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Effectiveness of Fly Ash, Dolomite, and Organic Fertilizers in Enhancing Oil Palm Seedling Growth

Yudhi Pramudya [a,*], Farrah Fadhillah Hanum [b], Azrian Makmum Muhammad [c], Budi Setya Wardhana [b], Saktiyono Sigit Tri Pamungkas [a]

[a] Department of Plantation Crop Farming, Polytecnic of Lembaga Pendidikan Perkebunan (LPP), Yogyakarta, Indonesia
[b] Magister of Chemical Engineering, Faculty of Technology Industry, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[c] Department of Plantation Management, Polytecnic of Lembaga Pendidikan Perkebunan (LPP), Yogyakarta, Indonesia

Abstract. *Oil Palm (Elaeis guineensis Jacq.) is a crucial plantation commodity in Indonesia's economy. The increasing global demand for oil palm has driven the expansion of oil palm plantations. However, this expansion is often constrained by limited fertile land. Fly ash, a byproduct of coal combustion, contains essential nutrients such as calcium, magnesium, and silica. Several studies suggest that fly ash potentially improves soil physical and chemical properties, as well as enhance nutrient availability for plants. This research aims to evaluate the effectiveness of adding fly ash in various growing media, dolomite, and organic fertilizers on the growth of oil palm seedlings. The study employs a Completely Randomized Design (CRD) with several treatment combinations, including fly ash, organic fertilizer, dolomite, and NPK 16:16:16 fertilizer doses. The results indicate that combining fly ash and organic fertilizer is the best choice for improving oil palm seedling growth. Additionally, adding NPK 16:16:16 fertilizer at 36 grams per polybag yields excellent growth results. Interaction analysis indicates significant effects of these combinations on seedling growth improvement. This preliminary study is expected to provide foundational information useful for further research on utilizing fly ash and other organic materials in oil palm cultivation and the potential application of this technology on a larger scale.*
Keywords: *dolomite fertilizer; fly ash; oil palm; seeding; seedling growth.*

Type of the Paper: Regular Article.

1. Introduction

Indonesia is a leading exporter of palm oil, with the global demand driving the expansion of palm oil plantations [1]. The cultivated area increased from 294,560 hectares in 1980 to 11.30 million hectares in 2016 [2]. However, this expansion is often constrained by limited fertile land, affecting plantation productivity. The productivity of oil palm relies heavily on seed quality and soil conditions, as nutrient availability is crucial for plant growth and health [3,4]. Enhancing seedling growth is vital, especially during the seedling stage, influencing future plant development [5]. One strategy to improve soil media involves utilizing natural materials and industrial by-products, such as fly ash, a by-product of coal combustion in power plants [6]. Fly ash, rich in organic matter and essential minerals, can enhance soil structure, enhance cation exchange

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* First corresponding author
Email: pramudyayudhi@polteklpp.ac.id

capacity (CEC), and provide necessary nutrients [7–9].

Ash coal, consisting of fly ash and bottom ash [10], contains macro-nutrients like iron (Fe), calcium (Ca), aluminum (Al), silicon (Si), potassium (K), and magnesium (Mg), along with micronutrients such as zinc (Zn), manganese (Mn), and copper (Cu), which can improve soil quality [11,12]. Additionally, dolomite, a carbonate mineral, is used to increase soil pH due to its high calcium and magnesium content [13]. Dolomite and manure are commonly applied to improve soil chemistry and biology; dolomite raises soil pH and provides essential nutrients, while manure boosts soil fertility by adding organic matter and enhancing microbial activity [14,15]. Phosphorus (P) is crucial for photosynthesis, root development, and the formation of flowers, fruits, and seeds [16]. In acidic soil, P often becomes unavailable to plants due to its fixation with soil colloids such as iron and aluminum [17,18]. In Indonesia, many agricultural areas suffer from nutrient-poor and acidic soils, often due to the presence of high iron and aluminum content, which bind essential nutrients like phosphorus, making them unavailable to plants. Fly ash and dolomite offer a cost-effective and sustainable solution to these challenges. Fly ash, rich in macro and micronutrients like iron (Fe), calcium (Ca), potassium (K), and magnesium (Mg), helps to amend the soil by providing nutrients that enhance soil fertility and plant growth. Dolomite, with its high calcium and magnesium content, is particularly valuable for neutralizing soil acidity, a common issue in Indonesian agricultural soils, improving nutrient availability and boosting plant health. Both materials play a crucial role in addressing soil fertility and pH issues while promoting sustainable farming practices through the utilization of industrial by-products.

Fly ash contains various macronutrients, such as iron (Fe), calcium (Ca), magnesium (Mg), and potassium (K). Fly ash typically contains 25–30% calcium, 2–5% magnesium, and small amounts of 1–3% potassium, which are essential for enhancing plant growth. These nutrients help promote root development and improve overall plant health. Additionally, fly ash provides trace elements such as zinc (Zn), manganese (Mn), and copper (Cu), which are necessary for proper enzymatic functions and metabolic processes in plants. The nutrient composition of fly ash makes it a valuable soil amendment, particularly in areas with nutrient deficiencies, such as parts of Indonesia.

Dolomite's calcium and magnesium improve phosphorus availability and mitigate harmful effects from aluminum and iron [19,20]. Organic materials like poultry manure replace inorganic fertilizers by releasing bound phosphorus and enhancing nutrient availability [21]. Given the limitations of macro-nutrient content in these mixtures, compound fertilizers such as NPK are essential to supplement macronutrients. NPK fertilizers are highly effective for plant growth, improving yields, and providing balanced nutrients [22,23]. This study aims to evaluate the effectiveness of fly ash combined with dolomite and manure in enhancing oil palm seedling growth. It is expected to provide new insights into using industrial waste and natural materials as sustainable solutions for increasing agricultural productivity, particularly in the development of more efficient and environmentally friendly palm oil plantations. This study differs from previous research by exploring the combined use of fly ash, dolomite, and manure, expected to enhance soil fertility, pH, and nutrient availability for improved oil palm seedling growth.

