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Pathogenic Fungi Causing Disease on Merbau Plants (*Intsia* spp.) in Sawesuma Village Forest, Urunum Guay District, Jayapura Regency

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ABSTRACT

Plant diseases result from the interaction of virulent pathogens, susceptible host plants, and favorable environmental conditions, often indicated by the appearance of growth abnormalities, referred to as symptoms, across various plant parts.This study aims to identify the species of Intsia plants affected by diseases and to determine the types of fungi responsible for causing diseases in *Intsia* sp. This research involved field surveys, observations, and sampling of pathogenic fungi, followed by fungal isolation and identification at the Mycology Laboratory and the FMIPA Biology Laboratory, Cenderawasih University, Jayapura. The methods employed included site surveys, sampling, isolation of pathogenic fungi causing diseases in *Intsia* sp. , identification of disease-causing fungi, and pathogenicity testing. Based on observations, the Intsia species affected by diseases were *Intsia bijuga* and *Intsia palembanica.* Four fungal species were identified as disease-causing agents in Intsia plants, including *Aspergillus* sp., *Penicillium* sp., *Fusarium* sp., and *Mucor* sp., along with one unidentified fungal species.

Key words: fungi; Jayapura; merbau (*Intsia* sp.); Sawesuma forest

INTRODUCTION

Merbau wood (*Intsia* spp.) has high economic value in both national and international markets due to its strong texture and resistance to wood-decaying fungi. The quality of merbau wood falls into strength class I, is resistant to dry wood termites, and belongs to durability class II, making it suitable as a raw material for building construction and household utensils (Gunawan *et al*., 2024). Merbau trees are a superior plant species in Papua forests because of their hard wood, which is why Papuan people often refer to them as "ironwood" (Sirami *et al*., 2018; Suharno *et al*., 2023).

Excessive exploitation of merbau wood (*Intsia* spp.) from forest areas has led to a decline in its abundance, making the species increasingly rare. The IUCN Red List v3.1 in 2020 classified merbau as "near threatened with extinction in the wild in the near future" (IUCN Red List of Near Threatened Species 2020). Meanwhile, conservation efforts remain limited and need to be enhanced to prevent extinction (Suharno *et al*., 2023). On the other hand, a decline in the quality of Intsia plants is also caused by other factors, such as infection by pathogenic diseases. Plant disease refers to a change or disruption in one or more parts of the physiological energy processes, resulting in a loss of coordination within the host (Tasik *et al*., 2023).

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Merbau plants (*Intsia* spp.) can be infected by fungi through spores that grow on young plant tissues, particularly on the leaves. Since leaves contain chlorophyll, this can inhibit the process of photosynthesis, causing the leaves to turn yellow and dry. According to Anshori *et al.* (2024), merbau plants are particularly susceptible to disease infections on their leaves. In general, Syifaudin *et al*. (2022) also noted similar conditions in sengon trees, where morphological changes such as the appearance of bright yellow spots on the leaves can spread, eventually turning the leaves yellow and dry.

Furthermore, in the stems of merbau trees infected by fungi, wilting symptoms may appear and the roots are often covered with fungal mycelium (Firmansyah *et al*., 2020). Merbau trees showing symptoms of fungal infection are likely affected due to the hot and humid climate of tropical countries like Indonesia, which provides an ideal environment for fungal growth. Plants are more vulnerable to diseases due to the interaction of pathogens, environmental conditions, and plant physiological state. Pathogens enter through openings in the plant's defense system, such as wounds or weakened tissue (Leu *et al*., 2021).

Therefore, the aim of this study is to identify the diversity of pathogenic fungi that infect *Intsia* spp. and cause disease. The results of this research can serve as a foundation for understanding fungal infections in merbau plants and the resulting plant diseases. In cultivation efforts, this information is crucial to prevent failures during the seedling process.

MATERIALS AND METHODS

Time and place of research

This research was conducted in Unurum Guay District, Jayapura Regency, Papua, from November to March 2021. The sampling site was located in the Sawesuma Village Forest, situated at 2°28'44.18" S and 139°49'22.80" E (Figure 1).

