JPT: Jurnal Proteksi Tanaman
(Journal of Plant Protection)
ISSN : 2580-0604, Online ISSN: 2621-3141
Terakreditasi: Sinta 4

Vol 6 No.1 (2022): 13 – 25
Website:http://jpt.faperta.unand.ac.id/index.php/jpt

Antagonism of Indigenous Fungi Collected from the Bamboo Clump against *Fusarium* sp., the Cause of Fusarium Wilt Disease in Garlic

Daya Antagonis Jamur Indigenus dari Rumpun Bambu terhadap *Fusarium* sp., Penyebab Layu Fusarium pada Bawang Putih

Ayu Lestiyani[1)*], Lia Fauziah[1)], Sugiyarto[2)]

[1)] Agrotechnology Department, Faculty of Agriculture, Universitas Tidar, Central Java, Indonesia
[2)] Department of Biology, Faculty of Mathematic and Natural Sciences, Universitas Sebelas Maret, Central Java, Indonesia

*E-mail: ayu.lestiyani@untidar.ac.id

Submitted: 04 March 2022 Accepted: 13 June 2022 Published: 30 June 2022

ABSTRACT

Indigenous fungi can be found around bamboo clumps. This study aimed to identify indigenous fungi isolated from the bamboo clump as biological control agents against pathogenic fungi of *Fusarium* sp. in garlic. The study was conducted from June to September 2021 at the Laboratory of Pest and Disease Observation, Temanggung Regency, Central Java, Indonesia. The current research design involved the following three steps, (1) Isolation and identification of the pathogenic fungi of *Fusarium* sp. in garlic, (2) Isolation and identification of indigenous fungi collected from the bamboo clump, and (3) Antagonism test of indigenous fungi isolated from the bamboo clump against *Fusarium* sp. in-vitro. The results showed that ten species were successfully identified, and five species had the potential as biological control agents against *Fusarium* sp. in garlic; *Penicillium* sp., *Mucor* sp., *Aspergillus* sp1, *Aspergillus* sp2, and *Trichoderma* sp. *Trichoderma* sp. revealed the highest antagonism (66.71%), while *Penicillium* sp. revealed the lowest antagonism (32.925%) against *Fusarium* sp. Based on their antagonistic potential, *Trichoderma* sp. showed the highest ability to suppress *Fusarium* sp. (66.71%), while the lowest one was *Penicillium* sp. (32.92%).

Keywords*: Allium sativum,* antagonist, biological control, identification

ABSTRAK

Jamur indigenus sudah ditemukan pada rumpun bambu. Penelitian ini bertujuan untuk mengidentifikasi jamur indigenus dari rumpun bambu tersebut dan menguji kemampuannya dalam mengendalikan *Fusarium* sp. pada tanaman bawang putih. Penelitian dilakukan bulan Juni sampai September 2021 di Laboratorium Pengamatan Hama dan Penyakit Kecamatan Kedu, Kabupaten Temanggung, Jawa Tengah, Indonesia. Penelitian dilaksanakan dalam tiga tahap (1) Isolasi dan identifikasi jamur patogen *Fusarium* sp. bawang putih, (2) Isolasi dan identifikasi jamur *indigenus* rumpun bambu, (3) Uji antagonis antara jamur indigenus rumpun bambu dengan jamur *Fusarium* sp. Hasil penelitian menemukan 10 spesies jamur indigenus pada rumpun bambu, lima

diantaranya berpotensi sebagai agens pengendali hayati *Fusarium* sp yaitu *Penicillium* sp., *Mucor* sp., *Trichoderma* sp., *Aspergillus* sp1, dan *Aspergillus* sp2. Daya antagonis tertinggi ditunjukkan oleh jamur *Trichoderma* sp. (66.71%), sedangkan yang terendah ditunjukkan oleh jamur *Penicillium* sp. (32.92%).

Kata kunci*: Allium sativum,* daya antagonis, identifikasi, pengendalian hayati

INTRODUCTION

Garlic (*Allium sativum*) is one of Indonesia's horticultural crops with high market potential because it offers several benefits, such as spices, cosmetics, medicine (Sholihin et al., 2016), and anti-bacterial source due to containing allicin. According to Titisari et al. (2019), the business opportunities for garlic cultivation in Indonesia are pretty high because the need and demand for this plant are more significant than national production. However, one of the problems found in increasing garlic production is the attack of the pathogenic fungi, *Fusarium* spp., which causes wilt disease symptoms.

Fusarium spp. are soil-borne pathogenic fungi with a variety of about 100 species that causes rapid damage to garlic (Pujiastuti et al., 2014), with attack intensity reaching 35% (Putra et al., 2019) to 75% (Mishra et al., 2014). The distribution of *Fusarium* spp. occurs through seeds, air, water, and soil (Titisari et al., 2019). Toxins produced by *Fusarium* spp. can cause plants to wither due to interference with cell wall permeability (Pakki, 2016). Symptoms of disease caused by *Fusarium* spp. among others, are leaves that turn yellow then dry, rotten tubers, and all parts of plant die (Satyagopal et al., 2014). According to Haryani and Tombe (2011), this disease is very detrimental that cause the death of thousands of hectares of plants, decreasing quality and quantity of yield.

To date, farmers are still highly dependent on synthetic pesticides for plant disease control despite knowing that long-term application will harm humans and the environment (Pamungkas and Ardiyanta, 2020) and leave residues (Hanudin and Marwoto, 2012). One of the recommended controls is the use of antagonistic microbes that are safe for the environment, can optimize the role of natural enemies which are part of the chain in the agroecosystem (Pamungkas and Ardiyanta, 2020; Sopialena, 2018), prevent economic losses and increase crop yields (Djafaruddin, 2010).

According to Isniah and Widodo (2015), non-pathogenic fungi do not show disease symptoms in plants, so the non-pathogenic fungi have opportunities as biological control agents. Studies on biological control by utilizing the potential of indigenous microbes are being carried out because many of them are found naturally in a particular area (Kumar and Gopal, 2015), easy to manufacture, safe for the environment, inexpensive, and effective (Reddy, 2011). Indigenous fungi can be found around bamboo clumps (Sujarwo, 2017).

