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BIOFERTILIZER AND BOTANICAL PESTICIDE EFFECTS ON OIL PALM SEEDLINGS

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ABSTRACT

This study evaluated the effects of biofertilizers (Trichoderma and mycorrhiza), citronella-based botanical pesticide, and their interaction on the vegetative growth and pest attack intensity of oil palm (Elaeis guineensis Jacq.) seedlings during the pre-nursery stage. The experiment used a 3 × 3 factorial randomized block design with three replications. The first factor was biofertilizer: control (P0), Trichoderma 15 g plant^{-1} (P1), and mycorrhiza 15 g plant^{-1} (P2). The second factor was citronella botanical pesticide: control (N0), 25 mL plant^{-1} (N1), and 50 mL plant^{-1} (N2). Plant height, stem diameter, leaf area, leaf number, and pest attack intensity were observed from 5 to 12 weeks after planting. Mycorrhiza significantly increased plant height at 10 weeks and leaf area at 12 weeks, while stem diameter was not significantly affected. Leaf number showed significant responses to biofertilizer at 7 weeks, botanical pesticide at 5 weeks, and their interaction at 5 and 6 weeks. Pest attack intensity was generally low and did not show a significant main or interaction effect across the observation period. The highest numerical values for plant height and leaf area were obtained with mycorrhiza, whereas the P2N2 combination produced the highest numerical leaf area at 12 weeks. The findings indicate that mycorrhiza has greater potential than Trichoderma for improving selected early growth traits of oil palm seedlings, while citronella pesticide can be incorporated into pre-nursery management without a statistically detectable growth penalty.

Keywords: oil palm; biofertilizer; mycorrhiza; Trichoderma; botanical pesticide

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INTRODUCTION

Oil palm (Elaeis guineensis Jacq.) is an economically important plantation crop in Indonesia, and the quality of planting material is a major determinant of subsequent field performance. Seedling management therefore needs to provide adequate nutrients, water, and protection from biotic stress. Fertilization is intended to improve nutrient availability because seedlings relying only on nutrients naturally present in the growing medium may experience restricted growth (Nengsih, 2020; Sulardi, 2022).

Mycorrhizal fungi form mutualistic associations with plant roots and can expand the effective soil exploration zone through external hyphae. This association is particularly relevant for phosphorus acquisition and can improve nutrient-use efficiency and seedling establishment (Febriyaniningrum et al., 2021; Smith & Read, 2020). In oil palm, mycorrhizal application has been reported to improve seedling growth, including responses associated with nutrient and water acquisition (Riduan et al., 2017; Sodikin et al., 2022; Rambe et al., 2023). Trichoderma is another beneficial fungus widely used as a biological control agent and plant-growth promoter. Its potential includes pathogen antagonism, nutrient mobilization, and improvement of root-zone conditions (Dwiastuti et al., 2015; Harman et al., 2021; Sutarman & Prahasti, 2022; Fitriani et al., 2023).

Botanical pesticides provide an alternative approach for managing insect pressure while reducing reliance on conventional synthetic pesticides. Citronella (Cymbopogon nardus) contains volatile compounds associated with repellent and insecticidal activity, and botanical insecticides are increasingly considered components of integrated pest management (Isman, 2020; Dwiwiyati et al., 2020; Sari & Putra, 2022; Lestari et al., 2023). The response of seedlings, however, depends on dose, formulation, application method, and environmental conditions; therefore, compatibility between biological fertilizers and botanical pesticides should be evaluated empirically (Rahman et al., 2024; Utami et al., 2023).

Previous studies in the same broad agricultural context have also demonstrated that factorial randomized-block experiments can reveal treatment-specific and interaction responses in plant growth. For example, Hasibuan et al. (2024) reported significant responses of beet growth and production to factorial treatment combinations in Algebra: Jurnal Pendidikan, Sosial dan Sains. Similarly, Azhari et al. (2025) evaluated factorial responses of cherry tomato to growth regulators and humic acid in the same journal. These studies provide a relevant methodological precedent for presenting agricultural experiments in the target journal.

