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Controlling Diseases in Porang Plants (*Amorphophallus muelleri* Blume) Using Endophytic Fungi *In vitro*

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Porang is a bulbous plant which has great development prospect in Indonesia. Porang bulbs has huge potential product, however it hasn't managed well and optimal. Nowadays Porang bulbs are widely used as raw material for making mannan flour which has high economic value and widely used in the food sector. The Sampling is taking location at trial garden of Teluk Dalam Agriculture Faculty of Mulawarman University, in Karang Tunggal Village, Tenggarong Seberang District, Kutai Kartanegara Regency, East Kalimantan Province.

This research aims to identify key diseases affecting the Porang plants, investigate their causes, and evaluate the potential of endophytic fungi as biological control agents. Laboratory activities involve isolating and identifying endophytic fungi from healthy Porang plants and pathogenic fungi from diseased ones. The study employs a Completely Randomized Design for testing antagonistic properties.

The result shows that the endophytic fungi which was isolated on porang plants from research location in trial garden of Teluk Dalam Agriculture Faculty of Mulawarman University, in Karang Tunggal Village, Tenggarong Seberang District, Kutai Kartanegara Regency, East Kalimantan

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Province. There are three types of endophytic fungi, namely: *Gliocladium* sp., *Trichoderma,* and *Aspergillus flavus*, whereas pathogen fungi which has been found attack Porang plants is *Fusarium* sp. and *Colletotrichum* sp. Those three endophytic fungi against two pathogenic fungi have a resistance level *of Fusarium* sp x endophytic fungi with an average of 42.58% and the magnitude of resistance *is Colletotrichum* sp x endophytic fungi with average of 40.05%.

Keywords: Gliocladium sp.; Trichoderma sp.; Aspergillus flavus; Fusarium sp.; Colletotrichum sp.; Amorphophallus muelleri blume.

1. INTRODUCTION

Porang (*Amorphophallus muelleri* Blume) is bulbous plant which has great development prospect in Indonesia [1]. Porang bulbs has huge potential product, however it hasn't managed well and optimal, whereas nowadays Porang bulbs are widely used as raw material for making mannan flour which has high economic value and widely used in the food sector. This mannan substance can be used for adhesives, celluloid materials, cosmetics, food, textiles and paper industry**.** The need for Porang continues to increase and Indonesia exports Porang in the form of cassava or flour to Japan, Australia, Sri Lanka, Malaysia, Korea, New Zealand, Pakistan, England, and Italy [1].

The presence of pest plant organisms (OPT) is one factor which inhibit the growth of Porang. Some diseases which attack Porang plants is bulb rotten disease caused by *Fusarium* sp fungus that is Pathogenic fungi that can infect plants with a very wide host range. This fungus attacks the vascular tissue and causes wilting toward the host plant by inhibiting water flow in the xylem tissue. The spreading of the fungus *Fusarium* sp. is very fast and can spread to other plant by infecting the root plant which used tube sprouts or mycelium. Root plant can infect directly through root tissue, or through lateral roots and through wounds, which then settle and develop in vascular bundles. After entering the root plant, the mycelium will develop until it reach cortex root tissue. When fungi mycelium reach xylem, then this mycelium will develop until infect vessels xylem. Mycelium which has infected vessels xylem, will be carried away to other part of the plant so that it bothers the circulation of nutrition and water on plant that cause plants become wilt and foul [2,3].

Other important disease is *Anthracnose*. *Anthracnose* is one of plant disease which attack various types of crops and cause yield damage and significant economic losses. Attack disease which caused by *Colletotrichum* sp. fungi has been reported all over world. *Colletotrichum* Genus is known as a group of pathogenic fungi that has a very wide range of hosts, especially those which developed in tropical areas [4]. One species from this genus has the widest host range, that is *C. gloeosporioides* which has infected many plants from the Solanaceae family [4,5,6]. The presence of those diseases has important economic meaning because it causes a decrease in quality and quantity of Porang production.

The development of organic agriculture is a big goal in the agricultural sector. Disease control must be done without using chemical pesticides, so biological control is very important to achieve truly organic agriculture. Biological control, which is currently becoming a trend to be developed, is to use endophytic microorganisms, namely microbiota which can live and associate with host plants, which has many positive roles for plants without causing disease on plants. Based on research [7] stated that different endophytic fungi were found on the same plant, such as rice plants planted in different places. Based on many research results, also stated that endophytic fungi can act as a controller of the growth of pathogens that cause disease on plants [7].

Controlling Pathogen using endophyte fungi is one important approach in plant agriculture and protection. Endophyte is the living microorganisms that is lived symbiotically inside plant network without causing disease or damage on that plant. Endophyte fungi is the most common endophyte used in this context. Some reason why controlling pathogen using endophyte fungi is important because Natural Plant Protection: Endophyte fungi can protect plant naturally against pathogen attack. They inhabit in plant network and can compete with pathogen for resources, such as nutrition and living space. This reduces the possibility in which pathogen can grow and expand, reduce infection risk; the Reduction of Using Chemical Pesticide: By using endophyte fungi to control pathogens, farmers can reduce dependency on dangerous chemicals pesticide [8]. This matter has significant benefit toward environment because it

reduces environmental pollution and human health risk related to the using of pesticides; the Enhancement of Plant Productivity: Effectively endophyte fungi can increase plant productivity by reducing loss results causing by pathogen attack. Healthy and Strong plants have potential to produce better results; Reduced Production Costs: Using endophytic fungi for pathogen control can reduce production costs as it reduces the need for pesticides, as well as costs associated with plant diseases and intensive preventive measures; Agricultural Sustainability: The use of endophytic fungi can improve agricultural sustainability by reducing negative impacts on the environment and human health. It can also reduce soil degradation due to overuse of pesticides; Does Not Lead to Pathogen Resistance: One of the problems with using pesticides is that pathogens can develop resistance to the chemicals. The use of endophytic fungi as a pathogen control method is less likely to cause resistance due to different interactions with the pathogen; and Compatibility with Organic Approaches: The use of endophytic fungi is often more compatible with organic farming practices because they are natural control agents and do not contain synthetic chemicals [4,9,10].

