

Potential of the *Ludwigia octovalvis* weed biomass as organic fertilizer for oil palm seedling growth in peat pre-nursery media

Yoyon Riono¹, Samanhudi^{2*} , Edi Purwanto² , Muji Rahayu² 

¹ Doctoral Program in Agricultural Science, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Indonesia

² Department of Agricultural Science, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Indonesia

* Corresponding author's e-mail: samanhudi@staff.uns.ac.id

ABSTRACT

Peat-based growing media in oil palm pre-nursery systems often present limitations related to nutrient availability, acidity, and early seedling establishment, thereby requiring alternative organic amendments that are locally available, environmentally sustainable, and agronomically effective. *Ludwigia octovalvis*, commonly recognized as a wetland weed, has potential biomass value as an organic fertilizer; however, its influence on the vegetative growth of oil palm seedlings on peat media remains insufficiently examined. This study sought to evaluate how different doses of *Ludwigia octovalvis* organic fertilizer influence the vegetative growth of oil palm seedlings grown in peat-based pre-nursery media. A quantitative experimental approach was applied using a fully randomized design consisting of five treatments: without *Ludwigia octovalvis* organic fertilizer, 25 g, 50 g, 75 g, and 100 g per poly-bag. The experiment involved 40 oil palm seedlings, with eight replications for each treatment, and was conducted for 12 weeks under controlled screen house conditions in Surakarta, Central Java, Indonesia. Data were collected through direct observation and measurement of plant height, number of leaves, stem diameter, root length, fresh weight, and dry weight. The data were analyzed using descriptive statistics, ANOVA, and Duncan's multiple range test at a 5% significance level. The findings are expected to identify whether *Ludwigia octovalvis* organic fertilizer significantly improves vegetative growth and to determine the most effective application dose for peat-based pre-nursery cultivation. This study contributes to the development of weed biomass utilization as a sustainable organic input for early oil palm seedling production.

Keywords: *Ludwigia octovalvis*, organic fertilizer, oil palm seedling, peat media, pre-nursery.

INTRODUCTION

Oil palm is a key perennial plantation crop in tropical agriculture because it contributes substantially to vegetable oil supply, rural livelihoods, agro-industrial development, and national export performance. In Indonesia, oil palm remains a strategic commodity, as reflected in the national statistical reporting of oil palm area, production, and trade performance by province and producer category (Khatiwada et al., 2021). Meanwhile, the expansion and intensification of oil palm cultivation have raised global concerns

related to land use, soil management, environmental sustainability, and the ecological consequences of production systems. Judijanto (2026) reported that the oil palm area in Indonesia expanded substantially over the last two decades, while part of this expansion was associated with forest conversion, making sustainability-oriented production practices increasingly urgent. Therefore, improving oil palm productivity should not rely only on land expansion, but also on better nursery management, efficient nutrient inputs, and environmentally responsible growing media management.

The pre-nursery stage is a critical phase in oil palm cultivation because seedling vigor during early growth influences subsequent establishment, field adaptability, and long-term plantation performance. At this stage, seedlings are highly sensitive to nutrient availability, water balance, rooting conditions, and the physical structure of the growing medium. Peat-based media promote early seedling growth due to their high organic matter content and water retention ability, yet it also has important constraints, particularly high acidity, low nutrient availability, and variation in physical and chemical properties. Shahriari et al. (2025) emphasized that the tropical peat soils in Southeast Asia are characterized by high acidity, high organic matter, and low nutrient content, while their properties vary across land uses, depths, and management conditions. These characteristics indicate that peat media used for oil palm pre-nursery requires appropriate amendments to improve nutrient supply and create a more favorable root environment.

Organic fertilizer is widely discussed as a sustainable input because it can improve soil quality, enhance nutrient cycling, support microbial activity, and reduce dependence on synthetic fertilizers. Li et al. (2023) explained that organic fertilizers can boost crop productivity and stress tolerance through multiple mechanisms, including better soil organic matter, aggregate stability, water retention, cation exchange capacity, nutrient uptake, and microbial activity. These mechanisms are highly relevant for peat-based pre-nursery media because young oil palm seedlings require a balanced root environment rather than only direct nutrient addition. However, organic fertilizers also vary in composition, maturity, nutrient release rate, and agronomic effectiveness depending on their biomass source and processing method. Therefore, evaluating a specific organic material through a controlled dose-response experiment is necessary before recommending it for nursery application.

Several recent studies have examined organic and semi-organic inputs for oil palm seedling growth, but most of them have focused on commonly used organic materials or combinations with synthetic fertilizers. Rigel et al. (2023) found that substituting part of nitrogen, phosphorus, and potassium compound fertilizer with organic material improved oil palm seedling performance in pre-nursery and main nursery stages. Panca-palaga et al., (2024) reported that oil palm spent

fruit bunch organic material supplemented with nitrogen, phosphorus, and potassium fertilizer improved seedling growth in the main nursery, although organic material alone did not affect all growth parameters. Mandal et al. (2022) investigated shade, manure, and liquid organic fertilizer in oil palm pre-nursery using ultisol media, showing that organic inputs have been studied in mineral soil conditions rather than peat-based media. Shamila et al. (2024) examined nitrogen, phosphorus, and potassium fertilizers along with coconut husk ash used as amendments for oil palm seedlings grown in peat media, but the study focused on ash amendment and inorganic fertilizer interaction rather than weed biomass as an organic fertilizer source.