Susanti et al. (2015) stated, high fungal populations were found collected from bamboo forests. The functional diversity of microbes from the bamboo rhizosphere plays a role in increasing plant growth. Soil from bamboo rhizosphere has been proven to suppress plant diseases from the soil (disease suppressive soil). According to Nurliana and Anggraini (2018), the soil around bamboo is often used as a medium for seeding plant seeds, and there are many antagonistic fungi. Tozlu et al. (2018) stated that *Trichoderma* sp. can suppress the growth of *Alternaria alternata*, a fungal pathogen that causes leaf

spot disease on cucumber plant. Asniah et al. (2013) reported, antagonistic fungi from the rhizosphere of bamboo clumps, such as *Paecilomyces* sp. can suppress clubroot disease in broccoli plants up to 18.75%.

Similarly, Susanti et al. (2015) found that indigenous fungi in bamboo rhizosphere soil can suppress *P. palmivora* attack on papaya seedlings, indicated by the lowest papaya seedling mortality (12%). The objectives of the study were to identify and collect the indigenous fungi from the bamboo clump and determine their potential in inhibiting the growth of *Fusarium* sp. causing the garlic wilt disease in-vitro.

METHODOLOGY

The research was carried out from June 2021 to September 2021 at the Laboratory of Temanggung Disease Pest (LPHP), Temanggung Regency, Central Java, Indonesia.

Methods

This study was conducted in 3 steps. The first step was aimed to identify the species of fungi attacking garlic that show symptoms of fusarium wilt disease. Ten garlic plants with fusarium wilt symptoms were collected from Kledung, Temanggung, Central Java, Indonesia. The second step was aimed to explore indigenous fungi from three bamboo clumps, which grow on bamboo fields in Bandongan, Magelang, Central Java, Indonesia. The fungi assumed to have potential biological control agents for pathogens will be tested further. The third step was aimed to determine the antagonistic ability of fungi species (2nd step), using completely randomized design which was carried out in five replications.

Isolation and identification of *Fusarium* sp. in garlic

Fusarium sp. were isolated from infected garlic, showing specific symptoms of fusarium wilt disease. The garlic samples were washed, roots cut for about one cm, and sterilized using 70% alcohol for one minute. Then, roots rinsed using distilled water twice, drained on dry tissue, and planted in PDA (Potato Dextrose Agar) media as described by Dwiastuti et al. (2015). The fungi isolates were purified and identified macroscopically and microscopically based on Barnett and Hunter (1998), Wanatabe (2002), and Campbell et al. (2013). Based on Agrios (2005), the fungi found will be grouped into potential as biological agents and pathogenic, and only the potential fungi were further studied.

Isolation and identification

Indigenous fungi were isolated from half-cooked rice, soaked in water, steamed until half-cooked rice, then incubated for 5 to 6 days in bamboo clumps (Reddy, 2011). The fungi isolates were isolated on PDA media (Potato Dextrose Agar) by direct planting method and incubated, then purified and identified. Identification of fungi were based on Barnett and Hunter (1998), Wanatabe (2002), and Campbell et al. (2013).

Observation of growth diameter

Observation of colony growth was done through a single culture of the antagonistic fungi and measuring the diameter of the fungi. Calculation of colony diameter of fungi isolates was performed by measuring the diameter of the radial direction (Figure 1) according to the method described by Achmad et al. (2013) and Risdianto et al. (2017) with the following formula:

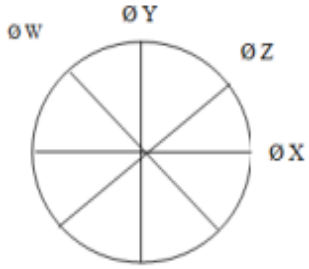

Figure 1. Measuring the growth diameter of indigenous fungi in petridish

Radial direction diameter = $\frac{\emptyset w + \emptyset x + \emptyset y + \emptyset z}{4}$; w is axis diameter w, x is axis diameter x, y is axis diameter y, z is axis diameter z

Antagonist test of indigenous fungi from the bamboo clump against *Fusarium* sp. in garlic

Testing the potential antagonistic of indigenous fungi from the bamboo clumps against the pathogenic *Fusarium* sp. in-vitro was carried out using the dual culture method (Figure 2) (Ningsih et al., 2016).

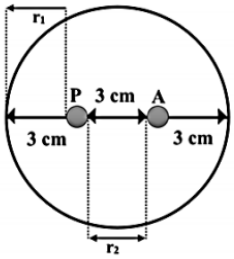

Figure 2. Schematic of the dual culture of pathogenic fungi and antagonist fungi; A = antagonist fungi, and P = pathogenic fungi

The antagonism ability is measured based on the inhibition percentage and antibiotics by evaluating the existence or absence of inhibition zone. Antagonistic potency of fungus growth inhibition based on the following formula:

Antagonistic potency = $\frac{r1 - r2}{r2}$ x 100 %

r1 = the radius of pathogenic fungi away from the antagonist fungi colony (mm)

r2 = the radius of the pathogenic fungi approaching the antagonist fungi colony (mm)

Criteria for the growth inhibition percentage (%) (Amaria et al., 2013) as following:

70-100% = High inhibition

40-69% = Moderate inhibition

0 - 39% = Low inhibition

Data analysis

Data of indigenous fungi were presented in images (photos), tables, and descriptions. Data on the growth diameter of indigenous fungi from the bamboo clump and antagonist test against *Fusarium* sp. in-vitro were analyzed using *Analysis of Variance* (ANOVA). If the data were significantly different, further testing with Duncan's 5% test was performed.

