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Fusarium Pathogen Control Test Using Biological Agents and Fungicides on *Acacia crassicarpa* Seedlings in Growth Chamber

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Abstract

Background: *Acacia crassicarpa is widely cultivated in Industrial Forest Plantations but is susceptible to Fusarium wilt, which can cause severe seedling losses up to 36.94%. The limitations of synthetic fungicides highlight the need for sustainable biological control alternatives. This study evaluated biological agents and fungicides for suppressing Fusarium infection in A. crassicarpa seedlings.* **Methodology:** *The research was conducted at the Plant Protection Division (PPD) Research and Development Laboratory, Sinar Mas Forestry, Perawang, Riau. The experiment was arranged in a Completely Randomized Design (CRD) with seven treatments, three replications, and four seedlings per replication, resulting in a total of 84 seedlings. The treatment included negative control, a positive control, Fusarium endophyte, Trichoderma, DSE, Merivon, and Octave. Observation parameters consisted of disease symptoms, seedling mortality percentage, latent period, and control effectiveness. Data were analyzed using ANOVA at a 5% significance level, followed by Duncan's Multiple Range Test (DMRT) for significant differences.* **Findings:** *The results indicated that the Fusarium endophyte and Octave fungicide treatment were the most effective, both achieving 100% control with no seedling mortality. Merivon fungicide showed 86% effectiveness with 8,33% mortality, while Trichoderma and DSE achieved moderate control with 57% and 43% effectiveness, respectively. The positive control exhibited the highest mortality rate at 58,33%. Re-isolation confirmed Fusarium as the primary causal pathogen responsible for seedling death. It can be concluded that both biological agents and fungicides effectively suppressed Fusarium infection on Acacia seedling.* **Contributions:** *The Fusarium endophyte shows great potential for development as an environmentally friendly biological control agents to support sustainable nursery management and reduce dependence on synthetic fungicides.*

Keywords: *Acacia; Biological control; Fusarium; Fungicide; Pathogen*

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INTRODUCTION

Acacia is planted in more than 80 countries, including Indonesia, with species such as *Acacia auriculiformis*, *Acacia mangium*, *Acacia crassicarpa*, and *Acacia aulacocarpa* (Libertus & Diba, 2020). Acacia (*Acacia crassicarpa*) is one of the forest tree species widely used in Industrial Forest Plantations (HTI) due to its rapid growth and good wood productivity. Kahfi & Umra (2018), stating that acacia is a fast-growing plant species with potential for industrial timber plantation land in Indonesia. This species plays an important role in the supply of pulp and paper raw materials in Indonesia. Acacia plants are able to adapt to marginal land, so they are often used for reforestation and greening (Kusuma et al., 2023). Despite its many advantages, acacia is susceptible to wilt disease caused by the *Fusarium* pathogen.

The main problem that often occurs in acacia nurseries is wilt disease caused by the *Fusarium* fungus. This pathogen can attack the root system and plant vessels, causing wilting and even death of seedlings. Adiwena et al., (2022) explain that *Fusarium* is a soil-borne pathogen that infects roots and spreads to xylem tissue through water flow in the roots. The *Fusarium* pathogen is a soil-borne pathogen that persists through chlamydospores (de Lamo & Takken, 2020). *Fusarium* wilt disease is difficult to control because the pathogen can survive for long periods in the soil via chlamydospores even in the absence of host plants (Satrah et al., 2023). Azmi et al., (2021) also explain that *Fusarium* infection in the early stages of growth can significantly reduce seedling survival rates. Hidayat et al., (2021) This disease is a serious obstacle in the provision of ready-to-plant seedlings in nurseries of Industrial Forest Plantations.

