Proceedings Academic Universitas Jambi
Volume 2, Issue 2, Juli, 2026

In Vitro Compatibility Evaluation of *Trichoderma harzianum*, Bacillus subtilis, and *Pseudomonas fluorescens* on King's B and PDA NA Media

Putri Dwi Mulyani[1]*, Triyuni Verza Abdilla[2], Hasna Ul Maritsa[3], Anggari Linda Destiana[4], Andini Vermita Bestari[5], and Ayu Nadila Safitri[6]

[1,2,3,4,5,6]Universitas Jambi, Jambi, Indonesia

*Corresponding Author: putri.dm@unja.ac.id

Abstract

In Vitro Compatibility Evaluation of *Trichoderma harzianum*, *Bacillus subtilis*, and *Pseudomonas fluorescens* on King's B and PDA-NA Media. Background: *Trichoderma harzianum*, *Bacillus subtilis*, and *Pseudomonas fluorescens* are widely used biological control agents, but their combined use requires compatibility assessment to prevent antagonistic interactions in microbial consortia. Objective: This study evaluated the in vitro compatibility of *T. harzianum* with *B. subtilis* and *P. fluorescens* on King's B and PDA-NA media. Methods: A dual-culture assay was conducted by observing inhibition zones and measuring the colony diameter of *T. harzianum* at 24 and 48 hours; percentage inhibition and Cohen's d effect size were then calculated. Results: On King's B medium, clear inhibition zones were observed and percentage inhibition reached 57.04% in *T. harzianum* x *B. subtilis* and 62.89% in *T. harzianum* x *P. fluorescens* at 48 hours, indicating strong antagonism. On PDA-NA medium, no inhibition zones were detected and inhibition values were lower, at 10.96% and 18.40%, respectively. Conclusion: The three microorganisms may be combined under nutrient conditions that do not strongly stimulate antagonistic metabolite production, supporting the development of multi-agent biocontrol formulations.

Keywords: *Trichoderma harzianum*; *Bacillus subtilis*; *Pseudomonas fluorescens*; compatibility; biocontrol

Cite This Article

Putri Dwi Mulyani, Triyuni Verza Abdilla, Hasna Ul Maritsa, Anggari Linda Destiana, Andini Vermita Bestari, Ayu Nadila Safitri6. (2026). In Vitro Compatibility Evaluation of *Trichoderma harzianum*, *Bacillus subtilis*, and *Pseudomonas fluorescens* on King's B and PDA-NA Media. Proceedings Academic Universitas Jambi, 2(2): e55580. DOI: 10.22437/proca.v2i2. 55580

Editor

Kevin Waldo, M.Pd

Article info

Received: Mei 15, 2026. Revised: Juli 6, 2026. Accepted: Juli 11, 2026

© 2026 The Author(s). Published with license by LPPM Universitas Jambi. This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International (CC BY 4.0 International). This license enables reusers to distribute, remix, adapt, and build upon the material in any medium or format, so long as attribution is given to the creator.

INTRODUCTION

Sustainable agriculture has become a critical approach to reducing excessive dependence on chemical pesticides because intensive chemical inputs can negatively affect environmental quality, soil microbial balance, and human health [1,2]. Excessive chemical inputs may also contribute to pathogen resistance, soil contamination, and disruption of beneficial soil microbial communities that support plant growth and health [1,2]. Therefore, biological approaches using biological control agents (BCAs) are increasingly promoted as safer and more environmentally friendly alternatives for plant disease management [2].

Several microbial agents, including *Trichoderma harzianum*, *Bacillus subtilis*, and *Pseudomonas fluorescens*, have been widely reported as effective BCAs against phytopathogens through mechanisms such as nutrient and space competition, antibiosis, mycoparasitism, and induction of systemic resistance in plants [4-7]. *T. harzianum* is known for its ability to degrade pathogenic fungal cell walls using hydrolytic enzymes [4,8]. *B. subtilis* produces antimicrobial lipopeptides such as surfactin and iturin [6], whereas *P. fluorescens* synthesizes siderophores and antibiotics that can inhibit fungal growth [5,9].

