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Effect of Different Mycorrhiza Treatments on Spore Counts in Oil Palm Topsoil

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Abstract

Mycorrhiza fungi are pivotal in oil palm cultivation, offering potential for enhanced growth and a reduced need for chemical fertilizers. However, the effectiveness of varying volumes and application timings of mycorrhiza remains an underexplored area. This gap, especially in the context of nursery-stage oil palm topsoil, challenges the advancement of sustainable cultivation practices. Addressing this, our study sought to evaluate the impact of different mycorrhiza volumes on spore counts in oil palm topsoil at nursery. Over a period of four months, we administered three levels of mycorrhiza treatments (0.5g, 1.0g, and 1.5g per plant) and conducted a thorough analysis using a 2-way ANOVA. The results revealed no statistically significant difference in spore counts due to varying mycorrhiza weights, as indicated by an F-value of 1.67 and a p-value of 0.209. However, the time factor, represented by different months, showed a significant impact on spore counts, with an F-value of 4.36 and a p-value of 0.014. Additionally, the interaction between mycorrhiza weight and month did not significantly influence spore counts, evidenced by an F-value of 0.31 and a p-value of 0.928. This study underscores the importance of temporal factors over mycorrhiza volume in oil palm nurseries and contributes valuable insights for optimizing sustainable cultivation practices.

1. Introduction

The global agricultural landscape is increasingly defined by the cultivation of oil palm (*Elaeis guineensis*), a key player in the production of edible oils, bioenergy, and economic development. At the heart of this success is the symbiotic relationship between oil palm plants and various microorganisms, particularly mycorrhiza fungi. These fungi are critical for plant growth, offering benefits like enhanced phosphorus absorption, increased disease resistance, and improved water relations [1]. Mycorrhizal associations also could serve as a promising alternative for managing stem root disease in oil palm plantations, leading to enhanced soil health and agricultural product outcomes [2]. In a world striving to meet the nutritional needs of a growing population, optimizing oil palm cultivation through an in-depth understanding of these symbiotic interactions is more important than ever.

Recent studies, such as those by [3], highlight the potential of mycorrhiza to significantly increase plant growth and nutrient uptake, notably nitrogen, phosphorus, and potassium. This is especially relevant for oil palms, where phosphorus is a vital nutrient. Enhanced phosphorus uptake through mycorrhiza associations can lead to more vigorous and productive plants. In the current agricultural climate, which emphasizes environmentally sustainable and efficient practices, understanding these mycorrhiza dynamics is crucial. Mycorrhizal associations play a pivotal role in sustainable and organic agriculture by fostering plant growth, enhancing yield quality, and diminishing the need for agrochemical usage [4].

The use of mycorrhiza fungi in agriculture has emerged as a promising strategy to boost crop yields while reducing reliance on chemical fertilizers. Studies like those conducted by [5] demonstrate the benefits of using mycorrhiza fungi over chemical fertilizers, including increased yields and mineral content. Within the realm of oil palm cultivation, optimizing mycorrhiza treatments is essential for maximizing the benefits of this symbiotic relationship. Our study seeks to add to this knowledge by exploring the effects of varying mycorrhiza application volumes and timings on spore counts in oil palm topsoil.

This research aims to shed light on the complex interplay between mycorrhiza fungi and oil palm, addressing a vital gap in current agricultural knowledge. By focusing on spore counts in topsoil as a measure of mycorrhiza activity, we aim to understand how different application volumes and timings affect these counts, thereby offering insights to optimize mycorrhiza treatments in oil palm cultivation.

2. Methodology

2.1 Study Area

The study was carried out at the FELCRA Berhad Research and Development (R&D) nursery in Perak, Malaysia (4°18'01"N 100°57'57"E) (Figure 1). This site was strategically chosen for its significance in oil palm cultivation. The experiment spanned a four-month period, allowing for an assessment of mycorrhiza effects on spore counts in oil palm topsoil over time.