Efforts to control *Fusarium* disease are generally carried out using synthetic fungicides. Khulillah et al., (2019), states that the use of fungicides is the most common and effective way to suppress the development of plant diseases in nurseries. The use of synthetic fungicides is the most common way to suppress the development of *Fusarium* so that it does not spread to other plants (Aji & Rohmawati, 2020). However, repeated use over the long term can lead to pathogen resistance and residues that contaminate the environment (Tarigan et al., 2024). Heriyanto (2019), stating that repeated use of high doses of chemicals can cause more complex cultivation problems. Syarifah et al., (2024), explain that fungicide residues can affect soil microorganisms that play an important role in soil fertility. Therefore, environmentally friendly and sustainable control alternatives are needed, one of which is by utilizing antagonistic microorganisms as biological agents. Subasari et al., (2025) *Fusarium* wilt disease control can be carried out through a biological agent approach using antagonistic agents.

Several microorganisms such as *Fusarium endophytes*, *Trichoderma*, and *Dark Septate Endophytes* (DSE) are known to have potential as biological control agents against soil-borne diseases. Endophytic *Fusarium* can live in plant tissue without causing disease symptoms, thus functioning as a natural protector against pathogenic infections (Fitriani et al., 2019). Sopialena et al., (2020), stated that *Fusarium endophytes* have the potential to act as biological agents in controlling plant pests and diseases. Susanti et al., (2021) also stated that *Fusarium endophytes* can suppress pathogen growth through competition for space and nutrients. Syarifah et al., (2024), stated that

Trichoderma from the rhizosphere soil of bamboo plants can control *Fusarium* pathogens. Fardani et al., (2024) DSE has the potential to act as a biological agent and can enhance plant growth under abiotic and biotic stress. According to Mateu et al., (2020) DSE colonization plays a role in increasing plant resistance to stress caused by salinity. This study aims to determine the effect of biological agents (*Fusarium endophytes*, *Trichoderma*, and DSE) and fungicides (Merivon and *Octave*) in inhibiting the development of *Fusarium* pathogens in acacia seedlings as a basis for developing effective and environmentally friendly disease control strategies.

METHOD

Research Location and Material

The research was conducted at the *Plant Protection Division* (PPD) *Research and Development* Laboratory, Sinar Mas Forestry, Perawang, Riau. The research activities took place from September 2024 to May 2025, covering the stages of inoculum preparation, seedling treatment, and observation in the growth chamber. The materials used were healthy and uniform acacia seedlings, *Fusarium* pathogen isolates, *Fusarium endophyte* isolates, *Trichoderma*, *Dark Septate Endophyte* (DSE), Merivon fungicide, *Octave* fungicide, *Potato Sucrose Agar* (PSA), sterile distilled water, 70% alcohol, and NaOCl. The tools used were a microscope, autoclave, laminar air flow, micro pipette, petri dish, Erlenmeyer flask, inoculation needle, hemocytometer, camera, and writing instruments.

Research Method

The method used in this study was a quantitative descriptive research method using a completely randomized design (CRD) with seven treatments and three replicates, each consisting of four seedlings per replicate, for a total of 84 seedlings. The treatments tested were negative control (without pathogen inoculation and without control), positive control (*Fusarium* inoculation without control), *Fusarium* endophytes*,* *Trichoderma*, *Dark Septate Endophyte* (DSE), Merivon fungicide, and *Octave* fungicide.

Research Implementation

Preparation of Pathogen and Biological Agent Suspensions

Fusarium pathogen isolates and biological agents (*Fusarium* endophytes, *Trichoderma*, and DSE) were propagated on PSA medium for seven days at room temperature (Hakim et al., 2020). Spore suspensions were prepared by adding sterile distilled water to the surface of the colonies and rubbing them until homogeneous. Spore density was adjusted using a hemocytometer to achieve a uniform density before use as inoculum.

Application of Biological Agents and Fungicides

Biological agents and fungicides (80 ml) were applied by watering twice before inoculation with the *Fusarium* pathogen at one-week intervals. This application was carried out with the aim of preventing initial colonization by the pathogen.

