



# Differences in the Percentage of Fusarium Wilt Disease Attacks and High Vegetative Growth of Purple Eggplant (*Solanum melongena* L.) Plants with Various Concentrations of Antagonist Fungus *Trichoderma harzianum*

Ketut Srie Marhaeni Julyasih <sup>1\*</sup>, I Putu Parwata <sup>2</sup>, Ni Putu Dian Pertiwi <sup>1</sup>

<sup>1</sup> Program Studi Biologi, Jurusan Biologi dan Perikanan Kelautan, FMIPA Universitas Pendidikan Ganesha, Singaraja -Bali, Indonesia.

<sup>2</sup> Program Studi Kimia, Jurusan Kimia, FMIPA Universitas Pendidikan Ganesha, Singaraja-Bali, Indonesia.

Received: June 17, 2025

Revised: July 10, 2025

Accepted: August 25, 2025

Published: August 31, 2025

Corresponding Author:

Ketut Srie Marhaeni Julyasih

[srie.marhaeni@undiksha.ac.id](mailto:srie.marhaeni@undiksha.ac.id)

DOI: [10.29303/jppipa.v11i8.12090](https://doi.org/10.29303/jppipa.v11i8.12090)

© 2025 The Authors. This open access article is distributed under a (CC-BY License)



**Abstract:** Microorganisms that have antagonistic properties against pathogens are an alternative as a material for control, such as *Trichoderma* sp. The use of biological agents has the potential to control plant diseases safely and environmentally friendly, *Trichoderma* sp is a fungus that can be a biocontrol agent because it is antagonistic to other fungi. *Trichoderma* sp is a fungus whose habitat is in the soil, including the Ascomycetes class which has green spores. This fungus has the potential for degradation of various heterogeneous substrates in the soil, positive interactions with the host, producing enzymes to improve plant nutrition. Until now, there has not been much research conducted on the competence of *Trichoderma* sp. isolates in inhibiting the development of Fusarium wilt disease. The purpose of this study was to test the difference in the percentage of Fusarium wilt disease attacks on eggplant plants and plant vegetative growth due to the provision of variations in the concentration of *Trichoderma* sp. The type of research conducted was a true experimental, with the research design used was a Completely Randomized Design using 6 treatments, namely with the treatment of *Trichoderma* sp. isolate concentration. grown on rice media with concentrations of 0%, 10%, 20%, 30% 40%, and 50%, each treatment was repeated 5 times so that there were 30 experimental units. The variables observed in this study were the differences in the percentage of Fusarium Wilt disease attacks and the high vegetative growth of purple eggplant plants. The data obtained were analyzed using the analysis of variance of the ANOVA test with a level of 5%. If there is a significant difference, it is continued with the Duncan test at a level of 5%. The results showed that there was a significant difference in the variation of *T. harzianum* concentration on the percentage of Fusarium wilt disease attacks, and the high growth of purple eggplant plants.

**Keywords:** Eggplant; Fusarium; *Trichoderma* sp; Wilt disease.

## Introduction

Eggplant plants (*Solanum melongena* L) is a vegetable plant that belongs to the Solanaceae family, is

plant vegetables important to four in the world after potatoes, tomatoes, and cucumbers. China is center production eggplant the world's largest, namely yielded 48% while production eggplant in India is 32% and

### How to Cite:

Julyasih, K. S. M., Parwata, I. P., & Pertiwi, N. P. D. (2025). Differences in the Percentage of Fusarium Wilt Disease Attacks and High Vegetative Growth of Purple Eggplant (*Solanum melongena* L.) Plants with Various Concentrations of Antagonist Fungus *Trichoderma harzianum*. *Jurnal Penelitian Pendidikan IPA*, 11(8), 153-160. <https://doi.org/10.29303/jppipa.v11i8.12090>

Indonesia is only by 10% of production world eggplant. Plants eggplant is one of product plant horticulture that has Lots spread across Indonesia. There are a number of type eggplant in Indonesia namely eggplant gelatik, eggplant kopek, eggplant eggplant, eggplant Japan, eggplant field, and eggplant bogor (Antaboga & Ervina, 2016).

Economic value eggplant Enough high, production eggplant not only for consumed public in the country itself (domestic) but already become commodity export. Form products that have been penetrate the export market is eggplant pickles that have been exported to Japan. Eggplant is also exported in preserved form, especially the purple eggplant type (Hartati et al., 2020). Eggplant is a type of vegetable that is known to have a very high nutritional content, namely vitamin A, vitamin B, vitamin C, potassium, phosphorus, iron, protein, fat, and carbohydrates (Hamidson et al., 2023).