The use of microbial consortia combining multiple BCAs has gained increasing interest because synergistic interactions may enhance the stability and spectrum of pathogen suppression [10,11]. However, before candidate microorganisms are formulated into a multi-strain biocontrol product, compatibility among the microbes must be evaluated to ensure that antagonistic behaviors do not occur between consortium members [12]. Incompatibility may lead to mutual inhibition and reduce overall efficiency during field application. Microbial physiological responses vary depending on the nutritional composition of the growth medium; therefore, in vitro compatibility should be assessed under different culture conditions [13].

A major challenge addressed in this research is the limited scientific information regarding the compatibility of *T. harzianum*, *B. subtilis*, and *P. fluorescens* when grown together on different media, particularly King's B and PDA-NA media, which may differentially influence microbial growth and the expression of antagonistic metabolites. Therefore, this study aimed to evaluate the in vitro interactions among these three BCAs on King's B and PDA-NA media through dual-culture assays by observing inhibition zones and the radial growth of *T. harzianum*. The results are expected to provide a scientific basis for the development of compatible and effective biocontrol microbial consortia to support environmentally sustainable plant disease management.

METHODS

Research Design

This study employed an in vitro laboratory experimental design to evaluate the compatibility of *Trichoderma harzianum*, *Bacillus subtilis*, and *Pseudomonas fluorescens* on two culture media, namely King's B and PDA-NA. The dual-culture approach was used to directly observe microbial interactions and potential antagonism among isolates. The research was conducted from August to November 2025 at the Microbiology Laboratory, Department of Biology, Faculty of Science and Technology, Universitas Jambi.

Research Target/Subject

The biological agents evaluated in this study consisted of *T. harzianum* (Th), *B. subtilis* (Bs), and *P. fluorescens* (Pf). All isolates were purified and maintained on selective media before testing to ensure viability and purity.

Research Procedure

1. Media preparation.

Two types of media were used: King's B agar and PDA-NA mixed medium. King's B agar is a nitrogen-rich medium known to stimulate fluorescent pigment production and secondary metabolite expression in *Pseudomonas spp*. PDA-NA mixed medium was prepared by combining Potato Dextrose Agar (PDA) and Nutrient Agar (NA) at a predetermined ratio to

provide a balanced carbon-nitrogen environment suitable for fungi and bacteria. All media were sterilized at 121°C for 15 minutes and poured into sterile Petri plates.

2. Rejuvenation and standardization of inocula.

Trichoderma harzianum was cultured on PDA for 5-7 days to allow adequate mycelial growth. Bacterial isolates, *B. subtilis* and *P. fluorescens*, were grown on NA and King's B, respectively, for 24 hours. *T. harzianum* inoculum was prepared using 6-mm mycelial discs cut from actively growing cultures.

3. Dual-culture assay.

Compatibility was assessed using the dual-culture method. A 6-mm mycelial disc of *T. harzianum* was placed on one side of the plate, and bacterial inoculum was streaked on the opposite side at a distance of approximately 3 cm. Control plates contained only *T. harzianum* on each medium. All treatments were conducted in duplicate. Plates were incubated at room temperature (28 ± 2°C) for 48 hours, with observations taken at 24 and 48 hours.

4. Observation of microbial interaction.

Microbial interactions were assessed at 24 and 48 hours based on growth direction, formation of inhibition zones, degree of colony overlap, and morphological changes at the interaction margin. Observations followed qualitative interaction models used in dual-culture studies [14,15].

Instruments and Data Collection Techniques

All experimental procedures were conducted aseptically in a laminar airflow cabinet. The materials used included *Trichoderma harzianum*, *Bacillus subtilis*, and *Pseudomonas fluorescens* isolates, King's B agar, mixed Potato Dextrose Agar-Nutrient Agar (PDA-NA), potato dextrose broth (PDB), nutrient broth (NB), sterile distilled water, micropipettes, sterile pipette tips, inoculation needles, Petri dishes, digital calipers, and an incubator set at 28 ± 1°C.

Dual-culture assays were performed by co-inoculating *T. harzianum* with a 5-mm mycelial plug and each bacterial suspension at 10^8 CFU/mL, using 10 µL inoculum, on opposite sides of a 9-cm Petri dish. Control plates contained *T. harzianum* alone. Plates were incubated at 28°C for 48 hours. Colony diameter of *T. harzianum* was measured at 24 and 48 hours using a digital caliper by averaging two perpendicular diameters [16]. Observation of inhibition zones was performed visually by examining the presence or absence of a clear zone at the interaction margin. Each treatment was conducted in duplicate to obtain quantitative growth data and qualitative inhibition patterns. All raw measurements were recorded in a laboratory logbook before statistical processing.

