JPT: Jurnal Proteksi Tanaman (Journal of Plant Protection)
p-ISSN : 2580-0604, e-ISSN: 2621-3141
Accredited: Sinta 3, DOAJ
Publisher: Universitas Andalas, Website: http://jpt.faperta.unand.ac.id/index.php/jpt
Vol. 9 No.1 (2025): 1 - 13

Endophytic Bacteria Consortia as Biocontrol Against Brown Spot Disease (*Helminthosporium oryzae*) and Growth Promotion in Rice

Eri Sulyanti, Zurai Resti*, Haliatur Rahma, Darnetty, Ujang Khairul, Nurhaliza, Silvia Oktaviani

Department of Plant Protection, Faculty of Agriculture, Universitas Andalas, Padang 25163, West Sumatra, Indonesia

*E-mail: zurairesti@agr.unand.ac.id

Received: 1 December 2024 | 1st Revised: 18 January 2025 | Accepted: 23 May 2025 | Published: 30 June 2025

Abstract

The brown spot disease (BSD) caused by *Helminthosporium oryzae* in rice can lead to yield losses of up to 45%. Using endophytic bacterial consortia as a biological agent is one of the most potential control methods for resisting the disease. This study aimed to obtain an endophytic bacterial consortium with the best efficacy in controlling BSD and its ability to enhance rice plant growth. Statistical analysis in this study was made using Analysis of Variance (ANOVA) with Duncan's Multiple Range Test (DMRT) in a randomized experimental design comprising five treatments with five replications. The treatments included: A (*Serratia marcescens* ULG1E4 + *S. marcescens* JB1E3), B (*S. marcescens* ULG1E4 + *S. marcescens* JB1E3 + *Serratia marcescens* JB1E2), C (*Bacillus sp.* SJI + *Serratia marcescens* ULG1E4), D (positive control), and E (negative control). Testing was conducted *in planta*, with the introduction of the bacterial consortium (10^8 cells/mL) via seed and root soaking methods. Subsequently, the leaves of 30-day-old rice plants were inoculated with *H. oryzae* by spraying a conidial suspension of 10^6 conidia/mL. Parameters observed included disease progression (incubation period, incidence, and severity), seedling growth metrics (height, leaf number, root length, fresh and dry biomass), and overall plant development (plant height, leaf number, and tiller count). The results demonstrated that the consortium of *Serratia marcescens* ULG1E4, *Serratia marcescens* JB1E3, and *Serratia marcescens* JB1E2 effectively controlled BSD, achieving a 53.69% reduction in disease severity and promoted rice plant growth, evidenced by a 30.63% increase in leaf number.

Keywords: Biocontrol, consortium, disease, incidence, *Serratia* spp.

Introduction

Rice is one of the food crops that play an important role in the Indonesian economy (Prasetia et al., 2022). Several efforts in increasing rice productivity have been made to meet rice demand in Indonesia (Norjamilah et al., 2021). However, one significant barrier remains—the susceptibility of rice crops to plant pathogens (Sudewi et al., 2020). Several important plant diseases affecting rice plants have been reported, such as blast disease which is caused by *Pyricularia oryzae*, sheath rot caused by *Sarocladium oryzae,* blight disease caused by *Rhizoctonia solani*, bacterial leaf streak caused by *Xanthomonas oryzae* pv. *oryzicola*, bacterial leaf blight caused by *Xanthomonas oryzae* pv. *oryzae* and brown spot disease (BSD) that caused by

Helminthosporium oryzae (Jiang et al., 2020; Surendhar et al., 2022).

H. oryzae, the agent of BSD in rice, is a significant pathogen in agriculture. BSD can significantly reduce rice productivity, with yield losses reach up to 45% (Aryal et al., 2016). This pathogenic fungus affects both the vegetative and generative phases of rice plants, causing symptoms such as oval-shaped brown spots with grayish-white centers on the leaves. The infection impairs the plant's photosynthetic ability, leading to leaf desiccation, a burnt appearance, and eventual death (Surendhar et al., 2022). Despite current strategies for managing this disease rely heavily on chemical fungicides, which are known to be effective in the short term, they have led to environmental contamination, pathogen resistance, and reduced soil health. These drawbacks highlight the pressing need for sustainable alternatives.

The use of potential endophytic bacteria, microorganisms that associate within plant tissues and function as promising biocontrol agents, can be used as alternative strategy on suppressing pathogen development through direct and indirect mechanisms. These bacteria boost plant resistance by inhabiting internal tissues and triggering the production of defense-related metabolites, ultimately strengthening the plant's ability to withstand disease (Cheng et al., 2020). Additionally, endophytic bacteria promote plant growth by solubilizing essential nutrients such as nitrogen and phosphorus, supplying iron through siderophore production, and synthesizing phytohormones such as cytokinins, gibberellins, and indole-3-acetic acid (IAA) (Santoyo et al., 2016; Tshikhudo et al., 2023).

