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Jakaba Undercover: Taxonomic Riddle and Potency in Indonesian Agriculture

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Abstract

Excessive use of chemical fertilizers leads to serious environmental and health issues, while organic biofertilizers offer a sustainable solution. *Jakaba* or "*jamur keberuntungan abadi*," a local liquid organic fertilizer derived from fungi, is increasingly used by Indonesian farmers. However, its taxonomy and potential applications require further investigation. Moreover, the effects of *jakaba* on *Fusarium* and its impact on maize growth remain unexplored. This study aims to characterize *jakaba* comprehensively, evaluate its anti-*Fusarium* properties, conduct pathogenicity tests, and assess its effects on maize growth. Morphological analysis of fresh *jakaba* fruiting bodies was conducted, and molecular identification was performed based on the internal transcribed spacer (ITS) 1/4 regions. The antagonistic test was done using plant pathogenic fungi (*Fusarium* sp.). In addition, *jakaba* was evaluated for its impact on the vegetative growth of maize. Observations identified *jakaba* as belonging to the genus *Corallomycetella*, characterized by coral-shaped fruiting bodies with an orange hue and a white tip. The hyphae are septate, spore hyaline, and ellipsoid. The Basic Local Alignment Search Tool (BLAST) analysis revealed that *jakaba* was *Corallomycetella repens*, with a query cover of 99% and a phylogenetic tree 96% bootstrap (BS) value. *Jakaba* exhibits antibiosis activity against *Fusarium* sp., with an inhibition rate of 5.64%. Although *C. repens* has been previously identified as a cause of root rot in Indonesia, the current study reveals that *jakaba* is not pathogenic to maize. Furthermore, the application of *jakaba*'s liquid organic fertilizer at a concentration of 40 ml l^{-1} significantly increased plant height, leaf length, leaf width, and stem diameter compared to other treatments. These findings highlight *jakaba* potential as a biofertilizer.

Keywords: anti-*Fusarium*; biofertilizer; *Corallomycetella repens*; organic fertilizer; pathogenic assay

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INTRODUCTION

Inorganic fertilizers have become a vital need for farmers in Indonesia because of their practicality, accessibility, affordability, and the immediate benefits they provide. However, despite these advantages, there are several significant negative impacts on the environment and human health (Purbosari et al., 2021). Excessive use of inorganic fertilizer causes serious environmental damage and can reduce agricultural yields (Rahman and Zhang, 2018). For example, long-term use of inorganic fertilizers on oil palm plantations causes a decrease in soil quality, nitrogen, and organic carbon, thereby reducing beneficial microbes in the soil (Salamat et al., 2021). Therefore, using organic fertilizer is more environmentally friendly

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because it does not leave dangerous chemical residues. Organic fertilizer can improve soil health and support sustainable agriculture, especially in developing countries including Indonesia. Organic fertilizer can also overcome nutrient deficiencies quickly, does not experience problems with nutrient leaching, and can be directly utilized by plants (Hadisuwito, 2012). The application of organic fertilizer can restore soil fertility and reduce the use of chemical fertilizers and pesticides for more efficient agricultural practices (Garbowski et al., 2023).

While growing awareness of the negative impacts of using inorganic fertilizers, the use of microorganisms in making organic fertilizer would be an innovative and feasible solution. Microorganisms such as bacteria, fungi, and actinomycetes can help decompose organic matter and increase nutrient availability for plants. For example, the organic fertilizers resulting from the use of microorganisms is JADAM microorganism solution (JMS). The name JADAM is an acronym for *Jayonul Damun Saramdul*, an organic fertilizer originating from South Korea. This fertilizer is produced through anaerobic fermentation using soil microbes as starters, potatoes as a carbon source, and coarse salt as a mineral source (Khairani, 2023). Fungi can also be used to make organic fertilizer. Liquid organic fertilizer from chicken manure can be made using biosca bioactivator and *Trichoderma harzianum* (Karim et al., 2018). Another research showed the addition of *Trichoderma* sp. to organic liquid fertilizer can increase dry soybean seed production by 38.42% compared to the control (Rapialdi et al., 2022). Fungi are involved in decomposing organic materials and producing nutrients for plant growth. In addition, they play a role in protecting plants against pathogenic microorganisms that affect soil health (Frac et al., 2018).

