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Application of Arbuskular Mycorrhiza and Various Doses of NPKMg Fertilizer (15:15:6:4) in Pre-Nursery Oil Palm (*Elaeis guineensis* Jacq.)

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Abstract

Oil palm (*Elaeis guineensis* Jacq.) is a leading vegetable oil-producing crop in Indonesia, particularly in the Kalimantan region, which has extensive oil palm plantations. However, during the pre-nursery stage, the growth of oil palm seedlings is highly influenced by the availability of optimal nutrients. This study aims to determine the interaction effect between Arbuscular Mycorrhizal Fungi (AMF) and NPKMg (15:15:6:4) fertilizer on oil palm seedlings at the pre-nursery stage and to identify the best dosage for improving fertilization efficiency. The research was conducted in Penyalimau Village and Pontianak State Polytechnic, using a factorial randomized block design (RBD) with two factors: AMF dosage (M_0 = control, M_1 = 5 g/polybag, M_2 = 10 g/polybag, M_3 = 15 g/polybag) and NPKMg dosage (N_0 = control, N_1 = 0.5 g/polybag, N_2 = 1 g/polybag, N_3 = 1.5 g/polybag). The results showed that the combination of AMF and NPKMg did not have a significant effect on the observed growth parameters. However, applying AMF at a dose of 15 g/polybag had a positive impact on plant height growth. These findings provide preliminary information useful for optimizing oil palm pre-nursery fertilization strategies, which have the potential to enhance fertilizer efficiency and promote sustainable seedling growth.

Keywords: *oil palm; AMF; NPKMg; pre-nursery; plant growth*.

Pembibitan Kelapa Sawit (*Elaeis guineensis* Jacq.) Pre-Nursery dengan Pemberian Mikoriza Arbuskular dan Dosis Pupuk NPKMg (15:15:6:4)

Abstrak

Kelapa sawit (*Elaeis guineensis* Jacq.) merupakan tanaman penghasil minyak nabati unggulan di Indonesia, terutama di wilayah Kalimantan, yang memiliki luas perkebunan kelapa sawit yang signifikan. Namun, dalam fase *pre-nursery*, pertumbuhan bibit kelapa sawit sangat dipengaruhi oleh ketersediaan unsur hara yang optimal. Penelitian ini bertujuan untuk mengetahui pengaruh interaksi antara Fungi Mikoriza Arbuskular (FMA) dan pupuk NPKMg (15:15:6:4) terhadap pertumbuhan bibit kelapa sawit pada tahap *pre-nursery*, serta menentukan dosis terbaik untuk meningkatkan efektivitas pemupukan. Penelitian dilakukan di Desa Penyalimau dan Politeknik Negeri Pontianak, menggunakan Rancangan Acak Kelompok (RAK) faktorial dengan dua faktor, yaitu dosis FMA (M_0 = kontrol, M_1 = 5 g/polibag, M_2 = 10 g/polibag, M_3 = 15 g/polibag) dan dosis NPKMg (N_0 = kontrol, N_1 = 0,5 g/polibag, N_2 = 1 g/polibag, N_3 = 1,5 g/polibag). Hasil penelitian menunjukkan bahwa kombinasi antara FMA dan NPKMg tidak memberikan pengaruh nyata terhadap parameter pertumbuhan yang diamati. Namun, pemberian FMA dengan dosis 15 g/polibag menunjukkan efek positif terhadap peningkatan tinggi tanaman. Temuan ini memberikan informasi awal yang berguna untuk mengoptimalkan strategi pemupukan pada pembibitan awal kelapa sawit, yang berpotensi meningkatkan efisiensi pupuk dan mendukung pertumbuhan bibit yang berkelanjutan.

Kata Kunci: *kelapa sawit; FMA; NPKMg; pre-nursery; pertumbuhan tanaman.*

Introduction

The oil palm (*Elaeis guineensis* Jacq.) is a priority crop in Indonesian plantations. This plant plays a significant role in Indonesia's economy, particularly as a provider of employment opportunities and a source of national foreign exchange earnings. Additionally, oil palm has a high economic value and is the highest producer of vegetable oil compared to other oil-producing plants such as soybean, olive, coconut, and sunflower (Riduan et al., 2017). In oil palm cultivation, the success of field planting and production yields heavily depends on the quality of the seedlings used. Nursery activities play an essential role in preparing planting materials (seedlings) for field planting, making it crucial to manage nurseries effectively (Situmorang et al., 2014).

