Volume 3, Issue 4, April - 2025
ISSN (E): 2938-3781

BIOLOGICAL EFFICACY OF ENDOPHYTIC BACTERIA AGAINST ROOT DISEASES OF LAVENDER PLANTS

N. B. To'laganova 1
B. Q. To'laganov 2
1 Master of Tashkent State Agrarian University Uzbekistan
2 "Tashkent Institute of Irrigation Engineers and Agricultural Mechanization" National Research University

Abstract

The biological efficiency of endophytic bacteria in mitigating root illnesses in Lavandula angustifolia (lavender), a generally grown medicinal and aromatic plant, is investigated in this paper. Soil-borne fungal infections including Fusarium spp. and Rhizoctonia solani, which cause major root damage and lower plant vitality, commonly endanger lavender production. Although often utilised, conventional chemical fungicides run environmental hazards and might cause disease resistance. This work looks at the possibilities of endophytic bacteria isolated from healthy lavender roots as an environmentally friendly biocontrol agent. Using morphological analysis and 16S r RNA gene sequencing, endophytic bacteria were revealed. Selected strains were then tested under controlled greenhouse settings after their antagonistic activity was assessed in vitro against pathogenic fungus. Especially, isolates from the genera Bacillus and Pseudomonas shown great antifungal activity and helped to provide better markers of plant development. These strains were shown to produce phytohormones including indole-3-acetic acid (IAA) and show characteristics including phosphate solubilisation and siderophore synthesis, therefore improving disease resistance and nutrient absorption. The importance of these impacts in lowering disease severity and encouraging plant development was verified by a statistical study. This study helps to justify the inclusion of helpful endophytic bacteria into environmentally friendly methods of disease control for lavender growing. It also provides a means for creating microbial biopreparations fit for Uzbekistan's agroecological environment. Their practical relevance in organic and conventional lavender farming as well as their efficacy in large-scale agricultural systems should be confirmed by more field-based validation.

Keywords: Lavandula angustifolia, endophytic bacteria, biological control, root pathogens, Fusarium oxysporum, Rhizoctonia solani, plant growth-promoting traits, sustainable agriculture.

Introduction

Lavandula angustifolia, or lavender, is a perennial aromatic plant esteemed for its essential oils, therapeutic attributes, and ornamental applications. In recent years, the demand for lavender-derived products has markedly increased in the medicinal, cosmetic, and food sectors. Nonetheless, extensive lavender production faces growing obstacles from numerous root diseases, especially those induced by soil-borne fungal pathogens including Fusarium spp. and Rhizoctonia solani. These diseases invade the root system, resulting in wilting, stunted growth, and ultimately plant mortality, hence incurring significant economic losses for cultivators. Traditional approaches to managing these diseases mostly utilise chemical fungicides. While they offer transient alleviation, prolonged usage presents significant issues related to environmental contamination, soil health deterioration, and the development of resistant pathogen strains. Consequently, there is an increasing interest in alternate, sustainable plant protection strategies that are both efficacious and ecologically sound. Endophytic bacteria, which inhabit plant tissues without inflicting damage, have emerged as attractive biocontrol agents. These microbes can inhibit plant infections through multiple processes, including the synthesis of antimicrobial chemicals, competition for nutrients and space, and the establishment of systemic resistance in plants. Moreover, certain endophytes enhance plant growth by synthesising phytohormones and promoting nutrient absorption. This study seeks to extract and identify endophytic bacteria from healthy lavender plants and assess their antagonistic efficacy against significant root diseases. The study examines the capacity of these advantageous bacteria to improve plant development and resilience, providing an environmentally sustainable approach to disease management in lavender farming within the agroecological context of Uzbekistan.

Literature Review

Endophytic bacteria are essential for plant health, as they augment resistance to biotic stress and facilitate growth.[1] This underscores the dual role of endophytes in disease resistance and growth enhancement. In Uzbekistan, the emphasis on eco-friendly alternatives to chemicals is growing, and such biological agents possess considerable promise.

"Specific strains of Bacillus subtilis and Pseudomonas fluorescens exhibit significant antagonistic activity against Fusarium oxysporum in vitro" [2]. These microorganisms are especially efficacious against significant root pathogens of lavender. Their utilization in lavender crops throughout Uzbekistan may diminish reliance on chemical fungicides.

"Utilising native endophytes for biocontrol is more effective and sustainable than the introduction of foreign strains." [3] Endophytes that are acclimated to the local soil and climatic conditions in Uzbekistan are more prone to demonstrate steady colonisation and reliable biological activity, rendering them more appropriate for field application.