Based on this rationale, this study aimed to determine the effects of Trichoderma and mycorrhiza, citronella botanical pesticide, and their interaction on oil palm seedling growth and pest attack intensity during the pre-nursery stage. The working hypothesis was that biofertilizer and botanical pesticide treatments would improve growth and reduce pest attack, with the possibility of an interaction between the two inputs.

RESEARCH METHODS

The experiment was conducted at Jl. Trompet, Medan Selayang, Medan, North Sumatra, Indonesia, from August to December 2025. The experimental site was prepared under 55% paranet shade, with good drainage and access to water. The growing medium was topsoil placed in 18 × 25 cm polybags. Oil palm sprouts were planted at one seed per polybag.

A 3 × 3 factorial randomized block design (RAK) was used with three replications. The biofertilizer factor consisted of P0 = control, P1 = Trichoderma 15 g plant^{-1}, and P2 = mycorrhiza 15 g plant^{-1}. The botanical pesticide factor consisted of N0 = control, N1 = citronella preparation 25 mL plant^{-1}, and N2 = citronella preparation 50 mL plant^{-1}. There were 27 plots, five plants per plot, and three sampled plants per plot, for a total of 135 plants.

Citronella botanical pesticide was prepared from 100 g of citronella material boiled in 2 L of water for approximately 40 minutes, cooled, and allowed to stand for 24 hours. Applications began at 5 weeks after planting and were repeated at one-week intervals until 12 weeks. Plant height, stem diameter, leaf area, and leaf number were measured weekly. Leaf area was estimated using the length × width × 0.57 method. Pest attack intensity was calculated from the observed damage categories using the weighted damage formula described in the thesis.

Data were analyzed using analysis of variance (F-test). When a treatment effect was significant, means were separated using Duncan's Multiple Range Test (DMRT) at the 5% level. The manuscript reports treatment means and significance patterns from the thesis rather than recalculating the original raw observations.

RESULTS AND DISCUSSION

The principal treatment responses are summarized in Tables 1–3. Significant effects were selective rather than universal: biofertilizer affected plant height at 10 weeks, leaf area at 12 weeks, and leaf number at 7 weeks; botanical pesticide affected leaf number at 5 weeks; and the interaction affected leaf number at 5 and 6 weeks. Stem diameter and pest attack intensity did not show significant treatment effects across the observation period.

Table 1. Selected significant responses of oil palm seedlings

Parameter	Observation	Treatment	Mean
Plant height	10 WAP	P2 (mycorrhiza)	15.89 cm
Leaf area	12 WAP	P2 (mycorrhiza)	18.73 cm²
Leaf number	7 WAP	P0 (control)	1.85 leaves
Leaf number	5 WAP	N0 (control)	1.00 leaves
Leaf number	6 WAP	P0N1 / P0N2	1.56 leaves

Table 1 shows that the strongest and most consistent numerical growth advantage was associated with mycorrhiza. At 10 weeks, P2 reached 15.89 cm, compared with 11.27 cm for Trichoderma and 9.37 cm for the control. At 12 weeks, P2 also produced the largest leaf area (18.73 cm²), exceeding P1 (16.99 cm²) and P0 (14.44 cm²).

The superior response of mycorrhiza is biologically plausible because the symbiosis can extend the effective root absorbing surface and improve phosphorus acquisition. The result is consistent with reports that arbuscular mycorrhiza can improve nutrient acquisition and seedling growth (Febriyaniningrum et al., 2021; Smith & Read, 2020; Riduan et al., 2017; Sodikin et al., 2022). The present result should nevertheless be interpreted as a parameter-specific response because stem diameter was not significantly affected. This distinction is important: a treatment may improve selected growth attributes without producing a statistically significant response in every morphological variable.

