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Soil nutrient and invertase-producing bacteria relation impact on cilembu sweet potato (*Ipomoea batatas* L.) growth: A study based on dry fields and paddy fields cultivation in Cilembu village Sumedang district

Abstract. Environment is one important factors that must be considered in supporting sweet potato productivity. Environmental factors can be biotic and abiotic, including the availability of nutrients and microbes in the soil. This study aimed to identify the nutrient content of the soil in paddy fields and dry fields, identify the total invertase microorganisms in paddy fields and dry fields, and identify the relationship between soil nutrients and microorganisms during the growth of Cilembu sweet potato in dry and paddy fields agroecosystems. This research was conducted on dry fields and paddy fields in Cilembu Village, Sumedang Regency. The experimental design used was a randomized block design (RBD) with six treatments and three replications: A; Rancing, paddy fields, B; Biang, paddy fields, C; Mencrang, paddy fields, D; Rancing, dry fields, E; Biang, dry fields, F; Mencrang, dry fields. The observed parameters included pH, C-organic, total-N, available-P, exchangeable-K, exchangeable-Na, exchangeable-Ca, and exchangeable-Mg, cation exchange capacity (CEC), and total invertase-producing bacteria. The results showed that in paddy fields, the pH was slightly acidic, and the nutrient content such as N, available P, exchangeable Ca, Mg, Na, CEC, and C-organic tended to be more available. Soil K and abundant invertase bacteria were more available in the dry fields. The activity of invertase bacteria had a close relationship with the K content. The information generated in this study could be used to determine an effective location to produce good quality sweet potato.

Keywords: Dry fields agroecosystem · Paddy fields · Plant nutrition · Invertase-producing microbes

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Introduction

Sweet potato is a versatile food crop highly adaptable to changing environments. According to several studies, it can grow and produce optimal yields in various environments (Mustamu et al., 2018; Karuniawan et al., 2021a; Maulana et al., 2022). In addition, this plant can also be used for food, feed, and industrial raw materials (Karuniawan et al., 2021b). These numerous benefits have made sweet potato one of the leading commodities in Indonesia, particularly in West Java.

The Cilembu sweet potato is a particularly popular variety in Indonesia and the world. This type of sweet potato has its own unique advantages, including the production of honey/caramel when baked or roasted (Astawan and Widowati, 2011; Lai et al., 2013). According to Solihin et al. (2018), the quality of the honey does not show significant differences when grown in different environments. However, Karuniawan et al. (2021a) reported different results, showing that the level of sweetness is greatly influenced by the interaction between the genotype and the environment, meaning that each gene will have different potential for sweetness when grown in different environmental conditions. Currently Cilembu farmers believe planting sweet potatoes in paddy fields is more profitable than dry fields. Hence, further research is needed to better understand the level of sweetness in Cilembu sweet potato.

The land in Cilembu Village is primarily comprised of dry fields and rainfed paddy fields. Sweet potato is typically planted on dry fields at the beginning or middle of the rainy season and in rainfed paddy fields areas after the rice harvest. Solihin et al. (2017) reported that the Rancing variety of Cilembu sweet potato showed no significant differences in sweetness quality when planted in paddy fields and dry fields. However, this needs to be re-examined as sweetness quality is a quantitative value strongly influenced by the environment and can change due to the interaction of genetics and the environment.

Soil characteristics, such as nutrient availability and microorganisms, can affect plant growth and yields. Plants need both macro and micro-nutrients throughout their life cycle, and soil microorganisms play a role in breaking down organic matter and increasing nutrients (Ortiz and Sansinenea, 2022). Element K plays a crucial role in tuber production and sugar content (Anda et al., 2018). A study also found that the population of bacteria in the soil during the growth of sweet potatoes in the Cilembu area was higher compared to outside of the Cilembu area (Tangapo et al., 2018). These results indicate that nutrients and microorganisms play a role in increasing the production and quality of sweet potatoes in the Cilembu area. Therefore, this study aimed to determine the soil nutritional content and total invertase microorganisms during the growth of Cilembu sweet potato on dry fields and paddy fields in the Cilembu area and their relationship.

