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The Effect of Providing Boiler Ash as a Planting Medium on Plant Growth of Vegetative Seeds of Palm Oil (*Elaeis guineensis* Jacq.*)* in Pre-Nursery

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Abstract

Oil palm (*Elaeis guineensis* Jacq.) is a major plantation commodity that plays a strategic role in the national economy. Seedling quality during the nursery phase is a critical factor in determining the success of cultivating this crop. Boiler ash, a byproduct of oil palm shell and fiber combustion, contains macronutrients such as nitrogen, phosphorus, potassium, and magnesium and has the potential to improve the quality of the growing medium. This study aims to test the effectiveness of boiler ash as a component of the growing medium on the vegetative growth of oil palm seedlings during the early nursery or pre-nursery phase. The study location is at the Indonesian Palm Oil Technology Institute's Practice Garden. The study lasted for 3 months. The design used was a non-factorial Randomized Block Design (RBD) with 5 treatments: A0 (topsoil + sand), A1 (topsoil + sand + boiler ash 40 g), A2 (topsoil + sand + boiler ash 60 gr), A3 (topsoil + sand + boiler ash 80 gr), and A4 (topsoil + sand + boiler ash 100 gr). Each combination was repeated five times. The growth parameters measured included seedling height, stem diameter, number of leaves, and the fresh and dry weights of the upper part and the roots. Data were analyzed using chromatography. ANOVA was conducted at the 5% significance level. Boiler ash treatment at various levels did not show a significant effect (tn) on all observed growth parameters of pre-nursery phase oil palm seedlings. Although there was no significant effect, treatment A3 showed the highest seedling height value, namely 19.02 cm, while treatment A2 had the highest fresh shoot weight, namely 3.32 g. Overall, the results indicate that using boiler ash as a component of the growing medium during the pre-nursery phase does not significantly increase oil palm seedling growth. However, the advantages of this study provide scientific certainty for practitioners that the use of boiler ash at a dose of up to 100 grams per seedling is safe as a component of the growing medium, without causing toxic effects or inhibiting seedling growth in the early phase. As a recommendation, for users who want to utilize boiler ash waste optimally, it is recommended to apply it during the main nursery phase when seed nutrient reserves have been exhausted, or to combine it with organic materials that enrich other nutrients.

Keywords: Ameliorant, Biomass, Nursery Initial, Ultisol, Waste Factory of Palm Oil

1. Introduction

Oil palm *Elaeis guineensis* Jacq. is a strategic plantation commodity for Indonesia. In this plant development process, seeds procured play a crucial role, as they directly affect productivity and sustainability. plantation business. (Allorerung et al., 2010). One of the fundamental obstacles to the growth of oil palm seedlings in the early nursery phase is the limited availability of essential nutrients and the suboptimal physical properties of conventional planting media, such as water retention capacity and soil aeration, which hamper root development and nutrient absorption in young plants. (Ardian et al., 2022). The oil palm is a monocotyledonous plant with fibrous roots. The first roots to emerge from a germinating seed are called the radicle (root bud) and the plumule (stem bud). These roots then die, followed by the growth of

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several fibrous roots originating from the base of the stem. The stem is called the plumule, and the oil palm plant has a straight and branching trunk (Wahyuni, 2007). Oil palm leaves have spiny leaf stalks connected to the main leaf vein (rachis) and are composed of leaflets (pinanta) on both sides.

Studies on the utilization of palm oil have been conducted, but most have focused on the main nursery phase. A study reported in the agricultural journal Agros showed that a dose of up to 60 g boiler ash per polybag during the main-nursery phase resulted in good growth. The seeds did not exceed the NPK fertilizer-based control treatment. Other studies also report that the combination of boiler ash and NPK fertilizer resulted in a significant interaction on seedling height and stem diameter, unlike the single boiler ash treatment. Meanwhile, a study on the combination of liquid waste and palm oil mill boiler ash in the pre-nursery phase reported a significant effect of 30 g of boiler ash on plant height and dry crown weight at 90 days after planting (Sari & Herman, 2023).

The novelty of this research lies in three aspects: (1) boiler ash was tested singly without any combination of other inorganic fertilizers, so that its pure effect on topsoil-sand media could be identified; (2) the dose range tested (40–100 g) was relatively higher than previous pre-nursery studies which generally tested doses below 30 g; and (3) observations were fully focused on the pre-nursery phase aged 5–9 weeks after planting (WAP), as a complement to data on the phase which is less frequently studied than the main-nursery (Dinas et al., 2019).

Each leaflet consists of bone leaves and leaf blades. Leaves can grow up to 1.2 meters long, with approximately 250-300 leaflets per leaf. At 5-6 years of age, plants produce 30-40 leaves per year, then decrease to 20-25 leaves per year as the plant ages (Soepadiyo Mangoensoekarjo, 2008).

When planting oil palms, the first step is to plant oil palm seedlings, as the oil palm nursery is the starting point that determines oil palm growth in the field. There are two stages of the nursery: the first, called the pre-nursery, where the seedlings are planted in small polybags until they are three months old. The second stage involves planting the seedlings in the main nursery, where they are grown in large polybags for 9 months (Hartanto, 2011).

