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Effectiveness of Local Indigenous Rhizobacterial Isolates in Enhancing Resistance of Shallot (*Allium cepa* L.) to *Fusarium oxysporum*

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Abstract. Fusarium wilt caused by Fusarium oxysporum remains a major limitation in shallot (Allium cepa L.) cultivation, severely reducing yield and crop quality. This study aimed to evaluate the effectiveness of native rhizobacterial isolates as biological inducers of resistance against Fusarium wilt under different organic growing media. A split-plot randomized complete block design was applied using three growing media (rice husk charcoal, manure, and their combination) and four rhizobacterial treatments (control and three local isolates: R1–R3) with three replications. Key physiological assays included the measurement of salicylic acid (SA) content and peroxidase (POX) enzyme activity as biochemical indicators of induced resistance. Results showed that the isolate from Waitii Village (R3) significantly reduced disease incidence to 52.67% compared with 86.56% in the control, while the combined organic medium (M2) further enhanced plant resistance. Increased SA (26.82 ppm) and POX activity exhibited strong negative correlations with disease incidence (R^2 = 0.60 and R^2 = 0.71, respectively), indicating their pivotal role in rhizobacteria-mediated defense activation. These findings confirm that indigenous rhizobacteria, when combined with organic amendments, effectively stimulate systemic acquired resistance and mitigate the severity of Fusarium wilt in shallots. The study highlights the potential of the R3 isolate as a sustainable bioinoculant candidate for integrated disease management. Further molecular identification, in vitro antagonism testing, and multi-location field validation are recommended to ensure its stability, efficacy, and applicability under diverse agroecological conditions.

Keywords: fusarium wilt; peroxidase; salicylic acid; shallot; split-plot

INTRODUCTION

The Bima Brebes shallot, prized amongst Indonesian farmers for its high yields and short harvest periods, often falls victim to the devastating Fusarium wilt. caused by the soil-dwelling fungus *Fusarium oxysporum* f.sp. cepae. The disease attacks the plant's vascular system, cutting off its lifeline and leaving the bulbs wilted and soon dead. Although fungicides have traditionally been used to combat the pathogen, their long-term environmental effects and tendency to breed resistance necessitate alternative controls. For those hearty Bima Brebes that avoid infection, yields as much as 55% greater can be obtained without the disease's interference. Still, developing strategies to protect this staple crop without harming the land remains a pressing priority, as shallots remain integral to both Indonesia's food markets and many dinner tables. Their bounty, though sometimes precarious, nourishes communities throughout the nation (Wijayanti et al., 2024). The need for sustainable, environmentally safe, and biologically based disease management strategies has therefore become increasingly urgent.

As agricultural technologies continue to progress, biotechnological methods such as employing rhizobacteria to manage disease offer promising avenues to enhance plant immunity (Hadi et al., 2023). Rhizobacteria aid not just soil nutrient accessibility but also play an essential role in heightening plant protection against harmful pathogens. Applying rhizobacteria has been shown to enhance plant defense mechanisms against pathogen attack (Anggraini et al., 2020). Leveraging indigenous shallot rhizobacterial isolates is particularly pivotal in substantially boosting resistance of non-native shallot varieties, especially towards the damaging

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Fusarium oxysporum. These rhizobacteria are naturally adapted to the local agroecosystem, allowing them to more effectively colonize the rhizosphere compared to foreign strains. Their adaptation permits them to secrete bioactive metabolites that can curb pathogens and induce systemic resistance in host plants. Although beneficial rhizobacteria are widely known to enhance plant growth and resistance through induced systemic resistance (ISR), their application in shallot cultivation, particularly against Fusarium wilt, remains limited. Existing research tends to focus on introduced microbial strains rather than indigenous ones, leaving a significant knowledge gap regarding the functional potential of local rhizobacteria naturally adapted to domestic soils. Research indicates that locally-occurring rhizobacteria are optimally suited to furnish protection against pathogens that indigenous plants have coevolved alongside (Romera et al., 2019); (Lamo & Takken, 2020). Based on these considerations, the present study aimed to evaluate the effectiveness of native rhizobacterial isolates in inducing resistance of shallot plants against Fusarium oxysporum infection under different organic growing media. Specifically, this research sought to (i) assess the influence of several local isolates (R1, R2, R3) on disease suppression, (ii) examine the interaction between rhizobacteria and organic media (rice husk charcoal, manure, and their combination) in enhancing plant health, and (iii) determine the biochemical indicators of induced resistance through salicylic acid (SA) and peroxidase (POX) enzyme activity.