Plant growth is greatly aided by the endophytic microbiome, which is also well known for its potential to produce bioactive chemicals with practical uses. Various bioactive natural products produced by endophytes include phenolic compounds, nitrogen compounds, vitamins, terpenoids, and other endogenous metabolites, as well as flavonoids, quinones, lignans, lignin, stilbenes, and tannins. Meanwhile, endophytic fungi are isolated from various parts such as leaves, stems, roots, flowers, fruits [1,11]. Pathogen control using endophytic fungi is an important approach to increase agricultural productivity, reduce the use of chemical pesticides, and support sustainable agriculture. However, it is important to remember that the effectiveness of endophytic fungi can vary depending on the type of plant, type of pathogen, and farm environment, so careful research and management are needed to achieve optimal results [12]

This study aims to identify important diseases on Porang (*Aspergillus muelleri Blume*) plants; explore endophytic fungi for those found on Porang plants and determine the ability of endophytic fungi found to suppress the growth of pathogens that cause diseases on Porang (*Aspergillus muelleri Blume*) plants.

2. MATERIALS AND METHODS

This research was conducted at the Plant Pest Disease Laboratory, OECF Building, Faculty of Agriculture, Mulawarman University. Materials used in the manufacture of Potato Dextrose Agar media, chloramphenicol, distilled water. Potatoes and dextrose are ingredients that are rich in the main nutrients for fungi, agar is a solidifier of the media, chloramphenicol is an ingredient that serves to prevent bacterial contamination.

The research design used in this study is a completely randomized design (CRD) with 10 repetitions. Those treatments are *Gliocladium* sp vs *Fusarium* sp (P1); *Trichoderma* sp. *vs Fusarium sp* (P2); *Aspergillus flavus vs Fusarium sp* (P3); *Gliocladium sp vs Cholletotrichum sp* (P4); *Trichoderma sp vs Cholletotrichum sp* (P5); *Aspergillus flavus vs Cholletotrichum sp* (P6)

2.1 Sampling Location

The sampling location in this study was located in the Mulawarman University experimental garden in Karang Tunggal Village, Tenggarong Seberang District. Samples taken from healthy Porang plants and sick Porang plants. The parts of the Porang plant that were sampled were roots, stems, leaves.

2.2 Preparation of Potato Dextrose Agar (PDA) Media

The materials used are potatoes as much as 200g, agar 20g, dextrose 20g and water approximately 500 ml. Potatoes are peeled and cut by 1 cm and put in 500 ml of water that has been heated on the stove, the potato stew is filtered to take the juice, after which agar and refined sugar are added and water is added until the solution becomes 1 L, chloramphenicol is added as much as 2 seeds, wait until it boils. After boiling, the PDA is put into a sterilized Erlenmeyer tube and cover the surface using cotton and aluminum foil. After that, put it in an autoclave to be sterilized at a pressure of 1.5 atm for 15 minutes. The media is ready to be used for isolation.

2.3 Isolation of Endophytic Fungi and Pathogenic Fungi

Isolation of endophytic fungi and pathogenic fungi is carried out by isolating the roots, stems, and leaves of healthy and diseased Porang plants, cut 1cm starting with washing the plant parts using alcohol. NaOCl solution 5% and

distilled water alternately for 1 minute. After cleaning, the sample pieces are planted on PDA media, make observations after 5 days and identified under a compound microscope by matching macroscopic or microscopic morphological characters based on guidelines [13].

2.4 Purification and Propagation of Fungi

Fungal purification is carried out from the results of isolation and identification of fungi that have been carried out previously. After identification, the fungal colonies are separated then take the spores using an ose needle and placed into a Petri dish containing new PDA media. Then the Petri dish was wrapped in plastic cling wrap.

Propagation of endophytic fungi and pathogenic fungi is done by harvesting fungi that have grown on PDA media after purification and transferring the fungal culture to new PDA media in order to obtain a large number of isolates.

2.5 *In vitro* Antagonism Test

In vitro antagonistic tests using the two-culture method were conducted in a 9 cm diameter petri dish containing PDA media. The inoculum of endophytic fungi and pathogenic fungi were planted side by side on the Petri dish media, each 3 cm away from the edge of the dish. Observations were made for seven days and the percentage of inhibition was calculated.

