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Review: The Efficacy of Several Agricultural Wastes as Ameliorant for Peat Degraded Soil: The Case of Kalimantan

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ABSTRACT

Various agricultural wastes are used as ameliorants to improve degraded peat soils, with a focus on cases in Kalimantan. Peat soil is one of the potential land resources for agriculture in Indonesia, with an area ranging from 12.59 to 14.90 million ha, spread across Kalimantan, Sumatra, and Papua. However, the use of peat soil for agriculture faces many obstacles, such as low pH, low base saturation, organic acid toxicity, and macro- and micronutrient deficiencies. The use of agricultural waste as an ameliorant to improve degraded peat soil has prospects and opportunities. Agricultural waste is rich in nutrients and, if managed well, can contribute to sustainable agriculture. This review outlines the characteristics and potential of various agricultural wastes, such as animal waste, food processing waste, crop residues, and hazardous agricultural waste. These wastes are abundantly available and cost-effective, making them a valuable resource for increasing soil fertility and crop yields. This review provides insight into the application of agricultural waste as an ameliorant for degraded peat soils in Kalimantan and identifies challenges and opportunities in this context. This information is important in enriching future peatland management strategies to increase the productivity and production of cultivated plants on peatlands.

Keywords: Agricultural Waste, Ameliorant, Peat, Kalimantan.

1. Introduction

Peatlands are wetland ecosystems that originate from piles of rotting organic material on the ground surface (Danarto *et al.*, 2023). Indonesian peat soil is classified as tropical peat, with an area ranging from 12.59 to 14.90 million ha, spread across the islands of Kalimantan, Sumatra, and Papua (Nurhayati, 2020; Anda *et al.*, 2021). Kalimantan Island has the second-largest peatland area after Sumatra, occupying 4.54 million ha of Indonesia's total peatland. The largest distribution is in the provinces of Central and West Kalimantan, with areas of 2.55 and 1.55 million ha, respectively. The regions with the smallest peatland areas are in the provinces of South Kalimantan and East Kalimantan, with areas of 46,294 and 181,809 ha, respectively (Anda *et al.*, 2021). However, the use of peatlands for agriculture faces many limiting factors, such as low acidity, low base saturation, organic acid toxicity, and nutritional deficiencies (Septiyana *et al.*, 2017), both macro- and micronutrients (Maftu'ah & Nursyamsi, 2019). Peat soil has low fertility due to its high acidity level, with a pH value of 3.0–4.0. Low availability of macronutrients in the form of organic compounds (Ichriani *et al.*, 2021).

One technology that can be applied to improve peatland management is the application of agricultural waste (Fahmi & Susilawati, 2020). Agricultural waste is the remainder of an agricultural business activity, which, if left untreated, can harm the environment (Nurmalasari *et al*., 2021). Improvement of soil nutrients can be done by adding soil-ameliorant materials from agricultural wastes. Recycling organic agricultural waste is a significant concern for improving soil properties (Sayara *et al*., 2020). Ameliorant is a material that can increase soil fertility by improving the physical, chemical, and biological conditions of the soil. It can be in the form of organic or inorganic materials. Several research results prove that ameliorants function to increase pH values, and nutrient availability, improve water content, and improve soil permeability (Hendra *et al*., 2015).

2. Potential and Characteristics of Agricultural Waste

Disposal of agricultural waste is a major concern in the world today because it is rich in nutrients, and disposal without initial processing can cause landfilling in the field, which can cause environmental pollution (Kamthan & Tiwari, 2017). Agricultural waste, if managed and utilized optimally, has the potential to become a sustainable resource that provides added value and is a major contributor to energy security and ecological sustainability (Awogbemi *et al*., 2022). Poor management of agricultural waste has caused a decline in agricultural productivity, thereby affecting the fulfillment of food needs. Therefore, it is very important to handle agricultural waste appropriately, as emphasized by various studies (Busari *et al*., 2024). Utilizing agricultural waste by managing waste using appropriate technology sustainably can reduce the environmental impact caused. Apart from being useful for preventing environmental pollution caused by this waste, it can also support a sustainable agricultural system that is environmentally friendly.