2. Materials and Methods

2.1. Equipment and material

The equipment used in this study included 35 cm x 35 cm polybags, buckets, hoes, rulers, an analytical balance, an oven, a 5000 mL measuring cylinder, writing instruments, and documentation equipment. The 35 cm x 35 cm polybags were chosen to provide adequate space for root growth. However, using different sizes could potentially affect the results by restricting root development or limiting nutrient absorption. The fly ash used in this study was sourced from a specific power plant. Variations in its composition across different plants could impact the results due to differences in nutrient content. DXP (Dura × Pisifera) Yangambi (PT Socfindo) oil palm seedlings were selected for their proven adaptability to the experimental conditions and their well-established growth traits, making them a reliable choice for this study. The materials used in this study included 3-month-old superior DXP Yangambi (Socfindo) oil palm seedlings, soil, fly ash from a power plant, organic manure, NPK 16:16:16 fertilizer, and dolomite fertilizer. The study was conducted during the transition from the dry to the rainy season (typically from October to March in tropical regions like Indonesia), as seasonal variations in temperature, such as temperature, rainfall, and humidity could significantly influence plant growth and nutrient availability. Sandy regosol soil, which is readily available at the Wedomartani Practice Farm (7°44'3.63"S, 110°26'33.22"E), was used in this study. The farm serves as a site for agricultural experiments and practical learning, focusing on testing innovative farming techniques.

2.2. Preparation of growing media

This study employed a Completely Randomized Block Design (CRBD) with a factorial arrangement consisting of two factors. The first factor, fly ash (F), had three levels: F0 (0 g/polybag, control), F1 (100 g/polybag + 18 g/polybag dolomite fertilizer), and F2 (100 g/polybag + 200 g/polybag organic fertilizer). The second factor, NPK 16:16:16 fertilizer (N), also had three levels: N0 (0 g/polybag, control), N1 (29 g/polybag), and N2 (35 g/polybag). The fertilizer was applied three times at two-week intervals, beginning two weeks after planting. The fertilizer was applied by sprinkling it in a circular pattern on the surface of the growing medium according to the specified treatment doses.

This treatment results in nine combinations with three repetitions, with each treatment containing one seedling as a sample. Thus, a total of 27 main seedlings were required, along with three reserve seedlings, bringing the total to 30 seedlings for this study. The combinations are presented in Table 1.

Table 1. The Combination of Growing Media Addition

Variations Code	Coal Ash	Dolomite or Organic Manure Additive	NPK
F0N0	without fly ash		without NPK
F0N1	without fly ash	-	29 gr/Polybag
F0N2	without fly ash	-	35 gr/Polybag
F1N0	100 gr	18 gr/Polybag of dolomite	without NPK
F1N1	100 gr	18 gr/Polybag of dolomite	29 gr/Polybag
F1N2	100 gr	18 gr/Polybag of dolomite	35 gr/Polybag
F2N0	100 gr	200 gr/Polybag of organic manure	without NPK
F2N1	100 gr	200 gr/Polybag of organic manure	29 gr/Polybag
F2N2	100 gr	200 gr/Polybag of organic manure	35 gr/Polybag

2.3. Procedure for observing seedling growth parameters

The observation of oil palm seedling growth parameters includes several key aspects. Plant height is measured from the base to the tip of the highest leaf using a ruler, with reference to a stake to minimize the influence of soil surface shrinkage. The measurement intervals of 14, 28, 42, and 56 days after planting (DAP) were selected to capture key stages of plant growth and development, providing a comprehensive understanding of growth patterns over time. Environmental conditions, such as light, temperature, and humidity, were not directly controlled during the observation period. However, these variables were monitored, and their potential impact was considered in the analysis to ensure that observed differences in plant growth were not influenced by external abiotic factors. The number of leaves is recorded at initial planting and every two weeks thereafter to monitor the leaf growth rate as an indicator of plant health. Stem diameter is measured biweekly using calipers, starting from planting, to assess stem development as an indicator of plant strength and health.

Root length is measured at the end of the study from the stem base to the longest root using a ruler. The fresh weight of the shoots and roots is also determined at the study's conclusion by weighing each part with an analytical balance to assess plant biomass growth. The dry weight of the shoots and roots is measured after oven-drying at 70°C for 48 hours until a constant weight is reached, providing data on total biomass production during the study. The dry weight of the shoot and root biomass is measured after oven-drying at 70°C for 48 hours until a constant weight is reached, providing an accurate assessment of total biomass production.

2.4. Measurement of pH and moisture of the growing medium

The pH and moisture of the growing medium were measured using a soil pH-moisture meter, starting at 14 days after planting (DAP) and continuing biweekly. This monitoring aimed to assess the growing medium's condition to ensure an optimal environment for plant growth. This research focused on assessing the growing medium, with external abiotic factors such as light intensity and insect infestation not measured, as the primary objective was to evaluate the impact of soil amendments on plant growth, and external factors were expected to have minimal influence during the study period.

2.5. Characterization of coal ash

The coal ash was characterized by analyzing its main chemical composition using X-ray fluorescence (XRF) at the Radiation Laboratory in Yogyakarta. Sub-Laboratory for Chemical Testing – BRIN, to assess the chemical elements that may influence its potential use.

2.6. Data analysis

The data were analyzed using Analysis of Variance (ANOVA) to assess significant differences between treatments. If significant differences were found, Duncan's Multiple Range Test (DMRT) at a 5% significance level was applied to identify specific differences between the treatment groups. The analysis aimed to confirm that the observed differences between treatments were not due to chance, providing a clearer understanding of treatment's effects on the variables studied. To enhance the reliability and consistency of the findings, the research included three repetitions.

