

Identification of Soil Bacteria in Several Paddy Fields (*Oryza sativa* L.) in Wita Ponda District

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Abstract

Rice (Oryza sativa L.) is a major agricultural commodity in Wita Ponda District and serves as the primary livelihood and economic support for local communities. However, rice productivity in this area remains relatively low, partly due to limited farmer knowledge regarding crop management and insufficient information on soil conditions, particularly soil nutrient content. This study aimed to identify soil bacteria present in paddy fields (Oryza sativa L.) in Wita Ponda District.

The research was conducted from March to May 2024. Soil samples were collected from five locations in Wita Ponda District at a depth of 0–20 cm. One composite soil sample from each location was used for bacterial identification as well as for soil pH and organic carbon (C-organic) analysis.

The results showed that a total of 1,184 bacterial isolates were identified from paddy fields located in Lantula Jaya, Bumi Harapan, Puntari Makmur, Emea, and Solonsa Jaya villages. Among these, 362 distinct bacterial isolates were grouped into four genera: Azotobacter (119 isolates), Bacillus (45 isolates), Marinococcus (181 isolates), and Corynebacterium (17 isolates). Soil pH values ranged from slightly acidic to neutral, with values of 6.49, 6.44, 6.90, and 6.68. Soil organic carbon content ranged from low to moderate, with values of 1.18%, 1.37%, 2.44%, 1.16%, and 1.81%.

Keywords : Soil bacteria identification; soil pH; organic carbon; paddy field; *Oryza sativa* L.



INTRODUCTION

Soil is the uppermost layer of the Earth's crust and constitutes a fundamental component of land that plays a crucial role in plant growth. It provides physical support, supplies essential nutrients, stores water, and facilitates gas exchange required for plant development (Ladjinga et al., 2020).

Rice (*Oryza sativa* L.) is an annual food crop belonging to the grass family and is characterized by its clump-forming growth habit. Rice is widely cultivated in Indonesia due to its high adaptability to diverse environmental conditions. It is one of the oldest cultivated crops, originating from Asia and West Africa, with rice cultivation dating back to approximately 3000 BC in Zhejiang, China (Kurniasari, 2022).

Land is a primary production factor in agricultural activities and is generally classified into dryland and wetland. Wetlands are commonly utilized for agricultural purposes because they are characterized by continuous water availability and favorable soil conditions. Rice is the dominant crop cultivated in wetland ecosystems, as it requires standing water during its growth cycle to achieve optimal yields. In contrast, dryland agriculture is practiced on land with limited water availability and often lacks reliable water sources such as rivers, lakes, or irrigation channels (Firiadi et al., 2018).

Paddy fields represent a unique agroecosystem commonly found in countries where rice is the main staple food. Unlike dryland soils, paddy soils are intentionally flooded to create optimal conditions for rice growth. Prolonged flooding can lead to permanent changes in soil physical, chemical, and biological properties (Liani, 2023). Paddy soils are considered anthropogenic soils because their characteristics are strongly influenced by land preparation and management practices (Suleman et al., 2016). Rapid technological development, land-use change, and population growth have increasingly threatened the sustainability of paddy fields, particularly due to land conversion for non-agricultural purposes (Fendy et al., 2021).

In Morowali Regency, particularly in Wita Ponda District, rice is a major food crop and serves as the primary source of livelihood for local communities. Paddy fields in this district are predominantly smallholder-managed and are distributed across several villages, including Lantula Jaya, Bumi Harapan, Puntari Makmur, Emea, and Solonsa Jaya.

According to the Central Bureau of Statistics (BPS, 2023), the total rice cultivation area in Morowali Regency in 2023 reached 7,453.85 ha, with a production of 26,940.49 tons and an average productivity of 3.614 tons ha⁻¹. In Wita Ponda District, the total cultivated area was 3,501.00 ha, with a harvested area of 2,625.00 ha, total production of 12,862.50 tons, and productivity of 3.674 tons ha⁻¹.





Soil quality refers to the capacity of soil to perform essential functions that support human needs and natural ecosystems over time (Purba et al., 2021). Soil quality assessment is commonly based on physical, chemical, and biological properties that reflect key soil processes (Padmawati et al., 2017). Among these, biological properties—particularly soil microorganisms—play a critical role in organic matter decomposition, nutrient cycling, and the maintenance of soil fertility and health (Hanafiah, 2009).

Sustainable agriculture is essential to improve environmental quality and conserve natural resources. Although modern agriculture associated with the Green Revolution has significantly increased agricultural productivity, it has also resulted in adverse environmental impacts. Excessive use of inorganic fertilizers, pesticides, herbicides, and intensive land exploitation over long periods has contributed to soil degradation, water and air pollution, and loss of biodiversity (Wulansari, 2020).