***Fusarium* Suspension Inoculation**

Fusarium suspension irrigation is carried out after the application of biological agents and fungicides. Acacia seedlings are wounded at the roots before planting. They are then irrigated with 13 ml of *Fusarium* pathogen suspension per seedling at a spore suspension concentration of 10^6 spora/mL.

Data Analysis

Observations were made to calculate the percentage of plants affected. This value was used to describe the severity of the attack on each treatment. The higher the percentage of infestation, the greater the susceptibility of plants to pathogen infection. Conversely, a low percentage of infestation indicates that the treatment is able to suppress the development of disease in acacia seedlings. The percentage of infected plants was calculated at the end of the observation using the formula (Triwidodo & Tanjung, 2020):

$$P = \frac{n}{N} \times 100\%$$

Information,
P = Percentage of plants affected (%)
n = Number of plants affected per treatment
N = Number of plants observed per treatment

RESULTS AND DISCUSSION

Symptoms of Disease and Development of *Fusarium*

Symptoms of *Fusarium* attack on acacia seedlings began to appear on the 8^{th} day after inoculation in the positive control treatment. Symptoms began with yellowing of the leaves, wilting, followed by stem necrosis and root rot as shown in Figure 1. Ulya et al., (2020), stated that the initial symptoms of *Fusarium* wilt are characterized by yellowing and drying of the lower leaves due to tissue death. This condition indicates that *Fusarium* pathogen infection attacks the root system and vascular tissue of plants, thereby inhibiting water and nutrient absorption. *Fusarium* is a soil-borne pathogen that infects roots and spreads to xylem tissue through water flow within the roots (Adiwena et al., 2022).


(a) (b) (c) (d)

Figure 1. Symptoms of *Fusarium* (seedling T2.1.1): (a) healthy plant, (b) wilting and yellowing, (c) falling off, (d) dead plant

Symptoms develop progressively. Plants that show initial symptoms in the first week usually experience a rapid decline in vitality. The following table shows the timing of initial symptoms and the development of *Fusarium* symptoms (Table 1).

Table 1. Time of onset of initial symptoms and progression of *Fusarium* symptoms

Treatment	Day Symptoms Appear	Day of Death
T4.3.1	24	27
T4.3.2	24	27
T2.1.3	15	17
T2.1.4	15	17
T2.2.3	15	17
T2.3.1	15	17
T2.3.3	15	17
T2.3.2	10	13
T2.1.1	8	17
T5.2.2	8	13
T5.1.1	6	8
T5.1.3	6	17
T5.3.2	6	8
T4.1.2	3	6
T6.1.1	3	6
T3.1, T3.2, T3.3	0	0
T7.1, T7.2, T7.3	0	0

Information: 1) Positive Control = T2.1.1, T2.1.3, T2.1.4, T2.2.3, T2.3.1, T2.3.2, T2.3.3. 2) Endofit *Fusarium* = T3.1, T3.2, T3.3. 3) *Trichoderma* = T4.1.2, T4.3.1,T4.3.2. 4) *Dark Septate Endophyte* = T5.1.1, T5.1.3, T5.2.2, T5.3.2. 5) Merivon = T6.1.1. 6) *Octave* = T7.1, T7.2, T7.3. 7) Repetition = 1,2,3. 8) Seed = 1,2,3,4.

Based on Table 1, the development of symptoms that occurred in the *Trichoderma* treatment showed a lower level of infection. The *Trichoderma* treatment showed a lower infection rate than other treatments, but the results varied between replicates. Some seedlings experienced wilting symptoms earlier and died quickly, while others only showed symptoms on day 24 and died on day 27. This indicates that the effectiveness of *Trichoderma* depends on its initial colonization ability in the root zone.