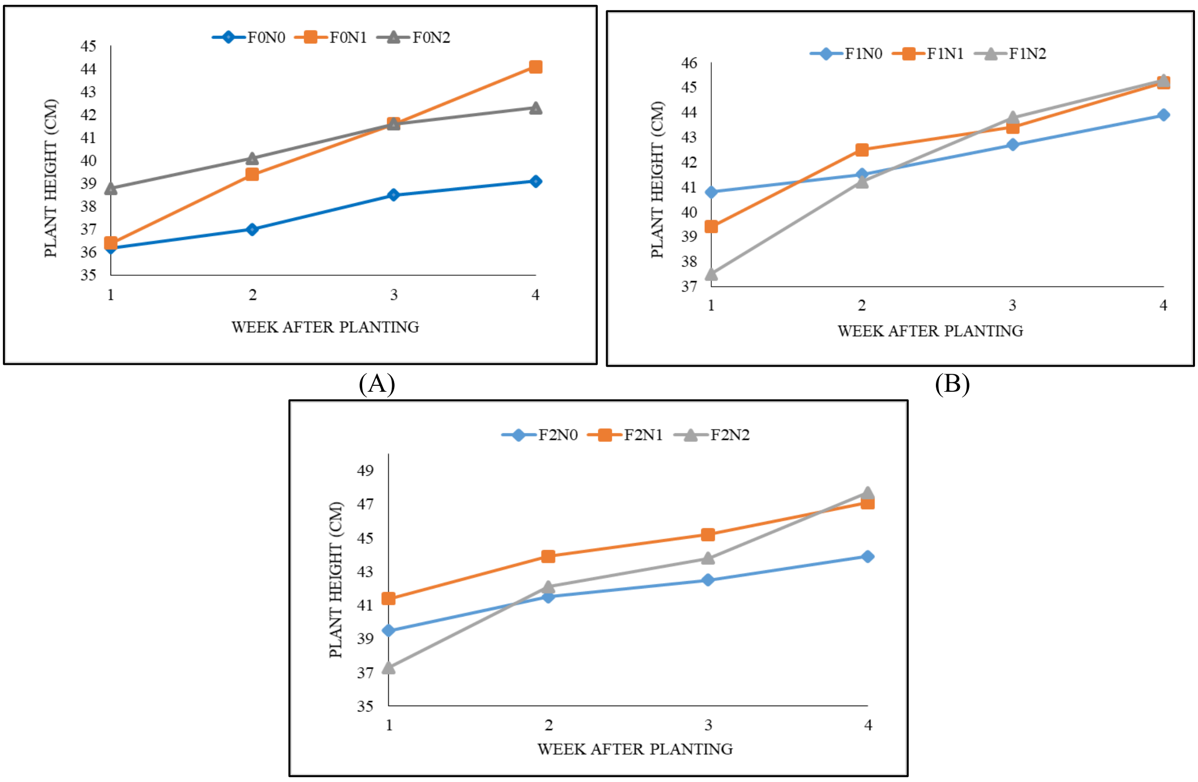
3. Results and Discussion

3.1. The effect of adding coal ash on oil palm seedling growth

3.1.2. The effect on the plant height

NPK fertilizer, combined with fly ash and manure, plays a crucial role in enhancing nutrient availability for plant growth, especially phosphorus (P) and nitrogen (N). Nitrogen in NPK promotes vigorous vegetative growth by stimulating leaf and stem development, which influences plant height. Phosphorus in NPK is essential for root development, energy transfer, and flowering, strengthening overall plant structure. Fly ash, rich in trace elements like magnesium and calcium, enhances soil structure and pH, improving phosphorus availability. Manure, rich in organic matter, supplies nitrogen and enhances soil microbial activity, facilitating nutrient uptake, particularly nitrogen. These elements work synergistically to improve nutrient availability and plant height. After a two-week adaptation period plant height was measured biweekly for two months. Plant height was measured with a tape measure from the soil surface to the longest leaf. Data from each observation were averaged and analyzed using analysis of variance for each treatment. The results are presented in Fig. 1.

Fig. 1 shows that the F2N2 treatment, a combination of fly ash, manure, and 36 grams of NPK fertilizer, resulted in the greatest plant height growth. Plant height is significantly influenced by nutrient absorption, particularly nitrogen, phosphorus, and potassium, which are essential for cell division, elongation, and photosynthesis [24,25]. The addition of manure and fly ash is thought to enhance phosphorus availability in the soil, as silicates in fly ash can displace phosphorus that would otherwise bind to silicate elements [10,26]. NPK fertilizer further supplies essential nutrients for plant growth [27], particularly nitrogen, which plays a critical role in amino acid synthesis, protein formation, and cell protoplasm development, thereby supporting overall plant growth [28]. The growth pattern observed in Fig.1 (B), where plant height does not directly correspond to fertilizer dosage, may be influenced by factors such as the initial soil nutrient content or external abiotic conditions. The significant impact of dolomite application, particularly after the first two weeks, may be attributed to its influence on nutrient availability. Dolomite can bind essential micronutrients such as Iron, manganese, copper, and zinc, which are crucial for plant physiological processes. This binding limits nutrient absorption, potentially slowing plant growth after the initial rapid development. Assessing the soil's initial nutrient content and incorporating data on external factors could offer a clearer explanation for these discrepancies.