One of potential organic fertilizers in Indonesia is *jakaba* or "*jamur keberuntungan abadi*". *Jakaba* is a fungus that grows from the incubation process of water used to wash rice, known as rice washing water or "*air leri*." *Jakaba* was discovered accidentally by farmers while producing liquid organic fertilizer in 2016 (Food Security and Agriculture Service of Ngawi, 2022). The incubation of rice washing water over 14 days emerging up fungus with a coral-like shape and brown color (Ani et al., 2023). Apart from "*air leri*," *jakaba* can be produced by adding bamboo roots. However, according to Susanto et al. (2024), *jakaba* can also be made from the roots of sensitive plants (*Mimosa pudica* Linn). Typically, *jakaba* is used in liquid form and applied to different parts of the plant. It is believed that applying *jakaba* to plants can accelerate the growth of stunted plants and prolong their lifespan (Food Security and Agriculture Service of Ngawi, 2022). The application of *jakaba* to *pakcoy* (*Brassica rapa* L.) at a dose of 40 ml l^{-1} could increase plant height and fresh weight compared to control treatments (Apriyanto et al., 2023). Conversely, the use of *jakaba* in cultivating red chilies on podzolic soil did not demonstrate any significant effects on the chili plants (Norliyani et al., 2023). According to research conducted by Rahmawati et al. (2023), the application of *jakaba* liquid organic fertilizer can enhance the growth of oil palm seedlings. Beyond its growth-stimulating properties, *jakaba* holds the potential as an anti-*Fusarium* agent in plants (Food Security and Agriculture Service of Ngawi, 2022). *Fusarium* is a serious problem in the Indonesian agricultural sector, including maize production (Widiastuti et al., 2020). Species of *Fusarium* can produce mycotoxins, which can be harmful to human and animal health (Mostafa and Kazem, 2011). However, there has been no research regarding the effect of applying *jakaba* on *Fusarium* and maize plant growth.

Research conducted by Jelata (2023) reported that the *jakaba* strain BHP01 is similar to *Cordyceps* sp. However, all *Cordyceps* species are known as entomopathogenic fungi, especially those that are parasitic on insects and arthropods (Olatunji et al., 2018). The researchers argued that *jakaba* is not a species of *Cordyceps*. Moreover, there is limited research on the use of *jakaba* in plants, and the available information is insufficient. Therefore, it is crucial to evaluate the taxonomical identity, anti-*Fusarium* activity, pathogenicity, and application of *jakaba* in maize cultivation. Based on this prior knowledge, the current study is interested in exploring the potential of *jakaba*. This research aims to identify *jakaba* morphologically and molecularly, determine anti-*fusarium* activity, pathogenic tests, and its effect on maize growth.

MATERIALS AND METHOD

Sample collection

This research was conducted from February to April 2024 at the Biology Department of IPB University. The fruiting body of *jakaba* was

collected from liquid organic fertilizer produced by the IPB University Vocational School (Mr. Iqbal). The specimen has been deposited at the Herbarium Bogoriense, Indonesia, under the collection number MR1.

Isolation and purification of *jakaba*

Sterilization of *jakaba* fruiting bodies followed the procedure outlined by dos Reis et al. (2022). The fruiting bodies were washed in 100 ml of alcohol 70% and NaOCl 2% and then rinsed using sterile distilled water. They were inoculated onto potato dextrose agar (PDA) (Himedia, containing potato extract, dextrose, and agar) media added with 500 ml l^{-1} chloramphenicol and incubated at room temperature for 7 days. The mycelium was then purified into new PDA media.

Morphological observation

The fruiting bodies were described based on macroscopic characters, following the method described by Putra (2021). These macroscopic characteristics include the habitat, growth manner, shape, ornamentation, and color. Microscopic characteristics such as spores and hyphae were observed following Barnett and Hunter (1998). The observation of *jakaba* was conducted using light microscope (Olympus BX5, Japan) with 1,000x magnification.

Characterization of *jakaba* isolates

The characterization of pure *jakaba* colonies on the media was described based on texture, color, zoning, sporulation, and diameter (Ezeonuegbu et al., 2022). The microscopic characteristics of the isolate were observed by attaching a portion of the isolate to a glass object, which was then given distilled water and covered with a cover slip. The *jakaba* were observed under a light microscope at 1,000x magnifications. *Jakaba* colonies in the form of mycelium structure and spore morphology were observed, following Barnett and Hunter (1998).

Molecular analysis

Jakaba fruiting bodies were extracted using Quick-DNA Fungal/Bacterial Miniprep Kit (Zymo Research, D6005) to obtain DNA. The forward primers used were ITS1 (5'-TCCGTAGGTGAACCTGCGG-3') and reverse primer ITS4 (5'-TCCTCCGCTTATTGATATGC-3') (White et al.,1990). Amplification of rDNA-ITS1/4 regions was carried out using kit MyTaq HS Red Mix, 2X (Bioline, BIO-25048) (B/7.2.1/IKP/003) and (B/7.2.1/IKP/004). The sequence amplification process involved PCR with 30 cycles with initial denaturation (94 °C, 5 minutes), denaturation (94 °C, 30 seconds), annealing (56 °C, 45 seconds), elongation (72 °C, 1 minute), and final elongation (72 °C, 10 minutes). The PCR products were sent to Genetika Science Indonesia, Inc. for sequencing using Sanger sequencing technology. The sequences obtained were aligned using Seqtrace 9.0. ITS genes were compared with GenBank® data (National Library of Medicine, MD, USA). The sequences were assembled using ChromasPro software, and the final sequences were submitted to GenBank to obtain an accession number. To assess their similarity with existing data, the sequences were analyzed using the Basic Local Alignment Search Tool (BLAST) in NCBI. The BLAST results (Table 1) were then used to choose published sequences. Species with Percentage Identity above 95% were selected and then analyzed using MEGA software version X (Pennsylvania State University, USA), maximum likelihood with kimura parameters, 1,000 of bootstrap (BS) value, and BS above 50 were shown on the tree.