Positive control treatment (*Fusarium* without control), symptoms began to appear on the 8th day after inoculation, characterized by yellowing and wilting leaves. This is in line with the research by Irfandri et al., (2025), *Fusarium* symptoms in shallots are characterized by yellowing leaves, twisted leaves, and rotting bulbs. All seedlings died around day 17, indicating that disease progression was rapid, occurring only nine days after the initial symptoms appeared. Some other seedlings showed symptoms on days 10 to 15 and all died by day 17. This indicates that *Fusarium* infection developed aggressively shortly after inoculation.

Treatment with *Dark Septate Endophyte* (DSE) showed symptoms that appeared later than the positive control. Some seedlings began to wilt on day 6 and died on day 8. This indicates that although DSE has potential as a biological agent, its ability to suppress *Fusarium* development is still not as effective as *Fusarium endophyte* treatment and *Octave* fungicide, which showed no symptoms of disease during the observation period.

Treatment with the fungicide Merivon resulted in only one seedling exhibiting wilting and death symptoms, while the other seedlings remained healthy until the end of the observation period. However, the effectiveness of Merivon was affected by inaccurate dosages or uneven application. This is consistent with Aji & Rohmawati (2020) research which found that the use of synthetic fungicides is the most common method to suppress the development of *Fusarium* so that it does not spread to other plants. This is also in line with research by Khulillah et al., (2019), which found that fungicides can suppress or prevent disease if applied appropriately and evenly. The *Fusarium endophyte* and *Octave* treatments showed the best results as no disease symptoms were found until the end of the observation period. Both treatments were effective in preventing *Fusarium* infection through different mechanisms.

Percentage of Seedling Mortality

The results of the analysis of variance (ANOVA) showed that *Fusarium* infection caused significant differences between treatments in the percentage of acacia seedling mortality ($\rho < 0.05$). The percentage of acacia seedling mortality due to *Fusarium* pathogen infection in each treatment can be seen in Table 2. The highest mortality rate was found in the positive control at 58.33 %, while the negative control, *Fusarium endophytes*, and *Octave* fungicide showed 0.00 % seedling mortality.

Table 2. Percentage of acacia seedling mortality per treatment

Treatment	Mortality (%)
T1	0.00^{a}
T7	0.00^{a}
T3	0.00^{a}
T6	8.33^{ab}
T4	25.00^{bc}
T5	33.33^{c}
T2	58.33^{c}

Information: Data was transformed into Arcsin $\frac{\sqrt{y+0,5}}{100}$. Numbers followed by the same letters were not significantly different between treatments in the DNMRT test at the 5% level.

Based on Table 2, the *Fusarium endophyte* and *Octave* treatments proved to be the most effective in suppressing disease development. According to Meutia et al., (2017), *Fusarium endophytes* act through competition for space and nutrients in plant tissues, while *Octave*, which contains the active ingredient *prochloraz*, is systemic and capable of reducing disease intensity (Sundari et al., 2023). The Merivon fungicide treatment resulted in a low mortality rate (8.33%), which was not significantly different from the negative control. Merivon contains the active ingredients *fluxaproxad* and *pyraclostrobin*, which are capable of suppressing *Fusarium* infection, although its effectiveness can be influenced by environmental conditions and the accuracy of application.

The biological agents *Trichoderma* and DSE also reduced seedling mortality compared to the positive control, by 25.00% and 33.33%, respectively. However, the effectiveness of both was still lower than that of systemic fungicides. Karim et al., (2020) stated that *Trichoderma* works through antagonistic mechanisms such as competition and antibiosis. Firmansyah et al., (2024) DSE showed the ability to colonize roots without causing disease. Overall, the positive control (without control) showed the highest mortality (58.33%), indicating the aggressiveness of the *Fusarium* pathogen and the importance of implementing effective control strategies to maintain the viability (ability to live) of acacia seedlings.

Latent Period

Observations show that the latent period of *Fusarium* disease varies depending on the treatment given (Table 3). Based on Table 3, the first symptoms of the disease appeared on day 3 and at the latest on day 24 after inoculation. The Merivon fungicide treatment (T6) showed the fastest symptoms on day 3, although only one seedling was infected, indicating consistently high control effectiveness.

