JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 7 NO. 3 September 2025

DOI :https://doi.org/10.36378/juatika.v5i2.4837
eissn 2656-1727
pissn 2684-785X
pages : 889 – 895

RESEARCH ARTICLE Open Access

Correlation of Aloe Vera-Based Liquid Organic Fertilizer with Growth Traits of Oil Palm (*Elaeis guineensis* Jacq.)

Umar Husein Abdullah[1,*], Ruhalena Wilis[2], Elviani[2], Nurlia Farida[2], Khairun Nisa[3]

Abstract
Aloe vera gel contains various secondary metabolites that contribute to the plant's beneficial properties. This study employed a correlation analysis test to investigate the relationship between Aloe vera LOF dosage and S.H, S.D, and NL in Oil Palm Seedlings (*Elaeis guineensis* Jacq.). This study was conducted in a controlled experimental garden managed by the Plantation Management Study Program at the Politeknik Indonesia Venezuela, located in Cot Suruy Village, Ingin Jaya District, Aceh Besar Regency. The study was conducted from March to July 2025. The garden temperature was maintained between 25˚C and 28˚C. Data analysis was carried out using SPSS 25 software. To see the correlation analysis between LOF, SH, SD, and NL in Oil Palm Seedlings (*Elaeis guineensis* Jacq.), a bivariate CA was used. The use of *Aloe vera* LOF at various doses (100-400 ml) was proven to have a significant effect on the vegetative growth of oil palm seedlings, especially on PH, SD, and NL. Aloe vera LOF, as a natural leaf fertiliser, can provide a significant positive effect on the vegetative growth of oil palm seedlings by increasing the height, diameter, and NL simultaneously.

Keywords: Number of Leaves, Pearson Correlations, Plant Height, Seedling, Stem Diameter

1. Introduction

The oil palm (*Elaeis guineensis* Jacq.) is currently the world's most productive oil crop, occupying a global cultivated area of approximately 19 million hectares and producing approximately 0.27 gigatons of fruit and 71.4 million tonnes of palm oil. This vast plantation area encompasses approximately 2.7 billion trees. Typically, oil palm plantations are replanted every 25 years, resulting in an average replanting rate of about 4% per year (Corley & Tinker, 2016). Consequently, around 100 million trees need to be replaced annually. Alongside the expansion of cultivated areas in recent decades, this has created a significant demand for oil palm saplings in nurseries, as well as for seedling production through seed germination or in vitro cloning (Cui et al., 2020). The problem of nutrient deficiency in oil palm plants is in Nitrogen (N): old leaves turn yellow, stunted growth, decreased FFB production, Phosphorus (P): weak roots, shrinking stems, disrupted flower formation, Potassium (K): yellow/orange spots on leaves, necrotic leaf edges, small bunches, low oil quality, Magnesium (Mg): old leaves turn yellow from the edges/tips, decreased photosynthesis, Boron (B): young leaves curl (hook leaf), disrupted flowering & fruiting, and micro nutrients (Mn, Zn, Cu, Fe): chlorosis occurs between leaf veins, abnormal growth of young leaves. In general, the impacts that can be seen are: stunted vegetative growth (leaves, stems, roots), decreased number and size of fresh fruit bunches (FFB), low oil content in fruit, plants are more susceptible to environmental stress and disease, and plantation productivity decreases significantly (Dubos & Raïssac, 2021; Sugianto et al., 2023).

LOF produced from agricultural waste and other industrial products is becoming increasingly popular worldwide. They are made through simple fermentation processes that use organic residues as carbon sources. These fertilisers are rich in essential nutrients for plant growth and contain beneficial microorganisms that aid in decomposing and recycling organic matter. During the fermentation stage, microbes play a key role in breaking down the substrates. As a result, the final product contains plant growth hormones such as auxins and cytokinins, along with organic acids and other growth-promoting

*Correspondence: umarah_1977@yahoo.co.id
1) Politeknik Indonesia Venezuela - l. Bandara Sultan Iskandar Muda, Cot Suruy, Kec. Ingin Jaya, Kabupaten Aceh Besar, Aceh 23371, Indonesia
2) Universitas Iskandar Muda - Jl. Kampus Unida No.15, Surien, Kec. Meuraxa, Kota Banda Aceh, Aceh 23234, Indonesia
3) Universitas Teuku Umar - Jl. Alue Peunyareng, Gunong Kleng, Kec. Meureubo, Kabupaten Aceh Barat, Aceh 23681, Indonesia

compounds (Phibunwatthanawong & Riddech, 2019). LOF is considered an environmentally friendly option for fertilisation. It is commonly applied to improve the deficiency of organic matter in the soil and helps enhance the physical, chemical, and biological properties of the growing medium. Its benefits include a more straightforward application, improved nutrient absorption, no harm to soil or plants, and enhanced nutrient availability (Gunawan et al., 2024).

