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SECRETARIAT
F-Technopark Building, Faculty of Agricultural Engineering and Technology,
Jalan Puspa No. 1, Campus IPB Dramaga,
Bogor Agricultural University, Bogor 16680, Indonesia
Phone: +62 81213736014; E-mail: ijop.maksi@gmail.com

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Renewable Water Filtration Innovation from Palm Oil Mill Effluent Waste

Sufina Azzahra*, Martha Rianna, Nabila Agustin

Department of Physics, Universitas Sumatera Utara, Medan, 20155, Indonesia

ABSTRACT

Indonesia is the largest palm oil producing country in the world. According to data from the North Sumatra BPS in 2021, palm oil production was 5,311,884 tons. Every palm oil factory disposes of its liquid waste, which results in waste pollution becoming a very crucial issue to be addressed immediately because it has many negative impacts. Palm oil mill effluent (POME) is rich in minerals and carbon, but POME waste is currently not fully utilized optimally. The purpose of this research is to produce the latest innovation in water filtration to realize SDGs 2045 on clean water and sanitation, and to study the effectiveness of magnetic which will be applied as clean water filtration by utilizing POME waste and natural sand containing α-Fe_2O_3, alumina (Al_2O_3), and magnetic minerals with well water as samples in this study. The combination of POME waste and natural sand with chemical synthesis and calcination methods at a temperature of 500 ^oC as activation of activated carbon and magnetic metals. The results of the synthesis of POME and natural iron sand obtained solids in the form of black powder. In the VSM test, the magnetization versus magnetic field data of Fe_3O_4/activated carbon POME obtained a magnetic saturation value of 10.13 emu/g. In the XRD test results of activated carbon materials, composites of activated carbon iron oxide and iron oxide and the synthesis results have diffraction patterns similar to the XRD database from JCPDS and in the COD and BOD tests. It proves a decrease in COD and BOD levels in well water before and after filtration with a large range, and indicates the success of the filtration process. In the AAS test as an identification of Fe metal in well water samples, Fe metal becomes <0.00206 (mg/L) starting from 0.01 (mg/L).

Keywords: Calcination, magnetic, natural sand

INTRODUCTION

Indonesia has more than 3.2 million square kilometers or around 3.28 billion square meters of water. Despite having a very large water area large, the country is facing a shortage of clean water due to the presence of dirty water in some areas. Basic needs such as water must be obtained by every human being, therefore making people have to buy it (Nainggolan *et al*. 2019). The Indonesian Ministry of Health has regulated the requirements for clean water as stated in Indonesian Ministry of Health Regulation No. 416 of 1990 concerning dissolved metal content in the quality of clean water used must be a maximum of 1.0 mg/L iron (Fe). In general, Indonesian people increase quality water with filtering water in a way conventional (Latuconsina *et al.* 2022). In this research, filtration which used is a renewable method which own better effectiveness compared to conventional method which is quite

*Corresponding author:
Department of Physics, Universitas Sumatera Utara, Medan
Corresponding authors: sufinaazzahra1@gmail.com

complicated, namely by utilizing palm oil mill effluent (POME).

Indonesia is the biggest producer and exporter of palm oil in the world. According to data from BPS (2021), North Sumatera in 2021 produce palm oil (PO) up to 5,311,884 tons. The total productivity of PO will be directly proportional to the waste produced. Compared with other types of waste, liquid waste from the palm oil industry or often referred to as palm oil mill effluent (POME) has the highest capacity level with a large environmental pollution impact. It is known that 1 ton of crude palm oil requires 5–7.5 tons of water and more of the remaining 50% ends up as POME (Putera *et al.* 2022). Every palm oil mill is also produce liquid waste which result as pollution waste, and it is a very crucial issue that needs to be addressed immediately because it has many implications. POME waste processing usually only uses technology which is implemented by covering conventional waste ponds (covered lagoons) with anaerobic system and not yet regarded as renewable innovation (Winanti 2019). POME waste is currently not fully utilized optimally, even though POME is rich in minerals and carbon which can potentially be convert to be a clean filtration water based on magnet with added sand nature (Lee *et al*. 2019). Natural sand is an abundant natural resource, contain various magnetic minerals, one of which is α-Fe_2 O_3 which is an oxide iron. It can used in sensor gas, catalyst, and material electrode. Besides, α-Fe_2O_3 can used as main material for making magnet permanent (Sihombing and Amiruddin 2020). This potencial is in harmony with our research objective: for producing the latest innovations in water filtration to realize SDGs 2030 regarding clean water and sanitation, and review the effectiveness of the magnetic which will be applied as clean water filtration by utilizing POME waste and sand aid natural.

The aim of this research is expected to produce and study on magnetic effectiveness that can be applied as renewable clean water filtration from waste POME and natural sand. The output targets of this research are as follows: (1) produce a progress report and final report on the potential for clean water filtration absorption of iron metal (Fe) after being innovated from POME waste and natural sand; and (2) scientific articles to be published at the national level as a reference source for the wider community.

MATERIALS AND METHODS

The material used in this research is POME waste, sand nature, HCl 37%, NaOH 2 M, ethanol 96%, aquadest. The equipment used in this research are beaker glass, Erlenmeyer flask, Erlenmeyer vacuum, vacuum machine, measuring cup, glass funnel, petri dish, analytical balance, furnace, centrifuge, oven, pipette drops, Whatman filter paper no.42, tea filter paper, universal indicator, hot plate and magnetic bar. The fixed variables in this research were the variations in POME concentration, and the natural sand used in the research in variations A, B, and C. The independent variable on this research was interval time on magnetic deposition process which generated. The dependent variable in this research wass characterized by scanning electron energy dispersive X-Ray microscope (SEM-EDX), vibrating sample magnetometer (VSM), X-Ray diffraction (XRD), and atomic absorption spectrophotometer (AAS).