3. RESULTS AND DISCUSSION

3.1 Fungal Morphology

The results of identification in the Laboratory of Plant Pests and Diseases, Faculty of Agriculture, Mulawarman University, found several fungi in Porang plant tissue. Endophytic fungi namely, *Aspergillus flavus, Gliocladium sp,* and *Trichoderma sp* while pathogenic fungi that are in Porang plant tissue are *Fusarium sp* and *Colletotrichum.*

3.1.1 Endophytic fungi on porang plant

Aspergillus flavus:

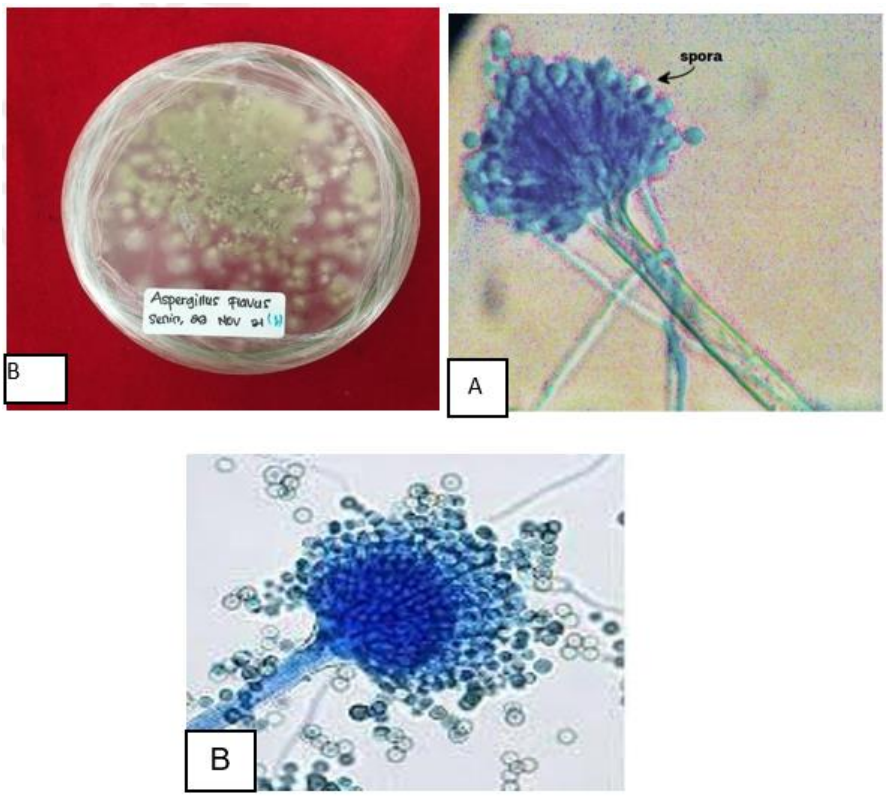


Fig. 1. A. Colony of *Aspergillus flavus* fungus *B. Conidiospores* and *Conidiophores of Aspergillus flavus* (100x) C. Illustration of *Aspergillus flavus* spores [13]

Macroscopically *Aspergillus flavus* fungal isolates that appear on petri dishes are green colonies, colorless conidiophores, rough, slightly rounded tops and rough conidia, non-circumscribed hyphae. According to guidebooks [13] and [14], microscopically *Aspergillus flavus* has long conidiophores (400 - 800 µm) and is relatively rough, the shape of the conidial head varies from columnar, radial, and spherical shapes (Fig. 1 B) [13], hyphae are intercepted, and colonies are compact. Colonies of *Aspergillus flavus* generally grow rapidly and reach a diameter of 6-7 cm in 10 - 14 days [13].

The results of the study obtained *Aspergillus flavus* colonies are granular, flat, with radial grooves, yellow in color at first but quickly become light to dark yellow green with age. The head of the conidiophore usually radiates, then divides to form a loose column (300-4000 in diameter), biseriate but has several philaid heads that are directly carried on the vesicle (uniseriate). Conidiophore stipes are hyaline and leathery. Conidia are globose to sub globose (3-6 in diameter), some strains produce brownish sclerotia [13]. *Aspergillus flavus* is a thread-shaped fungus and its spores are always in the air. This fungus can grow at temperatures between 17-42 with an ideal temperature of 15-30. Growth is optimal if the water content ranges between 15-30% with 87-98% humidity [15].