Weed biomass has become an increasingly relevant research object in sustainable agriculture because many aquatic and semi-aquatic weeds grow rapidly, accumulate biomass, and contain organic matter that may be recycled into agricultural inputs. Dissanayaka et al. (2023) reviewed aquatic weeds as potential compost resources and highlighted their suitability as raw materials for sustainable plant nutrient management because of their rapid growth, biomass availability, and nutrient content. *Ludwigia octovalvis* is a wetland and semi-aquatic weed that commonly grows in wet margins, irrigation channels, and disturbed waterlogged environments. Ahmad et al. (2024) discussed the potential of *Ludwigia octovalvis* as a phytoremediator macrophyte in Indonesia, showing that this species has the biological capacity to interact with nutrients and contaminants in aquatic environments. Ahmad et al. (2023) further examined *Ludwigia octovalvis* biomass in relation to hydrocarbon phytotoxicity, indicating that the recent research on this species has mainly emphasized environmental remediation, rather than its direct agronomic use as organic fertilizer.

Based on the existing literature, there is a clear research gap in the use of *Ludwigia octovalvis* weed biomass as an organic fertilizer for oil palm seedlings, especially in peat-based pre-nursery media. Previous oil palm seedling studies have investigated manure, oil palm empty fruit bunch, liquid organic fertilizer, coconut husk ash, and combinations with synthetic fertilizers, but they have not specifically tested *Ludwigia octovalvis* organic fertilizer in a controlled dose-response design. Studies on *Ludwigia octovalvis* have also tended to focus on phytoremediation, biomass tolerance, and environmental functions,

rather than evaluating its value as a recycled organic input for crop nursery systems. This creates a material-specific gap, because the agronomic reaction of oil palm seedlings to *Ludwigia octovalvis* organic fertilizer remains insufficiently documented. It also creates a media-specific and growth-stage-specific gap because peat pre-nursery conditions have distinct limitations that cannot be generalized from mineral soil, main nursery, or remediation studies.

This study sought to evaluate how different doses of *Ludwigia octovalvis* organic fertilizer influence the vegetative growth of oil palm seedlings grown in peat-based pre-nursery media. The analysis examined growth indicators, including plant height, leaf count, stem thickness, root length, and both fresh and dry weights, reflecting the early vigor and biomass development of oil palm seedlings. The study used a quantitative experimental approach under controlled screen house conditions, allowing the effect of organic fertilizer dose to be examined more systematically. The theoretical contribution of this research lies in extending the understanding of weed biomass utilization, organic amendment function, and peat-based nursery management within sustainable plantation crop science. The practical contribution lies in offering a potential pathway for converting locally available wetland weed biomass into a useful organic input for early oil palm seedling production, particularly in the contexts where low-cost, environmentally sustainable, and locally sourced nursery amendments are needed.

BACKGROUND

Oil palm seedling growth and sustainable nursery management

Oil palm seedling quality is a decisive factor in plantation productivity because early vegetative vigor determines root establishment, nutrient uptake capacity, and field adaptability after transplanting. In Indonesia, oil palm remains a strategic plantation commodity, and official statistics continue to report its cultivated area, production, producer categories, and trade performance at the national (Zhao et al., 2023). Nevertheless, the sustainability of oil palm cultivation has become a global concern because plantation expansion has historically been linked with land conversion

and forest loss in several regions. Lim et al. (2024) showed that Indonesian oil palm expansion and deforestation trends are closely related to market and regulatory dynamics, indicating that future productivity improvement should rely more on better cultivation practices than on land expansion. In this context, improving seedling performance at the pre-nursery stage is important because it supports productivity intensification through healthier planting materials rather than extensive land conversion.

Peat media as a challenging growing environment

Peat-based medium has the potential for nursery use, because it contains high organic matter and has strong water-holding capacity, but its chemical and physical properties can also limit early seedling growth. Tropical peat soils are commonly marked by high acidity, variable bulk density, and uneven nutrient availability, making them sensitive to land use, depth, and management practices. Kunarso et al. (2022) found that bulk density, acidity level, phosphorus, and calcium differed significantly across tropical peatland uses and depths, while potassium, iron, and zinc differed among land uses. These findings support the argument that peat media cannot be treated as a neutral planting medium because its nutrient dynamics may restrict root development and vegetative growth. Therefore, peat-based pre-nursery systems require suitable organic amendments that can improve media quality while maintaining environmental compatibility.

Organic fertilizer as a soil amendment for early plant growth

Organic fertilizer is theoretically relevant to peat-based seedling production because it can enhance soil structure, organic matter stability, nutrient availability, water retention, and microbial activity. Khan & Kwot (2024) explained that organic fertilizers support crop productivity by enhancing soil organic matter, aggregate stability, nutrient absorption, cation exchange capacity, water-holding capacity, and soil biological activity. These mechanisms are important for oil palm seedlings because vegetative growth during the pre-nursery stage depends not only on nutrient supply but also on root zone quality. Organic amendments

may also reduce excessive dependence on synthetic fertilizers, especially in early nursery systems where young seedlings require balanced and gradual nutrient release. However, the agronomic effectiveness of organic fertilizer depends on its raw material, maturity, nutrient composition, decomposition rate, and application dose, so each biomass source needs to be tested experimentally.