Boiler ash is a solid waste from palm oil mills, produced by the combustion of shells and fibers in boilers. Every 100 tons of fresh fruit bunches (FFB) processed can produce approximately 250 tons of boiler ash. kg to 400 kg. In addition, palm oil boiler ash contains inorganic cations, including potassium and sodium. (Wibowo, 2007). Further research indicates that boiler ash has the potential to be an effective ameliorant. Boiler ash has high base saturation, can increase soil pH, contains complete nutrients, and acts as a fertilizer. It can improve soil structure. (Sitorus et al., 2014).

Land topsoil is land which is very suitable as a growing medium for plants because the topsoil on Which Lots Contains nutrients, and this soil is generally black and originates from the decomposition of fallen and rotting leaves (Hanafiah, 2005). The nutrients plants need are generally obtained from fertilizers. Therefore, fertilizer is a key factor in determining plant growth rate and production (Nur Indah Mansyur, 2021). Watering provides water for plants, which acts as a nutrient solvent, maintains cell turgor pressure, and supports various physiological processes such as transpiration, root growth, and photosynthesis (Muhammad, FR 2016). The use of boiler ash as a growing medium for pre-nursery oil palm seedlings can yield useful insights for developing more effective and efficient oil palm cultivation technologies.

2. Material and Methods

The research took three months to complete. The research activities were conducted at the practice site of the Indonesian Palm Oil Technology Institute (ITSI) campus, located on Jalan Willem Iskandar, Medan District. Estate, Percut Sei Tuan District, Medan City, North Sumatra, at coordinates of approximately 3°37′ North Latitude, 98°42′ East Longitude, with an altitude of approximately 25 meters above sea level (*meters above sea level). level* /m above sea level)**.**

2.1. Tool and Materials

The equipment used included measuring tools, watering equipment, hoes, digital scales, cutter knives, stationery, bamboo, and various other supporting tools. The materials used in this study were PPKS DxP oil palm seedlings of the Simalungun variety. topsoil (top layer of soil), boiler ash, water for irrigation, polybags measuring 22 x 14 cm, paranet, and media sand (Susanti & Fitra, 2024).

2.2. Research Design

The experimental method was a non-factorial Randomized Block Design with one treatment factor, the application of boiler ash, divided into five dose levels. The first level (A0) was a control, a mixture of topsoil and sand without boiler ash. The second to fifth levels (A1 to A4) each are a mixture of topsoil and sand with added boiler ash at 40, 60,

80, and 100 grams respectively. Each treatment level was repeated 5 times, so that the 25 experimental units were randomly assigned within each replication group to control for variation in growing environments (Roziqin et al., 2025).

2.3. Stages Study

Research preparation began with clearing the area of weeds and other objects that could interfere with the research using a hoe. The planting medium used was ultisol soil obtained from Lubuk Pakam. Boiler ash from PTPN IV Adolina was used. The planting material used was D x P Simalungun variety oil palm seedlings obtained from the Palm Oil Research Center (PPKS). Boiler ash was applied by mixing it into ultisol soil at the specified treatment dosage.

Next, the mixed planting medium is put into polybags and arranged in the area. research with planting distance 90 cm x 90 cm. Plant maintenance activities include watering twice a day. Morning implemented between 07.00 to 10.00 WIB, while watering afternoon between 15.00 until 18.00 WIB. The goal is to maintain water and humidity in the growing medium. Furthermore, weeding is done manually both inside and outside the polybags at weekly intervals, depending on weed growth levels in the area. study.

2.4. Research Flow Chart

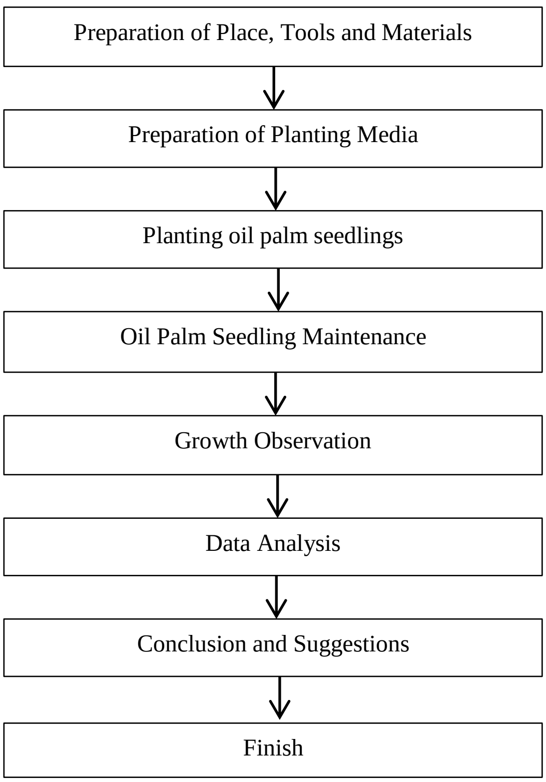

Figure 1. Flowchart Study

2.5. Observation

During the study, several plant parameters were recorded as observation data. These parameters were plant height (seedlings), stem diameter, number of leaves, root wet weight, root dry weight, crown wet weight, and crown dry weight. Observations of seedling height, stem diameter, and leaf number were conducted at biweekly intervals.

