

Effect of Organic Matter Types and Decomposition Times on the Growth of Oil Palm Seedlings in the Pre-Nursery Stage

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ABSTRACT

The growth of oil palm seedlings is greatly influenced by the quality of the planting medium, including the organic matter content used. The decomposition period of organic matter also determines the availability of nutrients for the plants from the early stages of growth. This study aimed to examine the effect of different types of organic matters and decomposition time on the growth of oil palm seedlings in pre-nursery cultivation. This study used a factorial experiment with a completely randomized design (CRD) consisting of two factors and three replications. The first factor was various types of organic matters (manure, legumes, water hyacinth). The second factor was the decomposition time of the organic matters observed in the first, second, and third weeks. Data from the research results were analyzed using analysis of variance (ANOVA) with a significance level of 5%. If significant difference was found, it was followed by the Duncan's Multiple Range Test (DMRT) at a 5% significance level. The results of this study generally showed that legume organic matters provided more stable and tend to be better results compared to manure and water hyacinth organic matters for all growth parameters of oil palm seedlings at the pre-nursery stage. Statistically, the results did not show significant differences between treatments. However, numerically, legume organic matters are more consistent in supporting the vegetative growth of oil palm seedlings. This research contributes not only to the technical aspects of cultivation but also enhances the understanding of the benefits of legume biomass as an effective and efficient nutrient source in supporting the early growth of oil palm seedlings.

Keywords: Organic matters, Decomposition times, Oil palm, Pre-nursery

INTRODUCTION

Farmers are beginning to embrace organic soil conditioners and fertilizers since they are thought to be more environmentally friendly and

boost agricultural output. The quality of the growing media has a big impact on how well oil palm seedlings grow. One method is by adding

organic matter, which is crucial for enhancing the soil's biological, chemical, and physical characteristics [1] [2]. By improving soil structure, cation exchange capacity, and nutrient availability, organic matter can promote the growth of plant canopies and roots [3].

Oil palm seedlings' early growth, particularly in the nursery stage, depends heavily on the nutrients they receive from organic matters [4]. Oil palm seedlings' early growth, particularly in the nursery stage, depends heavily on the nutrients they receive from organic matters [5]. It is still uncommon to use organic matter derived from plant degradation. For oil palm seedling nurseries to succeed, it is essential to comprehend the function of organic matter and the time it takes for them to decompose.

Manure is still the primary organic matter utilized in oil palm nurseries at the moment [6]. Actually, water hyacinth and legumes have a lot of potential as organic matter sources. As a source of organic matter for plants, legumes offer a lot of promise [7][8]. It is a sustainable agricultural practice since its application in conservation systems promotes soil productivity and health [9]. There is a lot of promise for water hyacinth (*Eichhornia crassipes*) as a plant source of organic matter [10][11]. However, the amount of time organic matter takes to decompose before being added to the planting media has a significant impact on how successful it is. When organic matter is introduced to soil, its functional qualities depend on its maturity and stability, which is correlated with the composition's evolution and increases the soil amendment's efficacy [12]. For oil palm seedlings to maintain root and canopy growth, organic matter must supply the necessary nutrients [13]. Therefore, more research must be done in order to give farmers more precise knowledge about organic matters and the best times for decomposition.

Good soil is composed of organic matter that helps with soil fertilization. Organic matter is frequently created by a group of organisms undergoing decomposition. Furthermore, organic matter is consist of substances that can be quickly decomposed by microorganisms, typically plant components like

fruits or leaves. The core element of sustaining soil fertility is organic matter. Farmers will benefit more from soil that retains its fertility. Organic matter can be used to produce fertilizer in addition to preserving soil fertility. One benefit of using organic fertilizers is that they provide little hazards. Chemical fertilizers, on the other hand, will have long-term negative impacts on the soil. Any organic compound that has experienced a change in its chemical composition is considered organic matter. The accumulation of organic substances that have weathered, whether naturally or intentionally, is another definition of organic matter. Organic matter is typically the consequence of the buildup of decomposed and weathered plant or animal remains.

The decomposition of organic wastes or organic matter in the soil is carried out by soil microorganisms, including bacteria, fungus, and actinomycetes. A range of organic and inorganic substances will be created if plant tissues in the soil break down as a result of the actions of different microbes. Phosphates (PO_4), sulfates (SO_4), nitrates (NO_4), ammonia (NH_3), carbon dioxide (CO_2), water (H_2O), and a number of other elements including calcium (Ca) are readily formed from proteins and carbohydrates. Decomposition of oils, fats, and waxes is comparatively challenging. The end product of the breakdown process is humus, a black material with a colloidal size. In the soil, humus has a strong buffering capacity, a high capacity to absorb water and nutrients, and other functions.