Antagonistic activity

The antagonistic activity of *jakaba* isolates against *Fusarium* sp. was carried out following Zhao et al. (2022) with modification. Plugs of *jakaba* and *Fusarium* sp. (collection of Mycology Laboratory, Biology Department of IPB University) were each inoculated into the PDA. The plugs were placed symmetrically at 3 cm between them in the petri dish with a diameter of 9 cm. *Jakaba* and *Fusarium* sp. plugs were also inoculated alone to another PDA as a control. Each treatment had 5 replications. Percent inhibition rate (IR) was calculated using Equation 1:

$$IR = \frac{(R1-R2)}{R1} \times 100\% \quad (1)$$

Where, R1 is the radius of the *Fusarium* in control plates and R2 is the radius of the *Fusarium* in tested plates.

Pathogenicity assay

A pathogenicity assay was carried out following Fauriah et al. (2023) with modification. The seeds were surface sterilized with sodium hypochlorite for 3 minutes, soaked in 70% alcohol for 1 minute, and rinsed with sterile distilled water. One seed was planted in a jar containing

PDA. One plug of *jakaba* was inoculated into each jar containing the seed. The control was PDA without *jakaba* isolates.

Application of *jakaba* to maize

The application of *jakaba* to maize was carried out using 3 treatments: *jakaba* liquid medium, *jakaba* fruiting bodies, and *jakaba* liquid medium + fruiting bodies. The application dose of *jakaba* liquid medium and liquid medium + fruiting bodies was 40 ml l^{-1} following Apriyanto et al. (2023). The application for *jakaba* fruiting bodies was based on Suherman et al. (2023) with a modification of 10 g $plant^{-1}$. The maize seeds used were Botani BS 01, produced by IPB University. Maize seeds were planted and grown for 7 days, after which maize plants with a uniform height of 5 cm were selected. Maize was planted in polybags with a diameter of 15 cm and soil volume of 700 g. Maize was planted in commercial organic soil at a daily temperature of 30 °C, with an air humidity of 70%. *Jakaba* application was carried out every 7 days for 30 days in accordance with Apriyanto et al. (2023) with modifications. Plant height, stem diameter, and leaf area were measured every odd day after application (Lin et al., 2018). There were 5 replications in each treatment.

Statistical analysis

The data were analyzed using R Studio (Venables et al., 2024) and were subjected to an analysis of variance (one-way ANOVA), and mean values were ranked by the Student-Newman-Keuls test at $p < 0.05$.

Table 1. Species, voucher, and GenBank accession numbers used in this study

Species	Voucher/ Strain	Accession number	Reference	Country
Corallomycetella repens	CBS 118.84	KC479755	Herrera et al. (2013) (GenBank NCBI)	Sri Lanka
Corallomycetella repens	CBS 358.49	KC479756	Herrera et al. (2013) (GenBank NCBI)	Indonesia
Corallomycetella repens	CBS 313.72	KC479757	Herrera et al. (2013) (GenBank NCBI)	India
Corallomycetella elegans	CBS 275.60	KC479753	Herrera et al. (2013) (GenBank NCBI)	Zaire
Corallomycetella elegans	P.C. 1261	KC479751	Herrera et al. (2013) (GenBank NCBI)	Brazil
Corallomycetella elegans	CBS 379.64	KC479754	Herrera et al. (2013) (GenBank NCBI)	Liberia
Cosmospora coccinea	A.R. 2741	HM484537	Herrera et al. (2013) (GenBank NCBI)	Germany
Cosmospora viridescens	CBS 102433	KC291731	Herrera et al. (2013) (GenBank NCBI)	Czech Republic
Microcera larvarum	A.R. 4580 e	KC291751	Herrera et al. (2013) (GenBank NCBI)	New Zealand
Nectria cinnabarina	A.R. 4477	HM484548	Herrera et al. (2013) (GenBank NCBI)	France
Nectria pseudotrichia	G.J.S. 09-1329	JF832647	Herrera et al. (2013) (GenBank NCBI)	Venezuela
Pleonectria cucurbitula	A.R. 2778	JF832603	Herrera et al. (2013) (GenBank NCBI)	Austria
Pleonectria lamyi	A.R. 2779	HM484544	Herrera et al. (2013) (GenBank NCBI)	Austria
Corallomycetella repens	MR1	PQ198063	This study	Indonesia
Stachybotrys chartarum	CBS 182.80	NR145083	Zeng and Zhuang (2022)	-