A field survey was carried out through site visits to the Sawesuma Village Forest, aimed at obtaining information regarding the presence of merbau wood trees (*Intsia* sp.) that were affected by pathogenic fungal diseases.

Pathogenic fungi isolation in merbau plant (*Intsia* sp.)

Isolation of pathogenic fungi on *Intsia* plants was carried out on the leaves, stems, and roots. Samples were taken to the laboratory for fungal isolation. For leaves, those showing symptoms of fungal infection were cut into square sections measuring 5–10 mm at the lesion edges. These pieces were then sterilized using a chloroform solution. Afterward, the leaf pieces were dried on

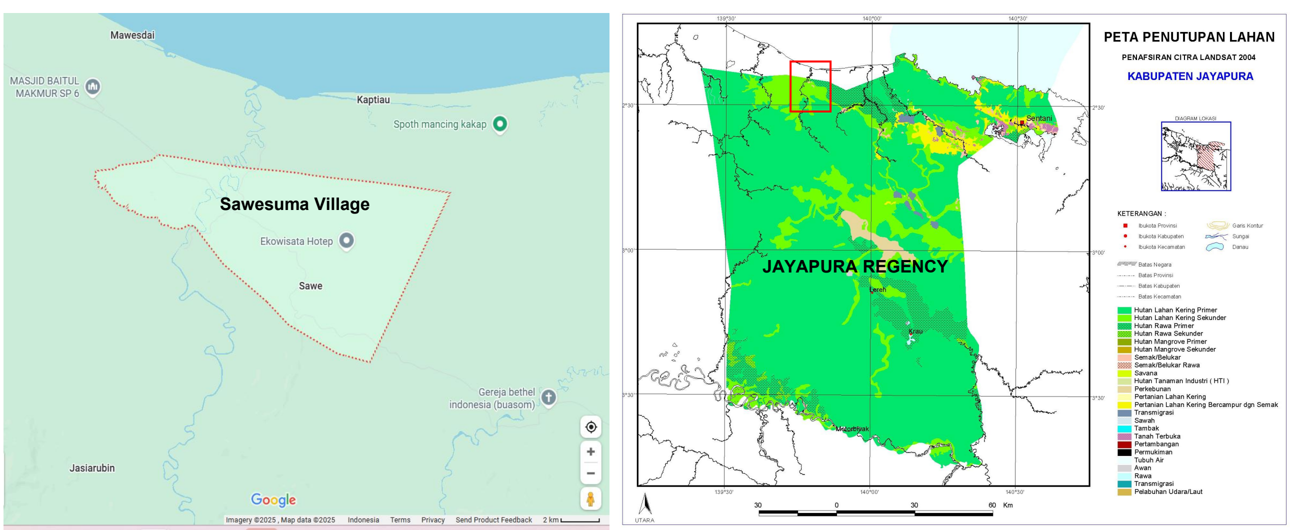

Figure 1. Locations samples taken (coordinate, S: 2°28′44.1″, E: 139°49′22.8″).

sterile filter paper and transferred into petri dishes containing Sabouraud Dextrose Agar (SDA) medium using sterile forceps (Agrios, 1996; Shivas & Beasley, 2005; Umayah & Purwantara, 2006).

For stems, those showing early symptoms were cut and immersed in chloroform solution for 3 minutes. The stem pieces were rinsed with distilled water three times and then dried with sterile blotting paper in a petri dish. The pieces were placed on a glass slide or other support to avoid direct contact with the moist blotting paper (Agrios, 1996). For roots, samples showing disease symptoms were cleaned with distilled water.