Data Analysis Technique

Data analysis was performed to determine the compatibility of *T. harzianum* with *B. subtilis* and *P. fluorescens* across different media conditions. The primary quantitative measure was percentage inhibition (PI), calculated using a formula adapted from microbial antagonism assays [17]:

$$PI = \frac{(Dc - Dt)}{Dc} \times 100$$

where:

Dc represents the colony diameter of *T. harzianum* in control plates (mm), and

Dt represents the colony diameter of *T. harzianum* in dual culture (mm).

Interpretation of PI followed compatibility classification used in biocontrol studies: PI < 25% = compatible or no meaningful inhibition; PI 25-50% = moderately compatible or partial inhibition; and PI > 50% = incompatible or antagonistic interaction [18,19]. Qualitative observations on the presence or absence of inhibition zones were integrated with PI values to strengthen compatibility categorization.

To quantify the magnitude of growth reduction beyond statistical significance, Cohen's d effect size was calculated for each treatment relative to the control using the equation

$$d = \frac{(M1 - M2)}{SD\ pooled}$$

where the pooled standard deviation was:

$$SD\ pooled = \sqrt{\frac{(SD1^2 + SD2^2)}{2}}$$

Cohen's d was interpreted using conventional thresholds: 0.2-0.49 = small effect; 0.5-0.79 = medium effect; and ≥0.8 = large effect [20].

A combined interpretaton using PI, inhibition-zone patterns, and effect-size magnitude was used to determine overall compatibility on each medium. Results were aligned with the research objectives to evaluate whether the three isolates could coexist and potentially be applied together as a biocontrol consortium.

RESULTS

Qualitative Compatibility Test Results

The compatibility test was conducted to determine the interactions among the antagonistic microbes *Bacillus subtilis*, *Pseudomonas fluorescens*, and *Trichoderma harzianum* by observing the presence or absence of antagonistic activity between isolates. For the compatibility assessment between the bacterial antagonists *P. fluorescens* and *B. subtilis*, the dual-culture method was performed on two media: Nutrient Agar (NA) and King's B. Based on the observations, *P. fluorescens* and *B. subtilis* were able to grow side by side without forming inhibition zones on both media types (Figure 1). This condition indicates that the two isolates were compatible in vitro and did not inhibit each other.

Such compatibility suggests that both microbes have the potential to be combined in a single biocontrol formulation because no antagonistic interaction was observed that could reduce their individual effectiveness. This result is consistent with previous findings indicating that *B. subtilis*, *P. fluorescens*, and *T. harzianum* can coexist without exhibiting antagonism and may even act synergistically in suppressing *Ralstonia solanacearum* in potato plants [21].

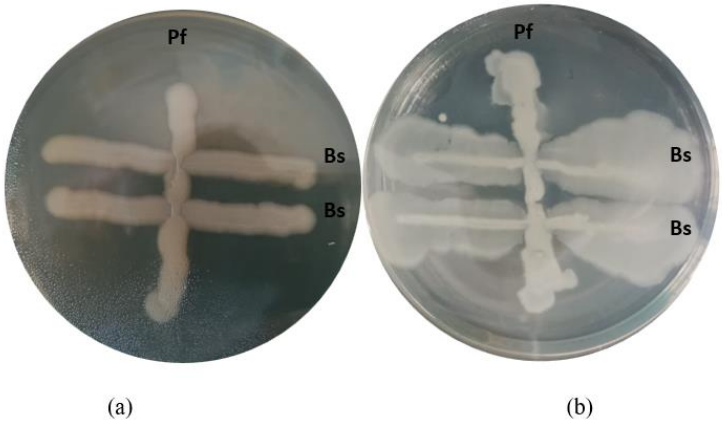


Figure 1. Compatibility test results of *Pseudomonas fluorescens* (Pf) and *Bacillus subtilis* (Bs) on (a) King's B medium and (b) Nutrient Agar (NA).