RESULTS AND DISCUSSION

Taxonomy

Corallomycetella repens (Berk. & Broome) Rossman & Samuels, Stud. Mycol. 42: 113 (1999)
Synonym:
Sphaerostilbe repens Berk. & M.A. Curtis, J. Linn. Soc., Bot. 14 (73 & 74): 114 (1875)
Corallomycetella heinsenii Henn., Hedwigia 43: 245 (1904)
Rhizostilbella rubra Wolk, Mykologisches Zentralblatt 4: 237 (1914)
Cephalosporium kashiense R.Y. Roy & G.N. Singh, Current Science 37: 535 (1968)
Acremonium kashiense (R.Y. Roy & G.N. Singh) W. Gams, Cephalosporium-artige Schimmelpilze: 138 (1971)
Corallomyces mauritiicola Henn., Hedwigia 43: 244 (1904)
Nectria mauritiicola (Henn.) Seifert & Samuels, Studies in Mycology 27: 160 (1985)
Stilbum hibisci Pat., J. Bot. (Morot) 5: 320 (1891)
Rhizostilbella hibisci (Pat.) Seifert, Studies in Mycology 27: 162 (1985)
Nectria coccinea var. *platyspora* Rehm, Annales Mycologici 7 (2): 137 (1909)
Nectria platyspora (Rehm) Weese, Annales Mycologici 8 (4): 465 (1910)
Stilbum incarnatum Wakker, De ziekten van het suikerriet op Java, die niet door dieren veroorzaakt worden: 197 (1898)
Stilbum incarnatum var. *dioscoreae* Sacc., Bolletino dell'Orto Botanico Regia dell'Universita de Napoli 6: 62 (1921)
Cephalosporium kashiensis R.Y. Roy & G.N. Singh (1968)
Corallomycetella heinesii Henn. (1904)

The fruiting body exhibited the general characteristics of being coral-like and orange in color with a white tip and measured 1 to 2 cm in length (Figure 1a). The *C. repens* colony (Figure 1d and 1e) on PDA formed a circular shape with a diameter of 3 cm after 7 days of incubation at room temperature. The colony was circular, its front view was cream-colored with a powder-like texture, the back view of the inner colony was dark brown, and the outside was cream-colored. There was a growth zone and no exudate in the colony. Microscopic examination of *C. repens* fruiting body and vegetative hyphae reveals brown septate hyphae with a size of ±4 µm (Figure 1b, 1f, and 1g). The spores observed are hyaline and ellipsoid in shape with a size of 5-12 × 3-4 µm (Figure 1c and 1h).

There are differences in colony morphology from Herrera et al. (2013), who described colonies with white aerial mycelium, a cotton-to-velvety texture, and synnemata structures after 14 days of incubation. These macroscopic morphological differences can be influenced by genetic mechanisms such as loss or gain of function alleles, phase variation, reversible phenotype switching, and aneuploidy. In addition, external factors, including the source and abundance of carbon and nitrogen, agar content, oxygen, and proximity to other microorganisms, can affect morphological variations within 1 species (Kowalski and Cramer, 2020). The characteristics of *C. repens* in this study exhibit several similarities with the isolates reported by Herrera et al. (2013), such as the presence of septate hyphae, ellipsoidal to ovoid spores with a truncated base, non-separated, smooth-walled, hyaline. However, the spore size they reported was larger at 13-19 × 7-11 µm than the isolates identified in the current study. This difference may be influenced by various environmental factors (Jeewon and Hyde, 2016). Currently, no previous studies have provided a comprehensive morphological characterization of *C. repens* from *jakaba*. This study is the 1st to address and identify the taxonomical identity of this species in Indonesia.

Phylogenetic analysis

The ITS sequence of researchers' specimen has been deposited in the NCBI GenBank database and can be accessed with the accession number PQ198063. The sequence was subjected to the BLAST in NCBI to compare the homology with previous data. Sequencing results were analyzed with taxonomic matches based on the BLAST results with the highest sequence similarity. Moreover, the sequences from selected BLAST results of this study (bold), 13 fungi sequences from (Herrera et al., 2013, GenBank), and selected BLAST results were used to reconstruct the phylogenetic tree. *Stachybotrys chartarum* was used as the outgroup (Zeng and