The demand for eggplant continues to increase in line with population growth, so eggplant production needs to be continuously increased. Eggplant production in Bali Province from 2020 to 2022 tends to decrease. In 2020 the result was 2,928 tons, in 2021 the production result was 1,560 tons, and in 2022 the eggplant production result only reached 1,193 tons (BPS, 2022).

The important obstacle in effort improvement productivity eggplant namely, pests and diseases that attack plant eggplant, condition less climate support, less land fertile, and action under cultivation good (Arsi et al., 2021). Organism the bully plants that can lower and even to thwart harvest like pathogen mold *Fusarium oxysporum.*, *Fusarium solani* and *Sclerotinia sclerotiorum* which cause disease wilting in plants eggplant. Disease withered *Fusarium* show typical signs and symptoms. The symptoms marked with plant become wilted, started from leaf part down and child bone leaf yellow (Poveda et al., 2020).

Control efforts has lots done by farmers with method watering with pesticide synthetic, but not yet give satisfactory results and expensive costs (Matthews et al., 2014). The government has emit policy in protection plant with apply technique Integrated Pest Management For control disturbance Organism The Disturber Plants (OPT) are prioritized For utilise agent control friendly environment. and use pesticide chemistry in a way wise that is as alternative final with dose in accordance needs.

Microorganisms that have characteristic antagonist to pathogen is alternative as material for control, such as mold *Trichoderma* sp. has characteristic antagonist to Microorganism pathogen (Boro et al., 2022; Joo & Hussein, 2022; Ren et al., 2020; Tyśkiewicz et al., 2022), as used for control disease plants and give results

positive for cultivated but until moment this not yet. There is resistant varieties to disease fusarium wilt. Utilization agent biological potential in control disease safe and friendly plants environment (Gupta et al., 2020; Kumar et al., 2017).

Research purposes is test difference percentage attack disease Fusarium wilt in plants eggplant and growth vegetative plant consequence giving variation concentration mold antagonist *Trichoderma harzianum*.

**Method**

This research was conducted in a *Green house* UPTD. Center for the Protection of Food Crops, Horticulture, and Plantations (BPTPHBUN). Biological Agents Pesticides Laboratory Biaung, Bali, Tegal Harum Street, Sakura Alley, Biaung, East Denpasar District, Denpasar City, Bali. The research was conducted from May 2024 to November 2024.

*Materials and tools*

Tools and Materials Materials used is 70% alcohol, specimen plant eggplant affected disease Fusarium wilt, specimen plant eggplant in good condition healthy, cotton, distilled water sterile, alcohol, Potato Dextrose Agar (PDA) media, plastic wrap, and sterile tissue, Tools used in study. This is petri dish, microscope, tweezers, scalpel, scales analytics, bottle Scott, beaker glass, object glass, cover glass, needle, camera, tools write, autoclave, incubator, bunsen, oven, magnetic stirrer, hotplate, cloth black and laminar air flow.

*Research methods*

The type of research conducted is true experimental, with the research design used is a Completely Randomized Design using 6 treatments, namely with isolate concentration treatments consisting of 0%, 10%, 20%, 30% 40%, and 50%, each treatment was repeated 5 times so that there were 30 experimental units. The treatments are:

**Table 1.** Variation of isolate concentration

Variation	Isolate Concentration %
I	0
II	10
III	20
IV	30
V	40
VI	50

*Research Implementation*

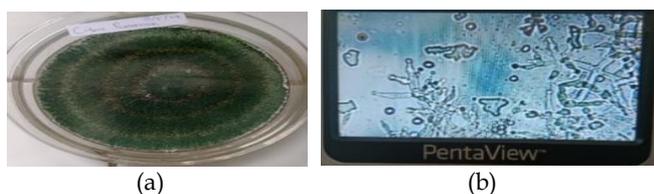
*Exploration and Isolation of Fusarium sp. Fungus*

Exploration carried out on land plant eggplant in the area Bedulu Gianyar. Plant eggplant that has symptom Fusarium wilt was taken and carried out

isolation network Plants. Network plants used is part base stem plant eggplant. Base the stem used 1 - 1.5 cm in size and split into two parts. After That done sterilization tiered with using 76% alcohol for 30 seconds and soaked to distilled water sterile for 1 minute with repeated twice and dried air it out with using sterile tissue. Specimens that have been dry can planted in PDA (Potato Dextrose Agar) media. Activities the done repetition as much as three times and incubated for 4 - 7 days. If hyphae Already appear can done observation moreover formerly with use microscope for ensure that growing mushrooms is mold *Fusarium* sp. If the fungus the show morphology mold *Fusarium* sp. then done purification mushrooms to avoid from contaminants other microbes.