To evaluate the compatibility of the antagonistic bacterial isolates *Pseudomonas fluorescens* and *Bacillus subtilis* with the antagonistic fungus *Trichoderma harzianum*, a dual-culture assay was conducted. Observations revealed the presence of inhibition zones between *T. harzianum* and both bacterial isolates on King's B medium. On PDA-NA medium, the mycelia of *T. harzianum* appeared adjacent to and in direct contact with bacterial colonies

without forming an inhibition zone (Table 1). Additionally, the growth of *T. harzianum* on King's B medium was relatively slow, whereas on PDA-NA medium the fungus exhibited a faster growth rate, as indicated by larger colony diameter and mycelial extension compared with the bacterial interaction on King's B medium (Figures 2 and 3).

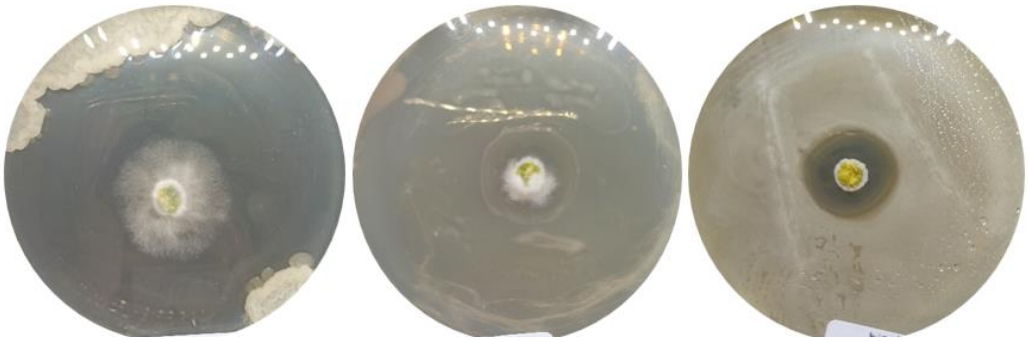
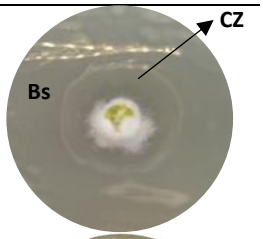
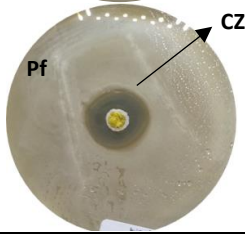
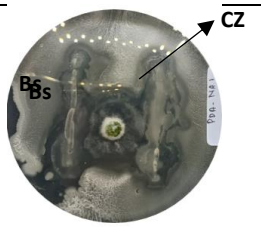
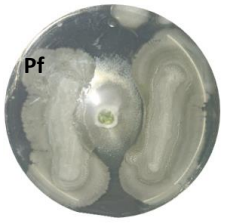


Figure 2. Compatibility assay of the antagonistic microbes *Trichoderma harzianum* (Th), *Pseudomonas fluorescens* (Pf), and *Bacillus subtilis* (Bs) on King's B medium after 48 hours: (a) control; (b) Th x Bs; (c) Th x Pf.

Figure 3. Compatibility assay of the antagonistic microbes *Trichoderma harzianum* (Th), *Pseudomonas fluorescens* (Pf), and *Bacillus subtilis* (Bs) on PDA-NA medium after 48 hours: (a) control; (b) Th x Bs; (c) Th x Pf.

Table 1. Qualitative results of the compatibility assay among Bacillus subtilis, *Pseudomonas fluorescens*, and *Trichoderma harzianum* after 48 hours.

Media	Treatment	Information	
		Clear zone	Figure
King's B	Th x Bs	Present	
	Th x Pf	Present	

Media	Treatment	Information	
		Clear zone	Figure
PDA-NA	Th x Bs	Absent	
	Th x Pf	Absent	

Notes: Bs = *B. subtilis*; Pf = *P. fluorescens*; Th = *T. harzianum*.

Growth of T. harzianum Colonies

Measurement of colony diameter at 24 and 48 hours showed a reduction in the growth of *T. harzianum* in bacterial combination treatments, particularly on King's B medium. Based on average colony diameter measurements for each treatment, all treatments had lower colony diameter values than the control. This reduction was attributed to interactions between *B. subtilis* and *P. fluorescens* with *T. harzianum*, which may involve antagonistic effects or competition for space and nutrients, interactions that were absent in control plates.

Table 2. Compatibility among Bacillus subtilis, *Pseudomonas fluorescens*, and *Trichoderma harzianum*.