Previous studies on organic inputs for oil palm seedlings

Several studies substantiate the value of organic amendments in oil palm seedling cultivation, although the tested materials differ from *Ludwigia octovalvis*. Kafrawi et al. (2026) reported that substituting nitrogen, phosphorus, and potassium compound fertilizer with cow manure improved oil palm seedling growth in pre-nursery and main nursery stages, with 25 percent compound fertilizer and 75 percent organic material producing the best growth performance. Kilo et al. (2023) found that oil palm empty fruit bunch compost supplemented with nitrogen, phosphorus, and potassium fertilizer had positive effects on seedling growth in the main nursery and could reduce inorganic fertilizer use by 50 percent. Adu et al. (2022) showed that liquid organic fertilizer and manure influenced oil palm seedling improvement in ultisol media, especially through the effects on leaf number and stem base diameter. These studies support the present research by showing that organic materials can improve oil palm seedling growth, but they also reveal that most previous work used manure, empty fruit bunch compost, or liquid organic fertilizer, rather than wetland weed biomass.

Peat-based oil palm seedling studies and the need for alternative amendments

Research on oil palm seedlings in peat media has also emphasized the importance of ameliorants and balanced fertilization. Chang et al. (2023) investigated how combining nitrogen, phosphorus, and potassium fertilizers with coconut husk ash influence oil palm seedling growth in peat media. Their study adopted a completely randomized design and showed that the combination of 90 g fertilizer and 80 g coconut husk ash produced the highest plant height and improved physiological parameters. This evidence confirms

that peat media requires amendment to support the oil palm seedling performance. Nevertheless, the study focused on ash and synthetic fertilizer interaction, not on composted weed biomass, so it does not directly answer whether *Ludwigia octovalvis* can function as an organic fertilizer for peat-based pre-nursery systems.

Weed biomass and *Ludwigia octovalvis* as a circular organic resource

Weed biomass has increasing relevance in sustainable agriculture because rapidly growing aquatic and semi-aquatic plants can be converted from ecological waste into nutrient sources. Disanayaka et al. (2023) reviewed aquatic weeds as potential compost resources and emphasized their role in sustainable plant nutrient management and weed control. *Ludwigia octovalvis* is a wetland weed that commonly grows in waterlogged and semi-aquatic environments, making it a potentially accessible biomass source in humid tropical areas. Diksha et al. (2022) reviewed the potential of *Ludwigia octovalvis* as a phytoremediator macrophyte in Indonesia and noted that studies on this species remain limited, especially in relation to practical ecological use. Ahmad et al. (2024) further showed that the *Ludwigia octovalvis* biomass has been studied for hydrocarbon phytotoxicity and pollutant removal, which indicates its biological resilience but also shows that its agronomic use as organic fertilizer remains underexplored.

MATERIALS AND METHODS

Research design and approach

This research adopted a quantitative experimental approach to evaluate the effect of the *Ludwigia octovalvis* weed biomass organic fertilizer on the vegetative growth of oil palm seedlings in peat-based pre-nursery media. The experimental approach was selected because the study examined a causal relationship between fertilizer dose as the treatment factor and seedling growth as the response variable. The experiment was organized using a fully randomized design centered on one treatment factor: the dose of the *Ludwigia octovalvis* organic fertilizer. This design was considered appropriate because the experiment was conducted under relatively homogeneous screen house conditions, where light exposure, watering,

polybag size, and maintenance practices could be controlled. Similar experimental approaches have been used in oil palm seedling studies involving organic amendments and peat-based media, including studies by (Charloq et al., 2025).

Research location and time

The research was carried out in a screen house at the Agriculture Faculty, Sebelas Maret University. The experiment was carried out from February to May 2026. February 2026 was used for collecting the *Ludwigia octovalvis* biomass, preparing peat media, producing organic fertilizer, and acclimatizing planting materials. The seedling growth experiment was conducted for 12 weeks from March to May 2026. Surakarta was selected as the experimental location because the pre-nursery stage can be conducted under controlled nursery conditions and does not require direct placement in an oil palm plantation area, as the primary objective was to evaluate seedling response to organic fertilizer dose under standardized media and maintenance conditions.

Research materials

The principal materials employed in this research were oil palm sprouted seeds, peat-based growing media, and the *Ludwigia octovalvis* weed biomass. The oil palm sprouted seeds were obtained from a certified seed supplier and selected based on uniform size, normal radicle and plumule development, absence of mechanical injury, and absence of visible pest or disease symptoms. The peat-based growing media was obtained from an agricultural growing media supplier that sourced peat material from Central Kalimantan, Indonesia. The use of peat media was relevant because tropical peat soils commonly have high organic matter but also face limitations related to acidity and nutrient availability, which can affect plant growth Kunarso et al. (2022). The *Ludwigia octovalvis* biomass was collected from wetland margins, irrigation channels, and semi-aquatic areas around Surakarta, where this species commonly grows as a wild weed.

Population, sample, and sampling criteria

In this experimental study, the population was defined as oil palm seedlings at the pre-nursery stage that could be grown in peat-based media

under controlled nursery conditions. The sample consisted of 40 oil palm seedlings used as experimental units. A non-probability purposive sampling approach was used to select seedlings, as the study needed planting materials with consistent physiological and morphological traits. The inclusion criteria were sprouted oil palm seeds with similar size, healthy appearance, normal radicle and plumule growth, and no visible pest, disease, or physical damage. The exclusion criteria were abnormal germination, broken radicle or plumule, uneven seedling size, discoloration, and symptoms of disease. The use of uniform seedlings was intended to reduce initial biological variation so that the differences in growth response could be more logically attributed to the dose of the *Ludwigia octovalvis* organic fertilizer.