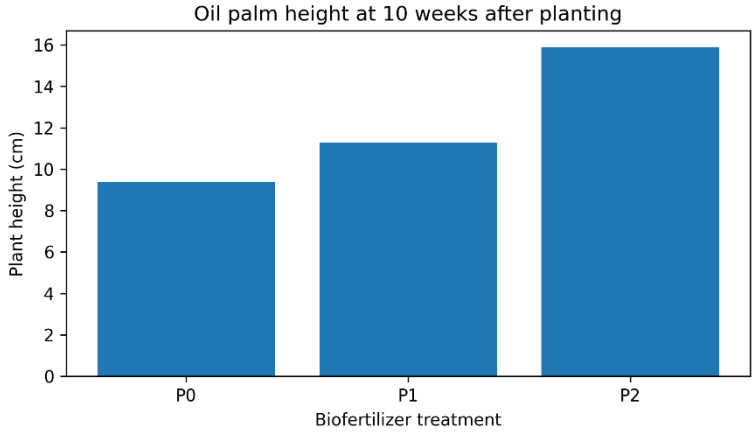


Figure 1. Oil palm height at 10 weeks after planting.

Table 2. Mean stem diameter and leaf area at 12 weeks

Biofertilizer	Stem diameter (mm)	Leaf area (cm²)	Significance
P0	5.88	14.44 c	Leaf area: significant
P1	5.84	16.99 b	Leaf area: significant
P2	6.32	18.73 a	Leaf area: significant

Stem diameter increased numerically over time in all treatments, but neither biofertilizer, botanical pesticide, nor their interaction produced a significant effect from 5 to 12 weeks. In contrast, leaf area at 12 weeks differed significantly among biofertilizer treatments, with P2 highest. This pattern suggests that mycorrhizal benefits in the present experiment were expressed more clearly through leaf expansion and height than through stem thickening. Similar parameter-specific responses have been reported in biological-input studies, where nutrient acquisition and root-zone effects do not necessarily translate uniformly across all growth traits (Krisdayani et al., 2020; Nasution et al., 2022).

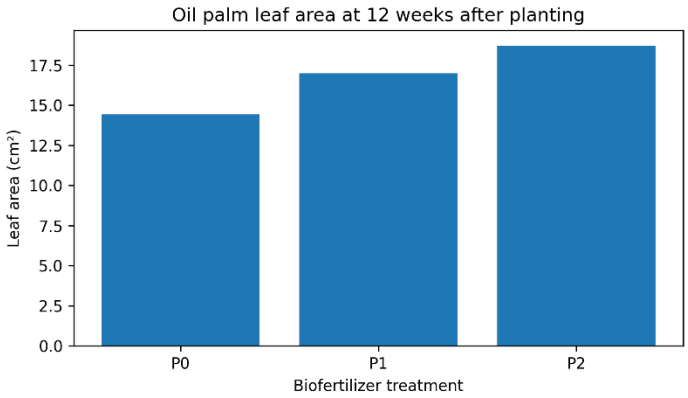


Figure 2. Oil palm leaf area at 12 weeks after planting.

The Trichoderma treatment was also associated with numerically higher values than the untreated control for several growth observations, but its effects were not consistently significant. Trichoderma can function both as a biological control organism and as a plant-growth promoter through effects on root development, nutrient availability, and microbial activity (Dwiastuti et al., 2015; Harman et al., 2021; Sutarman & Prahasti, 2022). The absence of a significant stem-diameter response in this experiment therefore does not negate its biological potential; rather, it indicates that under the specific pre-nursery conditions and dose used here, the response was not statistically strong enough for that parameter.