Materials and Methods

The methodology of the research involved selecting dry fields and paddy fields in Cilembu Village, Pamulihan District, Sumedang Regency, West Java for the study(latitude $6^0$54′17,2′′S, longitude $107^0$50′39,7′′E and latitude $6^0$54′13,1′′S, longitude $107^0$50′41,7′′E). The experiment was conducted from September 2022 to January 2023 used Randomized Block Design (RBD) with six treatments and three replications. The treatments were labeled as A (Rancing, paddy fields), B (Biang, paddy fields), C (Mencrang, paddy fields), D (Rancing, dry fields), E (Biang, dry fields), and F (Mencrang, dry fields). The parameters observed included pH (measured through electrometric method), C-organic (using the Walkley and Black method), N-total (using the Kjeldahl method), available P (using the Bray/Olsen method with spectrophotometry), base exchangeable K, Na, Ca, and Mg (measured through the NH_4OAc Extraction method and pH 7 Flame photometer measurement), Cation Exchange Capacity (measured through the NH_4OAc Extraction method at pH 7),(Soil Research Institute, 2009) and total bacterial invertase (measured through the Total Plate Count method)(Lase et al., 2021).

The experiment included several stages, including land preparation, fertilization, planting, maintenance, and soil sampling for chemical and biological analysis. The land preparation stage involved clearing the land of weeds and then loosening it to a depth of over 20 cm using a hoe. Bunds were also created, with a length of 5 m each, width of 70 cm, and a spacing of 30 cm between them. The experiment involved planting one cutting of each genotype with a spacing of 25 x 100 cm, and fertilizing the soil with organic and inorganic fertilizers. The organic fertilizer was applied at a dose of 10 tons/ha during land preparation, while the inorganic fertilizer was Phonska NPK (16-16-16) with a dose of 200 Kg/ha, applied 7 days after planting 1/3 dose and 45 days after planting 2/3 dose.

Planting involved inserting one cutting in each planting hole with a spacing of 25 cm x 100 cm and positioning each cutting in an "L" shape. The maintenance involved watering the plants and weeding the surrounding area. Watering was done at the start of planting. The soil or mounds were dry, and there was no rain while weeding was done when the area had an excessive growth of weeds, i.e., a month after planting. Soil sampling was conducted during the final vegetative stages period, or ±2 months after planting (Anda et al., 2018), and involved taking soil samples from five points diagonally at a depth of 10-30 cm. The soil samples were mixed evenly and a kilogram was taken for testing in the laboratory to measure the chemical properties and soil biology around the plant rhizosphere.

The data from the chemical and biological properties of the soil was then analyzed statistically using IBM SPSS Statistics version 25. If the results of the analysis of variance showed a significant difference, the Duncan mean value difference test was performed at a significance level of α = 5%. To determine the relationship between chemical properties and soil biology, a Principal Component Analysis (PCA) was performed. The R program software was used to assist with data processing for the PCA (Jolliffe IT, 2002).

Results and Discussion

Comparison of Soil Nutrient Conditions in paddy fields and dry fields in Cilembu Village. The results of the analysis of the chemical properties of the soil in paddy fields and dry fields planted with sweet potatoes (Rancing, Biang and Mencrang) were presented in Table 1. The soil pH values in the paddy fields were found to range from 6.13 to 6.21, while in the dry fields, the pH values were from 5.86 to 5.94. According to the Soil Research Institute (2009), these values are considered to be sughtly acide. The pH condition of the soil affects the ease with which nutrient ions can be absorbed by plants A neutral soil pH is the most optimal for providing nutrients to plants as most nutrients dissolve easily in these conditions and are easily absorbed (Karamina et al., 2018).

The results of the statistical analysis for C-organic content in paddy fields and dry fields showed significant differences. The C-organic content in paddy fields (Rancing, Biang, and Mencrang planting areas) was 2.54%, 2.34%, and 2.68%, respectively, while in the dry fields it was 2.01%, 1.77%, and 1.75%. C-organic is a major constituent of organic matter and thus, an overview of soil organic matter can be obtained from its C-organic content. Organic matter can increase ability to hold and store water, besides that it is closely related to the availability of nutrients in the soil.. Nutrients are absorbed by plants in the form of ionic cations and anions, with cations being absorbed more readily (Romadhon and Hermiyanto, 2021).

The results of the statistical analysis for soil nitrogen content in paddy fields and dry fields showed significant differences. The soil nitrogen values in paddy fields ranged from 0.24% to 0.26%, while in dry fields, it was from 0.18% to 0.19%. Nitrogen is one of the essential macronutrients for vegetative processes, and its absence during growth can result in stunted plant development (Solihin et al., 2019). Nitrogen is absorbed by plants from the soil in the form of ammonium (NH_4^+) and nitrate (NO_3^-) ions (Amir et al., 2014). These forms of nitrogen have mobile properties in the soil, making them susceptible to loss through leaching, volatilization into the atmosphere, or uptake by soil micro- and macro-organisms (Kusumandaru et al., 2015).