Nursery cultivation is the process of growing seedlings from seeds until they are ready for transplanting to the field. This process includes a preparation period of approximately one year, starting from sprouts until the development of complete young plants. High-quality oil palm seedlings are characterized by their robust growth and optimal appearance, as well as their ability to withstand environmental stress during transplantation (Agung et al., 2019). Nursery management is a crucial factor in the success of oil palm cultivation. The success of planting and production heavily depends on the quality of the seedlings used. Efforts to produce high-quality seedlings are carried out through nursery practices, as mistakes at this stage can significantly affect the growth and yield of oil palms in the field (Astianto et al., 2013).

The application of fertilizers with high efficiency can be achieved by improving soil support capacity and nutrient availability in the seedling growth medium. One way to meet these needs is through the combined use of inorganic NPKMg fertilizers and Arbuscular Mycorrhizal Fungi (AMF), which contribute to improving soil structure, enhancing carbon transport in root systems, addressing soil fertility degradation, protecting plants from diseases, and acting as agents for phytoremediation (Pulungan, 2013). The nitrogen (N) element in NPK fertilizers functions to prepare amino acids (proteins), nucleic acids, nucleotides, and chlorophyll in plants. The phosphorus (P) element serves as a medium for energy storage and transfer, while potassium (K) acts as an enzyme activator and aids in transporting assimilated products from the leaves to plant tissues (Barita et al., 2018). Magnesium (Mg) plays a crucial role in photosynthesis. It is absorbed in the form of Mg^{2+} and is a component of chlorophyll, which gives leaves their green color. Magnesium contributes not only to photosynthesis but also to generative processes and the development of plant organs. Mg fertilization can enhance plant height, stem diameter, and both fresh and dry weights of oil palm seedlings (Matana & Mashud, 2016).

The application of NPKMg fertilizer (15:15:6:4) has a significant effect on parameters such as stem diameter at 10 WAP (Weeks After Planting), total leaf area, fresh shoot weight, and dry shoot weight (Tambunan et al., 2015). Magnesium (Mg) is a macronutrient required by plants in large amounts, playing an essential role in the formation of chlorophyll, which is a key component of photosynthesis (Wahyuni & Manurung, 2020). However, the application of Kieserite (Mg fertilizer) showed no significant effect on plant height, leaf count, stem circumference, and dry shoot weight, although it did not yield significant results for the dry root weight of oil palm seedlings (Wahyuni & Manurung, 2020). To modify or improve soil conditions conducive to growth and high production, the use of mycorrhizal fungi can be applied. Mycorrhiza refers to a mutualistic symbiosis between certain fungi and plant roots. Arbuscular Mycorrhizal Fungi (AMF) are popular due to their broad associative capabilities, with most plants worldwide forming associations with these fungi, including oil palm, which naturally symbiotically interacts with AMF (Rini & Eftiyani, 2016). The development of AMF aims to reduce the excessive use of chemical fertilizers (Palasta & Viva, 2018). The application of AMF has been proven to enhance the growth of oil palm seedlings by increasing plant height, leaf count, fresh shoot weight, dry shoot weight, and root infection percentage (Rini & Efriyani, 2017). The application of 20 g of mycorrhizal biofertilizer per plant showed the best effects on oil palm seedling growth (Riduan et al., 2017).

Mycorrhiza has significant biological potential, including improving plant physiological conditions, serving as a bioprotective agent, increasing plant resistance to drought, playing a role in bio-geochemical cycles, synergizing with other microorganisms, and maintaining plant biodiversity. Numerous studies have demonstrated that mycorrhiza can enhance nutrient uptake and promote plant growth. Phosphorus (P) is the primary nutrient absorbed by mycorrhiza-infected plants, as it is required in relatively large amounts. The presence of mycorrhiza improves root growth and development, enabling plants to absorb water and nutrients more efficiently. The intensive network of mycorrhizal hyphae assists plants in absorbing water and nutrients more effectively (Kartika et al., 2016). Therefore, this study aims to investigate the growth response of oil palm (Elaeis guineensis Jacq.) seedlings to the application of AMF and NPKMg fertilizer (15:15:6:4) at the pre-nursery stage. AMF is expected to function as a soil amendment agent that enhances nutrient absorption and improves the availability of nutrients in NPKMg (15:15:6:4) fertilizer.