a. Trichoderma sp

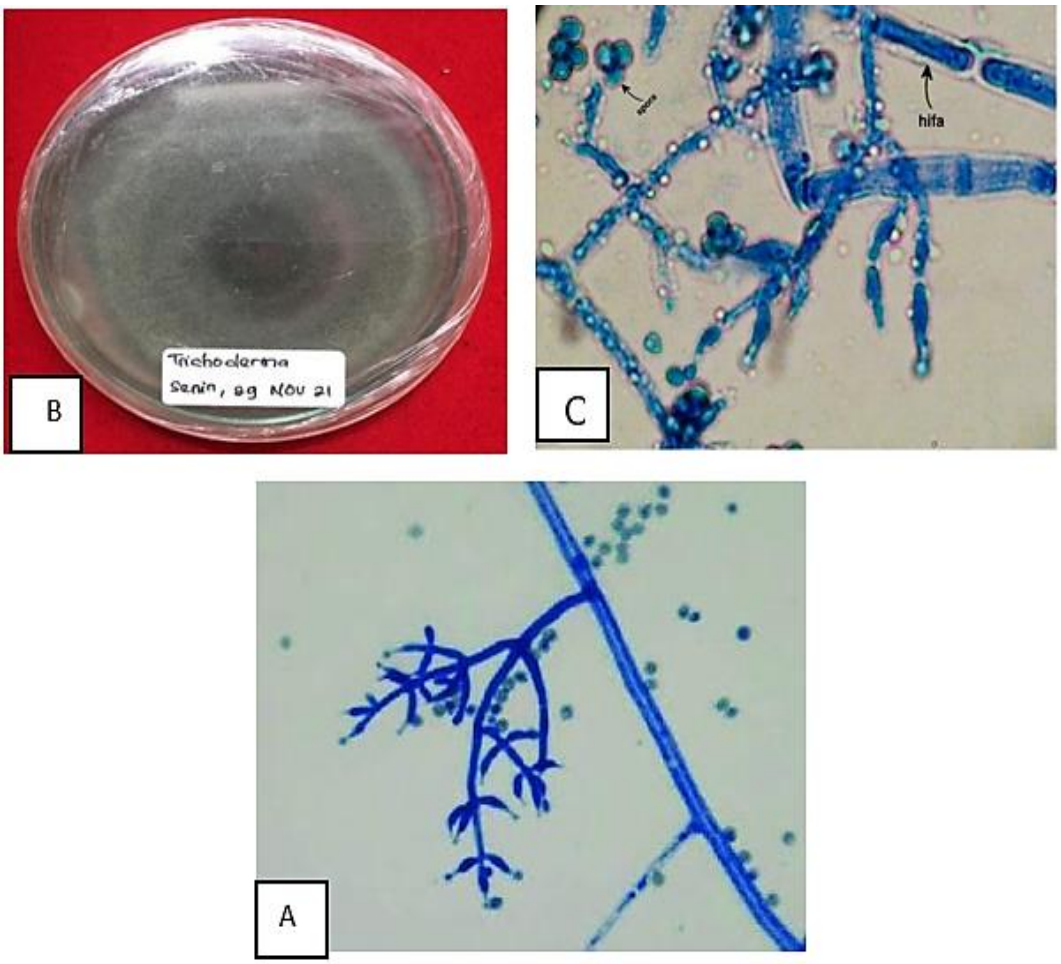


Fig. 2. A. Colonies of *Trichoderma* sp B. Hyphae and Spores of *Trichoderma* sp (100X) C. Spores and hyphae of *Trichoderma* sp [13]

Trichoderma sp. fungal macroscopically has the initial shape of a white colony and eventually turns dark green in the middle of the colony surrounded by mycelium which is still white and in the end the entire medium will be green. In accordance with the opinion of [16], (8) his research which says *Trichoderma* sp. on PDA media visually has a dark green color with a circular shape and the direction of growth that spreads in all directions, this fungus has a cotton-like texture. *Trichoderma* sp. is a type of fungus that is widespread in the soil and has microparasitic properties, while microscopically *Trichoderma* sp. has unconcentrated hyphae, at the end of the philaid there are conidia, has a lot of branching on conidiophores. In accordance with the statement of having round conidia, the hyphae possessed by this fungus are non-concentrated and smooth-walled, have hyphal branching that resembles a pyramid with philaids arranged in different groups between 2-3 philaids per group. The results of observations of morphological characteristics of *Trichoderma* isolates macroscopically and microscopically were matched with the identification book of fungal descriptions by [13].

Trichoderma sp. is an endophytic fungus that is able to produce growth hormones and control pathogenic fungi because it produces antibiotics such as *alametichin, paracelsin, trichotoxins* that can destroy fungal cells through damage to cell membrane permeability, and produces the enzyme.