Table 3. Latent period of *Fusarium* symptom emergence

Treatment	Latent Period (Days)
T4	3 – 24
T2	8 – 15
T5	6 – 8
T6	3
T3	0
T7	0
T1	0

Trichoderma treatment (T4) showed symptoms between days 3 and 24. This demonstrates *Trichoderma's* ability to slow disease progression. This is in line with research by Ihkwanisa et al., (2023), showing that Trichoderma colonies develop faster than Fusarium colonies. Syarifah et al., (2024), stated that *Trichoderma* from the rhizosphere soil of bamboo plants can control *Fusarium* pathogens. DSE treatment (T5) showed symptoms between days 6 and 8. This indicates that DSE provides protection against infection in the early stages, but is not as strong as *Trichoderma*.

The positive control treatment (T2) that was not given a control agent showed initial symptoms on days 8 to 15, with all seedlings dying on day 17. The uniform symptoms and mortality indicate the aggressiveness of the *Fusarium* pathogen in untreated conditions. Hidayat et al., (2021), explained that *Fusarium* is an important pathogen that causes a decline in crop productivity if not effectively controlled. In contrast, the *Fusarium* endophyte treatment (T3), *Octave* (T7), and negative control (T1) did not show any symptoms or seedling mortality during the observation period.

Control Effectiveness

The effectiveness of *Fusarium* control in acacia seedlings showed significant differences between treatments. Based on Table 4, the *Fusarium endophyte* treatment (T3) and *Octave* fungicide treatment (T7) showed the highest effectiveness, each with 100% no seedling mortality during the observation period. Merivon (T6) showed high effectiveness at 86%, followed by *Trichoderma* (T4) at 57% and DSE (T5) at 43%, while the positive control had the highest mortality rate at 58.33%.

Table 4. Effectiveness of *Fusarium* Control in Acacia Seedlings

Treatment	Effectiveness (%)	Pathogenic *Fusarium* Spore Density (conidia/mL)	Density of Biological Agent Spores (conidia/mL)
T3	100[a]	8,625 x 10^6	14,525 x 10^6
T7	100[a]	8,625 x 10^6	0,0
T6	86[ab]	8,625 x 10^6	0,0
T4	57[bc]	8,625 x 10^6	1,265 x 10^6
T5	43[c]	8,625 x 10^6	0,7 x 10^6

Information: Data transformed into Arcsin$\frac{\sqrt{y+0,5}}{100}$. Effectiveness compared to positive control (58.33%). Treatments T6 and T7 were treatments using fungicides.

Based on Table 4, the high effectiveness of *Fusarium endophytes* is due to their ability to compete with pathogens through antagonistic mechanisms. Suswanto & Ramadhan (2022) antagonistic mechanisms such as competition for space and nutrients and colonization of plant root tissues. The suspension of *Fusarium endophytes* spores with a density of 14.525 x 10^6 conidia/mL is almost double that of the pathogen, thus proving to be optimal for accelerating root tissue colonization and strengthening microbial competitiveness against pathogens. Nurani et al., (2018) High spore density increases the effectiveness of biological agents in controlling Fusarium through colonization and competitiveness .

Octave fungicide, which contains the active ingredient *prochloraz*, works by inhibiting the formation of important parts of the fungal cell wall. Application of *Octave* fungicide with the active ingredient *prochloraz* significantly reduces the intensity of diseases caused by *Fusarium* (Sundari et al., 2023). Meanwhile, Merivon fungicide, with the active ingredients *fluxapyroxad* and *pyraclostrobin*, works well as an inhibitor of fungal growth while also strengthening the plant's physiological resistance system. The use of synthetic fungicides can suppress the development of *Fusarium* that attacks plants (Aji & Rohmawati, 2020).