Table 3. Leaf number and pest attack intensity responses

Variable	Observation	Factor	Highest/lowest mean	Result
Leaf number	5 WAP	N	N0 = 1.00; N1 = 0.81; N2 = 0.89	Significant
Leaf number	6 WAP	P × N	P0N1/P0N2 = 1.56	Significant
Leaf number	7 WAP	P	P0 = 1.85; P1 = 1.56; P2 = 1.52	Significant
Pest intensity	5–12 WAP	P, N, P × N	No consistent separation	Not significant

Leaf number responded to the treatments during the early observation period. Biofertilizer significantly affected leaf number at 7 weeks, while botanical pesticide significantly affected leaf number at 5 weeks and the interaction was significant at 5 and 6 weeks. The control biofertilizer treatment had the highest mean at 7 weeks (1.85 leaves), while N0 was highest at 5 weeks (1.00 leaf). These results caution against assuming that the highest treatment dose automatically produces the greatest vegetative response. Botanical pesticides may influence plant responses indirectly through pest pressure, formulation characteristics, or short-term physiological effects (Isman, 2020; Rahman et al., 2024; Utami et al., 2023).

Pest attack intensity remained low during the experiment and the analysis reported no significant effect of biofertilizer, botanical pesticide, or their interaction from 5 to 12 weeks. At 12 weeks, the treatment means were within the same broad damage category, even though some combinations had lower numerical values at earlier observations. The lack of statistical significance is important for interpretation: the data do not justify the stronger claim that citronella pesticide definitively suppressed pest attack under these experimental conditions. Botanical insecticides can be effective, but their performance is sensitive to concentration, application frequency, persistence, target-pest biology, and environmental conditions (Isman, 2020; Sari & Putra, 2022; Lestari et al., 2023).

The interaction pattern was also limited. Although P2N2 produced the highest numerical leaf area at 12 weeks (20.17 cm²), the interaction was not statistically significant for leaf area. Therefore, the P2N2 combination should be described as the numerically highest combination rather than as a statistically proven synergistic treatment. This distinction strengthens the scientific interpretation of the study and avoids overstatement. The overall pattern supports the practical use of mycorrhiza as a promising biofertilizer for selected early growth traits, while citronella pesticide can be considered a complementary pest-management input whose efficacy requires further testing under higher or more variable pest pressure.

CONCLUSIONS

Mycorrhiza at 15 g plant^{-1} produced the strongest statistically supported improvement among the biofertilizer treatments, increasing plant height at 10 weeks and leaf area at 12 weeks, while stem diameter remained unaffected. Trichoderma did not produce statistically significant effects across most measured growth traits under the conditions of this experiment. Citronella botanical pesticide affected leaf number at 5 weeks, but pest attack intensity did not differ significantly among treatments. The P2N2 combination produced the highest numerical leaf area at 12 weeks, but the interaction was not statistically significant for that parameter. Thus, the most defensible conclusion is that mycorrhiza has greater potential for improving selected pre-nursery growth traits, whereas citronella pesticide should be viewed as a complementary management option requiring further efficacy testing.

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BIBLIOGRAPHY

Azhari, C. R., Kurniawan, D., & Berliana, Y. (2025). Respon pemberian ZPT giberelin dan asam humat terhadap pertumbuhan dan hasil tanaman tomat ceri. Algebra: Jurnal Pendidikan, Sosial dan Sains, 5(1), 12–28.

Dwiastuti, M. E., Fajri, M. N., & Yunimar. (2015). Potensi Trichoderma spp. sebagai agens pengendali Fusarium spp. penyebab penyakit layu pada tanaman stroberi. Jurnal Hortikultura, 25(4), 331–339.

Dwiwiyati, N. S., Hadiwiyono, Harsono, P., & Mawar, M. (2020). Pemanfaatan minyak serai sebagai bahan aktif nanovirusida untuk pengendalian penyakit kuning pada cabai. Journal of Community Empowering and Services, 4(2), 51–58.

Febriyaniningrum, K., Oktaftria, D., Nurfitria, N., Jadid, N., & Hidayati, D. (2021). Potensi mikoriza vesikular arbuskular sebagai biofertilizer pada tanaman jagung. Jurnal Biologi Tropis, 6(1), 25–31.