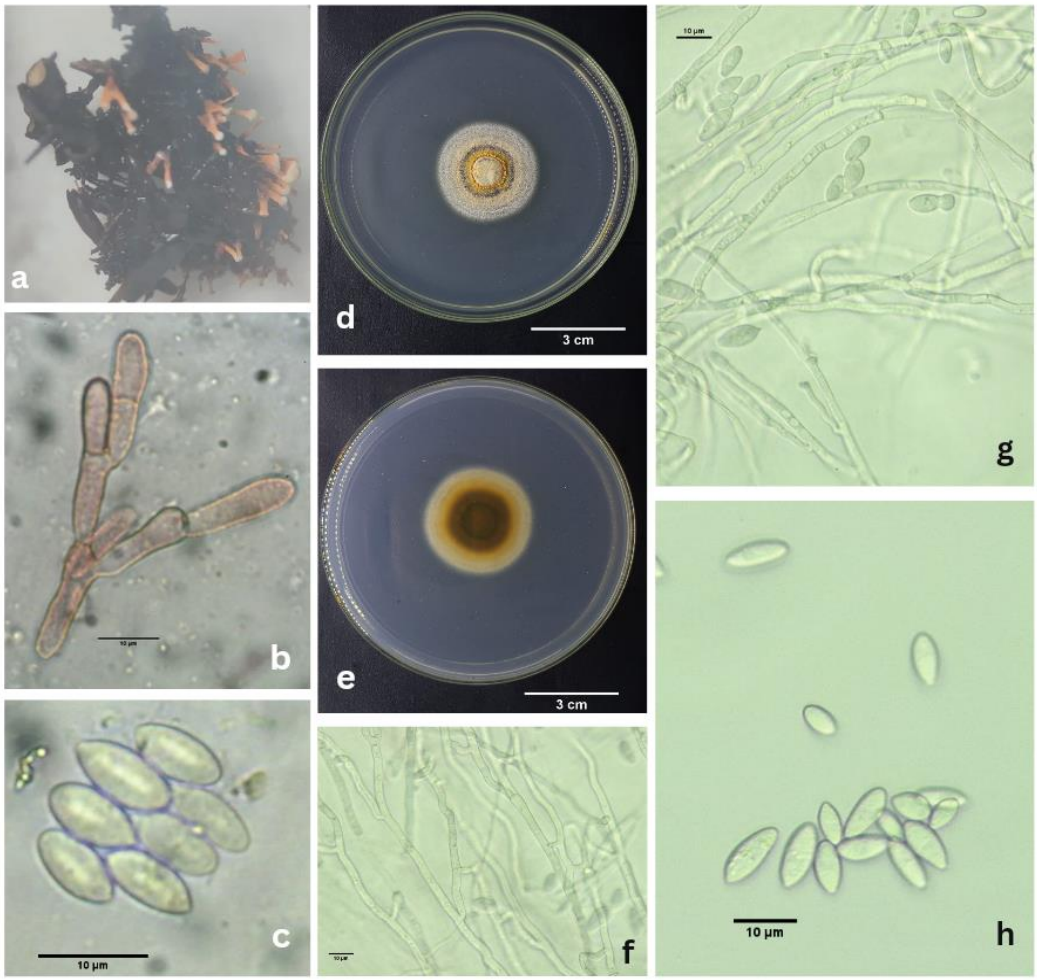

Figure 1. Macroscopic and microscopic morphology of *C. repens* MR1. Fruiting body (a), fruiting body hyphae (b), fruiting body spores (c), upper view of the colony in PDA medium (d), under view of the colony in PDA medium (e), septate hyphae (f, g), spores (h)

Zhuang, 2022) (Table 1). The phylogenetic tree was constructed with the maximum likelihood (ML) method using MEGA X software (Kumar et al., 2018). The results of phylogenetic tree construction indicate that researchers' isolate sequence is closely related to *C. repens* KC479755 from Sri Lanka, KC479756 from Indonesia, and KC479757 from India with a BS value of 96% (Figure 2).

Corallomycetella is a tropical fungus characterized by its bright orange-red to red rhizomorphs, which are a characteristic feature of its rhizostibella-like asexual forms (Herrera et al., 2013; Lombard et al., 2015). It belongs to the phylum of Ascomycota within the Nectriaceae family. The genus *Corallomycetella* comprises 2 species, *C. repens* and *C. elegans*. These 2 species are challenging to distinguish, except for the synnemata structure in *C. repens*. However, synnemata structure was not observed in the current study. Therefore, morphological and molecular data were combined to verify the specimen identity. Both morphology and molecular analyses confirmed that *jakaba* is composed of *C. repens*. Currently, *C. repens* is only known to exist primarily in South to Southeast Asia, including China, India, Sri Lanka, and Indonesia. This fungus can be found on the bark and roots of decaying or diseased tropical trees and can also be isolated from soil. Previously, this species was successfully isolated from Indonesia, from the bark and roots of *Carica papaya* in 1955 and 1948 (Herrera et al., 2013). Approximately 70 years later, the present study successfully isolated the same species but from different habitats and having a divergent role in the ecosystem. *C. repens* from *jakaba* was identified in liquid organic fertilizer. This identification highlights a new ecological role for *C. repens*, as the fungus shows potential for