Method

Materials and Equipment

The materials used in this study included oil palm sprouts of the DxP variety (a cross between Dura and Pisifera) obtained from the Parindu oil palm nursery. The soil medium was PMK soil, supplemented with Arbuscular Mycorrhizal Fungi (AMF) containing 99 spores per 100 grams. Compound fertilizer NPKMg with a composition of 15:15:6:4 was also used. Supporting materials included black polybags measuring 15 x 20 cm, water, shade nets (paranet), dolomite, wood, and wire. The equipment used included hoes, machetes, buckets, hand sprayers, measuring tapes, writing tools, calculators, analytical balances, ovens, and other relevant tools.

The research employed a factorial Randomized Block Design (RBD) with two factors. The first factor was the application of Arbuscular Mycorrhizal Fungi (AMF) based on Risbo (2019) with modifications, consisting of four treatments: M_0 (0 g/polybag as control), M_1 (5 g/polybag), M_2 (10 g/polybag), and M_3 (15 g/polybag). The second factor was the dosage of NPKMg fertilizer (15:15:6:4) based on Aditya et al. (2016) with modifications, comprising four levels: N_0 (0 g/polybag as control), N_1 (0.5 g/polybag), N_2 (1 g/polybag), and N_3 (1.5 g/polybag).

Preparation of Research Area and Planting Medium

The preparation of the research area involved using a 60% shade net (paranet) installed at a height of 1.5 meters (Aditya et al., 2016). The planting medium was composed of PMK soil and rice husks mixed at a ratio of 2:1, followed by sieving to ensure uniform texture. The mixed medium was then sterilized by steaming for 30 minutes to eliminate pathogens and pests (Rosana, 2011). After sterilization, the planting medium was placed into 15 x 20 cm polybags, with the addition of 20 g of dolomite per polybag. The polybags were then neatly arranged under the shade net (Amri et al., 2018).

Oil Palm Sprout Planting, AMF Application, and NPKMg Fertilizer Application

The oil palm sprouts were planted in planting holes with the radicle positioned downward and the plumule facing upward, then covered with soil. AMF was applied by sprinkling it into the planting holes before the sprouts were planted to support optimal seedling growth during the pre-nursery stage (Maulana et al., 2017). The NPKMg fertilizer application began four weeks after planting and was repeated in the sixth and eighth weeks (Risbo, 2019). Fertilizer doses were applied according to the predetermined treatments. Plant maintenance activities included watering, weeding, and pest and disease control. Watering was carried out every morning and afternoon with water volume adjusted to reach field capacity (Aditya et al., 2016). Weeding was conducted manually for weeds inside the polybags, while those outside the polybags were removed using hoes. Pest and disease control was implemented as necessary when signs of infestation or infection were detected.

Observation and Analysis

Observations in this study were conducted monthly, including measurements of plant height, number of fronds, and stem diameter. Final observations assessed AMF colonization in oil palm roots using the Clearing and Staining method. The clearing procedure began by washing oil palm roots with running water and cutting them into 1 cm sections. The root sections were then immersed in 10% KOH and boiled for 10 minutes. Afterward, the roots were washed with cold 10% KOH and soaked in 1% HCl for 1 minute. The staining process involved immersing the cleared root sections in 0.05% lactophenol trypan blue, boiling for 5–15 minutes, and soaking for 1–2 days. The stained roots were placed on microscope slides and observed under a microscope (Maulana et al., 2016). AMF infection in the roots was indicated by the presence of hyphae and vesicles. Ten root sections, each 1 cm long, were randomly selected and arranged on a single object class. Root colonization percentage was calculated using the following formula:

$$\text{Root Colonization Percentage} = \frac{\text{Total Colonization}}{\text{Total Root Sections}} \text{ x } 100\% \quad (1)$$

The level of root infection by AMF was classified based on guidelines from The Institute of Mycorrhizal Research and Development, USDA Forest Service, Athens, Georgia (Padri et al., 2015) as follows:

- Class 1: 0%–5% infection (very low)
- Class 2: 6%–25% infection (low)
- Class 3: 26%–50% infection (moderate)
- Class 4: 51%–75% infection (high)
- Class 5: 76%–100% infection (very high)

The observation data were analyzed using Analysis of Variance (ANOVA). To determine the differences between treatments, the Honest Significant Difference (HSD) test was conducted at a significance level of α = 0.05 (5%).