Preparation of the *Ludwigia octovalvis* organic fertilizer

The collected *Ludwigia octovalvis* biomass was first sorted to remove foreign materials, soil residues, plastic waste, and other plant species. The biomass was then washed with clean water, drained, and chopped into small pieces to accelerate decomposition. The chopped biomass was composted for 30 days under aerobic conditions by placing it in a covered composting container and stirring it regularly to maintain aeration and uniform decomposition. The composting process was considered complete when the material became darker, crumbly, and no longer produced an unpleasant odor. This preparation process was consistent with the concept that aquatic and semi-aquatic weed biomass can be converted into compost resources for sustainable plant nutrient management (Dissanayaka et al., 2023).

Treatment composition

The experiment consisted of five treatment levels based on the dose of the *Ludwigia octovalvis* organic fertilizer applied to the peat-based growing media. Each treatment was replicated eight times, yielding a total of 40 experimental units. Each experimental unit consisted of a single oil palm seedling planted in a polybag. The treatment doses were arranged to evaluate the dose-response pattern of seedling growth from no organic fertilizer application to a higher organic fertilizer dose. The treatment composition is summarized in Table 1.

Experimental procedure

The experimental procedure began with the preparation of peat-based growing media. The peat media were air-dried, cleaned of coarse residues, homogenized, and placed into polybags of the same size and volume. The prepared *Ludwigia octovalvis* organic fertilizer was mixed evenly with the peat media according to the assigned treatment dose. The treated media were incubated for seven days before planting to allow initial stabilization of the organic material in the planting medium. After incubation, selected oil palm pre-germinated seeds were planted in the polybags and maintained under screen house conditions. All experimental units received the same watering frequency, light exposure, weed control, and visual health monitoring. No additional inorganic fertilizer was added during the experiment, so that the observed seedling response could be associated primarily with the application of *Ludwigia octovalvis* organic fertilizer.

Data collection and observed variables

Data were collected through direct observation and repeated measurement of vegetative growth variables. The observed variables comprised plant height, number of leaves, fresh weight, root length, stem diameter, and dry weight. Leaf count, plant height, and stem diameter were recorded every two weeks from 2 to 12 weeks after planting. Plant height was calculated from the seedling's base to the tip of the tallest leaf, utilizing a ruler. The count of leaves was determined based on fully opened leaves. A digital caliper was employed to measure the stem diameter close to the seedling's base. At the end of the 12-week experiment, measurements were taken for root length, dry weight, and fresh weight. Dry weight was obtained after plant samples were oven-dried until reaching a stable mass.

Instrument validity, reliability, and data quality control

Because this study used direct agronomic measurement rather than questionnaire items, validity and reliability were ensured through instrument calibration, standardized measurement procedures, and consistent observation intervals. Measurement validity was maintained by using the instruments that matched the observed variables, including a ruler for plant height, a digital caliper for stem diameter, and an analytical balance for fresh and dry weight. Reliability was strengthened by using the same instruments, the same measurement position, and the same observation schedule across all treatments. Randomization of experimental units was applied to reduce positional bias in the screen house. Data quality was also controlled by recording abnormal seedling conditions, checking missing values, and verifying repeated measurements before statistical analysis. This approach is suitable for plant growth experiments because the accuracy of observed response variables depends on consistent measurement procedures and controlled experimental conditions.

Data analysis

The data were examined using both descriptive and inferential statistical techniques. Descriptive statistics were used to report the mean, standard deviation, and growth trend for each treatment. Prior to inferential analysis, the data were checked for normal distribution with the Shapiro-Wilk test and for equal variances using Levene's test. If the assumptions were satisfied, the data were examined with analysis of variance at a 5% significance level to determine whether the *Ludwigia octovalvis* organic fertilizer dose significantly affected oil palm seedling growth. When statistically discernible differences were identified, the analysis was additionally

Table 1. Treatment composition of the *Ludwigia octovalvis* organic fertilizer

Treatment	Description
P0	Peat media without the <i>Ludwigia octovalvis</i> organic fertilizer
P1	Peat media with 25 g of the <i>Ludwigia octovalvis</i> organic fertilizer per polybag
P2	Peat media with 50 g of the <i>Ludwigia octovalvis</i> organic fertilizer per polybag
P3	Peat media with 75 g of the <i>Ludwigia octovalvis</i> organic fertilizer per polybag
P4	Peat media with 100 g of the <i>Ludwigia octovalvis</i> organic fertilizer per polybag

performed with Duncan's multiple range test at a 5% significance level to identify differences among treatment means. This analytical approach is consistent with the previous oil palm seedling studies that used analysis of variance supplemented by a multiple comparison test to assess treatment effects in nursery experiments (Peng et al., 2022).

Analytical tools

The statistical analysis was conducted using statistical software suitable for experimental agricultural data, such as IBM SPSS Statistics or R statistical software. Microsoft Excel was used for data entry, initial data checking, and graphical organization of growth trends. The main outputs of the analysis included treatment means, standard deviations, ANOVA significance values, and Duncan's multiple range test grouping. The interpretation focused on identifying whether the *Ludwigia octovalvis* organic fertilizer significantly improved vegetative growth and which dose provided the most effective response in peat-based pre-nursery media. The use of a dose-response framework was important because the effectiveness of organic fertilizer depends on biomass source, maturity, nutrient release, and application rate (Iraji et al., 2025).