Research Stages

This research consists of several stages, namely preparation of raw materials, centrifugation of POME and sand nature, calcination of magnetic adsorbents, and application of magnetic adsorbents as filtration. All POME sample collection was taken from a palm oil industry factory. POME was taken to the laboratory to separate the liquid and the particle based on the specific gravity of each cell component using a centrifuge at 3000 rpm, supernatant was separated and solid was used for stage.

(a) (b) (c)

Figure 1 POME before centrifugation (a); centrifugation results containing supernatant and solids (b); and solids from centrifugation of POME (c).

Natural iron sand was the main precursor. First, POME was stirred using a magnetic stirrer, with 25 mL HCl 37% until homogeneous for 30 minutes at room temperature, then filtered with Whatman filter paper no. 42. Next, natural iron sand was stirred using a magnetic stirrer with 100 mL HCl 37% on room temperature for 30 minutes, then filtered using Whatman filter paper no.42. After filtering, each filtrate was slowly dripped into a 2 M NaOH solution which was stirred using a magnetic stirrer with distilled water. Then solution stirrer was reversed during 1 hour until form a precipitate. The precipitate was washed with distilled water then 96% ethanol, and filtered with Whatman filter paper no. 42 using Buchner filtration method. Then results the residue was dried in an oven.

The powder obtained after synthesis was calcined at a temperature of 500 °C for 4 hours in the furnace. Furthermore, the calcination results were characterized by atomic absorption spectrophotometer (AAS), scanning electron microscope energy dispersive X-Ray (SEM-EDX), vibrating sample magnetometer (VSM), and X-Ray diffraction (XRD). Turbid and yellow well water was used for extraction during magnetic application as filtration. Magnetic adsorbent was packed into a paper filter tea filter in the form of kraft type. After that, it was dipped into polluted water for improve the quality of water to be a clean water, then tested for chemical oxygen demand (COD), biological oxygen demand (BOD) and color changes.

RESULTS AND DISCUSSION

Achievement of External Targets of POME Centrifugation Result

From 4 L of centrifuged POME, the solids obtained were 315.3 g. The water content of centrifuged POME was found to be 97.9 ± 0.3%. Even after centrifugation, the water content in the centrifuged POME solids was still high, almost the entire mass of the sample was water. Even so, the appearance of POME looked like a fibrous paste. The results of this study are in line with the study conducted by Davies (2020) as the results of POME centrifugation after the supernatant was removed, produced solids in the form of a fibrous paste.

Synthesis Results of POME and Natural Iron Sand

The results of the synthesis of POME and natural iron sand were obtained in the form of black powder. In this case, the carbon source was POME, a liquid resulting from the palm oil milling process which is rich in will carbon (Abdullah *et al.* 2020). According to Mohammad (2021), carbon which contained on POME is 51.0%. Natural iron sand is synthesized so that the high surface energy has super-paramagnetic properties, and has high absorption power (Nengsih 2021).

Figure 2 Synthesis results.

Calcination Process Results

Calcination at 500 °C for 4 hours resulted in a color change from jet black to reddish brown. Magnetism can be proven with existence mineral magnetite dark brown in color which is magnetic (Karbeka *et al*. 2020). Properties this magnetism is obtained from the material natural and synthetic like sand natural iron. Material magnetic which originate from natural have oxidation iron which strong characteristic magnetic (Ningsih 2019).

Figure 3 Results of calcination of magnetic adsorbent.

Magnetism Test

Separation using magnetic force is called magnetic separation. To increase the efficiency of separation, this system must increase the magnetic force acting on the particles by increasing the volume of the particles, the relative magnetization between the particles (dispersoids) and the dispersing medium or the magnitude of the magnetic field gradient (Ahdiaty 2022). Most element content from adsorbent was element with magnetic characteristic, so the adsorbent have own magnetic properties (Rettob and Carbide 2019). Magnetic fields can enhance the adsorption rate by increasing mass transfer and increasing the adsorption capacity. Similarly, the use of controlled magnetic fields can ensure the adjustment of important parameters, by ensuring the adsorption of specific ions.

Figure 4 Magnetic test process

Atomic Absorption Spectrophotometer (AAS) Results

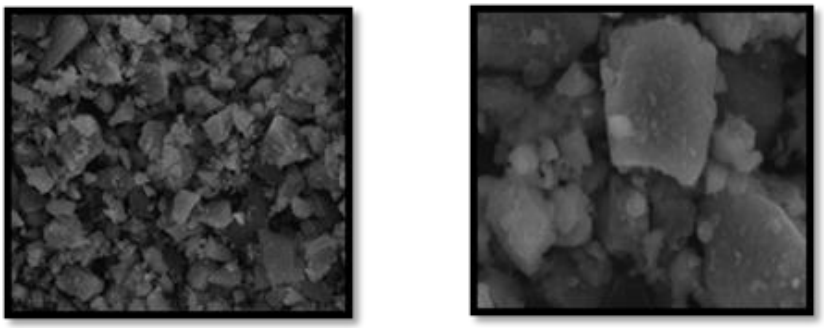
The presence of heavy metal components in magnetic adsorbents, and the application of external magnetic fields can easily separate the adsorbent from the solution and recycle or regenerate it for further use. In Table 1, the results of iron (Fe) magnetic adsorbents from variations A, B, and C are 31.5%, 38.2%, 37.56% respectively, which indicates that with the presence of iron metal oxide (Fe) in magnetic adsorbents, it can absorb water pollutants such as heavy metal ions dissolved in water.