Numerous studies showed that land degradation and a decrease in productivity have occurred on the majority of intensive agricultural farms, especially in relation to the soil's extremely low organic carbon concentration of 2%. However, about 2.5% organic carbon is required to reach maximum productivity. Organic fertilizers are highly advantageous for boosting agricultural output in terms of both quality and quantity, lowering pollution levels in the environment, and enhancing land quality in a sustainable manner. Long-term application of organic fertilizers can stop land degradation and boost land production. With a wide variety of physical properties and chemical components, the sources of materials for

organic fertilizers are quite varied, and the use of organic fertilizers has different effects on crops and land. Additionally, it plays a major part in enhancing the ecosystem and the soil's biological, chemical, and physical qualities. Humus is created when soil microorganisms break down organic fertilizers that have been given to the soil over a number of stages.

Lack of precise knowledge about the best organic ingredients to support pre-nursery oil palm seedling growth and the appropriate decomposition durations remains a significant issue underlying this study. The problem to be addressed in this study is which organic matters and decomposition durations are more effective in supporting the early growth of oil palm seedlings. Therefore, the purpose of this study is to scientifically investigate

the effects of various organic matters and decomposition times on oil palm seedling growth. As a result, this study is expected to provide nursery practitioners with useful scientific insights and practical solutions.

This research contributes new knowledge into the utilization of legumes and water hyacinth as organic matters, which, have not been extensively explored in oil palm nurseries. These organic matters support optimal root, canopy, and overall biomass growth of seedlings by improving soil structure and gradually enhancing nutrient availability. The effective use of organic matters is expected to improve oil palm seedling production efficiency and lessen reliance on costly and less environmentally friendly chemical fertilizers.

MATERIALS AND METHODS

This study employed a factorial experiment using a completely randomized design (CRD) with three replications and two factors. The first factor was the type of organic matter (B), consisting of four levels: no organic matter (B0), manure (B1), leguminous plants (B2), and water hyacinth (*Eichhornia crassipes*) (B3). The second factor was the decomposition time of the organic matter's (M), which included three levels: one week (M1), two weeks (M2), and three weeks (M3).

Twelve treatment combinations were applied based on these two factors, and each treatment was replicated three times with three samples. Analysis of variance (ANOVA) was used to examine the data from the study at a 5% significant level. The Duncan test or DMRT (Duncan multiple range test) was used to determine significant differences between treatments at the same significance level.

RESULTS AND DISCUSSION

Effect on Plant Height

Table 1 shows that different types of organic matters and decomposition times had an impact on the height of oil palm seedlings in the pre-nursery stage. The water hyacinth treatment with a 3-week decomposition period had the highest average seedling height (55.83 cm), while the water hyacinth treatment with a 1-week decomposition time had the lowest average (43.30 cm).

In general, organic matters from legumes provide more stable high growth for seedlings compared to other organic matters at all decomposition times. However, the ANOVA results showed no significant interaction between

the organic matter type and the decomposition time. Numerically, legume tended to be more stable in supporting the high growth of oil palm seedlings compared to other organic matters.

The high nitrogen content in legumes, which is crucial for plants' vegetative growth phase, contributes to the stability of seedling height growth [14]. Legumes also decompose more rapidly, which speeds up the availability of nutrients for plants [15]. On the other hand, several studies have found that manure consistently enhances seedling growth [16]. Therefore, this study provides new insights for oil palm nursery practitioners regarding the potential of legumes as

an environmentally acceptable, alternative organic substrate that supports steady seedling growth.

Table 1. Effect of organic matter types and decomposition times on pre-nursery oil palm seedling height (cm).

Treatment	Manure	Legume	Water Hyacinth	Mean
One week	48.16	52.81	43.30	49.10 a
Two weeks	51.50	50.73	54.74	50.82 a
Three Weeks	48.56	53.70	55.83	53.32 a
Mean	49.41 p	52.41 p	51.29 p	(-)

Note : means followed by the same letter in the same column or row indicate not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level
(-) : no significant interaction

Effect on Number of Leaves

Although the type of organic matter and the decomposition time affected the number of oil palm seedling leaves at the pre-nursery stage, Table 2 shows no statistically significant differences according to DMRT at the 5% significance level. The treatment using water hyacinth decomposed for two weeks produced the highest average number of leaves (12.90 leaves). Meanwhile, the treatment with water hyacinth decomposed for one week resulted in the lowest average (11.00 leaves).

