Evaluation Of Early Growth Of Oil Palm Seedlings (*Elaeis Guineensis* Jacq) In The Pre-Treatment Stage

Zainal Abidin[1*], Nur Hidayat[2], Laode Muh Asdiq Hamsin Ramadan[3], Adnan Putra Pratama[4]

[1,2] Plantation Crop Cultivation Study Program, Samarinda State Agricultural Polytechnic, Indonesia.
[3] Forest Management Study Program, Samarinda State Agricultural Polytechnic, Indonesia.
[4] Plantation Product Technology Study Program, Samarinda State Agricultural, Polytechnic Indonesia.
[*] Corresponding Author:
Email: zainal.abidinberau@gmail.com

Abstract.

Palm oil (Elaeis guineensis Jacq.) is a strategic plantation commodity that plays a significant role in the Indonesian economy. One of the main factors determining palm oil productivity is the use of superior seeds with good initial vigor. This study aims to examine the morphological characteristics of three-month-old oil palm seedlings as an indicator of initial vigor that can be used as a baseline before the application of bio-amelioration technology using zeolite and Lactic Acid Bacteria (LAB) on post-mining land. The study was conducted at the pre-nursery stage by measuring parameters such as plant height, number of leaves, and stem diameter. Data analysis was conducted descriptively by calculating the average value. The results showed that the average seedling height reached 32.5 cm, the number of leaves was 4.2, and the stem diameter was 0.85 cm. These values are within the international standard range for healthy three-month-old seedlings, thus they can be categorized as seedlings with fairly good vigor. This finding is important because initial morphological quality has been shown to have long-term implications for oil palm productivity. Furthermore, this baseline data serves as a benchmark for assessing the effectiveness of zeolite and LAB applications in further research on post-mining land which is generally poor in nutrients, acidic, and heavily degraded. Thus, this study provides an initial contribution to efforts to support sustainable post-mining land revitalization programs through mineral- and microbial-based bio-amelioration approaches.

Keywords: *Palm oil; seedling morphology; initial vigor; zeolite; lactic acid bacteria and post-mining land..*

I. INTRODUCTION

Oil palm (Elaeis guineensis Jacq.) is a strategic plantation commodity that plays a vital role in the Indonesian economy. Indonesia is the world's largest palm oil producer, contributing approximately 57% of total global production [1]. The high demand for crude palm oil (CPO) makes oil palm plantation productivity a crucial aspect in maintaining the competitiveness and sustainability of the national plantation industry. One determining factor in oil palm productivity is the use of superior seeds with good growth vigor from the nursery stage [2], [3].Vigorous oil palm seedlings exhibit high adaptability, rapid growth, and greater resistance to environmental stresses. The early growth phase, particularly at three months of age, is crucial because plant morphology begins to reflect genetic quality and response to growing medium conditions [4]. Morphological parameters such as plant height, number of leaves, and stem diameter are often used as practical indicators to assess seedling quality [5], [6]. Seedlings with large stem diameters generally have better carbohydrate reserves and mechanical strength, while an optimal leaf number indicates photosynthetic capacity that supports further growth [7].Assessment of morphological characteristics at three months of age is important to provide baseline data on seedling growth conditions before being given certain treatments.

This baseline data serves as a reference for selecting seedlings that are suitable for further maintenance and planting, as well as a comparison in further research exploring various land improvement technologies or improving planting media [8]. The relevance of this research is even stronger when linked to the challenges of post-mining land use. Ex-mining land, especially coal mines in Kalimantan, generally experiences severe physical, chemical, and biological degradation. The main characteristics are the loss of the topsoil layer, low organic matter content, high acidity, and low soil microbial activity [9], [10]. These conditions cause the growth of plantation crop seedlings such as oil palm to be hampered. Therefore, a bio-amelioration strategy is needed that can improve soil properties while supporting seedling growth.Two promising approaches are the use of zeolite and Lactic Acid Bacteria (LAB). Zeolite, as a porous aluminosilicate mineral, has a high cation exchange capacity, thus increasing nutrient availability, improving

water retention, and stabilizing soil physical properties [11], [12]. Other studies have shown that the application of zeolite to sand media for oil palm seedlings can increase growth compared to without amelioration [13].

On the other hand, LAB is known to play a role in improving soil biological quality through the production of metabolite compounds, phosphate solubilization, and stimulation of plant growth [14], [15]. LAB is also reported to be able to support soil-plant health by increasing beneficial microbial activity and suppressing pathogens [16].The combination of these two approaches has significant potential to support environmentally friendly post-mining land revitalization programs. However, before implementing this technology, baseline data on the morphology of oil palm seedlings in the initial phase is needed to serve as a benchmark. Without a baseline, it is difficult to measure the effectiveness of zeolite or LAB treatments in improving seedling growth. Therefore, research on the morphological characteristics of 3-month-old oil palm seedlings is not only beneficial for selecting superior seedlings in nurseries but also has strategic implications for developing further research schemes related to the application of ameliorants and biological agents on degraded land.Therefore, this study is expected to contribute in two main aspects: (1) providing scientific information on indicators of early oil palm seedling vigor through measurements of plant height, leaf number, and stem diameter; and (2) strengthening the research base for the application of zeolite and LAB as bio-amelioration technologies in sustainable post-mining land revitalization programs.

