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Effects of Dolomite and Phosphorus Fertilizer on P Availability and Rice Growth in Sipramin Affected Fields

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Abstract

Long-term use of Sipramin on rice fields can cause sodium accumulation, which negatively affects soil structure and nutrient availability, particularly phosphorus. This study aims to examine the effect of dolomite and phosphorus fertilizer application on phosphorus availability and rice plant growth in rice fields affected by Sipramin. The study was conducted from February to July 2025 using a completely randomized factorial design with two factors. The first factor was the number of dolomite doses: D0 (0 tons ha^{-1}), D1 (1.5 tons ha^{-1}), D2 (2 tons ha^{-1}), and D3 (3 tons ha^{-1}). The second factor consisted of five types of phosphorus fertilizers: P0 (no phosphorus fertilizer), P1 (NPK Phonska), P2 (SP-36), P3 (MKP), and P4 (MAP). This study used a completely randomized design (CRD) factorial (4 × 5) with three replications. The results showed that dolomite application significantly increased soil phosphorus availability, with the highest value observed in D3 (34.28 ppm) at 42 days after treatment (DAT). Phosphorus fertilizers with high P content, such as MAP and MKP, provided the best response in increasing available P. Dolomite application also significantly affected plant height during early vegetative stages (14 and 35 days after treatment). However, higher doses tended to reduce the number of tillers. For plant growth, a dolomite dose of 1.5 tons ha^{-1}, combined with phosphorus fertilizer, resulted in optimal performance. Thus, the optimal dolomite dose varied with the observed parameter, with 3 tons ha-1 most effective for increasing soil phosphorus availability and 1.5 tons ha^{-1} for supporting optimal rice growth.

1. Introduction

Intensive paddy field management generally involves the long-term application of chemical fertilizers to maintain crop productivity. In agricultural practices, these fertilizers are often applied repeatedly from one growing season to the next to sustain yield. One of the materials widely used in several regions is Sipramin. Sipramin is a fertilizer derived from the waste of amino acid fermentation processes, specifically a by-product of monosodium glutamate (MSG) production based on molasses (Bangun and Suryanto, 2020). It is also known as a by-product of amino acid fermentation, such as glutamate and L-lysine, originating from liquid waste generated during MSG production, and contains relatively high organic matter of approximately 8–12%. This organic content makes Sipramin a potential additional nutrient source for soil. In addition to organic matter, Sipramin contains various macronutrients, including N, P, K, Ca, and Mg, as well as micronutrients such as Cu and Zn. Among these elements, nitrogen is the most dominant and essential component, ranging from 4.9–6.1%, making Sipramin

widely utilized as a nitrogen fertilizer to support plant growth. Several studies have reported that the application of Sipramin can enhance nitrogen availability and promote vegetative growth (Utami, 2016).

Long-term use of Sipramin still raises concerns regarding sodium (Na) content and the possible presence of heavy metals. Sodium is known to affect soil structure stability, particularly in fine-textured soils. Na ions tend to cause dispersion of clay particles, resulting in unstable soil aggregates and deterioration of the soil structure. Soils with high sodium levels often have low permeability, are prone to compaction, and are less conducive to root development. Therefore, the use of materials that have the potential to increase soil sodium, including Sipramin, needs to be carefully managed, as it can harm soil physical properties when used continuously (Suntoro et al., 2012).

Long-term application of certain fertilizers can also alter soil chemical properties and affect nutrient dynamics, including phosphorus (P). Phosphorus is an essential nutrient for rice plants, playing a crucial role in root development, tillering, and energy metabolism. However, phosphorus availability in soil is often limited because it is readily adsorbed onto soil colloids or transformed into forms unavailable to plants. Disruptions in soil chemical balance may further reduce phosphorus uptake, thereby reducing plant growth and productivity (Dzikrullah et al., 2021). To address the decline in soil quality and improve nutrient availability, one potential approach is to apply dolomite and phosphorus fertilizers. Dolomite, which contains calcium (Ca) and magnesium (Mg), serves as a soil amendment to improve base-cation balance, enhance soil chemical properties, and facilitate the release of bound nutrients. As a liming material, dolomite can increase soil pH and improve the availability of Ca, Mg, and P (Amri et al., 2018). Previous studies have shown that applying 3 tons ha^{-1} of dolomite yields the best performance in rice production (Sudianto et al., 2018). Therefore, this study aims to evaluate the effect of dolomite application and various phosphorus fertilizer sources on phosphorus availability and rice plant growth in soils affected by Sipramin.