Agricultural waste, also called agro-waste, consists of animal waste (manure, animal carcasses), food crop waste, plant waste (corn stalks, bagasse, molasses, and residue from fruits and vegetables, pruning), and hazardous and toxic agricultural waste (pesticides, insecticides, herbicides, etc.) (Obi *et al*., 2016). Agricultural waste, in the form of crop residues and animal waste, is a widely available renewable resource and can be converted into useful products such as ash, charcoal, biochar, biofuel, animal feed, and compost. However, most of this waste is still underutilized, especially in developing countries (Sabiiti, 2011). All this waste is known to have high levels of N, K, and P, which will increase soil fertility and increase crop yields (Khalaf, 2019).

3. Perspective on the Efficacy of Agricultural Waste as an Ameliorant

Ameliorant is a soil amendment that can be used to increase soil fertility using various organic and inorganic components. Soil organic matter is very important in determining soil fertility; therefore, it is necessary to increase the use of organic materials such as biochar in amelioration. Soil ameliorants are a way to increase soil fertility by increasing plant growth. Organic and inorganic ameliorants are considered non-conventional fertilizers for better crop yields. The use of ameliorant materials, including composted sewage sludge, manure, biochar, weeds, and natural minerals, has been reported to increase soil fertility and plant productivity in degraded and suboptimal soils (Haryati *et al*., 2021).

Septiyana *et al*. (2017) stated that ameliorant plays a role in improving peat soil fertility, namely improving the root environment for plant growth by increasing pH, reducing organic acids and toxic ions, and increasing nutrient availability. Ameliorants containing polyvalent cations (Fe, Al, Cu, and Zn), laterite mineral soil, or river mud are very effective in reducing the negative effects of phenolic acids. The use of biochar made from agricultural waste as an ameliorant material is now being promoted because it is easy to obtain, cheap, and can last a long time in the soil because the decomposition process is slow or is relatively resistant to attack by microorganisms. The addition of biochar can increase soil fertility, restore the quality of degraded soil, increase crop yields, prevent leaching of nutrients, act as a remediation of organic contaminants, play a role in immobilizing heavy metals such as Cd, Zn, and Pb in the soil, absorb herbicides and pesticides, or neutralize toxins. Naturally in the decomposition of organic materials (Zamriyetti *et al*., 2018; Hairani *et al*., 2019). Biochar is made through a pyrolysis process that uses various biomass or other organic waste with a high C/N ratio, which is difficult to degrade so biochar is a stable organic material in the soil (Maulana *et al*., 2022).

Agricultural waste originating from rice plants, such as straw and rice husks, has the potential to be used as an ameliorant because it is present in large quantities compared to crop yields and is a potential source of organic fertilizer for increasing soil fertility. Providing ameliorant agricultural waste originating from rice plants applied in the form of compost or ash can increase soil pH because it contains Ca and Mg oxides (Yusuf, 2019; Noor *et al.*, 2024).

4. Results

Peat soil is a fragile natural resource and has a low carrying capacity for plant growth and production. One technology that can be applied to improve peatland management is the use of agricultural waste. Agricultural waste such as ash and biochar from rice husks can be used as an ameliorant to increase the fertility of peatlands. The research results of Fahmi & Susilawati (2020) show that the application of rice husk biochar and rice husk ash increases the pH of peat soil, the concentration of P and K can be exchanged in peat soil, thereby increasing chili harvests and reducing CO_2 emissions. Apart from that, rice husk ash combined with chicken manure is also able to increase soil pH. Soil pH determines whether or not macro and micronutrients are easily absorbed by plant roots. Adequate nutrients will affect plant growth, giving chicken manure also provides additional nutrients in the soil (Yusuf., 2019). The research results of Selvarajh *et al.* (2021) biochar contains basic cations (K^+, Ca^{2+}, Mg^{2+}, and Na^+). The release of these cations from rice straw biochar contributes to increasing soil pH because there is an exchange of protons between rice straw biochar and the soil. From the research results of Maftu'ah & Nursyamsi (2019), it is also stated that providing biochar can increase the fertility of peat soil (Charloq *et al*, 2024).