Available phosphorus (P-available) is a phosphorus nutrient that is readily utilized by plants. Phosphorus is absorbed by plants in the form of primary and secondary orthophosphate ions ($H_2PO_4^-$ and HPO_4^{2-}) (Umaternate et al., 2014; Firnia, 2018). It is one of the essential macro-nutrients for plants, and plays a role in photosynthesis, respiration, energy transfer and storage, cell division, and enlargement (Hasibuan et al., 2014). The available P-nutrients showed significant differences between the paddy fields and dry fields (Table 1). The phosphorus content in paddy fields (Rancing, Biang, and Mencrang) was 55.32 ppm, 59.77 ppm, and 56.85 ppm, respectively, while in the

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dry fields it was 50.52 ppm, 46.23 ppm, and 48.12 ppm. The level of available P is influenced by P input and the presence of phosphate rock in the soil (La Habi et al., 2018; Nugroho et al., 2020). Continuous and excessive phosphorus (P) input leads to an increase in P levels, resulting in a surplus of P in the field (Palembang et al., 2013; Fauzan et al., 2021). Although most soils contain substantial reserves of inorganic P, most of it is in a form that is not readily accessible to plants and is absorbed in an insoluble and tightly bound state. P-organic, however, can be converted into available inorganic P through hydrolysis or mineralization processes (Spain et al., 2018).

The Cation Exchange Capacity (CEC) is a measure of the total number of cations that can be exchanged on the surface of a negatively charged colloid, and is influenced by the presence of clay and organic matter fractions in the soil (Jayanti and Mowidu, 2015). The CEC of clays refers to the total number of cations adsorbed specifically by the clay fraction. A statistical analysis of the CEC values in paddy fields and dry fields revealed significant differences. The CEC values in paddy fields planted with Rancing, Biang, and Mencrang were 21.85, 21.15, and 21.32 cmol kg-1, respectively, while the values for dry fields with Rancing, Biang, and Mencrang plantings were 16.51, 17.32, and 16.45 cmol kg-1, respectively. Soils with high CEC values indicate that they have the ability to provide nutrients in the form of exchangeable cations. CEC values are influenced by various factors, such as soil pH, texture, and organic matter content (Zgorelec et al., 2019).

Table 1 also showed that the basic cation content, including Calcium (Ca), Magnesium (Mg), Potassium (K), and Exchangeable Sodium (Na), in paddy fields and dry fields planted with three sweet potato clones showed significant differences. In paddy fields planted with Rancing varieties, the average values of basic cations, such as exchangeable Ca, Mg, K, and Na, were 9.64 cmol kg^{-1}, 3.61 cmol kg^{-1}, 0.91 cmol kg^{-1}, and 0.31 cmol kg^{-1}, respectively. For paddy fields planted with Biang, the values were 9.74 cmol kg^{-1}, 3.87 cmol kg^{-1}, 0.90 cmol kg^{-1}, and 0.38 cmol kg^{-1}, respectively. Meanwhile, those planted with Mencrang had values of 10.92 cmol kg^{-1}, 3.44 cmol kg^{-1}, 1.01 cmol kg^{-1}, and 0.33 cmol kg^{-1}, respectively. The content of exchangeable Ca, Mg, K, and Na in dry fields planted with Rancing varieties were 8.28 cmol kg^{-1}, 2.14 cmol kg^{-1}, 1.22 cmol kg^{-1}, and 0.20 cmol kg^{-1}, respectively. For dry fields planted with Biang, the values were 7.46 cmol kg^{-1}, 1.96 cmol kg^{-1}, 1.17 cmol kg^{-1}, and 0.26 cmol kg^{-1}, respectively. Meanwhile, the dry fields planted with mencrang had values of 7.64 cmol kg^{-1}, 2.37 cmol kg^{-1}, 1.27 cmol kg^{-1}, and 0.23 cmol kg^{-1}.