Aloe vera gel contains various secondary metabolites that contribute to the plant's beneficial properties. The gel extracted from its leaves consists of approximately 98–99% water, with the remaining 1–2% comprising bioactive compounds, including vitamins, proteins, phenolic substances, and carbohydrates (Ning et al., 2017; Kumar et al., 2017; Canche et al., 2019). Among the most notable polysaccharides in Aloe vera gel is beta-(1→4) acetylated glucomannan, commonly known as acemannan (Quezada et al., 2017). Besides being a structural component of cell walls, glucomannan can also serve as a storage polysaccharide in membrane-bound granules within specialised tissues, such as the stems of Dendrobium orchids (Voiniciuc et al., 2022; He et al., 2017). In Aloe vera, acemannan functions as a solute that helps the plant withstand water scarcity (Salinas et al., 2019). Beyond their role in plant defence against environmental stress, secondary metabolites are highly valued for their health benefits to humans and their potential applications in pharmaceuticals, cosmetics, and various industries (Nikolaou et al., 2023).

Correlation analysis (CA) is used to determine the direction and nature of the relationship between two or more variables. A correlation is observed when a change in one variable is accompanied by a corresponding linear change in another variable, either in the same or in the opposite direction. The strength of this relationship is measured using a statistical value called the correlation coefficient (Roflin & Riana, 2022). In statistical testing, determining the correlation value is important not only for modelling the relationship between variables but also for analysing a series of complex correlations simultaneously. Such complex correlations may involve one or more dependent variables and one or more independent variables. These dependent and independent variables can be constructs formed from several indicator variables or single variables that are directly measurable or observable (Yannasari et al., 2024).

Research conducted by Madusari (2019) developed LOF from fermented oil palm fruit fibre and applied it to oil palm seedlings. The results of the study showed that the use of LOF was able to significantly increase the PH, SD, and NL of oil palm seedlings compared to the control treatment, with a Significant Difference. F value <0.05. Meanwhile, research by Husna et al. (2020) at the pre-nursery stage revealed that administering LOF at a concentration of 10% significantly increased the growth of oil palm seedlings, including a notable increase in the NL (Ariyanti et al., 2019). In a separate study, Abdullah et al. (2024) discovered through CA that PH, SD, and NL in jackfruit seedlings are interrelated. However, no significant correlations were found between watering frequency and any of these growth parameters. Specifically, watering every nine days did not significantly influence PH, SD, or leaf count. This study aims to determine the correlation analysis between different doses of Aloe vera LOF and plant height (SH), stem diameter (SD), and number of leaves (NL) in oil palm seedlings (Elaeis guineensis Jacq.).

2. Material and Methods

The study was conducted in a controlled-environment experimental garden managed by the Plantation Management Study Program at Politeknik Indonesia Venezuela, located in Cot Suruy Village, Ingin Jaya District, Aceh Besar Regency. The research location is at coordinates 5°30'42"N 95°23'36"E, with an altitude of 30 meters above sea level. The research took place from March to June 2025, with the garden temperature maintained between 25°C and 28°C. The tools used in this study were stationery, a cutter knife, a camera, a ruler, a notebook, and a pen. The materials used in this study were 2-month-old cacao seedlings, LOF *Aloe vera*, EM4, molasses, and water.

The medium used is soil, with each polybag containing soil that does not differ in nutrient content, which will ultimately affect the growth of *Elaeis guineensis* Jacq. The prepared oil palm seeds are planted in 15 x 18 cm polybags filled with soil, then the polybags are planted. The parameters observed were: pH was measured using a ruler from the soil surface to the tip of the highest stem. SD was measured vertically using a calliper. The NL counted were leaves that had fully opened. Leaf counting was carried out two weeks after planting. SD measurements were conducted 2 weeks after planting and then repeated weekly for seven weeks. This study used a non-factorial RBD.

The parameters observed were: PH was measured using a ruler from the ground surface to the tip of the highest stem. SD was measured vertically using a calliper. The NL counted were leaves that had fully opened. Leaf counting was carried out two weeks after planting. SD measurements were conducted 2 weeks after planting and then repeated weekly for 7 weeks. This study employed a non-factorial Randomised Block Design (RBD), comprising five treatment groups, each replicated five times. The treatments were arranged as follows: S0 = without application of *Aloe vera* fertiliser, S1 = application of 100 ml of *Aloe vera* LOF, S2 = application of 200 ml of *Aloe vera* LOF, S3 = application of 300 ml of *Aloe vera* LOF, and S4 = application of 300 ml of *Aloe vera* LOF. Each experimental unit consisted of 1 2-month-old Oil

Palm seedling, with a total of 25 Oil Palm plant seedlings. The flow diagram of this research is seen in Figure 1.

