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CONCENTRATION LEVEL TEST OF ANTAGONISTIC BACTERIA FROM OIL PALM RHIZOSPHERE ON VIABILIY AND VIGOR OF CHILI SEEDS INFECTED WITH *Colletotrichum sp.*

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Abstract. Chili production in Indonesia has declined due to anthracnose disease caused by *Colletotrichum* sp., which can infect plants from the seedling stage through harvest, thereby reducing seed viability and vigor. This study aimed to determine the optimal concentration of antagonistic rhizobacteria from the oil palm rhizosphere to improve the viability and vigor of infected chili seeds. The experiment used a Completely Randomized Design (CRD) with five treatments: BRS_0 (water control + *Colletotrichum sp.*), BRS_1 (10^6 cfu/ml), BRS_2 (10^8 cfu/ml), BRS_3 (10^{10} cfu/ml), and BRS_4 (10^{12} cfu/ml), with five replicates. The results of the study indicate that the application of rhizobacteria has a significant effect on seed viability and vigor. The BRS_3 treatment (10^{10} cfu/ml) showed better performance by increasing maximum growth potential (91.20%), germination percentage (76.00%), germination speed index (12.62%), germination uniformity (58.00%), vigor index (45.60%), and reducing *Colletotrichum sp*. infection by 10.40% compared to the control. These findings indicate that rhizobacteria have potential as a biological control agent to enhance seed quality under pathogen stress.

Keywords**:** *Chili, Colletotrichum sp., Rhizobacteria, Seed, Viability, Vigor*

INTRODUCTION

Red chili (*Capsicum annuum* L.) is a high-value horticultural commodity widely cultivated in Indonesia due to consistent market demand and relatively profitable selling prices. Its high economic value, coupled with a fairly complete nutritional profile, makes it widely utilized for both household needs and the food industry (Lombu *et al*., 2024). According to data from the Central Statistics Agency (2025), the production of large red chili peppers in Indonesia over the past three years has shown a decline. In 2022, production reached

4,584,394 tons, then dropped to 3,950,408 tons in 2023 , and continued to decline to 3,840,040 tons in 2024.

The decline in chili pepper production in Indonesia can be attributed to various factors, one of which is pest and plant disease infestations. Among the various diseases affecting chili peppers, anthracnose is a major disease in both tropical and subtropical regions caused by the fungus *Colletotrichum sp*. (Prihatiningsih *et al*., 2020). Losses due to anthracnose can reach up to 80% if environmental conditions support pathogen development (Prihatiningsih *et al*., 2020). Infection by *Colletotrichum sp.* can occur from the seedling stage through the production stage, making it a serious threat to the success of chili cultivation. Infection by this pathogen can inhibit the germination process, reduce seed vigor, and even cause death in chili seedlings (Yulia *et al*., 2019).

Environmentally friendly control measures are a key strategy for reducing anthracnose outbreaks in chili pepper plants. These efforts are necessary because the use of synthetic chemical fungicides has negative impacts, making it essential to adopt more sustainable control alternatives, such as the use of biological agents (Muliani *et al*., 2019). According to a study by Widianingsih *et al*. (2025), soil derived rhizobacteria from oil palm plantations were found to effectively suppress the development of anthracnose in red chili peppers. The most effective isolate reduced disease incidence by 66.67%, reduced symptom severity by 28.32%, and reduced chili fruit weight loss by 17.31%.

Based on this, it is necessary to conduct research on "Testing the Concentration Levels of Antagonistic Bacteria from the Oil Palm Rhizosphere on the Viability and Vigor of Chili Seeds Infected with *Colletotrichum sp*.".