Ca, Mg, and K are macronutrients that are needed by plants in relatively large quantities. Mg is absorbed by plants as Mg^{2+} ions, while Ca is absorbed as Ca^{2+} ions with the same valence (Soewandita, 2008). Mg is one of the elements of chlorophyll and is involved in photosynthesis, while Ca plays a role in stimulating the formation of root hairs, hardening stems, and stimulating seed formation. If the soil is low in calcium, the leaves can easily experience chlorosis. K is absorbed by plants as K+ ions and plays a role in the efficiency of water use, such as the process of opening and closing leaf pores and stomata (Apriliani et al., 2016). It also has a role in regulatory mechanisms, such as in the process of photosynthesis, carbohydrate translocation,

Table 1. Results of soil chemical analysis in paddy fields and dry fields

Treatments	paddy fields			dry fields		
	Rancing	Biang	Mencrang	Rancing	Biang	Mencrang
pH	6.21 b	6.13 b	6.17 b	5.94 a	5.86 a	5.90 a
C-Org(%)	2.54 c	2.34 bc	2.68 c	2.01 ab	1.77 a	1.75 a
Tot-N (%)	0,26 c	0.24 bc	0.26 c	0.18 a	0.19 ab	0.19 ab
Av-P(ppm)	55.32 abc	59.77 c	56.85 bc	50.52 abc	46.23 a	48.12 ab
CEC(cmol kg^{-1})	21.85 b	21.15 b	21.32 b	16.51 a	17.32 a	16.45 a
Exch-Ca(cmol kg^{-1})	9.64 bc	9.74 bc	10.92 c	8.28 ab	7.46 a	7.64 a
Exch-Mg(cmol kg^{-1})	3.61 b	3.87 b	3.44 b	2.14 a	1.96 a	2.37 a
Exch-K(cmol kg^{-1})	0.91 ab	0.90 a	1.01 abc	1.22 c	1.17 bc	1.27 c
Exch-Na(cmol kg^{-1})	0.31 d	0.38 f	0.33 e	0.20 a	0.26 c	0.23 b

Note: The mean value followed by the same letter is not significantly different based on Duncan's multiple range test at the 5% level and protein synthesis. However, because K has a relatively large hydrated form and a valency of 1, it is not strongly adsorbed by soil colloidal loads, so it is easily leached. Although sodium is not an essential nutrient, its presence in the soil can sometimes replace potassium for certain plants and is known as a functional element. It can also increase the solubility of K from minerals to soil solution (Mengel and Kirkby, 2001). The presence of Na affects not only the chemical properties of the soil but also its physical properties, particularly its structural stability. Its high concentration in the soil can cause disturbances in plant metabolism and affects the osmotic properties and stability of aggregates, besides having physiological effects.

Total population of invertase bacteria in paddy fields and dry fields in Cilembu village. In this study, the average abundance of invertase-producing bacteria was observed in dry fields and paddy fields in Cilembu Village planted with 3 different sweet potato clones (Figure 1). The average yield of the abundance of invertase-producing bacteria in paddy fields planted with Rancing, Mencrang, and Biang was 2.80 x 10^5 cfu g^{-1}, 2.42 x 10^5 cfu g^{-1} , and 2.94 x 10^5 cfu g^{-1} . As for dry fields, it was 3.26 x 10^5 cfu g^{-1}, 2.75 x 10^5 cfu g^{-1} and 3.08 x 10^5 cfu g^{-1}. The average value of the abundance of invertase-producing bacteria in dry fields and paddy fields is statistically different. In this study, it was shown that the treatment of paddy fields planted with Mencrang was lower while the dry fields with sharp sedges had the highest average value compared to other treatments.

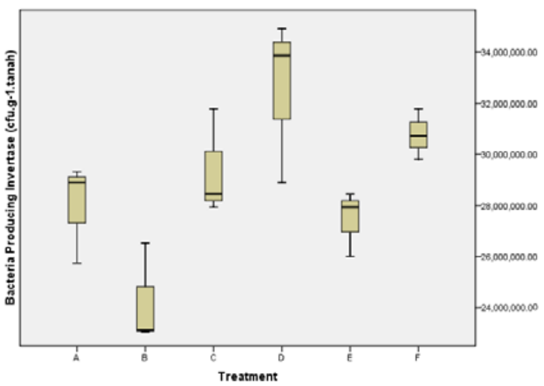

Figure 1. Box plot of the abundance of invertase-producing bacteria in the six treatments. X-axis code see material and methods section.

The abundance of invertase-producing bacteria in paddy fields and dry fields planted with three different sweet potato clones was influenced by various environmental factors, both biotic and abiotic. The content of organic matter in the environment can affect microbial populations, and in this study, it was observed that the organic matter content in dry fields was lower compared to that in paddy fields. Bacteria, as a type of microbe, play a significant role in the decomposition of organic matter through an enzymatic process. One of the enzymes produced by microbes during this process is invertase. High levels of microbial activity can affect the degradation process of high organic matter. In addition to organic matter, root exudates secreted by plants can also trigger the desired microbial growth and aggregation in the root area or rhizosphere zone. The effect of root exudation on the abundance and diversity of microbes in the rhizosphere zone is relatively higher compared to the non-rhizosphere zone (Prayudyaningsih, 2015; Nazir et al., 2016).