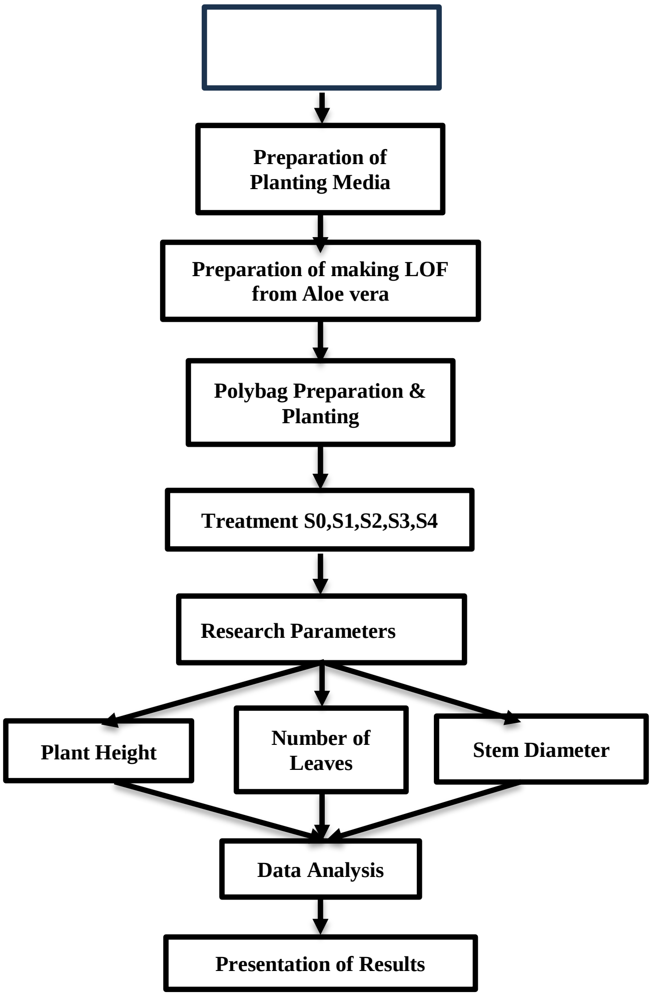

Figure 1. Diagram of This Research

The data was processed using the Statistical Package for the Social Sciences 25 (SPSS 25) application. To see the correlation analysis between LOF, SH, SD, and NL in Oil Palm Seedlings (*Elaeis guineensis* Jacq.), bivariate correlation analysis was used (Khriswanti et al., 2022; Triadiawarman et al., 2022; Afifah et al., 2025; Kim et al., 2023). Correlation refers to a numerical value that represents both the direction and strength of the relationship between two or more variables. This relationship is measured using a correlation coefficient, which ranges from -1 to +1. A positive sign indicates a direct (+) relationship, while a negative sign indicates an inverse (-) relationship. The degree of association between variables is commonly expressed through the correlation coefficient, denoted by the symbol "r". Guidelines for Multiple Correlation Tests in SPSS: If the value of the change in Sig. F <0.05 then:

$$r = \frac{n\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{(n\Sigma X^2 - (\Sigma X)^2)\,(n\Sigma Y^2 - (\Sigma Y)^2)}}$$

This is the Pearson correlation coefficient formula, which measures the strength and direction of a linear relationship between two variables X and Y. Where, n = number of data pairs, $\sum XY$ = sum of products of X and Y, $\sum X$, $\sum Y$ = sum of each variable, & $\sum X^2$, $\sum Y^2$ = sum of squared values. The criteria for analysing the correlation test are presented in Table 1 (Abdullah et al., 2024).

Table 1 . CA Test Correlation

No.	Correlation value	Information
1	0	There is no correlation between the two variables
2	> 0 – 0.25	The correlation is very weak
3	> 0.25 – 0.5	Correlation enough
4	> 0.50 – 0.75	Strong correlation
5	> 0.75 – 0.99	The correlation is robust
6	. = 1	The perfect correlation is positive
7	. = -1	Negative perfect correlation

The data obtained from the field were then tested for normality (Tsagris & Pandis, 2021; Schmidt & Finan, 2018) and homogeneity (Zhou et al., 2023; Kédagni & Mourifié, 2020; Sandrini & Camargo, 2022; Yozgatligil et al., 2016). Then, if the data were normally distributed and homogeneous, the analysis proceeded to the correlation statistical analysis.