The application of endophytic bacterial consortia has proven to be highly effective in controlling plant pathogens due to their ability to employ multiple mechanisms—such as competition, antibiotic production, and induced resistance—simultaneously, leading to enhanced pathogen suppression (Maciag et al., 2023; Kumar and Jagadeesh, 2016). For example, a consortium of endophytic bacteria comprising specific strains of *Bacillus sp.* and *Serratia marcescens* has been reported to suppress *Ralstonia solanacearum* infections in chili plants while promoting plant growth, increasing plant height by 38.38% and leaf count by 70% (Resti et al., 2018). Similarly, another study demonstrated that consortia of *Bacillus sp.* combined with *S. marcescens* effectively controlled bacterial leaf blight and promoted the growth of rice seedlings and plants (Resti et al., 2020). However, most of these studies focus on a limited range of pathogens and crop systems, with minimal exploration of their application against *H. oryzae* in rice.

Although individual endophytic bacteria show great promise, their synergistic effects in consortia remain underexplored, particularly against specific pathogens like *H. oryzae*. This study aimed to identify a bacterial consortium that can effectively suppress *H. oryzae* and promote rice growth. The findings of this study are expected to be a sustainable solution for rice disease management, especially in minimizing the impact of disease along promoting healthy rice production without applying chemical interventions.

Methods

This study used an experimental approach based on a completely randomized design (CRD) to ensure accurate and reliable results. The experiment consisted of five different treatments, including the application of specific endophytic bacterial consortia in selected treatments, while others served as controls or alternative comparisons with and without the introduction of such consortia. To strengthen the validity of the findings, each

treatment was repeated five times, with three plant units included in each repetition to account for natural variability. The details of the bacterial consortia used in each treatment are outlined in Table 1.

Table 1. Treatment of endophytic bacterial consortium

Treatment	Consortium
A	*Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3
B	*Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3 + *Serratia marcescens* JB1E2
C	*Bacillus* sp. SJI + *Serratia marcescens* ULG1E4
D	No treatment and not inoculated with *H. oryzae* (Control)
E	No treatment and inoculated with *H. oryzae* (Control)

Preparation of *H. oryzae*

The pathogen inoculum was derived from rice plants exhibiting brown spot symptoms. Pathogen isolation was conducted using directly plating onto Potato Dextrose Agar (PDA) medium, followed by purification to obtain a pure fungal culture (Waruwu et al., 2016). Fungal identification of *H. oryzae* was conducted through both macroscopic and microscopic methods, with a specific focus on hyphal morphology, conidial color, and conidial shape (Sobanbabu et al., 2018) (Figure 1).

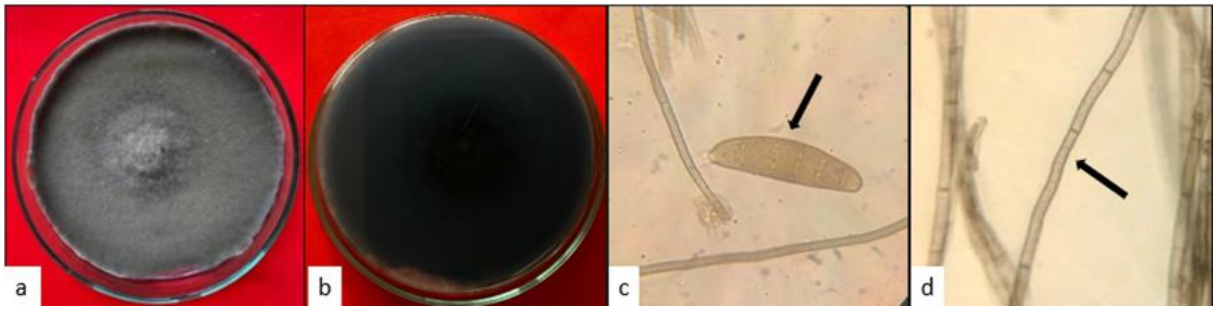


Figure 1. Macroscopic and microscopic characteristics of *Helminthosporium oryzae* (7 days after isolation). (a) Top view of fungal colony, (b) bottom view of fungal colony, (c) Conidia, (d) Hyphae (Magnification 400×)

A pathogenicity test was conducted to confirm the ability of the fungal isolate to cause brown spot symptoms on 30-day-old rice plants. A fungal suspension containing 10^6 conidia/mL was prepared, and 10 mL of the suspension was then sprayed onto rice leaves. Disease observations were made daily until the initial symptoms appeared which indicated by the occurrence of oval, yellowish-brown spots on rice leaves (Amorio and Cumagun, 2017).

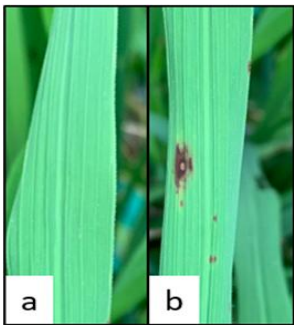


Figure 2. Pathogenicity test of *Helminthosporium oryzae* on rice plants (30 days after planting); (a) uninoculated rice leaves, (b) inoculated rice leaves.