The Relationship between Soil Nutrients and Invertase Bacteria using Principal Component Analysis (PCA). A Principal Component Analysis (PCA) was performed to investigate the relationship between environmental factors such as the agroecosystems of dry fields and paddy fields and the total microorganisms (invertase-producing bacteria) and soil nutrition (soil chemical properties: pH, organic-C, total-N, available-P, CEC, exchangeable Ca, Mg, K and Na. The results of the PCA for the six treatments tested based on soil characteristics showed two axes with eigenvalues between 8.487 and 1.092, and a cumulative value of 95.792% (Table 2). The first component (PC1) had a variation contribution of 84.871%, where all the elements tested had a significant impact on diversity.

The second component (PC2) had a variation contribution of 10.921% and was influenced by invertase-producing bacteria. According to the data obtained, the elements tested contribute to diversity, with some elements contributing positively and others negatively (Table 2). According to Haydar et al. (2007), elements that contribute positively indicate optimal contribution, while elements that contribute negatively indicate suboptimal contribution to diversity. In PC1, pH, C, CEC, N, P, Ca, Mg, and Na contribute the most, while elements K and invertase-producing bacteria make a suboptimal contribution. However,

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invertase-producing bacteria provide the maximum contribution to PC2.

In a separate study, Markos et al. (2022) used PCA to identify the environmental contribution to the yield and quality of maize. The results of the PCA analysis showed that the properties tested had a strong relationship, indicating that soil nutrients with positive and dominant values are closely related to invertase bacteria, which will ultimately affect the quality of sweet potato yields.

Table 2. The result PCA for total microbes and soil nutrients

Componen (PC)	1	2
Acidity (pH)	**0.962**	0.232
Carbon Organik (C-or)	**0.924**	0.360
Cation Exchange Capacity (CEC)	**0.987**	-0.001
Nitrogen (N)	**0.964**	0.121
Phosphorus (P)	**0.939**	0.047
Calcium (Ca)	**0.917**	0.328
Magnesium (Mg)	**0.974**	-0.033
Potassium (K)	**-0.961**	0.175
Sodium (Na)	**0.914**	-0.364
Invertase producing bacteria	**-0.613**	**0.787**
Variation (%)	84.871	10.921
Cumulative (%)	84.871	95.792

Note: *numbers in bold indicate discriminant >0.5 or <-0.5 and contribute to diversity (Jolliffe, 2002)

The relationship between each element and treatment can be visualized from the PCA biplot graph in Figure 2. The results reveal the formation of four quadrants, including quadrants I, II, III, and IV. Treatments or elements in the same quadrant exhibit a close relationship, while those in different quadrants display no close relationship (Maulana et al., 2018). Figure 2 illustrates that the dominant elements in quadrant 1 are C, Ca, pH, N, and P. These five elements have a strong interdependence, as evidenced by the angles formed by each element. In a separate study, Aziza et al. (2021) reported that properties with an acute angle (<90˚) have a very strong relationship. Additionally, there is also a treatment in quadrant 1, namely the paddy fields planted with Rancing and Mencrang, which demonstrates that these elements in this quadrant significantly influence the diversity in paddy fields. In quadrant 2, two elements (bacteria and K) form an obtuse angle (>90˚) away from the other elements, indicating an opposing relationship with other properties. There are also two treatments in quadrant 2 that display a fairly strong relationship with these two elements, namely the upland planted with Rancing and Mencrang. In quadrant 3, there is one treatment (E), the paddy fields planted with starter, but there are no elements tested. This indicates that the treatment tends to have a negative correlation with all other elements and treatments in the test. In quadrant 4, there are three elements, CEC, Mg, and Na, and one treatment, the paddy fields planted with Biang. These three elements have an acute angle with the elements in quadrant 1, indicating a strong relationship, but they primarily influence the location of paddy fields planted with Biang.

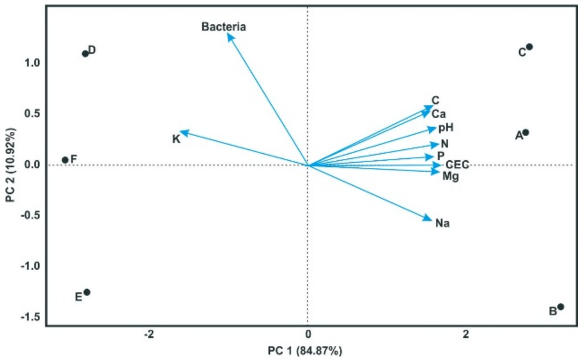

Figure 2. PCA biplot between treatments and elements tested in paddy fields and dry fields agro-ecosystems. Code see material and methods section.