The biological agent *Trichoderma* also showed fairly good control efficacy at 57%, even when inoculated at a spore density of 1.265 x 10^6 conidia/mL. Its antagonistic mechanisms, which include parasitism, antibiosis, and pathogen lysis, support this efficacy (Karim et al., 2020). In contrast, the DSE treatment, which had a spore density of 0.7 x 10^6 conidia/mL, showed the lowest effectiveness due to slow colonization.

CONCLUSION

The conclusion drawn from this study is that biological agents and fungicides are effective in inhibiting the growth of *Fusarium* pathogens. Treatment with *Fusarium endophytes* and *Octave* fungicide produced the most effective results, with 100% control efficacy. The fungicide Merivon showed an effectiveness of 86%, while the biological agents *Trichoderma* (57%) and DSE (43%) were less effective.

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REFERENCES

Adiwena, M., Siswanto, A., & Ngau, M. (2022). Pathogenic Fungi on Large Chili Plants in Border Areas. *Jurnal Ilmiah Respati*, *13*(2), 126–132. https://doi.org/10.52643/jir.v13i2.2463

Aji, O. R., & Rohmawati, Y. (2020). In vitro Antifungal Activity of *Morinda citrifolia* Leaves Extract Against *Fusarium oxysporum*. *Indonesian Journal of Biotechnology and Biodiversity*, *4*(1), 20–26. https://doi.org/https://doi.org/10.47007/ijobb.v4i1.51

Azmi, F., Chatri, M., Advinda, L., & Irdawati. (2021). Effect of Rambutan Leaf Extract (*Nepheliumlappaceum* L.) on Colony Diameter and Percentage of Growth of Inhibition *Fusarium oxysporum*. *Serambi Biologi*, *6*(1), 7–11. https://ejournal.unp.ac.id/students/index.php/bio/index

de Lamo, F. J., & Takken, F. L. W. (2020). Biocontrol by *Fusarium oxysporum* Using Endophyte-Mediated Resistance. *Frontiers in Plants Science*, *11*, 1–15. https://doi.org/10.3389/fpls.2020.00037

Fardani, C., Lisnawita, & Siregar, L. A. M. (2024). Potential of *Dark Septate Endophytes* North Sumatra Isolates Against *Ganoderma boninense* the Pathogen of Basal Stem Rot of Oil Palm. *Jurnal Fitopatologi Indonesia*, *20*(3), 154–164. https://doi.org/10.14692/jfi.20.3.154

Firmansyah, M. A., Surono, & Wulan Fitri, S. (2024). The Potential of *Dark Septate Endophyte* Fungi as a Biological Control of Teak Leaf Blight Pathogen in Vitro Muhammad. *Jurnal Silvikultur Tropika*, *15*(03), 293–299. https://doi.org/https://doi.org/10.29244/j-siltrop.15.03.293-299

Fitriani, M. L., Wiyono, S., & Sinaga, M. S. (2019). Colonization Potential of Arbuscular Mycorrhiza and Endophytic Fungi and Its Effectiveness in Control *Fusarium* Wilt on Shallot. *Jurnal Fitopatologi Indonesia*, *15*(6), 228–238. https://doi.org/10.14692/jfi.15.6.

Hakim, L., Kurniatuhadi, R., & Rahmawati. (2020). Physiological Characteristics of Halophilik Fungi Based On Enviromental Factors of Salt Water Well In Suak Village, Sintang, West Kalimantan. *Jurnal Biologi Makassar*, *5*(2), 227–232. https://doi.org/https://doi.org/10.20956/bioma.v5i2.11299

Heriyanto. (2019). Study On The Control of *Fusarium oxysporum* Wilt Disease With *Trichoderma* sp. in Chili Plants. *Jurnal Ilmu-Ilmu Pertanian*, *26*(2), 26–35. https://doi.org/https://doi.org/10.55259/jiip.v26i2.99

