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UTILIZATION OF *LAND APPLICATION* ON SOIL PHYSICAL AND CHEMICAL PROPERTIES OF OIL PALM PLANTATIONS

Deti Setia Khomariah, Nuraeni Dwi Dharmawati, Rengga Arnalis Renjani

Department of Agricultural Engineering, Faculty of Agricultural Technology, Stiper Agricultural University (INSTIPER) Yogyakarta

Jl. Nangka II Maguwoharjo, Depok, Sleman, Special Region of Yogyakarta 55282

Email: smaradeti22@gmail.com

ABSTRACT

The content of organic matter in palm oil mill effluent (POME) is quite high, so it has the potential to be an organic fertilizer for oil palm plantations through the *land application* method. Utilization of POME as land application can improve soil structure in the form of physical and chemical properties of soil in oil palm plantations. The purpose of this study was to analyze the impact of *land application* on physical properties (specific gravity, volume weight, porosity, and maximum plasticity), as well as soil chemical properties (pH, N, P, K, and C-Organic) at various distances and depths of land application. The test was conducted in 3 repetitions with a Completely Randomized Factorial Design (RALF) consisting of a distance factor of Near 50 cm (D), Middle 720 cm (S), and Far 5400 (J), and a depth factor consisting of 0-10 cm depth (1), 20-30 cm depth (2), and 50-60 cm depth (3). The results were tested using ANOVA and Duncan's further test. The use of *land application* affects soil physical properties and has optimal conditions at close distance (D) and depth (0-10 cm), namely soil specific gravity 1.862 g/cm^3, soil volume weight 0.07 g/cm^3, soil porosity 53.507%, and soil moisture 84.25%. The use of land application affects soil chemical properties and has optimal conditions at close distance (D) and depth (0-10 cm), namely pH 5.5, N was 0.215%, P was 0.078%, K was 184.33 ppm, and C was 12.20%.

Keywords: Distance, Depth, *Land Application*.

INTRODUCTION

Palm oil mill effluent (POME) contains organic waste generated by the agro-industry from the processing of oil palm fresh fruit bunches (FFB) to produce crude palm oil (CPO). This waste is a brownish liquid with water, oil, and organic solids (Nursanti, 2013). POME, if not treated further, will form ammonia, which is the effect of aquatic biota life and can cause a foul odour (Sado-Inamura & Fukushi, 2018). POME contains high organic matter, so it must be processed first so that it can be used as fertilizer. POME has a concentration of nutrients, with K between 1,000 - 1,875 mg/L, Mg 250 - 320 mg/L, and P 90 - 110 mg/L, which are elements needed by plants (Sisnayati et al., 2021). The use of POME for *land application* in the palm oil industry is used as a fertilizer or fertilizing material for oil palm plants. The basic principle of this land application is that POME contains elements that can enrich the soil, namely N, p, and K. The content of N and K in the effluent is very high, so it can function as a significant nutrient for oil palm growth (Saputra et al., 2021)..

The problem that needs to be analyzed is the impact of distance and depth variations in *land application* on the quality of soil physical and chemical properties in oil palm plantations.

45 Research related to the impact of *land application* on soil physical and chemical properties has not been widely studied, especially on the impact of variations in distance and depth of *land application*.

23 Previous research Mutaqin et al., (2022), discussing the effect of *land* application on soil physical properties, examined the effect of independent *land* application by making 1m deep bio pore holes in each plant sample, and the results of POME waste application had a significant effect on soil N-total and N uptake of producing oil palm plants. Several studies examined variations in distance and depth in *land* application, such as (Saputra et al. 2021) who examined the effect of POME application on the uptake of N, P, and K nutrients at a depth of 0-60 cm and the results of POME can increase the content of nutrients in the soil. Meanwhile, (Aryanto 2024) used a distance of 1, 2 and 3 m from the *flatbed* and a depth of 0-30 cm and 30-60 cm. Research (Fahlevi et al. 2019) used the zigzag method on a dead barrow with a depth of 0-20 cm.