The location of paddy fields has a higher availability of nutrients, such as pH, C-organic, N, P, CEC, Ca, Mg, and Na. Meanwhile, dry fields locations have more abundant nutrients for K and a greater abundance of invertase-producing bacteria. This is because paddy field has a higher organic matter content, resulting in better soil fertility. According to Mukherjee and Lal (2014), soil quality is influenced by the type of soil and its management. Improper management can cause soil damage and make it unable to support crop production. Intensive tillage in dry fields areas can reduce the content of organic matter and lead to soil acidification (Neina, 2019; Dewi et al., 2020).

Conclusion

Two agro-ecosystems have different fertility levels, both in terms of nutrition and microbial availability, which were part of the environmental components that supported plant productivity. In paddy fields, the availability of nutrients such as nitrogen, phosphorus, calcium, magnesium, sodium, cation exchange capacity, and organic carbon were higher, while potassium content and abundance of invertase bacteria were higher in dry fields. The close relationship between the abundance of invertase bacteria and potassium content was also noted. Bacteria and potassium had implications for increasing yields and sweetness levels of sweet potato.

References

Amir L, Sari AP, Hiola SF, Jumadi O. 2014. Ketersediaan Nitrogen Tanah dan Pertumbuhan Tanaman Bayam (Amaranthus tricolor L.) yang Diperlakukan dengan Pemberian Pupuk Kompos Azolla. J. Sainsmat, I(2): 167–180.

Anda M, Suryani E, Widaningrum W, Nursyamsi D. 2018. Soil Potassium Nutrient, Temperature and Rainfall Required To Generate 'Honey Taste' of Cilembu Sweet Potato. Indones. J. Agric. Sci., 19(1): 33. doi: 10.21082/ijas.v19n1.2018.p33-47.

Apriliani IN, Heddy S, Suminarti NE. 2016. Pengaruh kalium pada pertumbuhan dan hasil dua varietas tanaman ubi jalar (Ipomea batatas (L.) Lamb). J. Produksi Tanam., 4(4): 264–270. http://protan.studentjournal.ub.ac.id/index.php/protan/article/view/290.

Astawan M, Widowati S. 2011. Evaluation Of Nutrition And Glycemic Index Of Sweet Potatoes And Its Appropriate Processing To Hypoglycemic Foods. Indones. J. Agric. Sci., 12(1): 40–46. doi: http://dx.doi.org/10.21082/ijas.v12n1.2011.p40-46.

Aziza V, Ulimaz TA, Ustari D, Suganda T, Concibido V, et al. 2021. Keragaman Fenotipik Bunga Telang Double Petal Asal Indonesia dan Thailand Berdasarkan Morfologi Bunga. Al-Kauniyah J. Biol., 14(1): 78–89. doi: 10.15408/kauniyah.v14i1.15558.

Dewi E, Haryanto R, Sudirja R. 2020. Pengaruh Penggunaan Lahan dan Posisi Lereng Kandungan C-Organik dan Beberapa Sifat Fisik Tanah Inceptisols Jatinangor, Jawa Barat. AGROSAINSTEK J. Ilmu dan Teknol. Pertan., 4(1): 49–53. doi: 10.33019/agrosainstek.v4i1.37.

Fauzan A, Indarto I, Mandala M, Alam P, et al. 2021. Pemetaan Indeks Kualitas Tanah pada Lahan Tegalan di Kabupaten Jember Mapping of Soil Quality Index for Upland in Jember Regency. J. Tanah dan Iklim, 45(2): 133–144. doi: 10.21082/jti.v45n2.2021.129-140.

Firnia D. 2018. Dinamika Unsur Fosfor Pada Tiap Horison Profil Tanah Masam. J. Agroekoteknologi, 10(1): 45–52. doi: 10.33512/j.agrtek.v10i1.5464.

Hasibuan SY, Damanik M, Sitanggang G. 2014. Aplikasi pupuk SP-36 dan pupuk kandang ayam terhadap ketersediaan dan serapan fosfor serta pertumbuhan tanaman jagung pada ultisol Kwala Bekala. J. Online Agroekoteknologi, 2(3): 1118–1125.