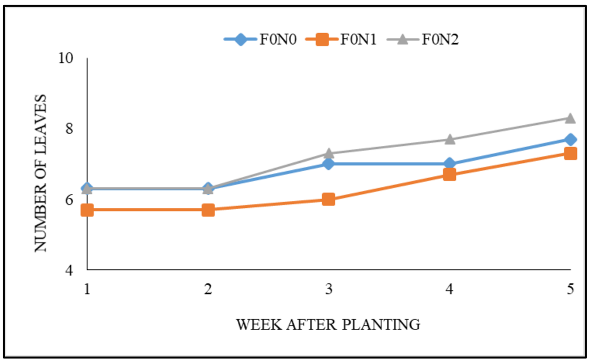


(C)

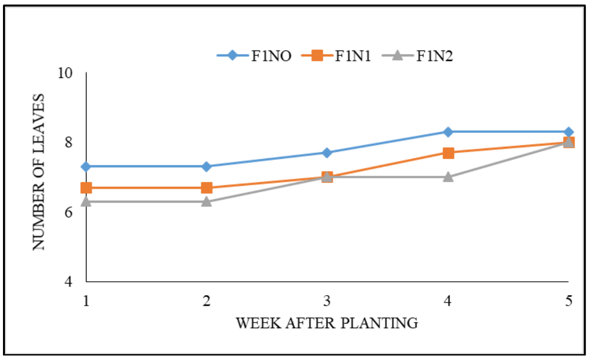
Fig. 1. The Effect of Planting Medium Variations on Seedling Height (A) Without Fly ash ; (B) Fly ash + Dolomite; (C) Fly ash + Organic Fertilizers

3.1.3. The effect on the number of leaves

The number of leaves were recorded from planting until the end of the study with observations conducted every two weeks for two months. Leaf counts were taken for each plant, and the data were averaged and analyzed using analysis of variance for each treatment. The results are presented in Fig. 2.



(A)



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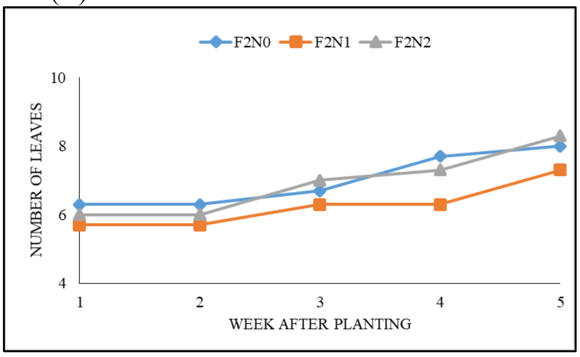


(C)

Fig. 2. Effect of Organomineral Application on Number of Leaves (A) Without Fly ash ; (B) Fly ash + Dolomite; (C) Fly ash + Organic Fertilizers

Fig. 2 shows that the F2N2 treatment, a combination of coal ash and manure with 36 grams of NPK fertilizer per polybag, resulted in the highest leaf count. This treatment provided sufficient nutrients to support leaf development, as essential nutrients from chicken manure and fly ash stimulated meristematic processes, promoting leaf growth as well as enhancing plant height and root length [10]. Leaves are essential for photosynthesis, directly impacting the plant's food production, while their number of leaves affects the overall photosynthetic output [29,30]. As plants grow, new shoots emerge, leading to increased leaf formation [31,32]. Nitrogen, a key nutrient for leaf development, is vital for chlorophyll synthesis, protein formation, and cell division, all of which support leaf formation [33,34].

3.1.4. The effect on the plant diameter

Plant stem diameter was measured from planting to the end of the study, with observations conducted every two weeks for two months. The results are presented in Fig. 3.

Fig. 4 indicates that the F2N2 treatment resulted in good plant stem diameter. The combination of fly ash and manure likely increases phosphorus (P) availability in the soil and supports stem diameter growth. According to Falah et al. [10], adding fly ash without manure can reduce phosphorus availability. Applying fertilizers containing essential macro-nutrients (N, P, K, and Mg) in appropriate doses supports plant growth. Still, insufficient doses have little effect, while excessive amounts can cause toxicity and stunted growth. Phosphorus (P) is crucial for stem enlargement, while potassium (K) accelerates meristematic tissue growth, strengthening the stem, and aiding in photosynthesis [35]. Additionally, magnesium (Mg) is necessary for transporting phosphorus within the plant and is involved in chlorophyll production, as noted by Hanum et al. [36]. A phosphorus deficiency (P) and potassium (K) can hinder growth, leading to small, weak stems and increased susceptibility to diseases and pests [37].