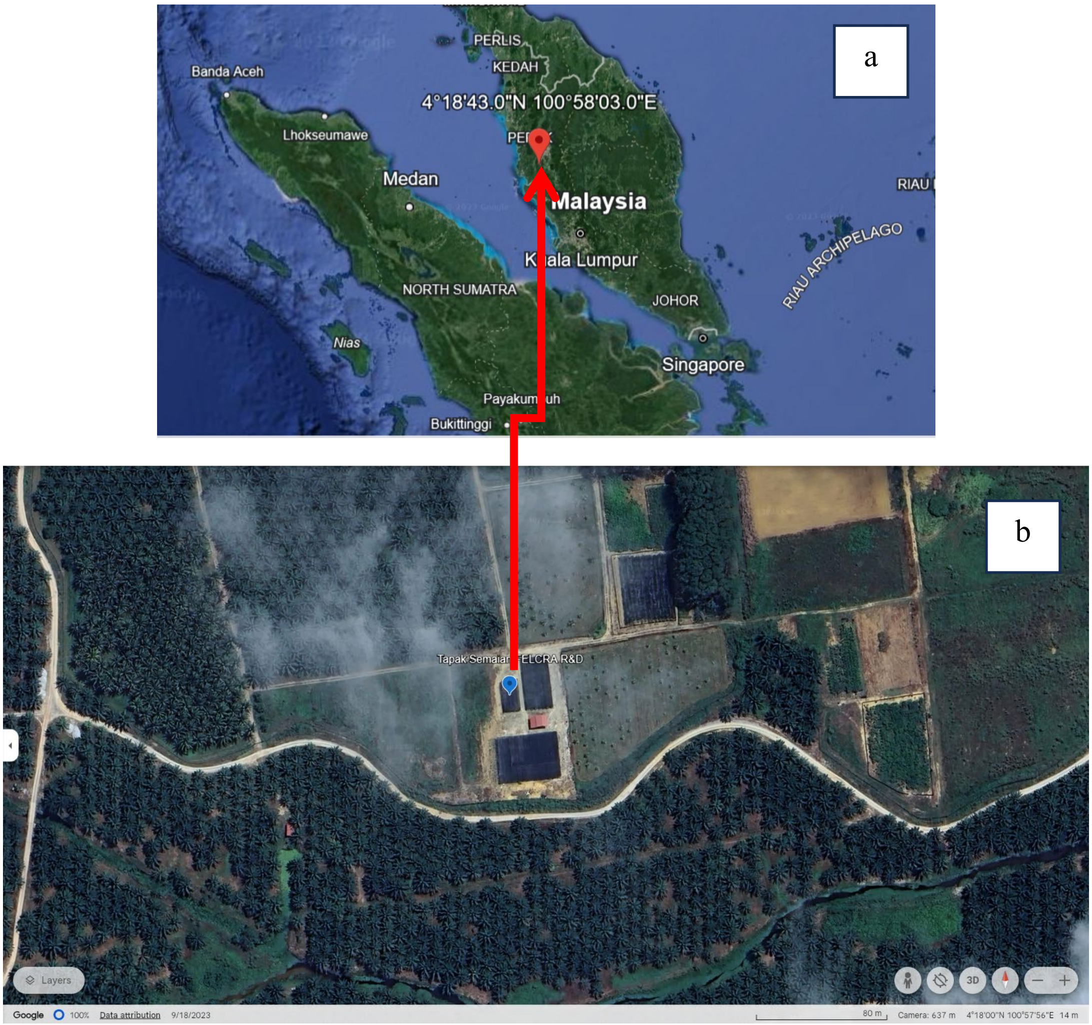

Fig. 1 *Map of peninsular Malaysia (a) and location of study plot in (b)*

2.2 Mycorrhiza Inoculum Treatments and Spore Analysis

The experiment involved three levels of mycorrhiza inoculum treatments: 0.5g, 1.0g, and 1.5g per oil palm planting materials. This range was selected to explore the dose-dependent effects on spore development in the topsoil. The method involved weighing followed by thorough mixing with water and sieving. The spore count was recorded as number of spores per 10g of soil. Each soil sample was replicated three times. The spore count was measured using wet sieving and decanting method [6]. The spore was observed by using a dissecting microscope with 40x magnification. The soil samples are then rinsed with 500 mL water and sieve through 710, 425, 250, 45, 32 and 20 micrometers (μm). Filter of those was collected in 50 ml petri dish with grid to undergo spore count using dissecting. Spores were observed and sorted based on the viability including shapes, sizes, and colors.

2.3 Data Analysis

The data collected from spore counting and identification were analyzed using IBM SPSS Statistics 21 software. A 2-way analysis of variance (ANOVA) was conducted to investigate the impact of two main factors: mycorrhiza treatment volumes and time (measured in months) on the variability of spore counts in oil palm topsoil.

