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Diversity of Rhizosphere Fungi Originating from Cocoa and Mahogany Plants in Tanuntung Village

Bau Mirta*, Muh. Noor Amin Sholeh, Muhlizha Azhari Nur, Mita Yusri

[1]Agrotechnology Study Program, Faculty of Science and Technology, Muhammadiyah University of Bulukumba, Bulukumba, Indonesia;

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*Corresponding Author: **Bau Mirta**, Agrotechnology Study Program/Faculty of Science and Technology, Muhammadiyah University of Bulukumba, Bulukumba, Indonesia;
Email: baumirta99@gmail.com

Abstract: Cocoa and mahogany are plantation crops that are often intercropped on the same agricultural land and are widely cultivated in Bulukumba, South Sulawesi including in the village of Tanuntung, Hero Lange-lange Subdistrict because they hold promising economic value; in the field of soil science, they can even be used to assess fungal diversity in the root zone as an indicator of soil fertility. In the fields of soil science and agricultural science, fungi are organisms that act as decomposers and biological agents and are capable of forming mutualistic symbiotic relationships with certain plant organs, such as roots. Therefore, this study aims to observe and calculate the diversity of rhizosphere fungi from cocoa and mahogany plants in Tanuntung Village with the hope of providing an important picture of the complexity of the microbial ecosystem around the root area and its correlation to soil fertility. The research method used was exploratory descriptive research, which involved collecting soil samples in the village of Tanuntung, followed by fungal isolation, fungal identification, screening of isolates, and analysis of rhizosphere fungal diversity. The results of the study showed that the calculation of the IKC value in the cocoa and mahogany rhizosphere was included in the high criteria with the IKC value obtained being 1.24 (cocoa) and 1.20 (mahogany). And based on the results of the identification carried out, the cocoa and mahogany rhizospheres have a diversity of fungi from the same species, namely from the genus Aspergillus sp., Fusarium sp., Penicillium sp. and Rhizopus sp. but the total number of fungi is different. With the high diversity of rhizosphere fungi, it proves that there is a good mutualistic symbiosis in the soil around the root area with fungi, which can also be used as a reference to determine good soil biological quality.

Keywords: Diversity; Cocoa; Mahogany; Rhizosphere fungi.

Introduction

Cocoa and mahogany are plantation crops that are often intercropped or planted in the same agricultural area. One of the benefits of growing cocoa is that mahogany trees can serve as shade trees (Reis et al., 2019). In addition, these two agricultural commodities are widely cultivated because they have high economic value, cocoa as a staple ingredient in the chocolate processing industry, while mahogany is a producer of wood or a staple material in the furniture and building industry. Most fundamentally, they have good climate compatibility in Indonesia. Cocoa and mahogany plants are also widely cultivated in Bulukumba, South Sulawesi, although known for its vast expanse of sea, the land is widely used for intercropping cocoa and mahogany. One of the areas in Bulukumba that often intercrops cocoa and mahogany in one agricultural area is in Hero Lange-lange District, specifically in Tanuntung Village. Tanuntung Village is a special village in Hero Lange-lange District with diverse regional potential compared to other villages because of its location which is partly on the coast, but it is still very possible to cultivate cocoa and mahogany plants on land.

Cocoa and mahogany plants are widely cultivated because they have promising economic value, however, in the scope of soil science, cocoa and mahogany plants can be used to observe the diversity of fungi, especially in the rhizosphere or the area around the roots as an indication of soil fertility as a medium for plant

growth. According to Wicaksono et al. (2025), an important indicator of soil fertility is the high proportion of decomposer fungi in the soil because this condition indicates that the decomposition of organic matter in the soil is very active which will potentially increase nutrient availability and support healthy soil structure and good aeration.

In general, in the scope of soil science to agricultural science, fungi as microbes are organisms that have an important role as decomposers to biological agents and have the ability to form mutualistic symbiosis with certain plant organs such as roots. Fungi that are abundant in the area around the roots are known as rhizosphere fungi. Rhizosphere fungi are microbes that can indirectly affect plant growth (by increasing plant growth) (Payangan et al., 2019). Beneficial and useful microbes to promote plant growth and yield are often explored from the rhizosphere of plants which are known as a habitat rich in microorganisms, however, the microbial community in the root system is influenced by the type of root and the species of the host plant itself (Bose and Gowrie, 2016).