b. Gliocladium sp

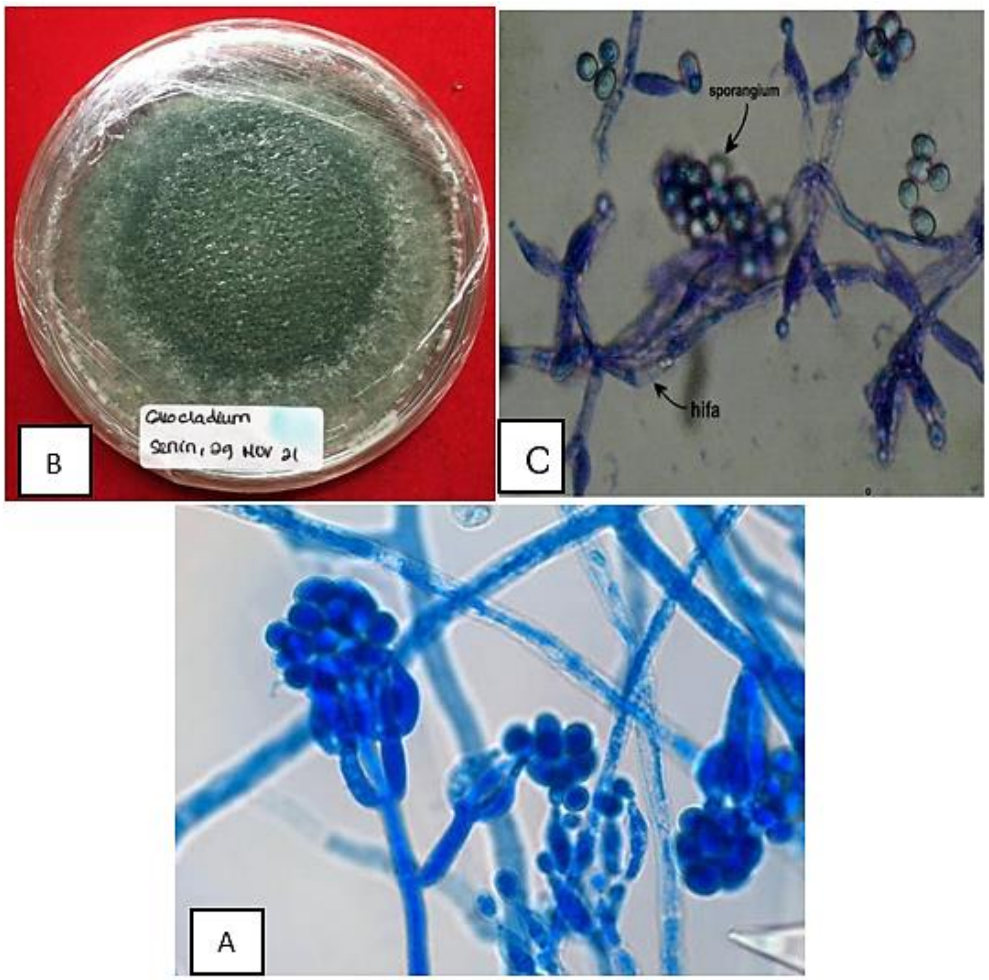


Fig. 3. A. Colony of *Gliocladium* sp B. Hyphae and Sporangium *Gliocladium* sp (100X) C. Hyphae and spores of *Gliocladium* sp [13]

Gliocladium sp. fungus macroscopically morphologically the color of the colony is greenish white, round, thin mycelium like velvet [12], while microscopically, *Gliocladium* sp. fungus has hyphae that are insulated with upright conidiophores, philaids form groups at the end of conidiophores and spores are round [13].

Gliocladium sp. is an endophytic fungus known to be able to parasitize pathogenic fungi, *Gliocladium* sp. and produce growth hormones that can spur plant growth and produce gliovirine and viridine compounds that can suppress the growth of pathogens [17].

3.1.2 Pathogenic fungi on porang plants

a. Fusarium sp

Fusarium sp fungus macroscopically the colony is white like cotton, then turns slightly yellowish white or beige, while microscopically the conidia are curved like a crescent moon, consisting of 3-5 septa, *Chlamydospores* have thick walls, produced at the end of the old mycelium or inside the macroconidia, consisting of 1-2 septa [13,10]

b. Collectotrichum sp

Fungus *Colletotrichum* sp macroscopically the color of the colony is white grey, the reverse of the colony is blackish brown, the growth is slow (3-6 mm in 24 hours), and in old cultures (more than 15 days) black stains appear on the surface of the colony, meanwhile microscopically it has concentrated and branched hyphae and produces transparent and elongated conidia with rounded or tapered ends between 10-16 µm long and 5-7 µm wide with black conidia mass [13,18,19].

Growth Rate: The growth rate of fungal colonies was carried out for seven days from the first day to the seventh day are presented in (Table 1).

Based on the Table 1 toward the average of fungal diameter. Fungal endophyte *Trichoderma* sp*, Gliocladium* sp, and *Aspergillus flavus* in 7 days are 5.71 cm, 5.93 cm and 5.26 cm, meanwhile fungal pathogen *Fusarium* sp and *Colletotrichum* sp are 4.74 cm and 3.11cm (HSI).

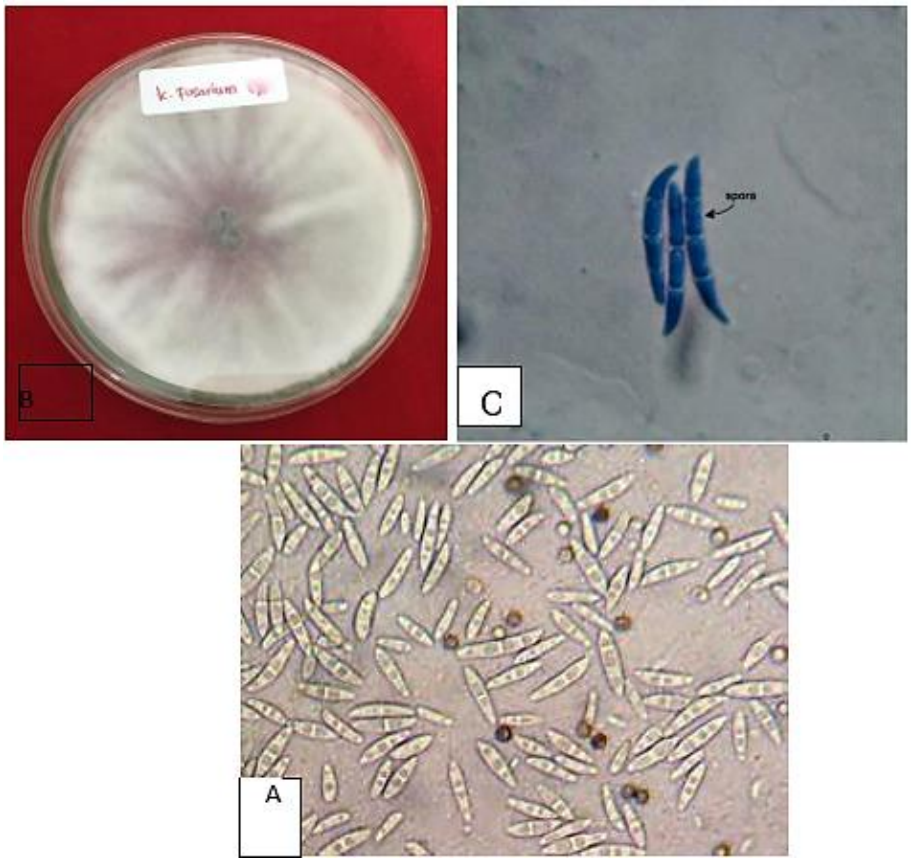
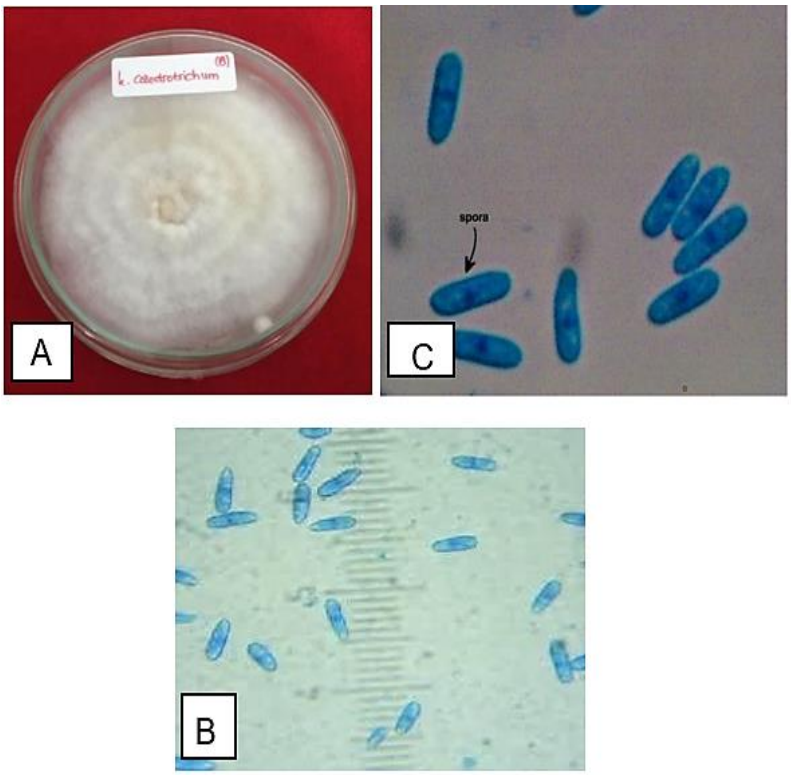


