JURNAL GEOGRAFI
Geografi dan Pengajarannya
ISSN : 1412 - 6982
e-ISSN : 2443-3977
Volume 22, Number 1, June 2024
https://journal.unesa.ac.id/index.php/jg

DOI : https://doi.org/10.26740/jggp.v22n1.p71-82

ANALYSIS OF RICE FIELD SOIL FERTILITY IN COASTAL GEOGRAPHICAL AREAS: A CASE STUDY OF SITUBONDO DISTRICT, JAWA TIMUR PROVINCE, INDONESIA

Sukron Romadhona[*1], Josi Ali Arifandi[2]

[1] Department of Doctoral Environmental Science, Faculty of Postgraduate, Diponegoro University, Indonesia
[2] Department of Soil Science Faculty Of Agriculture Jember University, Indonesia

ARTICLE INFO

Article history:
Received 3 Nopember 2023
Revised 30 May 2024
Accepted 30 May 2024

***Keywords*:**
soil fertility, paddy fields, land management

ABSTRACT

Soil fertility is a key factor in agricultural success, especially in rice fields, which are the main source of rice production. The research results showed significant variations in the physical and chemical properties of soil in the rice fields, which were the focus of the research. P2O5 for rice fields in Situbondo district is in the range of values from 19.34 me/100g to 142.29 me/100g, dominated by very high status. The distribution of K2O in the rice fields of Situbondo district is in the range of values from 16.95 me/100g to 395.99 me/100g, including low to very high status. The distribution of K2O is dominated by very high states. The distribution of organic C in rice field soil in Situbondo district is in the range of 0.93% to 6.54%. The organic C content is dominated by medium status. The KTK of Situbondo Regency is in the range of values from 10.18 me/100g to 48.23 me/100g. The KTK value is dominated by high status. Base saturation in the study area is classified as low to high, ranging from 19.43% - 78.89% and is dominated by status.

A. INTRODUCTION

Soil fertility is a function of many soil properties, many of which are interrelated. In most cases, the term 'soil fertility' describes the current state of the soil, meaning soil fertility is a combination of the current soil quality (mineral composition, soil texture) and the achieved qualities such as soil structure, soil organic matter (Sri Sumarniasih et al., 2021). Soil fertility is measured either by plant performance (yield) or by indicators such as SOM content, indicator plants, and water-holding capacity. Thus, managing fertility means acting to maintain, sometimes improve, the organic, mineral, physical, and biological status of the soil in order to achieve a certain level of production in a sustainable manner. Decreased soil fertility includes nutrient depletion (more nutrients are removed than added), nutrient mining (removal of high nutrient elements and no addition of nutrients), acidification (decrease in pH), loss of organic matter, and increase in toxic elements such as aluminium (Laudicina et al., 2023). Determining the

[*]Correspondence address: sukronromadhona@gmail.com

value of soil fertility can be done through a fertility assessment soil, which includes soil analysis. Soil analysis needs to be carried out to determine the pH, levels of nutrients, organic materials, and so on so that the content can be compared to the needs of each plant.

Soil fertility is a benchmark for the success of plant cultivation businesses because soil fertility status can determine the productivity of cultivated land. According to (Romadhona & Arifandi, 2020), soil fertility determines the amount of nutrients that are available and balanced to ensure optimum plant growth and development. The quality of each land is different. Rainfed (non-irrigated) rice fields have a low nutrient availability status when compared to irrigated rice fields due to the minimal availability of water, and they still depend on rainfall (Kolbe, 2022). Nutrient elements in rainfed rice fields are not balanced. Assessment of soil fertility status using soil indices can provide key information to improve effective strategies and techniques in the future to achieve sustainable agriculture. Soil Fertility Index (SFI) values can be used to develop fertility maps and make recommendations based on soil spatial variability in fertility management. Analyzes that allow the identification of the main limiting factors for agricultural production and enable decision-makers to improve the management of high-quality crops can increase land productivity (Abdullah et al., 2020).

Previous research has provided initial insights into soil fertility in various regions but needs to be updated and deepened with new research to understand changes occurring in soil fertility factors. In addition, it is hoped that the results of this research can provide guidance for farmers and rice field managers in efforts to increase agricultural productivity and sustainability (Aldababseh et al., 2018).