Preparation of Endophytic Bacterial Consortia

The pure cultures of endophytic bacteria used in this study were being provided in honor of Zurai Resti, who developed technique of obtaining pure cultures and maintained them grown on Nutrient Agar (NA) medium. The preparation of the endophytic bacterial consortia involved two main steps: preparation of the liquid culture and formulation of bacterial consortium. In the first step, liquid cultures of the endophytic bacteria were prepared in Nutrient Broth (NB) medium. Subsequently, 1 mL of the liquid culture for each endophytic bacterium was added to 49 mL of sterile coconut water in culture bottles for the consortium formulation. The mixtures were incubated on an orbital shaker at 150 rpm for 48 hours at room temperature. The population density of the consortia was assessed by comparing the turbidity of the suspension to a scale of 8 on the McFarland, which corresponded to a population density of 10^8 cells/mL (Yanti et al*.,* 2018).

Evaluation of Endophytic Bacterial Consortia

The potential of bacterial consortia as biocontrol agents against BSD (*H. oryzae*) in rice plants was evaluated using a planting medium composed of sterilized soil and manure in a 2:1 ratio, which were prepared through tyndallization. The consortia were introduced to the seeds and seedlings of the *Anak Daro* rice variety. For seed treatment, the seeds were soaked in a bacterial consortium suspension (10^8 cells/mL) for 15 minutes, with sterile distilled water serving as the control (Resti et al., 2013). Seedling treatment was conducted at 21 days after sowing (DAS) by immersing the roots in the same bacterial suspension for 15 minutes (Khaeruni et al., 2014). After treatment, the seedlings were transplanted into polybags and maintained in an experimental garden under controlled conditions.

Inoculation of *H. oryzae* in Rice Plants

The inoculation of *H. oryzae* was carried out on 30-day-old rice plants. A fungal suspension containing 10^6 conidia/mL was prepared, and 10 mL of the suspension was evenly sprayed onto leaves using a sprayer. After inoculation, the plants were covered with transparent plastic to maintain high humidity and potentially accelerate pathogen development (Amorio and Cumagun, 2017).

Observation

Disease progression

Investigation of the BSD progression pattern involved three main steps including the observation of the incubation period of *H. oryzae* until the first symptoms occur, followed by determination of disease incidence after inoculation of bacterial consortia, and observing severity of the symptoms appear. The incubation period, which refers to the time from inoculation to the appearance of the first symptoms, was monitored daily. The effectiveness of delaying the incubation period was calculated using a specific formula 1.

Disease incidence, which represents the proportion of plants showing symptoms within a population, was observed weekly from the initial symptom appearance up to 65 days after planting. This data was then evaluated using formula 2 to determine the extent of infection spread.

Additionally, disease severity, indicating the intensity of symptoms, was measured weekly from the onset of symptoms until 65 days after planting. This assessment was calculated using formula 3 to gain insights into how significantly the disease impacted the plants over time.

Table 2. Treatment effectiveness, Disease incidence, and Disease severity formula

Formula		Formula description	Reference
1. Treatment effectiveness (E)	$E = \frac{T - C_n}{C_n} \times 100\%$	E= Treatment effectiveness T = Treatment C_n= Negative control	Sivan and Chet (1986)
2. Disease incidence (DI)	$DI = \frac{n}{N} \times 100\%$	DI = Disease incidence n= number of affected seedlings N= total observed seedlings	Abbott (1987)
3. Disease severity (S)	$S = \frac{\Sigma(n \times v)}{N \times V} \times 100\%$	S= Disease severity n= number of affected leaves N= total number of leaves observed v= the score for each category V= highest score in the damage categories	IRRI (1996)

Seedling growth

Seedling growth, indicated by field emergence of seedlings from the soil surface, was monitored daily from sowing until 21 DAS. The percentage of field emergence and the effectiveness of seedlings emerge were calculated using following formula (Table 3).

Table 3. Effectiveness of seedlings emerging and percentage of seedlings emerging formula

Formula		Description	Reference
4. Effectiveness of seedlings emerging (E')	$E' = \frac{T - C_p}{C_p} \times 100\%$	E'= Effectiveness T = Treatment C_p= Positive control	Sivan and Chet (1986)
5. Percentage of seedlings emerging (P)	$P = \frac{b}{B} \times 100\%$	P = Percentage of seedlings emerging b = Number of seedlings emerging B = Number of seeds sown	

Formula 5 was applied to measure additional growth parameters, including seedling height, leaf count, length of root, fresh weight, and dry weight. These measurements were taken weekly until the seedlings were 21 days old. For dry weight determination, seedlings were wrapped in sterile paper, oven-dried at 60 °C for 5 hours, and weighed.