Results and Discussion

Mycorrhiza has significant biological potential, such as improving the physiological performance of plants, serving as a biological protector, enhancing plant resistance to drought, participating in bio-geochemical cycles, synergizing with other microorganisms, and maintaining plant biodiversity. Numerous studies have demonstrated that Mycorrhiza improves nutrient absorption and promotes plant growth. The primary nutrient absorbed by Mycorrhiza-infected plants is phosphorus (P), as it is required in relatively large amounts. The presence of Mycorrhiza leads to better root growth and development, which aids plants in the absorption of water and nutrients. The extensive hyphal networks formed by Mycorrhiza facilitate and enhance the plant's capacity to absorb water and essential nutrients (Kartika et al., 2016). The improved nutrient uptake and water absorption directly contribute to the better growth performance and physiological health of plants.

Root Infection Degree

The combination of Arbuscular Mycorrhizal Fungi (AMF) and NPKMg 15:15:6:4 fertilizer showed no significant effect on the degree of root infection. Microscopic observations indicated the presence of AMF infection in oil palm roots, marked by branching and rounded structures within the roots. However, the observed infection rates were relatively low, ranging between 10% and 30% (Table 1). This limited infection might have been caused by the leaching of Mycorrhiza due to rainfall.

Figure 1. Arbuscular Mycorrhizal infection in oil palm seedling roots

Siregar (2017) stated that AMF could be washed away by heavy rainfall or influenced by the availability of phosphorus (P) in the soil. The lower the available P, the higher the root colonization percentage and spore count. Furthermore, Puspitasari et al. (2012) noted that a high diversity of AMF spores could be attributed to more favorable, optimal, and compatible environmental conditions, as well as the absence of antagonistic fungi that inhibit AMF sporulation. These conditions can support the growth and development of AMF spores, potentially improving root colonization rates. The illustration of Arbuscular Mycorrhizal infection in oil palm roots is presented in Figure 1.

Table 1. Percentage of oil palm seedling roots infected by Mycorrhiza

Treatment	Infection Percentage (%)	Category
M_0N_0	0	Very Low
M_0N_1	0	Very Low
M_0N_2	0	Very Low
M_0N_3	0	Very Low
M_1N_0	0	Very Low
M_1N_1	10	Low
M_1N_2	10	Low
M_1N_3	10	Low
M_2N_0	20	Low
M_2N_1	30	Medium
M_2N_2	30	Medium
M_2N_3	10	Low
M_3N_0	10	Low
M_3N_1	10	Low
M_3N_2	0	Very Low
M_3N_3	10	Low

Note: M_0 (control), M_1 (Mycorrhiza 5 g/polybag), M_2 (Mycorrhiza 10 g/polybag), M_3 (Mycorrhiza 15 g/polybag); N_0 (control), N_1 (NPKMg 0.5 g/polybag), N_2 (NPKMg 1 g/polybag), N_3 (NPKMg 1.5 g/polybag).

Plant Height Growth

Plant height is a key indicator of plant growth. Plants undergo continuous growth and development every week. The application of fertilizers and microorganisms stimulates plant growth and development. The analysis of variance showed that the combination of Mycorrhiza and NPKMg 15:15:6:4 did not have a significant effect on the growth in plant height of oil palm seedlings in the pre-nursery stage. However, the single application of Mycorrhiza had a significant effect on plant height growth in the fourth week. The average monthly height increase of oil palm seedlings was greater with the application of Arbuscular Mycorrhiza and NPKMg 15:15:6:4 compared to the control without Mycorrhiza and NPKMg fertilizer (Table 2). This finding aligns with the study by Madusari et al. (2018), which demonstrated that the application of Mycorrhiza significantly increased plant height compared to treatments without Mycorrhiza. The application of Mycorrhiza at a dose of 15 g/polybag significantly increased the height of oil palm seedlings by 4.40 cm in the fourth week.