3. Results and Discussion

In Table 2, it can be seen that the variable without LOF *Aloe vera* is strongly related to the variables of plant height and SD of oil palm plants (as indicated by the ** sign). The variable of LOF *Aloe vera* is strongly related to the NL (as indicated by the * sign). The variable of LOF *Aloe vera* has a significant effect on the pH, SD, and NL of oil palm plants, with a significant change in value (Sig. F < 0.05), indicating a significant relationship. The increase in stem height and diameter is in line with the role of phytohormones in *Aloe vera* (e.g., auxin, gibberellin), which accelerate cell division and elongation, explaining the powerful relationship (**) with the height and diameter of oil palm stems. Because the growth hormones in *Aloe vera* (auxin, gibberellin) specifically accelerate upright growth and stem elongation (Irmadhani et al., 2025; Melati et al., 2024; El Sherif, 2017).

Table 3 shows that the variable of 100 ml of *Aloe vera* LOF is strongly related to the NL, and SD is strongly related to the NL of oil palm plants (as seen with the * sign). PH is strongly related to SD (as indicated by the ** sign). The variables of Aloe vera LOF and SD have a significant effect on pH, and NL shows a significant relationship (Sig. F change value <0.05). Several studies on *Aloe vera* have revealed that the use of LOF, including its extracts, can increase the NL and SD. This is due to the presence of natural growth regulators, such as humic acid, auxin, gibberellin, and cytokinin, which stimulate cell division and elongation while strengthening the physiological resistance of plants (Simi & Hossain, 2023; Cheena et al., 2022).

Table 2. Results of CA without LOF, with PH, SD, and NL.

Correlations		**LOF 0 ml**	**PH**	**S D**	**NL**
LOF 0 ml	PC	1	0.716**	0.830**	0.637*
	Sig. (2-tailed)		0,003	0,000	0.011
PH	PC	0.716**	1	0.416	0.234
	Sig. (2-tailed)	0.003		0.123	0.400
SD	PC	0.830**	0,416	1	0.513
	Sig. (2-tailed)	0,000	0.123		0.051
NL	PC	0.637*	0.234	0.513	1
	Sig. (2-tailed)	0.011	0.400	0.051	

*. The correlation is considered significant at the 0.05 level (2-tailed).
**. The correlation is considered significant at the 0.01 level (2-tailed).
PC = Pearson Correlation

Table 3. Results of CA of 100 ml LOF with PH, SD, and NL.

Correlations		**LOF 100 ml**	**PH**	**SD**	**NL**
LOF 100 ml	PC	1	0.031	0.388	0.580*
	Sig. (2-tailed)		0.914	0.153	0.023
PH	PC	0.031	1	0.860**	0.456
	Sig. (2-tailed)	0.914		0.000	0.087
SD	PC	0.388	0.860**	1	0.586*
	Sig. (2-tailed)	0.153	0.000		0.022
NL	PC	0.580*	0.456	0.586*	1
	Sig. (2-tailed)	0.023	0.087	0.022	

*. The correlation is considered significant at the 0.05 level (2-tailed).
**. The correlation is considered significant at the 0.01 level (2-tailed).

Table 4. Results of CA of 200 ml LOF with PH, SD, and NL.

Correlations		**LOF 200 ml**	**PH**	**SD**	**NL**
LOF 200 ml	PC	1	0.675**	0.086	0.700**
	Sig. (2-tailed)		0.006	0.760	0.004
PH	PC	0.675**	1	0.081	0.404
	Sig. (2-tailed)	0.006		0.775	0.135
SD	PC	0.086	0.081	1	0.173
	Sig. (2-tailed)	0.760	0.775		0.539
NL	PC	0.700**	0.404	0.173	1
	Sig. (2-tailed)	0.004	0.135	0.539	

*. The correlation is considered significant at the 0.05 level (2-tailed).

Table 5. Results of CA of 300 ml LOF with PH, SD, and NL.

Correlations		**LOF 300 ml**	**PH**	**SD**	**NL**
LOF 300 ml	PC	1	0.340	0.159	0.475
	Sig. (2-tailed)		0.215	0.572	0.073
PH	PC	0.340	1	0.445	0.128
	Sig. (2-tailed)	0.215		0.097	0.649
SD	PC	0.159	0.445	1	0.644**
	Sig. (2-tailed)	0.572	0,097		0.010
NL	PC	0.475	0.128	0.644**	1
	Sig. (2-tailed)	0.073	0.649	0,010	

*. The correlation is considered significant at the 0.05 level (2-tailed).

Table 6. Results of CA of 400 ml LOF with PH, SD, and NL.