It was hypothesized that the effectiveness of native rhizobacterial isolates in suppressing Fusarium wilt in shallot plants varies according to their origin and compatibility with the growing environment. The combination of organic growing media particularly the mixture of rice husk charcoal and manure with effective rhizobacterial isolates is expected to enhance induced systemic resistance compared to single treatments. Furthermore, it is hypothesized that increased levels of salicylic acid (SA) and peroxidase (POX) enzyme activity serve as key biochemical indicators of plant defense activation and exhibit a negative correlation with disease incidence, collectively contributing to improved plant resistance and reduced severity of Fusarium wilt infection

Rhizospheric microorganisms that inhabit the soil surrounding plant roots play a crucial role in naturally enhancing agricultural productivity. Investigating indigenous root-associated microbes holds potential to enhance their ability to sustain optimal plant flourishing in a balanced manner. Providing proper fertilization and conscientious soil stewardship are equally fundamental in advancing shallot production season after season. Harnessing the innate power of rhizobacteria local to domestic shallot crops has proven an environmentally friendly biological control in curbing the spread of Fusarium wilt. Locally-derived rhizobacterial colonies offer a naturally applicable approach to support shallot growth while safeguarding environmental balance for future generations. Whereas methods for pest and disease management that employ beneficial microbes can boost crop yields and lessen ecological damage, further exploration remains imperative (Khalimi & Leana, 2023; Ramadhani et al., 2020).

Investigations into how indigenous rhizobacterial isolates may enhance shallots' resistance to the devastating Fusarium have been scarce, particularly in-depth analyses seeking to unveil the intricate biological mechanisms underlying this enhanced resilience. Consequently, this research aims to identify locally relevant biological safeguards that are not only potent but also ecologically compatible. It is hoped the discoveries will prepare the ground for cultivating microbial-driven natural regulatory solutions for the sustainable farming of shallots, confronting the persistent threat of Fusarium wilt. Moreover, the findings may illuminate opportunities to bolster other susceptible edible alliums

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through optimizing beneficial relationships with indigenous microflora naturally equipped to thwart soil-borne diseases. This study aims to evaluate the effectiveness of native rhizobacterial isolates in enhancing the resistance of shallot (Allium cepa L.) plants against Fusarium oxysporum infection through systemic resistance induction mechanisms.

METHODS

This research was conducted from March 2024 to June 2025. The laboratory analyses were conducted at the Agronomy Unit Laboratory, Faculty of Agriculture, Halu Oleo University, Kendari, while the greenhouse experiments were carried out at the net house of the Faculty of Agriculture, Fisheries, and Animal Husbandry, Universitas Sembilanbelas November Kolaka.

The materials used in this study included local red onion (*Allium cepa* L.) rhizobacteria isolates originating from Kolaka Utara and Wakatobi Regencies, rice husk charcoal, farmyard manure, soil, and red onion seeds. The laboratory equipment used consisted of a UV-VIS spectrophotometer, Schott bottles, Petri dishes, Erlenmeyer flasks, spreaders, beakers, test tubes, analytical balance, autoclave, inoculation needle, micropipettes, pipette tips, measuring cylinders, spatulas, electric oven, vortex mixer, Eppendorf tubes, Bunsen burner, heat-resistant plastic, camera, laminar air flow cabinet, hot plate, germinator, plastic buckets, ruler, and writing tools.

