The Effect Of Palm Oil Mill Effluent On The Performance Of Several Palm OIL (*Elaeis Guineensis* Jacq.) Varieties In Torgamba Plantation

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Abstract

Palm Oil Mill Effluent (POME) is a by-product of palm oil processing that contains nutrients and organic matter, offering potential to improve crop productivity when applied through a Land Application (LA) system. This study analyzed the performance of two oil palm varieties on the LA area of Torgamba Estate and compared their production characteristics. A comparative quantitative (ex post facto) approach was applied to Afdeling VI production records up to June 2026, using bunch weight (kg/bunch), number of bunches (bunches/palm), and productivity (kg/ha) as parameters, analyzed with an independent-samples t-test at the 5% significance level. Variety A (planted 2009) showed higher average bunch weight (19.89 kg/bunch) than Variety B (17.80 kg/bunch), whereas Variety B (planted 2007) was superior in bunches per palm (5.17 vs 4.46) and productivity (12,913 vs 11,651 kg/ha). All three differences were statistically significant ($p < 0.05$). The results suggest that variety selection on LA areas should be aligned with production targets, while noting that the difference in planting year between varieties also influences the outcome.

Keywords*: POME; Land Application; oil palm varieties; crop performance*

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Introduction

Oil palm (*Elaeis guineensis* Jacq.) is one of Indonesia's primary plantation commodities, playing a vital role in increasing foreign exchange earnings, providing employment, and supporting national economic development. Palm oil productivity is influenced by various factors, including variety, soil fertility, climate, cultivation techniques, and fertilizer management.

During the processing of fresh fruit bunches (FFB), palm oil mills produce Palm Oil Mill Effluent (POME). In the past, this liquid waste was considered a source of environmental pollution. However, with advances in waste management technology, POME can be utilized as a liquid organic fertilizer through land application.

The use of POME has been reported to increase soil organic matter content, improve physical, chemical, and biological properties, and increase nutrient availability for plants. However, plant responses to liquid waste application are thought to differ between varieties due to differences in genetic characteristics and environmental adaptation. Some varieties tend to produce larger bunches, while others produce more bunches under certain conditions [1][2].

The Torgamba Plantation has implemented a Land Application system, making it an ideal location to evaluate the performance of several oil palm varieties in the area. The response of each variety is also influenced by soil type, plant age, climate, POME dosage, and plantation management; these factors must be taken into account when interpreting the results.

Research Objectives

a. To analyze the performance of several oil palm varieties in the POME Land Application area at the Torgamba Plantation.
b. To compare production characteristics (bunch weight, number of bunches, and productivity) across varieties in the area.

Literature Review

Oil palm (*Elaeis guineensis* Jacq.) is one of the main plantation commodities in Indonesia which makes an important contribution to foreign exchange, employment and economic development. The productivity of this plant is determined by the interaction of many factors, including variety, soil fertility and properties, climate, cultivation techniques, fertilizer management, and plant age [3]. Agronomically, the yield of fresh fruit bunches (FFB) is a function of two main components, namely the number of bunches per tree and the average bunch weight. Because these two components can act in opposite ways, plant performance evaluation should consider both simultaneously to obtain a comprehensive picture of productivity [9].

Palm Oil Mill Effluent (POME) is a byproduct of the FFB processing process. Physically, POME is a thick, brown liquid with a solids content of around 4–5%, mostly organic, and the remainder is dominated by water; this waste reacts acidically and has high COD and BOD values [6]. On the other hand, POME is rich in nutrients, especially nitrogen (N), phosphorus (P), and potassium (K), and contains calcium (Ca), magnesium (Mg), and a number of microelements. This nutrient and organic content makes POME potentially useful as a liquid organic fertilizer if managed properly [5][6].

Land Application (LA) is a method of utilizing POME by flowing treated waste into ditches or rorak on plantation land so that nutrients are absorbed into the soil. Before being applied, POME must go through a Wastewater Treatment Plant and meet quality standards, including a BOD value not exceeding 5,000 mg/L, a pH in the range of 6–9, and not be applied to peatlands, according to applicable regulations [8]. The LA practice through this rorak system is also applied to oil palm plantations in the Bengkulu region [7].