35 Based on previous research, there has been no research analyzing the quality of soil physical properties and the quality of soil chemical properties affected by *land application* in oil palm plantations. The test parameters in this study are distance variations: 50 cm, 720 cm, and 5400 cm and depth: 0 - 10 cm, 20 - 30 cm, and 50 - 60 cm. This study aims to analyze the physical and chemical characteristics of soil on land that uses land application variations in distance and soil depth.

RESEARCH METHODS

Place and Time of Research

The research was conducted in the palm oil plantation of PT XYZ, which is located in Simpang Hilir District, North Kayong Regency, West Kalimantan. The soil type in the research location is mineral. Soil analysis was conducted at the Central Laboratory of Instiper Yogyakarta, and the research took place from May 2024 to July 2024.

Tools and Materials

The tools used in this study include *ring* samples, mineral soil drills, *Chamry* China 60 kg manual sitting scales, *Richter* Germany 10 m *sounding* meter, iPhone 13 pro camera, plastic bags, rubber bands, plastic mats, Macbook Air 2020, SPSS Anova version 29.0.2.2 (20). The materials used in this study are POME that has been applied since 2016 and soil samples.

Research Stages

The research stages begin with preparing tools for soil sampling, conducting surveys and determining blocks affected by waste and blocks that are not affected by POME, taking samples at a distance of 50 cm from the flatbed with a depth of 0 - 10 cm, 20 - 30 cm, 50 - 60 cm, a medium distance of 720 cm with the same depth and a distance of 5400 cm from the flatbed with the same depth, which shows that at a distance of 50 cm and 720 cm is part of the soil affected by *land application*, while the distance of 5400 cm as a dick is part of the soil that is not affected by *land application.*

The parameters observed were land application parameters and physical properties consisting of specific gravity through the psychometric method (Blake, 1965; Viana et al., 2002; Agnew et al., 2003). Volume weight was performed using the wax method (Casanova et al., 2016; de Oliveira et al., 2021), and the moisture content using the gravimetric method (Kamble, 2024; Putrika & Hemelda, 2024; Dighe & Ranawat, 2024).

The chemical properties observed include pH H_2 O method (Basnet, 2024; Bakiev et al., 2024), N content Kjeldhal method (Peng et al., 2014; Behin & Sadeghi, 2016; Hao et al., 2024), P content of Olsen Extract method (Krishna Murthy et al., 2024; Ekebafe & Ekebafe, 2023)K available Morgan Wolf method (HS et al., 2020) and C organic walkey and black method (Hazarika et al., 2023, Abu El Haija et al., 2024; Pradhan et al., 2023).

Sampling

Soil sampling was carried out by considering the distance to the flatbed, namely a distance of 50 cm (Near), 720 cm (Medium) and 5400 cm (Far); at each sampling point, three depths were taken, namely 0 - 10 cm (1), 20 - 30 cm (2), 50 - 60 cm (3). The research sampling scheme is presented in Figure 1.

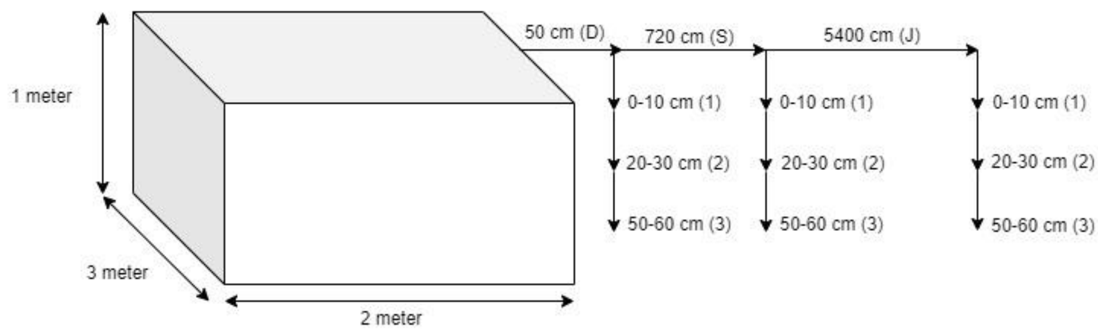


Figure 1. Sampling point

Statistical Analysis

Tests were conducted with three replications using RALF (Randomized Complete Factorial Design) and Duncan's Further test. The application used is SPSS Version 29.0.2.0 (20) (Muthiah et al., 2019)