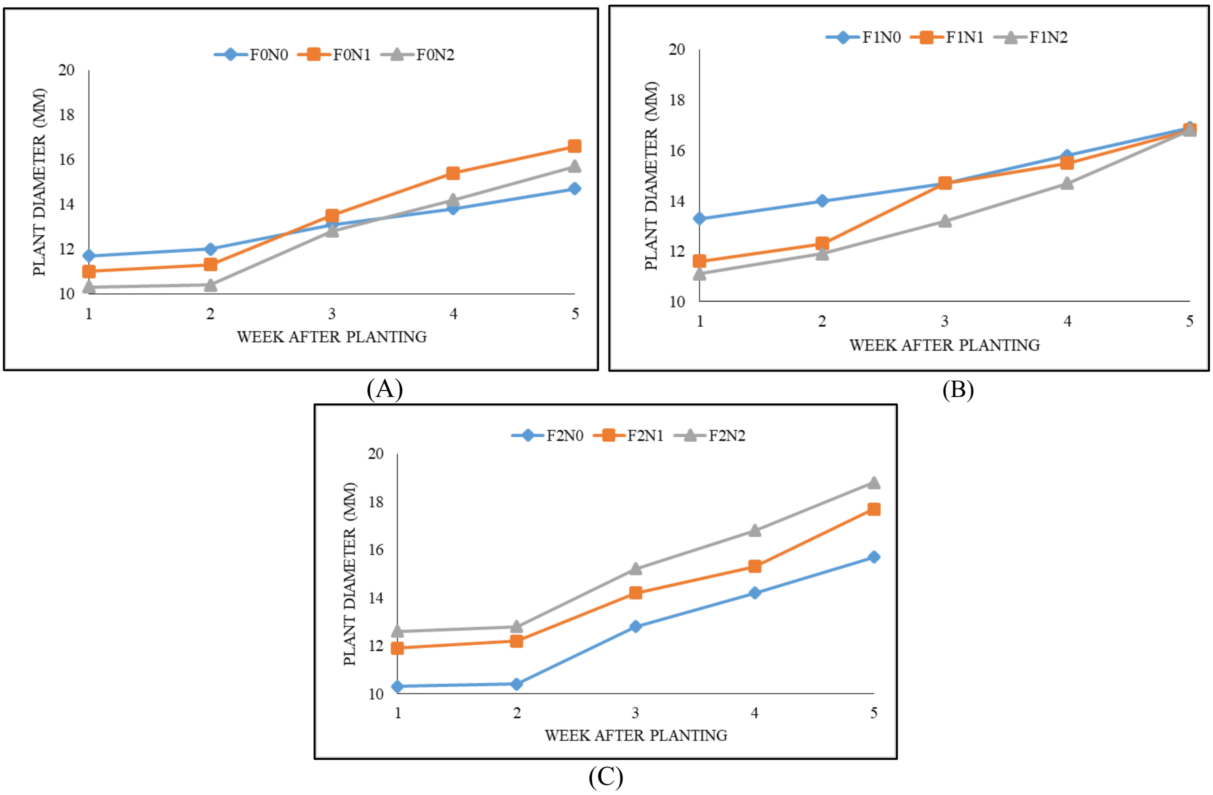


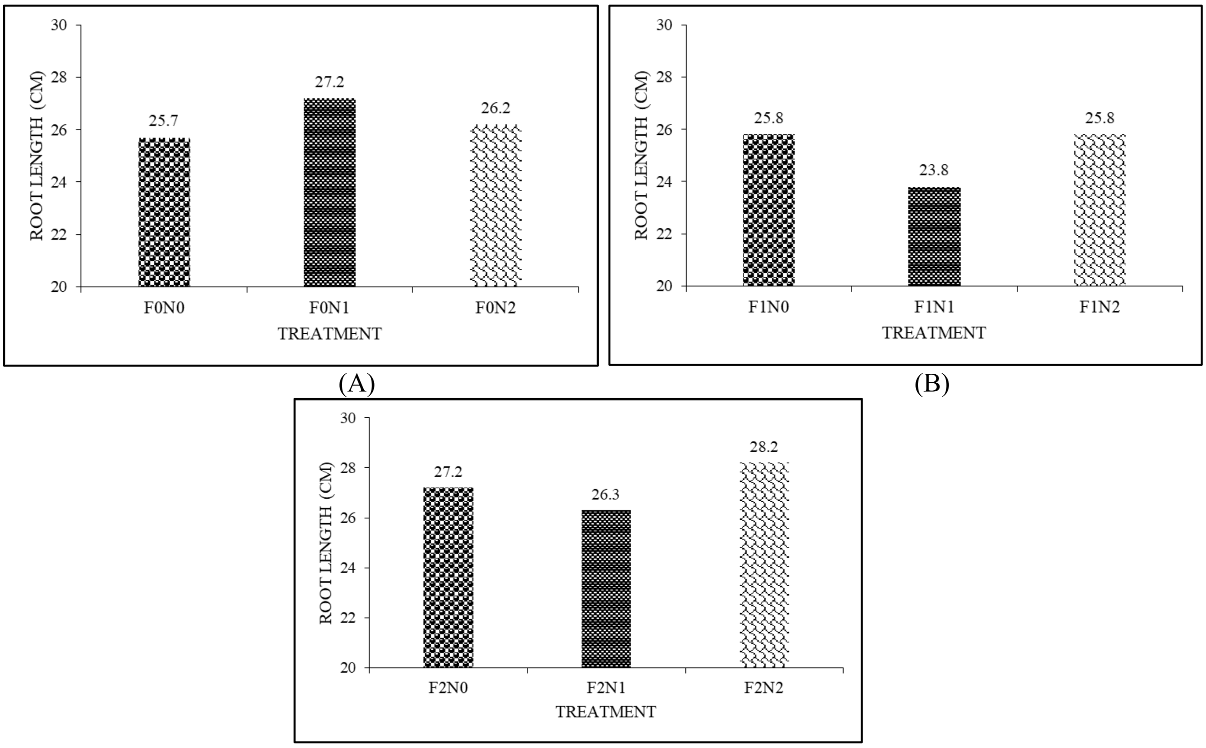
Fig. 3. Effect of Organomineral Application on Plant of Diameter (A) Without Fly ash ; (B) Fly ash + Dolomite; (C) Fly ash + Organic Fertilizers

3.1.5. Root length

Long-root observations were performed once, on the final day of the study (56 days after planting or HST). Measurements were done by removing plants and measuring the longest roots using a scratch. The data were aggregated for each sample and analyzed using fingerprint analysis. The results are presented in Fig. 4.

Fig. 4 illustrates that different treatments result in different root length, which is crucial for nutrient absorption from the soil. A more extensive root system enhances nutrient absorption, supporting plant growth during both vegetative and generative phases [38]. Research by Rahmawati et al. [39] indicates that good physical and chemical soil conditions enhance root system development, which positively correlates with overall plant growth. The combination of fly ash, manure, and 36 grams of NPK per polybag increases root length, indicating that the nutrient needs for plant growth were adequately met. Fly ash enhances phosphorus (P) availability in the soil by replacing phosphorus typically bound by aluminum (Al) with silica from the ash, making it more accessible to plants [10]. Phosphorus (P) is essential for root development, not only stimulating fruit and seed production but also promoting root system expansion. Andri and

Wawan [33] found that the supply of photosynthates from leaves, influenced by phosphorus, significantly impacts root growth by expanding the root development zone and promoting the growth of new primary roots. Additionally, factors such as soil temperature, aeration, water availability, and nutrient accessibility also influence root distribution patterns [40].