*Variation test concentration T. harzianum to percentage attack disease withered Fusarium sp. fungus*

Application variation concentration isolate *T. harzianum* in a way direct to plant eggplant to know concentration effective *T. harzianum* inhibit and can reduce percentage attack mold *Fusarium* sp. causes disease withered plant eggplant. Research carried out in a greenhouse with plant seed eggplant in polybags that have been filled with land compost. After plant 3 weeks old inoculated with isolate *Fusarium* with 10% concentration per polybag. Application mold antagonist *T. harzianum* done a week after inoculation mold *Fusarium* sp. Observation percentage attack disease and growth vegetative plant done 4 weeks after application *T. harzianum* in accordance treatment or after plant 8 weeks old. Isolate mold *T. harzianum* presented in Figure 1.



**Figure 1.** Morphology mold *T. harzianum*: (a) Morphology mold *T. harzianum* in a way macroscopic; (b) *T. harzianum* 400x magnification

Percentage attack disease counted with use Formula 1.

$$P = \frac{N}{v} \times 100\% \tag{1}$$

Information:

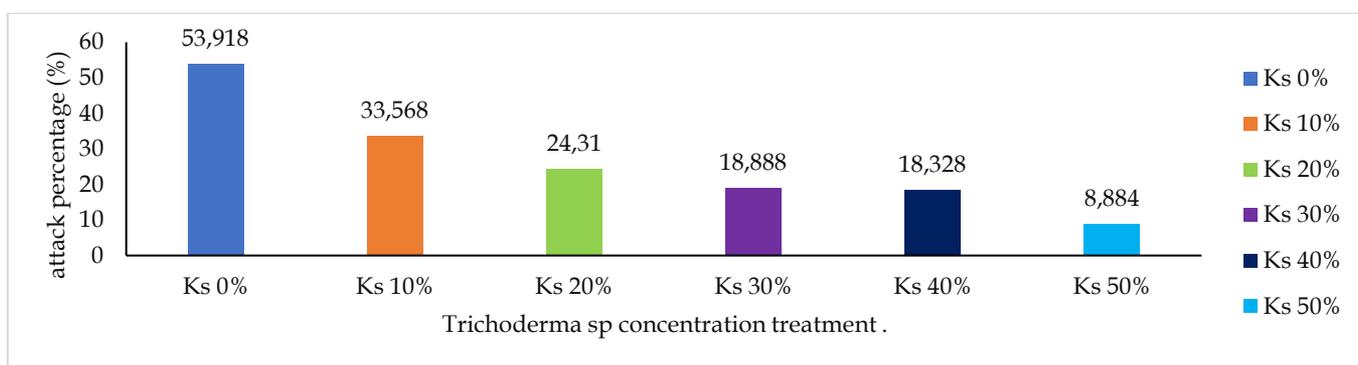
- Q: Percentage Attack (%)
- n : Amount infected leaves
- N : Total amount observed leaves

Data obtained analyzed with use one way test variance analysis anova, if there is difference significant among treatment further testing was carried out with Duncan's test at the 5% level.

**Results and Discussion**

*Percentage Attack Disease Fusarium Wilt in Plants Purple eggplant (Solanum mangolena L) with application variation concentration mold T. harzianum*

Average percentage attack disease withered *Fusarium* in applications *T. harzianum* after 4 (four) weeks application obtained results percentage attack disease highest on control (application *T.harzianum* 0%), which is 53.918± 6.939%. Percentage attack disease withered *Fusarium* lowest contained in the application *T. harzianum* concentration 50%, with average percentage attack 8.884 ± 9.294%, then concentration *T. harzianum*. 40% shows percentage attack 18. 328 ± 6.695 %, application *T. harzianum* 30% concentration indicates average percentage attacks 18,888 ± 5,940%, application *T.harzianum* 20% resulted in percentage attacks 24,310 ± 7,798 %, application 10% concentration indicates percentage attack disease withered of 33.5680 ± 8.597%. More details presented in the histogram of Figure 2.



**Figure 2.** Percentage Attack Disease Withered *Fusarium* with application variation concentration mold antagonist *T. harzianum*

Normality test results treatment variation concentration mold *T. harzianum* with using the Shapiro Wilk test obtained results significance each treatment more than 0.05 ( $p > 0.05$ ) this means the data is normally distributed, because all mark significance bigger than 0.05.