RESULTS AND DISCUSSION

***Land Application* Characteristics**

The use of *land application* at PT XYZ is a *flatbed* system with a size of 3 m long, 2 m wide, and 1 m deep. The volume of land required for application in oil palm plantations is 750 m^3 /ha/year, with a rotation of 3 times in 1 year (once every four months)/ha, which means the volume of POME per rotation is 250 m^3 /ha. The content of nutrients such as macro elements contained in POME is 450 mg N/l, 80 mg P/l, 1,250 mg K/l and 215 mg Mg/l (Nurwidayati et al., 2017). The characteristics of *Land Application* at PT XYZ can be seen in Table 1.

Table 1 Characteristics of Land Application at PT XYZ

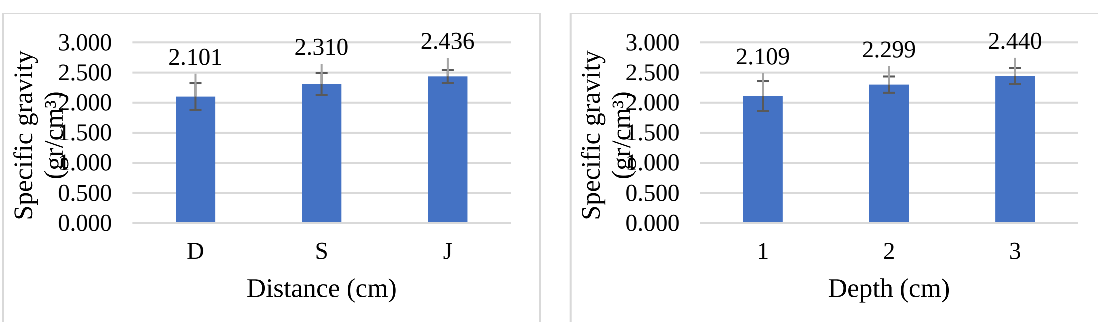
Parameters	Quality Standard	Radar
pH	6.0 - 9.0	6-9
BOD	5000	1.695 mg/L
COD	0	4.457 mg/L
Oils and fats	0	35.90 mg/L
Pb	0	0.216 mg/L
Cu	0	0.143 mg/L
Cd	0	0.038 mg/L
Zn	0	0.280 mg/L

The specific gravity of soil

The decomposed organic matter will form soil aggregates, making the previously dense soil crumblier and better structured. This better soil structure reduces soil density, allowing more air and water to enter the soil so that the specific gravity of the soil will decrease (Irawan et al., 2021).

The use POME in *land application* can improve soil quality, and long-term use for eight years does not cause negative effects on soil ecosystems (Odlare et al. 2011). Measurement of soil-specific gravity based on depth and distance showed an increase of 16%. This condition shows that organic matter in the form of POME in *land application* can improve soil structure by reducing specific gravity (Atmojo, 2003).

This condition can be caused by the surface layer of the soil (horizon A) having more oxygen and nutrients and the surface layer of the soil having direct access to new organic matter from leaves, twigs, and plant debris. (Risamasu & Marlisa, 2020).



(a) (b)

Figure 2. Soil specific gravity (a) by distance (b) by depth

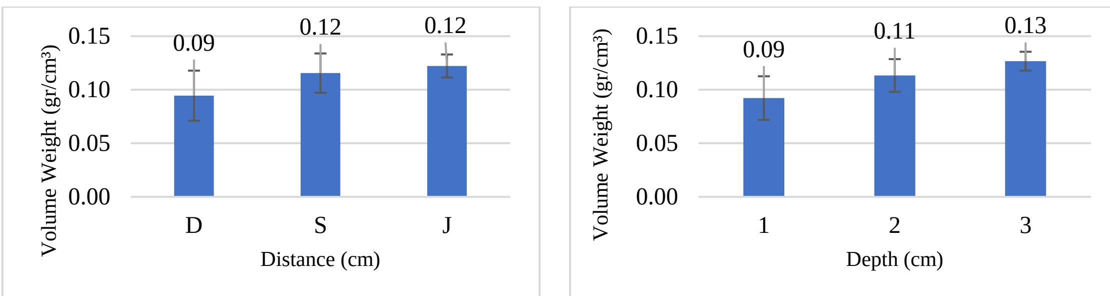
Soil Volume Weight

Soil volume weight is influenced by soil structure, organic content, soil texture, moisture content, and soil management. A soil structure with stable soil aggregates will increase soil volume weight, while a high organic matter content can increase soil porosity and form a crumblier soil structure.