Arbuscular Mycorrhiza (AM) is a type of biofertilizer that can be directly utilized by plants to promote growth. This biofertilizer contains fungi that form a symbiotic relationship with plant root systems, enhancing plant growth. Mycorrhiza increases the number of spores adhering to plant roots during planting, thereby accelerating the infection process (Nicolas et al., 2015 in Apria, 2022). This leads to increased Mycorrhizal infection in plant roots, which positively correlates with plant growth. The presence of Mycorrhiza aids plants in improving the absorption of nutrients, particularly phosphate, which is essential for vegetative growth. Arbuscular Mycorrhiza plays a crucial role as an entry point for nutrients absorbed by plant roots and fungal hyphae into the host cells. The arbuscule, a branched hyphal structure resembling a small tree found in the root cortex of the host plant, functions as a site for the exchange of primary metabolites between the Mycorrhizal fungi and plant roots (Brundrett, 2009).

The application of NPKMg fertilizer alone did not significantly affect the height growth of oil palm seedlings. This indicates that the applied dosage did not have a substantial impact on plant height. The interaction between Arbuscular Mycorrhiza and the plant failed to optimally support root growth, thereby limiting the absorption of phosphorus (P) and water. This condition may hinder the height growth of oil palm plants. As explained by Liebig's Law of the Minimum, plant growth will be optimal when all essential nutrients are available in adequate amounts. The overall and optimal availability of nutrients is determined by the element present in the lowest or most limiting quantity. According to Talanca (2010) as cited by Matsetio et al. (2014), Mycorrhiza does not infect the internal structure of the roots but only adheres to the external structure of the root system, leading to inefficient nutrient uptake.

Table 2. Average plant height increases of oil palm seedlings with Arbuscular Mycorrhizal Fungi and NPKMg fertilizer application

Category	**AMF Treatment**	**Dosage of NPKMg Fertilizer**				
		$\mathbf{N_0}$	$\mathbf{N_1}$	$\mathbf{N_2}$	$\mathbf{N_3}$	**Average**
Plant Height 4 Weeks After Planting (WAP)	M_0	4.07	3.62	4.23	4.42	4.08^{a}
	M_1	3.35	3.2	3.70	3.68	3.59^{b}
	M2	4.18	4.10	4.23	4.17	4.17^{ab}
	M_2	4.83	4.20	4.02	4.57	4.40^{a}
	Average	4.11	3.88	4.05	4.21	
Plant Height 8 Weeks After Planting (WAP)	M0	9.45	8.72	9.88	10.35	9.60
	M1	7.80	8.63	8.95	8.98	8.59
	M2	7.85	9.50	10.10	10.32	9.44
	M3	11.65	9.93	9.37	10.68	10.41
	Average	9.19	9.20	9.58	10.08	
Plant Height 12 Weeks After Planting (WAP)	M0	16.42	16.08	18.25	18.00	17.19
	M1	14.47	15.50	17.03	15.15	15.54
	M2	12.72	16.82	17.58	15.70	15.70
	M3	17.88	18.05	15.52	18.12	17.39
	Average	15.37	16.61	17.10	16.74	

Note: Values followed by different superscript letters within the same column indicate significant differences based on the HSD test at 5% level. M_0 (control), M_1 (Mycorrhiza 5 g/polybag), M_2 (Mycorrhiza 10 g/polybag), and M_3 (Mycorrhiza 15 g/polybag), N_0 (control), N_1 (NPKMg 0.5 g/polybag), N_2 (NPKMg 1 g/polybag), and N_3 (NPKMg 1.5 g/polybag).

Stem Diameter

Measurement of stem diameter was conducted to observe the development of the stem alongside plant growth. The application of Arbuscular Mycorrhiza and NPKMg fertilizer, either individually or in combination, did not significantly affect the stem diameter of oil palm seedlings from 4 MST to 12 MST. This may be attributed to the lengthy time required for Mycorrhiza to infect the roots of oil palm plants. According to the root infection degree calculation presented in Table 1, after 12 weeks, only 10-30% of Mycorrhiza was able to infect the roots. This percentage is classified as very low, thus insufficient to support root growth and maximize phosphorus (P) absorption, leading to suboptimal stem development. Pulungan (2017) similarly found that Mycorrhiza inoculation over 18 weeks did not yet show a visible response in jabon seedlings due to the incomplete root infection. This aligns with Tawakal (2009) as cited by Lubis (2019), who stated that Mycorrhiza fertilizers generally contain relatively low amounts of nutrients and are typically slow to become available in the soil. The delayed nutrient release results in insufficient nutrient availability to support plant growth effectively.