Haydar A, Ahmed M, Hannan M, Razvy M. 2007. Analysis of genetic diversity in some potato varieties grown in Bangladesh. Middle-East J. Sci. Res., 2(3–4): 143–145. https://www.researchgate.net/publication/242250988%0AAnalysis.

Jayanti KD, Mowidu I. 2015. Hubungan Antara Kadar Fraksi Pasir, Fraksi Klei, Bahan Organik dan Berat Volume Terhadap Kadar Air Tersedia Pada Tanah Sawah di Kabupaten Poso. J. Agropet, 12(1): 6–10.

Jolliffe IT. 2002. Principal component analysis (2nd edn, editor). Springer-Verlag, New York.

Karamina H, Fikrinda W, Murti AT. 2018. Kompleksitas pengaruh temperatur dan kelembaban tanah terhadap nilai pH tanah di perkebunan jambu biji varietas kristal (Psidium guajava l.) Bumiaji, Kota Batu. Kultivasi, 16(3): 430–434. doi: 10.24198/kultivasi.v16i3.13225.

Karuniawan A, Maulana H, Anindita PA, Yoel A, Ustari D, et al. 2021a. Storage root yield and sweetness level selection for new honey sweet potato (Ipomoea batatas [L.] Lam). Open Agric., 6(1): 329–345. doi: 10.1515/opag-2021-0219.

Karuniawan A, Maulana H, Ustari D, Dewayani S, Solihin E, et al. 2021b. Yield stability analysis of orange - Fleshed sweet potato in Indonesia using AMMI and GGE biplot. Heliyon 7(4): 1–10. doi: 10.1016/j.heliyon.2021.e06881.

ISSN: 1412-4718, eISSN: 2581-138x

Kusumandaru W, Hermiyanto B, Winarso S. 2015. Pertanian Analisis Indeks Kualitas Tanah Di Lahan Pertanian Tembakau Kasturi Berdasarkan Sifat Kimianya Dan Hubungannya Dengan Produktivitas Tembakau Kasturi Di Kabupaten Jember. Berk. Ilm. Pertan., 2(1): 1–6.

La Habi M, Nendissa JI, Marasabessy D, Kalay AM. 2018. Ketersediaan Fosfat, Serapan Fosfat, Dan Hasil Tanaman Jagung (Zea mays L.) Akibat Pemberian Kompos Granul Ela Sagu Dengan Pupuk Fosfat Pada Inceptisols. Agrologia 7(1). doi: 10.30598/a.v7i1.356.

Lai YC, Huang CL, Chan CF, Lien CY, Liao WC. 2013. Studies of sugar composition and starch morphology of baked sweet potatoes (Ipomoea batatas (L.) Lam). J. Food Sci. Technol., 50(6): 1193–1199. doi: 10.1007/s13197-011-0453-6.

Lase ERK, Giyanto, Santosa DA. 2021. Isolation, identification, and analysis of the invertase-producing bacteria abundance in sugarcane rhizosphere soil with different plant productivity levels. Biodiversitas 22(8): 3156–3162. doi: 10.13057/biodiv/d220809.

Markos D, Mammo G, Worku W. 2022. Principal component and cluster analyses based characterization of maize fields in southern central Rift Valley of Ethiopia. Open Agric., 7(1): 504–519. doi: 10.1515/opag-2022-0105.

Maulana H, Nafi'ah HH, Solihin E, Ruswandi D, Arifin M, et al. 2022. Combined stability analysis to select stable and high yielding sweet potato genotypes in multi-environmental trials in West Java, Indonesia. Agric. Nat. Resour., 56(4): 761–772. doi: 10.34044/J.ANRES.2022.56.4.10.

Maulana H, Prayudha HN, Mulyani RS, Ustari D. 2018. Variabilitas Genetik F 1 Orange Fleshed Sweet Potato (Ofsp) Asal Peru di Jatinangor Berdasarkan Karakter Agromorfologi Genetic Variability of F1 Orange Fleshed Sweet Potato (Ofsp) Origin Peru in Jatinangor Based On Agromorphological Traits. Zuriat, 29(November): 88–94.

Mengel K, Kirkby EA. 2001. Principles of plant nutrition. 5nd ed. International Potash Institute, Bern. Switzerland.

Mukherjee A, Lal R. 2014. Comparison of Soil Quality Index Using Three Methods. PLoS ONE, 9(8): e105981.

Mustamu YA, Tjintokohadi K, Grüneberg WJ, Karuniawan A, Ruswandi D. 2018. Selection of superior genotype of sweet-potato in Indonesia based on stability and adaptability. Chil. J. Agric. Res., 78(4): 461–469. doi: 10.4067/S0718-58392018000400461.