Fitriani, R., Wahyuni, S., & Prasetyo, B. (2023). Peran Trichoderma sp. sebagai agen hayati dalam meningkatkan pertumbuhan tanaman perkebunan. Jurnal Ilmu Pertanian Indonesia, 28(2), 145–154.

Harman, G. E., Doni, F., Khadka, R. B., & Uphoff, N. (2021). Endophytic strains of Trichoderma increase plants' photosynthetic capability. Journal of Applied Microbiology, 130(2), 529–546.

Hasibuan, A. S., Berliana, Y., Kurniawan, D., & Razali. (2024). Respon pertumbuhan dan produksi tanaman bit (Beta vulgaris L.) terhadap beberapa konsentrasi dan cara aplikasi paklobutrazol. Algebra: Jurnal Pendidikan, Sosial dan Sains, 4(4), 153–167. https://doi.org/10.58432/algebra.v4i4.1158

Isman, M. B. (2020). Botanical insecticides in the twenty-first century—fulfilling their promise? Annual Review of Entomology, 65, 233–249.

Krisdayani, P. M., Proborini, M. W., & Kriswiyanti, E. (2020). Pengaruh kombinasi pupuk hayati endomikoriza, Trichoderma spp., dan kompos terhadap pertumbuhan bibit sengon. Jurnal Sylva Lestari, 8(3), 400–410.

Lestari, D., Wibowo, A., & Nugroho, H. (2023). Aktivitas metabolit sekunder tumbuhan sebagai pengendali hama ramah lingkungan. Jurnal Hama dan Penyakit Tumbuhan Tropika, 23(1), 55–64.

Nasution, A., Harahap, F., & Lubis, R. (2022). Peran mikoriza dalam meningkatkan efisiensi metabolisme dan pertumbuhan kelapa sawit. Jurnal Agronomi Indonesia, 50(3), 321–329.

Nengsih, Y. (2020). Pemberian pupuk hayati dan pupuk anorganik terhadap pertumbuhan bibit kelapa sawit. Jurnal Ilmiah Universitas Batanghari Jambi, 15(4), 1–7.

Rahman, A., Siregar, M., & Putri, N. (2024). Respon fisiologis tanaman terhadap dosis pestisida nabati. Jurnal Biologi Pertanian, 16(1), 33–42.

Rambe, M. S., Kristalisasi, N. E., & Himawan, A. (2023). Pengaruh dosis mikoriza dan bahan organik terhadap pertumbuhan bibit kelapa sawit. Agroforetech, 1, 72–78.

Riduan, M., Rosmiah, & Aminah, R. I. S. (2017). Pengaruh pupuk hayati mikoriza dan volume air terhadap pertumbuhan bibit kelapa sawit. Klorofil, XII(1), 7–11.

Sari, D., & Putra, A. (2022). Efektivitas pestisida nabati serai wangi terhadap hama daun. Jurnal Perlindungan Tanaman, 26(2), 87–95.

Smith, S. E., & Read, D. J. (2020). Mycorrhizal symbiosis. Academic Press.

Sodikin, Erizal, Sulaiman, F., Amar, M., Achadi, T., Yakup, Y., Sefrila, M., & Apria. (2022). Pengaruh dosis pupuk hayati mikoriza pada pertumbuhan bibit kelapa sawit. Jurnal Agro Industri Perkebunan, 10(2), 141–152.

Sutarman, S., & Prahasti, T. (2022). Uji keragaman Trichoderma sebagai pupuk hayati. Jurnal Agrotek Tropika, 10(3), 421.

Sulardi. (2022). Budidaya tanaman kelapa sawit. PT Dewangga Energi Internasional.

Utami, R., Kurniawan, A., & Dewi, S. (2023). Pengaruh pestisida nabati terhadap pertumbuhan vegetatif tanaman. Jurnal Agrikultura, 34(2), 117–126.