Plant roots in their growth are able to secrete water-soluble compounds in the form of amino acids, sugars and organic acids that can provide food for microbes, so that the availability of food for microbes will have an impact on high microbial activity and are able to provide nutrients for plants (Widyati, 2013). The availability of nutrients or exudates has a very large capacity to increase the diversity of beneficial microbial communities (Adedayo & Babalola, 2023). The diversity of microorganisms, especially in soil, is influenced by the interaction between plants, soil fertility, physical environmental conditions, and pressure from other microorganisms. Therefore, the presence of various fungal species in the soil rhizosphere is influenced by the availability of nutrients in the soil rhizosphere to support the survival of the fungi.

The nutrient content in question is in the form of organic compounds in the form of remains of dead living things, soil physical and chemical factors (including texture, structure, temperature, soil water content, organic matter, and pH) (Syahputra et al., 2017). Therefore, certain plants with different nutrient content from other plants will have different species diversity even though they are cultivated on the same agricultural land. Therefore, this study aims to observe and calculate the diversity of rhizosphere fungi from cocoa and mahogany plants in Tanuntung Village with the hope of providing an important picture of the complexity of the microbial ecosystem around the root area and its correlation to soil fertility.

Materials and Methods

Material

The materials used in this study were soil samples taken from the rhizosphere area of cocoa and mahogany plants, plastic bags as containers for storing soil samples, raffia rope, 90% alcohol, distilled water, label paper, aluminum foil, tissue, cotton, plastic wrap, and Potato Dextrose Agar (PDA) media.

Method

Soil sampling

Soil sampling was conducted using a purposive sampling method (Mukrin et al., 2019), by taking soil samples from the rhizosphere of cocoa and mahogany in the same agricultural area in Tanuntung Village. In Tanuntung Village, with an agricultural area of approximately 1 ha, 10 soil sampling points were obtained. Each sample was obtained from five cocoa vegetation points and five mahogany vegetation points.

Fungal isolation and isolate screening

Isolation of rhizosphere fungi (soil fungi) was carried out using the pour method (multiple dilutions) (Fanida and Ardiningsih, 2019). A 1 gram soil sample was weighed and then suspended in 10 ml of sterile distilled water. After the soil was successfully suspended, it was shaken to mix homogeneously, 1 ml of the suspension solution was taken and placed into a test tube containing 9 ml of sterile distilled water and then shaken until homogeneous to obtain a dilution level of 10-1. The procedure was repeated until a dilution level of 10-7 was reached. Then, in vitro screening of the isolate was carried out by inoculating a single spore on a new PDA medium and incubated for 5 days. After the culture was 5 days old, the single colony that grew was transferred to another new PDA for working culture and stock culture (Abri et al., 2015).

Analysis of rhizosphere fungal diversity

The analysis of the species diversity index (H') was calculated using the Shannon formula (Hartoyo et al., 2019) as follows:

$$H' = \sum i\ Pi\ In\ (Pi)$$

Description: H' = Shannon Species Diversity Index
Pi = ni/N
ni = i33rd Type Density Value
N = Total Density

A diversity index value of ≤0.50 means that the diversity is classified as low and ≥0.50 to ≤0.75 is classified as moderate and ≥0.75 to close to 1 is classified as high (Odum 1996; Hartoyo et al., 2019).

Results and Discussion

Diversity of cocoa rhizosphere fungi

The results of rhizosphere fungal isolation on cocoa plants in Tanuntung Village indicate that there are various types of fungi with varying characteristics. A rich source of fungal biodiversity can be found in cocoa plantations and has potential as an agent for the decomposition of organic matter (Nirmalasari et al., 2022). The shape and color of rhizosphere fungal colonies after macroscopic isolation can be seen in Figure 1 below.