Table 1 Atomic Absorption Spectrophotometer (AAS) results.

No.	Variation	Parameter	Results (%)
1.	A	Fe	31.50
2.	B	Fe	38.20
3.	C	Fe	37.56

Characterization of *Scanning Electron Microscope-Energy Dispersive X-Ray* (SEM-EDX)

Characterization of magnetic adsorbent Fe_2O_3/POME activated carbon was carried out using SEM-EDX aims to determine the morphology of the surface of the Fe_3O_4/POME activated carbon adsorbent sample, and to determine the element content and its distribution. The image showed the SEM-EDX micromorphology of POME synthesis on the 3000x magnification that forms irregular crystal sizes. While on the morphology image of the magnetic adsorbent on the 20000x magni-



(a) (b)

Figure 5 Morphological form of POME synthesis(a); and morphological form of magnetic adsorbent (b).

Table 2 EDX characterization results on magnetic adsorbents.

Element	Concentration (%)
C	30.85
O	50.08
Fe	19.07

fication, it formed square chunk crystal sizes. In Fe_3O_4/POME activated carbon there are several elements contained, listed in Table 2 including carbon (C), oxygen (O), and iron (Fe). The largest element content in Fe_3O_4/POME activated carbon is oxygen with a per-centage of 50.08% where this oxygen element comes from the active group in activated carbon and its metal oxide produced from the pyrolysis process. The percentage of iron (Fe), carbon (C) and oxygen (O) elements obtained showed that the Fe_3O4 metal was successfully loaded on activated carbon.

Characterization of Vibrating Sample Magnetometer (VSM)

Magnetite Fe_3O_4 is one of the iron oxides that has the strongest magnetic properties among other iron oxides. Fe_3O_4 material is ferromagnetic in its pure state (Anbarasu *et al.* 2015). Therefore, the characterization of Fe_3O_4/POME activated carbon was carried out using VSM to determine the magnetic saturation value of a material. Figure 6 showed the measurement results of Fe_3O_4/POME activated carbon using VSM which was carried out at room temperature with the Hc value in range of 0 to 1T. The hysteresis curve obtained showed that the adsorbent was superparamagnetic as indicated by the Hc value approaching 0. From the curve it showed that the magnetization versus magnetic field data of Fe_3O_4/POME activated carbon obtained magnetic saturation value (Ms) is 10.13 emu/g. However, the saturation magnetization value (Ms) obtained is lower than the maximum saturation magnetization value

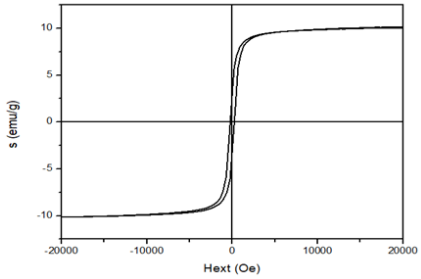


Figure 6 Results of Fe_3O_4 analysis/POME activated carbon.

of Fe_3O_4 which is 92 emu/g. This can be caused by the formation of a lower degree of Fe_3O_4 crystallinity. The saturation magnetization value decreases due to the presence of non-magnetic fractions such as activated carbon in the adsorbent. The higher the non-magnetic fraction contained, the saturation value (Ms) will also decrease.

X-Ray Diffraction Characterization

The following is the spectrum of the X-Ray Diffraction (XRD) test results on raw material. Interpretation of the XRD pattern in the Figure 7 can ensure the crystal plane and peak of the XRD spectrum. The images are the results of X-Ray Diffracto-meter (XRD) measurements of activated carbon, iron oxide-activated carbon composite, and iron oxide. The synthesized iron oxide has a diffraction pattern similar to the XRD database from JCPDS.

Application of Magnetic Adsorbent in Filtration

Water quality testing is needed to ensure the quality of drinking water. According to the law of the Ministry of Health of the Republic of Indonesia No. 32 of 2017, water quality testing includes physical and chemical parameters. The well water samples used were turbid and yellow with acidic pH. Figure 8, showed 8 applications of 0.50 g of magnetic adsorbent to 250 mL of turbid and yellow well water, and changes in producing clean water were seen overnight.

Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) tests on Well Water

COD and BOD tests in Table 3 showed that COD values are higher than BOD, this indicates the amount of organic matter that is chemically oxidized but cannot be oxidized biologically. Similar results were obtained by Syahrina *et al.* (2021) who stated that COD levels were higher than BOD. The test results proved a decrease in COD and BOD levels in well water before and after filtration with a large range, and this indicates success in the filtration process.

Atomic Absorption Spectro-photometer (AAS) Test on Well Water

The AAS test in Table 4 showed a decrease in iron levels in well water before and after filtration. This proved that mag-netic adsorbents have the potential to reduce iron levels in water.