The combined treatments showed no significant effect because the combination dosage of Arbuscular Mycorrhiza and NPKMg 15:15:6:4 was insufficient to stimulate an increase in the stem diameter of oil palm seedlings. This was also due to the relatively low dosage of Arbuscular Mycorrhiza and NPKMg 15:15:6:4, which failed to trigger a noticeable response in the vegetative growth of the stem diameter. According to Kartasapoetra (2002) as cited in Untung & Islan (2015), adequate and proportional amounts of nutrients such as N, P, K, and other elements are essential for plant growth. The presence of potassium (K) contributes to carbohydrate formation, starch translocation to the stem of oil palm seedlings, and facilitates nutrient transport from the roots to the stem (Andri & Wawan, 2017, as cited in Agung et al., 2019).

Table 3. Average stem diameter of oil palm seedlings with the application of Arbuscular Mycorrhizal Fungi and NPKMg Fertilizer

Category	AMF Treatment	Dosage of NPKMg Fertilizer				
		N_0	**N_1**	**N_2**	**N_3**	**Average**
Stem Diameter 4 Weeks After Planting (WAP)	M_0	1.50	1.58	1.58	1.63	1.57
	M_1	1.46	1.53	1.66	1.67	1.58
	M2	2.18	1.83	1.66	1.81	1.87
	M_2	1.54	1.75	2.03	1.67	1.74
	Average	1.67	1.67	1.73	1.69	
Stem Diameter 8 Weeks After Planting (WAP)	M0	3.15	3.23	3.21	3.12	3.17
	M1	3.16	3.15	3.19	3.46	3.24
	M2	4.37	3.68	3.19	3.66	3.72
	M3	3.51	3.62	3.83	3.60	3.64
	Average	3.55	3.42	3.36	3.46	
Stem Diameter 12 Weeks After Planting (WAP)	M0	4.33	4.17	4.28	4.07	4.21
	M1	4.26	4.27	4.16	4.61	4.33
	M2	4.21	4.79	4.06	4.21	4.32
	M3	4.94	4.52	4.00	5.25	4.68
	Average	4.44	4.44	4.13	4.54	

Note: Values not followed by letters indicate non-significant differences according to ANOVA at 5%. M_0 (control), M_1 (Mycorrhiza 5 g/polybag), M_2 (Mycorrhiza 10 g/polybag), and M_3 (Mycorrhiza 15 g/polybag); N_0 (control), N_1 (NPKMg 0.5 g/polybag), N_2 (NPKMg 1 g/polybag), and N_3 (NPKMg 1.5 g/polybag).

Number of Fronds

The results of variance analysis indicate that the combination of Arbuscular Mycorrhizal dosage and NPKMg fertilizer had no significant effect on the number of fronds from 4 WAP (Weeks After Planting) to 12 WAP. This was due to the very low infection rate of the Mycorrhiza, which hindered its interaction with the plant roots. As a result, the root system was unable to effectively absorb phosphorus nutrients or water, thereby inhibiting the increase in the number of oil palm fronds.

Table 4. Average number of fronds of oil palm seedlings with the application of Arbuscular Mycorrhizal Fungi and NPKMg fertilizer

Category	AMF Treatment	Dosage of NPKMg Fertilizer				
		N_0	**N_1**	**N_2**	**N_3**	**Average**
Number of Fronds 4 Weeks After Planting (WAP)	M_0	0.33	0.50	0.17	0.33	0.38
	M_1	0.17	0.50	1.00	0.33	0.50
	M2	0.50	0.50	0.50	0.33	0.46
	M_2	0.67	0.17	0.17	0.50	0.38
	Average	0.42	0.42	0.46	0.37	
Number of Fronds 8 Weeks After Planting (WAP)	M0	2.00	1.83	2.00	2.00	1.96
	M1	2.00	2.00	2.00	1.83	1.96
	M2	1.50	1.83	2.00	1.67	1.75
	M3	2.00	1.83	1.67	2.00	1.88
	Average	1.88	1.87	1.92	1.88	
Number of Fronds 12 Weeks After Planting (WAP)	M0	2.00	2.50	2.33	2.17	2.25
	M1	2.00	2.33	2.67	2.00	2.25
	M2	1.83	2.50	2.33	1.83	2.12
	M3	2.67	2.50	2.00	2.50	2.42
	Average	2.13	2.46	2.33	2.13	

Note: Values not followed by letters indicate non-significant differences according to ANOVA at 5%. M_0 (control), M_1 (Mycorrhiza 5 g/polybag), M_2 (Mycorrhiza 10 g/polybag), and M_3 (Mycorrhiza 15 g/polybag); N_0 (control), N_1 (NPKMg 0.5 g/polybag), N_2 (NPKMg 1 g/polybag), and N_3 (NPKMg 1.5 g/polybag).