Hidayat, N., Rajab, A., & Mudi, L. (2021). Invitro Testing of Endophytic Fungi From Rambusa Plant (*Passiflora foetida*) As a Biological Control Agents of *Fusarium* Wilt. *Jurnal Agrotech*, *11*(2), 64–70. https://doi.org/https://doi.org/10.31970/agrotech.v11i2.73

Ihkwanisa, N., Nugraheni, I. A., Kurniawati, T., & Fardhani, D. M. (2023). Antagonistic test of *Trichoderma* spp against *Fusarium* wilt in chili plants (*Capsicum annum*). *Proceeding of Seminar Nasional Penelitian Dan Pengabdian Kepada Masyarakat*, *1*, 244–252. https://proceeding.unisayogya.ac.id/index.php/prosemnaslppm/article/view/56

Irfandri, Silvina, F., & Ramadhoni, R. (2025). Incidence of Fusarium Wilt Disease (*Fusarium oxysporum f.sp. cepae*) in Shallot-Growing Areas of Riau Province. *Jurnal Agrikultura*, *36*(2), 243–251. https://doi.org/https://doi.org/10.24198/agrikultura.v36i2.62767

Kahfi, A. N., & Umra. (2018). Modeling Taper Equations to Estimate the Volume of Krasikarpa (*Acacia crassicarpa A. Cunn. Ex. Benth*) Logs in Peat Areas at PT. Bumi Mekar Hijau. *Sylva*, *7*(1), 22–29. https://doi.org/https://doi.org/10.32502/sylva.v7i1.1081

Karim, A., Rahmiati, & Fauziah, I. (2020). Isolation and Antagonist Testing of *Trichoderma* Against *Fusarium oxysporum* In Vitro. *Jurnal Biosains*, *6*(1), 18–22. https://doi.org/https://doi.org/10.24114/jbio.v6i1.16839

Khulillah, I. N., Abadi, A. L., & Aini, L. Q. (2019). The Effect of Fungicide on Diversity of Soil Bacteria in Batu City. *Jurnal Tanah Dan Sumberdaya Lahan*, *6*(2), 1209–1218. https://doi.org/10.21776/ub.jtsl.2019.006.2.1

Kusuma, A. B., Wadjdi, F. M., & Puspitarini, O. R. (2023). The Carrying Capacity of Acacia Trees (*Acacia crassicarpa*) of Different Ages as a Source of Food for Apis mellifera Bees in Tanjung Jabung, Jambi Province. *Jurnal Dinamika Rekasatwa*, *6*(2), 243–248. https://jim.unisma.ac.id/index.php/fapet/article/view/20110

Libertus, F. G., & Diba, F. (2020). Termite Attack Study on Acacia (*Acacia crassicarpa*) Plants in HTI land of PT Muara Sungai Landak Mempawah Districts. *Jurnal Hutan Lestari*, *8*(1), 211–216. https://doi.org/https://doi.org/10.26418/jhl.v8i1.39396

Mateu, M. G., Baldwin, A. H., Maul, J. E., & Yarwood, S. A. (2020). *Dark Septate Endophyte* Improves Salt Tolerance of Native and Invasive Lineages of Phragmites australis. *The ISME Journal*, *14*(8), 1943–1954. https://doi.org/https://doi.org/10.1038/s41396-020-0654-y

Meutia, C., Ulim, A., & Chamzurni, T. (2017). The Effectiveness of Multiple Endophytic Fungi to Suppress *Fusarium oxysporum* Attack on Banana Seedling

(*Musa paradisiaca*). *Jurnal Ilmiah Mahasiswa Pertanian Unsyiah*, *2*(3), 12–21. https://jim.usk.ac.id/JFP/article/view/4173/6578

Nurani, A. R., Sudiarta, I. P., & Darmiati, N. N. (2018). Testing the Effectiveness of *Beauveria bassiana Bals*. Fungus against Grayak Caterpillars (*Spodoptera litura* F.) on Tobacco Plants. *E-Jurnal Agroeteknologi Tropika*, *7*(1), 11–23. https://ojs.unud.ac.id/index.php/jat/article/view/38256