Seedling height parameters are measured from the soil level to the highest leaf tip. For stem diameter, measurements are taken using Vernier calipers. The number of leaves was determined by counting all the leaves formed on the plant. At the end of the study, the seedlings were removed from the polybags, and the roots and shoots were separated and weighed wet. The dry weight of the roots and shoots was then obtained by drying the samples in an oven at 80°C for 24 hours until a constant weight was achieved. or constant.

3. Results and Discussion

3.1. Plant Height (cm)

One parameter for assessing the effect of boiler ash dosage on plant growth is measuring the height of oil palm seedlings. The summary of seedling height measurements for each treatment is presented in the Table 1.

The analysis of variance results in Table 2 confirm that the addition of *boiler ash* did not significantly affect the height of oil palm seedlings at 5–9 WAP, so further DMRT testing was not necessary. The highest average seedling height was achieved by treatment A3 (80 g *boiler* ash) at 19.02 cm at 9 WAP.

These findings can be compared quantitatively with three previous studies. First, the study by Kuvaini & Surbakti (2019), which specifically tested *boiler ash* and wood charcoal as growing media for oil palm seedlings in *Pre-nursery* research, reported that the combination of *boiler ash* and wood charcoal had a significant effect on plant height. different from the results of this study, which are not real. This difference indicates that boiler ash is only effective in increasing seedling height.

Palm oil (cm)if combined with material improver other like charcoal wood, not given singly together topsoil-sand as in the study. Second, the research of Tarigan et al. (2024). In *the main-nursery phase, it was reported that the NPK-based control treatment (5 g)* produced better seedling growth than single *boiler ash.* Doses of 30–60 g, in line with the pattern in this study, where the addition of *boiler ash* did not significantly outperform the control. Third, a study about a combination.

Boiler ash from palm oil mills in *the pre-nursery* reported that *the boiler ash* dose of 30 g per new plant had a significant effect on plant height at 90 days after planting when combined with 4000 ml of liquid waste/plant, reinforcing the indication that a single dose of 40–100 g in this study was not yet optimal. The graphical image of plant height growth is shown.

3.2. Diameter Stem (cm)

Recapitulation of data on the impact of giving ash boiler with various doses on observation age 5 MST-9 MST is shown in the Table 2.

This pattern is consistent with reports that the interaction between boiler ash and NPK fertilizer is necessary to significantly stimulate stem diameter growth (the highest average of 17.90 mm in the combination of 45 g NPK and 45 g boiler ash). In contrast, *boiler ash* alone in both studies did not show a similar effect. Another study on mixed media of oil palm solid waste confirmed that the quality of the planting media greatly influences seedling growth because each type of media has a different nutrient content, which also explains why the addition of *boiler ash* in topsoil-sand media is not enough to change the growth rate of stem diameter in this relatively short *pre-nursery phase*. A study on oil palm fertilization in peatlands, published in the Journal of Tropical Plant Agronomy, also emphasized that the effectiveness of an ameliorant material depends heavily on its interaction with the plant's properties. Physical-chemical properties of the local plant media, not just the dose given.

Table 1. Average Tall Seeds Palm Oil

Treatment	5 MST	6 MST	7 MST	8 MST	9 MST
A0	7,68 ± 0,21	13,18 ± 0,42	15,64 ± 0,51	16,84 ± 0,48	17,80 ± 0,55
A1	8,32 ± 0,25	11,72 ± 0,38	14,36 ± 0,47	16,12 ± 0,52	17,70 ± 0,51
A2	8,54 ± 0,28	12,64 ± 0,41	15,40 ± 0,49	17,24 ± 0,55	18,88 ± 0,62
A3	7,24 ± 0,19	11,92 ± 0,35	15,68 ± 0,53	17,44 ± 0,58	19,02 ± 0,65
A4	7,72 ± 0,22	12,78 ± 0,39	14,78 ± 0,44	16,62 ± 0,49	18,46 ± 0,58
Amount	39,5	62,24	75,86	84,26	91,86
Average	7,9	12,45	15,17	16,85	18,37
Improvement	0.00	4.55	2.72	1.68	1.52
Significant	tn.	tn.	tn.	tn.	tn.

Note: Ftable at the 5% level for the repetition factor is 3.01, while Ftable for the treatment factor is also 3.01. At the 1% level, the F-table values for the replication and the treatment were 4.77 and 4.22, respectively. Symbol description: tn = not significantly different, *= significantly different, ** = very significantly different. MST = Weeks After Planting.