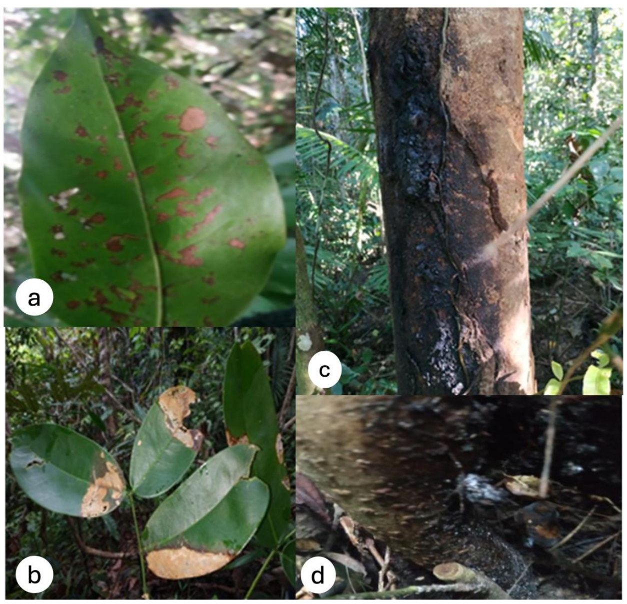

Figure 2. Symptoms of disease in *Intsia* sp. plants include: spotting and wilting on the leaves (a and b), lesions on the stem accompanied by the exudation of brownish fluid (c), and white spots appearing on the surface of the roots (d).

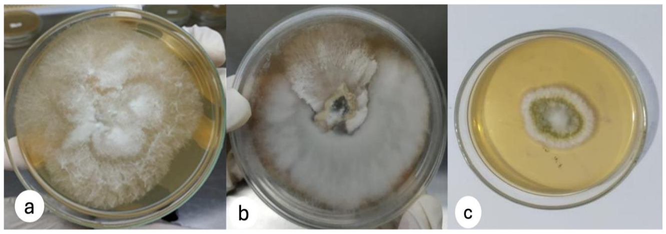

Figure 2. Fungal isolates obtained from *Intsia* plants: (a) isolate from root, (b) isolate from stem, and (c) isolate from leaf.

Roots were then cut into 5–10 mm sections. These root sections were immersed in chloroform solution for several minutes. The pieces were then rinsed individually with sterile distilled water (Agrios, 1996).

Purification of pathogenic fungal isolates

Purification of the pathogenic fungi was carried out by cutting part of the fungal mycelium and aseptically transferring it using an inoculation needle onto SDA medium. Pure cultures were then observed macroscopically and microscopically for identification. Maintenance of pure cultures was done by incubating them in an incubator at 28°C (Nakagiri, 2005).

Identification of pathogenic fungi

Identification of the pathogenic fungi was done by preparing slides. A pure culture was smeared aseptically using an inoculation needle on the surface of a glass slide containing 10% KOH solution and then stained with Parker ink until evenly distributed. Observations were made using a light microscope at various magnifications (Pohan, 2011). Identification was based on the books by Barnett & Hunter (1997) and Alexopoulos (1996). Identification of fungi was done by observing several macroscopic and microscopic morphological characteristics. Macroscopic observations included colony color, texture, shape, and edge form. Microscopic observations included hyphal structures, reproductive organs, spore and conidia shape (Apdillah *et al*., 2024).

Pathogenicity test

The pathogenicity test was conducted using Koch's Postulates method on sterilized *Intsia sp.* leaves, stems, and roots. The plant tissues were wounded and then inoculated with fungal cultures, covered with sterile moistened cotton, and sealed with tape. Disease incidence was determined based on visible symptoms.

Data analysis

Data were analyzed descriptively based on the types of fungi causing disease by observing symptoms on *Intsia sp.* plants. Fungal identification referred to the books by Barnett & Hunter (1972), Alexopoulos (1996), and previous research journals.