Figure 3. (a) shows the soil volume weight; the further away the volume weight value increases by 29%, and in Figure 3. (b), the diagram shows the deeper the *flatbed* distance, the soil volume weight content increases by 37%.

This condition can be caused by the provision that can increase the amount of pore space in the soil and form a crumbly soil structure that can reduce the value of soil volume weight so that the lowest soil volume weight is at a close distance that gets the closest organic material from the flatbed (Saputra, 2018).

The content of organic matter has a lower specific gravity compared to soil mineral particles, and a high organic matter content will reduce the volume weight of the soil in the upper layer so that depth 1 is higher than depths 2 and 3. (Surya, 2014).

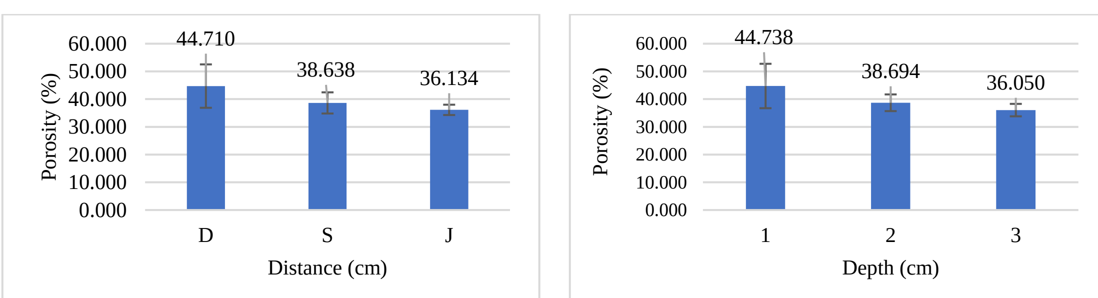


(a) (b)

Figure 3. Volume Weight (a) By distance (b) By depth

Soil porosity is influenced by soil texture, organic matter content, soil density, specific gravity, and soil volume. Soil texture that has fine particles, such as clay, has a higher porosity; this condition is caused by smaller and connected soil pore spaces. The addition of organic matter content such as POME, solid waste, and so on will help form soil aggregates so that the amount of soil pore space will increase so as to increase porosity.

Organic matter in the soil can change the soil structure, and sandy soil becomes more coherent, and clay soil becomes more decomposed so that the availability of oxygen needed by microorganisms is sufficient to improve soil porosity. Al-Showily & Hussein (2022) Figure 4. (a) shows that soil porosity based on distance decreased by 19%. Figure 4. (b) shows that soil porosity based on distance decreased by 19%.



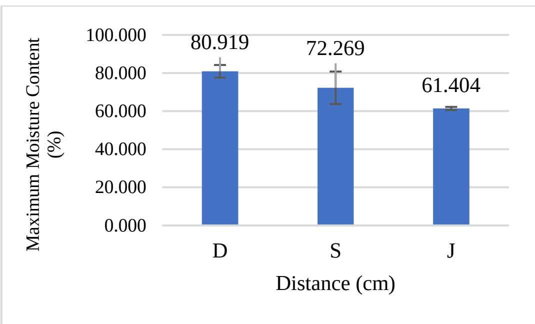
(a) (b)