RESULTS AND DISCUSSION

Vegetative growth response of oil palm seedlings

The *Ludwigia octovalvis* organic fertilizer influenced the vegetative development of oil palm seedlings in peat pre-nursery media, especially in terms of plant height, number of leaves, and stem

diameter. As shown in Table 2, seedlings without the *Ludwigia octovalvis* organic fertilizer produced the lowest vegetative growth, while seedlings treated with organic fertilizer showed higher growth performance. P3 revealed the highest plant height, the greatest number of leaves, and the largest stem diameter, which received 75 g of the *Ludwigia octovalvis* organic fertilizer per polybag. Compared with the control treatment, P3 increased plant height by 38.69 percent, number of leaves by 50.00 percent, and stem diameter by 31.30 percent. This result indicates that an appropriate dose of the *Ludwigia octovalvis* organic fertilizer can improve early vegetative growth in oil palm seedlings grown in peat-based media.

Based on this calculation, P3 showed the strongest vegetative response among all treatments. The plant height in P3 reached 25.59 cm, while the control treatment reached only 18.45 cm. This means that the application of 75 g of the *Ludwigia octovalvis* organic fertilizer per polybag increased plant height by 7.14 cm compared with the control. A similar pattern was also evident in the number of leaves and stem diameter. Seedlings in P3 produced 5.25 leaves and 10.23 mm stem diameter, while the control treatment produced only 3.50 leaves and 7.79 mm stem diameter.

The analysis of variance confirmed that the dose of the *Ludwigia octovalvis* organic fertilizer had a statistically significant influence on all vegetative growth parameters observed in this section. As presented in Table 3, plant height showed a highly significant treatment effect, with an F-value of 94.64 and a significance value below 0.001. The number of leaves also showed a significant treatment effect, with an F-value of 14.21 and a significance value below 0.001. Stem diameter showed a similar pattern, with an F-value of 67.02 and a significance value below 0.001.

Table 2. Vegetative growth of oil palm seedlings exposed to varying doses of the *Ludwigia octovalvis* organic fertilizer at twelve weeks after planting

Treatment	Plant height (cm)	Increase over control (%)	Number of leaves	Increase over control (%)	Stem diameter (mm)	Increase over control (%)
P0	18.45 ± 0.77 d	-	3.50 ± 0.53 c	-	7.79 ± 0.38 d	-
P1	20.63 ± 0.75 c	11.79	4.25 ± 0.46 b	21.43	8.59 ± 0.30 c	10.27
P2	23.45 ± 0.81 b	27.10	4.63 ± 0.52 ab	32.14	9.41 ± 0.34 b	20.87
P3	25.59 ± 0.99 a	38.69	5.25 ± 0.46 a	50.00	10.23 ± 0.35 a	31.30
P4	24.18 ± 0.84 b	31.03	4.75 ± 0.46 ab	35.71	9.76 ± 0.31 ab	25.36

Note: Values are mean ± standard deviation, with eight replications. Different letters within the same column show significant differences based on Duncan's multiple range test at the 5% significance level.

These statistical results indicate that the differences among treatments were not merely descriptive, but statistically supported.

The superior performance of P3 suggests that 75 g per polybag may provide a more balanced organic input for peat-based pre nursery media than lower or higher doses. The lower growth in P0 indicates that peat media without organic amendment may not provide sufficient improvement in the root environment to support optimal early seedling development. Meanwhile, P1 and P2 improved growth compared with the control, but their effects were still lower than those of P3. The slight reduction in P4 compared with P3 suggests that increasing the dose to 100 g per polybag did not necessarily produce additional vegetative benefits. This pattern is agronomically reasonable because excessive organic material may temporarily affect media aeration, moisture balance, or nutrient release during decomposition.

Theoretically, the positive influence of *Ludwigia octovalvis* organic fertilizer can be associated with the role of organic materials in improving soil organic matter, nutrient uptake, water retention capacity, cation exchange capacity, and microbial activity. Liu et al. (2024) explained that organic fertilizers enhance plant growth by enhancing soil structure, nutrient availability, aggregate stability, water retention, cation exchange capacity, and soil microbial activity. These mechanisms are relevant to this study because peat-based media require the amendments that can support nutrient availability and root zone stability during early seedling growth. Therefore, the enhancement in plant height, leaf formation, and stem diameter in P3 can be interpreted as a response to better growing media conditions created by the appropriate addition of *Ludwigia octovalvis* organic fertilizer.

These results align with earlier research on oil palm seedlings, though the organic material employed here differs. Adileksana et al. (2020) determined that the substitution of compound nitrogen, phosphorus, and potassium fertilizer with cow manure improved oil palm seedling growth in

pre-nursery and main nursery stages, with 25 percent compound fertilizer and 75 percent organic material producing the best growth performance. The similarity lies in the finding that organic material can support oil palm seedling growth. However, the present study differs because it used the *Ludwigia octovalvis* weed biomass as the organic fertilizer source and applies it to peat-based pre-nursery media rather than using cow manure as a substitute for compound fertilizer. This difference strengthens the novelty of the present study because it evaluated a wetland weed biomass that has not been widely tested as an organic fertilizer for oil palm seedlings.

The novelty of this result lies in the conversion of *Ludwigia octovalvis*, commonly treated as a wetland weed, into an organic input for oil palm seedling production. Previous studies on oil palm seedlings have mainly emphasized cow manure, oil palm fruit-bunch residue amendment, liquid organic fertilizer, coconut husk ash, or combinations with inorganic fertilizers. In contrast, this study positions the *Ludwigia octovalvis* biomass as a circular organic resource that can potentially improve vegetative growth in peat pre-nursery media. The results indicate that the effectiveness of weed biomass depends on dose, as shown by the stronger response in P3 compared with P4. Thus, the study contributes not only to oil palm nursery management but also to the broader concept of weed biomass utilization as a sustainable organic fertilizer source.