RESEARCH METHODOLOGY

This study was conducted from January to February 2026. The research was conducted at the Soil Laboratory and the Laboratory of Basic Sciences and Plant Protection, Faculty of Agriculture, Sultan Ageng Tirtayasa University, Serang City, Banten. The equipment and materials used included an autoclave, *laminar air flow* (LAF), incubator, container box, *shaker*, *sprayer*, petri dishes, micropipettes, Erlenmeyer flasks, test tubes, test tube racks, an oven, an inoculation loop, forceps, an analytical balance, an L-shaped rod, *a hotplate stirrer*, *a magnetic stirrer*, a Bunsen burner, a spatula, scissors, a jerry can, a tray, stationery, antagonistic bacterial isolates from the rhizosphere of oil palm plants from the collection of the Soil and Agroclimatology Laboratory, *Colletotrichum sp.* isolates collection from the Basic Sciences and Plant Protection Laboratory, red chili seeds of the Tanjung 2 variety, 70% alcohol, 90% alcohol, distilled water, water, NA medium, PDA medium, agar powder, amoxicillin, spirit, filter paper, plastic, rubber, labels, *aluminum foil*, plastic wrap, tissue, and documentation tools. This study used a non-factorial completely randomized design (CRD) consisting of 5 treatments, namely BRS_0 (water control + *Colletotrichum sp.*), BRS_1 (rhizobacteria 10^6 cfu/ml + *Colletotrichum sp.*), BRS_2 (rhizobacteria 10^8 cfu/ml + *Colletotrichum sp.*), BRS_3 (rhizobacteria 10^{10} cfu/ml + *Colletotrichum sp.*), and BRS_4 (rhizobacteria 10^{12} cfu/ml + *Colletotrichum sp.*). The response design in this study was:

1. Maximum Growth Potential
   This value is derived from the percentage of normal and abnormal seedlings by the end of the observation period (14 DAP). The calculation was performed using the following formula (Atin Yulyatin et al., 2023)

$$\text{MGP} = \frac{\Sigma \text{ Seeds germinate}}{\Sigma \text{ Total seeds sown}} \times 100\%$$

2. Germination Percentage
   Germination was determined based on the number of normal seedlings at the first (7 DAP) and second count (14 DAP) (Yulyatin *et al*., 2023).

$$\text{G} = \frac{\Sigma\,(NS\ I + NS\ II)}{\Sigma\ Total\ seeds\ sown} \times 100\%$$

   Description:
   ΣNS I = Number of normal seedlings at 7 DAP
   ΣNS II = Number of normal seedlings at 14 DAP

3. Germination Speed Index
   Germination speed index was calculated based on the daily increase in normal seedlings during the observation period (1–14 DAP) (Yulyatin *et al*., 2023).

$$\text{GR} = \sum_{i=0}^{i=n} \%\ NS/etmal$$

   Description:
   i = Observation time
   %NS = Percentage of normal seedlings at each observation time
   etmal = Observation at 24-hour intervals

4. Germination Uniformity
   Germination uniformity was determined based on the number of normal seedlings observed at 10 and 11 DAP, which correspond to the period between the first and second counts in the germination test (Yulyatin *et al*., 2023).

$$\text{GU} = \frac{(\Sigma NS(10) + \Sigma NS(11))/2}{\Sigma\ Total\ seeds\ sown} \times 100\%$$

5. Vigor Index
   Vigor index was calculated based on the number of normal seedlings at the first count (7 DAP) (Yulyatin *et al*., 2023).

$$\text{VI} = \frac{\Sigma\ Number\ of\ NS\ I}{\Sigma\ Total\ seeds\ sown} \times 100\%$$

6. Root Length
   Root length was measured on the final day of the germination observation period, at 14 days after sowing (DAP). Root length was determined by manually measuring the radicle from the base to the tip using a ruler (Sari *et al*., 2025).