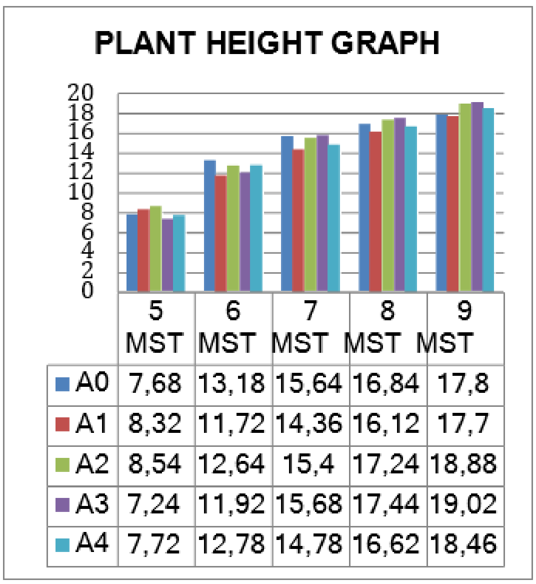

Figure 2. Chart Plant Height (cm)

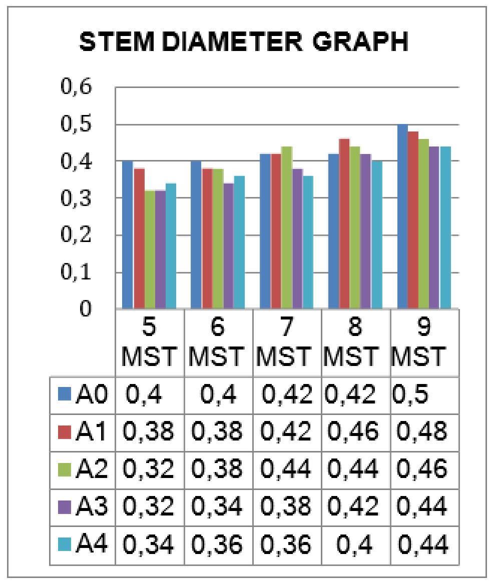

Figure 3. Chart Stem Diameter (cm)

Table 2. Diameter Stem (cm)

Treatment	5 MST	6 MST	7 MST	8 MST	9 MST
A0	0,40 ± 0,02	0,40 ± 0,01	0,42 ± 0,03	0,42 ± 0,02	0,50 ± 0,04
A1	0,38 ± 0,01	0,38 ± 0,02	0,42 ± 0,02	0,46 ± 0,03	0,48 ± 0,03
A2	0,32 ± 0,02	0,38 ± 0,03	0,44 ± 0,01	0,44 ± 0,02	0,46 ± 0,02
A3	0,32 ± 0,01	0,34 ± 0,02	0,38 ± 0,02	0,42 ± 0,01	0,44 ± 0,03
A4	0,34 ± 0.02	0,36 ± 0.01	0,36 ± 0.03	0,40 ± 0.02	0,44 ± 0.02
Amount	1.76	1.86	2.02	2.14	2.32
Average	0.35	0.37	0.40	0.43	0.46
Improvement	0.00	0.02	0.03	0.02	0.04
Significant	tn.	tn.	tn.	tn.	tn.

Note: F-table at the 5% level for the repetition factor is 3.01, while the F-table for the treatment factor is also 3.01. At the 1% level, the F-table values for the replication and the treatment were 4.77 and 4.22, respectively. Symbol description: tn = not significantly different, *= significantly different, ** = very significantly different. MST = Weeks After Planting.

The results of the analysis of variance in Table 3 show that the addition *of boiler* ash has no significant effect on the stem diameter of oil palm seedlings in the age range of 5–9 MST, so further DMRT testing is not necessary.

Increase diameter The lowest (0.02 cm) was recorded at 6 and 8 MST, while the highest increase (0.04 cm) occurred at 9 weeks after planting. The highest average diameter was actually obtained by the control treatment A0 (without *boiler ash*) at 0.50 cm at 9 weeks after planting, while the lowest average was recorded in treatments A2 and A3 (60 and 80 g of *boiler ash*) at 0.32 cm at 5 weeks after planting.

This pattern is interesting to compare with three previous relevant studies. First, research on the combination of *boiler ash* and NPK fertilizer during the main-nursery phase reported that the optimal increase in stem diameter (average 17.90 mm, or equivalent to 1.79 cm) was achieved only through the interaction of a 45 g NPK dose and 45 g boiler ash, not by *boiler ash* alone. This value is much higher than the highest average diameter reported in this study (0.50 cm), indicating that, in the absence of inorganic fertilizers, boiler ash alone is insufficient to significantly stimulate stem diameter growth in the early nursery phase significantly.

Second, research on *boiler ash doses* during the main-nursery phase reported that the control treatment (A0, based on 5 g NPK fertilizer) actually promoted seedling growth. This included stem diameter, which is better than the single-*boiler ash treatment* at a dose of 30–60 g. This finding is in line with the results of this study, where the control treatment A0 (without any *boiler ash* at all) actually recorded the highest average diameter (0.50 cm) compared to all treatments with a *boiler ash dose* (0.44–0.46 cm), or a difference of about 0.04–0.06 cm lower. In *the boiler* ash treatment compared to the control.

Third, a study on the combination of liquid waste and *boiler ash* from palm oil mills in the *pre-nursery phase* reported that a *boiler* dose of 30 g per new plant has a significant effect on growth parameters (leaf area and crown dry weight) when combined with 4000 ml of liquid waste per plant, but not when given alone. Comparison: This strengthens the indication that a single dose of 40–100 g of *boiler ash* on topsoil-sand media in this study, without a combination of liquid or other inorganic materials, is not yet in optimal condition to encourage a real increase in stem diameter, consistent with the pattern in the three comparative studies above.