2. Research Methods

2.1. Research Location

This research was conducted between February and July 2025. Soil sampling was carried out in February 2025 in Winongo Village, Manguharjo District, Madiun City, East Java. The stages of soil preparation, media provision, and planting were carried out in the greenhouse of the Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" East Java. All laboratory analysis activities were carried out at the Land Resources Laboratory (SDL), Faculty of Agriculture, UPN "Veteran" East Java.

2.1. Research Design

This study was conducted using a completely randomized design (CRD) with a factorial arrangement consisting of two factors. The first factor was dolomite application (D), which consisted of four dosage levels: where D0 = 0 tons ha^{-1} (control), D1 = 1.5 tons ha^{-1} (4.88 grams per 3.35 kg of soil), D2 = 2 tons ha^{-1} (6.5 grams per 3.35 kg of soil), and D3 = 3 tons ha^{-1} (9.75 grams per 3.35 kg of soil). The second factor consisted of five types of P fertilizers with a total nutrient content of 27 kg: P0 = no P fertilizer application (control), P1 = NPK Phonska, P2 = Super Phosphate (SP-36), P3 = MKP, and P4 = MAP. Thus, there were 20 treatment combinations. Each treatment was replicated three times, resulting in a total of 60 experimental units. The soil used as the application medium was 3.35 kg of BTKU soil.

2.3. Research Implementation Stages

Soil sampling was conducted in rice fields in Winongo Village, Manguharjo District, Madiun City, which had long been treated with Sipramin fertilizer, resulting in high sodium content. The soil was then prepared as a planting medium by drying, crushing, and sieving it to a 2 mm size, then placed in buckets at a uniform weight of 3 kg of BTKO soil or the equivalent of 3.35 kg of BTKU. Soil conditioners in the form of Super Mesh 80 dolomite and phosphorus fertilizers (NPK Phonska, SP-36, MKP, and MAP) were weighed according to the treatment, mixed evenly into the soil, and then incubated for one week. Planting was carried out with the Ciherang rice variety, and two-week-old seedlings were transplanted at a rate of 3 seedlings per pot. Soil samples for laboratory analysis were collected at three random points per treatment at two sampling times: 0 and 42 days after treatment (DAT).

3. Results and Discussion

3.1. Phosphorus Availability

At the initial condition before dolomite application (0 DAT), the available P value was 30.79 ppm, which is relatively high. However, the application of dolomite is expected to further increase phosphorus availability in Sipramin-affected rice fields, as this compound can alter soil reactions and nutrient dynamics. The initial available

P value at 0 DAT was used as the baseline for assessing changes in available P due to dolomite treatment at the observation stage (42 DAT).

The results of the observation indicate that dolomite treatment elicits a distinct response to available phosphorus (P). The highest average was observed in treatment D3, at 34.28 ppm, while the lowest was in treatment D0, at 30.70 ppm. Statistical analysis shows that D0 differs significantly from treatments D2 and D3 but not from D1. This difference in response suggests that increasing the dolomite dose can enhance phosphorus availability in the soil.