Various studies have shown that POME application through LA improves the chemical, physical, and biological properties of soil. A study in Karang Tinggi District, Central Bengkulu, reported that LA POME increased pH, K, Ca, and Mg content, cation exchange capacity (CEC), base saturation, and phosphorus and oil/fat content in the topsoil, with the effect tending to decrease with increasing soil depth [7]. Consistently, another study found that POME application significantly increased total microbial content, organic matter content, and soil pH [8]. Observations of plant rhizospheres also showed that land with POME application had higher total microbial content, organic carbon, soil respiration, and CEC than land without application [9]. Overall, these findings confirm the role of POME in enriching organic matter and increasing nutrient availability in the soil.

Improvement of soil properties by POME in turn supports plant growth and production. A study in Lampung reported that the use of POME tends to increase plant productivity in the range of 7.57–63.23% while potentially reducing the need for inorganic fertilizers [10]. From a physiological perspective, the supplied nutrients play specific roles: potassium (K) is important in the fruit filling process, nitrogen (N) supports vegetative growth and leaf formation, while phosphorus (P) plays a role in root formation and flower development. However, the magnitude of plant response to POME application is not uniform, but is influenced by variety, plant age, soil conditions, rainfall, application dose, and garden management [5][8].

Plant responses to environmental conditions, including POME application, are thought to differ between varieties due to differences in genetic traits. Classical research on oil palm found significant differences between hybrids in bunch number, average bunch weight, and FFB yield, as well as significant genotype-by-environment (year) interactions [9]. Evaluation of various dura × pisifera progenies also revealed significant variation in almost all yield and vegetative traits [10].

Importantly for this study, there is a tendency for a trade-off between yield components, namely a negative correlation between bunch number and average bunch weight [11]. This means that varieties that produce a high number of bunches tend to have lighter bunches, and vice versa. This phenomenon explains why two varieties can exhibit different production characteristics even when managed under similar conditions. In addition to genetic factors, plant age also determines bunch weight and yield; production generally increases until maturity and then plateaus, so comparisons between varieties with different planting years should be interpreted with caution [3].

Based on the above analysis, POME application through Land Application has been proven to improve soil properties and increase nutrient availability, thus supporting oil palm productivity. However, the magnitude of these benefits depends on the variety due to differences in genetic characteristics in nutrient utilization, and is influenced by environmental factors and plant age. Studies that specifically compare the performance of several varieties in a single Land Application area especially those that include a comparison without LA and standardize plant age are still limited. This research aims to fill this gap by evaluating the performance of several oil palm varieties in the Land Application area at the Torgamba Plantation, so that the results can provide a basis for selecting more appropriate varieties for production objectives.

Research Methodology

The research was conducted in the Land Application area of Division VI of the Torgamba Plantation from January to June 2026 using a comparative quantitative approach (ex post facto). Data were sourced from plantation production records (LM76 Division VI) and field observations.

The research subjects were two oil palm varieties in the Mature Plant phase: Variety A (planting year 2009; blocks W19, W22, W23, X19) and Variety B (planting year 2007; blocks Y19, Y20, Y21, Z19, Z20). The independent variable was the application of LCPKS through the Land Application system, while the dependent variables included bunch weight (kg/FFB), number of bunches (FFB/tree), and productivity (kg/ha).

Data were analyzed descriptively and then used an independent-samples t-test at the 5% significance level to test for differences in average values between varieties for each parameter. The analysis used SPSS.

Results

Data on oil palm production of Variety A and Variety B in the Land Application Afdeling VI area of Torgamba Plantation until June 2026 is presented in Table 1.