Rice Plant Growth Observation

The observation of plant growth, particularly through parameters such as field

emergence and seedling vigor, provides insight into the effectiveness of microbial consortia as plant growth-promoting agents. These endophytic bacterial consortia potentially enhance early plant development by improving nutrient availability, producing phytohormones, or offering protection against stress, thereby supporting their application in sustainable agricultural practices (Resti et al., 2018).

Rice plant growth was monitored by measuring plant height, leaf count, and the number of tillers. These observations were conducted weekly, starting from 7 days after planting (DAP) until the plants reached 35 DAP, with data analyzed using Formula 5.

The height of the plants, an indicator of vertical growth, was recorded by measuring the plant height from the bottom of the stem to the top of the tallest leaf. Leaf count was recorded at the same time to track foliage development. The number of tillers was counted starting from the emergence of the first tiller and continued until no new tillers formed. Together, these measurements provided a detailed picture of the plants' growth progression during the observation period.

Data Analysis

The collected data were analyzed using Analysis of Variance (ANOVA) using the SPSS software. If at least one significant difference among the treatment means was detected ($p < 0.05$), further analysis was conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

Results

Disease Progression

The analysis of variance on the effectiveness of endophytic bacteria in inhibiting BSD revealed significant differences compared to the control. The incubation period ranged from 6.07 to 13.94 days post-inoculation (DPI) (Table 4). Among the treatments, the incubation period did not significantly differ among the various endophytic bacterial consortia. However, treatment B (*S. marcescens* ULG1E4 + *S. marcescens* JB1E3 + *S. marcescens* JB1E2) exhibited the most extended incubation period accounted for 13.94 days, with the highest effectiveness in extending the incubation period, achieving an increase of 129.65%.

Although endophytic bacterial consortia were introduced, there was no notable decrease in the occurrence of BSD on rice plants. All plants, including those treated with the consortia and the control group, exhibited *H. oryzae* disease symptoms, with a disease incidence rate of 100%. However, regarding disease severity, treatment B demonstrated the highest effectiveness in reducing disease progression by 53.69%.

Table 4. Incubation period, disease incidence and severity of brown spot disease in rice plants introduced with endophytic bacterial consortium and inoculated with *H. oryzae* (35 DPI)

Treatment	Incubation period		Effectiveness (%)	Disease Incidence (%)	Disease severity (%)		Effectiveness (%)
A	13.00	a	114.16	100	22.44	b	49.39
B	13.94	a	129.65	100	20.53	b	53.69
C	11.33	a	86.65	100	24.90	b	43.84
E	6.07	b	0.00	100	44.34	a	0.00

Values followed by the same lowercase letter within the same column were not significantly different according to Duncan's Multiple Range Test (DMRT) at a 5% significance level.

Table notes:

- **Treatment A**: *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3
- **Treatment B**: *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3 + *Serratia marcescens* JB1E2
- **Treatment C**: *Bacillus sp.* SJI + *Serratia marcescens* ULG1E4
- **Treatment E**: Control (no treatment, inoculated with *H. oryzae*).

Disease Progression in Brown Spot Infection

The progression pattern of BSD on rice leaves showed a steady increase from the first to the fifth week after inoculation. The most pronounced escalation occurred in the negative control group, with disease symptoms appeared as early as the first week and intensifying significantly over time, peaking in the fifth week.

In comparison, the treated control group exhibited symptoms starting in the second week post-inoculation. Among rice plants treated with endophytic bacterial consortia, the severity of the disease remained relatively low and consistent across treatments throughout the five-week observation period (Figure 3)

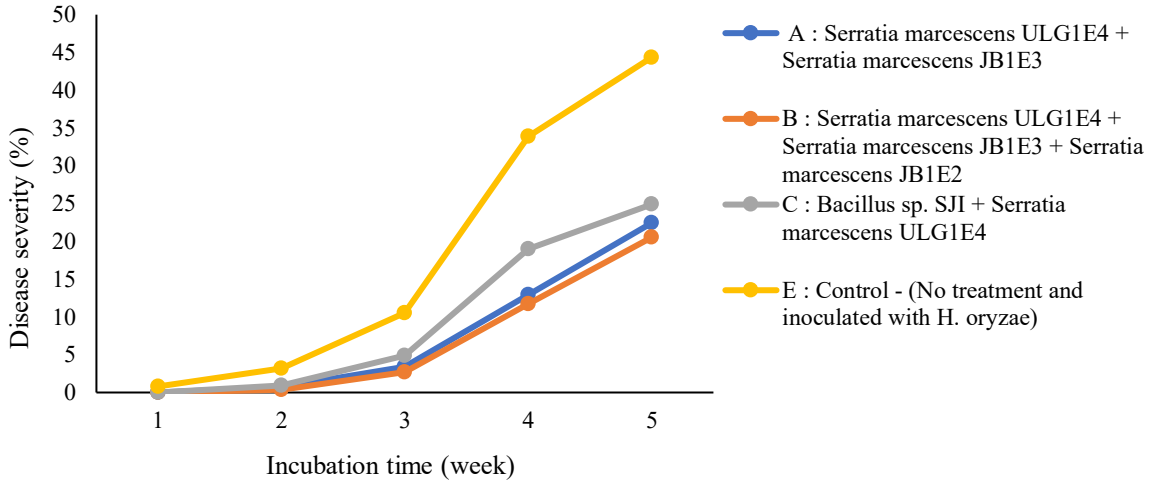


Figure 3. Rate of the disease severity development of brown spot (*Helminthosporium oryzae*) in rice plants introduced with endophytic bacterial consortium (1-5 weeks) after inoculation.