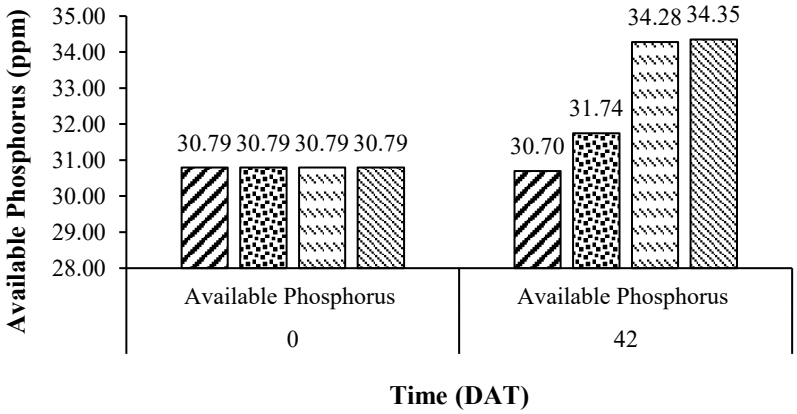

Figure 1 . Soil phosphorus availability based on the effect of dolomite dose at 0 DAT and 42 DAT.

The increase in available phosphorus is closely related to the rise in soil pH after dolomite application. More alkaline soil conditions reduce the activity of Al and H^+ ions, which generally bind phosphorus, making total phosphorus more readily available. In addition, increasing the dolomite dose is also thought to accelerate the decomposition of organic matter, which in turn increases the Ca and Mg content and stimulates soil microorganism activity. These processes contribute to the release of larger amounts of phosphorus.

This is reinforced by research (Syahputra et al., 2015) showing that near-neutral soil pH increases the availability of macronutrients. In addition, Ilham et al. (2019) stated that applying dolomite at varying doses tends to increase phosphate availability through organic matter decomposition and increased microbial activity. Thus, the increase in available P in this study can be attributed to interactions among changes in soil reactions, base-cation dynamics, and biological processes.

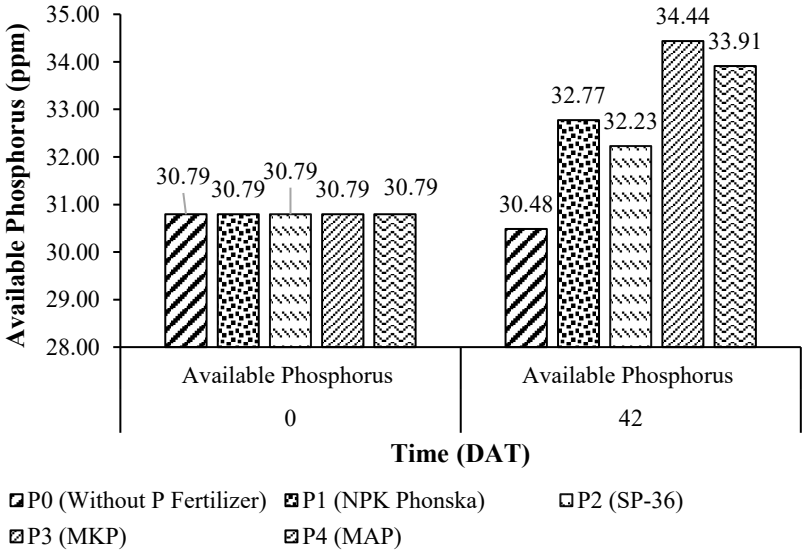

Figure 2. Soil phosphorus availability based on the effect of phosphorus fertilizer at 0 DAT and 42 DAT.

The results of the analysis of variance indicate that the application of various phosphorus fertilizers significantly increases available phosphorus in the soil at 42 DAT. Figure 2 shows that the treatment without P fertilizer (P0) produced the lowest value (30.48 ppm), indicating that without external phosphorus supplementation, the affected soil was unable to optimally increase P availability. Conversely, all phosphorus fertilizer treatments increased available phosphorus compared to the control. The results of the 5% BNJ test showed that P0 differed significantly from P1, P4, and P3, but not from P2. The P3 treatment was also significantly different from P0 and P2 but not from P1 and P4. This confirms that fertilizers with higher solubility and phosphorus content produce a stronger increase in available Phosphorus.