This study was carried out in a greenhouse under semi-controlled environmental conditions. Throughout the experiment, air temperature fluctuated between 28–32°C, with relative humidity maintained at 75–90%. The photoperiod corresponded to the natural tropical daylight cycle, without the addition of artificial light sources. Shallot plants were cultivated in pots measuring 30 cm in upper diameter, each containing 10 kg of growth medium prepared according to the treatment combinations. Irrigation was conducted twice daily morning and afternoon to sustain soil moisture close to field capacity and to avoid waterlogging conditions that might favor disease development. Fertilization was performed using a compound NPK fertilizer (15-15-15) at a rate equivalent to 300 kg per hectare, applied three times: at planting (0 DAP), (21 DAP), and (35 DAP), ensuring uniform nutrient availability among all experimental units.

The experiment employed a split-plot design, with the main plot factor consisting of three types of organic amendments: M0 = rice husk charcoal, M1 = manure, and M2 = a combination of rice husk charcoal and manure. The subplot factor consisted of four rhizobacterial isolates: R0 = no isolate, R1 = isolate from Pitulua Village (North Kolaka Regency), R2 = isolate from Totallang Village (North Kolaka Regency), and R3 = isolate from Waitii Village (Wakatobi Regency). Each combination of treatments (M × R) was allocated to a single pot representing one experimental unit, replicated three times (three blocks), resulting in a total of 36 experimental units. Three shallot plants were grown in each pot to maintain an adequate population for disease intensity assessment and to capture physiological variability among individual plants within treatments. The plant number was kept constant across all experimental units to prevent bias related to plant density.

The layout of the main and subplots followed a hierarchical arrangement. Each level of organic amendment (M) was assigned as a main plot within every block, while the four levels of rhizobacterial isolates (R) were randomly distributed within each main plot. Blocking was applied to control micro-environmental variability in the greenhouse, including differences in natural light intensity and airflow direction from the front to the back. All treatment units within each block were randomized to eliminate positional bias and ensure equal exposure of all treatments to environmental influences.

Data Analysis The observational data

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were analyzed using analysis of variance (ANOVA) and descriptive visual analysis based on qualitative indicators. If the F-test indicated a significant effect at the 95% confidence level, further analysis was conducted using Duncan's Multiple Range Test (DMRT) at a significance level of α = 0.05.

RESULTS AND DISCUSSION

The role of rhizobacterial isolates as inducers of plant resistance to Fusarium wilt disease can be observed through their ability to reduce disease incidence and stimulate the production of chemical compounds in plants as part of the resistance induction mechanism. The results of the analysis of variance (ANOVA) for the average incidence of Fusarium wilt under different growing media and rhizobacterial treatments are presented in Table 1.

Table 1 shows that the type of planting medium had a differential impact on the incidence of Fusarium wilt in shallots. The rice husk charcoal medium (M0) exhibited the highest disease incidence at 77.50%, followed by manure (M1) at 76.42%, and the combination of rice husk charcoal and manure (M2), which showed the lowest incidence at 67.50%. Although the differences were not statistically significant (ns), the trend suggests that the use of combined organic materials may be more effective in suppressing disease incidence than single-medium applications. In the treatment lacking rhizobacteria, disease incidence reached its highest at 86.56% among all treatments. The isolate from Totallang Village also exhibited a high disease incidence that was comparably undeterred at 83.33%, not differing significantly from the control. In contrast, the isolate from Pitulua Village reduced disease incidence to a significantly less 72.67% unlike the unmitigated control. The most powerful isolate originated from Waitii Village, with the lowest incidence at 52.67%, significantly different from other addresses with the condition.

Table 1. Average incidence of Fusarium wilt disease in shallots under different growing media and Rhizobacterial treatments

Growing Media	Disease Incidence (%)	
Rice Husk Charcoal (M0)	77,50	
Manure (M1)	76,42	tn
Rice Husk Charcoal + Manure (M2)	67,50	
Control (No Rhizobacteria) (R0)	86,56	a
(R1)	72,67	b
(R2)	83,33	a
(R3)	52,67	c

Note: Numbers followed by the same letter in the same column are not significantly different according to the DMRT test at a significance level of α = 0.05.