The analysis points to the availability of soil nutrients as a key factor. This finding is consistent with the study by Juliansyah (2018), which stated that the lack of soil nutrients is one of the reasons for the absence of significant frond formation in plants. Moreover, this condition is suspected to be due to the soil pH not being conducive to the development of Mycorrhiza, resulting in its suboptimal function and lack of significant effect on stem diameter growth (Tamin and Suci, 2020). The addition of NPKMg fertilizer can further acidify the soil, leading to nutrient unavailability due to increased H+ ions. This shift to acidic pH causes a significant rise in aluminum levels, which binds with phosphorus, rendering it inaccessible to plants (Nasrullah et al., 2015). According to Yama et al. (2021), nutrients can be fully absorbed when plants grow in suitable planting media. Therefore, changes in soil pH create unsuitable conditions for plant growth and development, particularly affecting the number of leaves.

Conclusion and Recommendations

The application of Arbuscular Mycorrhiza at a dose of 15 g per polybag showed a positive effect on the growth of oil palm plant height at 4 weeks after planting (WAP). The application of NPKMg fertilizer with a 15:15:6:4 formula did not have a significant effect on any of the observed parameters. Additionally, root infection by Arbuscular Mycorrhiza was observed, although the infection rate was very low, ranging between 10-30%. Future research should investigate higher doses of Mycorrhiza to explore its potential impact more comprehensively.

REFERENCES

Aditya, P. D., Candra, G., & Hartati, M. R. (2016). Pengaruh intensitas penyinaran dan dosis pupuk NPK terhadap pertumbuhan bibit kelapa sawit di pre-nursery. *Jurnal Agromas, 1*(1), 58–66.

Agung, A. K., Adiprasetyo, T. A., & Hermansyah, H. (2019). Penggunaan kompos tandan kosong kelapa sawit sebagai substitusi pupuk NPK dalam pembibitan awal kelapa sawit. *Jurnal Ilmu-Ilmu Pertanian Indonesia, 21*(2), 75–81.

Amri, A. I., Armaini, A., & Purba, M. R. A. (2018). Aplikasi kompos tandan kosong kelapa sawit dan dolomit pada medium subsoil inceptisol terhadap bibit kelapa sawit (*Elaeis guineensis* Jacq.) di pembibitan utama. *Jurnal Agroteknologi, 8*(2). https://doi.org/10.24014/ja.v8i2.3349

Apria. (2022). Pertumbuhan bibit pada dua varietas kelapa sawit (*Elaeis guineensis* Jacq.) di pre-nursery [Skripsi]. Universitas Sriwijaya.

Astianto, A., Ardian, & Khoiri, M. A. (2013). Pemberian berbagai dosis abu boiler pada pembibitan kelapa sawit (*Elaeis guineensis* J.) di pembibitan utama (main nursery). *Prosiding SEMNAS RTD Bidang Ilmu Kelapa Sawit BKS-PTN, 1*, 67–72.

Barita, Y., Prihastanti, E., Haryanti, S., Subagio, A., & Ngadiwiyana. (2018). The influence of granting NPK fertilizer and nanosilic fertilizers on the growth of ganyong plant (*Canna edulis* Ker.). *Journal of Physics: Conference Series, 1025*(1). https://doi.org/10.1088/1742-6596/1025/1/012054

Juliansyah, W. (2018). Respon pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) di pre-nursery terhadap pemberian biourin kambing [Skripsi]. UM Sumatera Utara.

Kartika, E., Duaja, M. D., & Gusniwati. (2016). Pertumbuhan tanaman kelapa sawit belum menghasilkan (TBM I) pada pemberian mikoriza indigen dan dosis pupuk organik di lahan marjinal. *Biospecies, 9*(1), 29–37.