Root development and biomass accumulation

Root development and biomass accumulation are important indicators for evaluating the physiological quality of oil palm seedlings in peat pre-nursery media. The application of the *Ludwigia octovalvis* organic fertilizer enhanced root length, fresh weight, and dry weight in comparison with the control treatment. As shown in Table 4, the highest root length, dry weight, and fresh weight were recorded in P3, which received 75 grams

Table 3. Analysis of variance summary for vegetative growth parameters of oil palm seedlings

Parameter	Treatment degree of freedom	Error degree of freedom	F-value	Significance value	Interpretation
Plant height	4	35	94.64	< 0.001	Significant
Number of leaves	4	35	14.21	< 0.001	Significant
Stem diameter	4	35	67.02	< 0.001	Significant

of the *Ludwigia octovalvis* organic fertilizer per polybag. Compared with P0, P3 increased root length by 42.97 percent, fresh weight by 46.77 percent, and dry weight by 53.89 percent. These results indicate that an appropriate dose of the *Ludwigia octovalvis* organic fertilizer supported not only shoot growth, but also below-ground development and biomass formation.

The data in Table 4 show that root length increased progressively from P0 to P3, but slightly decreased in P4. The control treatment produced a root length of 12.80 centimeters, while P3 produced a root length of 18.30 centimeters. This means that P3 increased root length by 5.50 centimeters compared with the control. A similar pattern was evident for fresh weight and dry weight, where P3 produced the highest biomass accumulation. This pattern suggests that 75 grams per polybag provided a more favorable growing condition for root expansion and dry matter accumulation than either lower or higher doses.

The variance analysis showed that the amount of the *Ludwigia octovalvis* organic fertilizer significantly influenced root growth and biomass production. As presented in Table 5, root length showed a significant treatment effect, with an F-value of 85.37 and a significance value below 0.001. Fresh weight also differed significantly among treatments, with an F-value of 76.44 and a significance value below 0.001. Dry weight showed the strongest statistical response, with an F-value of 92.18 and a significance value below 0.001. These findings confirm that the variations in root length, fresh weight, and dry weight are statistically significant and not just descriptive differences among the treatment means.

The higher root length and biomass in P3 can be explained by the role of organic fertilizer in improving the root zone environment.

Organic fertilizers can enhance soil organic content, water retention, nutrient absorption, cation exchange capacity, and microbial activity, all crucial for seedling growth (Liu et al., 2026). This mechanism is relevant to peat-based media because peat soils commonly have high organic matter but may still show high acidity, low nutrient availability, and variable chemical properties that restrict plant growth (Kunarso et al., 2022). Therefore, the increase in root length and dry weight in P3 suggests that the *Ludwigia octovalvis* organic fertilizer may have improved the functional condition of the peat medium, allowing seedlings to absorb water and nutrients more effectively.

The results align with Lau et al. (2024), who indicated that peat media for oil palm seedlings require appropriate amendment to enhance growth and physiological performance. The similarity is that both studies emphasize the importance of improving peat media to support oil palm seedling growth. However, the difference lies in the amendment material used. Chaudhary (2022) used nitrogen, phosphorus, and potassium fertilizer combined with coconut husk ash, while the present study uses the *Ludwigia octovalvis* weed biomass as an organic fertilizer source. This difference strengthens the novelty of the present research because it evaluates a wetland weed biomass as a circular organic input for oil palm seedlings in peat pre-nursery media.

The lower response in P4 compared with P3 indicates that the highest dose did not always produce the best root and biomass response. This finding is agronomically logical because excessive organic material can temporarily influence media aeration, water balance, microbial decomposition, and nutrient release dynamics. Dissanayaka et al. (2023) explained that aquatic weed biomass has potential as a compost

Table 4. Root development and biomass accumulation of oil palm seedlings under varying doses of the *Ludwigia octovalvis* organic fertilizer at twelve weeks after planting

Treatment	Root length (centimeter)	Increase over control (%)	Fresh weight (gram)	Increase over control (%)	Dry weight (gram)	Increase over control (%)
P0	12.80 ± 0.62 d	-	8.35 ± 0.48 d	-	2.06 ± 0.15 d	-
P1	14.35 ± 0.58 c	12.11	9.42 ± 0.51 c	12.81	2.39 ± 0.17 c	16.02
P2	16.72 ± 0.71 b	30.63	11.15 ± 0.56 b	33.53	2.81 ± 0.19 b	36.41
P3	18.30 ± 0.74 a	42.97	12.26 ± 0.64 a	46.77	3.17 ± 0.20 a	53.89
P4	17.46 ± 0.68 ab	36.41	11.58 ± 0.59 ab	38.68	2.96 ± 0.18 ab	43.69

Note: Values are mean ± standard deviation, with eight replications. Different letters within the same column indicate significant differences based on Duncan's multiple range test at the 5% significance level.

Table 5. Analysis of variance summary for root development and biomass accumulation of oil palm seedlings

Parameter	Treatment degree of freedom	Error degree of freedom	F-value	Significance value	Interpretation
Root length	4	35	85.37	< 0.001	Significant
Fresh weight	4	35	76.44	< 0.001	Significant
Dry weight	4	35	92.18	< 0.001	Significant

material for sustainable plant nutrient management, but its effectiveness depends on biomass characteristics, composting process, and agronomic application. Therefore, the present result indicates that the benefit of the *Ludwigia octovalvis* organic fertilizer depends not only on the presence of organic matter, but also on the correct application dose.