RESULTS

Identification of *Fusarium* sp. in garlic

Fungi isolate was obtained from samples showing symptoms of wilt disease was *Fusarium* sp., with the characteristics of a grayish-white colony color, the reverse color was pale cream, the colony texture was like cotton, there were conidiophores and conidia (Table 1, Figure 3).

Table 1. Morphological character of *Fusarium* sp. garlic in PDA media

Identification	Result
Surface color	Grayish white
Reverse	Pale cream
Texture	like cotton
Conidiophore	presence
Conidia	presence

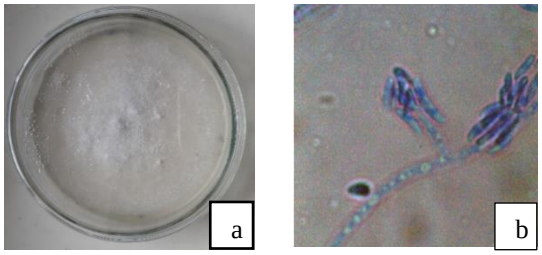

Figure 3. Morphological of *Fusarium* sp in garlic; (a) Macroscopic, (b) Microscopic

Identification of indigenous fungi from the bamboo clump

A total of ten fungi isolates were collected from the bamboo clump, two species of Aspergillus, two species of Fusarium, and the six others. Fungi that assumed as biological control agent were *Penicillium* sp., *Mucor* sp., *Aspergillus* sp., dan *Trichoderma* sp, and the others were pathogens (Tabel 2, Figure 4, and Figure 5).

Table 2. Morphological characteristics of indigenous fungi collected from a bamboo clump

Surface color in PDA	Reverse in PDA	Texture	Conidiophore	Conidia	Fungi septate	Species
black	pale cream	granular	presence	Presence	septate	*Aspergillus* sp1
yellowish-green	Cream	granular	presence	Presence	septate	*Aspergillus* sp2
black grey	black grey	like cotton	presence	Presence	septate	*Curvularia* sp.
pink	Pink	like cotton	presence	Presence	septate	*Fusarium* sp1
white	yellowish-white	like cotton	presence	Presence	septate	*Fusarium* sp2
greyish-white	greyish-white	fibrous	presence	Presence	non-septate	*Mucor* sp.
green (white on the side)	pale yellowish-brown	smooth	presence	Presence	septate	*Penicillium* sp.
dark grey	black	like cotton	absence	Absence	septate	*Rhizoctonia* sp.
brown grey	pale grey-brown	fibrous	presence	Presence	Non-septate	*Rhizopus* sp.
white tinge green	yellowish-white	velvety	presence	Presence	septate	*Trichoderma* sp.

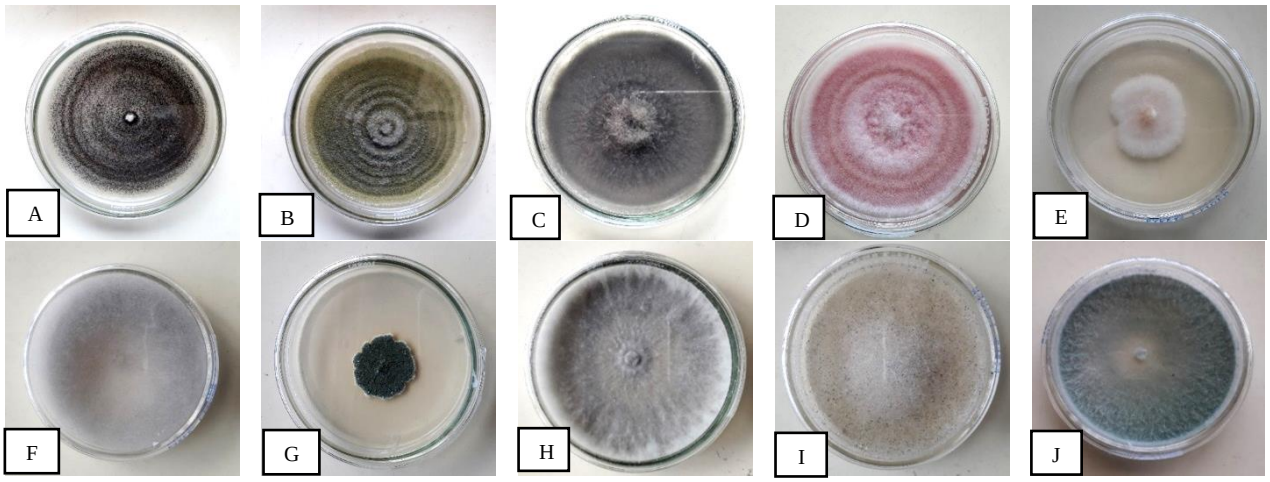

Figure 4. Morphological appearance of ten fungi collected macroscopically; (A) *Aspergillus* sp1 , (B) *Aspergillus* sp2, (C) *Curvularia* sp., (D) *Fusarium* sp1 (E) *Fusarium* sp2, (F) *Mucor* sp., (G) *Penicillium* sp., (H) *Rhizoctonia* sp., (I) *Rhizopus* sp., and (J) *Trichoderma* sp.