Media	Treatment	Mean ± SD of T. harzianum colony diameter (mm) 24 hours	Mean ± SD of T. harzianum colony diameter (mm) 48 hours	PI (%)	Compatibility category
King's B	Control	11.75 ± 2.50	33.75 ± 3.18		
King's B	Th x Bs	9.55 ± 0.78	14.50 ± 0.71	57.04	Incompatible
King's B	Th x Pf	8.73 ± 1.02	12.53 ± 0.46	62.89	Incompatible
PDA-NA	Control	26.75 ± 2.47	31.25 ± 6.01		
PDA-NA	Th x Bs	17.75 ± 1.70	27.83 ± 4.50	10.96	Compatible
PDA-NA	Th x Pf	22.25 ± 1.06	25.50 ± 0.00	18.40	Compatible

The PI data at 48 hours indicated that on King's B medium, the combinations of *T. harzianum* with *B. subtilis* and *P. fluorescens* showed PI values of 57.04% and 62.89%, respectively. These values fall into the high antagonism category, suggesting that both bacterial isolates were incompatible with *T. harzianum* under King's B medium conditions. In contrast, on PDA-NA medium, PI values for *T. harzianum* with *B. subtilis* and *P. fluorescens* were only 10.96% and 18.40%, respectively, and were classified as low inhibition or compatible interactions.

Effect Size Analysis (Cohen's d)

To quantify the magnitude of bacterial inhibition on *T. harzianum*, Cohen's d analysis was performed. This approach was used because the low number of replicates (n = 2) did not meet the assumptions required for parametric statistical tests. Cohen's d indicates the magnitude of difference between the control and treatment groups rather than merely whether the difference is statistically significant. Effect size therefore provides an indication of the biological relevance of differences among treatments. Because of the limited number of replicates, the statistical interpretation is descriptive and should be interpreted with caution.

Table 3. Effect size analysis (Cohen's d).

Media	Treatment	Mean TH (mm) ± SD	Mean of control (mm) ± SD	Cohen's d	Effect size category
King's B	Th x Bs	14.50 ± 0.71	33.75 ± 3.18	8.36	Very large/strong inhibition
King's B	Th x Pf	12.53 ± 0.46	33.75 ± 3.18	9.34	Very large/very strong inhibition
PDA-NA	Th x Bs	27.83 ± 4.50	31.25 ± 6.01	0.65	Moderate/weak inhibition
PDA-NA	Th x Pf	25.50 ± 0.00	31.25 ± 6.01	1.35	Moderate/moderate inhibition

Based on the effect size values, *B. subtilis* and *P. fluorescens* exhibited very strong inhibition against *T. harzianum* on King's B medium, with Cohen's d values of 8.36 and 9.34, respectively. These values indicate biologically substantial antagonistic interactions. In contrast, inhibitory effects on PDA-NA medium were lower, with d values of 0.65-1.35, suggesting that all three microorganisms still have potential to be combined in organic-based formulations.

DISCUSSION

The observed differences between King's B and PDA-NA media indicate that compatibility among *T. harzianum*, *B. subtilis*, and *P. fluorescens* is strongly influenced by nutrient composition. King's B medium is known to support the growth of *Pseudomonas fluorescens* and to induce fluorescent siderophore production and secondary metabolites [22,23]. In *Bacillus subtilis*, particular nutrient conditions can stimulate the biosynthesis of antifungal lipopeptides, including surfactin and fengycin [6,24]. Under such conditions, sufficient quantities of antifungal metabolites may be produced to inhibit *T. harzianum*, resulting in inhibition zones and reduced fungal colony diameter on King's B medium.

Conversely, PDA-NA medium appeared more supportive of fungal growth and reduced localized antibiosis. This may occur because complex carbon sources in PDA support filamentous fungal growth, while the mixed PDA-NA composition provides a more balanced carbon-nitrogen environment that may reduce excessive production or diffusion of antagonistic metabolites. As a result, coexistence without visible inhibition zones became more apparent. These findings are consistent with the principle that nutrient composition can regulate secondary metabolite expression and alter the balance between competition and coexistence among microbial biocontrol agents [13,18,25].

The difference between this study and previous reports does not necessarily represent a contradiction but rather highlights that microbial interactions are highly dependent on strain, physiological state, and the carbon-nitrogen characteristics of the medium. Previous work reported compatibility among *P. fluorescens*, *B. subtilis*, and *T. harzianum* in certain culture conditions [21], whereas the present study found strong antagonism on King's B medium and compatibility on PDA-NA medium. Both findings support the broader interpretation that medium composition is a major determinant of compatibility or antagonism through regulation of secondary metabolite expression.