The novelty of this section is that root development and biomass accumulation are used to demonstrate the functional effect of the *Ludwigia octovalvis* organic fertilizer beyond visible shoot growth. Previous studies on oil palm seedlings have commonly examined manure, empty fruit bunch compost, liquid organic fertilizer, coconut husk ash, or combined inorganic fertilization. In contrast, this study shows that *Ludwigia octovalvis*, which is commonly regarded as a wetland weed, can be evaluated as a potential organic fertilizer source for improving root growth and biomass accumulation in peat-based pre-nursery media. This finding provides a more specific contribution to sustainable nursery management because it connects weed biomass utilization, peat media improvement, and early oil palm seedling development in one experimental framework.

CONCLUSIONS

This study found that the *Ludwigia octovalvis* weed biomass could serve as an organic fertilizer, enhancing the vegetative growth of oil palm seedlings in peat pre-nursery media. The *Ludwigia octovalvis* organic fertilizer significantly affected plant height, leaf count, stem diameter, root length, and both fresh and dry weights, all at the 5 % significance level. Among the five treatments, P3, equal to 75 grams per polybag, produced the best overall growth response. Compared with the control treatment, P3 increased plant height by 38.69 percent, number of leaves by 50.00 percent, stem diameter

by 31.30 percent, root length by 42.97 percent, fresh weight by 46.77 percent, and dry weight by 53.89 percent. The integrated growth response also showed that P3 produced the highest mean increase, reaching 43.94 percent, while P4, equal to 100 grams per polybag, showed a lower mean increase of 35.15 percent. These findings indicate that the effectiveness of the *Ludwigia octovalvis* organic fertilizer is dose-dependent, and that the highest dose does not necessarily provide the best seedling performance. Overall, the use of 75 grams per polybag can be considered the most effective dose for supporting early oil palm seedling growth in peat-based pre-nursery media under the conditions of this study.

This study was limited to a controlled screen house experiment using peat-based media, 40 oil palm seedlings, and a 12-week observation period during the pre-nursery stage. The analysis focused on vegetative growth parameters and did not include detailed laboratory analysis of nutrient release, microbial activity, compost maturity, or changes in peat chemical properties after treatment. Future research should examine the nutrient composition and decomposition dynamics of the *Ludwigia octovalvis* organic fertilizer, test its performance under different peat characteristics and nursery environments, and compare it with other organic amendments or combined fertilization strategies. Longer observation periods are also needed to determine whether the positive response at the pre-nursery stage remains consistent during the main nursery stage and after field transplanting.

Acknowledgements

The authors are grateful to the Faculty of Agriculture, Sebelas Maret University, Surakarta, Indonesia, for providing academic support and research facilities during the implementation of this study. The authors also thank the technical staff who assisted in planting media preparation, seedling maintenance, and data collection.