Figure 4. Porosity (a) by distance (b) by depth

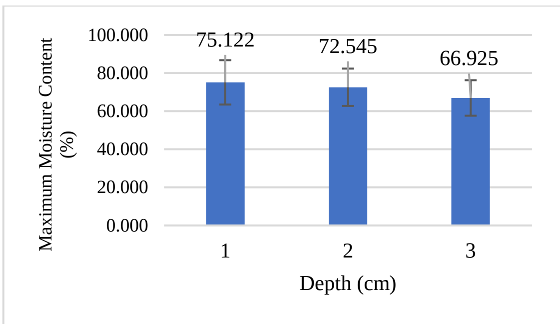
Maximal Moisture Content

Factors affecting soil moisture are good soil structure (stable soil aggregates) will increase water infiltration. Soil porosity also affects the amount of soil space that can hold water; the higher the porosity, the greater the potential of the soil to hold water, but micro soil pores, such as in clay soils, will have high moisture content, soils with high porosity tend to have a greater capacity to store water. Water content affects microbial activity, so porosity is closely related to soil moisture; the higher the porosity value, the greater the value of soil moisture. (Franzluebbers, 2020).

Figure 5. (a) shows a decrease from short distance (D) to long distance (J) by 24%. In Figure 5. (b) The maximum moisture diagram shows that the maximum moisture content value has increased by 11%. This condition is due to the soil structure that tends to be looser. Due to the provision of organic matter, soil porosity becomes higher, causing an increase in soil moisture. Nita et al. (2014). At depth 1 (10-10 cm) tends to be higher due to the direct influence of rain and watering (Rajagukguk, 2012).



(a)



(b)

Figure 5. Maximum Moisture Content (a) by distance (b) by depth

The effect of *the land application* on soil physical properties affects soil-specific gravity, soil volume weight, porosity, and maximum soil moisture. The measurement results of soil specific gravity, soil volume weight, porosity, and maximum moisture in the distance treatment had the highest value at a distance of 50 cm from the *flatbed* (D) and the depth treatment had the highest value at depth 1 (0-10 cm). This condition shows that the addition of organic matter through the *land application* system can improve soil structure.

In the study, Sánchez-Monedero et al. (2004) showed the addition of fresh sewage sludge mixture to the soil increased the size and activity of microbial biomass, twice the amount developed with mature compost (measured by BC and FDA).

PH

Soil pH and soil nutrients are the main factors in variations in bacterial and fungal diversity. Factors that affect soil pH are organic matter content, fertilizer use, drainage, and soil properties.

In this study, organic matter was added from POME, and the addition of immature organic matter can cause a decrease in pH because the decomposition process produces organic acids. (Rahmadanti et al., 2019).

The ANOVA test results show that distance and depth affect soil pH values, and there is an interaction effect between distance and depth on soil pH values. Further test results of distance and depth show (D) (1) significantly different from (M) (2) significantly different from (J) (3).

Nitrogen (N)

N is the main component of amino acids as the basis for the formation of proteins such as chlorophyll and enzymes; it also functions as vegetative growth such as roots, stems, and leaves. The level of available N in the soil is also influenced by the pH content of the soil; the pH content that is too high or too low reduces the absorption of available N in the soil reduced, besides N leaching can occur during high rainfall and in dry drainage conditions (Suparto, 2018).

In research, Johnston (1986) showed that the response to N fertilizer is greater in soils with higher organic matter content. The optimal treatment is located in D1 and D2, which is 0.21 ± 0.01%. The ANOVA test results show that distance and depth affect the N content, and there is an interaction effect between distance and depth on N content. The results of the distance further test show that (D) is significantly different from and (M) is significantly different from (J). The results of the further test of depth show that (1) is not significantly different from (2) but significantly different from (3).

Pospor (P)

Pospor is one of the important nutrients for plants that is useful for the process of reproduction and cell growth. P levels are influenced by several factors, namely organic matter content, soil pH, soil texture, soil structure and so on. The addition of organic matter can increase p levels in the soil. (Suyono & Citraresmini 2010)..

The content of C, N, and P in the soil generally tends to decrease along with the depth of the soil because the litter and plant residues are increasingly limited, so the development of microbes that decompose these nutrients decreases; the elements of N and P under the soil tend to be in a form that cannot be absorbed. Cleveland & Liptzin (2007) The level of available p is optimal with a value of 0.078 ± 0.06% or 780 ppm. Anova test results show that distance and depth affect N levels, and there is an interaction effect between distance and depth on N levels. Further test results of distance and depth show that (D) (1) is significantly different from (M) (2) but not significantly different from (J) (3).