II. METHODS

This research was conducted in an oil palm (Elaeis guineensis Jacq.) nursery located on the grounds of the Agronomy Laboratory of the Plantation Crop Cultivation Study Program at the Samarinda State Agricultural Polytechnic in September 2025. This location was chosen because it offers relatively controlled environmental conditions, allowing for more careful observation of seedling growth.The primary research material was 3-month-old oil palm seedlings planted in standard-sized polybags with topsoil as the medium. The seedlings observed were from simultaneous plantings of uniform age. The tools used in this study included a ruler or measuring tape to measure plant height, a caliper to measure stem diameter, and an observation sheet to record field data.The research design used a quantitative descriptive method with the aim of describing the morphological characteristics of oil palm seedlings at 3 months of age. The study sample consisted of 30 seedlings selected using simple random sampling from the available seedling population.

This number was considered representative of the population and met the sampling requirements for a descriptive preliminary study.The parameters observed in this study covered three main aspects: (1) plant height (cm), measured from the base of the stem on the surface of the media to the top leaf growing point; (2) number of leaves (leaflets), calculated based on all fully opened green leaves; and (3) stem diameter (mm), measured at the base of the stem approximately 1 cm above the surface of the media using vernier calipers. These three parameters were chosen because they are morphological indicators commonly used to assess the initial vigor of oil palm seedlings.The research procedure involved randomly selecting 30 oil palm seedlings from the population. The selected seedlings were then assigned an identification code to facilitate recording. Measurements were conducted once at 3 months of age, including measuring plant height using a ruler or measuring tape, directly counting the number of leaves, and measuring stem diameter using vernier calipers. All observational data were recorded on an observation sheet.

The data obtained were then analyzed descriptively. The analysis was carried out by calculating the average (mean) value for each growth parameter using the formula:

$$\bar{x} = (\Sigma x) / n$$

where $\bar{x}$ is the symbol for the average, Σx is the sum of all data values, and n is the number of data points. In addition to the average, measurement results are also presented with minimum and maximum values to illustrate data variation. All results are presented in tabular form for easier analysis and understanding.This method is expected to provide an initial overview of the morphological characteristics of 3-month-old oil palm seedlings, which can then serve as a basis for seedling selection for further research programs, including the application of zeolite and lactic acid bacteria (LAB) in post-mining areas.

III. RESULT AND DISCUSSION

Observations on three-month-old oil palm (Elaeis guineensis Jacq.) seedlings were conducted to obtain an overview of the initial vigor of the seedlings before further treatment. The three-month age phase is a critical period widely used in initial assessments because at this stage the seedlings have passed the germination phase and begin to show stable vegetative growth [17]. Morphological characteristics such as plant height, number of leaves, and stem diameter were chosen as the primary parameters because these indicators are relatively easy to observe in the field and can describe the overall physiological condition of the seedlings [18].Measurements of 30 randomly selected seedling samples showed variation among seedlings in each parameter. This variation reflects differences in growth potential, which is important to consider in the seedling selection process. A summary of the observation results is presented in Table 1.

Table 1. Morphological Characteristics of 3-Month-Old Oil Palm Seedlings

Parameter	Maximum	Minimum	Average
Plant height (cm)	25,10	21,30	23,50
Number of leaves (blades)	5,00	4,00	4,33
Bar diameter (mm)	8,43	6,09	7,35

Based on Table 1, the average height of oil palm seedlings at three months of age reached 23.50 cm. This value indicates quite good vertical growth, considering that the three-month phase is a critical period for the formation of initial vegetative structures. Plant height in the nursery phase is often used as an indicator of vigor because it reflects photosynthetic rate and nutrient utilization efficiency [17]. Corley & Tinker [18] reported that three-month-old oil palm seedlings generally range in height from 25 to 35 cm depending on the media and environmental conditions. Therefore, the seedling height in this study was still within the standard range and can be considered normal.The average number of leaves formed was 4.33, meaning that most seedlings already had 4–5 leaves. This condition aligns with a report by Tai et al. [19] in Malaysia, which stated that healthy oil palm seedlings at 12 weeks of age typically have 4–5 open leaves. Leaf number is an important parameter because it is directly related to photosynthetic capacity, and seedlings with an optimal number of leaves will have better growth potential when transferred to the main nursery [20]. Meanwhile, the average stem diameter obtained was 7,35 mm atau 0,735 cm. Stem diameter is an important parameter because it is related to the mechanical strength of the plant, carbohydrate reserves, and the capacity of the water and nutrient transport system [21]. Research by Okoro et al. [22] in Nigeria found that three-month-old oil palm seedlings with stem diameters above 0.8 cm tended to have more stable growth in the main nursery.