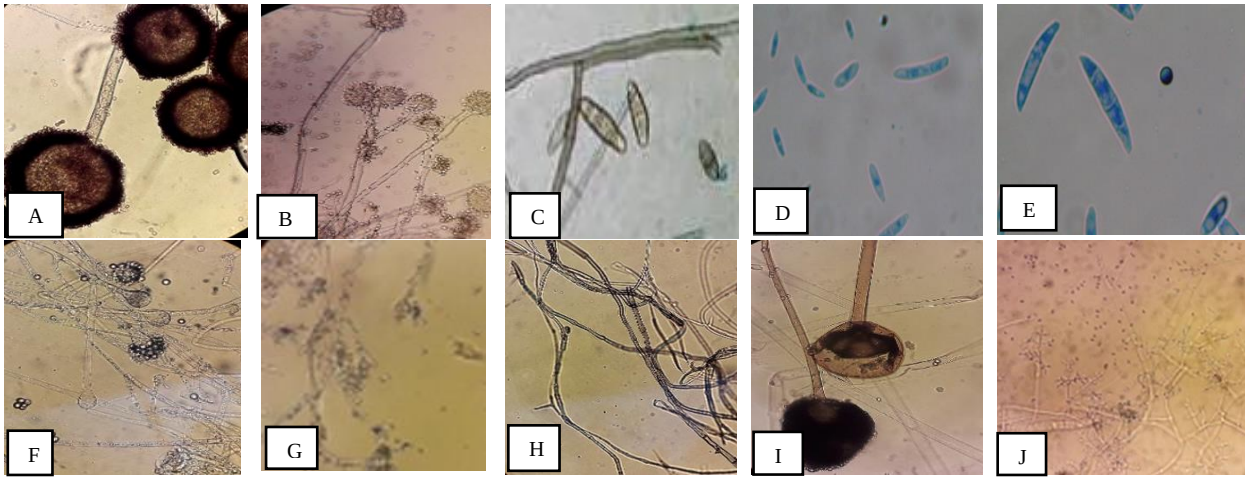

Figure 5. Morphological appearance of ten fungi collected microscopically; (A) *Aspergillus* sp1 , (B) *Aspergillus* sp2, (C) *Curvularia* sp., (D) *Fusarium* sp1 (E) *Fusarium* sp2, (F) *Mucor* sp., (G) *Penicillium* sp., (H) *Rhizoctonia* sp., (I) *Rhizopus* sp., and (J) *Trichoderma* sp.

Growth diameter of indigenous fungi from the bamboo clump

The growth diameter characters were significantly different amongst the indigenous fungi isolates collected from the bamboo clump observed in the present study. The longest growth diameter was seen on *Mucor* sp., *Trichoderma* sp. and *Rhizopus* sp., while the shortest was seen on *Penicillium* sp. (Table 3).

Table 3. Growth diameter of indigenous fungi from the bamboo clump

Species	Diameter (mm)
Penicillium sp.	32.58 a
Fusarium sp2	36.67 ab
Aspergillus sp1	72.75 c
Aspergillus sp2	76.00 c
Fusarium sp1	83.33 cd
Curvularia sp.	85.17 cd
Mucor sp.	90.00 d
Trichoderma sp.	90.00 d
Rhizopus sp.	90.00 d
Rhizoctonia sp.	90.00 d

Note: Numbers followed by the same notation show results that are not significantly different (Duncan 5%)

Antagonism of indigenous fungi from the bamboo clump against *Fusarium* sp. in garlic

Observation of the antagonistic potential of fungal isolates was used to determine the ability of indigenous fungi derived from the bamboo clump to inhibit *Fusarium* sp. in-vitro. Five out of 10 indigenous fungi isolates were collected from the bamboo clump, coded by *Penicillium* sp., *Mucor* sp., *Aspergillus* sp. 1, *Aspergillus* sp. 2 and *Trichoderma* sp., were potential to be used potentially used as antagonist fungi based on Agrios (2005). The other fungi were assumed as pathogens. The highest Inhibition percentage of indigenous fungi against *Fusarium* sp. was *Trichoderma* sp. (66.71%), and the lowest was *Penicillium* sp (Table 4).

Table 4. Potential antagonist of indigenous fungi from the bamboo clumps against *Fusarium* sp.

Species	Growth inhibition (%)
Penicillium sp.	32.92 a
Mucor sp.	38.12 ab
Aspergillus sp. 2	51.65 c
Aspergillus sp. 1	63.09 d
Trichoderma sp.	66.71 d

Note: Numbers followed by the same notation show results that are not significantly different (Duncan 5%)

In seven days of observation, the increase of growth diameter was seen rapidly in *Rhizopus* sp., *Rhizoctonia* sp., *Trichoderma* sp., and *Mucor* sp., but growth slowed on the 3rd and 4th day of observation, while the growth of the other six fungi was seen to continue to increase, although slowly until seven days (Figure 6).

DISCUSSION

The fungus found to attack garlic was *Fusarium* sp. (Table 1). It has a morphological grayish-white colony color, and the reverse color is pale cream; the texture colony is like cotton, with conidiophore and conidia (Leslie dan Summerell, 2006; Campbell, 2013; Sari et al., 2018). Arifin et al. (2021) reported that symptoms of fusarium wilt disease featured wilting, chlorosis, and tubers.

A total of ten species of fungi isolates were collected from the bamboo clump, two species from Aspergillus, two species from Fusarium, and the six others (Table 2). *Aspergillus* sp. has the appearance of different colony colors. *Aspergillus* sp1 had a black colony with yellowish-white color on the other side (Figure 4A). *Aspergillus* sp2 had a yellowish-green colony, sometimes