These discoveries suggest that the disease-curing potential of rhizobacterial strains is closely tied to their geographical origin. The rhizobacteria isolated from Waitii Village demonstrated the strongest potential for decreasing disease incidence, possibly owing to adaptations to local environmental conditions or an enhanced ability to secrete antimicrobial metabolites against Fusarium pathogens. Accordingly, capitalizing on indigenous microbes native to Waitii Village, especially those perpetually present in local soils, may offer an auspicious organic strategy to reduce the virulence of Fusarium wilt through natural means. Some rhizobacterial isolates have been reported to

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reduce disease severity, potentially through production of inhibitory secondary metabolites, although this was not directly tested here, which are inhibitory to the pathogen, such as F. oxysporum. Waitii Village was isolated to have some potential; however, there is much to be learned about the complex chemical communication pathways between beneficial microbes, and it can be manipulated to biologically control these harmful soilborne diseases in an ecologically safe/sustainable fashion (Anggraini et al., 2020; Nurikhsanti et al., 2024). Use of organic agents such as rhizosphere bacteria has been shown to reduce the prevalence of Fusarium wilt disease in the crop (Khaeruni et al., 2020).

The two-way statistical analysis revealed that the interaction between planting media type and rhizobacteria had no significant effect on disease incidence ($p>0.05$). Therefore, the disease suppression observed in the R3 isolate treatment was not attributed to a specific combination of growing media but rather reflected the intrinsic biological capability of the isolate to induce plant defense mechanisms. This finding indicates that the primary effect is driven more strongly by the rhizobacterial factor than by the type of medium used, emphasizing that the physiological quality of the R3 isolate plays a crucial role in modulating plant responses to *Fusarium* infection. Nevertheless, it should be noted that this study did not include *in vitro* antagonism assays against *Fusarium oxysporum* (e.g., dual culture tests), nor analyses of siderophore, protease, or other antifungal metabolite production that could directly elucidate the biochemical mechanisms of the R3 isolate. Consequently, the mode of action of R3 remains indicative and is supported mainly by physiological plant responses, particularly increased SA and peroxidase activity. Further research under controlled laboratory conditions is therefore strongly recommended to confirm whether R3 exhibits direct antibiosis or acts primarily through an *Induced Systemic Resistance* (ISR) mechanism.

Rhizobacteria induce resistance in plants against the lethal soilborne fungus Fusarium by the signaling cascade through their secreted metabolites. Some benign bacteria, also in the rhizosphere, let off salicylic acid and other secondary chemicals that crop roots understand (salicylic acid's a version of aspirin) and they prime the whole plant to defensively gear up. Salicylic acid (SA), is a signaling molecule known to participate in systemic acquired resistance (SAR) pathways in plants. Activation of SAR signaling pathways can improve plant preparedness against pathogen infection by Fusarium, the wilt pathogen, thereby greatly reducing the havoc this lethal soil-borne pathogen usually wreaks. Some of these rhizobacteria have several ways by which to help plants fight off threats by producing an array of protective compounds and triggering complex defense responses through complex signaling networks that make plants more resistant to devastating diseases (Yanti et al., 2020); (Parnidi et al., 2021). In addition, rhizobacteria contribute directly by supplying phytohormones and essential nutrients, which not only support plant growth but also enhance the plant's ability to cope with biotic stress.

Figure 1 shows that treatments combining organic materials and rhizobacteria were associated with higher Salicylic Acid concentrations in plant tissues compared to the control, which assumes a pivotal part in a plant's immune response against disease-causing organisms. The increase in salicylic acid levels suggests that certain microbes may contribute to enhanced physiological resistance against pathogen attack. The amalgamation of M2R3 brought about the highest salicylic acid production at 26.82 pieces per million, while the lowest value was seen in the control without any treatment at 18.36 pieces per million. This shows that applying natural assets and soil microbes can upgrade a plant's physiological reaction to pathogenic

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anxiety. Unadulterated compost directly contributes to exacerbating natural issues in the soil, which enhances the soil's ability to hold onto and release nutrients, such as phosphorus, essential for synthesizing salicylic acid in plants (Rahmawati et al., 2021). As natural issues separate, natural acids are delivered that support expanding dirt pH and nutrient availability, as well as fortify the plant's defense system by increasing the production of salicylic acid.