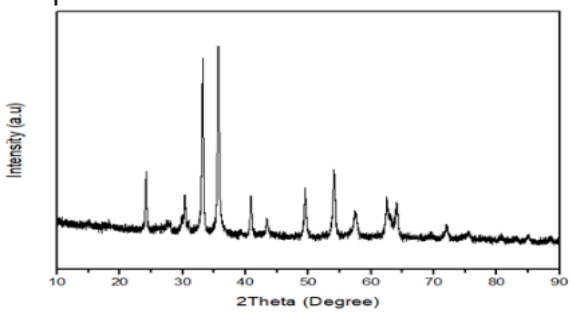


Figure 7 Diffractogram results of Fe_3O_4/ POME activated carbon.

(a) (b) (c)

Figure 8 Cloudy and yellow well water (a); application of filtration to cloudy and yellow well water (b); and well water after filtration (c).

Table 3 COD and BOD of well water.

Parameter	Before filtration (mg/L)	After filtration (mg/L)
Fe	0.01	< 0.00206

Table 4 AAS test on well water.

Parameter	Before filtration (mg/L)	After filtration (mg/L)
COD	151.78	35.41
BOD	75.68	19.36

CONCLUSION

In the results of the synthesis of POME/narural sand, the results of iron (Fe) magnetic adsorbents from variations A, B, and C were 31.5%, 38.2%, 37.56% respectively, which indicates the presence of iron metal oxide (Fe) in the magnetic adsorbent. The largest element content in Fe_3O_4/activated carbon POME is oxygen with a percentage of 50.08%. This oxygen element comes from the active group in activated carbon and its metal oxide produced from the pyrolysis process. XRD pattern interpretation test, ensured the crystal plane and the peak of the XRD spectrum. From the AAS test for identified the Fe metal in well water samples, Fe metal becomes very low <0.00206 (mg/L).

REFERENCES

Abdullah MF, Jahim JM, Abdul PM, Mahmod SS 2020. Effect of carbon/nitrogen ratio and ferric ion on the production of biohydrogen from palm oil mill effluent (POME). Biocatal Agric Biotechnol. 23:101445.

Ahdiaty R. 2022. Anions adsorption in aqueous solution with magnetic nanocomposite Fe_3O_4/activated carbon. [Thesis]. Universitas Islam Indonesia, Yogyakarta.

Anbarasu M, Anandan M, Chinnasamy E, Gopinath V, Balamurugan K. 2015. Synthesis and characterization of polyethylene glycol (PEG) coated Fe_3O_4 nanoparticles by chemical co-precipitation method for biomedical applications. Spectrochim Acta A Mol Biomol Spectrosc. 135:536–539.

BPS (Central Bureau of Statistics). 2021. Plantation Crop Production of PTPN II, III, and IV By Plant (Ton). 2018–2021. North Sumatra: BPS Publishing.

Davies E, Deutz P, Zein SH. 2020. Single-step extraction-esterification process to produce biodiesel from palm oil mill effluent (POME) using microwave heating: a circular economy approach to making use of a difficult waste product. Biomass Convers Biorefin. 12:1–11.

Karbeka M, Koly FVL, Tellu NM. 2020. Characterization characteristic magnet-ism of iron sand of Puntaru Beach, Alor Regency-NTT. Lanthanida Journal. 8(2): 108–116.

Latuconsina H, Gadi ES, Isomudin A, Berlian HL, Ubaidillah Z, Azizah PN, Infant MA. 2022. Clean water filtration and water source rescue in Mulyoasri Village, Ampelgading District, Malang Regency. Agrokreatif: Scientific Journal of Community Service. 8(1):120–128.

Lee ZS, Chin SY, Lim JW, Witoon T, and Cheng CK. 2019. Treatment technology of palm oil mill effluent (POME) and olive mill wastewater (OMW): a brief review. Environ Technol Innov. 15:100377.

Mohammad S, Baidurah S, Kobayashi T, Ismail N, Leh CP. 2021. Palm oil mill effluent treatment processes – a review. Processes. 9(5):739.

Nainggolan AA, Arbaningrum R, Dear A, Dear DJ, Syaddad MA. 2019. Tool processing water baku simple with system filtration. Widyakala Journal.

6: 12–20.
Nengsih S. 2021. Literature review: synthesis of iron sand into magnetite nanoparticles through the application of coprecipitation method. Amina. 3(3): 112–122.
Ningsih F. 2019. Analysis of the effect of grinding time on resistivity and iron content (Fe_3O_4) in iron sand synthesized in the Regency Bima. [Thesis]. University State Islam Mataram, Mataram.
Putera DA, Matondang AR, Sembiring MT, Dermawan AA 2022. Application of seven tools to identify liquid waste (POME) levels in palm oil company. Sigma Teknika. 5(1):22–29.
Rettob AL, Karbeka M. 2019. Influence concentration solution hf on process preparation to level magnetic material elements of sand iron. Walisongo J Chemist. 2(1):6–9.
Sihombing M, Amiruddin E. 2020. Synthesis and characterization of nanoparticles Fe_2O_3 from Pasir Alam, Logas Village, Kuantan Singingi Regency. J Communication Physics Indonesia. 17(2): 68–73.
Syahrina E, Ilza M, Linggawati A. 2021. Analysis of wastewater contamination in boreholes around the ruminant RPH Cipta Karya Panam Pekanbaru. EcoNews. 4(1):9–15.
Winanti WS, Prasetiyadi P, Wiharja W. 2019. Palm oil mill processing effluent (POME) into biogas with fixed type anaerobic system bed without process neutralization. J Environ Technol. 20(1)143. DOI: 10.29122/jtl.v20i1.3248

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Hydrogel Plus as Alternative Technology In Sustainable Oil Palm Agriculture

Mahmudin[1*], M. Ilham Batubara[2]