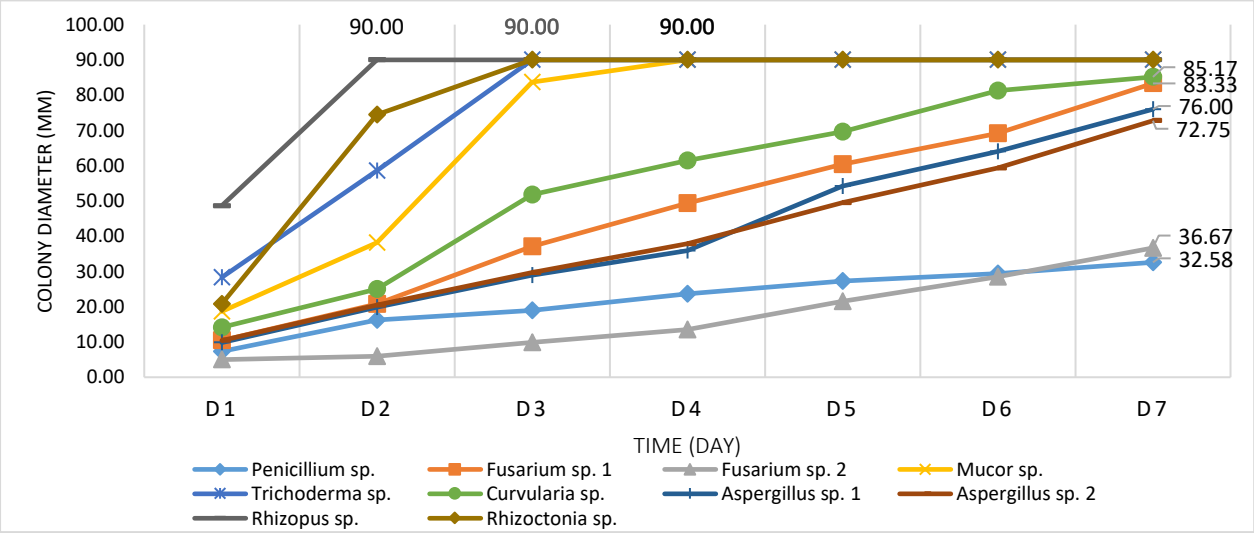

Figure 6. Growth diameter of indigenous fungi from the bamboo clump

brownish-yellow or cream (Figure 4B). According to Campbell (2013), *Aspergillus* sp. grows with a radial appearance. *Aspergillus* sp. has a granular texture, single conidiophore, perpendicular, and growing tip. Phialids at the tip are very clearly spread over the entire surface (Barnet and Hunter, 1998). Conidia are round to oval in shape (Campbell, 2013). According to Suryani et al. (2020), *Aspergillus* sp. had septate and it has the potential to control *Fusarium oxysporum* f.sp. capsici with inhibition up to 82% (Maulana et al., 2016).

Curvularia sp. had a blackish grey colony, including reversed colony. The texture of the colony was like cotton (Figure 4C). *Curvularia* sp. has septate hyphae, single or branched conidiophores, erect, straight, or bent. Conidia are upright or curved, bearing apical and lateral conidia, and have four cells, a dark brown color, mainly on the two central cells (Watanabe, 1937). *Curvularia* sp. Includes one of the pathogens that cause leaf spot disease on mustard plants (Suganda and Wulandari, 2018).

Fusarium sp1 had pink and white colors colony (Figure 4D), and *Fusarium* sp2 had a white colony with yellowish-white (Figure 4E). According to Barnet and Hunter (1998), the texture of *Fusarium* sp. is like cotton. *Fusarium* sp. shows conidiophores that vary, singly or in groups, and irregularly branching. There are two types of hyaline conidia, macroconidia and microconidia. Macroconidia are slightly curved or bent at the pointed end, canoe-shaped and multicellular, while microconidia have one cell, oval or round. Some conidia have 2 or 3 cells, slightly curved or oval. Ningsih et al. (2012) reported that *Fusarium* sp. has insulated hyphae. In addition, Soenartiningsih et al. (2016) reported that *Fusarium* sp. is a soil-borne pathogenic fungus that can infect various plants, affecting agricultural production.

Mucor sp. had a greyish-white colony, reverse greyish-white, and fibrous colony texture (Figure 4F). *Mucor* sp. showed the presence of hyaline conidiophores and round spores and non-septate hyphae. That can be used as an antagonist fungus, such as *Fusarium* sp. in potato (Izzatinnisa et al., 2020). *Penicillium* sp. had a macroscopic appearance of green and white colonies (Figure 4G). According to Campbell (2013), *Penicillium* sp. has a smooth colony surface texture, the conidiophores arise from a single mycelium and branches at the ends,

penicillate, and phyalids at the ends. Conidia are 1 celled, hyaline, and mostly ovoid or spherical (Barnet and Hunter, 1998). *Penicillium* sp. has septate (Suryani et al., 2020). Generally found in the residual of organic matter and soil, which can be used as a biological control agent in several plant diseases (Abadi, 2003). According to Ortriana (2011), *Penicillium* sp. is a biological control of *Pythium* sp. with an antimicrobial antagonist mechanism. *Rhizoctonia* sp. had dark grey colony and then will be black, colony texture like cotton (Figure 4H). According to Barnet and Hunter (1998), the microscopic characteristics of *Rhizoctonia* sp. showed the presence of hyaline mycelium, long, insulated mycelium cells, branch septa derived from the main hyphae, asexual fungi fruiting bodies, and has no conidia. This fungus is parasitic on plants, especially on roots, because it is a soil-borne fungus that can cause a decrease in plant production (Soertaningsih et al., 2015). *Rhizoctonia* sp. includes pathogens that cause stem rot and root rot in plants (Abadi, 2003).

Rhizopus sp. had a brownish-grey colony and pale brownish-grey reverse (Figure 4I). *Rhizopus* sp. has a fibrous colony texture (Novariza et al., 2015), septate hyphae (Suryani et al., 2020), conidiophores erect, single or branched; it has a yellowish to dark brown color and rhizoids directly connected to the conidiophores bearing sporangia in the shoots. Sporangia are round in shape and brown to black (Watanabe, 1937). *Rhizopus* sp. can cause soft rot disease in fruits and vegetables during storage (Abadi, 2003). According to Nursadin et al. (2012), *Rhizopus* sp. is a warehouse fungus that causes damage to agriculture, it will be carried away until storage.

Trichoderma sp. had a white tinge green surface color and texture like velvety, conidia, conidiophore, and septate hyphae (Figure 4J). According to Watanabe (1937), *Trichoderma* sp. has a dark green, yellow color with a spreading bearing shape. *Trichoderma* sp. has hyaline conidiophores, many branches, single phialid, or in groups. One celled conidium, hyaline, has an ovoid shape and is arranged in the terminal (Barnet and Hunter, 1998). *Trichoderma* sp. has septate hyphae (Watanabe, 1937), lives in the soil, cellulolytic, and speedy growth (Abadi, 2003). *Trichoderma* sp. is parasitic on other fungi (Barnet and Hunter, 1998). According to Alfizar et al. (2013), *Trichoderma* sp. can inhibit the growth of the *Fusarium* sp. *Colletotrichum capsici*, and *Sclerotium rolfsii* in-vitro.