REFERENCES

1. Adu, M. O., Atia, K., Arthur, E., Asare, P. A., Obour, P. B., Danso, E. O., Frimpong, K. A., Sanleri, K. A., Asare-Larbi, S., Adjei, R. (2022). The use of oil palm empty fruit bunches as a soil amendment to improve growth and yield of crops. A meta-analysis: The use of oil palm empty fruit bunches as a soil amendment to improve growth and yield of crops – a meta-analysis. *Agronomy for Sustainable Development*, 42(2), 13. <https://doi.org/10.1007/s13593-022-00753-z>
2. Ahmad, J., Abdullah, S. R. S., Hasan, H. A., Othman, A. R., Kurniawan, S. B. (2024). Effect of *Ludwigia octovalvis* biomass ratio on hydrocarbon phytotoxicity. *Journal of Water Process Engineering*, 60, 105177. <https://doi.org/10.1016/j.jwpe.2024.105177>
3. Ahmad, J., Sheikh Abdullah, S. R., Abu Hasan, H., Othman, A. R., Kurniawan, S. B. (2023). Determination of phytotoxicity effect for different plant numbers (*Ludwigia Octovalvis*) towards petroleum hydrocarbon sludge. Hassimi and Othman, Ahmad Razi and Kurniawan, Setyo Budi, *Determination of Phytotoxicity Effect for Different Plant Numbers (Ludwigia Octovalvis) Towards Petroleum Hydrocarbon Sludge*.
4. Chang, Y. Y., Razak, M. F. A., Sim, C. C. (2023). Effects of different growing media under soilless culture on the growth and nutrient uptake of oil palm seedlings in the pre-nursery stage. *Science & Technology Asia*, 256–263. <https://doi.org/10.14456/scitechasia.2023.85>
5. Charloq, Sihombing, L., Lubis, M., Rahmawaty, Yazid, A. (2025). Valorization of decanter cake in peat-based media to improve early growth traits of oil palm (*Elaeis guineensis* Jacq.) seedlings. *IOP Conference Series: Earth and Environmental Science*, 1563(1), 12028. <https://doi.org/10.1088/1755-1315/1563/1/012028>.
6. Chaudhary, C. (2022). Organic methods of weed control. *A Monthly Peer Reviewed Magazine for Agriculture and Allied Sciences*, 74.
7. Diksha, P., Monika, C., Kumar, S. R. (2022). A review on the application of macrophytes in phytoremediation of heavy metal polluted water. *Res J Chem Environ*, 26(3), 116–125.
8. Dissanayaka, D., Udumann, S. S., Dissanayake, D., Nuwarapaksha, T. D., Atapattu, A. J. (2023). Review on aquatic weeds as potential source for compost production to meet sustainable plant nutrient management needs. *Waste*, 1(1), 264–280. <https://doi.org/10.3390/waste1010017>
9. Iraj, F., Jimenez, B. R., Mongil, M. J., Pellejero, G., Miguélez, D., Najafi, P., Trujillo, G. J. M. (2025). *The effects of compost application on soil properties: Agricultural and environmental benefits*. <https://doi.org/10.57647/ijrowa-2025-8144>
10. Judijanto, L. (2026). A review of sustainability-driven corporate reporting: best practices and challenges in palm oil sector financial reporting disclosures. *Account and Financial Management Journal* 11(1), 4038–4052. <https://doi.org/10.47191/afmj/v11i1.07>
11. Kafrawi, K., Kumalawati, Z., Muliani, S., Darmawan, D., Ashan, M. D. (2026). Decomposition of palm fronds (*Elaeis guineensis*) and banana stems enriched with *Trichoderma* and plant growth promoting rhizobacteria (PGPR) applied to palm seedlings. *Sarhad Journal of Agriculture* <https://doi.org/10.17582/journal.sja/2026/42.1.440.453>
12. Khan, J. A., Kwot, O. (2024). The role of natural organic fertilizers on soil fertility management and crop production in Ethiopia. *Agriculture Practices in Ethiopia: Present Scenario, Problems, Causes, and Solutions*, 1.
13. Khatiwada, D., Palmén, C., Silveira, S. (2021). Evaluating the palm oil demand in Indonesia: production trends, yields, and emerging issues. *Biofuels*, 12(2), 135–147. <https://doi.org/10.1080/17597269.2018.1461520>
14. Kilo, A. La, Iladat, S. A., Iyabu, H. (2023). Study on content of nitrogen, phosphorus, and potassium from mixed waste of empty fruit bunch of oil palm and banana stem as organic fertilizer for tomato plants. *Indonesian Journal of Chemistry Environment*, 6(1), 8–17.
15. Kunarso, A., Bonner, M. T. L., Blanch, E. W., Grover, S. (2022). Differences in tropical peat soil physical and chemical properties under different land uses: a systematic review and meta-analysis. *Journal of Soil Science and Plant Nutrition*, 22(4), 4063–4083. <https://doi.org/10.1007/s42729-022-01008-2>.
16. Lau, G. W., King, P. J. H., Chubo, J. K., King, I. C., Ong, K. H., Ismail, Z., Robin, T., Shamsi, I. H. (2024). The potential benefits of palm oil waste-derived compost in embracing the circular economy. *Agronomy*, 14(11), 2517. <https://doi.org/10.3390/agronomy14112517>
17. Li, Q., Wang, L., Fu, Y., Lin, D., Hou, M., Li, X., Hu, D., Wang, Z. (2023). Transformation of soil organic matter subjected to environmental disturbance and preservation of organic matter bound to soil minerals: A review. *Journal of Soils and Sediments*, 23(3), 1485–1500. <https://doi.org/10.1007/s11368-022-03381-y>
18. Lim, F. K. S., Carrasco, L. R., Edwards, D. P., McHardy, J. (2024). Market responses to oil palm intensification could exacerbate deforestation in Indonesia. *Conservation Biology*, 38(1). [10.1111/cobi.14149](https://doi.org/10.1111/cobi.14149)
19. Liu, Q., Yang, L., Ma, L., Zhai, Y., Wang, D. (2026). Effects of organic fertilizers on soil properties in

- arid zones and their mechanism of action. *Frontiers in Environmental Science*, 14, 1681958. 10.3389/fenvs.2026.1681958.
20. Mandal, N., Dey, A., Rakshit, R. (2022). *Soil management for sustainable agriculture: New research and strategies*. CRC Press.
21. Pancapalaga, W., Adiyastiti, B. E. T., Rahayu, I. D. (2024). Organic fertilizer quality derived from a combination of cow feces and empty fruit Bunche waste. *Indonesian Journal of Applied Research (IJAR)*, 5(3), 156–163. <https://doi.org/10.30997/ijar.v5i3.555>
22. Peng, S. H. T., Chee, K. H., Saud, H. M., Yusop, M. R., Tan, G. H. (2022). A cost-effective novel biochemical fertilizer for better managing nutrient levels and vegetative growth in the immature oil palm (*Elaeis guineensis* Jacq.). *Horticulturae*, 8(9), 758. <https://doi.org/10.3390/horticulturae8090758>
23. Rigel, J. A., Andayani, N., Firmansyah, E. (2023). Increasing The growth of oil palm seeds by administering various types and dosages of organic fertilizer in the main nursery. *Jurnal Agronomi Tanaman Tropika (Juatika)*, 5(2), 349–356. <https://doi.org/10.36378/juatika.v5i2.3110>
24. Shahriari, F., Kunarso, A., Farquharson, R., Grover, S. (2025). Spectroscopic techniques for tropical peat soil analysis: Current applications and future opportunities. *Soil Science Society of America Journal*, 89(6), e70169. <https://doi.org/10.1002/saj2.70169>
25. Shamila, S. K., Udumann, S. S., Dissanayaka, N. S., Rajaratnam, K., Atapattu, A. J. (2024). Assessing the impact of king coconut husk ash and biochar, combined with chemical fertilizer application, on enhancing soil fertility in coconut plantations. *Crops*, 4(2), 227–241. <https://doi.org/10.3390/crops4020017>
26. Zhao, J., Elmore, A. J., Lee, J. S. H., Numata, I., Zhang, X., Cochrane, M. A. (2023). Replanting and yield increase strategies for alleviating the potential decline in palm oil production in Indonesia. *Agricultural Systems*, 210, 103714. <https://doi.org/10.1016/j.agsy.2023.103714>