By considering these various factors, this research aims to analyze soil fertility in rice fields, with a focus on the current condition of soil fertility, factors that influence soil fertility, and the implications for food production and agricultural sustainability. Thus, this research will make an important contribution to efforts to maintain and increase the productivity of rice fields, which are the main source of food for the Indonesian people.

B. METHOD

Soil sampling was carried out at each location in the study area during two periods. The first phase of the year was in June when topsoil samples from different farmers' fields were taken to a depth of 0-20 cm and characterized. Soil sampling in the second phase of September consisted of systematic sampling from each plot at a topsoil depth of 0-20 cm using a soil drill. Sampling was carried out 17 times at each sampling point in one plot. Depending on the plot size, samples are taken from a maximum of 5 sampling points. A total of 17 equivalent basic samples per sampling point were taken into one composite sample. In total, 64 composite soil samples were taken into account for the database in the first phase of the year in June throughout the study area.

The sampling location during the first phase of June was recorded with GPS. (Determination of Sample Points: Soil samples are taken randomly from the rice fields to be studied. In this study, [number of samples] sample points were chosen to represent existing variations in soil fertility (Heckman, 2013). Sampling: Soil sampling was carried out using a soil sampler. Auger) to a depth of approximately [sample depth] cm. Each sample was taken from the root zone of the rice plant at that depth (Darlita & Joy, 2017).

Soil texture analysis is carried out using the analytical pipette method or other appropriate methods. Analysis of organic matter content is carried out using the Walkley-Black method or a similar method. Soil pH analysis is carried out using the electrometric method or pH meter. Analysis of macronutrient content (nitrogen, phosphorus and potassium) is carried out using appropriate chemical extraction methods, such as the Kjeldahl method for nitrogen and the Bray-1 method for phosphorus. Analysis of micronutrient content (e.g., iron, copper, zinc) is carried out by appropriate methods, such as spectrophotometry or appropriate determination methods (Neswati et al., 2021).

Soil sampling during the second phase of the year in September was carried out by (i) using the GPS coordinates of the sampling location for the first phase of the year in June and (ii) confirming the correct soil sampling location by the plot owner. Field surveys were carried out to identify land characteristics and soil morphology and take soil samples. Observation of land characteristics consists of land physiographic conditions (slope, relief, land management, rock conditions, erosion hazard) and soil morphology conditions (horizon composition, soil depth, colour, texture, structure, consistency, root conditions, coarse materials in the soil) . To bridge farmers' ignorance of land characteristics and problems in the field, it is necessary to classify soil fertility capabilities. This research analyzes soil fertility classes based on land characteristics so that obstacles in land management can be identified. It is hoped that this assessment of soil fertility status will be initial information for farmers in managing land appropriately towards sustainable agriculture.

C. RESULT AND DISCUSSION

C.1. RESULT

A complete soil chemical analysis was carried out on several variables that greatly determine the level of soil fertility, so as to produce a conclusion on the fertility classification of the study area. Based on examples of soil analysis results in the laboratory from paddy fields in Situbondo district, data was obtained which was then interpreted according to the criteria set by the Soil and Agroclimate Research Center. The results of this interpretation will later be used to determine the fertility status of the Situbondo rice fields.

C.2. DISCUSSION

a. Phosphorus (P)

The availability of P nutrients is influenced by several factors, such as pH, parent material, soil organic matter and clay mineral fixation. The P2O5 content of paddy soil in Situbondo district is in the range of 19.34 me/100g to 142.29 me/100g and is classified as low to very high status, which is dominated by very high status. Low status in Situbondo district is only found in two places, namely in Arjasa District and Banyuputih District. The low P content is thought to be influenced by the phosphate element content of the parent soil material. The research area originates from alluvium parent material, which is formed from gravel, sand, and mud parent material and was deposited not far from its source, namely around the Sampean River.

Alluvium soil is poor in P but rich in interchangeable bases such as K, Ca, Na, and Mg. To further increase phosphorus, the soil pH must be in the range of 5.5-7.0 (optimal pH for P availability). Because at a pH that is too acidic (low) and too alkaline (high), it will be easier for phosphorus retention to occur. Addition. The addition of organic materials and the provision of phosphate-solubilizing microorganisms can also help increase phosphorus availability.