7. Disease Infection Rate
   Evaluation was conducted by visually assessing the condition of each seed to identify signs of infection. Observations were made regarding the infection rate on day 14 DAP and then calculated using the formula (Harahap *et al*., 2015).

$$\text{Infection (\%)} = \frac{\text{A} + \text{B}}{\text{C}} \times 100\%$$

   Description:
   A = Number of non-germinated seeds
   B = Number of necrotic or dead seedlings
   C = Total number of incubated seeds

RESEARCH PROCEDURE

The study began with the sterilization of all equipment and materials to ensure aseptic conditions. NA and PDA media were prepared and sterilized using an autoclave, and subsequently used for the rejuvenation of rhizobacterial and *Colletotrichum sp*. isolates. Rhizobacterial isolates revived from the oil palm rhizosphere were cultured and prepared as suspensions, followed by serial dilution to determine bacterial density using the Total Plate Count (TPC) method. Meanwhile, *Colletotrichum sp*. isolates were revived on PDA medium and prepared as a spore suspension. Chili seeds were inoculated with *Colletotrichum sp*. suspension via a 30-minute soak and incubated for 3 days to ensure infection occurred. Next, the seeds were soaked in rhizobacteria suspensions at various concentrations (10^6, 10^8, 10^{10}, and 10^{12} cfu/ml) for 30 minutes. The treated seeds were then planted using the paper roll test in plastic (UKDdP) method.

DATA ANALYSIS

Data were analyzed using analysis of variance (ANOVA). If significant differences were found, the data analysis was continued with *Duncan's Multiple Range Test* (DMRT) at a 5% significance level.

RESULT AND DISCUSSION

Maximum Growth Potential

The results of the study on the effect of the concentrations levels of antagonistic bacteria derived from the oil palm rhizosphere showed a highly significant effect on the maximum growth potential of red chili seeds infected with *Colletotrichum sp*., as presented in Table 1.

Table 1. Effect of treatment with different concentrations of antagonistic bacteria from the oil palm rhizosphere on the maximum growth potential (%)

Treatment		MGP
BRS_0	Water control + *Colletotrichum sp.*	64.00 c
BRS_1	10^6 cfu/ml rhizobacteria + *Colletotrichum sp.*	80.00 b
BRS_2	10^8 cfu/ml rhizobacteria + *Colletotrichum sp.*	81.60 b
BRS_3	10^{10} cfu/ml rhizobacteria + *Colletotrichum sp.*	91.20 a
BRS_4	10^{12} cfu/ml rhizobacteria + *Colletotrichum sp.*	84.00 b
Average		**80.16**

Note: Numbers followed by the same letter in the same column indicate results that have no significant effect at the 5% DMRT follow up test.

Based on the observations in Table 1, the application of rhizobacteria from the oil palm rhizosphere at various concentrations was able to increase the maximum growth potential of chili seeds infected with *Colletotrichum sp*. compared to the control. The control treatment (BRS_0) showed the lowest value of 64.00%, indicating that pathogen infection inhibits germination through seed tissue damage and disruption of physiological processes. Harahap *et al*. (2015), stated that fungal infection in seeds is known to cause rotting, seedling necrosis, and even seedling death.

An increase in maximum growth potential occurred across all rhizobacteria treatments, with the highest value observed in BRS_3 (10^{10} cfu/ml) at 91.20%. This indicates

that rhizobacteria play a role in maintaining seed viability even under pathogen-infected conditions. The high maximum growth potential value reflects that the seeds still possess good physiological capacity for germination. Mudi *et al*. (2023), stated that the use of rhizobacteria derived from the oil palm rhizosphere has been proven to enhance seed viability and vigor, including increasing maximum growth potential.

Rhizobacteria treatment at a concentration of 10^{10} cfu/ml showed the highest effectiveness in enhancing seed germination capacity compared to other treatments. This indicates that optimal inoculum density plays a crucial role in supporting the germination process. At this concentration, the rhizobacteria population is believed to be able to colonize optimally on the seed surface and produce growth regulators that play a role in stimulating germination. This aligns with the findings of Simanjuntak *et al*. (2019), who noted that inoculum density influences the number of potential inoculum and the effectiveness of rhizobacteria, including their role in regulating the production of growth hormones such as auxin, cytokinin, and gibberellin, which are essential during the germination process.

Germination Percentage

The results of the study on the effect of the concentration levels of antagonistic bacteria from the oil palm rhizosphere showed a very significant effect on the germination capacity of red chili seeds infected with *Colletotrichum sp*., as presented in Table 2.