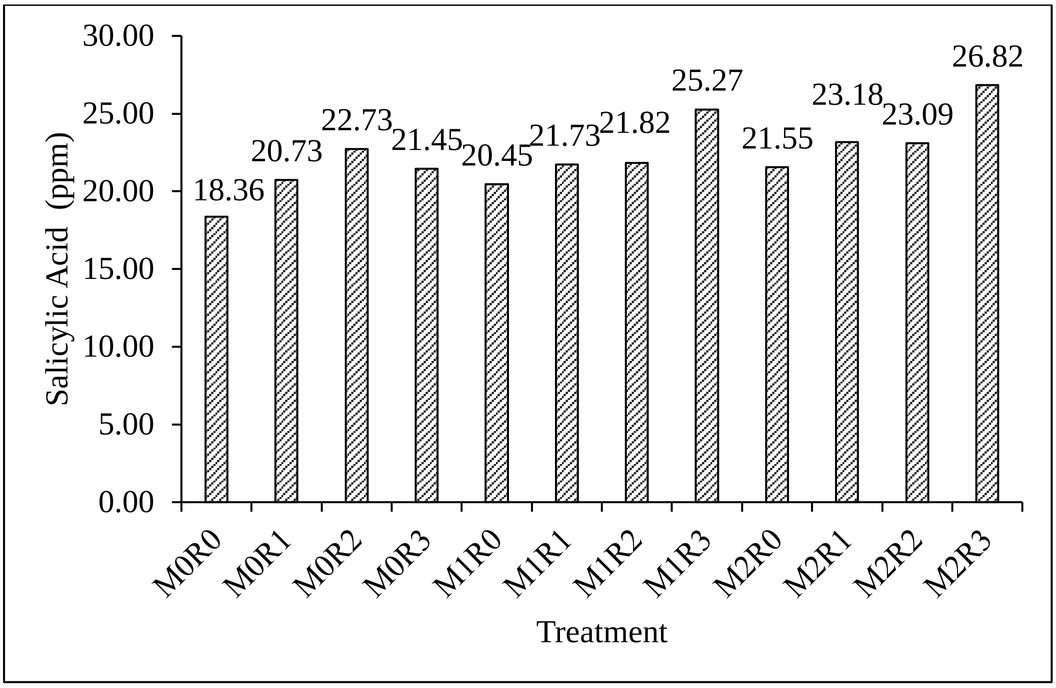

Figure 1. The ability of rhizobacteria to produce salicylic acid in shallot plants.

The use of selected soil bacteria led to a more optimized upregulation of salicylic acid synthesis compared to applications lacking such microbes. Certain microorganisms have the potential to become endophytes, facilitating the generation of compounds that enhance defensive responses in plants against infectious organisms through stimulated salicylic acid biosynthesis (Nurhakiki et al., 2022). This pathway is tied to the ability of bacterial isolates to boost metabolic activity inside host plants, thereby promoting the formation of secondary anti-pathogen metabolites, including salicylic acid, in response to the detection of aggressors (Abna et al., 2023). Both the organic inputs and the selected bacterial strains themselves help to enhance plant resistance by reinforcing the protective mechanisms and by increasing salicylic acid levels. These results underscore the important roles of both treatments in enhancing the well-being of crops while opening new directions for more sustainable and effective disease and pest control methods in agriculture

Rhizobacteria inhabit plant roots, developing beneficial relationships by releasing useful substances. One such microorganism synthesizes the enzyme peroxidase, vital to plant functioning and stress reactions. Peroxidase aids crucial physiological processes and daily metabolism, as recent investigations have found (Ariani et al. 2022). This assists in withstanding dangers while carrying out essential duties. Another pivotal influence controlling soilborne disease caused by Fusarium wilt is the levels of salicylic acid and related peroxidase activity. Salicylic acid serves as an internal defense signal, activating peroxidase and bolstering resistance. Research indicates it induces this

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enzyme, elevating the plant's defenses against fungal pathogens, for example, Fusarium oxysporum. Peroxidase has been implicated in several plant defense-related processes. Moreover, peroxidase plays an integral role in plant growth and development through the regulation of certain processes, including lignification, suberization, auxin catabolism, and response to environmental stresses. Without sufficient peroxidase activity, plants struggle to ward off invasive fungi and have difficulty adapting to changing conditions in the rhizosphere. The connection between salicylic acid amounts, peroxidase enzyme activity, and Fusarium wilt severity is shown clearly in the figure. It illustrates their interplay in combating the fungus, with salicylic acid spurring peroxidase to better protect the roots. This collaborative defense mechanism helps determine disease impact on the plant.