Nazir N, Kamili AN, Zargar MY, Khan I, Shah D, et al. 2016. Effect of Root Exudates on Rhizosphere Soil Microbial Communities. J. Res. Dev., 16(March 2019): 88–95.

Neina D. 2019. The Role of Soil pH in Plant Nutrition and Soil Remediation. Appl. Environ. Soil Sci., 2019(3). doi: 10.1155/2019/5794869.

Nugroho PD, Arifin M, Devnita R. 2020. Response of Volcanic Ash Nano Particles and Phosphate Rocks Application on Selected Chemical Properties of Inceptisols in Cilembu, West Java. J. Tanah dan Iklim, 44(2): 44(2), pp. 1410–7244.

Ortiz A, Sansinenea E. 2022. The Role of Beneficial Microorganisms in Soil Quality and Plant Health. Sustain., 14(9). doi: 10.3390/su14095358.

Palembang JN, Jamilah, Sarifuddin. 2013. Kajian Sifat KImia Tanah Sawah Dengan Pola Pertanaman Padi Semangka di Desa Air Hitam Kecamatan Lima Puluh Kabupaten Batubara Studying on Chemical Properties of Paddy Soil by Applying Rice-Watermelon Cropping Pattern at Air Hitam Village, Lima Puluh Subdi. J. Online Agroekoteknologi, 1(4): 1154–1162.

Prayudyaningsih R. 2015. Mikroorganisme tanah bermanfaat pada rhizosfer tanaman umbi di bawah tegakan hutan rakyat Sulawesi Selatan. Pros Sem Nas Masy Biodiv Indon 1: 954–959. doi: 10.13057/psnmbi/m010453.

Romadhon MR, Hermiyanto B. 2021. Penentuan Indeks Kesuburan Tanah di Sub DAS Dinoyo, Kabupaten Jember. J. Tanah dan Iklim, 45(1): 27. doi: 10.21082/jti.v45n1.2021.27-37.

Soewandita H. 2008. Studi kesuburan tanah dan analisis kesesuian lahan untuk komoditas tanaman perkebunan di Kabupaten Bengkalis. J. Sains dan Teknol. Indones., 10(2): 128–133.

Soil Research Institute. 2009. Analisis Kimia Tanah, Tanaman, Air, dan Pupuk. Edisi 2. Balai Penelitian Tanah, Bogor.

Solihin MA, Sitorus SRP, Sutandi A, Widiatmaka W. 2017. Karakteristik Lahan Dan Kualitas Kemanisan Ubi Jalar Cilembu. J. Pengelolaan Sumberd. Alam dan

Lingkung. (Journal Nat. Resour. Environ. Manag., 7(3): 251–259. doi: 10.29244/jpsl.7.3.251-259.

Solihin MA, Sitorus SRP, Sutandi A, Widiatmaka W. 2018. Discriminating land characteristics of yield and total sugar content classes of cilembu sweet potato (Ipomoea batatas L.). Agrivita, 40(1): 15–24. doi: 10.17503/agrivita.v40i1.1148.

Solihin E, Sudirja R, Yuniarti A. 2019. Modifikasi Pupuk N Untuk Peningkatan Efisiensi Penyerapan Hara Tanaman Jagung (Zea mays L .). Agro Wiral Odra, 2(2): 60–66.

Spain AV, Tibbett M, Ridd M, McLaren TI. 2018. Phosphorus dynamics in a tropical forest soil restored after strip mining. Plant Soil, 427(1–2): 105–123. doi: 10.1007/s11104-018-3668-8.

Tangapo AM, Astuti DI, Aditiawati P. 2018. Dynamics and diversity of cultivable rhizospheric and endophytic bacteria during the growth stages of cilembu sweet potato (Ipomoea batatas L. var. cilembu). Agric. Nat. Resour., 52(4): 309–316. doi: 10.1016/j.anres.2018.10.003.

Umaternate GR, Abidjulu J, Wuntu AD. 2014. Uji Metode Olsen dan Bray dalam Menganalisis Kandungan Fosfat Tersedia pada Tanah Sawah di Desa Konarom Barat Kecamatan Dumoga Utara. J. MIPA, 3(1): 6. doi: 10.35799/jm.3.1.2014.3898.

Zgorelec Z, Grahovac B, Percin A, Jurkovic V, Gandjaeva L, et al. 2019. Comparison of two different CEC determination methods regarding the soil properties. Agric. Conspec. Sci., 84(2): 151–158.