The longest growth diameter was seen on *Mucor* sp., *Trichoderma* sp., *Rhizopus* sp., and *Rhizoctonia* sp. (90 mm), while the shortest was seen on *Penicillium* sp. (Table 3). The increase in growth diameter was seen rapidly in *Rhizopus* sp., *Rhizoctonia* sp., *Trichoderma* sp., and *Mucor* sp. (Figure 6). Fungi have the longest diameter because hyphae are long and spread a lot so it is easier to absorb nutrients (Rahmawati et al., 2020). This is different from *Penicillium* sp. which has a different hyphae structure. According to Nail et al. (2020), the fungi colonies are getting bigger every day due to increased cell volume. In addition, the fungi with high growth diameter are the potential to be used as antagonist fungi. According to Amaria et al. (2015), the higher the growth rate of antagonistic fungi, the more effective in suppressing the growth of pathogenic fungi. Therefore, the speed of fungi growth can indicate the mechanism of space and nutrient competition against pathogens.

Indigenous fungi that have the potential were *Trichoderma* sp and *Aspergillus* sp1 despite having criteria of moderate inhibition (Table 4). Each type of antagonist fungi has mechanism for suppressing the growth of pathogens. The ability of antagonistic fungi against pathogens carried out in-vitro can be

used to indicate their ability to inhibit the growth of pathogens in the field (Amaria et al., 2015). *Trichoderma* sp. becomes dominant because of the speed growth in media culture, reflecting a possibility of space competetion has occurred between *Trichoderma* sp. and *Fusarium* sp.

According to Dewi et al. (2015), the growth of *Trichoderma* sp. tended to be faster, suppressing pathogenic fungi growth. The growth of *Trichoderma* sp. causes a hyperparasitic antagonist mechanism known as antagonistic, which can grow covering the entire PDA medium, covering pathogenic colonies (Purwantisari et al., 2008). The antagonist mechanism in *Trichoderma* sp. has begun with coiled hyphae, then intervention, penetrating the pathogenic hyphae, reducing the hyphae size and the particles (Dwiastuti et al., 2015). Another antagonistic potency of the *Trichoderma* sp through the secretion of antibiotic compounds leading to the inhibition of the growth of pathogen was also reported by Ningsih et al. (2016). In this regard, the antibiotic compounds produced in the form of alamethicin, paracelsian, and trichotomy can cause damage to cell permeability of membrane. *Trichoderma* sp. also produces the chitinase enzyme, which causes cell wall lysis (Harman et al., 2008). The resulting enzyme compounds can inhibit the growth of pathogenic fungi (Fety et al., 2015).

Fungi from the genus Aspergillus and Mucor have a mechanism of antagonistic ability against pathogenic fungi by a competetive means that enables them to control the available growth space directly and competition for nutrients on PDA media (Sarah et al., 2018). The higher growth ability of the antagonistic fungi led to the inhibition of the mycelium growth of pathogenic fungi (Ziedan et al., 2013). In previous studies, these fungi that belong to the Aspergillus could inhibit the growth of *Fusarium* sp. in-vitro. The growth of hyphae can suppress the growth of the pathogenic fungi (Andriastini et al., 2018). On the other hand, the fungal antagonist derived from Mucor could produce the hydroxy cyanide (HCN) compound, which can suppress the growth of pathogens (Cadha et al., 2015).

The antagonist of *Penicillium* sp. against *Fusarium* sp. showed a low antagonistic ability, mainly because the fungi growth was much slower than the others. However, *Penicillium* sp. is reported to have an antagonistic ability. According to Abadi (2003), competition and antibiosis (penicillin) were the antagonistic mechanism observed from *Penicillium* sp. for controlling fungi pathogenic fungi. Based on Putra and Purwantisari (2018), *Penicillium* sp. produced an antibiotic compound in the form of Penicillin which can inhibit cell wall synthesis, thereby can suppress the growth of pathogenic fungi.

CONCLUSION

A total of 10 species of fungi were successfully obtained from bamboo clumps, and five of them had the potential as biological control agents against *Fusarium* sp. in garlic; *Penicillium* sp., *Mucor* sp., *Aspergillus* sp1, *Aspergillus* sp2, and *Trichoderma* sp. Based on their antagonistic potential, *Trichoderma* sp. revealed the highest ability to suppress *Fusarium* sp. (66.71%), while the lowest one was *Penicillium* sp. (32.92%).

REFERENCES

Abadi AL. 2003. Ilmu penyakit tumbuhan I. Bayumedia Publishing. Malang.

Abadi AL. 2003. Ilmu penyakit tumbuhan III. Bayumedia Publishing. Malang.

Achmad E, NH erliyana and EA Octaviani. 2013. Pengaruh pH, penggoyangan media, dan penambahan serbuk gergaji terhadap pertumbuhan jamur *Xylaria* sp. Jurnal Silvikultur Tropika 4(2): 57-61.

Agrios G. 2005. Plant pathology. 5th ed. New York, USA: Academic Press.

Alfizar, Marlina, and F Susanti. 2013. Kemampuan antagonis *Trichoderma* sp. terhadap beberapa jamur patogen in-vitro. Jurnal Floratek 8: 45-51.

Amaria W, T Efi, and H Rita. 2013. Identifikasi jamur antagonis sebagai agens hayati jamur *Rigidoporus microsporus* pada tanaman karet. Journal of Industrial and Beverage Crops 4(1): 20-31.

Amaria W, R Harni, and Samsudin. 2015. Evaluasi jamur antagonis dalam menghambat pertumbuhan *Rigidoporus microporus* penyebab penyakit jamur akar putih pada tanaman karet. Jurnal Tanaman Industri dan Penyegar 2(1): 51-60.