These findings have practical implications for microbial consortium formulation. *P. fluorescens*, *B. subtilis*, and *T. harzianum* are recommended to be formulated together only in carriers or substrates that do not strongly promote dominant antibiosis, such as organic compost-based carriers, organic peat soil, or other substrates with balanced carbon-nitrogen characteristics. The high compatibility observed on PDA-NA suggests that in natural rhizosphere conditions, where nutrients are generally complex and not extreme, these three microbes may have potential to coexist and provide complementary roles as biofertilizers and biocontrol agents.

A limitation of this study is the low replication number, which restricts inferential statistical testing and makes the results primarily descriptive. Future studies should increase replication, test additional media and carrier materials, evaluate microbial population dynamics over longer incubation periods, and validate consortium performance in planta or under greenhouse and field conditions. Such follow-up studies are necessary to determine whether in vitro compatibility on PDA-NA can translate into stable colonization and effective disease suppression in crop systems.

CONCLUSIONS

This study demonstrates that the compatibility among *Trichoderma harzianum*, *Bacillus subtilis*, and *Pseudomonas fluorescens* is strongly influenced by the composition of the growth medium. The three isolates showed clear compatibility on PDA-NA, a carbohydrate-rich medium that supports simultaneous growth without the formation of inhibition zones, whereas King's B medium promoted stronger antagonistic interactions. The contrasting results between the two media indicate that nutrient conditions capable of stimulating antibiosis can reduce consortium compatibility. These findings provide an important foundation for designing stable and compatible microbial consortium formulations for biocontrol or biofertilizer applications in the field.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING

This work was supported by the PPM Grant provided by Universitas Jambi.

ACKNOWLEDGMENT

The authors would like to thank Universitas Jambi for supporting this research through the PPM Grant scheme.

AUTHOR CONTRIBUTIONS

Conceptualization, P.D.M. and H.U.M.; methodology, P.D.M. and T.V.A.; validation, P.D.M.; formal analysis, P.D.M. and T.V.A.; investigation, P.D.M., A.V.B., and T.V.A.; resources, P.D.M.; data curation, P.D.M. and T.V.A.; writing - original draft preparation, P.D.M.; writing - review and editing, P.D.M.; visualization, P.D.M. and T.V.A.; supervision, P.D.M.; project administration, A.L.D., P.D.M., and N.A.S.

DECLARATION OF ARTIFICIAL INTELLIGENCE USE

AI-based tools were used only to support language refinement, formatting consistency, and reference style adjustment during manuscript preparation. The authors critically reviewed all AI-assisted outputs to ensure the integrity and reliability of the manuscript. The final decisions, interpretations, and conclusions presented in this article remain solely the responsibility of the authors.

REFERENCES

1. Pathak VM, Verma VK, Rawat BS, Kaur B, Babu N, Sharma A, et al. Current status of pesticide effects on environment, human health and its eco-friendly management as bioremediation: a comprehensive review. Front Microbiol. 2022;13:962619. doi:10.3389/fmicb.2022.962619.
2. Pandit MA, Kumar J, Gulati S, Bhandari N, Mehta P, Katyal R, et al. Major biological control strategies for plant pathogens. Pathogens. 2022;11(2):273. doi:10.3390/pathogens11020273.
3. Harman GE, Howell CR, Viterbo A, Chet I, Lorito M. *Trichoderma* species - opportunistic, avirulent plant symbionts. Nat Rev Microbiol. 2004;2(1):43-56. doi:10.1038/nrmicro797.
4. Harman GE. Overview of mechanisms and uses of *Trichoderma* spp. Phytopathology. 2006;96(2):190-194. doi:10.1094/PHYTO-96-0190.