[1]Politeknik Manufaktur Negeri Bangka Belitung, Sungai Liat, Kabupaten Bangka, Kepulauan Bangka Belitung 33215
[2]PT. Arara Abadi, Pinang Sebatang, Tualang, Siak Regency, Riau 28685

ABSTRACT

Palm oil (*Elaeis guineensis* Jacq.) is one of the most important plantation crops in the agricultural sector. However, during the dry season the production of palm oil is decreasing, due to the reduced availability of water especially on peatlands. One way to overcome this problem is by the use of Hydrogel Plus technology (hydrogel base bagasse with the addition of *Pseudomonas fluorescens*). This study aimed to determine the role of Hydrogel Plus (hydrogel with the addition of *Pseudomonas fluorescens*) to the growth and production of oil palm on the peat during the dry season. The method used in this research is the experimental method using Completely Randomized Design. Treatment was done by 4 treatments and each treatment was repeated 5 times, so the experimental unit amounted to 20 units. The treatments include (P1) Control, (P2) hydrogel application (P3) application of *Pseudomonas fluoresces* suspension and (P4) Hydrogel Plus applications. Based on the result of the research, it can be concluded that hydrogel administration with the addition of *Pseudomonas fluorescens* bacteria tends to have a significant effect on leaf diameter, leaf number, and height of plant at each treatment; only at plant height on treatment of *Pseudomonas fluorescens*; and only hydrogel treatment which has no real effect. Utilization of Hydrogel Plus can provide effect to oil palm plant growth and production, to be a specific effort as an alternative technology in sustainable oil palm management in peatlands during dry season.

Keywords: Hydrogel plus, palm, peatland, *Pseudomonas fluorescens*

INTRODUCTION

Palm oil (*Elaeis guineensis Jacq*.) Is one of the most important plantation crops in the agricultural sector. This is because palm oil is able to generate the greatest economic value per hectare compared to other oil or fat producing plants. However, in the dry season, the production of oil palm is decreasing due to the lack of water availability especially in the peatlands (Sunarko 2007). Peatland is a land with water saturated soil, formed from sediments derived from the accumulation of residues of ancient tissue that decay, with a thickness of more than 50 cm (Harni *et al.* 2012). In the rainy season the water content in the peatlands will be fulfilled, while in the dry season peatlands will deficit of water. The water deficit will result in a decrease in palm oil production. To overcome this, it requires specific handling

*Corresponding author:
Politeknik Manufaktur Negeri Bangka Belitung
Jalan Timah Raya, Kawasan Industri Air Kantung, Sungailiat, Bangka Belitung
Email: mudinalonik@gmail.com

and environmentally friendly method with the use of Hydrogel Plus technology (hydrogel base bagasse with the addition of *Pseudomonas fluorescens*). Hydrogel Plus is a hydrogel added with *Pseudomonas fluorescens* which has been proven can absorb and release water depending on external stimuli, such as the pH, humidity, temperature, and environmental stresses around it. In general, hydrogels are able to absorb distilled water up to 500 times the weight of the dry volume (Tung and Lori 1990). The application of hydrogels on farmland has been proven to increase the retention of groundwater because the water wasted outside the root zone is capable of being absorbed by the hydrogel material, and can then be reused up to 95% of the water stored in this material (Jhurry 2008). The content of *Pseudomonas fluorescens* bacteria in hydrogels is also capable of spurring growth and production of oil palm because the bacteria have properties as plant growth promoting rhizobacteria (PGPR) that produce indoleacetic acid (IAA) hormones and produce auxin, gibereline and cytokinin hormones, which will spur and promote growth plants and produce pseudobactins that can increase induced systemic resistance (Susanto 2008). Based on the above background, it is necessary to research about hydrogel plus in sustainable cultivation of oil palm, especially in the peat land during dry season. This research aimed to find out the role of Hydrogel Plus (hydrogel made from sugar cane with *Pseudomonas fluorescens*) to growth and production of oil palm on peatland during dry season.

MATERIALS AND METHODS

The making of Hydrogel Plus was held at the Plant Disease Laboratory of the Faculty of Agriculture, Riau University, Pekanbaru. Application of Hydrogel Plus was carried out at UPT Experimental Garden of Faculty of Agriculture of Riau University, Pekanbaru. This research was conducted for 2 months. This study used Hydrogel Plus (hydrogel with addition *Pseudomonas fluorescens*) in the form of granules that applied directly to oil palm plants for approximately 40 days. The method used in this research is the experimental method using Completely Randomized Design. Treatment was done by 4 treatments and each treatment was repeated 5 times, so the experimental unit amounted to 20 units. The treatments given were P1= Control, P2= Hydrogel application treatment, P3= Treatment of *P. fluorescens* application, P4= Treatment of hydrogel applications with the addition of *P. fluorescens.*

Data obtained from this study was analyzed by statistical analysis of two ways analysis of variance (ANNOVA) with the help of statistical package for social science program (SPSS for Windows Version 16.0). If the results obtained were significantly different, then it was proceed by Duncan test at 5% confidence level to see the influence of each treatment.