Therefore, this study was conducted to evaluate soil quality in paddy fields of Wita Ponda District through the identification of soil bacteria, which serve as important biological indicators of soil fertility and ecosystem health.

MATERIALS AND METHODS

Study Area

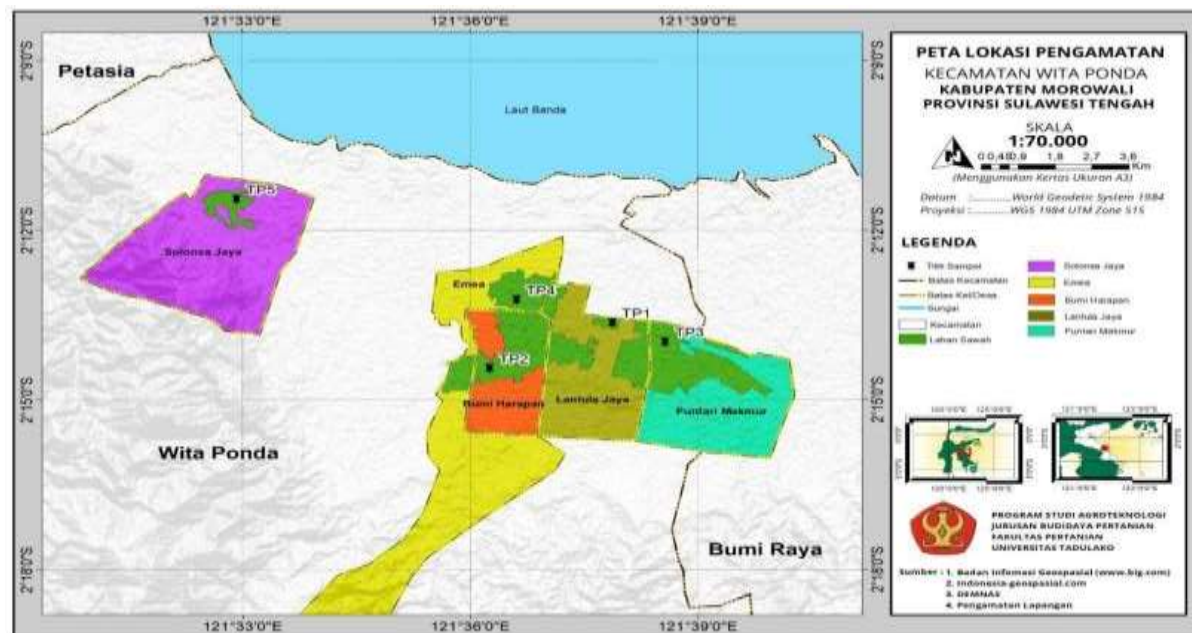
The study was conducted in Wita Ponda District, Morowali Regency, Central Sulawesi, Indonesia. Geographically, the study area is located at approximately 2°13'24.41" S latitude and 121°37'28.44" E longitude. Administratively, Wita Ponda District is bordered by Tolo Bay to the north, Bumi Raya and West Bungku districts to the east, West Bungku District and South Sulawesi Province to the south, and North Morowali Regency to the west.

Wita Ponda District covers an area of 519.70 km² and consists of eight villages, namely Bumi Harapan, Emea, Lantula Jaya, Moahino, Puntari Makmur, Sampeantaba, Solonsa, Solonsa Jaya, and Ungkaya. The total population is approximately 18,908 inhabitants. The research sites were located in five villages: Lantula Jaya, Bumi Harapan, Puntari Makmur, Emea, and Solonsa Jaya. The sampling area in Lantula Jaya, Bumi Harapan, Puntari Makmur, and Emea covered approximately 1 ha (100 m × 100 m), while in Solonsa Jaya it covered 2 ha (200 m × 200 m). The topography of all sites was relatively flat.



Time and Place of Study

The study was carried out from December 2024 to May 2025. Soil sampling was conducted in Lantula Jaya, Bumi Harapan, Puntari Makmur, Emea, and Solonsa Jaya villages, Wita Ponda District. Soil chemical and microbiological analyses were performed at the Soil Science Laboratory and the Plant Pest and Disease Laboratory, Faculty of Agriculture, Universitas Tadulako, Palu.



Research Design

This study employed a field survey method supported by laboratory soil analysis. Sampling locations were determined using a land-use map that served as the land unit map. The soil sampling points are presented in Figure 1.

Soil Sampling Procedure

Soil sampling points were determined based on the predetermined working map. The geographic coordinates of each sampling point were verified in the field using a Global Positioning System (GPS). Five sampling locations were selected, with three subsampling points at each location. However, only one representative coordinate was used to represent each location. Soil samples were collected at a depth of 0–20 cm. A total of five composite soil samples were obtained from the study area. The coordinates of each sampling location are presented in Table 1.