Correlations					
		LOF 400 ml	**PH**	**SD**	**NL**
LOF 400 ml	PC	1	0.259	0.375	0.740**
	Sig. (2-tailed)		0.352	0.168	0.002
PH	PC	0.259	1	0.221	0.423
	Sig. (2-tailed)	0.352		0.428	0.117
	N	15	15	15	15
SD	PC	0.375	0.221	1	0.188
	Sig. (2-tailed)	0.168	0.428		0.501
NL	PC	0.740**	0.423	0.188	1
	Sig. (2-tailed)	0.002	0.117	0.501	

*. The correlation is considered significant at the 0.05 level (2-tailed).

Simi & Hossain (2023) reported that the use of organic fertilisers—whether in the form of compost, manure, or LOF—significantly increased Aloe vera growth parameters, including LN & PH, compared to control treatments or inorganic fertilisers. Research on *Aloe vera* and other plants also shows a strong correlation between SD & PH, as larger stems support taller and more mechanically stable plant growth. For example, studies on *Aloe vera* have shown a positive relationship ($r \geq 0.7$) between leaf diameter and leaf number, pH, and total biomass (Nejatzadeh, 2024; Chowdhury et al., 2021). The results of this study are quantitatively consistent with the findings of Ajeng et al. (2020), study on organic fertilizer/biofertilizer and compost (reports of an increase in height of around 10–35%, a significant increase in stem diameter, and an increase in the number of leaves of tens of percent), and all showed statistical significance ($p < 0.05$).

In Table 4, it can be seen that the variable of 200 ml of *Aloe vera* LOF is strongly related to the pH and NL of oil palm plants (as indicated by the ** sign). The variable of *Aloe vera* LOF has a significant effect on pH and NL (the change value is significant, with Sig. F < 0.05, indicating a significant relationship). Research conducted by Sukmawan and Riniarti (2022) shows that the application of foliar fertiliser, both in powder and liquid form, can significantly increase PH and NL in oil palm seedlings. ANOVA analysis supports the effectiveness of the liquid fertiliser, indicated by the Sig. F value <0.05, which indicates a significant difference between the treatment and the control (Zahrah et al., 2024; Sukmawan & Riniarti, 2022). In addition, the use of planting media enriched with LOF from vegetable waste also significantly increases the vegetative growth of oil palm seedlings, including PH and NL (Setyawati et al., 2024; Seman et al., 2018; Onwubiko et al., 2015). Thus, 200 ml of *Aloe vera* LOF, which is included in a similar foliar fertiliser category, can have a positive effect on the vegetative growth of plants.

In Table 5, the use of 300 ml of LOF shows that the SD variable is strongly related to the NL in oil palm plants (as indicated by the ** sign). SD affects the NL (the change value of Sig. F <0.05, indicating a significant relationship). Research conducted by Sukmawan & Riniarti (2022) evaluated various growth variables in oil palm seedlings, including PH, SD, NL, and other vegetative indicators. The results of the correlation matrix analysis showed that SD and NL were closely related, with R^2 values ranging from 0.519 to 0.765, depending on the parameters observed. This indicates that increasing SD is significantly related to increasing NL. Meanwhile, another study by Madusari et al. (2024) proved that liquid fertiliser derived from oil palm fibre waste can significantly increase vegetative growth, including stem height, diameter, and NL in oil palm seedlings (Rahnama et al., 2017).

In Table 6, it can be seen that the variable of 400 ml of *Aloe vera* LOF is strongly related to the NL of oil palm plants (as indicated by the ** sign). The variable of Aloe vera LOF has a significant effect on the NL (the value of the change in Sig. F <0.05, indicating a significant relationship). That *Aloe vera* LOF can significantly increase the number of oil palm leaves (Al-Huqail et al., 2023; Adu et al., 2022; Ajeng et al., 2020; Chen et al., 2018). Each treatment in this study can be seen in Figure 2.

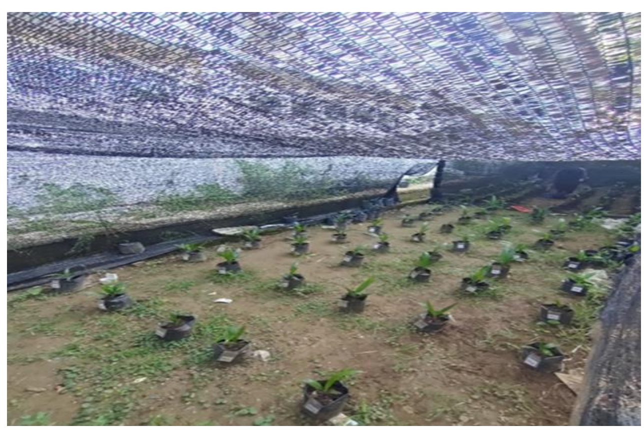

Figure 2. The top left row, number two from the end, is marked with S0 and is followed by the top right row marked S4 on oil palm seedlings.

