages (Melapi, Sayut, Suka Maju, and Urang Unsa) showed very low BS (< 16%), while the other two villages Ingko Tambe, and Kedamin Hulu showed low BS (20–30%). These low BS are in line with the observed acidic pH, indicating that most pf the exchange sites are occupied by acidic cations (Rawal et al., 2019). The data indicates nutrients deficiencies due to the limited availability of essential cations required by plants. According to Agegnehu et al. (2021), low soil base saturation and pH values indicate that the soil has experienced intensive weathering and leaching, which is a common occurrence in tropical soils.

Table 3 shows the relationship between pH, CEC, and Base Saturation values in the Padi Raja Uncak rice field soil, which reveals challenges and opportunities for improving effective soil management at the location. Soils that are classified as acidic with low base saturation levels require liming to increase soil pH and provide sufficient base cations for plants (Zhang et al., 2023). According

Table 3. Some chemical properties of soil in Raja Uncak rice fields

Location	pH		CEC cmol(+)kg^{-1}		BS (%)	
Melapi	4.59±0.07	A	38.75±2.05	H	8.58±0.89	VL
Suka Maju	4.42±0.02	VA	49.24±1.98	VH	11.60±2.04	VL
Urang Unsa	4.83±0.09	A	21.89±1.08	M	13.13±1.61	VL
Sayut	4.47±0.07	VA	33.41±0.99	H	10.56±1.41	VL
Ingko Tambe	4.82±0.08	A	15.22±0.64	L	25.74±1.133	L
Kedamin Hulu	4.72±0.20	A	40.96±2.89	VH	20.06±1.40	L

Note: Data is presented as mean ± standard error (n=4). Description: VA = very acid, A = acid, VL = very low, L = low, M = moderate, BS base saturation. Result of chemical laboratory analysis and soil fertility, 2024.

to Purnamasari et al. (2021), increasing the base saturation value of the soil after lime application can effectively increase the availability of nutrients needed by plants. Liming will be more successful in locations in Melapi and Suka Maju villages which have high CEC values, so that when the pH is increased and the availability of nutrients increases, these nutrients can be stored more through binding by soil colloids. These findings indicate that it is very important to carry out soil characteristic-based management in the Raja Uncak rice cultivation system related to differences in soil capacity to store nutrients, which are caused by variations in CEC values and soil base saturation at each location. This location-specific approach is needed to create a policy for developing Raja Uncak rice that can increase soil fertility and optimal yields while maintaining its traditional elements.

Soil fertility status

Table 4 provides an overview of the soil fertility status at six Raja Uncak rice growing sites. The table assesses five important soil fertility parameters: BS, CEC, total, total potassium (K-total), phosphorus (P-total), and organic carbon (C-organic). These parameters collectively reflect a comprehensive assessment of the soil's nutrient retention and supply capacity, pH buffering capacity, and overall fertility (Nair and Nair, 2019). The concluding column integrates these individual factors to provide a comprehensive fertility status for each site. The comprehensive method for assessing soil fertility is essential to understanding the complex of interactions of factor that influence crop productivity in the Raja Uncak rice cultivation system.

The soil CEC values showed a noteworthy pattern (Table 4). Kedamin Hulu and Suka Maju villages showed very high CEC levels, while the other four villages showed low – high CEC values. High cation exchange capacity is usually associated with increased nutrient retention and improved soil structure, suggesting that Melapi and Suka Maju mayu have soils with hight nutrient holding capacity. However, this potentil benefit was significantly undermined by the BS results. Four sites showed very low BS levels, with four sites classified as "very low" and two sites as "low". The low base saturation indicates that most of the soil exchange sites are occupied by acid cations (H^+ and Al^{+3}) rather than basic nutrient cations (Ca^{+2}, Mg^{+2}, K^+, Na^+). This scenario can result in nutrient deficiencies and possible soil acidity problems, which can significantly affect crop growth and yield (Vista *et al.*, 2024).

The result for total potassium (total-K), and total phosphorus (total-P) content of the soils provide an overview of the long-term nutrient status of these soils. Total-P levels included moderat in four villages (Melapi, Suka Maju, Urang Unsa, and Sayut), high in two villages (Sayut and Ingko Tambe). The result indicated a favorable phosphorus reserve in the soil, which has the potential to sustain long-term crop production with appropriate management (Van Doorn et al., 2024). The availability of phosphorus in the soil for plant uptake depends on factors such as soil pH and organic matter content (Penn and Camberato, 2019). In contrast, total soil K levels were all in the moderate category t all six sites. Although not particularly low, these moderate total K levels mentioned in the previous table suggest that potassium management may be an area of potential improvement in the Raja Uncak system. Increasing potassium availability can be done by fertilizing organic matter rich in potassium, such as organic fertilizer from rice straw and rice husk.

Result for organic carbon (C-organic) were particularly striking, with five of the six sites

Table 4. Soil fertility status on Raja Uncak rice cultivation land

Location	CEC	BS	P-total	K-total	C-organic	Status
Melapi	H	VL	M	M	VH	L
Suka Maju	VH	VL	M	M	VH	L
Urang Unsa	M	VL	M	M	VH	L
Sayut	H	VL	H	M	VH	M
Ingko Tambe	L	L	H	M	H	L
Kedamin Hulu	VH	L	M	M	VH	L

Note: Description: VH = very high, M = moderate, L = low, H = high, VL = very low. Result of chemical laboratory analysis and soil fertility, 2024.

classified as "very high" and one site, Ingko Tambe, classified as "high". High levels of organic carbon are a prominent positive characteristic, indicating soils rich in organic matter. The presence of high soil organic matter enhances a variety of beneficial soil properties, such as increased a variety of beneficial soil poperties, such as increased water retention, improved nutrient cycling, improved soil structure, and increased microbial activity (Voltr et al., 2021). Although the P-total and K-total content values are classified as moderate to high, the soil fertility status in the Raja Uncak rice cultivation area is classified as moderate - low. The Raja Uncak Rice planting locations in Urang Unsa, Sayut, Ingko Tambe and Kedamin Hulu villages have low soil fertility status. This shows that sufficient levels of organic matter and nutrients do not indicate high soil fertility status if the soil base saturation value is still low. This is in accordance with the statement of Naorem et al. (2023) that increasing soil fertility requires a balance of nutrients in the form of base cations, such as K, Ca, Mg and Na in the soil, the four nutrient levels of which will be reflected in the soil base saturation value.

CONCLUSION

The availability of nutrients in the soils cultivated with Raja Uncak rice showed variations based on the type of element and location. The levels of total N and available P were in the high-very high category in all locations, while the C_{add} levels were in the very low-low criteria. The soil fertility status in the Raja Uncak rice planting areas in Melapi, Suka Maju, Urang Unsa, Ingko Tambe and Kedamin Hulu villages was low, while in Sayut village the soil fertility status was moderat. All locations in the Raja Uncak rice cultivation area had the main limiting factor in the form of very low-low base saturation values.

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