Compared to other organic matters, legume organic matter consistently produced more uniform leaf count values at every decomposition stage. The ANOVA finding indicated no significant interaction between the type of organic matters and decomposition time. Nonetheless, legume organic matter tended to result in more

stable leaf count outcomes, suggesting their potential as a reliable input for seedling growth.

Higher nitrogen levels in legumes are thought to be the cause of this stability. Nitrogen is crucial for plant vegetative growth and can enhance aeration and growing medium structure [17][18]. Higher concentrations of organic carbon and total nitrogen are produced when legume matters are added to the soil, which benefits plant development [19]. Nonetheless, some research claimed that manure is better since it has a wider variety of macro and micronutrients [16]. The novelty of this research lay in the combination of using legume organic matters and decomposition time, which had not been extensively studied before-specifically for oil palm seedlings in pre-nursery stage. This study provided new insights, showing that legumes have the potential to serve as a more environmentally friendly organic planting medium and consistently support leaf growth.

Table 2. Effect of organic matter types and decomposition times on leas number of pre-nursery oil palm seedlings (leaves).

Treatment	Manure	Legume	Water Hyacinth	Mean
One week	12.70	12.00	11.00	11.93 a
Two weeks	12.60	12.60	12.90	12.53 a
Three Weeks	12.00	12.90	12.60	12.63 a
Mean	12.43 p	12.50 p	12.17 p	(-)

Note : means followed by the same letter in the same column or row indicate not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level
(-) : no significant interaction.

Effect on Root Length

Table 3 shows that the type of organic matter and decomposition time had an effect on the root length of oil palm seedlings. However statistically speaking, the Duncan test at the 5% level did not show any significant differences. The manure treatment decomposed for one week produced the longest roots (84.84 cm). Meanwhile, the water hyacinth treatment that was degraded for three weeks had the shortest roots (54.67 cm). Compared to other organic matters, root lengths resulting from legume organic matters were more consistent across different decomposition times. During the pre-nursery stage, the use of legume organic matters more consistently supports the root growth of oil palm seedlings.

Although no statistically significant difference was observed, legume organic matters generally demonstrated greater stability in sustaining the root length growth of oil palm seedlings during the pre-nursery stage compared to other organic matters. This may be attributed to their high nitrogen content, which promotes stronger and longer root development [20]. Furthermore, legume matters are a useful organic supplement for sustainable agriculture because they can improve nitrogen cycling and soil microbial activity [21]. However, several studies have reported that manure regularly enhances root growth [22]. The novelty of this research is providing new information that legumes have the potential to be an alternative organic matter that is more environmentally friendly and stable in supporting the growth of oil palm seedling root length in the pre-nursery.

Table 3. Effect of organic matter types and decomposition on the root length of pre-nursery oil palm seedlings (cm).

Treatment	Manure	Legume	Water Hyacinth	Mean
One week	84.84	72.67	65.17	69.17 a
Two weeks	60.00	70.16	73.66	63.83 a
Three Weeks	56.67	68.50	54.67	65.46 a
Mean	67.17 p	70.44 p	64.50 p	(-)

Note : means followed by the same letter in the same column or row indicate not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level

(-) : no significant interaction

Effect on Fresh Root Weight

Table 4 shows that the fresh root weight of oil palm seedling was influenced by the type of organic matter and the decomposition time. However, the ANOVA test indicated no significant interaction between the types of organic matter and the decomposition times. Neither actor had a statistically significant effect on the fresh root weight of oil palm seedlings. The highest fresh root

weight was recorded in the treatment with manure decomposed for 2 weeks, which was 2.77 grams. Meanwhile, the lowest fresh root weight was found in the treatment with water hyacinth decomposed for 1 week, which was 1.24 grams. Manure organic matter tended to produce higher fresh root weight compared to legumes and water hyacinth across all decomposition times. These findings suggest that manure has greater potential to enhance the fresh root weight of oil palm seedlings during the pre-nursery stage.

Table 4. Effect of organic matter types and decomposition times on the fresh root weight of pre-nursery oil palm seedlings (g).