RESULTS AND DISCUSSION

General description of the research location
Sawesuma Village is located within the Unurum Guay District. The village is situated in an area that remains predominantly forested. The Sawesuma

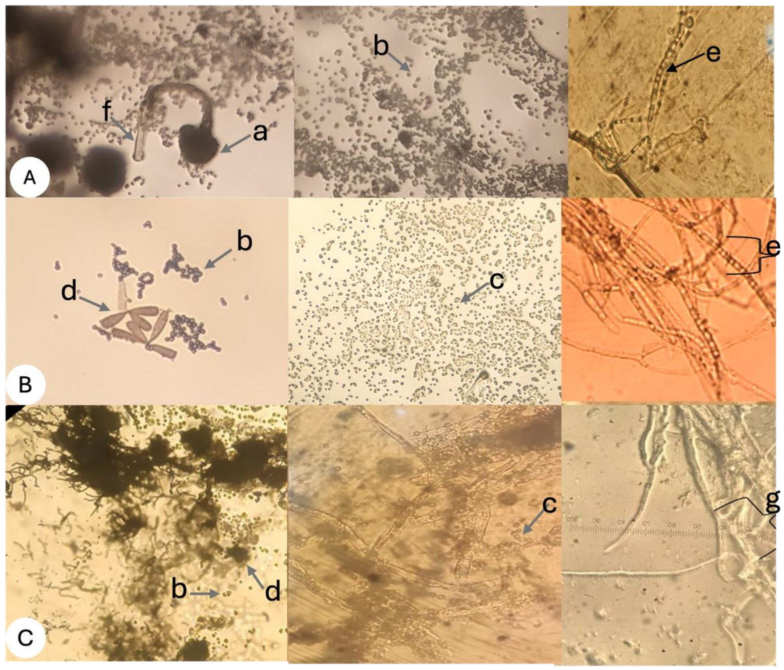

Figure 3. A. Microscopic view of *Aspergillus* sp. B. Microscopic view of *Fusarium* sp. C. Microscopic view of *Mucor* sp.; a. conidial head, b. conidia, c. spores, d. macroconidia, e. septate hyphae, f. conidiophore, g. non-septate hyphae.

Table 1. Results of fungal isolation based on macroscopic and microscopic characteristics.

Morphological Characteristics	Isolate of fungi		
	Aspergillus sp.[1)]	*Fusarium* sp.[2)]	*Mucor* sp.[3)]
Macroscopic			
Colony shape	Reguler	Reguler	Reguler
Colony color	Green	White	White
Reverse colony color	White	White	White
Colony margin	Smooth	Lobed	Thread-like
Elevation	Raised	Convex	Raised
Colony texture	Velvety	Cottony	Cottony
Colony diameter	7.6 cm	5.3 cm	8 cm
Microscopics			
Hyphae	Septate	Cottony	Cottony
Conidia shape	Round	Round	Round
Conidiophore	Single	Branched	Branched

Note: [1)] Isolated from leaf tissue, [2)] Isolated from stem tissue, [3)]Isolated from root tissue

Table 2. Observation of Koch's postulates on *Intsia* sp. plants

Isolate	Infected organ	Treatment		Symptoms caused	
		Wounded	Scratched	Formmation	Colour
D1.1	Leaf	√	-	Irreguler	Pale Yellow
D1.2	Leaf	-	√	Circular in the Centre	Dark Brown
D2.1	Leaf	√	-	Irregular	Dark Brown
D2.2	Leaf	-	√	Irregular with small spots	Light Yellow with Slight white
B1.1	Stem	√	-	Irreguler and spreading	Light Yellow with Slight white
B1.2	Stem	-	√	Oval	Blackish brown
B2.1	Stem	√	-	Irregular	Dark Brown
B2.2	Stem	-	√	Curcular and Spreading	Dark Brown