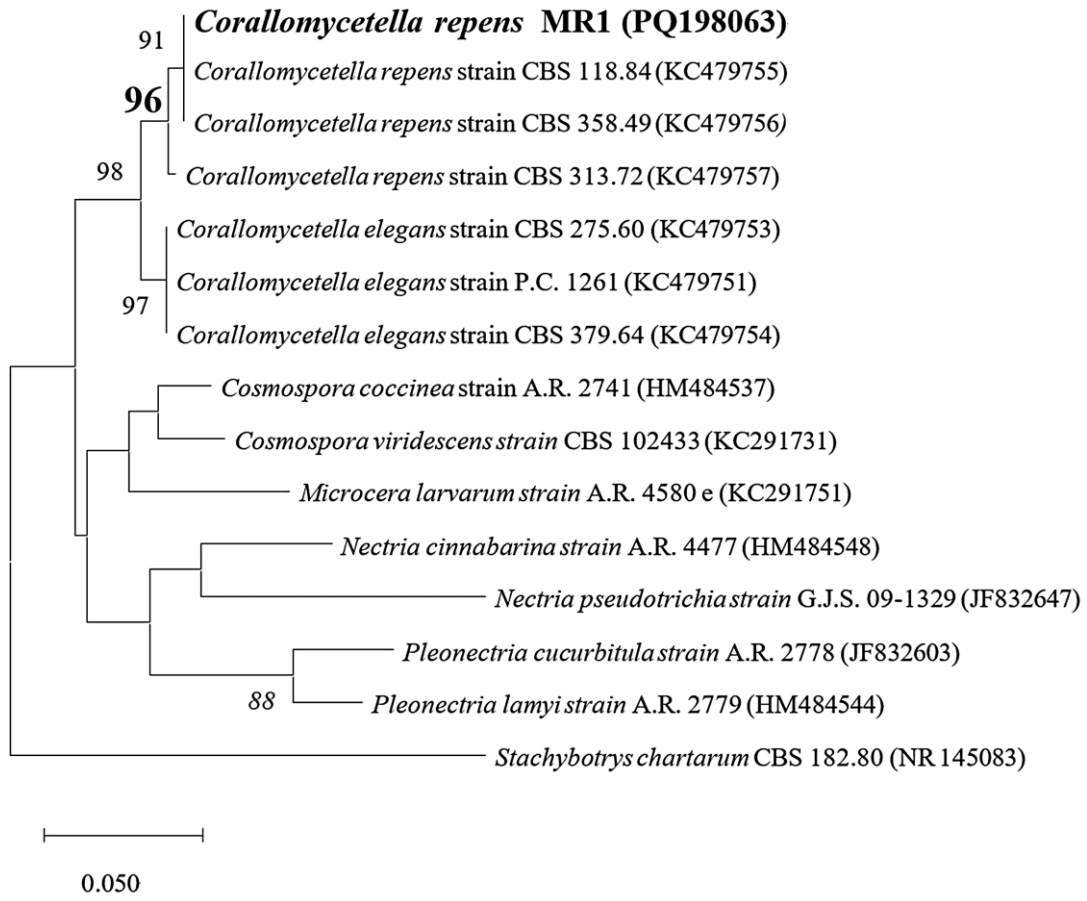

Figure 2. The phylogenetic tree of *C. repens* Voucher MR1 (bold) and related species based on ITS rDNA sequences

Note: BS values > 50% are indicated at the nodes (1000 replication). The scale bar refers to an evolutionary distance of 0.050

enhancing plant growth. The dual roles of *C. repens* as both a pathogen and a plant growth-promoting fungus in Indonesia warrant further investigation. Investigating the genetic and environmental factors that influence its dual roles could provide valuable insights into its biology and potential applications in agriculture. Additionally, identifying the conditions that promote its beneficial role over its pathogenic one could help develop strategies to harness its positive effects while mitigating any negative impacts.

Antagonistic activity

The antagonist test was carried out for 7 days against the pathogenic fungus *Fusarium* sp. (Table 2). The antagonistic test results showed that *C. repens* produced an inhibition percentage with an average of 5.64%. Although the isolate was not able to optimally inhibit the growth of *Fusarium* sp., it could cause *Fusarium* sp. aerial hyphae to become thinner (Figure 3). *C. repens* and categorized to pose the low inhibitory activity against the pathogenic fungus *Fusarium* sp. due to a percentage inhibition of less than 25% following the explanation of Zivkovic et al. (2010). The inhibitory mechanism of *C. repens* against *Fusarium* sp. observed in this study was identified as antibiosis. Antibiosis is characterized by the presence of an inhibition zone between the pathogenic and antagonistic fungi, alterations in the hyphal structure of the pathogenic fungi, and pigment production on the lower surface of

Table 2. Percentage inhibition of *jakaba* against *Fusarium* sp.

Replication	Percentage of inhibition (%)
1	7.3
2	2.8
3	7.8
4	2.3
5	8.0
Average	5.64

the antagonistic fungi (Thambugala et al., 2020). This study shows that the inhibition zone between *C. repens* and *Fusarium* sp. antibiosis mechanism can occur because fungi can produce inhibitory metabolites or antibiotic compounds (Thambugala et al., 2020).