RESULTS AND DISCUSSION

Table 1 showed that Hydrogel administration with the addition of *Pseudomonas fluorescens* bacteria tends to have a significant effect on leaf diameter, leaf number, and height of plant at each treatment, and only at plant height on treatment of *Pseudomonas fluorescens,* and hydrogel treatment which has no significant effect. This may be suspected because the application of hydrogels on farms has proven to increase the retention of groundwater because the water wasted outside the root zone is absorbed by the hydrogel material and can then be reused up to 95% of the water stored in this material (Jhurry 1997). In addition, hydrogel applications are also able to increase soil moisture, lower water stress, which then improve the performance of plant growth. The addition of bacteria *Pseudomonas fluorescens* to hydrogels is also very beneficial because *P. fluorescens* has properties as bacteria that increase plant growth. This bacteria has properties as plant growth promoting rhizobacteria

Table 1 Result of height plant, leaf number, and leaf diameter

Treatment	Height Plant	Leaf Number	Leaf Diameter
P1	32.39[b]	4.60[b]	1.76[c]
P2	35.20[ab]	4.60[b]	1.84[bc]
P3	36.10[ab]	5.00[b]	2.03[b]
P4	40.00[a]	6.60[a]	2.10[a]

(PGPR) because it produces indolacetic acid (IAA). *P. Fluorescens* also produces auxin, gibberellin, and cytokinin hormones which will stimulate and increase plant growth and produce pseudobactins that can increase induced systemic resistance (Susanto 2008).

These bacteria also produce large amounts of phytohormones especially IAA to stimulate growth and stem lengthening in plants (Rao 1994). *P. flourescens* living in plant roots can act as microorganisms of phosphate solvents, bind to nitrogen and produce plant growth regulators for plants so that with these capabilities *P. flourescens* can be utilized as biological fertilizers that can provide nutrients for plant growth (Ardiana 2012). The use of hydrogel main ingredients will provide a positive advantage in the cultivation of oil palm plants because it is able to store water 200 times its weight so it is suitable to be applied in peatland that experienced drought during the dry season. Hydrogels made with the addition of *P. fluorescens* bacteria will be active after application in the field.

CONCLUSION

Administration of hydrogel with the addition of *Pseudomonas fluorescens* bacteria tends to have a significant effect on leaf diameter, leaf number and plant height at each treatment, and only at plant height in treatment of *P. fluorescens* and hydrogel treatment alone which has no significant effect. From the results of the study, it can be concluded that Hydrogel Plus (hydrogel with the addition of *P. fluorescens*) have a potency and important role in increasing the growth and production of oil palm in the peat season during the dry season.

REFERENCES

Ardiana K. 2012. *Pseudomonas flourescens* Bacteria exploration and Development. Yogyakarta (ID): UGM Press.

Harni R, Supramana MS, Sinaga, Giyanto, Supriadi. 2012. The mechanism of endophytic bacteria controls the *Pratylenchus brachyurus* nematodes on patchouli plants. Buletin Littro. 23(1):102–114.

Jhurry D. 2008. Agricultural Polymers. Conference Proceedings of the 2nd annual meeting of Agricultural Scientists. Mauritius.

Rao S. 1994. Soil Microbeth and Plant Development. Jakarta (ID): Universitas Indonesia Press.

Sunarko. 2007. Practical Hints of Cultivation and Processing of Oil Palm. Jakarta: Agromedia Pustaka.

Susanto L. 2008. Introduction to Biological Control of Plant Diseases. Jakarta (ID): PT. Raja Grafindo Persada.

Tung WY, Lori GL. 1990. Hydrophilic polymers-their response to soil amendments and effect on properties of a soil less potting mix. J Am Soc Hort Sci. 115:943.

Zohuriaan Mehr. 2008. Superabsorbent polymer materials: A review. Iran Polym J. 17(6):451–47.

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Intercropping Land Kale on Hypopodium Leftover Oil Palm Fronds Pruning

Ardian Ramadhan, Dwiky Ardiansyah Nasution*

Department of Agronomy and Horticulture, IPB University, Bogor, 16680 Indonesia

ABSTRACT

The horticultural consumption of land kale in Indonesia is still quite high due to its complete nutritional content. However, limited cultivation land is an obstacle to the production of land kale. On the other hand, Indonesia has a very large area of oil palm plantations because it is a superior commodity as a foreign exchange earner. But it is unfortunate that the output obtained is only oil palm fresh fruit bunches (FFB). Therefore, it is necessary to create an integrated agricultural model such as intercropping so that the output obtained is more and profitable economically and environmentally sustainable. Intercropping is a method of agricultural cultivation by planting two or more commodities in the same area to maximise land use and maximise productivity. Intercropping in oil palm is not carried out in producing crops due to constraints on cultivation land area. However, by using a new agricultural cultivation method, namely cultivation on the hypopodium of the remaining leaf pruning, oil palm producing plants can still be intercropped. Hypopodium is the tip or base of the leaf that connects to the plant stem. The hypopodium area that is already wide enough in producing plants can be used as a place for kale plant growth. In addition, the content of organic matter in the hypopodium can be used as a source of nutrients and as an organic substrate. This type of primary research with qualitative methods shows the results that the intercropping method of kale with oil palm on the hypopodium of the remaining pruning of oil palm leaves can be done, so that the output out of the farm is more.

Keywords: Integrated agriculture, new agricultural cultivation, organic substrate, palm oil frond hypopodium, sustainability.