Table 2. Effect of treatment with different concentrations of antagonistic bacteria from the oil palm rhizosphere on the germination percentage (%)

	Treatment	GP
BRS_0	Water control + *Colletotrichum sp.*	48.80 b
BRS_1	10^6 cfu/ml rhizobacteria + *Colletotrichum sp.*	71.20 a
BRS_2	10^8 cfu/ml rhizobacteria + *Colletotrichum sp.*	73.60 a
BRS_3	10^{10} cfu/ml rhizobacteria + *Colletotrichum sp.*	76.00 a
BRS_4	10^{12} cfu/ml rhizobacteria + *Colletotrichum sp.*	71.20 a
	Average	68.16

Note: Numbers followed by the same letter in the same column indicate results that have no significant effect at the 5% DMRT follow up test.

The results of the study indicate that the application of rhizobacteria from the oil palm rhizosphere at various concentrations tends to increase the germination rate of chili seeds infected with *Colletotrichum sp*. compared to the control. Treatment BRS_3 (10^{10} cfu/ml) yielded the highest value of 76.00%, followed by BRS_2 (73.60%), and BRS_1 and BRS_4 at 71.20% and 71.20%, respectively However, all these rhizobacteria treatments were not significantly different from one another at the 5% level, indicating that each concentration provided a relatively similar response in enhancing germination capacity.

The treatment at a concentration of 10^{10} cfu/ml (BRS_3) showed a tendency toward the highest germination rate compared to the others. This indicates that at this concentration, rhizobacteria are more effective in supporting the formation of normal seedlings. The increase in germination rate is believed to be related to

the role of rhizobacteria in stimulating the physiological activity of seeds during the germination process. This is supported by the research of Syamsuddin *et al*. (2022), which found that treating seeds with rhizobacteria can improve the viability and vigor of red chili seeds by increasing their germination rate by up to 375%. This indicates that the application of rhizobacteria can maintain seed viability and enhance their ability to germinate normally even under pathogen-infected conditions.

Conversely, the control treatment (BRS_0) showed the lowest value of 48.80% and differed significantly from all rhizobacteria treatments. The low germination rate in the control indicates that *Colletotrichum sp*. infection can inhibit the germination process through seed tissue damage and physiological disruption. Anagha *et al.* (2024), also stated that *Colletotrichum* is known to infect seeds down to the embryo, thereby reducing the seed's ability to develop into a normal seedling and even causing seedling death.

Germination Speed Index

The results of the study on the effect of the concentration levels of antagonistic bacteria from the oil palm rhizosphere showed a very significant effect on the germination speed index of red chili seeds infected with *Colletotrichum sp*., as presented in Table 3.

Table 3. Effect of treatment with different concentrations of antagonistic bacteria from the oil palm rhizosphere on the germination speed index (%/day)

Treatment		GSI
BRS_0	Water control + *Colletotrichum sp.*	7.40 c
BRS_1	10^6 cfu/ml rhizobacteria + *Colletotrichum sp.*	10.00 b
BRS_2	10^8 cfu/ml rhizobacteria + *Colletotrichum sp.*	11.68 ab
BRS_3	10^{10} cfu/ml rhizobacteria + *Colletotrichum sp.*	12.62 a
BRS_4	10^{12} cfu/ml rhizobacteria + *Colletotrichum sp.*	11.26 ab
Average		10.59

Note: Numbers followed by the same letter in the same column indicate results that have no significant effect at the 5% DMRT follow up test.

In Table 3, the application of rhizobacteria from the oil palm rhizosphere influenced the germination speed index of red chili seeds infected with *Colletotrichum sp.* The control treatment (BRS_0) showed the lowest germination speed index of 7.40%/day, indicating that pathogen infection without rhizobacteria treatment can inhibit the germination process. All rhizobacteria treatments showed increased germination rates compared to the control, with the highest value observed in BRS_3 (10^{10} cfu/ml) at 12.62%/day. This indicates that rhizobacteria application can improve seed germination rates.