Pathogenicity assay

Pathogenicity assays were carried out to evaluate the effect of *C. repens* on maize growth. Maize was grown on PDA for 7 days. On the 1st day, sterile maize seeds were added with *C. repens*. The results indicated that *C. repens* had no observable negative effect on maize roots, stems, and leaves (Figure 4). A previous study reported that *C. repens* is a plant pathogen (Herrera et al., 2013). It is known to be a saprophytic species parasitizing plant roots, particularly in poorly drained soils (Seifert, 1985). The disease caused by this species typically manifests as yellowing and rotting of leaves, often accompanied by an unpleasant odor (Seifert, 1985). More interestingly, *Sphaerostilbe repens* (synonym to *C. repens*) is known to cause stem, root, and tuber rot (Obilo and Ikotun, 2009). According to Booth and Holliday (1973), this fungus causes several plant diseases including the violet root rot in *Theobroma cacao*, root rot in *Carica papaya*, and stinking root disease in several tropical woody plants. In general, species within Nectriaceae family grow on live and rotten wood substrates, soil, other fungi, and insects. These species are also reported as endophytes and opportunistic pathogens in plants and humans (Zeng and Zhuang, 2022). In contrast, the isolates found in the present study were not pathogenic to plants, specifically maize. This finding suggests that further investigation is needed to determine whether *jakaba* fungi are pathogenic to other crops in Indonesia. Most pathogenic fungi have host species specificity, which means they infect a limited range of plant species and cause disease primarily in those hosts (Borah et al., 2018). Proteins and secondary metabolites produced by fungal pathogens can determine host specificity (Li et al., 2020).

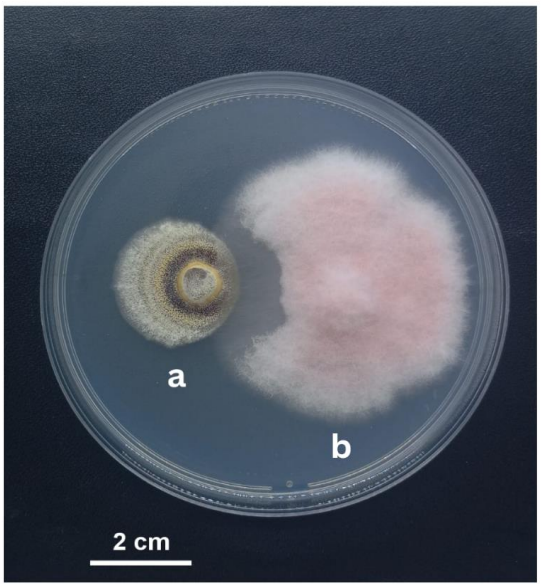

Figure 3. Antagonistic activity test of *C. repens* (a) against *Fusarium* sp. (b)

Application of *jakaba* to maize

The application of *jakaba* liquid organic fertilizer to maize revealed significant differences among treatments (Table 3 and Figure 5). The treatment using a dose of 40 ml l^{-1} of *jakaba*'s liquid medium yielded the best results and was significantly distinct from other treatments. This finding aligns with previous studies demonstrating the effectiveness of *jakaba* liquid organic fertilizer at a dose of 40 ml l^{-1} in enhancing leaf length, plant height, and plant fresh weight of *pakcoy* (*Brassica rapa* L.) (Apriyanto et al., 2023). Similarly, the application

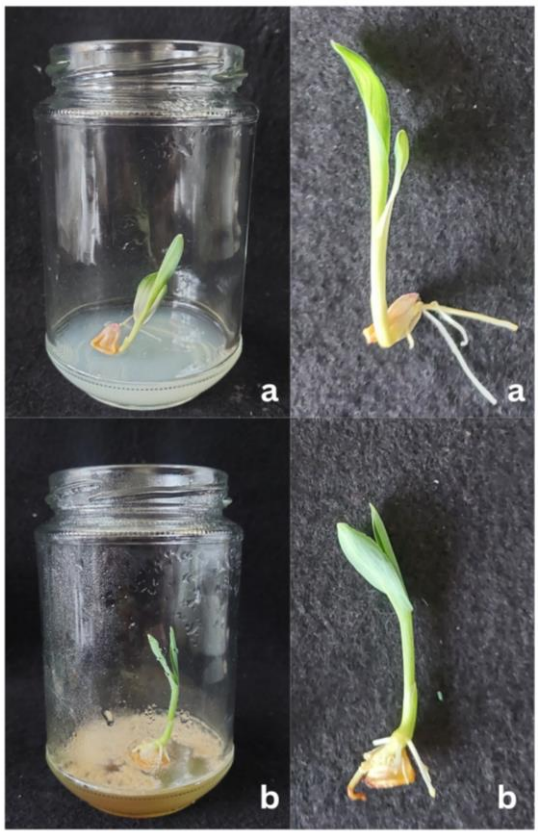

Figure 4. Fungal pathogenicity test results showing no negative effect to maize (a) control (b) challenged with *C. repens*