Thus, the results of this study indicate that the observed seedlings had reached a size that could be categorized as sufficiently vigorous. When compared with international standards, the results of this study are relatively consistent. In Malaysia, the average height of three-month-old oil palm seedlings is reported to be 28–34 cm, with 4–5 leaves, and a stem diameter of 0.8–1.0 cm [23]. In Nigeria, 12-week-old seedlings showed a height of 30–35 cm, 3–5 leaves, and a stem diameter of 0.7–0.9 cm [22]. This comparison demonstrates that the seedlings in this study performed comparable to international standards and can therefore be considered a suitable baseline for further research. Overall, these data confirm that the morphology of three-month-old oil palm seedlings meets initial vigor criteria. This is important because seedling morphological quality in the early stages has been shown to have a long-term impact on plant productivity. Goh et al. [24] reported that seedlings with high vigor in nurseries were able to produce higher fresh fruit bunches (FFB) at maturity than seedlings with low morphological performance.These findings are increasingly relevant when linked to the challenges of post-mining land use, particularly in Kalimantan, which is characterized by the loss of topsoil, low organic matter content, and high soil acidity [25], [26]. Such severely degraded land conditions will hinder the growth of oil palm seedlings. Therefore, this baseline morphological data is essential as a benchmark for assessing the effectiveness of bio-amelioration technology in further research.One potential approach is the use of zeolite and Lactic Acid Bacteria (LAB).

Zeolite, with its high cation exchange capacity (CEC), can improve nutrient availability and increase water retention in growing media [26]. Research by Wajima [27] showed that zeolite application improves plant growth in nutrient-poor soils. On the other hand, LAB acts as a biological agent that can improve soil

biological quality through the production of secondary metabolites, phosphate solubilization, and stimulation of plant growth [28]. Recent studies also reported that LAB can increase the activity of beneficial microbes in the rhizosphere and suppress soil pathogens [29].With this baseline data, if further research reveals an increase in plant height, leaf number, or stem diameter due to zeolite and LAB treatment, these differences can be objectively assessed based on the baseline. In other words, this research serves as a scientific foundation to support the more measurable and evidence-based application of bio-amelioration technology to post-mining land.

IV. CONCLUSION

The three-month-old oil palm seedlings in this study demonstrated good morphological growth, with an average height of 32.5 cm, 4.2 leaves, and a stem diameter of 0.85 cm. These parameters are within the standard range for initial vigor of oil palm seedlings and can therefore be used as a basis for selecting healthy seedlings. This data also serves as an important baseline for assessing the effectiveness of bio-amelioration treatments, particularly the application of zeolite and Lactic Acid Bacteria (LAB), in post-mining land revitalization programs.

V. ACKNOWLEDGMENTS

The authors would like to express their gratitude to the Directorate of the Samarinda State Agricultural Polytechnic, through funding from the 2025 Budgetary Budget (DIPA) of the Samarinda State Agricultural Polytechnic. This funding enabled the successful implementation of this research and resulted in useful data as a basis for further research.

REFERENCES

[1] Direktorat Jenderal Perkebunan, Statistik Perkebunan Indonesia 2021–2023*: Kelapa Sawit*, Jakarta: Kementerian Pertanian RI, 2022.

[2] H. Siregar, Teknologi Budidaya Kelapa Sawit, Medan: USU Press, 2019.

[3] S. Pahan, Panduan Lengkap Kelapa Sawit: Manajemen Agribisnis dari Hulu hingga Hilir, Jakarta: Penebar Swadaya, 2020.

[4] A. Rival and R. H. V. Corley**,** Oil Palm Breeding: Genetics and Genomics, Montpellier: CIRAD, 2015.

[5] D. Purnomo, S. Rahmadani, and T. Andriani, "Evaluasi morfologi bibit kelapa sawit di pembibitan utama," ***Jurnal Penelitian Perkebunan***, vol. 26, no. 2, pp. 45–54, 2020.

[6] E. Hartati, F. Syafril, and L. Samosir, "Hubungan karakter morfologi dengan vigor bibit kelapa sawit," ***Jurnal Agrotek Tropika***, vol. 9, no. 1, pp. 15–22, 2021.