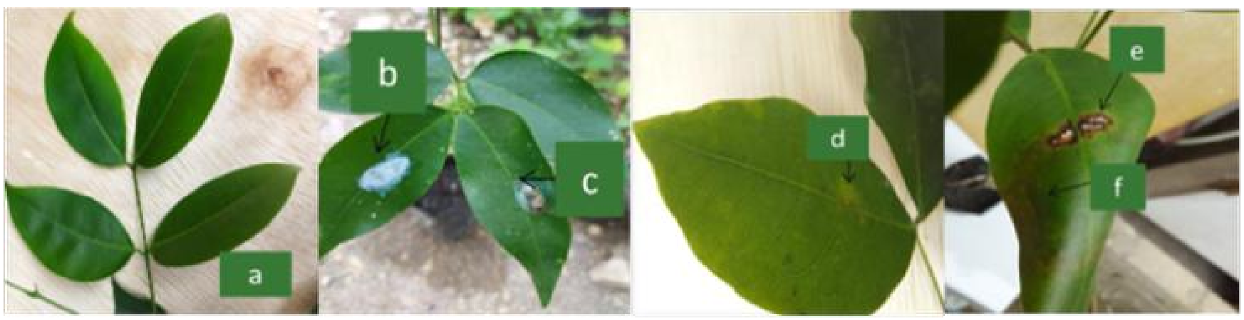

Figure 4. a. Healthy leaf of *Intsia* sp., b. treatment by scratching, c. treatment by wounding, d. symptoms (scratching treatment), e. wounding treatment, f. symptoms (wounding treatment).

Figure 5. a. Healthy stem of *Intsia* sp., b. treatment by scratching, c. symptoms (scratching treatment), d. symptoms (wounding treatment), e. wounding treatment.

Village Forest, located in Jayapura Regency, covers an area of 3,853.13 hectares (BPSKJ, 2024). Geographically, this forest lies at coordinates 2º28′44.18″ S and 139º49′22.80″ E, with an elevation ranging from 50 to 111 meters above sea level (Figure 1). The humidity ranges from 50% to 70%, and the area has a tropical climate. The research site within the Sawesuma Village Forest is a proposed location for ecotourism development. This area is home to several high-value commercial plant species found in Papua, such as *Intsia* sp. and *Pometia pinnata* (Tasik *et al.*, 2023). The forest also contains several open areas that allow sunlight to penetrate easily, and plant species such as *Macaranga gigantea* and *Guazuma ulmifolia* have been observed—indicating that this forest is classified as a secondary forest (Ziyadatun *et al.*, 2022).

Symptoms of disease attacks on *Intsia* sp. plants

Merbau (*Intsia*) is a plant that grows naturally in wet forests and is commonly associated with other forest vegetation. The distribution of merbau wood species in Papua includes *I. bijuga* and *I. palembanica*, both of which are exploited commercially and are now considered threatened species (U-thoomporn *et al.*, 2022). Based on observations in the forest of Sawesuma Village, Unurum Guay District, Jayapura Regency, Papua Province, disease symptoms caused by fungal pathogens were predominantly found on *I. bijuga* (coastal merbau). This species is highly dominant in the Sawesuma Village forest. According to Anggio *et al.* (2022), merbau grows well in moist soils (occasionally waterlogged), dry soils, sandy soils, and rocky soils. *I. bijuga* typically inhabits lowland areas and is capable of growing at elevations of 0–450 meters above sea level. Meanwhile, the *I. palembanica* species found in the Sawesuma forest had a relatively low population. Based on morphological observations, the pathogenic disease symptoms in *I. bijuga* were identified in samples from the leaves, stems, and roots, while in *I. palembanica*, symptoms were found in the leaves and stems.

Morphological observation of disease symptoms in *Intsia* sp. plants was carried out using an exploratory method by recording coordinate points and establishing sampling plots. The forest area was 700 m² with 5 sampling plots, starting from an elevation of 53 to 108 meters above sea level. The observations were conducted to describe the disease symptoms affecting *Intsia* sp. plants.

Results of pathogenic fungi isolation

The results of the study showed that the isolation of pathogenic fungi causing disease in *Intsia* sp. plants, which were isolated from leaves, stems, and roots, revealed the presence of three fungal genera. These include the genus *Aspergillus* found on (leaves and stems), *Fusarium* on (leaves and stems 2), and *Mucor* found on (roots 2) (Figure 3).