Based on homogeneity test results using Levene's test obtained results significance 0.837 This is means  $p > 0.05$ , with thus data variant is homogeneous. After the data is normally distributed and homogeneous, then to be continued with one way test anova to know whether there is difference meaning in between treatment concentration *T. harzianum* to disease Fusarium wilt significance test results one-way anova show p value =0.000, this means  $p < 0.05$ . This is means there is difference meaning in between treatment to percentage attack disease Fusarium wilt sp. to know the difference between treatment Further multiple comparison testing was carried out using the Duncan test (Table 2).

**Table 2.** Multiple comparison test results a number of treatment variation concentration mold antagonist *T. harzianum* to percentage attack disease Fusarium wilt sp.

Treatment	Average disease attack (%)
Ks 0% (Control)	53.918 ±16.733 a
Ks 10%	33.568 ± 8.597 b
Ks 20%	24.310 ± 7.798 bc
Ks 30%	18.888 ±16.733 cd
Ks 40%)	18.328 ±20.000 cd
Ks 50%	8.884 ± 9.294 d

Note: Average values accompanied by the same letter indicate no significant difference, significant at the Duncan test level of 5%

Percentage attack disease highest Fusarium wilt contained in the control (without application *Trichoderma* sp.) fungus with average attack 53.9180 ±16.733 % and different meaningful with treatment variation application concentration *T. harzianum* Percentage attack disease withered consequence lowest Fusarium fungus contained in the treatment application mold antagonist as much as 50% with average attacks 8.884 ± 9.294%. This is due to mold *T. harzianum* have ability in hinder development a pathogen covering competition for source power, parasitism, production compound antibacterial, and lysis pathogenic cells. More details condition attack disease withered Fusarium of plants eggplant with application various concentration *T. harzianum* presented in Figure 3.

Biocontrol agent mold from the genus *Trichoderma* is effective for control pathogens. Some mechanism antagonistic for hinder development pathogen applied by *T. harzianum* covering competition for source power, parasitism, production compound antibacterial, and

lysis cell pathogen (Akter, 2025; Mustofa & Hastuti, 2024). In addition ability the *T.harzianum* also produces enzymes, antibiotics, and toxins that are capable of press growth of pathogens, even can kill pathogens and organisms disease contagious soil (OPT). Biofungicide *T. harzianum* contain a number of type enzyme such as 1,3-β-glucanase, chitinase, protease, cellulase, and cellobiase, have role important in control plant disease (Asmi et al., 2023; Panicker & Sayyed, 2022).



**Figure 3.** Percentage Attack Disease *F. oxysporum* on plants eggplant purple with application various concentration *T. harzianum*

Antagonistic mechanism *T. harzianum* to pathogen land can through three method that is produce enzyme extracellular beta (1,3) gluconase and chitinase which can dissolve wall cell pathogens, producing trichodermin toxin which can poison propagul pathogen plant in the area rhizosphere and produces antibiotics gliotoxin and viridin are produced mold *Trichoderma viridae* (Akrami & Yousefi, 2015; Nasrin et al., 2018).

*Trichoderma* sp. fungus is nature mycoparasites and antiVbiosis against pathogen, easy bred as well as easy adapt to various substrate, growing fast and very tolerant to change weather. Then *Trichoderma* also functions as competitor in utilise room, time and nutrition so that capable press activity pathogen contagious land. The ability of each species *Trichoderma* sp. in control fungus pathogen different different matter This due to morphology and physiology are also different, species from *Trichoderma harzianum*, *Trichoderma viridae* and *Trichoderma koningii* which have been utilized as biopesticides and spread wide in various type land plant food, vegetables and plantations show very effective results control pathogen contagious