The research results of Saputra & Sari (2021) showed that applying ameliorant to peat soil had a positive effect on soil pH, growth, and rice yields. Providing this ameliorant changed the condition of peat soil which was very acidic (pH <4.0) to alkaline (pH >6.0) which was suitable for the growth of rice. This ameliorant material contains complete nutrients so it increased soil productivity to support plant growth. White oyster mushroom baglog waste (*Pleurotus ostreatus*) also increased the soil's ability to hold water. By increasing the soil's ability to hold water and increasing the soil pH by adding baglog waste, the absorption of water and nutrients increases (Ali *et al.*, 2021).

Based on the research results of Saputra *et al.* (2023) showed that the application of coffee grounds compost, rice straw compost, and oyster mushroom baglog at different doses affected changes in pH in peat soil. Oyster mushroom baglog compost has a high pH of 9.22, rice straw compost had a pH of 8.51, and coffee grounds compost had a pH of 8.45 (Saputra *et al.*, 2024; Nengsih *et al.*, 2024; Jumar & Saputra, 2021). Soil amendments that have a high pH had great potential to increase the pH of peat soil (Figure 1). From the research results of Sopiana *et al.* (2024) providing rice straw compost increased soil pH so that it can help the vegetative growth of Liberica coffee seedlings in peat soil.

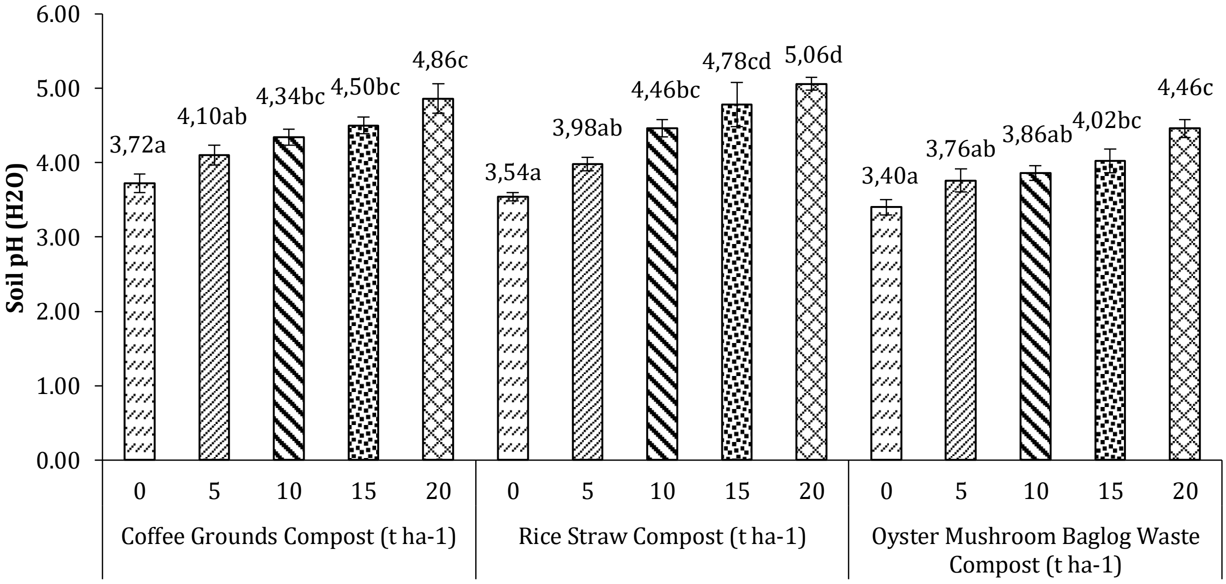

Figure 1. pH of peat soil applied with compost made from coffee grounds, rice straw, and oyster mushroom baglog waste. The line above the bar chart is the *standard error* (n=5). The same letter above the line indicates that the treatment has no different effect based on HSD 5%. Source: Saputra *et al.* (2023).