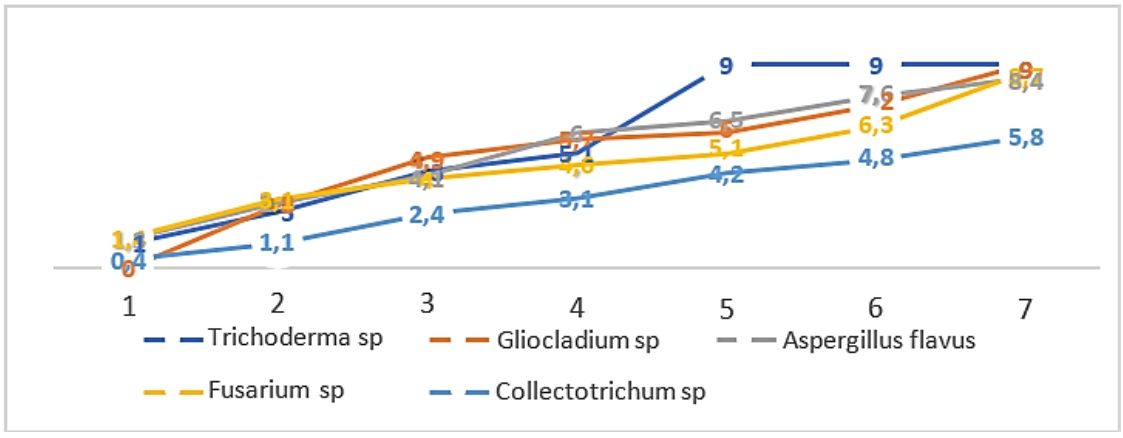
Fig. 4. A colony of *Fusarium* sp B. *Fusarium* spore (100X) C. *Fusarium* spore sp [13]



Picture 1. A. Colony *Colletotrichum* sp B. Spores *Colletotrichum* sp (100X) C. Spores *Colletotrichum* sp [13]

Table 1. Observation of the average diameter of fungal endophyte colony and fungal pathogen (cm)

Fungal Names	Observation Day to							Average
	1	2	3	4	5	6	7	
Trichoderma sp	1.1	2.5	4.3	5.1	9	9	9	5.71
Gliocladium sp	0.7	2.8	4.9	5.7	6	7.2	9	5.93
Aspergillus flavus	1.3	2.9	4.1	6	6.5	7.6	8	5.26
Fusarium sp	1.4	3.1	4	4.6	5.1	6.3	9	4.74
Colletotrichum sp	0.4	1.1	2,4	3.1	4.2	4.8	6	3.11
Average								4.95



Picture 2. Diagram of the growth of fungal endophyte and Pathogen diameter

Density Spores:

The highest spore density of endophytic fungi was obtained by *Trichoderma* sp at 96.3 x 10-4, *Aspergillus flavus* at 78.7 x 10-4, and *Gliocladium* sp at 27.4 x 10-4, while the pathogenic fungus *Fusarium* sp had a spore density of 32.6 x 10-4 and *Colletotrichum* sp at 42.8 x 10-4.

Trichoderma sp and *Aspergillus flavus* fungi produce many spores and rapid growth and produce substances that can inhibit the development of pathogenic fungi [16]. The high density of spores does not show high inhibition as well, because each endophytic fungus has a different enzyme content and the success of a microorganism in inhibiting pathogens is not only influenced by environmental factors and the number of spores, but also influenced by germination power (spore viability) and virulence [12,15].