Rice Seedling Growth

The results showed that endophytic bacterial consortia positively influenced rice seed germination and seedling growth, outperforming the control. The field emergence rate ranged from 91% to 97%, with treatment C (*Bacillus sp.* SJI + *S. marcescens* ULG1E4) showing the highest improvement in field emergence percentage, with a 6.59% increase compared to the control. Seedling height varied from 27.71 to 37.31 cm, with treatment B (*S. marcescens* ULG1E4 + *S. marcescens* JB1E3 + *S. marcescens* JB1E2) being the most effective, achieving a 34.64% increase. While the number of leaves did not show significant differences across treatments, all consortia increased leaf count by 5.26%. Root length ranged from 3.58 to 7.65 cm, and treatment B stood out with the most significant improvement, increasing root length by 98.70%. These results are shown in Table 5 and Figure 4 below.

Table 5. Seedling growth, including height, leaf number, and root length, of rice plants treated with endophytic bacterial consortia (21 days after sowing)

Treatment	Field emergence rate		E (%)	Seedling height (cm)		E (%)	Number of leaves (blades)		E (%)	Root length (cm)		E (%)
A	95.0	a	4.39	35.26	a	27.24	4.00	a	5.26	6.40	a	66.23
B	96.0	a	5.49	37.31	a	34.64	4.00	a	5.26	7.65	a	98.70
C	97.0	a	6.59	36.18	a	30.56	4.00	a	5.26	7.30	a	89.61
D	91.0	b	0.00	27.71	b	0.00	3.80	a	0.00	3.85	b	0.00

Values followed by the same lowercase letter within the same column were not significantly different according to Duncan's Multiple Range Test (DMRT) at a 5% significance level.

Table notes:

- **Treatment A**: *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3
- **Treatment B**: *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3 + *Serratia marcescens* JB1E2
- **Treatment C**: *Bacillus sp.* SJI + *Serratia marcescens* ULG1E4
- **Treatment D**: Control (no treatment, not inoculated with *H. oryzae*)



Figure 4. Comparison of rice seedling growth at 21 days after sowing (DAS) for each treatment in the Anak Daro variety (a) *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3 (b) *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3 + *Serratia marcescens* JB1E2 (c) *Bacillus sp.* SJI + *Serratia marcescens* ULG1E4 (d) Control.

Additionally, the consortia greatly influenced the fresh and dry weight of rice seedlings, with the fresh weight values ranging from 0.13 to 0.27 g and dry weight between 0.030 and 0.049 g. Both treatments B and C demonstrated the highest improvements in fresh weight (107.69%) and dry weight (63.33%) values, respectively. These results highlight the capability of endophytic bacterial consortia, particularly treatments B and C, in enhancing rice seedling vigor and early growth performances. These results are shown in Table 6 below.

Table 6. Fresh weight and dry weight of rice seedlings introduced with endophytic bacterial consortium (21 days after sowing)

Treatment	Seedling fresh weight (g)		Effectiveness (%)	Seedling dry weight (g)		Effectiveness (%)
A	0.19	b	46.15	0.046	a	53.33
B	0.27	a	107.69	0.049	a	63.33
C	0.26	a	100.00	0.049	a	63.33
D	0.13	c	0.00	0.030	b	0.00

Values followed by the same lowercase letter within the same column were not significantly different according to Duncan's Multiple Range Test (DMRT) at a 5% significance level.

Table notes:
- **Treatment A**: *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3
- **Treatment B**: *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3 + *Serratia marcescens* JB1E2
- **Treatment C**: *Bacillus sp.* SJI + *Serratia marcescens* ULG1E4
- **Treatment D**: Control (no treatment, not inoculated with *H. oryzae*)

Rice Plant Development

The variance analysis demonstrated that rice plant growth, as indicated by plant height, leaf number, and tiller number traits, was significantly enhanced by the introduction of endophytic bacterial consortia compared to the control (Table 7). Plant height ranged from 83.40 to 91.60 cm, of which the greatest plant height of 91.60 cm was observed in treatment B (*S. marcescens* ULG1E4 + *S. marcescens* JB1E3 + *S. marcescens* JB1E2) with an effectiveness of 8.01%. A comparison of rice plant growth obtained in present study is presented in Figure 5.