The results of research by Fadhli *et al.* (2023) are that oil palm ash has an influence on the growth of cayenne pepper plants, with the best dose being 70%. Providing palm kernel ash can also increase base saturation (Rahmadini *et al*., 2020). This increase in base saturation will have an effect on increasing their availability in the soil. This of course can increase the uptake of nutrients and improve plant metabolism, thereby influencing the increase in plant height. Oil palm empty fruit bunch ash can also increase soil pH and have a significant effect on increasing exchangeable-K levels (Marlina *et al*., 2021). Research conducted by Ramanda *et al.* (2022) showed that the application of oil palm ash at different doses had a significant effect on the pH of peat soil (Figure 2). Based on the research results of Pratiwi *et al.* (2023) also showed that the application of empty palm fruit bunch ash and manure was able to increase the pH of peat soil, thereby helping the growth of corn plants (Arpah *et al*., 2020).

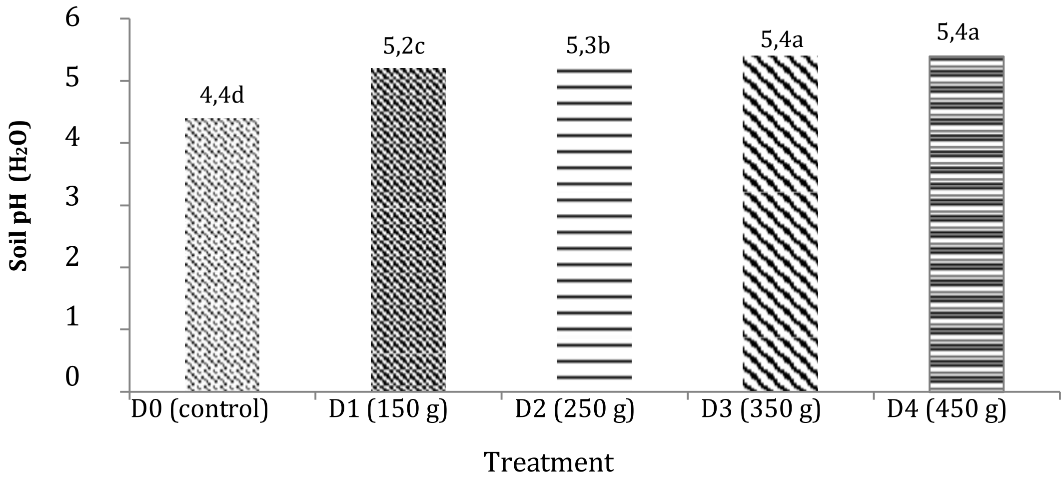

Figure 2. The pH reaction of peat soil due to the influence of the application of empty oil palm ash. D0= no palm oil empty culm ash, D1= palm oil empty culm ash 150 g polybag^{-1}, D2= palm oil empty culm ash 250 g polybag^{-1}, D3= palm oil empty culm ash, D4= palm oil empty culm ash 450 g polybag^{-1}. Numbers followed by the same letter are not significantly different based on DMRT 5%. Source: Ramanda *et al.* (2022).

Boiler ash is one of the palm oil processing wastes that comes from burning palm oil boilers. Boiler ash has great potential as a soil amendment because of its high nutrient content (Rosyidi *et al*., 2022), besides boiler ash has a high pH (Hamzah *et al*., 2019) so boiler ash is suitable for use as an ameliorant in peat soil which has a low pH. The use of boiler ash as a soil amendment (soil ameliorant) significantly increases the productivity of oil palm plants. Research conducted by Tandiono *et al*. (2024) shows that the application of soil ameliorant can increase the yield of oil palm fresh fruit bunches (FFB) production and reduce CO_2 emissions. Apart from that, the use of boiler ash as a soil ameliorant also improves the chemical properties of peat soil, such as pH, total potassium, and cation exchange capacity (CEC).

5. Conclusions

Utilization of agricultural waste as an ameliorant material has the potential to improve the characteristics of damaged peat soils. Waste such as animal waste, food processing waste, and plant waste can be used to increase peat soil fertility. The application of technology for utilizing agricultural waste as an ameliorant is expected to contribute to more sustainable peatland management in the Kalimantan region.