5. Haas D, Defago G. Biological control of soil-borne pathogens by fluorescent pseudomonads. Nat Rev Microbiol. 2005;3(4):307-319. doi:10.1038/nrmicro1129.
6. Ongena M, Jacques P. *Bacillus* lipopeptides: versatile weapons for plant disease biocontrol. Trends Microbiol. 2008;16(3):115-125. doi:10.1016/j.tim.2007.12.009.
7. Raaijmakers JM, Vlami M, de Souza JT. Antibiotic production by bacterial biocontrol agents. Antonie Van Leeuwenhoek. 2002;81(1-4):537-547. doi:10.1023/A:1020501420831.
8. Harman GE. Multifunctional fungal plant symbionts: new tools to enhance plant growth and productivity. New Phytol. 2011;189(3):647-649. doi:10.1111/j.1469-8137.2010.03614.x.
9. Raaijmakers JM, Mazzola M. Diversity and natural functions of antibiotics produced by beneficial and plant pathogenic bacteria. Annu Rev Phytopathol. 2012;50:403-424. doi:10.1146/annurev-phyto-081211-172908.
10. Zin NA, Badaluddin NA. Biological functions of *Trichoderma* spp. for agriculture applications. Ann Agric Sci. 2020;65(2):168-178. doi:10.1016/j.aoas.2020.09.003.
11. Latha P, Anand T, Prakasam V, Jonathan EI, Paramathma M, Samiyappan R. Combining *Pseudomonas*, *Bacillus* and *Trichoderma* strains with organic amendments and micronutrient to enhance suppression of collar and root rot disease in physic nut. Crop Prot. 2011;30(6):757-763. doi:10.1016/j.cropro.2011.02.001.
12. Prasad RD, Rangeshwaran R, Anuroop CP, Phanikumar PR. Bioefficacy and shelf life of conidial and chlamydospore formulations of *Trichoderma harzianum*. Indian J Agric Sci. 2015;85(1):19-24.
13. Duffy BK, Defago G. Environmental factors modulating antibiotic and siderophore biosynthesis by *Pseudomonas fluorescens* biocontrol strains. Appl Environ Microbiol. 1999;65(6):2429-2438. doi:10.1128/AEM.65.6.2429-2438.1999.
14. Porter CL. Concerning the characters of certain fungi as exhibited by their growth in the presence of other fungi. Am J Bot. 1924;11(3):168-188.
15. Badalyan SM, Innocenti G, Garibyan NG. Interactions between xylotrophic mushrooms and mycoparasitic fungi in dual-culture experiments. Phytopathol Mediterr. 2004;43(1):44-48.
16. Campanile G, Ruscelli A, Luisi N. Antagonistic activity of endophytic fungi towards Diplodia corticola assessed by in vitro and in planta tests. Eur J Plant Pathol. 2007;117:237-246. doi:10.1007/s10658-006-9089-1.
17. Fokkema NJ. The role of saprophytic fungi in antagonism against Drechslera sorokiniana on agar plates and on rye leaves. Physiol Plant Pathol. 1973;3(2):195-205.
18. Dennis C, Webster J. Antagonistic properties of species-groups of *Trichoderma*: II. Production of volatile antibiotics. Trans Br Mycol Soc. 1971;57(1):41-48. doi:10.1016/S0007-1536(71)80011-0.
19. Dennis C, Webster J. Antagonistic properties of species-groups of *Trichoderma*: I. Production of non-volatile antibiotics. Trans Br Mycol Soc. 1971;57(1):25-39. doi:10.1016/S0007-1536(71)80077-3.
20. Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed. Hillsdale: Lawrence Erlbaum Associates; 1988.
21. Hanudin, Marwoto B, Hersanti, Muharam A. Kompatibilitas *Bacillus subtilis*, *Pseudomonas fluorescens*, dan *Trichoderma harzianum* untuk mengendalikan *Ralstonia solanacearum* pada tanaman kentang. J Hortik. 2012;22(2):172-179.
22. King EO, Ward MK, Raney DE. Two simple media for the demonstration of pyocyanin and fluorescin. J Lab Clin Med. 1954;44(2):301-307.
23. Sadeghi A, Karami Z, Moosavi N. Production of siderophores and antifungal compounds by *Pseudomonas fluorescens* strains. Afr J Biotechnol. 2012;11(35):8734-8740. doi:10.5897/AJB12.054.
24. Harwood CR, Cranenburgh R, van Sinderen D. *Bacillus subtilis*: from soil bacterium to industrial workhorse. Curr Opin Biotechnol. 2018;50:26-32. doi:10.1016/j.copbio.2017.10.004.
25. Shafi J, Tian H, Ji M. *Bacillus* species as versatile weapons for plant pathogens: a review. Biotechnol Biotechnol Equip. 2017;31(3):446-459. doi:10.1080/13102818.2017.1320466.