(A) (B)

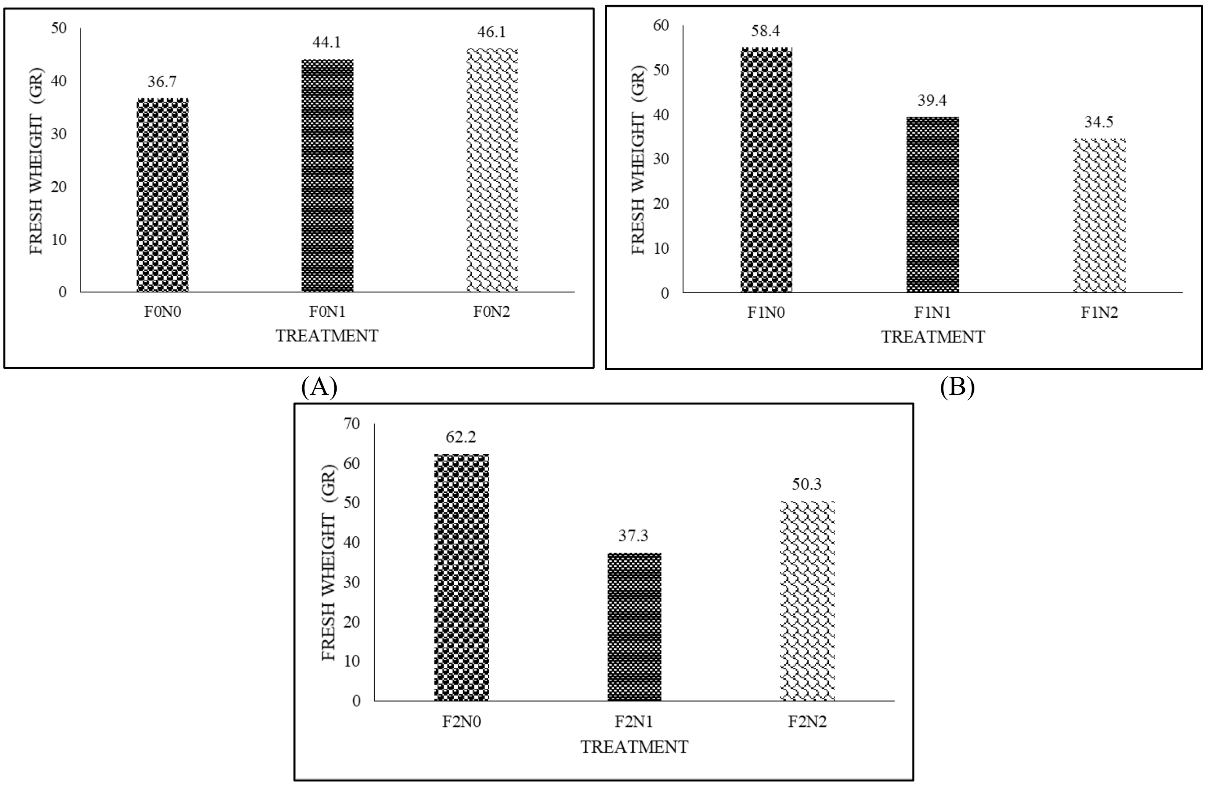
(C)

Fig. 4. Effect of Organomineral Application on Root of Length (A) Without Fly ash ; (B) Fly ash + Dolomite; (C) Fly ash + Organic Fertilizers

3.1.6. Fresh weight of crown and root

Observations of the fresh weight of the crown and roots were made once after 56 days after planting (HST), which was the last observation. Measurements were made by weighing the fresh weight of the crown and roots of plants that had been removed, using an analytical balance. Observation data were then averaged for each sample and analyzed using analysis of variance. The results of crown and root fresh weight observations are presented in Fig. 5.

Fresh weight of plants refers to the weight of the plant while it is still alive, measured before water loss causes wilting [41,42]. Research findings indicate that the F2N0 treatment, involving fly ash mixed with manure without additional NPK fertilizer, produced the highest fresh weight of shoots and roots. However, pest attacks during the final observation led to leaf drop, affecting the results. Fresh weight is influenced by the plant's ability to absorb nutrients from the growing medium, enabling optimal growth. This aligns with Herdhiansyah et al. [43], who state that nutrient availability in the growing medium impacts the fresh weight of plants. Furthermore, taller plants with more leaves have an increased carbohydrate formation from assimilation, leading to greater fresh weight [44].