Satrah, V. I. T. N., Asdar, Khaeruni, A., Bande, L. O. S., Rahman, A., Ulfa, N. I., & Ariyanti, E. L. (2023). Biological control of *Fusarium* wilt disease in tomato plants (*Solanum lycopersicum* L.) using endophytic bacteria from wild plants. *Jurnal Agroteknos*, *13*(3), 107–113. http://ojs.uho.ac.id/index.php/agroteknos

Sopialena, Suyadi, Sofian, Tantani, D., & Azizi Nur, F. (2020). Effectiveness of Endophytic Fungi as a Control for Blast Disease in Rice Plants (*Oryza sativa*). *Jurnal Agrifor*, *19*(2), 355–366. https://doi.org/10.31293/af.v19i2.4813

Subasari, A., Efri, Wibowo, L., & Titik Nur, A. (2025). Characteristics and Antagonist Test of Some *Trichoderma* Isolates Against The Cause of Wild Disease (*Fusarium oxysporum*) On Tomatoes (*Lycopersicum esculentum* Mill). *Jurnal Agrotek Tropika*, *13*(1), 240–245. https://doi.org/http://dx.doi.org/10.23960/jat.v13i1.8719

Sundari, D., Wibowo, A., Joko, T., Widiastuti, A., & Arlyna Budi, P. (2023). Diversity of Shallot Rhizomicrobiome and Twisted Disease Suppression with The Application of *Bacillus* spp . and *Trichoderma* asperellum. *Jurnal Fitopatologi Indonesia*, *19*(4), 156–165. https://doi.org/10.14692/jfi.19.4.156 **[*In Indonesian language*]**

Susanti, A., Afifah, N., & Febrianti, R. (2021). Suppression of Endophytic Fungi Against Pathogens in Sweet Gondang Guava Plants. *Jurnal Viabel Pertanian*, *15*(1), 1–15. http://ejournal.unisbablitar.ac.id/index.php/viabel%0AAmbar

Suswanto, I., & Ramadhan, T. H. (2022). Using of some endophyte fungies to suppresed wilting disease on ginger (*Zingiber officinale Rosc.*) in peatsoil. *Jurnal Agrotek UMMAT*, *9*(1), 43–50. https://doi.org/10.31764/jau.v9i1.6894

Syarifah, S. M., Ofivah Permata, S., & Bimantara, A. (2024). Pathogen Biological Control of *Fusarium oxysporum f.* sp. capsica using Isolated *Trichoderma* sp. of Bamboo Rhizosphere from Kedu District, Temanggung Regency. *Jurnal Ilmu Pertanian Indonesia (JIPI)*, *29*(3), 454–460. https://doi.org/10.18343/jipi.29.3.454

Tarigan, R. Y., Mayasari, U., & Nasution, R. A. (2024). Testing The Activity of Cat Tail Leaves Acalypha Hispida Essential Oil As a Natural Fungicide Against *Sclerotium rolfsii* and *Fusarium oxysporum* In-Vitro. *Jurnal Biologi Makassar*, *9*(1), 97–104. https://journal.unhas.ac.id/index.php/bioma

Triwidodo, H., & Tanjung, M. H. (2020). Shallot (*Allium Ascalonicum*) Pests and Its Control Measures in Brebes, Central Java. *Jurnal Agroekoteknologi*, *13*(2), 149–154. https://doi.org/https://doi.org/10.21107/agrovigor.v13i2.7131

Ulya, H., Darmanti, S., & Rejeki Siti, F. (2020). Leaf Growth of Chili Plants (*Capsicum annuum* L.) Infected with *Fusarium oxysporum* at Different Plant Ages. *Jurnal Akademika Biologi*, *9*(1), 1–6. https://ejournal3.undip.ac.id/index.php/biologi/article/view/27739

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