The highest increase occurred in the MKP (P4) and MAP (P1) treatments. These two fertilizers provided a stronger positive response because they have high phosphorus content: MAP contains 61% P, and MKP contains 52% P. The higher P content enabled both fertilizers to provide more orthophosphate ions that were more readily available in the soil, thereby increasing the concentration of available P more effectively than other phosphorus fertilizers.

3.2. Plant Height

Plant height is an important parameter that reflects rice plant vegetative growth and describes the response of plants to the treatment. Plant height growth is strongly influenced by nutrient availability, soil conditions, and environmental factors during the growth period (Manurung et al., 2020). The results of the analysis of variance showed that the combination treatment of dolomite and phosphorus fertilizer did not have a significant effect on plant height at 7, 14, 21, 35, 49, 63, and 84 days after sowing (DAS). This indicates that the two treatments did not interact to increase plant height growth. However, the single dolomite treatment showed a significant effect at 14 and 35 days after sowing.

Table 1. Rice plant height with treatment of various doses of dolomite and various sources of phosphorus fertilizer on land affected by Sipramin

Treatment	Plant Height (cm)						
	7 DAS	14 DAS	21 DAS	35 DAS	49 DAS	63 DAS	84 DAS
Dolomite							
D0 = Without dolomite	26.39	40.53^{a}	59.59	77.49^{a}	81.43	83.67	88.90
D1 = 1.5 tons ha^{-1}	25.05	40.60^{ab}	58.86	75.23^{a}	80.64	83.87	88.93
D2 = 2 tons ha^{-1}	24.51	37.48^{b}	57.69	75.05^{a}	80.89	83.82	88.93
D3 = 3 tons ha^{-1}	23.26	36.09^{b}	54.83	70.34^{a}	79.19	81.77	86.20
Tukey's HSD 5%	ns	4.26*	ns	4.93*	ns	ns	ns
Fertilizer							
P0 = Without fertilizer	23.76	37.96	56.85	73.12	80.86	84.03	88.67
P1 = NPK Phonska	24.55	36.88	56.49	74.09	81.84	83.97	89.50
P2 = SP-36	25.44	38.66	59.16	75.00	82.92	85.46	88.63
P3 = MKP	25.31	41.06	59.04	73.87	79.62	82.42	86.67
P4 = MAP	24.94	38.18	57.18	72.73	77.82	80.54	87.75
Tukey's HSD 5%	ns	ns	ns	ns	ns	ns	ns

Note: The same numbers followed by the same letters in the same column indicate no significant difference in the Tukey's HSD 5% test.

The results of Tukey's HSD 5% test (Table 1) show that at 14 DAS and 35 DAS, dolomite treatment had a significant effect on plant height because during the vegetative phase, rice plants are very sensitive to changes in soil pH and base cation availability. Dolomite, which contains calcium (Ca) and magnesium (Mg), can increase soil pH and suppress aluminum (Al) saturation, thereby improving root conditions and enhancing nutrient uptake. Increasing pH to a more neutral condition is also important because nutrient availability is optimal within that pH range, thereby supporting maximum vegetative growth (Peliyarni and Rahmahwati, 2025).

Overall, treatment P2 (SP-36 fertilizer treatment) tended to produce taller plants compared to other treatments. This is in line with Prakosa et al. (2020), which explains that SP-36 functions as a nutrient source rather than a soil conditioner. SP-36 fertilizer, which has the chemical formula $Ca(H_2PO_4)_2$, contains Ca, which can increase the pH of H_2O through the process of soil colloid saturation. This increase in pH makes soil conditions more conducive to phosphorus absorption, enabling more optimal plant growth. Thus, the increase in plant length across several treatments indicates that both dolomite and phosphorus fertilizers continue to support growth, even though their interaction does not show a significant effect.

Moderate doses of dolomite (D1 and D2) appear to give better results than low (D0) and high (D3) doses. This is because excessive dolomite application can cause nutrient imbalances, such as decreased availability of Fe, Mn, and Zn due to excessively high pH increases (Saragih et al., 2025). This condition can reduce phosphorus uptake

and inhibit plant growth. Therefore, moderate doses of dolomite can create ideal soil conditions for enhanced nutrient availability and increased microbial activity, which supports rice plant growth.