Based on observations (Figure 2), the characteristics of infected leaves include the appearance of yellow spots that gradually cover the entire leaf surface. The underside of the leaf has small, round, brownish spots that expand over time and become irregular in shape. Symptoms caused by *Aspergillus* sp. can lead to various morphological symptoms depending on the fungal species, environmental conditions, and host plant type. Typical symptoms often resemble leaf spot or blight diseases (Shen *et al*., 2024).

The colony of *Aspergillus* sp. appeared green with white edges and showed orderly growth (Figure 3). This genus has septate and hyaline hyphae. This is supported by the study of Noerfitryani & Hamzah (2018), who reported that the macroscopic characteristics of *Aspergillus* fungi on culture media include surfaces ranging from light green to dark green and black, with a powdery texture. The microscopic characteristics are shown in Figure 4. The conidia are spherical in shape, with septate and hyaline hyphae. The microscopic characteristics of *Aspergillus* sp. colonies include vesicles that are round to semi-spherical, conidia that are also round to semi-spherical with irregular ornamentation such as protrusions and spines. The conidial heads are black, spherical in shape, and tend to split into distinct columns (Figure 4).

Symptoms found on the stem of *Intsia* sp.

The stem surface of *Intsia* sp. was observed to be dark brown to black in color, exuding a brownish sap, and the texture appeared fragile (Figure 2). The genus identified from these disease symptoms was *Fusarium*, a fungal genus commonly associated with plant diseases. Soil type plays a crucial role in determining the severity of disease caused by *Fusarium* sp., particularly due to the physical and chemical differences that influence soil microorganisms and the pathogen's ability to survive and develop (Yan *et al*., 2022).

The growth of Fusarium shows optimal development at a soil pH of 5.5–7.0. Acidic soil accelerates microconidia germination and root penetration (Li *et al*., 2023). Colonies of Fusarium sp., as seen in Figure 3, appear as white, cotton-like mycelium. Fusarium fungi tend to grow and spread slowly, mainly in a lateral direction. According to Reoslan *et al*. (2025), microscopic observations (Figure 3) show that Fusarium initially appears pure white and gradually turns whitish-brown. It has small and simple conidiophores, while some are larger, short-branched, and clustered. The conidia are hyaline and consist of two types: macroconidia and microconidia. Macroconidia are multi-celled, oval-shaped, and crescent-like, while microconidia are single-celled and egg-shaped (Figure 4).

In Intsia sp. plants, Fusarium attacks the stem, resulting in cancer-like symptoms (Figure 2). The stem becomes decayed and emits a slightly ammoniacal odor. If the base is cut, a brown ring-shaped discoloration appears in the vascular bundles. Fusarium not only infects stems and leaves but can also invade through the roots, causing xylem occlusion and ultimately plant death (Adusei *et al*., 2025). According to Soleha *et al*. (2022), this fungus forms mycelium between cells, particularly in the bark and parenchymal tissues near the infection site. Fusarium sp. is highly detrimental, as it causes pathological wilting in plants, which often ends in death.

Symptoms observed on the roots of Intsia sp. (Figure 2) include white spots. The roots were identified to be infected by a fungus from the genus Mucor sp. (Figure 3), a saprophytic fungus commonly found in soil. According to Chanda *et al*. (2022), Mucor sp. can be found in various habitats including soil, decaying plant matter, organic decomposers, and moist environments. Under normal conditions, this fungus is non-pathogenic to plants; however, if the roots are already infected by root-knot nematodes, *Mucor* may invade and cause disease.

Based on colony observations of *Mucor* sp. (Figure 3), the macroscopic characteristic is white in color. Microscopically, Mucor sp. has wide, ellipsoidal, semi-globular, and smooth-walled sporangiospores, consistent with the description by Helena (2022). Chlamydospores are abundant within the sporangiophores and appear yellow. These findings are consistent with the identification manual by Gandjar et al. (1999). Some Mucor species can sporulate at temperatures of 5–20°C, even up to 30°C. This aligns with the study showing that *Mucor* sporulates rapidly on SDA media incubated at room temperature. According to Suryansyah (2024), Mucor fungi cause powdery white spots on oil palm seedlings, while in Intsia sp., similar symptoms appear on the roots. The infection is influenced by ambient temperature and moist soil. According to Wang (2022), this fungus is cosmopolitan in soil and capable of producing spores that can be dispersed by water, wind, animals, or humans. These spores can survive in favorable environments and facilitate the spread of the fungus to new habitats.