Figure 1. Results of isolation of cocoa rhizosphere fungi

Fungal colony growth was observed 3-5 days after dilution (DAP) and could be distinguished by its morphology. After macroscopic observation, cocoa rhizosphere fungi could also be observed microscopically using a microscope to calculate the diversity of the rhizosphere fungi. The diversity index value of cocoa rhizosphere fungi in Tanuntung Village can be seen in Table 1.

Table 1. Diversity index of rhizosphere fungi species in cocoa plants in Tanuntung Village

No.	Types of cocoa Rhizosphere Fungi	Amount	Pi (ni/N)	ln Pi	Pi. ln Pi
1	*Aspergillus*sp.	2	0.18	-1.70	-0.31
2	*Fusarium*sp.	5	0.45	-0.79	-0.36
3	*Penicillium*sp.	3	0.27	-1.30	-0.35
4	*Rhizopus*sp.	1	0.10	-2.40	-0.22
	Total	**11**			***1.24**

Note: The diversity index value is classified as high or H' (high)
*Criteria based on (Odum 1996 in Hartoyo et al., 2019).

The Fungal Diversity Index (IKC) value obtained in Table 1 is 1.24 whichclassified as high criteria (H' = high), and based on the identification results, 4 different fungal species were obtained, namely fungi from the genus Aspergillus sp. obtained 2 isolates, Fusarium sp. 5 isolates, Penicillium sp. 3 isolates and Rhizopus sp. 1 isolate, with a total of 11 isolates identified. This shows that, in the cocoa rhizosphere of Tanuntung Village, there is a high level of fungal diversity which is influenced by the organic acid content required by the fungi, available in the cocoa rhizosphere. This is in line with Wicaksono et al. (2025) who found that the high proportion of rhizosphere fungi indicates an active symbiosis between the host plant and the fungus. The interactions that occur between plants and microbes are important for plant development, especially in mutualistic symbiosis (Jesus et al., 2026). In soil, fungal diversity is influenced by several factors, namely soil water content, organic matter content, and temperature (Sosa-Gomez et al., 2001) in (Permadi et al., 2018).

The optimal temperature for rhizosphere fungi to grow optimally is 20-30°C.°C (Triasih et al., 2022). Meanwhile, according to Hasanah et al. (2024), cocoa requires an ideal temperature of 20-30°C for growth.°C. So the research results show that the high value of the fungal diversity

index in the cocoa rhizosphere is also influenced by temperature or the temperature suitability between the host plant (cocoa plant rhizosphere) and the microbes that live (rhizospheric fungi) in the area around the cocoa roots. This is in line with the research findings of Rincon et al. (2021), who found that the composition and diversity of AMF fungi in Ivory Coast cocoa plantations are significantly influenced by climate differences.

Diversity of mahogany rhizosphere fungi

The results of rhizosphere fungus isolation on mahogany plants in Tanuntung Village indicate that there are various types of fungi with varying characteristics. The shape and color of rhizosphere fungal colonies after macroscopic isolation can be seen in Figure 2. The growth of fungal colonies was observed 3-5 days after dilution (DAP) and could be distinguished by their morphology. After macroscopic observation, mahogany rhizosphere fungi could also be observed microscopically using a microscope. A microscope can help simplify the process of identifying fungal rhizospheres by observing fungal conidia and conidiophores (Mirta & Rasyid, 2023), to calculate the diversity of the rhizosphere fungi. The diversity index value of mahogany rhizosphere fungi in Tanuntung Village can be seen in Table 2.