In general, the three quantitative comparison shows a consistent pattern: the effectiveness of *boiler ash* on the diameter of oil palm seedling stems. This effect is only apparent when combined with inorganic fertilizer (NPK) or accompanying liquid materials, not when applied singly to topsoil-sand media as in this study. The stem diameter graph is as follows.

3.3. Number of Leaves (strands)

Data observation amount leaf (strands) at the age of 5 MST to 9 MST from the results of statistical analysis are shown in the following table.

Table 3. Average Amount Leaf (strand)

Treatment	5 MST	6 MST	7 MST	8 MST	9 MST
A0	1,0 ± 0,08	1,0 ± 0,11	1,6 ± 0,15	2,0 ± 0,18	2,2 ± 0,20
A1	1,4 ± 0,12	1,8 ± 0,14	2,2 ± 0,19	2,6 ± 0,22	3,0 ± 0,25
A2	1,4 ± 0,10	1,6 ± 0,13	2,0 ± 0,17	2,2 ± 0,21	2,6 ± 0,24
A3	1,4 ± 0,11	1,4 ± 0,12	1,8 ± 0,16	2,0 ± 0,19	2,4 ± 0,22
A4	1,4 ± 0,09	1,4 ± 0,11	1,8 ± 0,15	2,0 ± 0,18	2,2 ± 0,21
Amount	6,6	7,2	9,4	10,8	12,4
Average	1,32	1,44	1,88	2,16	2,48
Improvement	0,00	0,12	0,44	0,28	0,32
Significant	tn	tn	tn	tn	tn

Note: The F-table at the 5% level for the repetition factor is 3.01, and for the treatment factor it is also 3.01. At the 1% level, the F-table values for the repeat test and the treatment were 4.77 and 4.22, respectively. Information symbol: tn. = not significantly different, *= significantly different, ** = very significantly different. MST = Weeks After Planting.

The ANOVA results in Table 3 indicate that the provision of boiler ash did not significantly affect the number of leaves in the 5–9 MST age range, so further DMRT testing was not carried out. The highest average number of leaves was achieved in treatment A2 (60 g *boiler ash*) of 2.6 leaves at the age of 9 MST, while the control treatment A0 actually produced the lowest number of leaves (1.0 strand on 5 MST, increasing became 2.2 strands on 9 MST).

Quantitative comparison with previous research shows contrasting patterns. Kuvaini & Surbakti (2019) reported that the combination of *boiler ash* and wood charcoal had an effect related to amount leaf seeds in *pre-nursery* Far different from the unrealistic results in this study, which indicates the role of charcoal as a factor supporting important which no present on this study. Temporary That, Tarigan et al.'s (2024) research on *the main nursery* also reported no significant effect (tn) of *boiler ash* on leaf number over 16 weeks. After application, in line with the pattern in this study, although at a different nursery phase. Research on the combination of NPK fertilizer and *boiler ash* in *the main nursery* also confirmed that growth parameters, such as the number of new leaves, were significantly affected by the NPK-boiler ash dose interaction, not by boiler ash alone, consistent with the conclusion of this study. A graph of the number of leaves is shown in the figure below.

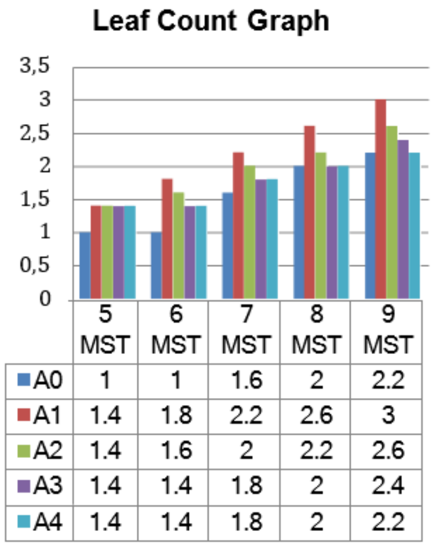

Figure 4. Chart Amount Leaf (Strand)

3.4. Fresh Weight (g)

The results of measuring the fresh weight of oil palm seedlings at 9 weeks after planting, influenced by the boiler ash dose treatment, are presented in the table below. This.

Table 4. Fresh Weight Title (g)

Treatment	9 MST
A0	2.94 ± 0.11
A1	2.62 ± 0.09
A2	3.32 ± 0.14
A3	2.94 ± 0.12
A4	2.85 ± 0.10
Amount	14.67
Average	2,934
Improvement	0
Significant	tn.

Note: The F-table at the 5% level for the repetition factor is 3.01, while for the treatment factor it is also 3.01. At the 1% level, the F-table values for the replication and the treatment were 4.77 and 4.22, respectively. Symbol description: tn = not significantly different, *= significantly different, ** = very significantly different. MST = Weeks After Planting.

The analysis of variance data indicated that the boiler ash dose did not cause a significant difference in the fresh weight of oil palm seedlings at 9 weeks post-treatment (WAP), so further DMRT analysis was not necessary. The fresh weight of the highest-achieved treatment A2 (60 g *boiler ash*) amounted to 3.32 g, while the lowest value (2.62 g) was in treatment A1 (40 g).