Tabel 1. Realisasi statistik produksi Varietas A (TT 2009) dan Varietas B (TT 2007) pada areal Land Application

Varietas / Thn Tanam	Block	wide (Ha)	Number of trees	Trees /Ha	Number of TBS	TBS /Phn	Kg/TBS (RBT)	Production TBS	
Varietas A (2009)	W19	24,80	3.360	135	14.986	4,46	19,86	297.622	12.001
	W22	24,23	3.390	140	14.068	4,15	19,84	279.109	11.519
	W23	24,26	3.370	139	13.076	3,88	19,97	261.128	10.764
	X19	21,25	2.694	127	13.335	4,95	19,77	263.633	12.406
Subtotal TM		**94,54**	**12.404**	**131**	**55.375**	**4,46**	**19,89**	**1.101.532**	**11.651**

2009									
Varietas B (2007)	Y19	24,87	3.327	134	18.132	5,45	17,65	320.029	12.868
	Y20	24,69	3.390	137	19.187	5,66	17,99	345.174	13.980
	Y21	24,61	3.370	137	16.479	4,89	17,76	292.667	11.892
	Z19	24,26	3.210	132	17.591	5,48	17,71	311.537	12.842
	Z20	23,75	3.280	138	17.253	5,26	17,87	308.311	12.982
Subtotal TM 2007		**122,18**	**17.161**	**140**	**88.642**	**5,17**	**17,80**	**1.577.718**	**12.913**
TOTAL 2009+2007		**216,72**	**29.565**	**136**	**144.017**	**4,87**	**18,60**	**2.679.250**	**12.363**

Sumber: LM76 Afdeling VI Kebun Torgamba

The results of the independent sample t-test on the block data for each parameter are summarized in Table 2.

Tabel 2. Summary of the t-test comparing the performance of Varieties A and B

Parameter	Variety A	Variety B	Valuet	p-value
Number of bunches (FFB/tree)	4,46	5,17	-3,74	0,014 — significant (B is higher)
Bunch weight (kg/FFB, RBT)	19,89	17,80	28,16	<0,001 — significant (A is higher)
Productivity (kg/ha)	11.651	12.913	-2,56	0,039 — significant (B is higher)

Discussion

Observation results show that the two varieties have different production characteristics. Variety B produces a higher number of bunches per tree (5.17) than Variety A (4.46), while Variety A produces heavier bunches (19.89 Kg/FFB) than Variety B (17.80 Kg/FFB). At the level of productivity, Variety B is superior (12,913 kg/ha) compared to Variety A (11,651 kg/ha). The t-test shows that these three differences are statistically significant at the 5% level (Table 2).

These character differences are genetic traits that are commonly found in various oil palm varieties. Because productivity is determined by both the number and weight of bunches, evaluation of variety performance should consider both parameters simultaneously to obtain a comprehensive picture [12].

From a physiological perspective, the application of LCPKS via Land Application affects the availability of nutrients, especially potassium (K), which plays an important role in fruit filling. Nitrogen (N) supports vegetative growth and leaf formation, while phosphorus (P) plays a role in root formation and flower development. This combination of nutrients supports sustainable bunch formation. These findings are in line with previous research which states that the use of POME improves the physical, chemical and biological properties of soil, increases organic matter content, and reduces the need for inorganic fertilizers [13]. However, the magnitude of the plant response is influenced by variety, plant age, soil conditions, rainfall and garden management.

Practically, these results provide important information for plantation managers that variety selection in the Land Application area needs to be adjusted to production objectives. If the main target is high bunch weight, Variety A is more suitable; whereas when emphasizing the number of bunches per tree and productivity per hectare, Variety B is superior.

Research Limitations

a. The two varieties were planted in different years (A: 2009; B: 2007), so differences in performance could partly be influenced by differences in plant age, not just variety factors.
b. The research did not include a comparison area without Land Application (control), so the magnitude of the POME "influence" cannot be directly isolated; Results are more appropriately interpreted as a comparison of variety performance under Land Application conditions.
c. The number of observation units is relatively small (4 vs 5 blocks), so generalization of the results requires caution.

Conclusion

In the LCPKS Land Application area at the Torgamba Plantation, Varieties A and B exhibited significantly different production characteristics. Variety A had a higher average bunch weight, while Variety B excelled in the number of bunches per tree and productivity per hectare. These differences are thought to be influenced by the genetic characteristics of each variety in nutrient utilization, as well as external factors such as plant age and environmental conditions. Therefore, variety selection for Land Application areas should be tailored to the plantation's production objectives.