Nevertheless, the range of seed germination rates in this study (7.40–12.62%/day) remains relatively low. According to Lesilolo *et al*. (2013), good seed germination rates typically fall within the 20–30% range, and higher values reflect better seed vigor. These values indicate that seed vigor remains low, which can be characterized by slow germination, an increase in abnormal seedlings, and high susceptibility to pest and disease attacks.

Nuraini *et al*. (2018), also state that seeds with low vigor exhibit reduced growth capacity, as evidenced by slower germination rates, an increased number of abnormal seedlings, and greater susceptibility to pest and disease attacks, which can ultimately reduce crop productivity.

The low germination rate is suspected to be caused by infection with *Colletotrichum sp*., which can produce enzymes such as cellulase and pectinase, thereby damaging seed tissues and inhibiting the germination process (Yulyatin *et al*., 2023). Nevertheless, the differences in values among treatments indicate that rhizobacteria still play a role in enhancing seed germination speed index. This is related to the role of rhizobacteria as biological agents capable of stimulating seed physiological activity and accelerating the germination process.

Germination Uniformity

The results of the study on the effect of the concentration levels of antagonistic bacteria from the oil palm rhizosphere showed a significant effect on germination uniformity of red chili seeds infected with *Colletotrichum sp*., as presented in Table 4.

Table 4. Effect of treatment with different concentrations of antagonistic bacteria from the oil palm rhizosphere on germination uniformity (%)

Treatment		GU
BRS_0	Water control + *Colletotrichum sp.*	48.00 b
BRS_1	10^6 cfu/ml rhizobacteria + *Colletotrichum sp.*	53.60 ab
BRS_2	10^8 cfu/ml rhizobacteria + *Colletotrichum sp.*	56.40 a
BRS_3	10^{10} cfu/ml rhizobacteria + *Colletotrichum sp.*	58.00 a
BRS_4	10^{12} cfu/ml rhizobacteria + *Colletotrichum sp.*	56.40 a
Average		54.48

Note: Numbers followed by the same letter in the same column indicate results that have no significant effect at the 5% DMRT follow up test.

Based on Table 4, red chili seeds were still able to grow relatively uniformly despite being infected with *Colletotrichum sp*. The control treatment (BRS_0) showed the lowest uniformity of growth at 48.00%, indicating that pathogen infection can reduce the seeds' ability to germinate uniformly. During the infection process, the pathogen utilizes the food reserves within the seeds, thereby reducing the energy that should be used for growth (Maya & Seal, 2014). Lesilolo *et al*. (2013), stated that uniformity of growth reflects the seeds' ability to utilize energy reserves efficiently; seeds with low vigor generally exhibit less uniform growth.

The application of rhizobacteria at various concentrations showed an increase in growth uniformity compared to the control. The highest value was obtained in the BRS_3 treatment (10^{10} cfu/ml) at 58.00%, followed by BRS_2 (56.40%), BRS_4 (56.40%), and BRS_1 (53.60%). However, there were no significant differences among all rhizobacteria treatments at the 5% level, indicating that each concentration produced relatively similar responses. This increase in germination uniformity suggests that rhizobacteria play a role in improving seed vigor, particularly regarding the uniformity of germination timing. These results align with the study by Syamsuddin *et al*. (2021),

who reported that nearly all rhizobacterial isolates of the genus were capable of improving seed germination uniformity compared to untreated seeds.

The germination uniformity values in this study ranged from 48–58%, which falls into the moderate category. According to Lesilolo *et al*. (2013), germination uniformity values generally range from 40–70%, with values ≥70% indicating high vigor, while values ≤40% indicate low vigor. Although it has not yet reached the high category, the rhizobacteria treatment still showed a significantly better value compared to the control, thus indicating an improvement in the physiological condition of the seeds in supporting more uniform germination.