Table 7. The development of rice plants exposed to endophytic bacterial consortia and inoculated with *H. oryzae* (35 days after emergence)

Treatment	Plant height (cm)		E (%)	Leaf count (blades)		E (%)	Tiller count (stems)		E (%)
A	86.10	bc	1.53	89.13	b	18.41	23.87	b	17.00
B	91.60	a	8.01	98.33	a	30.63	26.40	a	29.41
C	88.30	b	4.12	90.06	b	19.64	24.40	b	19.60
D	84.80	c	0.00	75.27	c	0.00	20.40	c	0.00

Values followed by the same lowercase letter within the same column were not significantly different according to Duncan's Multiple Range Test (DMRT) at a 5% significance level.

Table notes:
- **Treatment A**: *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3
- **Treatment B**: *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3 + *Serratia marcescens* JB1E2
- **Treatment C**: *Bacillus sp.* SJI + *Serratia marcescens* ULG1E4
- **Treatment D**: Control (no treatment, not inoculated with *H. oryzae*



Figure 5. Comparison of the growth of rice plants aged 49 days after planting that were treated with endophytic bacteria, (a) *Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3 + *Serratia marcescens* JB1E2, (b) positive control.

Number of leaves per plant ranged from 75.27 to 98.33, with treatment B again showing the highest leaf count at 98.33, corresponding to a 30.63% improvement over the control. Similarly, the number of tillers per plant varied from 20.40 to 26.40. Treatment B produced the highest number of tillers (26.40), with an effectiveness of 29.41%, while treatments A (*Serratia marcescens* ULG1E4 + *Serratia marcescens* JB1E3) and C (*Bacillus sp.* SJI + *Serratia marcescens* ULG1E4) showed non-significant differences but still outperformed the control.

Discussion

The use of endophytic bacterial consortia has proven effective in inhibiting BSD caused by *H. oryzae* while promoting the

growth of rice plants and seedlings (Table 4, 5, 6, 7). These consortia are carefully formulated combinations of endophytic bacteria that work together to suppress pathogens and enhance plant health. Each bacterial species in the consortium has unique mechanisms that complement one another, creating a synergistic effect. Research by Kumar and Jagadeesh (2016) supports this approach, highlighting that microbial consortia are often more effective at controlling plant diseases due to their diverse mechanisms of action. Similarly, a study by Resti et al. (2022) showed that a consortium of *S. marcescens* strains (ULG1E4 and JB1E3) was more successful in controlling *Curvularia oryzae* than when an individual bacterium was applied.

In this study, Consortium B (*S. marcescens* ULG1E4, JB1E3, and JB1E2) performed exceptionally well by extending the incubation period of BSD and reducing its severity by 53.69% compared to untreated plants (Table 4). A longer incubation period reflects enhanced plant resistance, as shorter incubation times are often linked to higher disease susceptibility (Norjamilah et al., 2021). The bacteria in the consortium likely act as biocontrol agents by triggering the plant's innate defenses. This aligns with earlier findings where consortia of *Bacillus* and *Serratia* species successfully suppressed diseases like bacterial wilt in chili plants and rice bacterial leaf blight (Resti et al., 2018).

The disease suppression observed may also be linked to the bacteria's ability to stimulate the production of defensive enzymes such as peroxidase. Previous studies have shown that introducing endophytic bacteria increases peroxidase activity in resistant plants (Resti et al., 2017). Additionally, endophytic bacteria from the genus *Bacillus* such as *Bacillus sp.* HI and *Bacillus sp.* SJI are known to produce salicylic acid, a compound play a major role in plant defense mechanisms (Resti et al., 2018). By colonizing plant tissues, these bacteria not only can prevent pathogen attacks, but they can also enhance the plant's production of secondary metabolites and defense enzymes, as noted by Elsharkawy et al. (2022).

Beyond disease control, the application of endophytic bacteria significantly improved the growth of rice plants. Consortium B was the most effective, increasing seedling height by 34.64% (Table 6), leaf count by 30.63%, and tiller number by 29.41% (Table 7) compared to untreated plants. These benefits are attributed to the bacteria's ability to solubilize phosphate and produce the plant hormone indole-3-acetic acid (IAA). This hormone is essential for cell elongation, root development, and tissue differentiation. Cheng et al. (2024) observed that bacterial consortia could produce higher IAA concentrations than individual strains, further boosting plant growth.

The bacteria in Consortium B, primarily from the genera *Bacillus* and *Serratia*, are also known for their ability to fix nitrogen and solubilize phosphate (Alori et al., 2017). These traits enhance nutrient availability to the plants. For example, *S. marcescens* produces chitinolytic enzymes that degrade fungal cell walls and release antifungal compounds like prodigiosin, which also exhibit antibacterial, antiprotozoal, and anticancer properties (Wang et al., 2020). These features enable the consortium to not only suppress BSD but also promote healthy growth. Combining these complementary abilities creates a powerful tool for managing plant health and productivity in rice cultivation.

Conclusion

All the endophytic bacterial consortia tested in this study successfully suppressed the brown spot disease (*Helminthosporium oryzae*) severity and stimulated the growth of

rice seedlings and plants. Among all the tested treatment, Consortium B (*S. marcescens* ULG1E4 + *S. marcescens* JB1E3 + *S. marcescens* JB1E2) exhibited the best performance, with a disease severity reduction effectiveness of 53.69% and an increase in leaf count effectiveness of 30.63%.