The high P content in the soil is also still dominantly caused by the influence of the parent material. Mlandingan, Bungatan, Kendit, and Panarukan subdistricts are in the Ringgit formation group, which is composed of rocks with minerals consisting of basalt, leucite basalt, pyroxene and hornblende (Sri Sumarniasih et al., 2021). Asembagus District's high P is possible because of the high level of organic matter. Organic anions from high levels of decomposition of organic matter can bind Al, Fe, and Ca ions from the soil so that P can easily be released from the Fe-P, Al-P, and Ca-P bonds (Ayeyemi et al., 2023).

Soil pH also affects phosphorus availability. Acidic soil tends to bind phosphorus so that it is not available to plants.

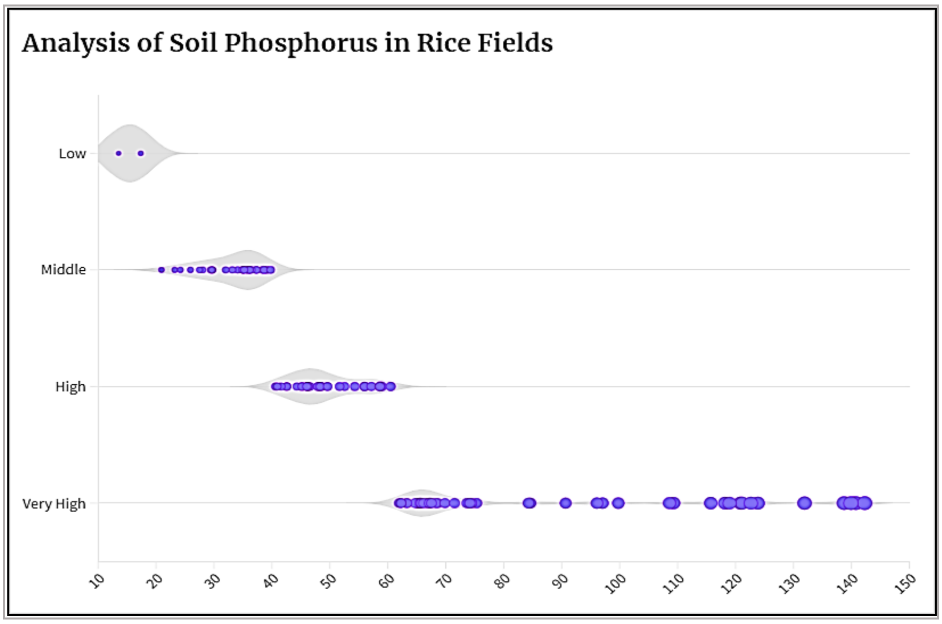

Figure 1. Distribution of phosphorus analysis results in rice fields

On the other hand, alkaline soil can increase the availability of phosphorus. Most plants grow best in a soil pH between 6.0 to 7.0 to maximize phosphorus availability.

Table 1. P_2O_5 levels in rice fields in Situbondo Regency

Status	P_2O_5 me/100g	Subdistrict
Low	19.34	Arjasa
(10.0 - 20.0)	19.76	Banyuputih
Middle	28.06	Kapongan
(21.0 - 40.0)	35.66	Panji
	36.13	Situbondo
	23.23	Panarukan
	35.07	Kendit
	35.74	Bungatan
	37.33	Kapongan
	38.78	Banyuputih
High	48.01	Mlandingan
(41.0 - 60.0)	59.01	Suboh
	46.04	Jatibanteng
	55.95	Sumbermalang
	56.21	Jangkar
	58.32	Asembagus
Very High	61.94	Kecamatan Besuki
(> 60)	65.67	Banyuglugur
	65.51	Mangaran

Source: Result of primary data analysis

b. Potassium (K)

The K2O value of rice fields in Situbondo district is in the range of 16.95 me/100g to 395.99 me/100g, including low to very high status. The distribution of K2O is dominated by very high states. Low status is found in Sumbermalang and Jatibanteng sub-districts. The low K content of rice field soil can be caused by leaching, erosion and straw carried by the harvest (Irawan et al., 2021). The Sumber Malang and Jatibanteng areas are located on the northern slopes of the Argopuro mountains with an altitude of 100 – 1,223 meters above sea level. The low K content in this area is thought to be caused by frequent erosion and landslides in the area; soil particles in areas affected by erosion are also transported so that the top soil layer as a place for organic material to collect is reduced.