Table 1. Geographic coordinates of soil sampling locations

Sampling site	Latitude (S)	Longitude (E)
Lantula Jaya	2°13'39.82"	121°37'52.71"
Bumi Harapan	2°14'28.01"	121°36'15.70"
Puntari Makmur	2°13'59.95"	121°38'34.47"
Emea	2°13'15.41"	121°36'37.12"
Solonsa Jaya	2°11'28.63"	121°32'55.81"

Soil samples were collected near the rice root zone by excavating the soil using a crowbar. Approximately 0–20 cm depth soil samples were taken using sterile metal spoons, placed into transparent plastic bags, and labeled according to the sampling location.

Soil Chemical Analysis

Soil samples were air-dried for approximately 4 × 24 hours, then crushed and sieved using 0.5 mm and 2.0 mm sieves. Soil chemical properties analyzed included soil pH and organic carbon (C-organic). Soil pH was measured using a pH meter, while soil organic carbon content was determined using the Walkley and Black method. The variables observed and analytical methods used are summarized in Table 2.

Microbial Isolation and Identification

Ten grams of soil from each sample were weighed and placed into sterile test tubes containing 90 mL of distilled water, then homogenized thoroughly. Serial dilutions were prepared up to 10^{-7} . Three final dilution levels (10^{-3} , 10^{-5} , and 10^{-7}) were selected for microbial isolation. One milliliter from each dilution was inoculated onto Nutrient Agar (NA) media and incubated at 25–30°C for 24 hours.

After incubation, bacterial colonies were observed and counted. Morphological characteristics of bacterial colonies, including colony shape, color, size, elevation, and total colony number, were recorded as presented in Table 3.

Data Analysis

Data analysis was conducted using descriptive quantitative and microbiological approaches. Soil bacterial characteristics were described based on direct observation of colony morphology using a colony counter. Observed parameters included colony size, color, shape,

margin, and elevation of bacterial colonies isolated from paddy field soils in Lantula Jaya, Bumi Harapan, Puntari Makmur, Emea, and Solonsa Jaya villages, Wita Ponda District.

RESULTS AND DISCUSSION

Soil pH

The results of soil pH analysis from the five sampling locations in Lantula Jaya, Bumi Harapan, Puntari Makmur, Emea, and Solonsa Jaya villages, Wita Ponda District, are presented in Table 2.

Table 2. Soil pH values at different sampling locations

Table 3. Soil organic carbon content at sampling locations

Sampling site	Organic C (%)	Category
Lantula Jaya	1.18	Low
Bumi Harapan	1.37	Low
Puntari Makmur	2.44	Moderate
Emea	1.15	Low
Solonsa Jaya	1.81	Low

Soils from Lantula Jaya, Bumi Harapan, Emea, and Solonsa Jaya villages exhibited low C-organic content, with values of 1.18%, 1.37%, 1.15%, and 1.81%, respectively. In contrast, soils from Puntari Makmur village showed moderate C-organic content (2.44%).

Soil organic carbon is a key indicator of soil fertility, as it influences soil structure, nutrient availability, and microbial activity. Organic matter in soil consists of plant residues, microbial biomass, dissolved organic compounds, and stable humic substances. According to Husnaeni (2018), low soil organic carbon content may result from limited organic matter input from vegetation and insufficient return of crop residues to the soil. Organic matter accumulation primarily occurs in the topsoil layer; therefore, organic carbon content generally decreases with increasing soil depth.

Low to moderate organic carbon levels may limit microbial activity and nutrient cycling in paddy soils. Therefore, the incorporation of organic amendments such as crop residues or organic fertilizers may improve soil quality and sustain long-term productivity.

Morphological Characteristics of Soil Bacteria

The results of microbial isolation from soil samples collected in Lantula Jaya, Bumi Harapan, Puntari Makmur, Emea, and Solonsa Jaya villages are presented in Table 6. A wide diversity of bacterial colony morphologies was observed across all sampling sites.

Bacterial colonies exhibited various morphological characteristics, including shapes such as rhizoid, filamentous, circular, oval (spindle-shaped), irregular, serrated, transparent, and edged forms. Colony colors varied from cream, milky white, yellow, orange, reddish-orange, to fluorescent yellowish hues. Colony elevation ranged from convex, pulvinate, flat, ring-shaped convex, to concave forms, while colony sizes varied from pinpoint to large.

The total number of bacterial isolates varied among locations and dilution levels. In Lantula Jaya, the number of isolates at dilutions 10^{-3} , 10^{-5} , and 10^{-7} were 145, 54, and 34 isolates, respectively. In Bumi Harapan, 119, 45, and 18 isolates were obtained. Puntari Makmur showed 175, 98, and 78 isolates, while Emea had 92, 83, and 17 isolates. In Solonsa Jaya, 105, 24, and 24 isolates were recorded at the same dilution levels.