Declaration

Author contribution

Eri Sulyanti designed the study, conducted the experiments, and drafted the manuscript. Zurai Resti supervised the study, revised the manuscript, and is the corresponding author. Haliatur Rahma, Darnetty, Ujang Khairul, Nurhaliza, and Silvia Oktaviani contributed to data collection, laboratory work, and manuscript revision. All authors read and approved the final manuscript.

Funding statement

This research was funded by the Faculty of Agriculture, Universitas Andalas, in accordance with Research Contract number: 01/PL/PSK/PNP/FAPERTA-Unand/2024, for the fiscal year 2024.

Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abbott WS. 1987. Classic paper: Abbott's formula. A method of computing the effectiveness of an insecticide. Journal of the American Mosquito Control Association 3(2): 302-303. https://pubmed.ncbi.nlm.nih.gov/3333059

Alori ET, BR Glick, OO Babalola. 2017. Microbial phosphorus solubilization and its potential for use in sustainable agriculture. *Frontiers in Microbiology* 8: 971. DOI: 10.3389/fmicb.2017.00971

Amorio DJH, C Cumagun. 2017. Pathogenicity and cytological examination of adapted and non-adapted Bipolaris species on resistant and susceptible cultivars of rice and corn. Mycosphere 8(3): 377–391. DOI: 10.5943/mycosphere/8/3/3

Aryal L, G Bhattarai, A Subedi, M Subedi, B Subedi, GK Shah. 2016. Response of rice varieties to brown spot disease of rice at Paklihawa, Rupandehi. Globale Insititute for Research and Education 5(2): 50–54. DOI: 10.5958/2394-448X.2022.00023.2

Cheng Q, S Sun, X Ning, M Qiao, W Chen, P Zhang, K Liu, Y Ding. 2024. A synergistic indole-3-acetic acid-producing synthetic bacterial consortium benefits walnut seedling growth. *Agronomy* 14(8): 1657. DOI: 10.3390/agronomy14081657

Cheng T, XZ Yao, CY Wu, W Zhang, W He, CC Dai. 2020. Endophytic *Bacillus megaterium* triggers salicylic acid-dependent resistance and improves the rhizosphere bacterial community to mitigate rice spikelet rot disease. *Applied Soil Ecology*. DOI: 10.1016/j.apsoil.2020.103710

Elsharkawy MM, RM Sakran, AA Ahmad, SI Behiry, A Abdelkhalek, MM Hassan, AA Khedr. 2022. Induction of systemic resistance against sheath blight in rice by different *Pseudomonas* isolates. *Life* 12(3): 349. DOI: 10.3390/life12030349

IRRI. 1996. Bacterial leaf blight. (On-line). http://www.knowledgebank.irri.org/riceDoctor_MX/Fact_Sheets/Diseases/Bacterial_Leaf_Blight.htm

Jiang N, J Yan, Y Liang, Y Shi, Z He, Y Wu, Q Zeng, X Liu, J Peng. 2020. Resistance genes and their interactions with bacterial blight/leaf streak pathogens (*Xanthomonas oryzae*) in rice (*Oryza sativa* L.)—an updated review. *Rice* 13: 3. DOI: 10.1186/s12284-019-0358-y

Khaeruni A, A Rahim, Syair, Adriani. 2014. Induksi ketahanan terhadap penyakit hawar daun bakteri pada tanaman padi di lapangan menggunakan rizobakteri indigenos. Jurnal Hama Dan Penyakit Tumbuhan Tropika 14(1): 57-63. DOI: 10.23960/j.hptt.11457-63

Kumar KH, KS Jagadeesh. 2016. Microbial consortia-mediated plant defense against phytopathogens and growth benefits. South Indian Journal of Biological Sciences 2(4): 395-403. 10.1016/j.soilbio.2015.04.001

Maciag T, E Kozieł, P Rusin, K Otulak-Kozieł, S Jafra, R Czajkowski. 2023. Microbial consortia for plant protection against diseases: more than the sum of its parts. *International Journal of Molecular Sciences* 24(15): 12227. DOI: 10.3390/ijms241512227

Norjamilah, Mariana, IS Budi. 2021. Ketahanan penyakit bercak coklat (*Helminthosporium* sp.) pada padi beras merah, padi beras hitam, lokal siam, dan unggul ciherang. Jurnal Proteksi Tanaman Tropika 4(3): 372–379. DOI: 10.20527/jptt.v4i3.900

Prasetia AA, S Jazilah, U Badrudin. 2022. Pengaruh sistem tanam terhadap pertumbuhan dan produksi beberapa varietas tanaman padi (*Oryza sativa* L.). Biofarm: Jurnal Ilmiah Pertanian 18(1): 53-61. DOI: 10.31941/biofarm.v18i1.1887