Potassium is also an element that has a relatively large size in the hydrated form and has a valence of 1, so this element is not strongly absorbed by colloidal surface charges, so it easily experiences leaching (Kolbe, 2022). (Khadka et al., 2018) revealed that the loss of K due to transport by plants is large, sometimes 3-4 times greater than phosphorus, and this affects the amount of K available in the soil. This is what causes the low K value in these two regions. Intensive land management causes K losses due to harvesting tend to be faster when compared with the natural addition of K to the soil.

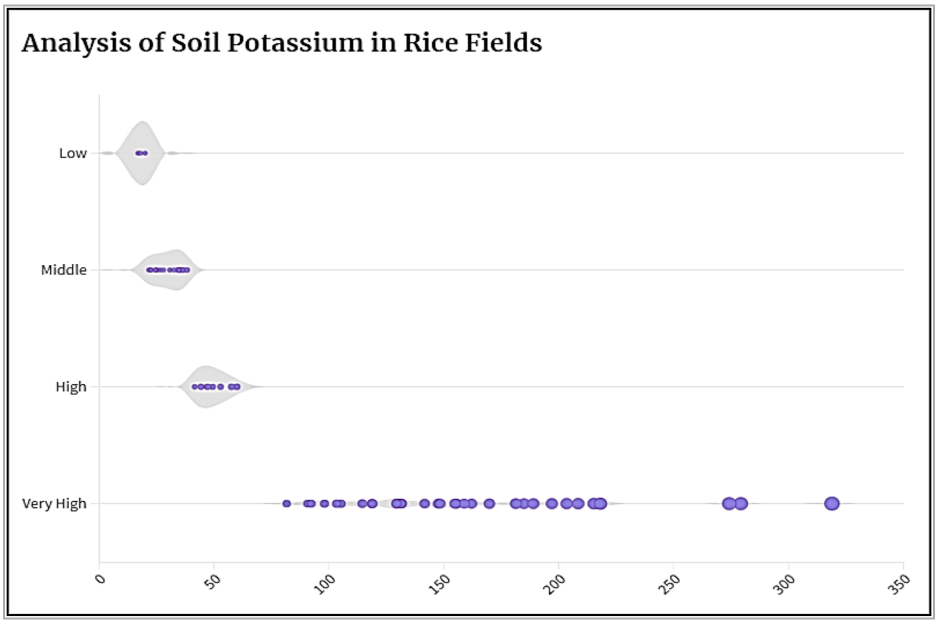

Figure 2. Distribution of potassium analysis results in rice fields

Content Soil K2O is determined by the conditions of soil formation; low K2O status in the soil can be caused by low CEC on the soil, low CEC can reduce the capacity of the ground not to hold K. High potassium distribution is found in areas where the parent material is volcanic ash from Mount Ringgit and Raung which is ultra alkaline to intermediate in nature. This parent material is rich in exchangeable bases such as K so the saturation of exchangeable cations in most rice fields in Situbondo Regency is relatively high. Based on the geological map of Situbondo Regency, (Jawang, 2021), the Ringgit – Beser, Bondowoso – Situbondo mountain complex, East Java, has a collection of volcanic rocks that have a high potassium content. The high K levels may also be influenced by irrigation water and straw return. This increase in K status can come from irrigation water that is rich in K. The contribution of K from irrigation water for paddy fields in East Java is quite large, ranging from 20-74 kg/ha/season (Agustina et al., 2022). Paddy fields are scarce. K deficiency occurs because, in urgent situations, the need for K nutrients can be met from soil, irrigation water and rice straw, which contain quite high levels of K nutrients (Sunaina et al., 2019). K2O availability is also related to soil depth. Plants can access K2O found in the top layer of soil more easily than in the bottom layer of soil.