(A) (B)

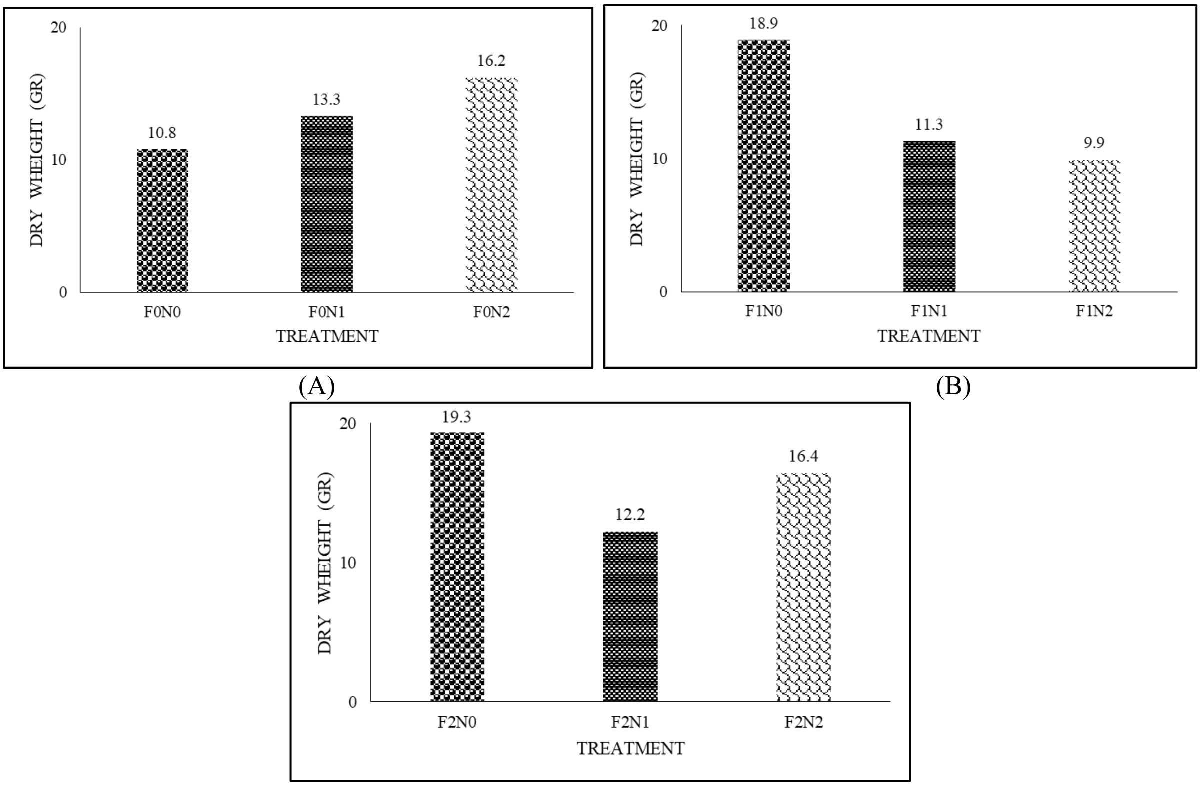
(C)

Fig. 5. Effect of Organomineral Application on Fresh Weight of Crown and Root (A) Without Fly ash ; (B) Fly ash + Dolomite ; (C) Fly ash + Organic Fertilizers

3.1.7. Dry weight of crown and root

Observations of crown and root dry weight were conducted once, on the final day of the study (56 days after planting or HST). Measurements were conducted weighing the dry weight of the plant crown and roots after being baked at 700°C for 48 hours. Observation data were then averaged for each sample and analyzed using analysis of variance. The observation results of crown and root dry weight are presented in Fig. 6.

The dry weight of plants reflects the accumulation of organic compounds produced through photosynthesis and plant growth [45]. The study indicated that the F2N0 treatment, involving the utilization of fly ash mixed with manure without additional NPK fertilizer, resulted in the highest dry weight of shoots and roots, despite challenges such as pest attacks leading to leaf drop. Plant dry weight is strongly influenced by growth, which can be observed from the increase in fresh weight and dry matter accumulation. Better plant growth leads to higher dry weight, as photosynthesis, a critical metabolic process involving light, CO_2, O_2, chlorophyll, and water, occurs in the leaves. More leaves lead to increased photosynthesis [46,47]. This directly impacts the increase in both fresh and dry weight. A direct relationship exists between dry and fresh weight, with plants that efficiently absorb nutrients yielding greater dry weight. Dry weight results from the accumulation of organic compounds derived from inorganic substances, primarily water and CO_2. According to Ariyanti et al. [48], roots play a crucial role in nutrient absorption, contributing to increased dry weight. Overall, increasing dry weight depends on photosynthetic efficiency and the plant's ability to absorb nutrients from the soil. Supportive environmental conditions such as adequate light, water, and nutrients, as well as protection from pests and diseases, being key to achieving optimal dry weight.



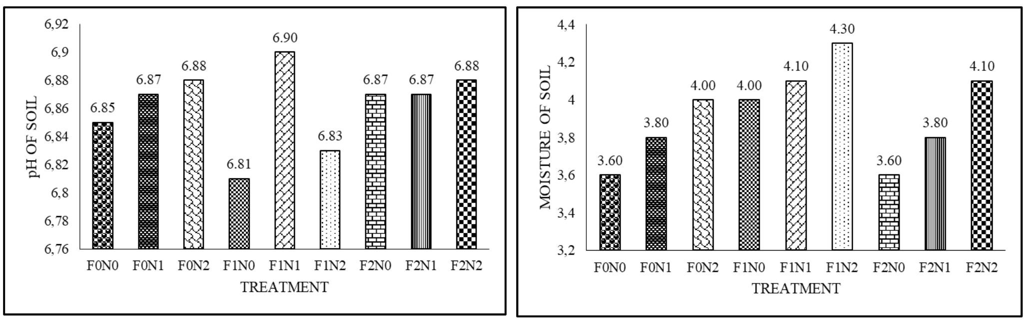
(A) (B)

(C)

Fig. 6. Effect of Organomineral Application on Dry Weight of Crown and Root (A) Without Fly ash ; (B) Fly ash + Dolomite ; (C) Fly ash + Organic Fertilizers

3.2. Effect of coal ash addition on ph and moisture of planting media

The pH and humidity monitoring of the planting medium is conducted once every fourteen days after planting (HST). Neutral pH is ideal for oil palm seedling growth, as it supports nutrient availability. The transition from dry to rainy season affects root health, photosynthesis, and nutrient absorption by influencing moisture levels, potentially improving growth during the rainy season. The observation data were aggregated for each sample and analyzed using the analyzing prints. The results of fresh weight observations of the headings and roots are presented in Fig. 7.