References

Ali, F., Kartina, R., Sari, R. M., & Taisa, R. (2021). Pengaruh limbah baglog dan sungkup plastik terhadap pertumbuhan dan hasil cabai merah keriting. *Agrovigor*, 14(1): 72–76. DOI: https://doi.org/10.21107/agrovigor.v14i1.9223.

Anda, M., Ritung, S., Suryani, E., Sukarman, Hikmat, M., Yatno, E., Mulyani, A., Subandiono, R. E., Suratman, & Husnain. (2021). Revisiting tropical peatlands in Indonesia: semi-detailed mapping, extent and depth distribution assessment. *Geoderma*, 402: 1-14. https://doi.org/10.1016/j.geoderma.2021.115235.

Arpah, M., Marlina, & Apriyanto, M. (2020). Effect of grant palm oil ash to the growth and production of two corn varieties (*Zea mays* L.) in peatland. *International Journal of Scientific & Technology Research*, 9: 990-993.

Awogbemi, O., & Kallon, D. V. V. (2022). Pretreatment techniques for agricultural wast. *Case Studies in Chemical and Environmental Engineering*, 6: 100229. DOI: https://doi.org/10.1016/j.cscee.2022.100229.

Busari, R. A., Alabi, K. P., Adebayo, R. K., & Dada, J. O. (2024). Rapid composting using a novel agricultural waste shredder. *FUOYE Journal of Engineering and Technology*, 9(1): 1-6.

Charloq, Yazid, A., & Yohanes, A. (2024). Respon pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) dengan pemberian beberapa jenis biochar pada tanah gambut. *Jurnal Pertanian Agros*, 26(1): 4421-4427.

Danarto, W. P., Muhtar, G. A., Fahmi, H., Prasakti, Y., Yahya, D., & Hasanah, N. (2023). Carbon stock estimation in small-scale peat ecosystems based on the ndvi vegetation index on the google earth engine cloud computing platform. *Geografika Journal*, 4(2): 154-163. DOI: https://doi.org/10.20527/jgp.v4i2.10809.

Fadhli, M., Oksana, O., Ramadhani, E., & Hera, N. (2023). Aplikasi abu janjang kelapa sawit sebagai substitusi dolomit terhadap pertumbuhan dan hasil tanaman cabai rawit (*Capsicum frutescens* L.). *In Prosiding Seminar Nasional Integrasi Pertanian dan Peternakan*, 1(1): 173-180.

Fahmi, A., & Susilawati, A. (2020). The utilization of agricultural waste for peatland management; in case chili cultivation. *IOP Conf. Series: Materials Science and Engineering*, 980(1): 012069. DOI: https://doi.org/10.1088/1757-899X/980/1/012069.

Hairani, A., Susilawati, A., Alwi, M., & Noor, M. (2021). The potency of biochar to improve water quality in tidal swampland. *IOP Conf. Series: Earth and Environ Sci.*, 648: 012184. DOI: https://doi.org/10.1088/1755-1315/648/1/01218.

Hamzah, M. H., Muhammad. F., Ahmad, A, Hasfalina. C. M., & Mohammed. A. (2019). Prospective application of palm oil mill boiler ash as a biosorbent: effect of microwave irradiation and palm oil mill effluent decolorization by adsorption. *International Journal of Environmental Research and Public Health*, 16: 3453. DOI: https://doi.org/10.3390/ijerph16183453.

Haryati, U., Irawan, & Maswar. (2021). Application of mulch and soil ameliorant for increasing soil productivity and its financial analysis on shallots farming in the upland. *IOP Conference Series: Earth and Environmental Science*, 648: 012155. DOI: https://doi.org/10.1088/1755-1315/648/1/012155.

Hendra, H., Nelvia, N., & Wardati, W. (2015). Aplikasi amelioran jerami dan sekam padi pada tanah gambut terhadap pertumbuhan dan produksi kedelai. *Jurnal Agroteknologi Tropika*, 3(2): 45-51.