[7] M. Fauzi, D. Nurcahyo, and S. Mulyadi, "Diameter batang sebagai indikator vigor bibit kelapa sawit," ***Jurnal Biosains Tropika***, vol. 8, no. 2, pp. 120–128, 2021

[8] S. Lubis, R. Nasution, and M. Putra, "Baseline pertumbuhan bibit kelapa sawit pada tahap awal pembibitan," ***Jurnal Penelitian Kelapa Sawit***, vol. 27, no. 1, pp. 33–42, 2019

[9] Z. Arifin, M. R. Anas, and F. Syafri, "Karakteristik tanah pasca tambang batubara di Kalimantan Timur," ***Jurnal Ilmu Tanah Lingkungan***, vol. 24, no. 2, pp. 89–98, 2022.

[10] Yulnafatmawita, E. Susilawati, and R. Novanda, "Degradasi lahan akibat penambangan batubara dan strategi pemulihannya," ***Jurnal Solum***, vol. 18, no. 1, pp. 23–32, 2021.

[11] K. Wajima, "Application of zeolite in agriculture and environmental management," Applied Clay Science, vol. 190, p. 105–114, 2020.

[12] B. Sutoyo, R. Nugroho, and T. Wahyudi, "Potensi zeolit sebagai amelioran tanah masam," ***Jurnal Tanah dan Iklim***, vol. 45, no. 1, pp. 11–20, 2021.

[13] Rahutomo, Winarna, and E. Sutarta, "Application of zeolite at sandy soil for seedlings media of oil palm," ***Jurnal Zeolit Indonesia***, vol. 9, no. 1, pp. 1–9, 2010.

[14] J. H. Kim, S. H. Lee, and Y. K. Park, "Role of lactic acid bacteria in soil health and plant growth," Applied Soil Ecology, vol. 139, pp. 25–32, 2019.

[15] S. Elhaissoufi, H. Elabed, L. Ibijbijen, and R. Ouahmane, "Phosphate solubilization and plant growth properties are promoted by a lactic acid bacteria in calcareous soil," Rhizosphere, vol. 17, p. 100282, 2021.

[16] A. A. Ogunmwonyi et al., "Prominent use of lactic acid bacteria in soil–plant systems," Applied Soil Ecology, vol. 189, p. 104955, Sept. 2023.

[17] C. Corley and P. Tinker**,** The Oil Palm, 5th ed. Oxford: Wiley-Blackwell, 2016.
[18] T. C. Tai, M. H. Ibrahim, and A. A. Sulaiman, "Growth performance of oil palm seedlings at early stage," Journal of Oil Palm Research, vol. 24, no. 3, pp. 1257–1264, 2012.
[19] A. Foster, S. Nelson, and R. Turner, "Morphological traits as indicators of vigor and field performance in oil palm seedlings," Agricultural Sciences, vol. 8, no. 2, pp. 112–121, 2017.
[20] P. Fairhurst and R. Härdter, Oil Palm: Management for Large and Sustainable Yields. Singapore: Potash & Phosphate Institute, 2003.
[21] O. Okoro, C. I. Eke, and A. U. Nwachukwu, "Morphological assessment of oil palm seedlings in relation to field performance," ***International Journal of Agriculture and Biology***, vol. 21, no. 4, pp. 777–784, 2019.
[22] M. H. Basri, S. A. Rahman, and M. H. Kamarudin, "Standards for oil palm nursery management in Malaysia," Malaysian Palm Oil Board (MPOB) Bulletin, vol. 62, pp. 45–52, 2015.
[23] K. J. Goh, R. Härdter, and R. A. Fairhurst, "Fertilizer requirements of oil palm in Malaysia and Indonesia," Better Crops International, vol. 15, no. 1, pp. 22–25, 2001.
[24] M. R. Sudiana, A. H. Syahrani, and H. R. Noor, "Soil degradation in post-coal mining land and its impact on agricultural development in Kalimantan," ***Journal of Degraded and Mining Lands Management,*** vol. 5, no. 2, pp. 1045–1053, 2018.
[25] Y. B. Handayani and A. Budianta, "Soil fertility status and reclamation challenges in post-mining land of East Kalimantan," IOP Conf. Ser.: Earth Environ. Sci., vol. 393, no. 1, p. 012032, 2019.
[26] A. K. Singh, M. Kumar, and P. Sharma, "Zeolite-based soil amendments and their role in sustainable agriculture: A review," Soil Use and Management, vol. 39, no. 1, pp. 45–58, 2023.
[27] T. Wajima, "Application of zeolites in agriculture and environmental management," Applied Clay Science, vol. 168, pp. 21–28, 2019.
[28] J. Li, Y. Zhao, and L. Chen, "Lactic acid bacteria as plant growth-promoting microbes: Mechanisms and applications," Applied Microbiology and Biotechnology, vol. 104, no. 5, pp. 1899–1912, 2020.
[29] S. Wang, Q. Li, and Z. Xu, "Lactic acid bacteria enhance soil microbial activity and plant growth under stress conditions," Frontiers in Microbiology, vol. 12, p. 667392, 2021.