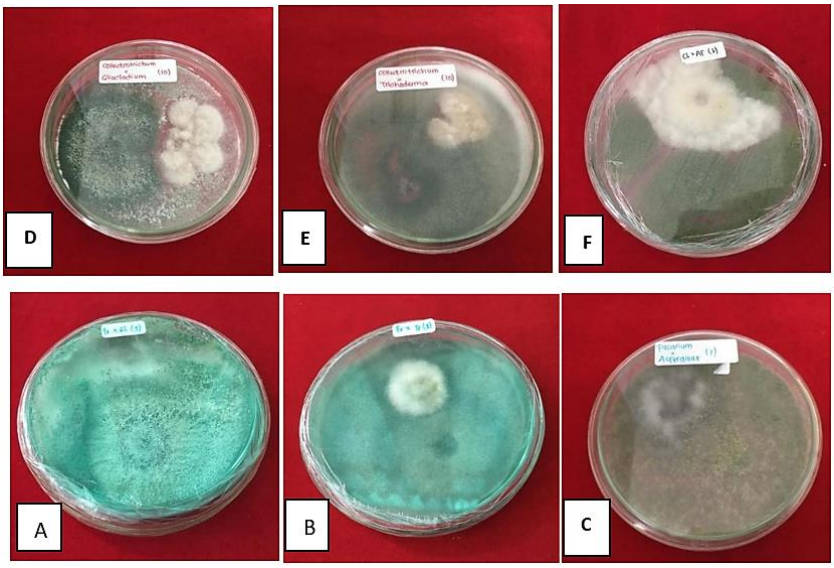
Percentage of Inhibition: The results of the variance test of the antagonistic power of antagonistic fungi against pathogenic fungi showed very significant differences. The average inhibition of each antagonistic fungus against pathogenic fungi on day 7 observation is presented in Table 3.

P1: *Gliocladium* sp vs *Fusarium* sp, P2: *Trichoderma* sp vs *Fusarium* sp, P3: *Aspergillus flavus* vs *Fusarium* sp, P4: *Gliocladium* sp vs *Colletotrichum* sp, P5: *Trichoderma* sp vs *Colletotrichum* sp, P6: *Aspergillus flavus* vs *Colletotrichum* sp

In-vitro inhibition test percentage of antagonistic fungi against fungi that cause pathogens on Porang plants, the highest percentage of inhibition in testing *Fusarium* sp vs *Trichoderma* sp with an average of 48.89% followed by *Fusarium* sp vs *Gliocladium* sp with an average of 43.97% and *Fusarium* sp vs *Aspergillus flavus* with an average of 34.58%. *Trichoderma* sp fungus is an isolate that has the highest percentage because this fungus is able to antagonize other fungi with faster growth.

The highest percentage of inhibition in testing *Colletotrichum* sp vs endophytic fungi is *Colletotrichum* sp vs *Gliocladium* sp with an average of 47.14% followed by *Colletotrichum* sp vs *Trichoderma* sp with an average of 38.13% and the lowest percentage of inhibition is *Colletotrichum* sp *Aspergillus flavus* with an average of 35.57%.

Trichoderma sp, *Aspergillus flavus* and *Gliocladium* sp. can be used as biocontrol agents against several soil-borne pathogenic fungi because they can produce extra-cellular enzymes glucose, and chitinase, which can dissolve the cell walls of pathogens [9,2,11].



Picture 3. (A) Mechanism antagonist *Gliocladium* sp vs *Fusarium* sp. (B) Mechanism antagonist *Trichoderma* sp vs *Fusarium* sp. (C Mechanism antagonist *A. flavus* vs *Fusarium* sp. (D) Mechanism Antagonist *Gliocladium* sp vs *Chollectotrichum* sp. (E) Mechanism *Trichoderma* sp vs *Chollectotrichum sp* antagonist (F) Mechanism antagonist *A. flavus* vs *Chollectotrichum* sp

Table 2. Density spores of fungal endophyte and pathogen

Fungal Names	Density Spores
***Trichoderma* sp**	96.3 x 10^4
***Gliocladium* sp**	27.4 x 10^4
Aspergillus flavus	78.7 x 10^4
***Fusarium* sp**	32.6 x 10^4
***Colletotrichum* sp**	42.8 x 10^4

Table 3. Percentage of inhibition test of antagonistic fungi against fungi on Porang plants

Treatment	Average
P6	33.40a
P3	34.86a
P5	42.62b
P1	43.97bc
P4	44.13bc
P2	48.89c

Description: Average scores which followed by the same letters showed no significant difference on the 5% BNT test (BNT= 3.04)

4. ANTAGONISTIC MECHANISM

The antagonistic mechanism of endophytic fungi against pathogenic fungi was carried out for seven days after incubation. The observation results are presented in (Table 4). The antagonistic mechanism shows that the two fungi tested suppress each other's growth, in this observation there are three mechanisms observed, namely competition, antibiosis, and parasitism.

Picture 3. (A) Mechanism antagonist *Gliocladium* sp vs *Fusarium* sp. (B) Mechanism antagonist *Trichoderma* sp vs *Fusarium* sp. (C) Mechanism antagonist *Aspergillus flavus* vs *Fusarium* sp. (D) Mechanism Antagonist *Gliocladium* sp vs *Chollectotrichum* sp. (E) Mechanism *Trichoderma* sp vs *Chollectotrichum sp* antagonist (F) Mechanism antagonist *Aspergillus flavus* vs *Chollectotrichum* sp.