The combined treatment of dolomite with MKP (P3) and MAP (P4) fertilizers also increased plant height, although not as much as P1 and P2. It is suspected that the plant response to MKP (monopotassium phosphate) and MAP (monoammonium phosphate) treatments is influenced by the properties of these two fertilizers, which are easily soluble and quickly available to plants. High solubility enables phosphorus from MKP and MAP to enter the soil solution more quickly, allowing it to be immediately absorbed by the roots. Phosphorus plays a crucial role in energy transfer within plant cells through ADP and ATP, and can enhance nitrogen utilization efficiency. In addition to nitrogen and phosphorus, potassium also plays an important role in plant growth. Potassium functions in protein formation and strengthens plant tissues. This is in line with the statement by Syamsiah et al. (2021) that potassium activates various enzymes and promotes the translocation of carbohydrates from leaves to other parts of the plant.

The results at 84 DAS showed that the combination of treatments D1P1, D2P1, and D2P2 had the highest plant height, reaching 90–93 cm. This combination demonstrates synergy between dolomite, a soil conditioner, and phosphorus fertilizer, which serves as the primary source of nutrients for growth. Sufficient phosphorus availability, supported by neutral soil conditions, accelerates cell division and stem elongation. This is likely due to the fixation of P with Al and Fe in the early vegetative stage, which makes P difficult for plants to absorb. At 84 DAS, dolomite is thought to help neutralize soil pH, allowing nutrients to be more easily absorbed and plant growth to be more optimal (Sudianto et al., 2018).

3.3. Number of Tillers

The results of Tukey's HSD 5% (Table 1) show that at both 35 DAS and 49 DAS, the treatment without dolomite (D0) produced a higher number of offspring compared to several dolomite treatments. At 35 HST, D0 differed significantly from treatments D2 and D3, whereas D1 remained in the "not significantly different" category. A similar pattern occurred at 49 DAS, where D0 still had the highest number of tillers and was significantly different from D2, while D1 and D3 were in the middle group and not significantly different. These findings indicate that dolomite application up to 49 days after sowing (DAS) had no positive effect on tiller formation. This is likely due to the rapid increase in pH resulting from dolomite application, which may disrupt micronutrient balance during the vegetative phase. The near-neutral pH resulting from high lime application may also reduce the availability of zinc, iron, and copper, thereby inhibiting plant growth.

Table 2. Number of rice plant tillers with treatment of various doses of dolomite and various sources of phosphorus fertilizer on land affected by Sipramin

Treatment	Number of Tillers					
	14 DAS	21 DAS	35 DAS	49 DAS	63 DAS	84 DAS
Dolomite						
D0 = Without dolomite	3.47	7.53	20.00^{b}	21.00^{b}	21.00^{b}	21.00^{b}
D1 = 1.5 tons ha^{-1}	3.67	7.67	18.53^{ab}	19.53^{ab}	19.53^{ab}	19.53^{ab}
D2 = 2 tons ha^{-1}	3.07	6.93	16.80^{a}	17.67^{a}	17.67^{a}	17.67^{a}
D3 = 3 tons ha^{-1}	3.27	7.33	17.13^{a}	18.40^{ab}	18.40^{ab}	18.40^{ab}
Tukey's HSD 5%	ns	ns	2.82*	2.89*	2.89*	2.89*
Fertilizer						
P0 = Without fertilizer	3.33	7.42	17.42	17.92	17.92	17.92
P1 = NPK Phonska	3.17	6.92	16.75	17.50	17.50	17.50
P2 = SP-36	3.50	7.08	18.33	20.25	20.25	20.25
P3 = MKP	3.42	7.58	18.33	19.25	19.25	19.25
P4 = MAP	3.42	7.83	19.75	20.83	20.83	20.83
Tukey's HSD 5%	ns	ns	ns	ns	ns	ns

Note: The same numbers followed by the same letters in the same column indicate no significant difference in the Tukey's HSD 5% test.