Compared with the research of Kuvaini & Surbakti (2019), which reported that the combination of *boiler ash* and wood charcoal had a significant effect on plant biomass/physiology (including crown weight), the insignificant results in this study indicate that the presence of porous materials such as wood charcoal plays an important role in improving aeration and cation exchange capacity of the media, so that nutrients from *boiler ash* are more available to plants. These conditions did not occur in pure topsoil-sand media in this study. Research by Tarigan et al. (2024) on *the main nursery* also reported that the wet weight of the crown was not significantly different due to a single application of boiler ash during 16 weeks after application, reinforcing the consistent pattern that *boiler ash* alone has not significantly affected the accumulation of fresh canopy biomass at various nursery stages. Meanwhile, a study of the combination of liquid waste and *boiler ash* in *the pre-nursery* reported that the dry weight of the canopy (which correlated with fresh weight) is only significantly affected by the dose of 30 g of *boiler* ash combined with 4000 ml of liquid waste/plant, rather than by a single higher dose *of boiler ash as in this study. The graph of the fresh weight of the shoots, in grams, is shown below.*

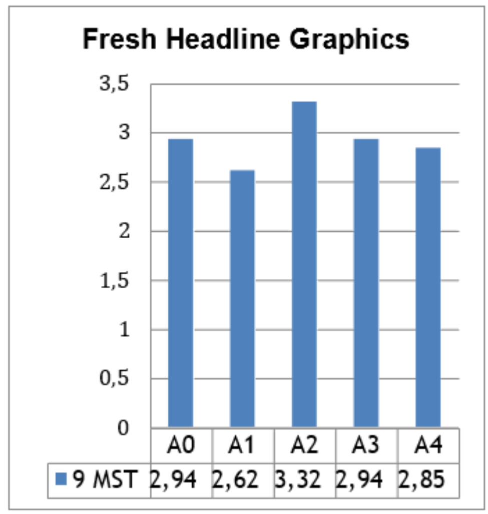

Figure 5. Chart Fresh Weight (gr)

3.5. Dry Weight Title (g)

The results of the dry weight measurements for the 9 MST oil palm seedling crowns influenced by the boiler ash dose treatment are presented in the Table 5.

Table 5. Dry Weight (gr)

Treatment	9 MST
A0	0.69 ± 0.02
A1	0.57 ± 0.02
A2	0.67 ± 0.03
A3	0.70 ± 0.03
A4	0.63 ± 0.02
Amount	3.26
Average	0.652
Improvement	0
Significant	Mr.

Note: The F-table at the 5% level for the repetition factor is 3.01, and for the treatment factor it is also 3.01. At the 1% level, the F-table values for the replication and the treatment were 4.77 and 4.22, respectively. Symbol description: tn = not significantly different, *= significantly different, ** = very significantly different. MST = Weeks After Planting.

Analysis of variance indicates that *the boiler ash dose* did not result in significant differences in the dry weight of seedling shoots. Oil palms were aged 9 weeks after planting, so further DMRT analysis was not performed. The maximum dry weight of the crown was achieved with treatment A3 (80 g of boiler ash; 0.70 g), while the minimum value (0.57 g) was observed with treatment A1 (40 g).

Quantitative comparisons with three previous studies reinforce this pattern. First, a study on the combination of liquid waste and palm oil mill *boiler ash in the pre-nursery* reported that *boiler ash at* a dose of 30 g/plant had a significantly different effect on the dry weight of the crown in contrast to the non-significant results in this study, even though the doses used were higher (40–100 g). This difference indicates that the effectiveness of *boiler ash* on dry canopy weight is determined more by its interaction with the accompanying liquid nutrient source, not by the size of the dose. That alone. Second, Kuvaini & Surbakti (2019) reported the real effect of *boiler ash* and wood charcoal on plant physiology/biomass in *the pre-nursery*, in line with the indication that porous materials such as wood charcoal contribute to improving nutrient absorption, which leads to the accumulation of dry weight of the canopy factors that are not present in the topsoil-sand combination in the study.

Third, the study by Tarigan et al. (2024) in *the main-nursery* reported no significant difference in shoot dry weight (tn) due to single boiler ash for 16 weeks after application, consistent with the non-significant results in this study even at different nursery phases, *confirming* that the response pattern of shoot dry weight to single *boiler ash* was relatively similar in both *the pre-nursery* and *main-nursery*. The bar chart of shoot dry weight (grams) is shown in the figure below.

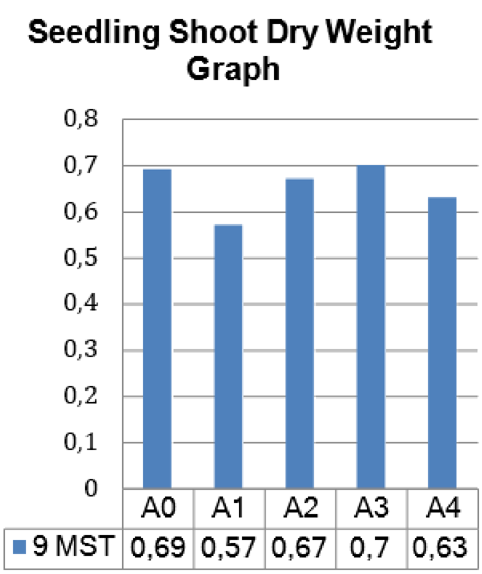

Figure 6. Dry Weight (gr)

3.6. Fresh Root Weight (gr)

The following table presents the results of observations of the fresh weight of plant roots at 9 weeks after planting with boiler ash treatment.