4. Conclusion

The use of LOF Aloe vera at an optimal dose (200–400 mL) has a significant effect on the vegetative growth of oil palm seedlings, including increasing plant height, stem diameter, and leaf number. The phytohormone content (auxin, gibberellin, cytokinin) and humic acid play a role in accelerating cell division and elongation, strengthening the stem, and stimulating leaf formation. These results indicate that LOF Aloe vera has the potential to be an effective natural foliar fertilizer in strengthening the early phase of oil palm seedling growth.

References

Abdullah, U. H., Nurfaizah, N., Yana, D., Akbar, H., Wilis, R., & Rosa, E. (2024). Correlation analysis between watering interval, stem height, stem diameter, and number of leaves in jackfruit seedlings (*Artocarpus heterophyllus* Lamk). *JERAMI: Indonesian Journal of Crop Science, 7*(1), 10–17. https://doi.org/10.25077/jijcs.7.2.13-16.2024

Adu, M. O., Atia, K., Arthur, E., Asare, P. A., Obour, P. B., Danso, E. O., ... & Andersen, M. N. (2022). The use of oil palm empty fruit bunches as a soil amendment to enhance crop growth and yield: A meta-analysis. *Agronomy for Sustainable Development, 42*(2), 13. https://doi.org/10.1007/s13593-022-00753-z

Afifah, E. N., Sari, I. A., Susilo, A. W., Firmanto, H., Malik, A., Fukusaki, E., & Putri, S. P. (2025). Correlation between sensory attributes and metabolomic profiles of cocoa liquor from different cacao genotypes. *Food Chemistry: X,* 102498. https://doi.org/10.1016/j.fochx.2025.102498

Ajeng, A. A., Abdullah, R., Malek, M. A., Chew, K. W., Ho, Y. C., Ling, T. C., ... & Show, P. L. (2020). The effects of biofertilizers on growth, soil fertility, and nutrient uptake of oil palm (*Elaeis guineensis*) under greenhouse conditions. *Processes, 8*(12), 1681. https://doi.org/10.3390/pr8121681

Al-Huqail, A. A., Kumar, P., Kumari, S., & Eid, E. M. (2023). Biosolids application enhances the growth of *Aloe vera* plants and provides a sustainable practice for nutrient recirculation in agricultural soils. *Environmental Science and Pollution Research, 30*(47), 104246–104257. https://doi.org/10.1007/s11356-023-29763-4

Ariyanti, M., Maxiselly, Y., Rosniawaty, S., & Indrawan, R. A. (2019). The growth of oil palm with oil palm midrib organic fertiliser and humic acid. *Jurnal Penelitian Kelapa Sawit, 27*(2), 71–82. https://doi.org/10.22302/iopri.jur.jpks.v27i2.84

Canche-Escamilla, G., Colli-Acevedo, P., Borges-Argaez, R., Quintana-Owen, P., May-Crespo, J. F., Cáceres-Farfan, M., Yam Puc, J. A., Sansores-Peraza, P., & Vera-Ku, B. M. (2019). Extraction of phenolic components from an *Aloe vera* (*Aloe barbadensis* Miller) crop and their potential as antimicrobials and textile dyes. *Sustainable Chemistry and Pharmacy, 14,* 100168. https://doi.org/10.1016/j.scp.2019.100168

Chen, Y., Camps-Arbestain, M., Shen, Q., Singh, B., & Cayuela, M. L. (2018). The long-term role of organic amendments in building soil nutrient fertility: A meta-analysis and review. *Nutrient Cycling in Agroecosystems, 111*(2), 103–125. https://doi.org/10.1007/s10705-017-9903-5

Cheena, J., Veni, V. K., & Sreenivas, M. (2022). Effect of different organic manures and biofertilizers on growth and yield of aloe (*Aloe barbadensis*). *The Pharma Innovation Journal, 11*(5), 265–268.