INTRODUCTION

Land kale (*Ipomoea reptans* Poir.) is a leaf vegetable horticultural commodity that is often processed by the Indonesian people as a source of fibre (Syarifudin *et al.* 2022). Green plants from the *convolvulaceae* family have hollow stems, intermittent leaves, and white flowers that produce bags and contain four seeds (Prasetia and Pupitasari 2023). This plant, which can grow in low and highlands, has high nutritional content and value (Devinta *et al.* 2022). In one serving of boiled land kale weighing 100 g, there are about 23 calories, 2.2 g of fibre, 2.9 g of protein, 3.6 g of carbohydrates, and only 0.4 g of fat. Land kale is also a source of vitamin A, vitamin C, vitamin K1, folic acid, iron, and calcium. Not only that, land kale also contains important compounds such as lutein and kaempferol, which can support

*Corresponding author:
Department Agronomy and Horticulture
IPB University, Bogor, Indonesia
Email : dwikiardiansyah04@gmail.com

eye health and reduce the risk of chronic diseases. The demand for kale for food in Indonesia is quite high with an average of 9.43 per capita per day (BPS 2019). Therefore, land kale must be cultivated sustainably so that the demand can be fulfilled domestically and even exported. Oil palm crop (*Elaeis guineensis Jacq*.) is one of the plantation crops that has an important role in the national economy, especially in providing labour and foreign exchange earnings for the country (Anggraeni and Hukom 2021). Based on data from the Central Bureau of Statistics (BPS), Indonesia, which is the first-ranked oil palm exporting country in the world, has a land area of 15.34 million hectares with a total production of 46.82 million tonnes in 2022, and earns foreign exchange of up to 600 trillion in 2023 (BPS 2023). However, the integration and sustainability of almost all oil palm plantations is still very minimal, this is seen from the output obtained, which is only in the form of oil palm fresh fruit bunches (FFB). The very wide spacing of oil palm plantations, which ranges above 7 metres per plant, and the minimal utilisation of other parts of the oil palm plant, must be made integrated and sustainable innovations so that they can overcome other agricultural problems such as limited land for vegetable horticulture cultivation and other problems.

The oil palm plant has some distinctive morphology, although it is a staple but its roots are fibrous spread, its trunk is upright can reach 24 m and generally unbranched. Its leaves are compound with a tapered elongated shape, and its flowers are monoecious, male flowers are elongated oval, while female flowers are rounded and are fruit ovules. Oil palm plant maintenance includes fertilisation, weed control, and pruning. Pruning is an activity to regulate the number of leaves (supporting fronds) on oil palm plants by cutting the ends of unproductive (old) leaves using dodos (Wasil and Chairudin 2023). However, pruning generally leaves the tip of the frond still attached to the stem, namely the hypopodium. The remaining fronds of the pruning (hypopodium) are not utilised and are only overgrown with weeds or ferns, even though there are organic materials from the crumbs of oil palm plants that collect in the cracks of the hypopodium and can be used as a substrate for plant growth media. Intercropping is a system of planting two or more different commodities in the same cultivation area (Warman and Kristiana 2018).

Intercropping is an integrated and sustainable agricultural technique because cultivation inputs can be taken from within the system and the output will be more and more profitable both economically and its impact on the environment than mono-culture cultivation systems. In Indonesia, the intercropping agricultural cultivation method in oil palm plantations is only applied to immature plants (TBM). Meanwhile, in producing plants (TM) it has not been applied because the land area that is not planted already has other functions, namely as a frond stack and as a harvesting road for fresh fruit bunches (FFB). However, this can be resolved with a new innovative agricultural cultivation technique, namely cultivation on the hypopodium of remnant fronds of mature oil palms. This was reinforced by a limited trial of planting land kale on the hypopodium of mature oil palm frond residues.

MATERIALS AND METHODS

The research “Intercropping Land Kale on Hypopodium Leftover Oil Palm Fronds Pruning” was conducted at Cikabayan Oil Palm Plantation in month of September for 5 weeks. The oil palm plants used were two producing plants (TM). The hypopodium height used was 60 cm above ground level to 170 cm to facilitate planting and maintenance with a total of 20 hypopodium planting holes per plant. The land kale seeds used were local seeds with a total of 2 seeds per hypopodium. Maintenance includes weed control in the hypopodium area and watering. The addition of organic materials or planting media is done on some hypopodiums to

ensure the nutritional content of kale plants can be fulfilled during their growth period. The type of research used is simple primary research. The primary research method is a direct trial on the media or the thing to be studied in this experiment is the intercropping of land kale on the hypopodium of the remaining pruning of oil palm fronds (Gulo 2000). The results of the data obtained from this experiment were analysed and concluded. The type of research used in this study is exploratory qualitative and direct analysis. Data from primary research conclusions in the form of qualitative data will be analysed descriptively. Then, the descriptive data is explained based on the author's point of view plus reinforcement in the form of research documentation so that the conclusions obtained can be used as a reference for further research.

RESULTS AND DISCUSSION

Oil palm plants that can be used for intercropping the hypopodium system are plants that have produced with an age of more than equal to 8 years or TM-5 or hypopodium with a width of more than 15 cm. This is intended so that the width of the hypopodium is wide enough to cultivate vegetable horticultural crops, and there is enough organic matter in it. If the media on the hypopodium is insufficient, then other media inputs must be added from outside so that the intercropping cultivation process can still take place. The results of the limited trial of land kale cultivation on the hypopodium of the remaining pruning of oil palm leaves were obtained as in Table 1. The cultivation on the oil palm hypopodium was successful although the results were not as good as cultivation with conventional methods. This success is due to the fact that the planting media substrate on the hypopodium is nutritionally sufficient, because it contains the remaining crumbs of oil palm plant parts and soil (dust) which is in the top soil when it is blown away by the wind or splashes of rainwater.