Table 6. Fresh Root Weight (gr)

Treatment	9 MST
A0	3.27 ± 0.11
A1	3.22 ± 0.09
A2	3.04 ± 0.08
A3	3.15 ± 0.10
A4	3.37 ± 0.12
Amount	16.05
Average	3.21
Improvement	0
Significant	Mr.

Note: F-table at the 5% level for the repetition factor is 3.01, while for the treatment factor it is also 3.01. At the 1% level, the F-table values for the repeat test and the treatment were 4.77 and 4.22, respectively. Information symbol: tn.= not significantly different, *= significantly different, ** = very significantly different. MST = Weeks After Planting.

The analysis of variance indicated that the boiler ash dose did not cause a significant difference in the fresh root weight of oil palm seedlings aged 9 weeks after planting, so further DMRT analysis was unnecessary. The maximum fresh root weight achieved by treatment A4 (100 g of boiler ash) was 3.77 g *(note: Table 7 lists 3.37 g*, while the minimum value (3.04 g) was in treatment A2 (60 g).

Research by Tarigan et al. (2024) on *the main nursery* also reported that the wet weight of the roots did not differ significantly (tn) due to *boiler ash* alone, in line with the results of this study. In contrast, research on the combination of palm shell ash and swiftlet manure fertilizer in *the main nursery* reported that root growth parameters were only significantly affected when the shell ash was combined with an organic material source such as swiftlet manure, rather than given alone, strengthening the indication that *boiler ash* /swallow manure shell single Generally, it has not significantly affected root growth, either in *the pre-nursery* or *main-nursery*. Research by Kuvaini & Surbakti (2019) also confirmed that wood charcoal, not *boiler ash* alone, is the main contributor to improving media aeration, which supports the development of the seedling root system. weight fresh root in unit grams can be seen in the Figure 7.

3.7. Dry Root Weight (gr)

Fresh weight measurement results for the roots of oil palm seedlings 9 weeks after planting, which are affected by the boiler ash dose treatment, are presented in the Table 8. The analysis of variance data indicates that *the boiler ash dose* does not cause a significant difference in the dry weight of Palm Oil seedling roots. Palm oil age was 9 MST. Further DMRT analysis was not required. The maximum root dry weight value was achieved in treatment A4 (100 g *boiler ash*) of 0.37 g, while the minimum value (0.30 g) was in treatment A2 (60 g).

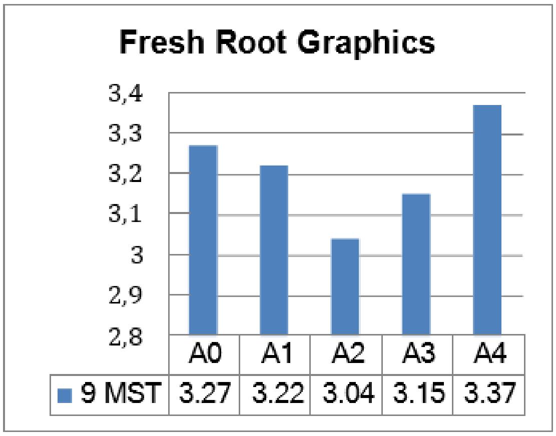

Figure 7. Fresh Weight of Roots (gr)

Table 8. Dry Root Weight (gr)

Treatment	9 MST
A0	0.61 ± 0.02
A1	0.67 ± 0.02
A2	0.75 ± 0.03
A3	0.49 ± 0.01
A4	0.52 ± 0.02
Amount	3.04
Average	0.608
Improvement	0
Significant	Mr.

Note: The F-table at the 5% level for the repetition factor is 3.01, while for the treatment factor it is also 3.01. At the 1% level, the F-table values for the replication and the treatment were 4.77 and 4.22, respectively. Symbol description: tn = not significantly different, *= significantly different, ** = very significantly different. MST = Weeks After Planting.

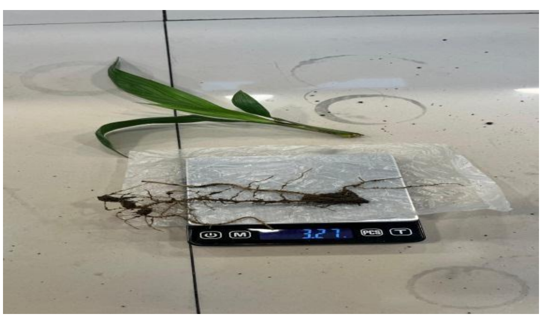

Figure 8. Weight Fresh Roots (gr)

As a quantitative comparison, research by Tarigan et al. (2024) on *the main nursery* reported that root dry weights were also not significantly different due to single *boiler ash, strengthening the consistent pattern across* nursery phases in this study. The study on the combination of liquid waste and boiler ash in pre-nursery reported that new rooting-related parameters showed significant responses when boiler ash was combined with palm oil mill effluent, but not as a single treatment. Meanwhile, research on the combination of NPK and *boiler* ash in *the main nursery* reported that the fresh root weight parameter and dry root weight did not show significant differences even with the addition of NPK fertilizer, indicating that the root weight parameter in general is indeed more difficult influenced by treatment of planting media compared to canopy parameters, possibly because root development is more influenced by the physical properties of the media (porosity, density) than the nutrient content of the media alone.