The inhibitory mechanism of antagonistic fungi against pathogenic fungi up to seven after incubation. Macroscopic observations showed that all isolates of antagonistic fungi had a competition mechanism, namely isolates of *Gliocladium* sp vs *Fusarium* sp, *Trichoderma* sp vs *Fusarium* sp, *Aspergillus flavus* vs *Fusarium* sp, *Gliocladium* sp vs *Colletotrichum* sp, *Trichoderma* sp vs *Colletotrichum* sp, *Aspergillus flavus* vs *Colletotrichum* sp. It was seen that the growth of endophytic fungi was faster than the growth of pathogenic fungi. According to [1,10,12,20] that the antagonistic agent *Trichoderma* sp. lives as a hyperparasite, produces antibiotics namely glyoxin and viridian, so it has the ability to grow faster, resulting in competition for nutrients and space. The antagonistic mechanism of endophytic fungi against pathogenic fungi is competition and antibiosis. Types of competition antagonists were obtained from observations on *Fusarium* sp and *Colletotrichum* sp., types of competition and parasitism antagonists were obtained from observations on *Fusarium* sp vs *Trichoderma* sp, *Fusarium* sp vs *Gliocladium* sp, *Colletotrichum* sp vs *Tricoderma* sp and *Colletotrichum* sp vs *Gliocladium*.sp, while the antibiosis antagonist mechanism was obtained from observations of *Fusarium* sp vs *Aspergillus flavus* and *Colletotricum* sp vs *Aspergillus flavus* [21,22]. This is in accordance with the statement of Octriana [12] that *Trichoderma* sp and *Gliocladium* sp. antagonize pathogenic fungi with antagonistic types of competition and parasitism, while the fungus *A. flavus*. antagonizing fungal pathogens with antibiosis type antagonists. [12,23,7,17].

Aspergillus flavus, Trichoderma sp., and *Gleiocladium* sp. are fungi known to be an effective biological control agent in controlling various plant pathogens, including *Fusarium* and *Colletotrichum* spp. *Trichoderma*'s ability to control these pathogens is related to several biological mechanisms and complex interactions. Some reasons why *Aspergillus flavus, Trichoderma* sp. and *Gleiocladium* sp. are able to control *Fusarium* and *Colletotrichum* sp. Space and Nutrient Competition: *Aspergillus flavus, Trichoderma* sp. and *Gleiocladium* sp. are able to grow faster than *Fusarium* and *Colletotrichum* spp. in the same environment [19].

Table 4. The antagonistic mechanism of endophytic fungi against the fungus

Treatment	Type of Mechanism		
	Competitive	**Parasitism**	**Antibiosis**
P1 (*Gliocladium* sp vs *Fusarium* sp)	+	+	-
P2 (*Trichoderma* sp vs *Fusarium* sp)	+	+	-
P3 (*Aspergillus flavus* vs *Fusarium* sp)	+	-	+
P4 (*Gliocladium sp* vs *Collecotrichum* sp)	+	+	-
P5 (*Trichoderma sp* vs *Collecotrichum* sp)	+	+	-
P6 (*Aspergillus flavus* vs *Collecotrichum* sp)	+	-	+

Description: An antagonistic mechanism occurs (+). There is no antagonistic mechanism (-).

Trichoderma produces enzymes such as *chitinase* and *glucanase* that can damage the cell wall of the pathogen, thus taking nutrients from the pathogen and inhibiting its growth; Antibiosis: *Aspergillus flavus, Trichoderma* sp. and *Gleiocladium* sp. produce various antimicrobial compounds such as antibiotics, peptides and enzymes that can kill or inhibit the growth of *Fusarium* and *Colletotrichum* spp. These compounds have strong antimicrobial activity and can inhibit the development of pathogens; Induction of Plant Defense System: *Aspergillus flavus, Trichoderma* sp. and *Gleiocladium* sp. can also stimulate plant defense systems (such as immune responses) through the production of certain compounds such as elicitors. This can make plants more resistant to pathogen attack, including *Fusarium* and *Colletotrichum* spp.; Parasitism: Some species of *Aspergillus flavus, Trichoderma* sp., and *Gleiocladium* sp. also have the ability to become direct parasite to *Fusarium* and *Colletotrichum* spp. [16,15].

With various control mechanisms such as competition, antibiosis, induction of plant defence systems, parasitism, and interaction with the *rhizosphere*, *Aspergillus flavus* sp., *Trichoderma* sp. and *Gliocladium* sp. can be very effective tools in controlling the pathogens *Fusarium* and *Colletotrichum* spp. As a biological control agent, *Trichoderma* also has the advantage of not having a negative impact on the environment and human health, such as chemical pesticides [10,15].

5. CONCLUSION

1. Endophytic fungi found in Porang plants are *Trichoderma* sp on the roots, *Aspergillus flavu*s on the stem, and *Gliocladium* sp and pathogens found are *Fusarium sp* fungus causing tuber rot and *Colletotrichum* fungus sp. causing Anthracnose disease*;*
2. *Trichoderma* endophytic fungi have the highest inhibitory power with an average of 48.89% in *In-vitro* testing against *Fusarium* sp and followed by *Gliocladium fungus* sp with an average of 44.13% in *in-vitro* testing against *Colletotrichum* sp.
3. The endophytic fungi *Trichoderma* sp., *Gliocladium* sp., and *Aspergillus flavus* sp. can be used as biological control agents of *Fusarium* sp. and *Colletotrichum* sp.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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