Pathogenicity test on *Intsia* sp. plants

Plant disease is a condition in which a plant undergoes continuous physiological dysfunction, leading to the appearance of symptoms and signs. These physiological disturbances may be caused by biotic factors, such as fungi, or abiotic factors, such as temperature, humidity, nutrients, and minerals (Avelia *et al*., 2024). The pathogenicity test refers to Koch's postulates, which state that to establish an organism as the causal agent of a disease, several criteria must be met. First, the organism must be consistently associated with the host plant in every case of the disease. Second, the organism (pathogen) must be isolated and cultured into a pure culture. Third, when the isolated culture is inoculated onto a healthy plant, it must reproduce the same symptoms observed in the diseased plant. Fourth, the pathogen must be re-isolated from the newly diseased host and be identical to the originally isolated organism.

Koch's postulates serve to prove that when an isolate from a diseased plant is inoculated into a healthy one, it will produce disease symptoms identical to those found in the naturally infected plant (Avelia *et al*., 2024). In this observation, isolates from leaves and stems showing disease symptoms were inoculated onto healthy *Intsia* sp. plants to examine the resulting symptoms.

Based on the results of the pathogenicity test on Intsia leaves, two treatments were applied: scratch-inoculation and wound-inoculation. After inoculating the *Intsia* leaves with different treatments, symptoms were monitored for approximately 38 days. However, not all inoculated leaves showed the same disease symptoms as observed in the field. Leaf isolates inoculated using scratch and wound treatments showed different symptoms. In the scratch treatment, the isolate caused slight fading and the appearance of faint yellowish-white spots. In contrast, the wound treatment resulted in brownish symptoms on the leaves, with a softened leaf texture (Figure 5).

The emergence of these pathogenic symptoms may be influenced not only by the inoculation but also by abiotic and biotic factors. Environmental conditions such as temperature, humidity, and light play a crucial role in the development of disease symptoms (Mardhiansyah *et al*., 2025).

Stem isolates inoculated by both scratch and wound treatments showed similar symptoms in terms of color and shape, characterized by dark brown lesions with slow progression. The variation in symptoms caused by pathogens is influenced by the interaction between susceptible host plants and environmental conditions—especially favorable weather—that allow for symptom development (Sastrahidayat, 2013). Inoculation of Fusarium genus on Intsia stems using scratch and wound treatments produced symptoms closely resembling those observed in the field. The observed symptoms included dark brown to blackish lesions around the inoculation site (Figure 6). These symptoms gradually caused wilting in the Intsia plant. According to Agrios (2005), wilting can occur rapidly or slowly, marked by browning and death of leaves and succulent shoots, eventually leading to plant death.

CONCLUSION

Based on the results of the study, it was found that *Intsia* spp. plants can be infected by pathogenic fungi. The isolation process identified three types of disease-causing fungi on *Intsia* plants: *Aspergillus* sp., *Fusarium* sp., and *Mucor* sp. *Intsia* spp. plants infected by pathogenic fungi showed characteristic symptoms, such as yellow spots on the leaves that gradually covered the entire leaf surface. The undersides of the leaves had small, irregularly shaped brownish spots. The stems of infected plants appeared dark brown to black and exuded a brown sap, resulting in a fragile stem texture. Diseased roots showed white patches on their surface.

The findings of this study are expected to serve as a basis for disease management in *Intsia* (merbau) plants, which are widely used in land rehabilitation efforts, particularly in the Papua region. Merbau is a native plant species found in Papua and holds significant ecological and economic value.

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