I. INTRODUCTION

1.1. Background

Rice plants (Oryza sativa L.) have become one of the main food sources for the Indonesian population in the form of rice. The demand for rice continues to increase every year, but its productivity has declined. Based on data from the Central Statistics Agency (Badan Pusat Statistik, 2023), rice production in 2023 is estimated to be 53.63 million tons, a decrease of 1.12 million tons compared to the previous year, which was 54.75 million tons. Additionally, rice production used to meet the consumption needs of the population is also estimated to decrease by 645.09 thousand tons, to around 30.90 million tons in 2023.

The decline in rice plant productivity is influenced by several factors. Factors that also contribute to the decline in rice plant productivity include the presence of pathogens that infect the plants. One of the pathogens that infect rice seeds is the bacterium Xanthomonas oryzae, which causes bacterial leaf blight (HDB) (Agustiansyah, 2010). Bacterial leaf blight can reduce rice productivity by 30-40%, thereby decreasing the quality of the produced rice. (Hadianto et al., 2016). This disease also attacks rice plants from the vegetative phase to the generative phase. The symptoms of rice plants infected with Xanthomonas oryzae appear on the edges and tips of the leaves, changing color to yellow, brown, and eventually grayish. If the intensity of the disease attack increases, the plants become wilted and dry, then spread to the base of the plants (Masnilah et al., 2020).

Efforts to control leaf blight disease that have been commonly practiced include spraying with synthetic bactericides. However, excessive use of synthetic bactericides will cause damage because they leave residues, thereby impacting the balance of the ecosystem. In addition, other control measures that can be taken include planting resistant rice varieties, land cleaning, and crop rotation with non-host plant varieties for the pathogen (Fadil et al., 2023). However, some of these control efforts have not been effectively implemented because the intensity of the disease caused by *Xanthomonas oryzae* is quite high. The increase in disease intensity is influenced by environmental changes such as seasonal transitions, the more virulent nature of the pathogen, and the presence of disease-resistant genes.

(Pinem & Syarif, 2018). Therefore, more efficient and sustainable prevention strategies are needed to suppress and control leaf blight disease in rice plants.

Planting resistant varieties accompanied by seed treatment before planting using environmentally friendly biological agents with the application of the bacterium *Paenibacillus* sp. is one of the effective strategies to reduce the severity of diseases caused by *Xanthomonas oryzae* infection. Based on research (Marwan et al., 2016), the treatment of the endophytic bacterium *Paenibacillus* sp. as a biological agent on rice seedlings before planting effectively reduces leaf blight intensity by 76.1 to 86.16% and suppresses the number of empty grains by 35.5 to 57.9%.

The ability of *Paenibacillus* sp. as a biological agent in controlling rice plant diseases is supported by its capability to produce antagonistic antibiotic compounds that effectively suppress the development of pathogenic microorganisms (Jannah et al., 2023). *Paenibacillus* is suspected to suppress disease attacks thru enzymatic activity, particularly thru the production of chitinase and β-1,3-glucanase enzymes (Nurosid et al., 2018). Based on the research (Mumpuni & Rohmah, 2021), Paenibacillus sp. bacteria can be used as a biocontrol agent to reduce the incidence and severity of leaf blight disease by 16.66% and 4.68% at 4 MST.

The *Paenibacillus* sp. isolate used in this study was taken from samples of healthy rice plant leaves among the sick ones, collected from several points in the rice fields of Lakarsantri District, Surabaya City, and has undergone morphological, physiological, biochemical, and microscopic characteristic identification. Based on the identification that has been conducted, the bacterial isolate resembles the *Paenibacillus* bacteria. *Paenibacillus* sp. is classified as a gram-positive bacterium with rod morphology and the ability to produce endospores, forming colonies with round morphology, irregular edges, flat elevation, and white color. According to the research (Dalimunthe et al., 2023), *Paenibacillus* bacterial colonies are generally circular in shape, with irregular edges, flat elevation, and white color.

The *Paenibacillus* sp. bacterial isolate obtained from the sampling has not yet been researched, so several isolates were added as comparisons to determine the effectiveness of the *Paenibacillus* sp. bacterial isolate. The comparison isolate in this study is the *Paenibacillus polymyxa* isolate obtained from the Balai Besar

Perbenihan dan Proteksi Tanaman Perkebunan Surabaya (BBPPTP). BBPPTP is a research center under the Ministry of Agriculture and has the task of conducting exploration, propagation, and distribution activities of biological agents to the community, especially farmers. As a result, this isolate has been directly used by farmers to control diseases in several regions of East Java (BBPPTP, 2023).

Another comparison isolate is the *Bacillus* sp. BTH 22 isolate, isolated by Dr. Ir. Arika Purnawati, MP, which has been tested in several studies and is capable of suppressing bacterial leaf blight disease. Based on the research (Sayekti, 2024), the treatment of *Bacillus* sp. isolate BTH 22 with a dose of 20 ml can extend the incubation period by 7.7 days after inoculation (DAI) and has the lowest intensity of bacterial leaf blight disease at 23.5%, as well as increasing plant height by up to 58.5 cm. The Bacillus sp. isolate BTH 22 with a dose of 20 ml was used as a comparison based on the relationship between the general *Bacillus* and *Paenibacillus*. According to (Annisa & Lestari, 2016), the genus *Paenibacillus* was previously part of the genus *Bacillus* but has dissimilarities based on the consensus region of 16S rRNA.

The research conducted will be treated using a bactericide containing 20% *Streptomycin* as the active ingredient with a formulation in the form of a suspensible powder (Wettable Powder/WP) (Medi, 2016). Based on the research (Nasir et al., 2019), the use of a bactericide containing *streptomycin sulfate* is effective in reducing the intensity of HDB attacks by 92.23% and increasing harvest productivity by 3.4% compared to the control without treatment. This treatment is used as a comparison for the treatment using the biological agent *Paenibacillus* sp.

Based on this issue, efforts are needed to control leaf blight disease in rice plants thru research aimed at determining the effectiveness of seed soaking application using the bacterium *Paenibacillus* sp. in reducing the severity of leaf blight disease due to *Xanthomonas* sp. infection, as well as improving rice plant growth.

1.2. Problem Formulation

The formulation of the problem that serves as the basis for this research is:

1. Is the seed soaking treatment using the *Paenibacillus* sp. bacterial isolate at a dose of 20 ml/g of seed more effective in improving germination capacity,

growth rate, and seed vigor index compared to the *Bacillus* sp. BTH 22 and *Paenibacillus polymyxa* isolates?

2. Can the application of seed soaking using the bacterial isolate *Paenibacillus* sp. at a dose of 20 ml/g seed extend the incubation period, reduce the intensity of bacterial leaf blight disease, and improve rice plant growth?

1.3. Purpose

The objectives to be achieved thru this research are:

1. To determine that the seed soaking treatment using the *Paenibacillus* sp. bacterial isolate at a dose of 20 ml/g of seed is more effective in increasing germination rate, growth rate, and seed vigor index compared to the *Bacillus* sp. BTH 22 and *Paenibacillus polymyxa* isolates.
2. To determine the effectiveness of applying the *Paenibacillus* sp. bacterial isolate at a dose of 20 ml/g in extending the incubation period, reducing the severity of bacterial leaf blight, and enhancing rice plant growth.

1.4. Benefit

This research can contribute to control of bacterial leaf blight and serve as an alternative reference for readers in addressing bacterial leaf blight attacks on rice plants.