Vigor Index

The results of the study on the effect of the concentration level of antagonistic bacteria from the oil palm rhizosphere showed a very significant effect on the vigor index of red chili seeds infected with *Colletotrichum sp*., as presented in Table 5

Table 5. Effect of treatment with different concentrations of antagonistic bacteria from the oil palm rhizosphere on the vigor index (%)

Treatment		VI
BRS_0	Water control + *Colletotrichum sp.*	32.80 b
BRS_1	10^6 cfu/ml rhizobacteria + *Colletotrichum sp.*	33.60 b
BRS_2	10^8 cfu/ml rhizobacteria + *Colletotrichum sp.*	44.80 a
BRS_3	10^{10} cfu/ml rhizobacteria + *Colletotrichum sp.*	45.60 a
BRS_4	10^{12} cfu/ml rhizobacteria + *Colletotrichum sp.*	39.20 ab
Average		39.20

Note: Numbers followed by the same letter in the same column indicate results that have no significant effect at the 5% DMRT follow up test.

The application of rhizobacteria from the oil palm rhizosphere at various concentrations affected the vigor index of red chili seeds infected with *Colletotrichum sp*. The control treatment (BRS_0) showed the lowest value of 32.80% and was not significantly different from BRS_1 (10^6 cfu/ml) at 33.60% and BRS_4 (10^{12} cfu/ml) at 39.20%. This indicates that at both low and very high concentrations, the effectiveness of rhizobacteria in enhancing seed vigor is not yet optimal. This aligns with Tabriji *et al*. (2016), who noted that the effectiveness of PGPR is highly influenced by concentration, with a specific range being most effective in promoting plant growth.

The highest vigor index value was obtained in the BRS_3 treatment (10^{10} cfu/ml) at 45.60%, which was not significantly different from the BRS_2 treatment (10^8 cfu/ml) at 44.80%, but was significantly different from the other treatments. This indicates that this concentration is more effective in enhancing seed vigor even under pathogen-infected conditions. These results align with the study by (Simanjuntak *et al*. (2019), which reported that rhizobacteria with specific inoculum densities can significantly increase the seed vigor index. Plant-growth-promoting rhizobacteria (PGPR) help improve plant growth and seed vigor. PGPR act as biostimulants, biofertilizers, and bioprotectants that support plant growth and development.

In general, the seed vigor index in this study was still relatively low, both in the

control and in the rhizobacteria treatments. This is likely related to the low values of germination speed index and uniformity of germination obtained. According to Nuraini *et al*. (2018), seeds with high vigor generally have the ability to germinate faster and more uniformly, reflecting good adaptability to the growing environment. Thus, although the application of rhizobacteria has not yet been able to optimally increase vigor, treatments at certain concentrations still show potential in improving seed physiological quality.

Root Length

The results of the study on the effect of the concentration levels of antagonistic bacteria from the oil palm rhizosphere did not show a significant effect on the root length of red chili seeds infected with *Colletotrichum sp*., as presented in Table 6.

Table 6. Effect of treatment with different concentrations of antagonistic bacteria from the oil palm rhizosphere on the root length (cm)

	Treatment	Rooth Length
BRS_0	Water control + *Colletotrichum sp.*	5.78
BRS_1	10^6 cfu/ml rhizobacteria + *Colletotrichum sp.*	6.18
BRS_2	10^8 cfu/ml rhizobacteria + *Colletotrichum sp.*	5.95
BRS_3	10^{10} cfu/ml rhizobacteria + *Colletotrichum sp.*	5.40
BRS_4	10^{12} cfu/ml rhizobacteria + *Colletotrichum sp.*	5.53
	Average	5.77

The application of rhizobacteria from the oil palm rhizosphere at various concentrations showed variations in seedling root length. The highest value was obtained in the BRS_1 treatment (10^6 cfu/ml) at 6.18 cm, while the lowest value was found in BRS_3 (10^{10} cfu/ml) at 5.40 cm. Although there were differences among treatments, the results of the analysis of variance indicated that rhizobacteria treatment had no significant effect on seedling root length. This suggests that the application of rhizobacteria at various concentrations has not yet been able to significantly stimulate root growth during the germination phase. This finding is consistent with the report by Cahyani *et al.* (2017), which states that the application of rhizosphere microbes does not always have a significant effect on plant growth parameters, including root length.