Ichriani, G. I., Sulistiyanto, Y., & Chotimah, H. E. N. C. (2021). The use of ash and biochar derived oil palm bunch and coal fly ash for improvement of nutrient availability in peat soil of Central Kalimantan. *Journal of Degraded and Mining Lands Management,* 8(3): 2703-2708.

Jumar, J., & Saputra, R. A. (2021). Kompos Limbah Pertanian untuk Meningkatkan Produksi Padi di Lahan Sulfat Masam: Kompos Limbah Pertanian dan Pengolahannya. Banjarbaru: CV. Banyubening Cipta Sejahtera.

Kamthan, R., & Tiwari, I. (2017). Agricultural wastes-potential substrates for mushroom cultivation. *European Journal of Experimental Biology*, 7(5): 1-4. DOI: https://doi.org/10.21767/2248-9215.100031.

Khalaf, A. A., Desa, S., & Baharum, S. N. B. (2019). Overview of Selected native seeds in agricultural wastes and its properties, *Medico-legal*, 19(2): 306-312.

Maftu'ah, E., & Nursyamsi, D. (2019). Effect of biochar on peat soil fertility and NPK uptake by corn. *Agrivita*, 41(1): 64–73. DOI: http://doi.org/10.17503/agrivita.v41i1.854.

Maulana, A., Herviyanti, Prasetyo, T. B., Harianti, M., & Lita, A. L. (2022). Effect of pyrolysis methods on characteristics of biochar from young coconut waste as ameliorant. *IOP Conf. Series: Earth and Environmental Science*, 959: 012035. DOI: https://doi.org/10.1088/1755-1315/959/1/012035.

Nengsih, H. S., Hayati, R., & Nuriman, M. (2024). Pengaruh kombinasi kompos jerami padi dan pupuk kandang ayam terhadap ketersediaan hara NPK dan pertumbuhan tanaman jagung manis di tanah gambut. *Jurnal Pertanian Agros*, 26(1): 176-187.

Noor, M., Wahdah, R., Saputra, R. A., Sari, N. N., Mulyawan, R., & Jumar, J. (2024). *Kesuburan dan Kesehatan Tanah: Lahan Basah Suboptimal.* Depok: RajaGrapindo Persada/Rajawali Pers.

Nurhayati. (2020). Pengaruh pemberian amandemen pada tanah gambut terhadap pH tanah gambut dan pertumbuhan vegetatif tanaman kedelai. *Wahana Inovasi*, 9(1): 1-8.

Nurmalasari, A. I., Supriyono, Budiastuti, M. T. S., Nyoto, S., & Sulistyo, T. D. (2021). Pengomposan jerami padi untuk pupuk organik dan pembuatan arang sekam sebagai media tanam dalam demplot kedelai. *PRIMA: Journal of Community Empowering and Services*, 5(2): 102-109. DOI: https://doi.org/10.20961/prima.v5i2.44766.

Obi, F. O., Ugwuishiwu, B. O., & Nwakaire, J. N. (2016). Agricultural waste concept, generation, utilization and management. *Nigerian Journal of Technology (NIJOTECH)*, 35(4): 957-964.

Pratiwi, D. O., Budianta, D., Warsito, & Ayu, I. W. (2023). Use of local resources from oil palm bunch ash combined with cow manure to grow and produce sweet corn (*Zea mays saccharata* Sturt) planted in peat soil to support smart agriculture. *Journal of Smart Agriculture and Environmental Technology*, 1(3): 84-93. DOI: https://doi.org/10.60105/josaet.2023.1.3.84-93.

Rahmadini, D. D., Aziza, N. L., & Saputra, R. A. (2020). Germination and growth of seedlings from polyembry-onic siamese orange seeds on peat soil media applying several ameliorants. *Agrin*, 24(2): 125-136. DOI: https://doi.org/10.20884/1.agrin.2020.24.2.538.