3. Result and Discussion

The analysis examined three levels of mycorrhiza weights (0.5g, 1.0g, and 1.5g). The treatment exhibited an F-value of 1.67, with a p-value of 0.209, suggesting that there is no statistically significant difference in spore counts due to varying mycorrhiza weights (Table 1). Conversely, the analysis of four distinct months revealed an F-value of 4.36 with a significant p-value of 0.014, indicating a notable statistical difference in spore counts across different months. The interaction between treatment and month showed an F-value of 0.31 and a p-value of 0.928, demonstrating that the interplay between mycorrhiza weight and month is not statistically significant.

Table 1 *Analysis of variance and model summary*

Analysis of variance			
Source	DF	F-Value	P-Value
Treatment	2	1.67	0.209
Month	3	4.36	0.014
Treatment*Month	6	0.31	0.928
Model summary			
S	R-sq	R-sq(adj)	R sq(pred)
33.8994	43.19%	17.16%	0.00%

The findings regarding the minimal impact of mycorrhiza concentration on spore counts in oil palm topsoil prompt a re-evaluation of mycorrhiza's role in spore production. The negligible effect within the studied weight range (0.5g, 1.0g, 1.5g) suggests that factors beyond mycorrhiza concentration are influential in spore count variability. This calls for a broader approach in oil palm cultivation practices.

Furthermore, the study emphasizes the importance of temporal factors in spore count variation. The significant impact during specific months may be related to seasonal changes, moisture levels, or other environmental factors. This finding aligns with the research of [7] on *Agave maximiliana*, where mycorrhiza colonization led to heightened growth over time. Such insights are vital for optimizing mycorrhiza applications in Malaysia's unique climate.

The absence of a significant interaction effect between mycorrhiza weight and month suggests that temporal factors affecting spore counts operate independently of mycorrhiza treatment. This independence is crucial for predicting outcomes and streamlining cultivation strategies for spore count optimization.

The study's modest adjusted R-squared value (17.16%) indicates that additional variables, such as soil moisture, temperature, and biological factors, may also play a role in spore count dynamics. AMF root colonization rates were insignificantly negatively correlated with EC, soil temperature, P, K, Fe, Cu, Zn, and Mn but significantly positively correlated with soil pH, soil moisture, and insignificantly positively correlated with N and OC ($P < 0.05$) [8]. On the other hand, [9] believed elevated iron concentrations in cotton soils promote increased presence of arbuscular mycorrhizal fungi and root colonization. Conversely, soils deficient in nitrogen and those with high levels of phosphorus and potassium hinder fungal growth. In addition, chito-oligosaccharide application also enhances arbuscular mycorrhiza formation in *Medicago truncatula* roots. This effect is achieved through the regulation of genes related to strigolactone biosynthesis and fungal accommodation over a span of several weeks [10].

Future studies should explore these variables to develop a more comprehensive model, enhancing our understanding and refining cultivation practices in the Malaysian oil palm industry. As the industry evolves, integrating mycorrhiza applications with a deep understanding of temporal dynamics and additional variables could enhance sustainability and productivity, contributing to responsible agricultural practices.

4. Conclusion

This study's in-depth analysis has revealed that while varying mycorrhiza weights (0.5g, 1.0g, 1.5g) do not significantly affect spore counts in oil palm topsoil, the distinct temporal variations observed across four months highlight the substantial influence of environmental or seasonal factors on spore production. The absence of a significant interaction between mycorrhiza weight and time suggests that these temporal factors may operate independently of mycorrhiza concentration, offering valuable insights for optimizing application strategies. Furthermore, the model's limited explanatory power, with an adjusted R-squared value of 17%, points to the existence of other unexplored variables that influence spore count, such as soil moisture, temperature, or additional biological factors. This finding underscores the complexity of the spore production process in oil palm cultivation and the need for further comprehensive research to uncover these dynamics fully. By advancing our understanding of the intricate relationship between mycorrhiza treatments, time, and environmental factors, this study contributes significantly to the broader field of sustainable agriculture, particularly in the optimization of mycorrhiza use for enhanced oil palm growth and productivity.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Syazwan Shahidan, Rohaya Mohd Yusof, Nadia Mohd Fadzil* ***data collection:*** *Rohaya Mohd Yusof, Siti Nurizzati Izal* ***analysis and interpretation of results:*** *Noraini Ruslan;* ***draft manuscript preparation:*** *Mohamad Asyraf Hasli, Noraini Ruslan, Syazwan Shahidan, Mohd Amirulhakim.*

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