Based on observation data, land kale experienced rapid height growth, but narrower and shorter leaves. This occurred because the level of shade was high enough to cause etiolation which stimulated more auxin hormones, thus spurring plant growth quickly. But the small amount of light in the shaded area is a problem because photosynthesis is not maximised, making the land kale plants have smaller leaves and roots that are not strong. Therefore, the selection of shade-tolerant land kale varieties is a requirement for intercropping oil palm and land kale using the hypopodium method.

To get the best results, it is necessary to regularly control weeds and insects around the hypopodium. The high intensity of insects in their activities disrupts the growth of land kale plants because insects such as ants tend to dredge little by little the planting media that already exist around the palm fronds, so that it does not rule out the supply of nutrients and the ability of plant roots to be less than optimal which results in consistency of growth. In addition to insects, the growth of weeds found in the land kale planting area is more dominant in

Table 1 Yield of land kale of each organ part.

	Yield (Observed at Harvesting)
Roots	Shorter roots, not many branches, and very low binding capacity to the media compared to conventionally grown plants.
Stems	The stems of landraces grown using the hypopodium method were longer, but the diameter was smaller and the stems were more flexible than those grown conventionally.
Leaves	The average ratio of the number of leaves of field kale grown using the hypopodium method to conventional is 7:9 (2 leaves less). The colour of the leaves was lighter and the length and width were three times smaller than those of conventionally grown kale.

growth. The ability of weeds grows faster than land kale plants. This indicates that weeds compete with the main crop for water and nutrient supply.

The intercropping cultivation system between land kale and oil palm between the fronds is economically valuable. This cultivation system does not require expensive costs because the planting media used is the cross-sectional area of the fronds that have been filled with organic material from the weathering of the fronds and additional planting media composition such as dolomite, manure and so on to increase the essential nutrients needed by plants. Oil palm entrepreneurs can obtain land kale as daily consumption and can even be a side income from their oil palm if the expected production is achieved. From the large number of fronds in oil palm plants, it is very potential in increasing the production of land kale plants, but it needs to be considered in the management of the land kale plant canopy above it. The development of this system can be a solution to utilise the growing space of plants that have economic potential so that this system should continue to be carried out to get more benefits than monoculture cultivation systems in oil palm plants.

Figure 1 Planting land kale plants on the oil palm hypopodium.

Figure 2 Land kale 3 weeks after planting.

Figure 3 Land kale 5 weeks after planting, ready for harvest.

CONCLUSION

Intercropping between oil palm and horticulture such as land kale on the hypopodium can be done although the results are not good due to the influence of etiolation. To get maximum results in hypopodium cultivation, seeds that are resistant to oil palm shade and good maintenance are needed, especially in nutrient and water management. The hypopodium intercropping method has the advantage that the results obtained from the garden are more economical and environmentally friendly even without land cultivation and minimal capital. The oil palm hypopodium intercropping method is very suitable for cultivating plants that are not too large and resistant to shade. Further research needs to be done to find out which plants are more suitable for cultivation with the intercropping method on the remaining hypopodium of oil palm leaf pruning.

REFERENCES

Anggraeni D, Hukom A. 2023. Analysis of the palm oil industry in south Kalimantan in the perspective of sustainable development. J Innov Manag. 1(2):198–209.

BPS (Central Bureau of Statistics). 2019. Expenditure on Consumption of the Indonesian Population: Based on the Results of the March 2019 Susenas Survey. Jakarta (ID): Badan Pusat Statistik.

BPS (Central Bureau of Statistics). 2023. Indonesia Palm Oil Statistics 2022. Jakarta (ID): Badan Pusat Statistik.

Devinta S, Fahrudi A, Primaswara R. 2022. Prototype monitoring and control of watering kale plants using website-based arduino. Jati. 6(1):229–236.

Gulo W. 2000. Research Methodology. Jakarta (ID): Gramedia Widiasarana Indonesia.

Prasetia MA, Pupitasari RA. 2023. Utilisation of land kale as quality animal feed. Trop J Anim Sci. 4(1):17–23.

Syarifudin AA, Hutahaean ADE, Widiawira BY, Rahmania MG, Panjaitan MA, Priyankha MA, Wiguna RRDPR, Al'amin VR, Wicaksana WA, Taufikurrahman. 2022. Training on land kale cultivation using hydroponic system in Banjarsari Village. JCS. 2(1):65–69.

Wasil A, Chairudin C. 2023. Effect of the number of fronds in the pruning process on the production of oil palm (*Elaeis guineensis* Jacq) in Tanoh Makmue Plantation. Biofarm. 19(1): 39–45.

Warman GR, Kristiana R. 2018. Mengkaji sistem tanam tumpangsari tanaman semusim. Proceeding Biology Education Conference: Biology, Science, Environmental, and Learning, 15(1):791–794.

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Purnamasari MI, Prihatna C, Gunawan AW, Suwanto A. 2012. Isolasi dan identifikasi secara molekuler *Ganoderma* spp. yang berasosiasi dengan penyakit busuk pangkal batang di kelapa sawit. J Fitopatol Indones. 8(1):9-15. DOI: 10.14692/jfi.8.1.9.

Van Duijn G. 2013. Traceability of the palm oil supply chain. Lipid Technol. 25(1):15-18. DOI: 10.1002/lite.201300251.

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Otegui MS. 2007.Endosperm: development and molecular biology. In: Olson OA, editor. Endosperm cell walls: formation, composition, and functions. Heidelberg (DE): Springer. p. 159-178.

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