Treatment	Manure	Legume	Water Hyacinth	Mean
One week	2.1	2.07	1.24	1.83 a
Two weeks	2.77	2.1	2.25	2.18 a
Three Weeks	2.31	2.5	2.19	2.48 a
Mean	2.39 p	2.22 p	1.89 p	(-)

Note : means followed by the same letter in the same column or row indicate not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level

(-) : no significant interaction

Effect on Root Dry Weight

Table 5 shows the type of organic matter and the decomposition times on the dry weight of oil palm seedling roots at the pre-nursery stage. The different kinds of organic matter and the decomposition time did not significantly interact, according to the ANOVA results. The dry root weight of the oil palm seedlings was not greatly impacted by the types of organic matters or the decomposition times. The legume treatment with a 3-week decomposition produced the highest root dry weight, weighing 0.75 grams. At 0.32 grams, the water hyacinth treatment had the lowest root dry weight after one week of decomposition. Across all decomposition times, the organic matter from legumes had more consistent and generally higher root dry weight results than other organic matters. When it comes to helping oil palm seedlings at the pre-nursery stage increase their dry

root weight, legume organic matter works better than manure and water hyacinth.

By improving soil structure, aeration, and porosity—all of which are critical for root growth—legume matters can strengthen the physical structure of organic legume cover crops (CC) [26]. There are notable advantages to using legumes in the planting system for agricultural activities, as evidenced by the growing medium's enhanced physical structure, which efficiently promotes root growth [9]. The novelty of this research lies in demonstrating that legumes consistently support the dry root weight of oil palm seedling under pre-nursery conditions, a finding that hasn't been thoroughly examined before. This finding also contributes to develop sustainable and eco-friendly oil palm nursery practices.

Table 5. Effect of organic matter types and decomposition times on the dry root weight of pre-nursery oil palm seedlings (g).

Treatment	Manure	Legume	Water Hyacinth	Mean
One week	0.49	0.52	0.32	0.49 a
Two weeks	0.72	0.64	0.66	0.61 a
Three Weeks	0.47	0.75	0.61	0.69 a
Mean	0.56 p	0.64 p	0.53 p	(-)

Note : means followed by the same letter in the same column or row indicate not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level

(-) : no significant interaction

Effect on Fresh Canopy Weight

Although the Duncan test at the 5% level did not show statistically significant differences,

Table 6 shows that the fresh weight of oil palm seedling canopies at the pre-nursery stage was influenced by the type of organic matter and decomposition time. The treatment with water

hyacinth decomposed for two weeks had the highest fresh canopy weight (8.84 grams). Meanwhile, the treatment with water hyacinth decomposed for one week had the lowest (4.71 grams). The ANOVA results indicated there was no significant interaction between the types of organic matter and the decomposition times. The fresh weight of oil palm seedling canopies was not significantly affected by the different types of organic matter or the decomposition times. However, compared to other organic matters, legume organic matters generally provided more consistent results and tended to produce higher fresh canopy weights. One significant finding from this study is that organic matters derived from legumes shows higher

potential to continuously sustain the growth in fresh weight of the canopies of oil palm seedlings during the pre-nursery stage. The addition of organic legume matters enhances soil texture and structure, thereby stimulates aeration and porosity for plant growth [27]. Legumes also contribute to better physical structure of the growing medium by elevating its porosity and cation exchange capacity—all of which are essential for supporting the growth of canopy biomass [19]. In addition to developing environmentally friendly oil palm nursery technology that can be used in the field, this research's novelty highlights that using legume organic matters consistently enhances the fresh weight of oil palm seedlings in the pre-nursery stage.

Table 6. Effect of organic matter types and decomposition times on fresh canopy weight of pre-nursery oil palm seedlings (g).

Treatment	Manure	Legume	Water Hyacinth	Mean
One week	6.51	7.46	4.71	6.65 a
Two weeks	8.18	7.69	8.84	7.62 a
Three Weeks	6.34	8.62	8.78	8.20 a
Mean	7.01 p	7.92 p	7.44 p	(-)

Note : means followed by the same letter in the same column or row indicate not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level
 (-) : no significant interaction

Effect on Dry Canopy Weight

Table 7 shows that the dry weight of oil palm seedling canopies was influenced by the type of organic matter and decomposition time, although statistically did not show significant differences based on the Duncan test at the 5% level. The water hyacinth treatment with two weeks of decomposition produced the canopies with the highest dry weight (2.16 grams). Meanwhile, the water hyacinth treatment with one week of decomposition produced the lowest dry weight (1.07 grams). When compared to other organic matters at different decomposition times, legume organic matters generally offered more stability and tended to produce higher dry weight results of the canopies. During the pre-nursery stage, legume organic matters were more likely to reliably

increase the dry weight of the canopies of palm oil seedlings.