Ramanda, R. F., Setiawan, B., & Wijaya, A. (2022). Pengaruh pemberian abu janjang kosong kelapa sawit terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) pada media gambut. *Journal of Agro Plantation*, 1(2): 93-102. DOI: https://doi.org/10.58466/jap.v1i2.1244.

Rosyidi, S. A. P., Idiajir, B., Akhir, N. M., Rahmad, S., Lestari, N.P., Widoanindyawati, V., Al-Sabaeei, A. M., Milad, A., Mashaan, N. S., & Yusoff, N. I. (2022). Physical, chemical and thermal properties of palm oil boiler ash/rediset-modified asphalt binder. *Sustainability*, 14: 3016. DOI: https://doi.org/10.3390/su14053016.

Sabiiti, E. (2011). Utilising agricultural waste to enhance food security and conserve the environment. *African Journal of Food, Agriculture, Nutrition, and Development*, 11(6): 1-7.

Saputra, R. A., & Sari, N. N. (2021). Ameliorant engineering to elevate soil pH, growth, and productivity of paddy on peat and tidal land. *IOP Conf. Series: Earth and Environmental Science*, 648: 012183. DOI: https://doi.org/10.1088/1755-1315/648/1/012183.

Saputra, R. A., Bahjatussaniah, Zidani, M. A., Rahcmawati, L., & Rahman, M. R. A. (2023). Tingkat keeratan hubungan pH tanah dan akar edamame pada media tanah gambut yang diaplikasi kompos berbahan ampas kopi, jerami padi, dan limbah baglog jamur tiram. *Agriprima,* 7(2): 116-130. DOI: https://doi.org/10.25047/agriprima.v7i2.621.

Saputra, R. A., Ramadani, Q., & Jumar, J. (2024). Kompos limbah baglog jamur tiram sebagai alternatif budidaya edamame di tanah gambut. *Jurnal Teknologi Lingkungan*, 25(1): 071-079. DOI: https://doi.org/10.55981/jtl.2024.3562.

Sayara, T., Basheer, Salimia, R., Hawamde, F., & Sánchez, A. (2020). Recycling of organic wastes through composting: Process performance and compost application in agriculture. *Agronomy* 10(11): DOI: https://doi.org/10.3390/agronomy10111838.

Selvarajh, G., Ch'ng, H. Y., Zain, N. M., Sannasi, P., & Azmin, S. N. H. M. (2021). Improving soil nitrogen availability and rice growth performance on a tropical acid soil via mixture of rice husk and rice straw biochars. *Applied Sciences*, 11(1): 108-125. DOI: https://doi.org/10.3390/app11010108.

Septiyana, Sutandi, A., & Indriyati, L. T. (2017). Effectivity of soil amelioration on peat soil and rice productivity. *Journal of Tropical Soils*, 22(1): 11–20. DOI: http://dx.doi.org/10.5400/jts.2017.v22i1.11-20.

Sopiana, Ramanda, R. F., Kurniawan, T., Rosmalinda, & Mahruf, H. (2024). Aplikasi kompos jerami padi di media gambut untuk meningkatkan pertumbuhan bibit kopi liberika. *Journal of Agro Plantation*, 3(1): 210-218. DOI: https://doi.org/10.58466/jap.v3i1.1517.

Tandiono, J., Thamrin, Hapsoh, & Warningsih, T. (2024). Utilization of soil ameliorant to control emission in oil palm plantation on tropical peat soil. *Jurnal Ilmiah Agrineca*, 24 (1): 41-50. DOI: https://doi.org/10.36728/afp.v24i1.2809.

Yusuf, M. I. S. E. Y. (2019). Pengaruh kombinasi amelioran pupuk kandang dan abu sekam padi terhadap pertumbuhan dan produksi kedelai (*Glycine max*) pada tanah gambut. *Jurnal Agro Indragiri*, 4 (2): 13-24. DOI: https://doi.org/10.32520/jai.v4i2.1270.

Zamriyetti, Kamila, S., & Mayly, S. (2018). The Influence of biochar types of soil and dosage soybean substration. *International Journal for Innovative Research in Multidisciplinary Field*, 4(9): 1-6.