Figure 9. Root Dry Weight (gr)

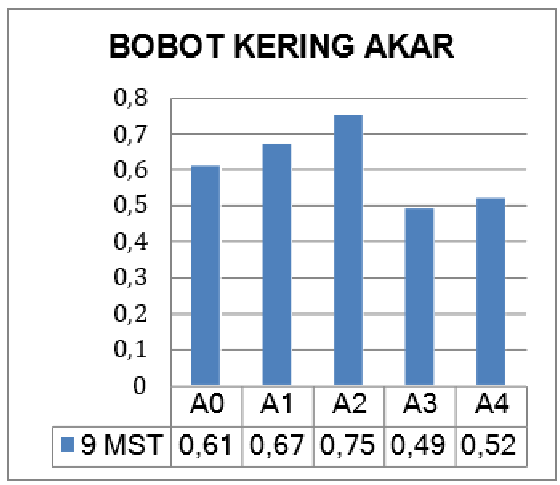

Figure 10. Dry root weight (g)

The inevitability of the influence of ash. *The effect of boiler ash* on fresh crown weight is in line with the report that the parameters of fresh crown weight, fresh root weight, and fresh seedling weight were also not significantly different due to *boiler ash treatment* in the *main-nursery phase*, so that the same response pattern appears consistent in two different nursery phases. Studies on the combination of oil palm shell ash and organic fertilizer also confirmed that the response in new crown weight was clearly visible when boiler ash was combined with other organic materials, but not when given singly. This strengthens the conclusion that a single dose of 40–100 g of ash in topsoil-sand media was not sufficient to trigger significant accumulation of canopy biomass within three months of observation. Comparison with Studies on Ash-Based Planting Media and Alternative Nutrients on Oil Palm Seedlings and Other Plants

There were no significant differences in any oil palm seedling growth parameters with the provision of boiler ash. This study is in line with the pattern reported by Saragih et al. (2026) in a study of the provision of liquid organic fertilizer (POC) made from goat manure and straw waste as a nutritional supplement for AB Mix in the pre-nursery phase of oil palm seedlings using a wick hydroponic system. The study reported that the control treatment based on a single inorganic nutrient (AB Mix) produced an average seedling height of 30.33 cm at 12 weeks after planting (WAP), higher than the combination of AB Mix with goat manure POC or straw waste, which reached only 28.02 cm. However, the difference was not statistically significant either. This pattern supports the indication in this study that organic materials or additional ameliorants applied singly, or those with a relatively slow nutrient-release process, do not significantly contribute to the initial growth of oil palm seedlings compared to other nutrient sources. readily available and easily absorbed by plants.

Temporary that, if reviewed from regarding ash-based materials as ameliorants, the results of the study by Lenin et al. (2026) on the application of coal fly ash combined with various sources of organic materials in paddy fields (Oryza sativa L.) showed a pattern that contrasted with this study. *Fly ash* with a high silica content (43.95% SiO_2) combined with cow manure compost at a proportion of 75% of the dry weight of the compost (PKF4 treatment) was proven to be able to increase grain dry weight significantly up to 108.33 g pot $^{-1}$, the highest among all treatment combinations tested. The study also reported a positive correlation between silica content in the material ameliorant and results in paddy fields. This difference in response patterns indicates that the effectiveness of ash-based materials is highly dependent on their chemical characteristics (available silica and macronutrient content), their mixture proportions with organic matter, the type of plant tested, and the observed growth phase. The oil palm boiler ash used in this study has different chemical characteristics from coal *fly ash, so a single dose of 40–100 g in topsoil-sand media may not have reached the optimal proportion.* To trigger a real growth response in *pre-nursery*-phase oil palm seedlings, the proportion of *fly ash* above 50% of the dry weight of the new compost showed an increase, resulting in real growth on rice plants.

In general, a comparison of the two studies confirms that, in both oil palm and lowland rice plants, the success of applying waste-based alternative ameliorants — both liquid organic and ash — is largely determined by formulation, dosage, and their combination with complementary nutrient sources, rather than solely by the type of material used.

4. Conclusion

A dose of 40–100 g of boiler ash did not have a significant effect on any vegetative growth parameters of oil palm seedlings during the pre-nursery phase, including plant height, number of leaves, stem diameter, and the fresh and dry weights of the crown and roots. The advantage of this study lies in providing comparative data on single doses of boiler ash during the early nursery phase, an area that has been minimally explored to date, and in confirming that the results show no significant impact.

Boiler ash is not beneficial; rather, it indicates that the dosage, application method, and observation period in this study were not optimal for eliciting a genuine response in the seedlings.

For users and practitioners in nurseries, it is recommended not to rely solely on boiler ash during the pre-nursery phase. Instead, it should be combined with inorganic fertilizers (such as NPK) or other organic materials. Its application should be more carefully considered during the main nursery phase, when seed nutrient reserves have been depleted, and the plants' response to external nutrients becomes more pronounced.

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