Andriastini DA, Y Ramona, and MW Proborini. 2018. Hambatan in vitro cendawan antagonis pada *Fusarium* sp., penyebab penyakit pada buah naga (*Hylocereus undatus* (Haw.) Britton & Rose). Jurnal Metamorfosa 5(2): 224-233.

Arifin L, S Indarti, and A Wibowo. 2021. Identification of pathogens causing bulb rot disease on garlic (*Allium sativum* L.) in Central Java, Indonesia. Jurnal Perlindungan Tanaman Indonesia 25(1): 74-85.

Ariyanti AEL, Suriani, and SS Wahab. 2021. Potensi mikroba antagonis *Bacillus cereus* dan *Trichoderma* sp. terhadap patogen penting tanaman jagung. Agriculture System Journal 1(1): 23-29.

Asniah, Widodo, and S Wiyono. 2013. Potensi cendawan asal tanah perakaran bambu sebagai endofit dan agen biokontrol penyakit akar gada pada tanaman brokoli. Jurnal Hama dan Penyakit Tumbuhan Tropika 13(1): 61-68.

Barnet HL and BB Hunter. 1998. Ilutrated genera of imperfect fungi. 4th eds. Burges Publishing. Minneapolis.

Cadha N, R Prasad, and A Varma. 2015. Plant promoting activities of fungi endophytes associated with tomato roots from Central Himalaya, India and their interaction with *Piriformospora indica.* International Journal of Pharma and Bio Sciences 6(1): 333-343.

Campbell CK, EM Johnson, and DW Warnock. 2013. Identification of pathogenic fungi. 2nd eds. Public Health Laboratory Service. London.

Dewi IP, T Maryono, TN Aeny, and S Ratih. 2015. Kemampuan *Trichoderma* sp. dan filtratnya dalam menekan pertumbuhan *Sclerotium rolfsii* secara *in vitro*. Jurnal Agrotek Tropika 3(1): 130-133.

Djafaruddin. 2008. Basics of plant disease control. Earth Literature. Jakarta.

Dwiastuti ME, MN Fajri, and Yunimar. 2015. Potensi *Trichoderma* spp. sebagai agens pengendali *Fusarium* spp. penyebab penyakit layu pada tanaman stroberi (*Fragaria x ananassa* Dutch). Jurnal Hortikultura 25(4): 331-339.

Fety S, Khotimah, and Mukarlina. 2015. Uji antagonis jamur rizosfer isolat lokal terhadap *Phytoptora* sp. yang diisolasi dari batang langsat (*Lansium domesticum* Corr.). Protobiont 4(1): 218-225.

Hanudin and B Marwoto. 2012. Prospek penggunaan mikroba antagonis sebagai agens pengendali hayati penyakit utama pada tanaman hias dan sayuran. Jurnal Litbang Pertanian 31(1): 8-13.

Haryani TS and OM Tombe. 2011. Pemanfaatan bakteri antagonis terhadap pengendalian jamur patogen *Fusarium oxysporum* dan *Phytopthora capsici* secara *in vitro*. Ekologia 11(2): 11-21.

Isniah US and Widodo. 2015. Eksplorasi Fusarium nonpatogen untuk pengendalian penyakit busuk pangkal pada bawang merah. Jurnal Fitopatologi Indonesia 11(1):14-22.

Izzatinniza, U Utami, and A Mujahidin. 2020. Uji antagonisme beberapa fungi endofit pada tanaman kentang terhadap *Fusarium oxysporum* secara *in vitro*. Jurnal Riset Biologi dan Aplikasinya 2(1): 18-25.

Karim A, Rahmiati, and I Fauziah. 2020. Isolasi dan uji antagonis *Trichoderma* terhadap *Fusarium oxysporum* secara *in vitro*. Jurnal Biosains 6(1): 18-22.

Kumar BL and DVRS Gopal. 2015. Effective role of indigenous microorganisms for sustainable environment. Journal Biotechnology 5(6): 867-876.

Leslie JF and BA Summerell. 2006. The Fusarium laboratory manual. USA: Blackwell Publishing.

Mishra RK, RK Jaiswal, D Kumar, PR Saabale, and A Singh. 2014. Management of major diseases and insect pests of onion and garlic: A comprehensive review. Journal of Plant Breeding and Crop Science 6(11): 160-170.

Nail YAF, Ernawati, and Suryani. 2020. Pemanfaatan kulit pisang kepok (*Musa paradisiaca* Linn.) dan kulit ubi kayu (*Manihot utilisma* Pohl.) sebagai media alternatif pertumbuhan jamur *Rhizopus* sp. Jurnal Biosains dan Edukasi 2(1): 24-28.

Neeraj S, K Sushila, D Neeraj, P Milind, and P Minakshi. 2014. Garlic: A pungent wonder from nature. Journal of Pharmacy 5(7): 523-529.

Ningsih R, Mukarlina, and R Lida. 2012. Isolasi dan identifikasi jamur dari organ bergejala sakit pada tanaman jeruk siam (*Citrus nobilis* var. *microcarpa*). Protobiont 1(1): 1-7.

Ningsih H, US Hastuti, dan D Listyorini. 2016. Kajian antagonis *Thricoderma* Spp. terhadap *Fusarium Solani* penyebab penyakit layu pada daun cabai rawit (*Capsicum frustescens*) secara *in vitro*. Proceeding Biology Education Conference 13(1): 814-817.

Nurliana and N Anggraini. 2018. Eksplorasi dan identifikasi *Thricoderma* sp. lokal dari rizosfer bambu dengan metode perangkap media nasi. Jurnal Agrohita 2(2): 41-44.

Nursadin, I Suswanto, and Supriyanto. 2012. Screening of lignocellulolytic acidophilic antagonists from peat soil against fusarium wilt disease. Jurnal Perkebunan dan Lahan Tropika 2(1): 27-33.

Octriana L. 2011. Potensi agen hayati dalam menghambat pertumbuhan *Phytium* secara *in vitro*. Buletin Plasma Nutfah 17(2): 138-142.