The high nitrogen content and easy decomposition of legume organic matters increase the availability of nutrients for plant canopy growth, improving soil fertility, and nitrogen fixation [28]. Nitrogen components are released more quickly from legume matters, giving plants vital nutrients [29][7]. As a result, the research's novelty is in demonstrating that, in comparison to other organic materials, legume organic materials are more reliable and efficient at raising the dry weight of oil palm seedlings in the pre-nursery stage. This finding significantly advances the development of legume-based organic planting media technology, which is more beneficial to the environment, useful, and applicable in oil palm nurseries.

Table 7. Effect of organic matter types and decomposition times on dry canopy weight of pre-nursery oil palm seedlings (g).

Treatment	Manure	Legume	Water Hyacinth	Mean
One week	1.39	1.7	1.07	1.51 a
Two weeks	1.86	1.79	2.16	1.80 a
Three Weeks	1.45	2.02	2.05	1.93 a
Mean	1.57 p	1.84 p	1.76 p	(-)

Note : means followed by the same letter in the same column or row indicate not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level

(-) : no significant interaction

Effect on Plant Dry Weight

Table 8 shows that the total dry weight of oil palm plants at the pre-nursery stage was influenced by the type of organic matter and decomposition time, but statistically did not show significant differences based on the Duncan test at the 5% level.

The water hyacinth treatment with a 2-week decomposition time produced the highest

plant dry weight (2.83 grams). Meanwhile the water hyacinth treatment with a 1-week decomposition time resulted in the lowest dry weight (1.38 grams). Compared to other organic matters at different decomposition times, legume organic matters consistently provided more stable and greater dry weight results. The total dry weight of oil palm seedlings at the pre-nursery stage might be increased more consistently by legume organic ingredients.

Table 8. Effect of organic matter types and decomposition times on plant dry weight of pre-nursery oil palm seedlings (g).

Treatment	Manure	Legume	Water Hyacinth	Mean
One week	1.88	2.22	1.38	1.99 a
Two weeks	2.58	2.4	2.83	2.42 a
Three Weeks	1.92	2.74	2.65	2.61 a
Mean	2.13 p	2.45 p	2.29 p	(-)

Note : means followed by the same letter in the same column or row indicate not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level

(-) : no significant interaction

Legume organic matters has high nitrogen content and may decompose easily, thus providing nutrients to plants more efficiently. It is effective in supplying vital nutrients for plants because of its rapid decomposition, which enhances nutrient availability [30]. Because of their organic matter, legume materials have the ability to enhance soil nitrogen levels and the growth of succeeding plants [31]. As a result, agronomically, legume organic matters have shown more consistency in raising the total dry weight of oil palm seedlings, though not

being statistically substantially different. Therefore, by directly evaluating the efficacy of legumes—which were previously more commonly known as cover crops but have not been frequently used especially as nursery planting media—this study offers innovation. The growth of nursery science will benefit from this discovery, which also serves as a guide for enhancing pre-nursery organic-based, eco-friendly oil palm planting media.

CONCLUSION

The results of this study generally indicated that legume organic matters provided more stable and tended to be better results compared to manure and water hyacinth organic matters for all growth parameters of oil palm seedlings at the pre-nursery stage, including seedling height, number of leaves, root length, fresh root weight, dry root weight, fresh shoot weight, dry shoot weight, and total dry weight of the plants. Numerical results indicated that legume organic matters were more consistent in enhancing the vegetative growth of oil palm seedlings, even though statistical data did not indicate significant differences between treatments. These results have significant implications for the culture of pre-nursery oil palm seedlings, as the use of legumes as organic matters in the growing medium has been

shown to provide more stable and sustainable growth supports.

This study offers new insights into the potential of legumes as organic matters for providing optimal nursery condition for oil palm seedlings, making them a useful guide for creating sustainable growing media. This study advances knowledge of the advantages of legume biomass as a productive and efficient source of nutrition for promoting the early growth of oil palm seedlings in addition to enhance technical elements of production. The study limitation is it had not looked at how nutritional elements change as each organic molecule decomposition is one of its limitations. Therefore, further research is required to fully examine the nutritional content, decomposition process, and periodic physiological reactions of the plants.

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