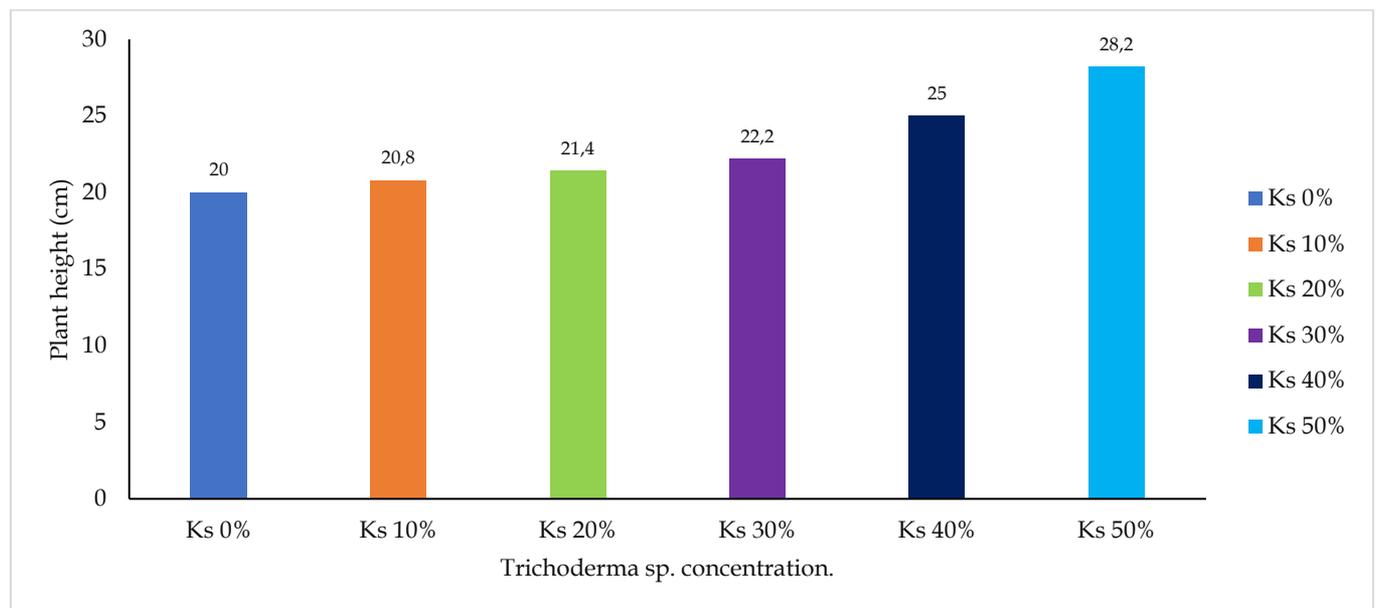
land (Anjum et al., 2020; Jamil et al., 2021; Yanti et al., 2025).

Decrease average percentage attack disease *Fusarium* wilt in plants eggplant purple compared to backwards with improvement concentration *T. harzianum* given to each treatment. This is because of content in each concentration *T. harzianum* used and applied influential significant to percentage attack disease caused by the pathogen *F. oxysporum* (Akter, 2025). The more tall concentration *T. harzianum* is used so content material bioactive compounds in *T. harzianum* the more lots or high on each treatment different (Li et al., 2018; Sallam et al., 2019) Novita et al., 2021).

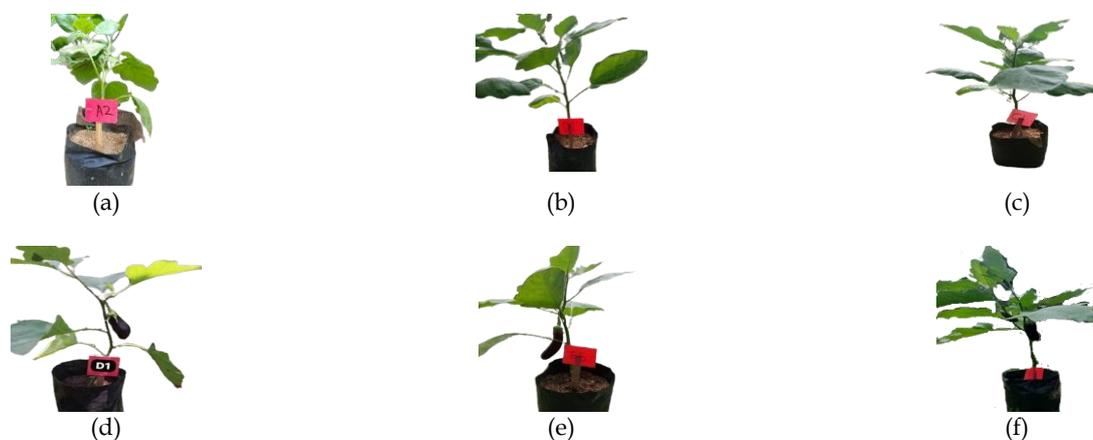
**Growth High Vegetative Plant Purple Eggplant**

Results of analysis of the vegetative growth of purple eggplant plants after 4 (four) weeks of

*T.harzianum* application obtained the average height of purple eggplant plants in the application of *T. harzianum* with a concentration of 50%, namely  $28,200 \pm 0.836$  cm, showing the highest plant height results, then the treatment of *T. harzianum* concentration of 40% obtained a plant height of  $25,000 \pm 0.797$  cm, a concentration of 30% with an average height of  $22,200 \pm 1.483$  cm, a concentration of 20% with an average plant height of  $21,400 \pm 1.483$  cm, a concentration of 10% with an average plant height of  $20,800 \pm 1.303$  cm. While the average plant height in the application of *Trichoderma* sp. with a concentration of 0%, namely  $20,000 \pm 1,000$  cm (Figure 4). Plant conditions after 3 months, shows ability flowering and fruiting under treatment concentration 30% to with 50% *T.harzianum* as in Figure 5.