The data show that treatment D1 (D1P0, D1P1, D1P2, D1P3, D1P4) tends to produce a competitive number of seedlings, ranging from 16 to 23 seedlings at 84 DAS, with D1P1 and D1P3 reaching 19 and 23 seedlings, respectively. Dolomite serves as a source of calcium and magnesium, which can increase soil pH, allowing plants to absorb nutrients more efficiently and grow optimally (Ilham et al., 2019). The increase in soil pH due to dolomite application can reduce the toxicity of aluminum and iron, which often inhibit growth in acidic soils. However, excessive dolomite application in some treatments (D3) showed a tendency toward fewer seedlings than moderate doses, suggesting that optimal conditions for dolomite application exist to support maximum seedling formation.

Phosphorus fertilizer plays a crucial role in the formation of rice tillers, as observed in various fertilizer treatments, including P0, P1, P2, P3, and P4. Sufficient phosphorus availability in the early vegetative phase (7-35 days after sowing) allows plants to form productive tillers more optimally. At 21 to 35 days after sowing, treatments with phosphorus fertilizer, such as D0P2, D1P1, D2P3, and D3P2, began to show faster tillering compared to treatments without phosphorus. Phosphorus is an essential nutrient that plays a crucial physiological role in supporting early plant growth, particularly during root and shoot formation. The availability of adequate phosphorus can increase the absorption of other nutrients. This element plays a crucial role in various biochemical processes, including photosynthesis, respiration, energy transfer and storage, as well as mechanisms of cell division and enlargement (Zulputra et al., 2014). Additionally, phosphorus contributes to root system development, increases the number of tillers, and accelerates the flowering and fruit ripening phases (Astutik et al., 2023). An increase in the number of tillers is closely associated with increased phosphorus uptake, as this element is essential for cell division and serves as an energy source for various metabolic activities in plants (Putri et al., 2017).

4. Conclusion

Dolomite application significantly increased soil phosphorus availability with the highest value obtained at a dose of 3 tons ha^{-1}. Phosphorus fertilizers with high P content such as MAP and MKP, showed the best performance in enhancing available P. Dolomite also affected plant height during early growth stages. However, higher doses tended to reduce the number of tillers. For plant growth, a dolomite dose of 1.5 tons ha^{-1}, combined with phosphorus fertilizer such as NPK Phonska or SP-36, produced optimal performance. Thus, the optimal dolomite dose varied depending on the observed parameter with 3 tons ha^{-1} for phosphorus availability and 1.5 tons ha^{-1} for rice growth.

References

Amri, A.I., Armaini, A., Purba, M.R.A. 2018. Aplikasi kompos tandan kosong kelapa sawit dan dolomit pada medium sub soil Inceptisol terhadap bibit kelapa sawit (Elaeis guineensis Jacq.) di pembibitan utama. Jurnal Agroteknologi 8(2), 1–8. https://doi.org/10.24014/Ja.v8i2.3349

Astutik, L.W., Tripama, B., Wijaya, I. 2023. Peningkatan produksi tanaman tomat (*Lycopersicum esculentum* mill.) melalui pemberian pupuk fosfor (P) dan mangan (Mn). Journal of Agrotechology Science 1(2), 1–8. https://doi.org/10.47134/callus.v1i2.2025

Bangun, K.O., Suryanto, A. 2020. Kombinasi pemberian pupuk urea dan pupuk SP-36 terhadap pertumbuhan vegetatif tanaman nanas (*Ananas comosus* L.) Cv. Queen. Jurnal Produksi Tanaman 8(11), 1059–1067.