Kalium (K)

Available K levels in soil are used as a measure of soil fertility. Available K supports good root growth, which is important for the uptake of water and nutrients from the soil. Organic matter can help bind K and increase the capacity of the soil to hold nutrients; this condition is due to the high activity of microorganisms that can increase the availability of K for plants (Jalaluddin et al., 2016).

In their research, Etesami et al. (2017) used bacteria or microorganisms to decompose K so that it is available in the soil for plants to absorb; this system is able to increase plant growth and minimize the application of K fertilizer. K levels are optimal with a value of 157.11 ± 27.32

ppm. Anova test results show that distance and depth affect N levels, and there is no interaction effect between distance and depth on N levels. The results of the distance further test show that (D) is significantly different from (M) significantly different from (J). The results of the depth test showed that (1) was significantly different from (2) but not significantly different from (3).

C - Walkey and Black Organic

Organic matter is the main source of C-organic in soil. As organic matter decomposes, it releases carbon, which becomes part of C-organic. The more organic matter that is added to the soil, the more C-organic content is produced (Siregar, 2017). This condition is caused by the C-Organic contained in the soil, which consists of microorganism cells, plant and animal decomposition, humus, and carbon compounds (Nelson & Sommers, 1996). (Nelson & Sommers, 1996). The optimal values are 12.20 ± 0.12 % and 11.58 ± 0.57 %. The ANOVA test results show that distance and depth affect the N content, and there is an interaction effect between distance and depth on N content. The results of further tests on distance and depth show that (D) (1) is significantly different from (M), and (2) is significantly different from (J) (3).

Table 2 Effect of distance on soil chemical properties

Treatment	Parameters				
	pH	N (%)	P (%)	K (ppm)	C (%)
D(50 cm)	5,00±0,35[a]	0,20±0,03[a]	0,002±0,04[a]	157,11±27,32[a]	11,48±0,76[a]
S(720 cm)	4,72±0,23[b]	0,15±0,01[b]	0,001±0,00[b]	134,33±15,60[b]	6,16±2,30[b]
J(5400 cm)	4,28±0,18[c]	0,04±0,01[c]	0,001±0,00[b]	22,89±9,94[c]	1,89±1,56[c]

Table 3 Effect of depth on soil chemical properties

Treatment	Parameters				
	pH	N (%)	P (%)	K (ppm)	C (%)
1(0-10cm)	4,99±0,48[a]	0,14±0,08[a]	0,027±0,01[a]	121,00±78,86[a]	8,22±4,28[a]
2 (20-30 cm)	4,52±0,31[b]	0,13±0,08[a]	0,001±0,00[b]	102,56±72,75[b]	6,37±5,11[b]
3 (50-60 cm)	4,49±0,30[b]	0,11±0,06[b]	0,001±0,00[b]	90,78±64,58[b]	4,93±5,18[c]

The results showed that the effect of *land* *application* on soil chemical properties affected the content of pH, N, p, K available and C-Organic. The treatment with the highest and optimal content value was treatment D1 (50 cm distance from the *flatbed* and 0-10 cm depth). This condition shows that the addition of organic matter through the *land application* system can improve soil chemical properties even though it has not reached maximum conditions, such as in pH, N, p, and K available. The maximum condition is achieved in the C-Organic parameter. The acidic pH of the soil affects the availability of nutrients in the soil. Organic matter will improve soil chemical properties, especially C-Organic, through the decomposition process (Sasongko, 2010).

CONCLUSIONS

Based on the results of the research that has been done, it is concluded that the use of *land application* affects the physical properties of the soil and has optimal conditions at close distance (D) and depth (0-10 cm), namely soil-specific gravity 1.862 g/cm^3, soil volume weight

0.07 g/cm^3 soil porosity 53.507%, and soil moisture 84.25%. The use of *land application* affects soil chemical properties and has optimal conditions at close distance (D) and depth (0-10 cm), namely pH 5.5, N 0.215%, p 0.078%, K available 184.33 ppm, C-Organic 12.20%.

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