Table 3. The effect of *jakaba* application on maize

Treatment	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Stem diameter (cm)
Control	67.3±2.9[a]	50.3±2.3[a]	21.3±0.3[ab]	1.36±0.07[ab]
Jakaba's liquid medium 40 ml l^{-1}	69.0±2.9[a]	51.0±2.3[a]	24.9±0.3[a]	1.44±0.07[a]
Fruiting body 10 g $plant^{-1}$	58.2±2.9[b]	46.2±2.3[a]	19.1±0.3[b]	1.20±0.07[ab]
Jakaba's liquid medium 40 ml l^{-1} + fruiting body 10 g $plant^{-1}$	54.7±2.9[b]	32.8±2.3[b]	14.6±0.3[c]	1.12±0.07[b]
p-value	0.008	0.000	0.001	0.036

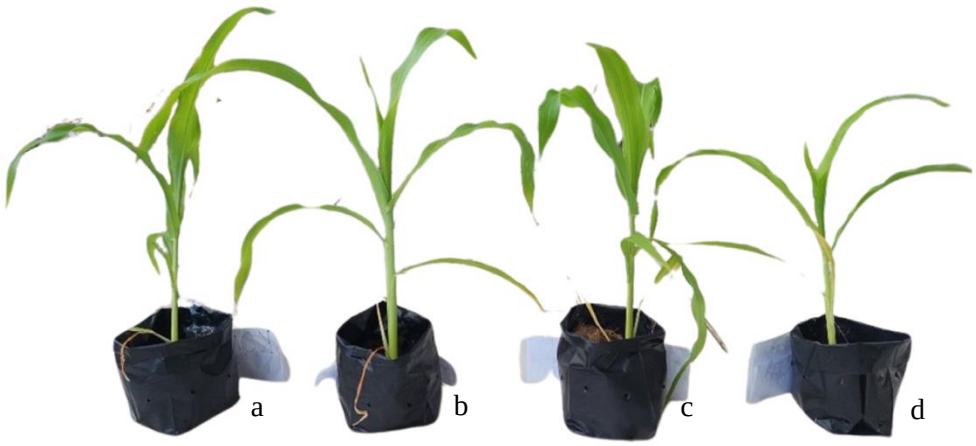

Figure 5. Application *jakaba* on maize. Control (a), *jakaba*'s liquid medium 40 ml l^{-1} (b), fruiting body of *jakaba* 10 g $plant^{-1}$ (c), *jakaba's* liquid medium 40 ml l^{-1} + fruiting body 10 g $plant^{-1}$ (d)

of 450 ml l^{-1} of *jakaba* to oil palm seeds has been reported to increase the growth of oil palm seedlings (Rahmawati et al., 2023).

The chemical and physical properties of *jakaba* have been identified in a previous report, revealing a C-organic content of 0.14%, a C/N ratio of 0.56, N content of 0.24%, P content of 0.00%, and K content of 0.02% (Susanto et al., 2024). These values are below the Indonesian National Standard (SNI) for liquid organic fertilizer (Susanto et al., 2024). According to Batool (2024), maize requires essential nutrients such as N, P, and K as well as other micronutrients to support its growth and development. The role of these nutrients in *jakaba* liquid organic fertilizer is not significant in maize growth. However, the increase in maize growth observed in the *jakaba*'s liquid medium treatment suggests that microbes and *jakaba* could play a crucial role in plant growth.

The microbes in *jakaba* originate from bamboo roots, which are classified as plant growth promoting rhizobacteria (PGPR). Zhang et al. (2022) identified the microbiome community in the bamboo forest rhizosphere, comprising *Proteobacteria*, *Acidobacteria*, *Bacteroidetes*, and *Verrucomicrobiota*. Yuan et al. (2021) highlighted that soil nitrogen absorption is influenced by specific bacteria such as *Flavobacterium*, *Bacillus*, and *Stenotrophomonas*. Maya et al. (2022) successfully isolated *Pseudomonas* from the bamboo rhizosphere, which exhibits the ability to dissolve phosphate and produce auxin. Microbes in bamboo roots play a significant role in maize growth, making the *jakaba* liquid medium treatment more effective than other treatments. Further research is necessary to elucidate the composition of *jakaba* liquid medium and *jakaba* metabolites, as these are currently proven to contribute to enhanced plant growth. The findings of this study underscore the potential of *jakaba* as a promising biofertilizer, leveraging the natural capabilities of these microbes to enhance plant growth. Understanding these components could lead to optimized formulations and broader applications in sustainable agriculture.

CONCLUSIONS

This study successfully identified *jakaba* using morphology and molecular analysis (ITS gene) and concluded it as *C. repens*. Although *C. repens* has been reported as a plant pathogen, the pathogenicity test results indicate

that it is not pathogenic to maize. Furthermore, the evaluation of *C. repens* against *Fusarium* sp. shows promising results despite its low inhibitory activity. The application of *jakaba* to maize at a dose of 40 ml l^{-1} can enhance growth compared to other treatments, thereby suggesting that *jakaba* has potential as a fertilizer in agriculture. This study recommends further comprehensive physical, chemical, and microbiological tests on *jakaba* liquid organic fertilizer to elucidate its role in plant growth.

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