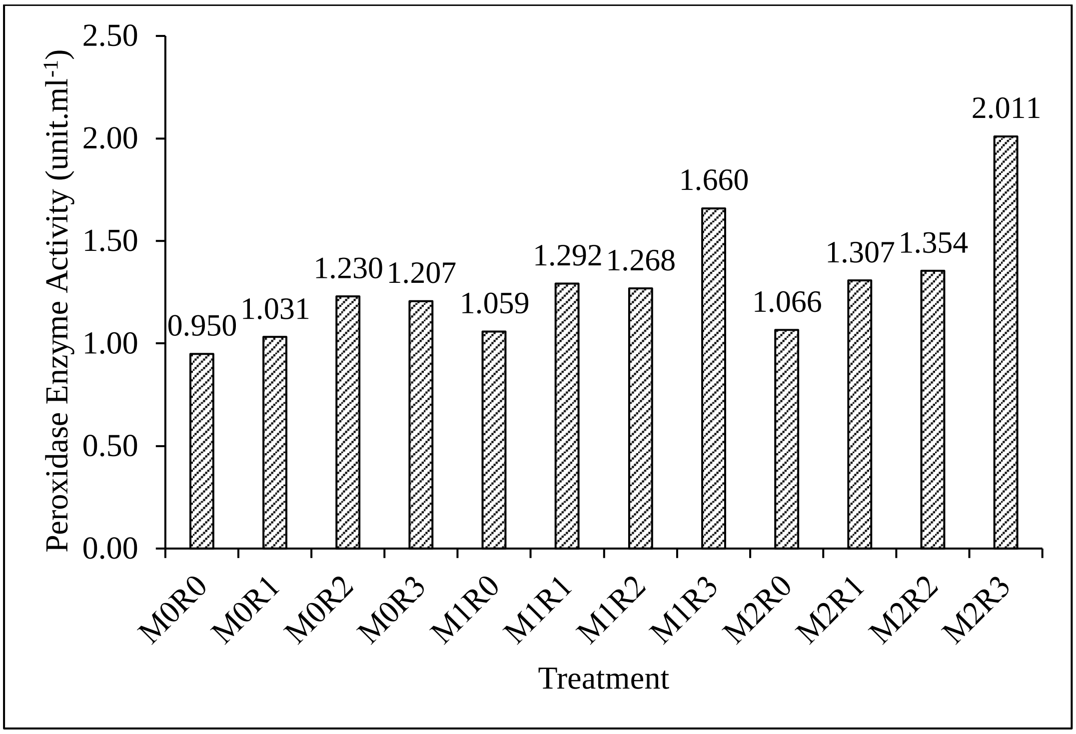

Figure 2. Peroxidase Enzyme Activity in Shallot (Allium cepa L.) Induced by Local Rhizobacterial Isolates.

Figure 2 indicates that peroxidase activity tended to be higher in treatments combining organic media and rhizobacteria in shallot crops. The surge in peroxidase activity is associated with both the kind of sowing surroundings applied and the presence of indigenous rhizobacterial isolates. The optimum peroxidase activity was observed in the amalgamated mixture of manure-derived increasing materials and rhizobacterial inoculation, whereas the lowest activity occurred in the charcoal husk grounds lacking any microbial inoculation. These outcomes underscore the importance of selecting suitable growing environments and the deployment of rhizobacteria to support natural processes and plant protection mechanisms in shallots. This pattern suggests that both media type and inoculation contribute to variation in peroxidase levels, although the interaction effect requires cautious interpretation. While charcoal husk on its own does slightly spur such enzymatic endeavors, incorporating appropriate microbes can rouse usually dormant biochemical tactics to further the plant.