Based on colony morphology and microscopic observations, four bacterial genera were identified: *Bacillus*, *Azotobacter*, *Corynebacterium*, and *Marinococcus*. According to Bonnet et al. (2020), morphological identification using selective and non-selective culture media is an effective preliminary approach for characterizing bacterial diversity in soil ecosystems.

Bacterial Genera Identified

Genus *Bacillus*

Bacterial isolates belonging to the genus *Bacillus* exhibited circular, irregular, edged, and serrated colony shapes, with milky white, yellow, and orange coloration. Colony elevation ranged from flat to pulvinate. These characteristics are consistent with descriptions in *Bergey's Manual of Determinative Bacteriology* (Holt et al., 1994).

Members of the genus *Bacillus* are Gram-positive, rod-shaped bacteria capable of forming endospores, allowing them to survive under unfavorable environmental conditions. *Bacillus* spp. are widely distributed in soil and are known for their ability to solubilize phosphate, enhance plant growth, degrade pesticides, and suppress plant pathogenic microorganisms. Previous studies have reported that *Bacillus* spp. can promote rice growth by improving phosphorus availability and plant nutrient uptake (Oktrisna et al., 2017).



Genus *Azotobacter*

Isolates identified as *Azotobacter* displayed irregular, spindle-shaped, and serrated colony forms with milky white coloration. These characteristics correspond to descriptions provided by Holt et al. (1994). *Azotobacter* spp. are Gram-negative, aerobic, free-living nitrogen-fixing bacteria commonly found in soil and aquatic environments.

Azotobacter plays an important role in sustainable agriculture due to its ability to fix atmospheric nitrogen and produce plant growth-promoting substances such as indole-3-acetic acid (IAA). Previous studies have shown that *Azotobacter* isolates can enhance seed germination, plant growth, and nitrogen availability in soil, leading to improved crop productivity (Widiastuti et al., 2010; Nurmas et al., 2014).

Genus *Corynebacterium*

Isolates belonging to the genus *Corynebacterium* exhibited circular colony shapes with milky white coloration and flat to convex elevation. These features are consistent with descriptions in *Bergey's Manual* (Holt et al., 1994). *Corynebacterium* spp. are Gram-positive bacteria commonly found in soil and plant-associated environments.

Corynebacterium spp. have been reported to play a role in biological disease control by suppressing plant pathogenic bacteria, such as *Xanthomonas oryzae*, and enhancing rice growth and productivity. Additionally, some isolates are capable of solubilizing phosphate, making them potential candidates for biofertilizer development (Despita et al., 2017; Hefdiyah and Shovitri, 2014).

Genus *Marinococcus*

Isolates identified as *Marinococcus* showed diverse colony shapes, including circular, irregular, serrated, transparent, and edged forms. Colony colors ranged from yellow, cream, orange, reddish-orange, to fluorescent yellow. Colony elevation varied from concave, flat, to ring-shaped convex forms. These characteristics align with descriptions by Holt et al. (1994) and Vos et al. (1923).

Marinococcus spp. are Gram-positive bacteria commonly associated with saline environments, including marine and saline soils. These bacteria are recognized as potential plant growth-promoting rhizobacteria (PGPR) due to their ability to fix nitrogen, solubilize phosphate, and produce antibacterial compounds. Previous studies have identified *Marinococcus* as a promising PGPR candidate capable of enhancing soil fertility and suppressing harmful microorganisms (Kusumawardani, 2018; Chalia, 2018).



CONCLUSION AND RECOMMENDATIONS

Conclusion

Based on the results of this study, a total of 1,184 bacterial isolates were identified from paddy field soils (*Oryza sativa* L.) located in Lantula Jaya, Bumi Harapan, Puntari Makmur, Emea, and Solonsa Jaya villages, Wita Ponda District. These isolates were classified into four bacterial genera, namely *Azotobacter* (119 isolates), *Bacillus* (45 isolates), *Marinococcus* (181 isolates), and *Corynebacterium* (17 isolates).

Soil pH in the study area ranged from slightly acidic to neutral, indicating favorable conditions for rice cultivation and microbial activity. Soil organic carbon content ranged from low to moderate, suggesting limited organic matter input in most sampling locations. The presence of beneficial bacterial genera associated with nitrogen fixation, phosphate solubilization, and plant growth promotion indicates that paddy field soils in Wita Ponda District possess biological potential to support sustainable rice production.

Recommendations

To improve the comprehensiveness of the research findings, future studies are recommended to conduct soil sampling at different rice growth stages, particularly at 20 and 60 days after planting. Additionally, further molecular identification techniques are suggested to confirm bacterial taxonomy and to better understand the functional roles of soil bacteria in paddy field ecosystems.

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