The low root length values are suspected to be related to the high number of abnormal seedlings and non-germinating seeds due to infection by *Colletotrichum sp.* Abnormal seedlings generally experience physiological disturbances, preventing them from forming an optimal root system. Pathogen infection during the early stages of germination can cause tissue damage, such as root and stem necrosis, cotyledon shedding, and stunted root growth (Suharti *et al*., 2018). These conditions result in suboptimal root development, leading to shorter root lengths.

Disease Infection Rate

Research results on the effect of the concentration level of antagonistic bacteria from the oil palm rhizosphere showed a very significant effect on the disease infection rate in red chili seeds infected with *Colletotrichum sp*., as *presented in Table 7.*

Tabel 7. Effect of treatment with different concentrations of antagonistic bacteria from the oil palm rhizosphere on the disease infection rate (%)

Treatment		Infection Rate
BRS_0	Water control + *Colletotrichum sp.*	37.60 c
BRS_1	10^6 cfu/ml rhizobacteria + *Colletotrichum sp.*	21.60 b
BRS_2	10^8 cfu/ml rhizobacteria + *Colletotrichum sp.*	17.60 ab
BRS_3	10^{10} cfu/ml rhizobacteria + *Colletotrichum sp.*	10.40 a
BRS_4	10^{12} cfu/ml rhizobacteria + *Colletotrichum sp.*	18.40 ab
Average		21.12

Note: Numbers followed by the same letter in the same column indicate results that have no significant effect at the 5% DMRT follow up test.

Based on Table 7, the application of rhizobacteria from the oil palm rhizosphere was able to reduce the infection rate *of Colletotrichum sp*. in red chili seeds compared to the control. The control treatment (BRS_0) showed the highest infection rate of 37.60%, indicating that without treatment, the pathogen more easily infects the seeds. This infection can damage seed tissue, inhibit the germination process, and reduce seed viability and vigor. These findings align with the report by Ilyas *et al*. (2015), which stated that *Colletotrichum capsici* infection in chili seeds can reduce germination capacity and overall seed quality.

All rhizobacteria treatments showed lower infection rates compared to the control, with the lowest rate observed in the BRS_3 treatment (10^{10} cfu/ml) at 10.40%. These results indicate that a concentration of 10^{10} cfu/ml is the most effective in suppressing pathogen infection. This reduction in infection rates is likely related to the ability of rhizobacteria to inhibit pathogen growth through competition for space and nutrients, as well as the production of antagonistic compounds. This is supported by the research of Rosadiah *et al*. (2015), who reported that rhizobacteria are capable of suppressing the infection rate of the pathogen *P. capsici* in plants. Rhizobacteria can compete with pathogens for space and nutrients, as well as produce compounds that can suppress pathogen development.

Seeds infected with *Colletotrichum sp*. in this study were characterized by the appearance of mycelium or hyphae on the seed surface and failure to germinate. Infection can also occur at the seedling stage, characterized by symptoms ranging from wilting to seedling death. These conditions indicate that the pathogen is capable of attacking seeds both before and after germination. This is consistent with (Maya & Seal (2015), who stated that *C. capsici* infection can disrupt plant physiological processes from the early stages of growth, eventually leading to death due to the development of the necrotrophic phase.

CONCLUSION AND RECOMMENDATIONS

Based on the research results, it can be concluded that treatment with rhizobacteria from the oil palm rhizosphere at a concentration of 10^{10} cfu/ml showed better values for the parameters of maximum growth potential at 91.20%, germination rate at 76.00%, germination speed index at 12.62%, uniformity of growth of 58.00%, and vigor index of 45.60%, as well as reducing the infection rate *of Colletotrichum sp*. in

chili seeds by 10.40% compared to the control treatment. Therefore, the use of rhizobacteria from the oil palm rhizosphere at a concentration of $^{10^{10}}$cfu/ml is recommended to improve the viability and vigor of red chili seeds infected with *Colletotrichum sp.*

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