The use of nutrient-rich growing

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mediums, such as manure, can enhance soil fertility, which in turn positively impacts plant productivity. The inclusion of organic materials improves both the chemical and physical properties of the soil, creating optimal conditions for advantageous biological management agents that support plant growth. Manure is renowned to offer fundamental nutrients and helpful microorganisms that trigger key enzymes in plant physiological processes, particularly peroxidase, which participates in plant protection responses against biotic and abiotic stress (Budias, Udayana, and Wirajaya 2022); (Pepadu et al., 2021). Rhizobacteria contribute to the advancement of enzymatic activity in plants. The software of rhizobacterial microorganisms can extend the potential of plant enzymes. Research has demonstrated that the usage of organic media in shallot cultivation has yielded greater efficacy in supporting plant growth through the years. Studies indicate that the integration of organic materials into planting mediums nourishes soil microflora. These microorganisms play a vital role in nutrient cycling and supporting plant functions that lead to improved yields (Kamaludin & Wahyuningsih, 2021; Titiaryanti & Hastuti, 2022).

While the connection among earthy components and microbial strains exhibited a manifold sway on the enzyme activity of shallots in an intricate style that was frequently perplexing to foretell, this subtle uncovering sheds light on the crucial importance of stabilizing both the structure of the developing substrate and the approaches for presenting microorganisms so as to bolster how crops withstand obstacles and produce copious collections. The interaction between soil materials and microbes demonstrated a complex impact on the enzyme activity of shallots, often making it puzzling to predict. This delicate finding highlights the vital importance of balancing the composition of the growing medium and the strategies for introducing bacteria to enhance how plants withstand challenges and yield abundant harvests. The negative association observed between SA/peroxidase and disease incidence supports the possibility that these physiological responses are involved in resistance, although this relationship remains correlational.

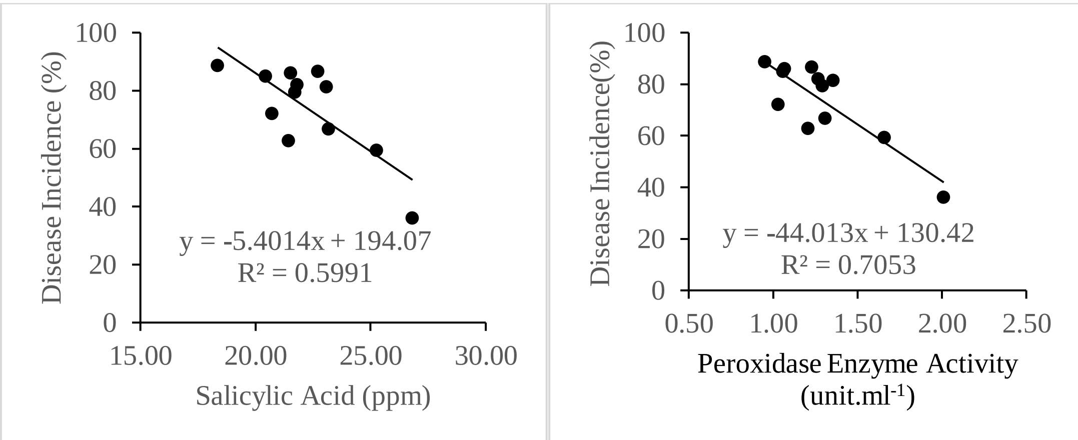

Figure 3. Relationship between salicylic acid production (a) and peroxidase enzyme activity (b) with disease incidence in shallot plants.