**Figure 4.** Average Growth High Vegetative Plant Purple Eggplant after application mold *Fusarium* reason disease wilt and fungus antagonist *T. harzianum*



**Figure 5.** Plant conditions eggplant that is capable bear fruit after 3 months old during treatment concentration *T.harzianum*: (a) 0% (control); (b) 10%; (c) 20%; (d) 30%; (e) 40%; and (f) 50%

Normality test results to tall plant eggplant show  $p$  value  $> 0.05$ , this means the data is normally distributed. Based on homogeneity test results using Levene's test obtained results significance 0.254. This is means  $p > 0.05$ , with thus data variant is homogeneous.

Significance test results one-way anova show  $p$  value = 0.000, meaning  $p < 0.05$ . This is show there is difference meaning in between treatment to tall plant eggplant to know the difference between treatment Further multiple comparison testing was carried out using the Duncan test (Table 3).

**Table 3.** Multiple comparison test results tall plant eggplant with *Fusarium* sp. application and variation concentration mold antagonist *T. harzianum*

Treatment	Average plant height (cm)
Ks 0% (Control)	20.000 ± 1.000 a
Ks 10%	20.800 ± 1.303 ab
Ks 20%	21.400 ± 1.483 ab
Ks 30%	22.200 ± 1.483 b
Ks 40%)	25.000 ± 0.797 c
Ks 50%	28.200 ± 0.836 d

Note: Average values accompanied by the same letter indicate no significant difference, significant at the Duncan test level of 5%

Analysis results statistics to tall plant eggplant obtained results on the application mold antagonist 50% shows different in a way meaningful with treatment others, and lowest in control with tall average plant height 20,000 ± 1,000 cm. Growth and yield plant eggplant purple naturally need nutrients as the nutrients needed plants, besides Plant nutrients also need water. In addition fertility land become factor important support for be noted. Giving mold *Trichoderma* sp. on plants besides play a role in produce antifungal compounds as controller biological to mold or pathogens, also have role in availability nutrients for plant.

The occurrence difference growth vegetative tall plant eggplant in each treatment variation concentration *Trichoderma* sp. possibly due to availability nutrition for growth and development plant eggplant the different. *Trichoderma* sp. besides play a role as trigger growth Plants can also play a role in to describe nutrients such as N and P are needed in growth plants (Novita et al., 2021). Nitrogen is needed plant for stimulate growth and provide color green on the leaves (Yang et al., 2003). Fungus *Trichoderma* sp. can break material organic contained in compound complex so that nitrogen can available for plants, and growth vegetative plant runs optimally if nitrogen is functioning in help growth plant like formation of new shoots and leaves new needed

plant can available and can absorbed by plants (Sepwanti et al., 2016).

## Conclusion

There is difference in a way significant ( $p > 0.05$ ) against percentage attack disease *Fusarium* and growth vegetative tall plant eggplant purple consequence giving variation concentration mold *T. harzianum* with percentage attack highest located on the control with an average average highest on control namely 53.918 ± 6.939 % and lowest in concentration *T. harzianum* 50%, namely 8,884 ± 9,294 %. Average tall plant highest found in concentration *T. harzianum* 50 % , namely 28,200 ± 0.836 cm and the lowest in the control that is 20,000 ± 1,000 cm.

## Acknowledgment

Thank you we convey our love to Ganesha University of Education which has provide research funding Basic Research Group in 2024 through the DIPA BLU Fund of Ganesha University of Education with number contract 1328/UN48.16/LT/2024.

## Authors Contribution

This article was compiled by three authors who worked together to carry out each stage, namely K.S. M. J., I. P. P., and N. P. D. P.

## Funding

This research funding by Basic Research Group in 2024 through the DIPA BLU Fund of Ganesha University of Education with number contract 1328/UN48.16/LT/2024.

## Conflicts of Interest

Authors declare no conflicts interest in this paper.