Table 2. K_2O levels in rice fields in Situbondo Regency

Status	K_2O me/100g	Subdistrict
Low (10.00 - 20.00)	16.95	Sumbermalang
	20.04	Jatibanteng
Middle (21.00 - 40.00)	22.57	Mangaran
	26.52	Banyuputih
	24.54	Asembagus
	36.74	Panji
	32.85	Situbondo
High (41.0 - 60.0)	47.00	Besuki
	59.96	Kapongan
	57.65	Jangkar
	52.86	Arjasa
	52.09	Panarukan
Very High (> 60)	82.00	Kendit
	68.87	Suboh
	74.65	Banyulugur
	109.70	Bungatan
	90.77	Mlandingan

Source: Result of primary data analysis

c. C organic

Organic matter is an indicator that needs to be considered because it is very unstable, and its content changes very quickly depending on soil management. The organic content of the soil is very small, namely 1 - 5% of the total weight of mineral soil, but its influence on the physical, chemical and biological properties of the soil is very large. Soil organic matter content is calculated against soil C content using the formula BO (%) = C (%) x 1.724. The organic C content of paddy soil in Situbondo district is in the range of 0.93% to 6.54%, with very low to very high status. The organic C content is dominated by medium status. Very low organic C status was found in Sumber Tengah village, Bungatan subdistrict, and low status was found in Suboh, Mlandingan and Kapongan subdistricts. It is suspected that farmers never return the remaining harvest or harvest the crops by transporting all the harvest. In fact, harvest residues found on the surface of the soil in cultivated plants are litter material and are a source of BO.

The depth of the layer determines the BO content. Organic material is found in the top layer; the lower you go, the less it decreases (Mahbub et al., 2023). In general, BO in the soil accumulates in the top layer (Laekemariam & Kibret, 2020). At low status, the organic material content is also suspected to have a deep tillage layer due to frequent tillage, such as using a tractor or other ploughing equipment. The deeper the processing is carried out, the lower the remaining surface soil BO will be. Efforts to add soil organic matter can be done by returning harvested plant residues, planting types of plants that can restore soil fertility with crop rotation or adding compost from livestock manure. High status is in the sub-districts of Jatibanteng, Suboh, Panarukan, Mangaan, Anchor, Banyuputih Panji, and Asembagus. The high organic C status is influenced by many factors. Organic matter can increase or remain available in the soil, one of which is due to the high clay content of the soil; increasing the percentage of soil micropores can slow down the decomposition process of organic matter (Romadhon & Hermiyanto, 2021).

Apart from clay content, differences in soil processing systems also affect the availability of organic material. Minimum tillage generally results in greater retention of organic matter than maximum or conventional tillage, so that the organic matter content on the soil surface with minimum tillage is greater than organic matter in the tilled layer with conventional tillage (Romadhona et al., 2020). Very high status is only found in one place, namely Asembagus sub-district.