Dzikrullah, M., Mindari, W., Priyadarshini, R. 2021. Efektivitas serapan P dan hasil padi (*Oryza sativa* L.) sawah akibat pemberian pupuk Si dan asam humat. Jurnal Plumula 9(1), 36–47. https://doi.org/10.33005/plumula.v9i1.105

Ilham, F., Prasetyo, T.B., Prima, S. 2019. Pengaruh pemberian dolomit terhadap beberapa sifat kimia tanah gambut dan pertumbuhan serta hasil tanaman bawang merah (*Allium ascalonicum* L). Jurnal Solum 16(1), 29–39. https://doi.org/10.25077/jsolum.16.1.29-39.2019

Manurung, F.S., Nurchayati, Y., Setiari, N. 2020. Pengaruh pupuk daun gandasil terhadap pertumbuhan, kandungan klorofil dan karotenoid tanaman bayam merah (*Alternanthera amoena* Voss.). Jurnal Biologi Tropika 3(1), 24–32. https://doi.org/10.14710/jbt.1.1.24-32

Peliyarni, P., Rahmahwati, R. 2025. Peran pupuk hilado (hijau lamtoro dan dolomit) dalam revitalisasi kesuburan lahan bekas tambang aspal untuk budidaya padi Wakawondu. Perbal: Jurnal Pertanian Berkelanjutan 13(3), 349–357. https://doi.org/10.30605/perbal.v13i3.7013

Prakosa, F.H., Widodo, R.A., Peniwiratri, L. 2020. Pengaruh dosis zeolit dan pupuk SP-36 terhadap ketersediaan P pada Latosol dan serapan P padi gogo (*Oryza sativa* L.). Jurnal Tanah dan Air 17(1), 1–10. https://doi.org/10.31315/jta.v17i1.3989

Putri, F.M., Suedy, S.W., Darmawanti, S. 2017. Pengaruh pupuk nanosilika terhadap jumlah stomata, kandungan klorofil dan pertumbuhan padi hitam (*Oryza sativa* L. Cv. Japonica). Buletin Anatomi dan Fisiologi 2(1), 72–79. https://doi.org/10.14710/jekk.v%25vi%25i.1096

Saragih, S.W., Lubis, R., Adhyaksa, Y., Hasibuan, M.E.W., Sembiring, A., Nasution, I.H., Sigit, Anggraini, D.M., Meliala, B.A. 2025. Pengaruh nilai pH tanah terhadap potensi penggunaan lahan pertanian Secanggang Kabupaten Langkat. Jurnal Agro Fabrica 7(1), 1–8.

Sudianto, E., Ezward, C., Mashadi. 2018. Pengaruh pemberian dolomit dan pupuk kotoran sapi terhadap pertumbuhan dan produksi padi sawah (*Oryza sativa* L.) menggunakan tanah sawah bukaan baru. Jurnal Sains Agro 3(1), 21–16. https://doi.org/10.36355/jsa.v3i1.196

Suntoro, Widjayanto, H., Hartanto, A.P. 2012. Pengaruh Imbangan pupuk anorganik dan pupuk sipramin terhadap ketersediaan P dan K serta hasil tanaman padi (*Oryza sativa* L.) pada Vertisols (Musim Tanam II). Jurnal Ilmu Tanah dan Agroklimatologi 9(1), 73–92.

Syahputra, D., Alibasyah, M.R., Arabia, T. 2015. Pengaruh kompos dan dolomit terhadap beberapa sifat kimia Ultisol dan hasil kedelai (*Glycine max* L. Merril) pada lahan berteras. Jurnal Manajemen Sumberdaya Lahan 4(1), 535–542.

Syamsiah, M., Ramli, Akbar, W.N.I. 2021. Respon tanaman sawi hijau (*Brassica parachinensis*) terhadap pemberian dosis pupuk kompos dari limbah kulit buah jarak pagar (*Jatropha curcas*). Agroscience 11(2), 121–140. https://doi.org/10.35194/agsci.v11i2.1796

Utami, A.R. 2016. Pemanfaatan sludge limbah industri MSG sebagai bahan baku pupuk organik. Jurnal Teknologi Proses dan Inovasi Industri 2(1), 53–57.

Zulputra, Wawan, Nelvia. 2014. Respon padi gogo (*Oryza sativa* L.) terhadap pemberian silikat dan pupuk fosfat pada tanah Ultisol. Jurnal Agroteknologi, 4(2), 1–10.