Resti Z, Eri S, Reflin. 2018. Konsorsium bakteri endofit sebagai pengendali hayati *Ralstonia solanacearum* dan pemacu pertumbuhan tanaman cabai. *Proseding Seminar Nasional Masyarakat Biodiv Indonesia* 4(2): 208–214. DOI: 10.13057/psnmbi/m040219

Resti Z, Habazar T, Putra DP, Nasrun. 2013. Skrining dan Identifikasi Isolat Bakteri Endofit Untuk Mengendalikan Penyakit Hawar Daun Bakteri pada Bawang Merah. *Journal of Tropical Plant Pests and Diseases* 13(2): 167–178. DOI: 10.23960/j.hptt.213167-178

Resti Z, Liswarni Y, Martinius. 2020. Endophytic Bacterial Consortia as Biological Control of Bacterial Leaf Blight and Plant Growth Promoter of Rice (*Oryza sativa* L.). *Journal of Applied Agricultural Science and Technology* 4(2): 134–145. DOI: 10.32530/jaast.v4i2.146

Resti Z, Martinius, Y Liswarni. 2022. Kemampuan Antagonis Bakteri Endofit dan Konsorsiumnya terhadap Pertumbuhan Jamur *Curvularia oryzae* Bugnic Antagonism of Endophytic Bacteria and the Consortium Against *Curvularia oryzae* Bugnic. *Jurnal Proteksi Tanaman* 4(1): 35–43. DOI: 10.25077/jpt.6.1.34-42.2022

Resti Z, Reflin, S Gani. 2017. Antagonistic and Plant Growth Promoting Potentials of Indigenous Endophytic Bacteria of Shallots. *International Journal of Science and Applied Technology IJSAT* 2(2): 42–49. oai:repo.unand.ac.id:7735

Santoyo G, G Moreno-Hagelsieb, MC Orozco-Mosqueda, BR Glick. 2016. Plant growth-promoting bacterial endophytes. *Microbiological Research* 183: 92–99. DOI: 10.1016/j.micres.2015.11.008

Sivan A, I Chet. 1986. Biological Control of *Fusarium* spp. in Cotton, Wheat and Muskmelon by *Trichoderma harzianum*. *Journal of Phytopathology* 116(1): 39–47. DOI: 10.1111/j.1439-0434.1986.tb00892.x

Sobanbabu G, KG Sabarinathan, VK Parthiban, V Ramamoorthy. 2018. Isolation, Screening and Identification of Virulent Isolates of *Bipolaris oryzae* Causing Rice Brown Spot and Sarocladium oryzae Causing Sheath Rot Disease. *International Journal of Current Microbiology and Applied Sciences* 7(09): 930–939. DOI: 10.20546/ijcmas.2018.709.112

Sudewi S, Ala A, Baharuddin, F Muhammad. 2020. Keragaman Organisme Pengganggu Tanaman (OPT) pada Tanaman Padi Varietas Unggul Baru (VUB) dan Varietas Lokal pada Percobaan Semi Lapangan. *Agrikultura* 31(1): 15-24. DOI: 10.24198/agrikultura.v31i1.25046

Surendhar M, Anbuselvam Y, JJS Ivin. 2022. Status of Rice Brown Spot (*Helminthosporium oryza*) Management in India: A Review. *Agricultural Reviews* 43(Of): 217–222. DOI: 10.18805/ag.R-2111

Tshikhudo PP, K Ntushelo, FN Mudau. 2023. Sustainable applications of endophytic bacteria and their physiological/biochemical roles on medicinal and herbal plants: review. *Microorganisms* 11(2): 453. DOI: 10.3390/microorganisms11020453

Wang SL, VB Nguyen, CT Doan, TN Tran, MT Nguyen, AD Nguyen. 2020. Production and potential applications of bioconversion of

chitin and protein-containing fishery byproducts into prodigiosin: a review. *Molecules* 25(12): 2744. DOI: 10.3390/molecules25122744

Waruwu A, Soekarno B, A Munif. 2016. Metabolite of Endophytic Fungi Isolated from Rice as an Alternative to Control Seed-borne Pathogenic Fungi on Rice. *Jurnal Fitopatologi Indonesia* 12(2): 53–61. DOI: 10.14692/jfi.12.2.53

Yanti Y, Warnita, Reflin, M Busniah. 2018. Indigenous endophyte bacteria ability to control Ralstonia and Fusarium wilt disease on chili pepper. Biodiversitas Journal of Biological Diversity 19(4): 1532- 1538. DOI: https://doi.org/10.13057/biodiv/d190446

How to cite: Sulyanti E, Z Resti, H Rahma, Darnetty, U Khairul, Nurhaliza, S Oktaviani. 2025. Endophytic Bacteria Consortia as Biocontrol Against Brown Spot Disease (*Helminthosporium oryzae*) and Growth Promotion in Rice. JPT: Jurnal Proteksi Tanaman (Journal of Plant Protection) 9(1): 1 – 13.