Pakki S. 2016. Cemaran mitotoksin, bioekologi patogen *Fusarium verticillioides* dan upaya pengendaliannya pada jagung. Jurnal Penelitian dan Pengembangan Pertanian 35(1): 11-16.

Pamungkas PB and Ardiyanta. 2020. Meningkatkan pemahaman akan pengendalian OPT bawang putih pada anggota kelompok tani Ngudi Rahayu. Jurnal Pengabdian Masyarakat 3(2): 104-110.

Pujiastuti N, Hadiwiyono, and Subagiya. 2014. Peningkatan infeksi patogen busuk pangkal pada bawang putih oleh *Meloidogyne* dengan variasi kerapatan inokulum. Agrosains 16(1):1-6.

Purwantisari S, RS Ferniah, and B Raharjo. 2008. Pengendalian hayati penyakit lodoh (busuk umbi kentang) dengan agens hayati jamur-jamur antagonis isolat lokal. Jurnal Biologi dan Pembelajarannya 10(2): 13-19.

Putra IMTM, TA Phabiola, and NW Suniti. 2019. Pengendalian penyakit layu *Fusarium oxysporum* f.sp. capsici pada tanaman cabai rawit *Capsicum frutescens* di rumah kaca dengan *Trichoderma* sp. yang ditambahkan pada

kompos. Jurnal Agroekoteknologi Tropika 8(1): 103-117.

Putra MBI and S Purwantisari. 2018. Kemampuan antagonisme *Pseudomo-nas* sp. dan *Penicillium* sp. terhadap *Cercospora nicotianae in vitro.* Jurnal Biologi 7(3): 1-7.

Rahmawati, RA Setiawati, E Rusmiyanto PW. 2020. Pertumbuhan isolat jamur pasca panen penyebab busuk buah pisang ambon (*Musa paradisiaca* L.) secara *in vivo.* Jurnal Biologi Makassar 5(2): 210-217.

Reddy R. 2011. Cho's global natural farming. South Asia Rural Reconstruction Association (SARRA). Karnataka.

Risdianto H, T Setiadi, S H Suhardi, and W Niloperbowo. 2007. Pemilihan spesies jamur dan media imobilisasi untuk produksi enzim ligninolitik. Prosiding Seminar Nasional Rekayasa Kimia dan Proses: D-13-1 – D-13-6. Bandung.

Sarah, Asrul, and I Laksani. 2018. Uji antagonis jamur *Aspergillus niger* terhadap perkembangan jamur patogenik *Fusarium oxysporum* pada bawang merah (*Allium Cepa Agregatum* L. *aggregatum group*) secara *in vitro*. E-Jurnal Agroteknologi dan Agribisnis 6(2): 266-273.

Sari Widya, S Wiyono, A Nurmansyah, A Munif, and R Poerwanto. 2018. Keanekaragaman dan patogenisitas *Fusarium* spp. asal beberapa kultivar pisang. Jurnal Fitopatologi Indonesia 13(6): 216.

Satyagopal K, SN Sushil, P Jeyakumar, G Shankar, OP Sharma, D Boina, SK Sain, Ram Asre, KS Kapoor, S Arya, S Kumar, CS Patni, C Chattopadhyay, SA Pawar, A Shukla, U Bhale, K Basanagoud, HP Mishra, SD kabote, AY Thakare, AS Halepyati, MB Patil, AG Sreenivas, N Sathyanarayana and S Latha. 2014. AESA based IPM package for garlic. National Institute of Plant Health Management. Fariabad.

Sholihin Y, E Suminar, WH Rizky, and GG Pitaloka. 2016. Pertumbuhan eksplan meristem bawang putih (*Allium sativum* L.) kultivar tawangmangu pada berbagai komposisi kinetin dan GA3 in vitro. Jurnal Kultivasi 15(3): 172-178.

Soertaningsih, M Akil, and NN Andayani. 2015. Cendawan tular tanah (*Rhizoctonia solani*) penyebab penyakit busuk pelepah pada tanaman 38 jagung dan sorgum dengan komponen pengendaliannya. Ilmu Pengetahuan dan Teknologi Tanaman Pangan 10(2): 85-91.

Sopialena. 2018. Pengendalian hayati dengan memberdayakan potensi mikroba. Mulawarman University Press. Samarinda.

Suganda T and DY Wulandari. 2018. *Curvularia* sp. jamur patogen baru penyebab penyakit bercak daun pada tanaman sawi. Jurnal Agrikultura 29(3): 119-123.

Sujarwo W. 2017. Bamboo resources, cultural values, and Ex-Situ conservation in Bali, Indonesia. Reinwardtia 17(1): 67-75.

Suryani Y, O Taupiqurrahman, and Y Kulsum. 2020. Mikologi*.* PT. Freeline Cipta Granesia. Padang.

Susanti WI, R Widyastuti, and S Wiyono. 2015. Peranan tanah rizosfer bambu sebagai bahan untuk menekan perkembangan patogen *Phytophthora palmivora* dan meningkatkan pertumbuhan bibit pepaya. Jurnal Tanah dan Iklim 39(2): 65-74.

Titisari A, E Setyorini, S Sutriswanto, and H Suryantini. 2019. Kiat sukses budidaya bawang putih. Pusat Perpustakaan dan Penyebaran Teknologi Pertanian. Bogor.

Tozlu E, N Tekiner, R Kotan, and S Ortucu. 2018. Investigation on the biological control of *Alternaria alternata*. Indian

Journal of Agricultural Sciences 88(8): 1241-1247.

Watanabe T. 1937. Pictorial atlas of soil and seed fungi: Morphologies of cultured fungi and key to species. CRC Press. New York.

Ziedan ESHE, ESH Farrag, and AF Sahab. 2013. First record and preliminary evaluation of *Mucor hiemalis* as biocontrol agent on inflorescence brown rot incidence of date palm. Archives of Phytopathology and Plant Protection 46(5): 617-626.