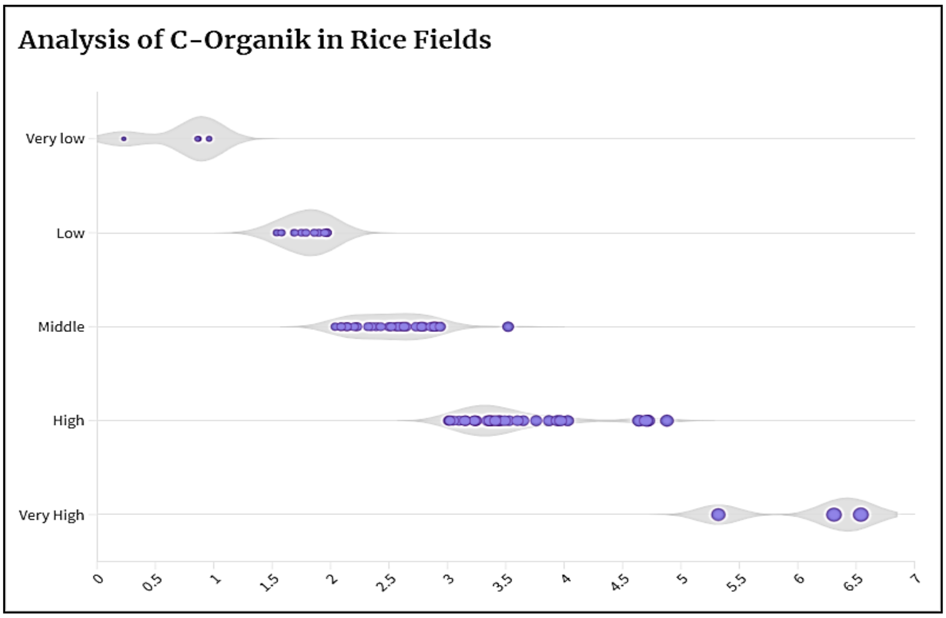

Figure 3. Distribution of C-Organik analysis results in rice fields

According to (Romadhona & Arifandi, 2020), if the acid concentration of Kaliputih, which is a source of irrigation, is very high, farmers will switch to planting sugar cane. So, it can be expected that the return of sugarcane harvest residues will be able to contribute higher levels of organic C because the glucose content of sugarcane is greater than that of s

Table 3. C-organic levels in rice fields in Situbondo Regency

Status	C organic (%)	Subdistrict
Very Low (< 1.00)	0.93	Bungatan
Low (1.00 - 2.00)	1.75	Mlandingan
	1.9	Kapongan
	1.86	Suboh
Middle (2.01 - 3.00)	2.9	Sumbermalang
	2.09	Arjasa
	2.77	Situbondo
	2.54	Kendit
	3.12	Jangkar
	3.75	Jatibanteng
High (3.01 - 5.00)	3.39	Mangaran
	3.87	Panarukan
	4.67	Panji
	3.56	Banyuputih
	4.89	Jangkar
	4.12	Kapongan
Very High (> 5.00)	5.32	Asembagus

Source: Result of primary data analysis

Based on the results of this research, even though it is at moderate status, in fact, the quality of the soil in the Situbondo rice fields is generally already at a level that can be worrying, but if this condition is allowed to continue and there is no effort to increase the organic matter content of the soil, then it is not impossible This land will become critical land. C-organics play a supporting role and supply nutrients for plant growth. Organic materials may be required to increase soil fertility and store micronutrients and factors

D. CONCLUSION

Results of a series of studies show that P2O5 of Situbondo district's rice fields is in the range of values from 19.34 me/100g to 142.29 me/100g and is classified as low to very high status, which is dominated by very high status. The distribution of K2O in the rice fields of Situbondo district is in the range of values from 16.95 me/100g to 395.99 me/100g, including low to very high status. The distribution of K2O is dominated by very high states. The distribution of organic C in rice field soil in the Situbondo district is in the range of 0.93% to 6.54%, with very low to very high status. The organic C content is dominated by medium status. The fertility status of Situbondo district ranges from low to high status, dominated by medium status.

BIBLIOGRAPHY

Abdullah, N., Zolkafli, A., Mansor, N. S., & Chik, N. A. (2020). Farmer's knowledge in land suitability evaluation and farmers' awareness in organic farming for sustainable agriculture: A case study in Perlis. *IOP Conference Series: Earth and Environmental Science*, *616*(1). https://doi.org/10.1088/1755-1315/616/1/012041

Agustina, C., Kusumarini, N., & Rayes, M. L. (2022). *PENGELOLAAN LAHAN SAWAH Mapping of Soil Fertility Capability Classes as a Baseline for Issue Identification and Management Practices in Paddy Fields*. *9*(2), 421–429. https://doi.org/10.21776/ub.jtsl.2022.009.2.23

Aldababseh, A., Temimi, M., Maghelal, P., Branch, O., & Wulfmeyer, V. (2018). Multi-criteria evaluation of irrigated agriculture suitability to achieve food security in an arid environment. *Sustainability (Switzerland)*, *10*(3). https://doi.org/10.3390/su10030803

Ayeyemi, T., Recena, R., & Mar, A. (2023). *Circular Economy Approach to Enhance Soil Fertility Based on Recovering Phosphorus from Wastewater*.