## References

- Akrami, M., & Yousefi, Z. (2015). Biological control of *Fusarium* wilt of tomato (*Solanum lycopersicum*) by *Trichoderma* spp. as antagonist fungi. *Biological Forum-An International Journal*, 7(1), 887. Retrieved from <https://shorturl.asia/p5Llh>
- Akter, M. (2025). *Association of fungi with targets Spp. and their management* [Thesis: University of Dhaka]. Retrieved from <https://shorturl.asia/PGDbo>
- Anjum, N., Shahid, A. A., Iftikhar, S., Mubeen, M., Ahmad, M. H., Jamil, Y., Rehan, M. K., Aziz, A., Iqbal, S., & Abbas, A. (2020). Evaluations of *Trichoderma* isolates for biological control of *Fusarium* wilt of chili. *Plant Cell Biotechnology and Molecular Biology*, 21(59–60), 42. Retrieved from <https://shorturl.asia/anITC>
- Antaboga, L. V., & Ervina, O. (2016). Pengaruh Umur Bibit Pindah Tanam dan Macam Pupuk Daun Terhadap Pertumbuhan dan Hasil Tanaman

- Terong (*Solanum Melongena* L.). *Jurnal Ilmu Pertanian Tropika Dan Subtropika*, 1, 12–22. Retrieved from <https://shorturl.asia/srYvQ>
- Arsi, A., Abdindra, G. G., Kusuma, S. S. H., & Gunawan, B. (2021). Pengaruh teknik budidaya terhadap serangan penyakit pada tanaman terung ronggo (*Solanum melongena*) di Desa Gunung Cahya Kecamatan Buay Rawan, Kabupaten Ogan Komering Ulu Selatan. *Journal Plantasimbiosa*, 3(2), 27–39. Retrieved from <https://jurnal.polinela.ac.id/jps/article/view/2263>
- Asmi, M. J., Rizali, A., & Wahdah, R. (2023). Uji Ganda 3 Jenis *Trichoderma* terhadap Penyebab Layu Fusarium (*Fusarium oxysporum*) pada Tanaman Bawang Merah (*Allium ascalonicum* L.) secara In Vitro. *Agroekotek View*, 5(1), 36–48. <https://doi.org/10.20527/agtview.v5i1.4360>
- Boro, M., Sannyasi, S., Chettri, D., & Verma, A. K. (2022). Microorganisms in biological control strategies to manage microbial plant pathogens: a review. *Archives of Microbiology*, 204(11), 666. <https://doi.org/10.1007/s00203-022-03279-w>
- Gupta, P. K., Singh, S. K., & Shikha, S. (2020). In vitro efficacy of different fungicides against *Fusarium solani* isolate causing root rot of papaya (*Carica papaya* L.). *Inter. J. Chem. Studies*, 8(3), 221–224. <https://doi.org/10.22271/chemi.2020.v8.i3c.9229>
- Hamidson, H., Adrian, R., Umayah, A., & Gunawan, B. (2023). Insidensi dan Identifikasi Penyakit Layu pada Terong (*Solanum melongena* L.) di Desa Tanjung Pering, Kabupaten Ogan Ilir, Provinsi Sumatera Selatan. *Seminar Nasional Lahan Suboptimal*, 10(1), 963–973. Retrieved from <https://conference.unsri.ac.id/index.php/lahansuboptimal/article/view/2556>
- Hartati, H., Azmin, N., Nasir, M., Bakhtiar, B., & Nehru, N. (2020). Penggunaan Media Tanam Hidroponik Terhadap Produktivitas Pertumbuhan Tanaman Terong (*Solanum melongena*). *Oryza: Jurnal Pendidikan Biologi*, 9(2), 14–20. <https://doi.org/10.33627/oz.v9i2.381>
- Jamil, A., Musheer, N., & Ashraf, S. (2021). Antagonistic potential of *Trichoderma harzianum* and *Azadirachta indica* against *Fusarium oxysporum* f. sp. *capsici* for the management of chilli wilt. *Journal of Plant Diseases and Protection*, 128(1), 161–172. <https://doi.org/10.1007/s41348-020-00383-1>
- Joo, J. H., & Hussein, K. A. (2022). Biological control and plant growth promotion properties of volatile organic compound-producing antagonistic *Trichoderma* spp. *Frontiers in Plant Science*, 13, 897668. <https://doi.org/10.3389/fpls.2022.897668>
- Kumar, R., Singh, S. K., Kumari, A., Kumar, A., & Yadav, S. (2017). In vitro evaluation of various bio-control agents against *Fusarium solani* isolated from Papaya (*Carica papaya* L.). *Int. J. Curr. Microbiol. App. Sci*, 6(4), 40–50. <https://doi.org/10.20546/ijcmas.2017.604.006>
- Li, Y.-T., Hwang, S.-G., Huang, Y.-M., & Huang, C.-H. (2018). Effects of *Trichoderma asperellum* on nutrient uptake and *Fusarium* wilt of tomato. *Crop Protection*, 110, 275–282. <https://doi.org/10.1016/j.cropro.2017.03.021>
- Matthews, G. A., Bateman, R., & Miller, P. (2014). *Pesticide application methods*. John Wiley & Sons.
- Mustofa, A., & Hastuti, U. S. (2024). Antagonism and mycoparasitism mechanism of *T. harzianum* against pathogenic fungus species of *F. oxysporum* and *Capnodium* sp. *Inornatus: Biology Education Journal*, 4(1), 1–10. Retrieved from <https://journalfkipunipa.org/index.php/ibej/article/view/581>
- Nasrin, L., Podder, S., & Mahmud, M. R. (2018). Investigation of Potential Biological Control of *Fusarium Oxysporum* f. sp. *Lycopersici* by Plant Extracts, Antagonistic sp. and Chemical Elicitors. *Fungal Genomics & Biology*. <https://doi.org/10.4172/2165-8056.1000155>
- Novita, N., Firmansyah, E., & Isnaeni, S. (2021). Keefektifan *Trichoderma* sp. Dalam mengendalikan layu *Fusarium* pada tanaman mentimun (*Cucumis sativus* L.). *AGROSCRIPT: Journal of Applied Agricultural Sciences*, 3(1). Retrieved from <https://e-journal.unper.ac.id/index.php/agroscript/article/download/621/526>
- Panicker, S., & Sayyed, R. Z. (2022). Hydrolytic enzymes from PGPR against plant fungal pathogens. In *Antifungal Metabolites of Rhizobacteria for Sustainable Agriculture* (pp. 211–238). Springer. [https://doi.org/10.1007/978-3-031-04805-0\\_10](https://doi.org/10.1007/978-3-031-04805-0_10)
- Poveda, J., Abril-Urias, P., & Escobar, C. (2020). Biological control of plant-parasitic nematodes by filamentous fungi inducers of resistance: *Trichoderma*, mycorrhizal and endophytic fungi. *Frontiers in Microbiology*, 11, 992. <https://doi.org/10.3389/fmicb.2020.00992>
- Ren, X., Zhang, Q., Zhang, W., Mao, J., & Li, P. (2020). Control of aflatoxigenic molds by antagonistic microorganisms: Inhibitory behaviors, bioactive compounds, related mechanisms, and influencing factors. *Toxins*, 12(1), 24. <https://doi.org/10.3390/toxins12010024>
- Sallam, N. M. A., Eraky, A. M. I., & Sallam, A. (2019). Effect of *Trichoderma* spp. on *Fusarium* wilt disease of tomato. *Molecular Biology Reports*, 46(4), 4463–4470. <https://doi.org/10.1007/s11033-019->