(A) (B)

Fig. 7. Effect of Organomineral Application on Average (A) pH of Soil ; (B) Moisture of Soil or Humidity

Soil pH indicates the level of acidity or alkalinity, with lower values reflecting higher acidity and higher values indicating greater alkalinity [49,50]. As shown in Fig. 7, the pH values in this study were generally neutral across treatments, influenced by factors such as soil type and the addition of fly ash, dolomite, and manure. The soil used was regosol with a pH between 6 and 7, containing 0.94% organic carbon, 70.95 ppm available nitrogen, a pH of 6.24, and a cation exchange capacity (CEC) of 6.04 me/g [51]. The highest soil pH was observed in treatment F1N1, which involved mixing fly ash with dolomite and 29 grams of NPK per polybag. This increase is likely due to the alkaline nature of fly ash (pH 10–13) and the calcium (Ca) and magnesium (Mg) in dolomite, which release OH ions through hydrolysis, thereby raising the pH [52]. Fly ash also enhances soil pH and can increase soil's negative charge through the release of H^+ ions from clay minerals [53]. Proper use of fly ash and dolomite can significantly improve soil conditions, especially in acidic soils, although caution is needed to avoid excessive pH increases.

Soil moisture, affected by evaporation, transpiration, and percolation, represents the amount of water stored in the soil's pores [54]. In this study, treatment F1N2 had the highest soil moisture value of 4.2, likely due to the optimal water retention in soil pores. Factors affecting soil moisture include rainfall, soil type, and evapotranspiration rate [55]. Soil moisture is essential for plant growth, serving as an indicator of water availability. The transition from dry to the rainy season significantly influenced soil moisture, with increased rainfall enhancing moisture levels by adding water to soil pores. Soil type also affects moisture retention, with well-structured soils holding more water. High evapotranspiration rates during dry seasons can reduce soil moisture, while the rainy seasons typically increase it. The high moisture levels observed in treatment F1N2 reflect effective water retention, ensuring adequate water availability for photosynthesis and overall growth. Understanding the factors affecting soil moisture is crucial for optimizing plant growth.

3.3. Effect of chemical composition on oil palm seedling growth

Characterization of coal ash samples was performed using X-Ray Fluoroscopy (XRF) analysis, with the results of the chemical composition presented in Fig. 8.

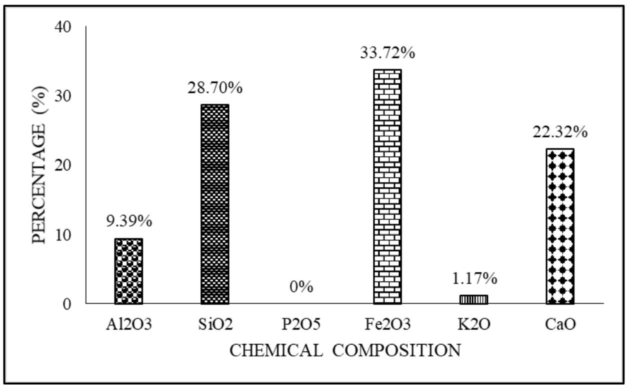


Fig. 8. Results of X-Ray Fluoroscopy (XRF) Analysis

Fig. 8 indicates that the highest component in the fly ash sample is Fe_2O_3 at 33.72%, followed by SiO_2 at 28.70%, and CaO at 22.32%, with these three elements being the dominant components. Other elements include Al_2O_3 at 9.39% and K_2O at 1.17%, while P_2O_5 was not detected in the sample based on XRF analysis. Research conducted at the Politeknik LPP Yogyakarta Teaching Factory Laboratory in Wedomartani over approximately 2.5 months (10 weeks) indicated that the initial planting conditions were conducted during the transition from the dry to rainy season, which led to irregular watering of the oil palm seedlings. The presence of weeds required manual control. The study used Regosol sandy soil available in the Wedomartani practice field and certified seedlings from PT. Socfindo, variety DXP Yangambi, known for its greater environmental stress tolerance.

4. Conclusions

Research findings reveal that combining fly ash with manure is the most effective method for enhancing oil palm seedling growth. Additionally, the application of NPK 16:16:16 at a dosage of 36 grams per polybag yields excellent growth results. There is a significant interaction between fly ash and NPK 16:16:16, which notably enhances seedling growth. This study confirms that using fly ash and manure, along with NPK fertilizer, can be an effective strategy to boost oil palm productivity. Future research on oil palm productivity should evaluate the environmental safety of fly ash, focusing on its potential toxicity, leaching, air quality impacts, and long-term effects, while investigating safe application rates and bioremediation strategies. These findings could contribute to the sustainable use of industrial by-products in agriculture.

Abbreviations

Not applicable.

Data availability statement

Data will be shared upon request by the readers.

CRediT authorship contribution statement

Yudhi Pramudya: Conceptualization, Methodology, Resources, Formal analysis, Investigation, Data curation, Funding acquisition, Writing – review & editing. Farrah Fadhillah Hanum: Writing – original draft, Validation, Data curation, Formal analysis, Conceptualization. Azrian Makmum Muhammad: Conceptualization, Project administration, Data curation, Writing – original draft. Budi Setya Wardhana: Resources, Formal analysis, Investigation, Funding acquisition, Writing – review & editing. Saktiyono Sigit Tri Pamungkas: Validation, Data curation, Formal analysis, Methodology, Resources, Formal analysis.

Declaration of Competing Interest

The authors of this manuscript declare no conflict of interest or competing interest.

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