Darlita, R. R., & Joy, B. (2017). *Analisis Beberapa Sifat Kimia Tanah Terhadap Peningkatan Produksi Kelapa Sawit pada Tanah Pasir di Perkebunan Kelapa Sawit Selangkun*. *28*(1), 15–20.

Heckman, J. R. (2013). *Soil Fertility*

Management a Century Ago in Farmers of Forty Centuries. 2796–2801. https://doi.org/10.3390/su5062796

Irawan, T. B., Soelaksini, L. D., & Nuraisyah, A. (2021). *Analisa Kandungan Bahan Organik Kecamatan Tenggarang , Bondowoso , Curahdami , Binakal dan Pakem untuk Penilaian Tingkat Kesuburan Tanah Sawah Kabupaten Bondowoso (2)*. *21*(2), 73–85.

Jawang, U. P. (2021). *Penilaian Status Kesuburan dan Pengelolaan Tanah Sawah Tadah Hujan di Desa Umbu Pabal Selatan , Kecamatan Umbu Ratu Nggay Barat (Assessment of Fertility Status and Management of Rain-fed Rice Fields in Umbu Pabal Selatan Village , Umbu Ratu Nggay Barat D*. *26*(3), 421–427. https://doi.org/10.18343/jipi.26.3.421

Khadka, D., Lamichhane, S., Bhurer, K. P., Chaudhary, J. N., & Lakhe, L. (2018). *Soil Fertility Assessment and Mapping of Regional Agricultural Research*. *4*(April), 33–47.

Kolbe, H. (2022). *Comparative Analysis of Soil Fertility, Productivity and Sustainability of Organic Farming in Central Europe — Part 1 : Effect of Medium Manifestations on Conversion, Fertilizer Types and Cropping Systems*.

Laekemariam, F., & Kibret, K. (2020). *Explaining Soil Fertility Heterogeneity in Smallholder Farms of*. *2020*.

Laudicina, V. A., Ruisi, P., & Badalucco, L. (2023). *Soil Quality and Crop Nutrition*. 10–13.

Mahbub, I. A., Tampubolon, G., & Farni, Y. (2023). *MELALUI APLIKASI PUPUK ORGANIK Increasing Soil Fertility and Lowland Rice Yield through Organic Fertilizer Application*. *10*(2), 335–340. https://doi.org/10.21776/ub.jtsl.2023.010.2.17

Neswati, R., Baja, S., & Lopulisa, C. (2021). A modification of land suitability requirements for maize in the humid tropics of South Sulawesi. *IOP Conference Series: Earth and Environmental Science*, *921*(1). https://doi.org/10.1088/1755-1315/921/1/012012

Romadhon, M. R., & Hermiyanto, B. (2021). *Penentuan Indeks Kesuburan Tanah di Sub DAS Dinoyo , Kabupaten Jember Determination of Soil Fertility Index in Dinoyo Sub Watershed , Jember Regency*. *45*(1), 27–37.

Romadhona, S., & Arifandi, J. A. (2020). Indeks Kualitas Tanah Dan Pemanfaatan Lahan Sub Daerah Aliran Sungai Suco Kabupaten Jember. *Geography: Jurnal Kajian, Penelitian Dan Pengembangan Pendidikan*, *8*(1), 37–45.

Romadhona, S., Mutmainnah, L., Wibowo, C., & Setiawati, T. C. (2020). "assessment of Coastal Vulnerability Index on potential agricultural land-CVI, Banyuwangi Regency." *E3S Web of Conferences*, *142*, 1–8.

https://doi.org/10.1051/e3sconf/202014201002

Sri Sumarniasih, M., Simanjuntak, D. D., & Arthagama, I. D. M. (2021). Evaluasi status kesuburan tanah sawah di Subak Kerdung dan Subak Kepaon, Kecamatan Denpasar Selatan. *Agrovigor: Jurnal Agroekoteknologi*, *14*(2), 123–130. https://doi.org/10.21107/agrovigor.v14i2.10899

Sunaina, B., Kumar, J. R., Rupak, K., & Mahesh, R. (2019). *Malaysian Journal of Sustainable Agriculture (MJSA) A CASE STUDY ON SOIL FERTILITY STATUS AND MAIZE PRODUCTIVITY IN DANG*. *3*(2), 56–59.