Figure 3. (a) and (b) demonstrate that increases in salicylic acid and peroxidase enzyme activity are each linearly and negatively correlated with the incidence of Fusarium wilt. Each 1 ppm increase in salicylic acid and 1 ml/unit increase in

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peroxidase enzyme activity reduced disease incidence by 5.40% (following the equation Y = -5.4014 + 194.07; R^2 = 0.5991) and 44.01% (following the equation Y = -44.013 + 130.42; R^2 = 0.7053), respectively. While increased salicylic acid and peroxidase enzyme activity account for much of the variation in disease incidence levels, their interplay in the plant's complex defense system is more nuanced. Nearly sixty percent of infections can be attributed to increased salicylic acid production, and over seventy percent correlate with enhanced peroxidase activity. However, taking a wider view, salicylic acid serves as a key instigator in bolstering the plant's resistance to invaders such as Fusarium through prompting the activity of protective enzymes like peroxidase. In turn, this stimulation of the defense mechanisms systemically counters biological threats at their source. The intimate interrelationships between salicylic acid, peroxidase, and other elements of the response against such pathogens deserve deeper investigation to fully illuminate the elegant balance plants maintain (Tarigan et al., 2019; Suganda & Wulandari, 2019). Salicylic acid, as a plant growth hormone, plays a critical role in defense responses and can enhance the production of peroxidase enzymes, which function to eliminate free radicals and strengthen plant cell walls against infection (Zhu et al., 2022; Mufti et al., 2023). Salicylic acid is essential in regulating various physiological processes, including the synthesis of defense compounds and the activation of enzymes such as peroxidase. The induction of peroxidase activity by salicylic acid can effectively reduce pathogen-induced damage (Raut & Borkar, 2015). Peroxidase enzymes have been reported in the literature to contribute to the detoxification of Reactive Oxygen Species (ROS), which can reduce cellular damage, including degradation of chlorophyll and membrane lipids (Mohebby et al., 2021).

Salicylic acid functions as a plant hormone involved in regulating multiple aspects of growth and promoting resistance against pathogen-caused stress. Its application considerably reduces disease infection levels by optimizing peroxidase enzyme activity, as evidenced by (Yuniati et al., 2020). This study demonstrates that the exogenous application of salicylic acid promotes the enhancement of plant metabolism, thereby contributing to increased disease resistance. The rise in peroxidase activity is not only induced by salicylic acid but also by other treatments aimed at strengthening plant defense mechanisms. The use of salicylic acid in agriculture can be considered an effective strategy for controlling the impact of Fusarium wilt disease through the enhancement of defense-related enzymes and the reduction of disease incidence.

This research presents several inherent limitations that should be acknowledged when interpreting its outcomes. The restricted sample size inevitably weakens the statistical robustness and constrains the extent to which the findings can be generalized across wider populations. Moreover, since the experiments were conducted under controlled greenhouse conditions, variations in plant responses and rhizobacterial performance may emerge under field conditions characterized by more complex environmental dynamics. The absence of molecular identification for the isolates further limits the precision in determining their taxonomic classification and genetic traits. In addition, the observed correlation between elevated salicylic acid (SA) concentrations, peroxidase enzyme activity, and plant resistance remains associative rather than demonstrably causal, thus requiring further investigation to establish a definitive mechanistic relationship

To reinforce the findings of this study, a series of more targeted follow-up actions should be undertaken. Initially, the molecular characterization of the R3 isolate must be conducted to precisely define its taxonomic classification and elucidate its phylogenetic relationship with other recognized rhizobacteria using 16S rRNA gene

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sequencing analysis. Subsequent investigations should include comprehensive in vitro antagonism assays aimed at assessing the R3 isolate's inhibitory potential against Fusarium oxysporum and identifying its underlying mechanisms, whether through antibiosis, competition, or other modes of action. Field validation under diverse soil types and climatic conditions is also essential to verify the reproducibility and stability of its effectiveness in real-world agricultural settings. Ultimately, the formulation and stability evaluation represent a pivotal phase in developing a bioinoculant product that is both practical and reliable, guaranteeing that the R3 isolate maintains its viability, stability, and bioefficacy during storage and application.

CONCLUSION

This study shows that local shallot rhizobacterial isolates, particularly from Waitii Village (R3), effectively suppress the incidence of Fusarium wilt disease. The combination of rice husk charcoal and manure (M2) serves as an effective growing medium, supporting rhizobacterial activity and enhancing plant health. Rhizobacteria are able to induce systemic plant resistance by increasing salicylic acid production and peroxidase enzyme activity, which have been shown to negatively correlate with disease intensity.

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