Lubis, M. G. R. (2019). Pengaruh pupuk organik cair dan pupuk NPK 17:17:17 terhadap pertumbuhan bibit tanaman kakao (*Theobroma cacao* L.) [Skripsi]. Universitas Muhammadiyah Sumatera Utara.

Madusari, S., Danie, I. Y., Jumardin, Bella, T. L., & Rizki, A. B. (2018). Pengaruh inokulasi mikoriza arbuskular terhadap pertumbuhan dan produksi tanaman cabai (*Capsicum annuum* L.). *Prosiding Seminar Nasional Sains dan Teknologi*, 1–8.

Matsetio, A. M., Tunjung, P., & Yenny, S. (2014). Jenis dan potensi fungi mikoriza asal tanah pasca tambang batubara dalam mengendalikan penyakit busuk batang *Fusarium* sp. pada tanaman jagung [Skripsi]. Universitas Bengkulu.

Matana, Y. R., & Mashud, N. (2016). Respons pemupukan N, P, K, dan Mg terhadap kandungan unsur hara tanah dan daun pada tanaman muda kelapa sawit. *Buletin Palma, 16*(1), 23–31.

Maulana, A., Wirianata, H., & Wijayani, S. (2017). Pengaruh saat aplikasi fungi mikoriza arbuskula dan komposisi media terhadap pertumbuhan bibit kelapa sawit di pre-nursery. *Jurnal Agromast, 2*(1).

Palasta, R., & Viva, R. M. (2018). Pertumbuhan bibit kelapa sawit dengan aplikasi fungi mikoriza arbuskular dan beberapa dosis pupuk fosfat. *Jurnal Agro Industri Perkebunan, 5*(2), 97.

Pulungan, A. S. S. (2013). Infeksi fungi mikoriza arbuskula pada akar tanaman tebu (*Saccharum officinarum* L.). *Jurnal Biosains Unimed, 1*(1), 43–46.

Puspitasi, D., Purwani, K. L., & Muhibuddin, A. (2012). Eksplorasi vesicular arbuskular mycorrhiza (VAM) indigenous pada lahan jagung di Desa Torjun, Sampang Madura. *Jurnal Sains dan Seni ITS, 1*, 19–22.

Rini, M. V., & Efriyani, U. (2016). Respons pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) terhadap pemberian fungi mikoriza arbuskular dan cekaman air. *E-Journal Menara Perkebunan, 4*(2), 107–116. https://doi.org/10.22302/ppbbi.jur.mp.v84i2.225

Risbo, W. (2019). Aplikasi mikoriza arbuskula dan berbagai dosis pupuk NPK 20-20-20 pada pembibitan pre-nursery kelapa sawit (*Elaeis guineensis* Jacq.) [Skripsi]. Universitas Muhammadiyah Sumatera Utara.

Riduan, M., Rosmiah, & Aminah, R. I. S. (2017). Pengaruh pemberian pupuk hayati mikoriza dan volume pemberian air terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) pada stadia pre-nursery. *Klorofil, 11*(1), 7–11.

Situmorang, F., Hapsoh, & Manurung, G. M. E. (2014). Pengaruh mulsa serbuk gergaji dan pupuk NPK terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) pada fase main nursery. *Jurnal Online Mahasiswa Fakultas Pertanian Universitas Riau, 1*(1), 1–12.

Tambunan, M. M., Simanungkalit, T., & Irwansyah, T. (2015). Respons pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) terhadap pemberian kompos sampah pasar dan pupuk NPKMg (15-15-6-4) di pre-nursery. *Jurnal Online Agroteknologi, 3*(1).

Untung, R., & Islan. (2015). Pemberian pupuk NPKMg (15-15-6-4) dan interval waktu pemberian pupuk pelengkap cair terhadap pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) di pembibitan utama. *JOM Faperta, 2*(2), 10–17.

Wahyuni, M., & Manurung, W. A. (2020). Hubungan hara K-Mg dan pengaruhnya terhadap kadar hara daun bibit kelapa sawit (*Elaeis guineensis* Jacq.). *Jurnal Agrosains dan Teknologi, 5*(1), 19–26.

Yama, D. I., Okto, I., & Ricka, A. (2021). Hubungan serapan P dengan pertumbuhan setek lada pada aplikasi kompos ampas tahu dan jerami padi. *Agrotechnology Research Journal, 5*(2), 77–84.