Chowdhury, T., Chowdhury, M. A. H., Qingyue, W., Enyoh, C. E., Wang, W., & Khan, M. S. I. (2021). Nutrient uptake and pharmaceutical compounds of *Aloe vera* as influenced by integration of inorganic fertiliser and poultry manure in soil. *Heliyon, 7*(7), e07464. https://doi.org/10.1016/j.heliyon.2021.e07464

Corley, R. H. V., & Tinker, P. B. (2016). *The oil palm*. Wiley Blackwell. https://doi.org/10.1002/9781118953297

Cui, J., Lamade, E., & Tcherkez, G. (2020). Seed germination in oil palm (*Elaeis guineensis* Jacq.): A review of metabolic pathways and control mechanisms. *International Journal of Molecular Sciences, 21*(12), 4227. https://doi.org/10.3390/ijms21124227

Dubos, B., & De Raïssac, M. (2021). El Niño modifies nutrient status in oil palm and helps foliage to recover from yellowing symptoms: New analysis and perspectives. *Cahiers Agricultures, 30,* 34. https://doi.org/10.1051/cagri/2021021

El Sheriff, F. (2017). *Aloe vera* leaf extract as a potential growth enhancer for *Populus* trees grown under in vitro conditions. *American Journal of Plant Biology, 2*(4), 101–105. https://doi.org/10.11648/j.ajpb.20170203.13

Gunawan, M. F., Subroto, G., Savitri, D. A., & Farisi, O. A. (2024). Effect of dose and type of liquid organic fertiliser on early growth of cocoa seedlings (*Theobroma cacao* L.). *Protech Biosystems Journal, 3*(2), 102–109.

He, C., Wu, K., Zhang, J., Liu, X., Zeng, S., Yu, Z., Zhang, X., Teixeira da Silva, J. A., Deng, R., & Tan, J. (2017). Cytochemical localisation of polysaccharides in *Dendrobium officinale* and the involvement of DoCSLA6 in the synthesis of mannan polysaccharides. *Frontiers in Plant Science, 8,* 173. https://doi.org/10.3389/fpls.2017.00173

Husna, M., Salamah, U., Herman, W., & Agwil, W. (2023). The improvement of oil palm seedlings through shade, manure, and organic liquid fertiliser in Ultisol media. *Planta Tropika, 11*(1), 33–40. https://doi.org/10.18196/pt.v11i1.13415

Irmadhani, D., & Dewi, S. K. (2025). Efektivitas ZPT alami dari filtrat bawang merah dan lidah buaya terhadap pertumbuhan tanaman cabai rawit (*Capsicum frutescens* L.). *LenteraBio: Berkala Ilmiah Biologi, 14*(1), 35–41. https://doi.org/10.26740/lenterabio.v14n1.p35-41

Kédagni, D., & Mourifié, I. (2020). Generalized instrumental inequalities: Testing the instrumental variable independence assumption. *Biometrika, 107*(1), 35–47. https://doi.org/10.1093/biomet/asz051

Kumar, S., Kumar, R., & Dahiya, D. S. (2017). Effect of organic manures and biofertilizers on growth, yield, and quality of *Aloe vera* under semi-arid conditions. *Indian Journal of Agricultural Research, 51*(6), 594–598. https://doi.org/10.18805/IJARe.A-328

Liang, Y., Li, S., & Xu, Q. (2022). Long-term application of organic amendments improves soil fertility and crop productivity in tropical regions: A meta-analysis. *Soil and Tillage Research, 220,* 105354. https://doi.org/10.1016/j.still.2022.105354

Lombardi, N., Vitale, S., Turrà, D., Reverberi, M., Fanelli, C., Zjalic, S., ... & Altomare, C. (2018). Root exudates of stressed plants stimulate and attract *Trichoderma* soil fungi. *Molecular Plant-Microbe Interactions, 31*(10), 982–994. https://doi.org/10.1094/MPMI-01-18-0019-R

Lu, J., Yang, R., Zhao, H., Liu, B., Yang, Y., & Zeng, Y. (2019). Influence of *Aloe vera* extract on growth and physiological characteristics of wheat seedlings under drought stress. *Plant Physiology and Biochemistry, 145,* 197–205. https://doi.org/10.1016/j.plaphy.2019.10.029

Mahlia, T. M. I., Ismail, N., Hossain, M. A., & Silitonga, A. S. (2019). Palm oil and its sustainability: Challenges and opportunities. *Renewable and Sustainable Energy Reviews, 110,* 575–589. https://doi.org/10.1016/j.rser.2019.05.032

Mansor, M., Nor, N. M., & Wahab, N. A. (2021). Use of oil palm biomass for sustainable agriculture: A review. *Sustainability, 13*(18), 10447. https://doi.org/10.3390/su131810447

Manurung, E., Sembiring, M., & Situmeang, B. (2020). Pengaruh pemberian pupuk organik cair lidah buaya (*Aloe vera*) terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) di pembibitan awal. *Jurnal Agroekoteknologi FP USU, 8*(1), 76–82.

Marbun, M. S., Lubis, R., & Sitepu, I. R. (2023). Pengaruh kombinasi pupuk organik cair lidah buaya dan pupuk kandang ayam terhadap pertumbuhan bibit kakao (*Theobroma cacao* L.). *Agroteknologi Tropika, 12*(2), 92–98.