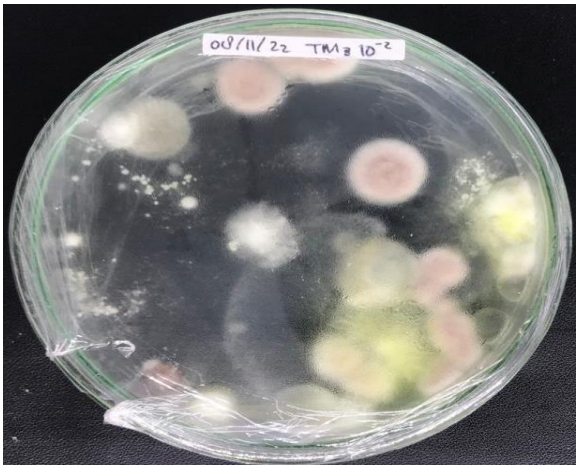

Figure 2. Results of isolation of mahogany rhizosphere fungi

Table 2. Rhizosphere fungal diversity index of mahogany plants in Tanuntung Village

No.	Types of cocoa Rhizosphere Fungi	Amount	Pi (ni/N)	ln Pi	Pi. ln Pi
1	*Aspergillus*sp.	2	0.17	-1.80	-0.30
2	*Fusarium*sp.	6	0.50	-0.70	-0.35
3	*Penicillium*sp.	3	0.25	-1.39	-0.35
4	*Rhizopus*sp.	1	0.08	-2.48	-0.21
	Total	**12**			***1.20**

Note: The diversity index value is classified as high or H' (high)
*Criteria based on (Odum 1996 in Hartoyo et al., 2019).

Table 2 shows that the results of the Fungal Diversity Index (IKC) calculation are included in the high criteria (H' = high) with the IKC value obtained being 1.20. The calculation of the IKC value is based on the number of fungi obtained from the isolation results. The composition and delivery of fungi can be assessed based on the number of fungal isolates (N) and species as statistical units (Safaie et al., 2024). The fungi come from 4 different genera, namely from the genus Aspergillus sp. obtained 2 isolates, while from the genus Fusarium sp. the most are 6 isolates, Penicillium sp. obtained 3 isolates and Rhizopus sp. obtained 1 isolate. This shows that, in the mahogany rhizosphere in Tanuntung Village, there is a high level of fungal diversity, influenced by the absence of suppression of fungal populations around the mahogany root area. The presence and morphological structure of fungi depend on plant and fungal species, as well as environmental conditions such as soil toxicity (salinity, drought, and the deposition of inorganic residues) (Reyes et al., 2023). Mahogany is a plant that can stimulate the diversity of rhizosphere fungi because it is a perennial plant surrounded by other vegetation, whether it functions as ground cover (grass) or even other vegetation that is intentionally cultivated. Tsufac et al. (2021) found that vegetation (trees) scattered across agricultural land significantly contributes to soil fertility or nutrient availability (N, P, K), as well as high soil biodiversity.

Apart from these factors, another factor influencing the high IKC in the mahogany rhizosphere is the absence of fungal population suppression due to the application of inorganic fertilizers and pesticides, as mahogany is a perennial plant that does not rely on specific inorganic fertilizers and pesticides for its growth,

but rather on biofertilizers applied during the nursery phase. Conversely, the use of biofertilizers is used as an effort to reduce dependence on chemicals and encourage the sustainable growth and development of microbial and tree species (Liu & Poobathy, 2021). According to Wisdawati et al. (2019), the application of inorganic chemicals, if not applied based on tolerable amounts and doses, will cause ecological stress that impacts the suppression of rhizosphere fungal populations and vice versa. Furthermore, the main factors that can influence fungal diversity are environmental factors, vegetation type, plant roots and interactions that occur between microbes (Sieber and Grunig, 2006, in Irawati et al., 2017).

Conclusion

Based on the research results obtained, it can be concluded that the value of the Fungal Diversity Index (IKC) of the rhizosphere of cocoa and mahogany plants in Tanuntung Village is classified as high (cocoa rhizosphere with an IKC value of 1.24 and mahogany rhizosphere with an IKC value of 1.20). In addition to its high IKC value, the cocoa and mahogany rhizosphere based on fungal identification also has a diversity of fungi from the same species, namely from the genus Aspergillus sp., Fusarium sp., Penicillium sp. and Rhizopus sp. but the total number of fungi is different. With the high diversity of cocoa and mahogany rhizosphere fungi in Tanuntung Village also proves that there is a good mutualistic symbiosis in the soil around the root area with fungi, which can also be used as a reference to determine good soil biological quality.

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