For further research, it is recommended to include a control area without Land Application, standardize plant age between varieties, and increase the number of observation units to more convincingly separate the effects of POME and variety

References

[1] Ginting, E. N. (2020). Pentingnya bahan organik untuk meningkatkan efisiensi dan efektivitas pemupukan di perkebunan kelapa sawit. WARTA Pusat Penelitian Kelapa Sawit, 25(3), 139-154.

[2] Dinata, S. A., Saputra, I., & Juanda, B. R. (2026). Pengaruh Aplikasi Palm Oil Mill Effluent (POME) Terhadap Indeks Kualitas Tanah dan Produktivitas Kelapa Sawit (Elaeis guineensis Jacq.). *Jurnal Agrotek Lestari*, *12*(1), 30-40.

[3] Pahan, I. (2012). Panduan Lengkap Kelapa Sawit. Jakarta: Penebar Swadaya.

[4] Direktorat Jenderal Perkebunan. (2023). Statistik Perkebunan Kelapa Sawit Indonesia. Jakarta: Kementerian Pertanian.

[5] Sukisno, & Arianto, W. (2024). The impact of land application of palm oil mill effluents on some soil chemical characteristics in the District Karang Tinggi, Bengkulu Tengah Regency, Province of Bengkulu. BIO Web of Conferences, 123, 01023. https://doi.org/10.1051/bioconf/202412301023

[6] Sakiah, Febrianto, E. B., & Manurung, A. (2018). The Effect of Palm Oil Mill Effluent on Total Microbes, Soil Respiration, Organic Matters and Soil pH in Oil Palm Plantation. Resources and Environment, 8(6). http://article.sapub.org/10.5923.j.re.20180806.02.html

[7] Siahaan, M., Sakiah, Sutanto, A. S., Lawary, A., & Mahmuda, R. (2021). The study of soil biological and chemical properties on palm oil plant rhizosphere with and without palm oil mill effluent applications. IOP Conference Series: Earth and Environmental Science, 819, 012003. https://doi.org/10.1088/1755-1315/819/1/012003

[8] Febriana, D., Madusari, S., & Sari, V. I. (2022). SWOT analysis of utilization of palm oil mill effluent to improve soil quality and crop productivity (case study at PT X, Lampung, Indonesia). IOP Conference Series: Earth and Environmental Science, 1041, 012046. https://doi.org/10.1088/1755-1315/1041/1/012046

[9] Obisesan, I. O., & Fatunla, T. (1983). Genotype × environment interaction for bunch yield and its components in the oil palm (Elaeis guineensis Jacq.). Theoretical and Applied Genetics, 64(2), 133–136. https://doi.org/10.1007/BF00272720

[10] Rafii, M. Y., Isa, Z. A., Kushairi, A., Saleh, G. B., & Latif, M. A. (2013). Variation in yield components and vegetative traits in Malaysian oil palm (Elaeis guineensis Jacq.) dura × pisifera hybrids under various planting densities. Industrial Crops and Products. https://www.sciencedirect.com/science/article/abs/pii/S0926669013000381

[11] Babu, K., Mathur, R. K., Shil, S., & HP, B. (2021). Genome-wide association study (GWAS) of major QTLs for bunch and oil yield related traits in Elaeis guineensis L. PubMed ID: 33691957. https://pubmed.ncbi.nlm.nih.gov/33691957/

[12] Putera, D. A., Matondang, A. R., Sembiring, M. T., & Dermawan, A. A. (2022). Penerapan Seven Tools Untuk Mengidentifikasi Kadar Limbah Cair (Pome) Di Perusahaan Kelapa Sawit. Sigma Teknika, 5(1), 022-029.

[13] Ratnasari, I. F. D., Devi, D., & Setyawan, I. A. Y. (2024). Aplikasi limbah Palm Oil Mill Effluent (POME) terhadap sifat kimia tanah pada perkebunan kelapa sawit. *Jurnal Media Pertanian*, *9*(2), 113-118.