Martínez-González, J. C., González-Chávez, M. C. A., & Carrillo-González, R. (2017). Impact of organic amendments on the growth of *Aloe vera* and the dynamics of soil carbon and nitrogen in semiarid degraded soils. *Journal of Arid Environments, 142,* 16–24. https://doi.org/10.1016/j.jaridenv.2017.03.001

Munyuli, T., Wale, E., & Mungai, N. (2022). Biofertilizer use in Sub-Saharan Africa: A review of impacts on soil health and crop yield. *Agronomy, 12*(1), 114. https://doi.org/10.3390/agronomy12010114

Ndukwe, O. K., Akubugwo, E. I., & Onwuka, G. I. (2020). Comparative evaluation of *Aloe vera* leaf and cow dung as organic fertilisers on maize (*Zea mays* L.) performance. *Journal of Applied Science and Environmental Management, 24*(1), 49–54. https://doi.org/10.4314/jasem.v24i1.8

Nurtjahya, E., & Suyono, S. (2021). Growth response of oil palm seedlings (*Elaeis guineensis* Jacq.) to biofertilizer and organic matter application. *Jurnal Tanah dan Iklim, 45*(2), 127–136. https://doi.org/10.21082/jti.v45n2.2021.127-136

Okoroafor, U. C., & Ndukwe, O. K. (2021). Growth response of maize (*Zea mays* L.) to combined application of *Aloe vera* extract and NPK fertilizer. *Nigerian Journal of Agricultural Science, 3*(1), 18–24.

Panjaitan, S., Mulyadi, A., & Lubis, A. (2024). Pemberian kombinasi pupuk organik cair lidah buaya (*Aloe vera*) dan pupuk kandang sapi terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.). *Jurnal Pertanian Tropika, 11*(1), 23–29.

Rahman, S. A., Hashim, Z., & Nor, N. M. (2023). Integrated use of organic and inorganic fertilisers for sustainable oil palm production. *International Journal of Agricultural Sustainability, 21*(5), 678–691. https://doi.org/10.1080/14735903.2023.2175528

Rao, R., Rao, M., & Hossain, M. (2020). Organic amendments improve nutrient availability and soil health in tropical agriculture: A review. *Soil Systems, 4*(4), 70. https://doi.org/10.3390/soilsystems4040070

Rini, K. S., & Sulastri, L. (2023). Respon pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) terhadap pemberian pupuk organik cair lidah buaya (*Aloe vera*). *Agrotek Indonesia, 8*(1), 12–19.

Sembiring, D., Lubis, R., & Silaban, B. (2022). Pengaruh pemberian pupuk organik cair lidah buaya (*Aloe vera*) terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) di pembibitan utama. *Jurnal Agroekoteknologi FP USU, 10*(2), 112–120.

Singh, V. P., & Kumar, P. (2019). Role of *Aloe vera* in sustainable agriculture: A review. *International Journal of Current Microbiology and Applied Sciences, 8*(5), 2256–2264. https://doi.org/10.20546/ijcmas.2019.805.265

Situmorang, M., & Lubis, R. (2021). Pengaruh pemberian pupuk organik cair lidah buaya (*Aloe vera*) terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) di media gambut. *Jurnal Pertanian Tropika, 10*(2), 65–71.

Suhartono, R., Santoso, B. B., & Wijayanti, M. (2022). Application of compost and liquid organic fertiliser improves soil fertility and growth of *Elaeis guineensis*. *Tropical Plantation Journal, 9*(2), 102–110.

Tampubolon, D., Nasution, E. H., & Simanjuntak, P. (2023). Pengaruh pupuk organik cair lidah buaya terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.). *Jurnal Agroteknologi Tropika, 11*(2), 87–93.

Umar, S., Yusuf, R., & Natsir, M. (2024). Growth and physiological response of oil palm (*Elaeis guineensis* Jacq.) seedlings to organic fertiliser application. *Indonesian Journal of Agricultural Research, 7*(1), 22–29.

Wang, J., Zhang, L., & Yang, C. (2023). Effect of organic liquid fertilisers on photosynthetic rate and biomass accumulation in tropical perennial crops. *Agronomy Journal, 115*(4), 1678–1687. https://doi.org/10.1002/agj2.21113

Zhou, Y., Zhu, Y., & Wong, W. K. (2023). Biochar and organic fertiliser co-application enhances nutrient cycling and carbon sequestration in oil palm plantations. *Environmental Research, 232*, 116325. https://doi.org/10.1016/j.envres.2023.116325