04901-9

- Sepwanti, C., Rahmawati, M., & Kesumawati, E. (2016). Pengaruh varietas dan dosis kompos yang diperkaya *Trichoderma harzianum* terhadap pertumbuhan dan hasil tanaman cabai merah (*Capsicum annuum* L.). *Jurnal Kawista Agroteknologi*, 1(1), 68-74. Retrieved from <https://shorturl.asia/9ioW3>
- Tyśkiewicz, R., Nowak, A., Ozimek, E., & Jaroszuk-Ścisel, J. (2022). Trichoderma: The current status of its application in agriculture for the biocontrol of fungal phytopathogens and stimulation of plant growth. *International Journal of Molecular Sciences*, 23(4), 2329. <https://doi.org/10.3390/ijms23042329>
- Yang, W.-H., Peng, S., Huang, J., Sanico, A. L., Buresh, R. J., & Witt, C. (2003). Using leaf color charts to estimate leaf nitrogen status of rice. *Agronomy Journal*, 95(1), 212-217. <https://doi.org/10.2134/agronj2003.2120>
- Yanti, Y., Albana, H., Nafisah, S., Faradiba, P., & others. (2025). The potential of *Trichoderma* spp. for controlling fusarium wilt disease and promoting the growth of chili plants. *IOP Conference Series: Earth and Environmental Science*, 1469(1), 12013. <https://doi.org/10.1088/1755-1315/1469/1/012013>