I. INTRODUCTION

1.1 Background of the Research

Red beans (*Phaseolus vulgaris* L) are one of the most widely cultivated legume crops in tropical and subtropical regions due to their high nutritional value and significant economic potential. In addition to being an important source of Plant-based protein, fiber, and micronutrients in human food. Red beans also contain a variety of bioactive compounds that provide health benefits (Martínez-Alonso *et al*., 2022). In Indonesia, red beans are recognized as the second-highest phosphorus source among all leguminous crops. Their market value remains relatively high, primarily because red bean yields are lower than those of other legumes such as soybeans, peanuts, and mung beans (Andrew *et al.,* 2023). The productivity of red beans is often threatened by several plant pathogens, among them *Fusarium oxysporum*. This soil-borne fungus is responsible for vascular wilt disease and affects plant growth.

F. oxysporum is a soil-borne pathogen that is widely distributed and capable of infecting more than 120 plant species. The infection typically manifests as root rot and stunted plant growth (Cai *et al*., 2022). *Fusarium* is also one of the most significant fungal genera responsible for plant disease, not only causing substantial yield losses but also producing mycotoxins that contaminate grains at a global scale. The soil-transmitted nature of this pathogen enables it to spread vascular wilt disease rapidly

among plants (Alkhalifah *et al.,* 2023). The mycotoxins produced by *F. oxysporum* represent a serious threat to food safety and public health, making it one of the dominant pathogens in legume crops (Cai *et al*., 2022). In fact, *Fusarium* ranks among the top five most destructive plant pathogenic fungi worldwide. Infected plants often exhibit severe symptoms including chlorosis, necrosis, wilting of young shoots, and eventually plant death, leading to poor transplantation success and reduced crop productivity (Rahman *et al*., 2021). Various methods have been applied to control plant-pathogenic fungi, with chemical fungicides being one of the most common strategies. However, the use of fungicides poses potential risk to human health, non-target organisms, and for the environment.

One of the promising approaches to suppress the growth of pathogenic fungi is the utilization of endophytic fungi. Endophytic fungi are natural components of the plant micro-ecosystem that influence the physiological activities of their host plants by producing indole-3-acetic acid (IAA), supporting biosynthetic processes, enhancing nutrient acquisition, and releasing stress-adaptive metabolites. These metabolites not only help to protect the host plant against pathogen invasion but also provide endophytes with a secure habitat and nutrient supply from the host (Simamorea *et al*., 2021). Over the past few decades, endophytic microbial communities have attracted increasing attention in the agricultural sector. Endophytes have been widely explored as biofertilizers, biocontrol agents,

and stress modulators, positioning them as eco-friendly strategies for sustainable environmental management (Singh *et al.,* 2022). Therefore, many fungal endophytes exhibit characteristics as Plant Growth-Promoting Fungi (PGPF).

PGPF possesses several functional capabilities that contribute directly or indirectly to plant growth, including phosphate solubilization, production of IAA, siderophores, cellulase, and chitinase, as well as the ability to induce resistance against various plant diseases (Naziya *et al*., 2020). PGPF colonizing the rhizosphere are particularly beneficial to plants, as they enhance nutrient availability, improve growth performance, and stimulate defense response (Murali *et al*., 2021). In addition to growth-promoting, PGPF plays a significant role as antagonists or biocontrol agents. They achieve this through multiple mechanisms, such as competing with pathogens for space and nutrients, producing growth hormones, solubilizing essential minerals, resisting parasitism, efficiently colonizing plant roots, and inducing systemic resistance (ISR) in plants. Several fungal genera have been identified with potential as PGPF, including *Gliocladium, Penicillium, Phoma, Phytophthora, Rhizoctonia, Talaromyces,* and *Trichoderma* (Adedayo and Babalola, 2023).

The application of PGPF provides an eco-friendly alternative that reduces the reliance on chemical control agents while protecting plants from biotic and abiotic stresses. Therefore, the exploration of fungal endophytes from the roots of red bean plants is highly relevant. Based on

these considerations, the present study aims to isolate and identify fungal endophytes from the roots of red bean plants and evaluate their potential as biocontrol agents against *F. oxysporum,* as well as their phosphate solubilization, and IAA production. The research results are expected to contribute to the development of sustainable strategies for managing *F. Oxysporum* infection and enhancing the role of PGPF in red bean cultivation.

1.2 The Formulation of Problem

1. What are the macroscopic and microscopic morphological characteristics of endophytic fungal isolates obtained from the of roots red bean plant (*Phaseolus vulgaris* L.)?
2. Do any endophytic fungal isolate from red bean (*Phaseolus vulgaris* L.) exhibits potential antagonistic activity against the phytopathogen *Fusarium oxysporum*?
3. Do endophytic fungal isolates from the roots of red bean (*Phaseolus vulgaris*) that exhibit the highest antagonistic activity demonstrate potential as Plant Growth Promoting Fungi (PGPF) based on phosphate solubilization and indole-3-acetic acid (IAA) production?
4. What are the species identities of the selected red bean endophytic fungi using Internal Transcribed Spacer (ITS)?

1.3 The Aims of Research

1. This research aims to identify the macroscopic and microscopic diversity of endophytic fungal isolated from the red bean plant.
2. This research aims to find the antagonistic potential of red bean endophytic fungal isolates against the phytopathogen *F. oxysporum*.
3. This research aims to find the potential of red bean endophytic fungi as Plant Growth Promoting Fungi.
4. This research aims to identify the species of red bean endophytic fungal isolates with the best antagonistic ability based on ITS molecular identification.

1.4 The Significance of Research

Providing information to readers about the potential of red bean endophytic fungi as a biocontrol agent to inhibit the growth of *F. oxysporum*. In addition, the potential of PGPF that can be utilized as biofertilizers. This can be utilized in agriculture, especially organic farming and farmers producing red bean crops.