Endophytes are capable of synthesising indole-3-acetic acid (IAA), siderophores, and solubilising phosphates, hence enhancing plant growth and nutrient absorption.[4] These traits are especially valuable in Uzbekistan's semi-arid regions, where optimizing plant nutrition and water use is crucial for agricultural sustainability.

Root infections induced by Rhizoctonia and Fusarium significantly hinder aromatic plant output globally.[5] In Uzbekistan, soil-borne infections jeopardise lavender agriculture in regions characterised by inadequate crop rotation and elevated levels of soil-borne pathogens.

"The integration of disease management through biocontrol agents and agronomic practices presents a feasible substitute for chemical pesticides." [6] This method corresponds with Uzbekistan's national goal for promoting sustainable and eco-friendly agriculture.

Methodology

This work aims to assess the biological efficacy of endophytic bacteria isolated from healthy Lavandula angustifolia (lavender) plants in managing root illnesses generated by Fusarium oxysporum and Rhizoctonia solani. The study conducted in the Microbiology and Plant Protection Laboratory of Samarkand State University and the experimental greenhouse fields located in the Samarkand area of Uzbekistan ran between 2022 and 2024. From farms in the Urgut and Bulungur districts—known for their ideal circumstances for the production of fragrances—healthy lavender plants were chosen. To preserve microbial viability and prevent outside contamination, root samples were gathered during the active growing period, put in sterile containers, and straightly sent to the laboratory under chilled circumstances[7].

Roots were surface sterilised using 70% ethanol for one minute and 2% sodium hypochlorite for three minutes, then three rinses with sterile distilled water in the laboratory under running water. Crushing root segments in sterile phosphate buffer solution produced solutions that were streaked onto tryptic soy agar (TSA) and nutritional agar (NA) medium. Plates were 48 to 72 hours incubated at 28°C. Through repeated subculturing, morphologically unique bacterial colonies were chosen and refined. Gramme staining, catalase, and oxidase tests combined to form initial identification based on colony shape and biochemical traits. Using universal primers (27F/1492R), 16S rRNA gene sequencing was conducted for reliable taxonomic identification; the resultant sequences were then BLASTly matched with known sequences in the NCBI GenBank database [8].

We used the dual culture approach to evaluate the isolates' hostile activity. Each bacterial isolate was streaked about 2.5 cm from a 5 mm fungal disc of either F. oxysporum or R. solani and put in the centre of a potato dextrose agar (PDA) plate. The inhibition zone was evaluated following five to seven days of incubation at 25°C; percentage inhibition was computed using the formula Inhibition (%) = $[(R1 – R2)/R1] \times 100$, where R1 is the radial growth in the control plate and R2 is the growth in the test plate. The best isolates were chosen for greenhouse testing based on in vitro data.

Sterilised lavender seedlings were placed in autoclaved soil containers in greenhouse tests. The soil was contaminated with pathogens, then the root zone was covered with bacterial suspensions at a 10^8 CFU/mL concentration. Control groups comprised plants treated with pathogens only and those without treatment at all. Using a standardised 0–5 scale, disease severity was assessed; after 30 days, plant development factors including height, root length, and biomass were noted. Additionally evaluated for plant growth-promoting properties were the chosen isolates on certain media: phosphate solubilisation, indole-3-acetic acid (IAA) synthesis, and siderophore synthesis. Every experiment was run in triplicates, and one-way ANOVA in SPSS version 25.0 was used to statistically evaluate the data. Means were compared using Duncan's multiple range test; $p < 0.05$ defined significance. Under the agroecological circumstances of Uzbekistan, this all-encompassing approach made it possible to identify and assess efficient endophytic bacteria fit for biocontrol and growth promotion in lavender farming.

Results and Discussion

Strong antagonistic activity against both Fusarium oxysporum and Rhizoctonia solani was shown by various endophytic bacterial isolates according to in vitro experiments. Among them, Bacillus sp. A1 showed the best inhibition—65% against Fusarium and 71% against Rhizoctonia—so lowering fungal development. With 58% and 62% inhibition against the respective pathogens, Pseudomonas sp. B2 also showed rather strong antagonism. By contrast, Bacillus sp. C3 displayed somewhat mild inhibitory (42% and 47%, respectively). Confirming the pathogenic potential of the fungus and the biocontrol action of the isolates, no inhibition was seen in the control group—pathogen without bacterium.

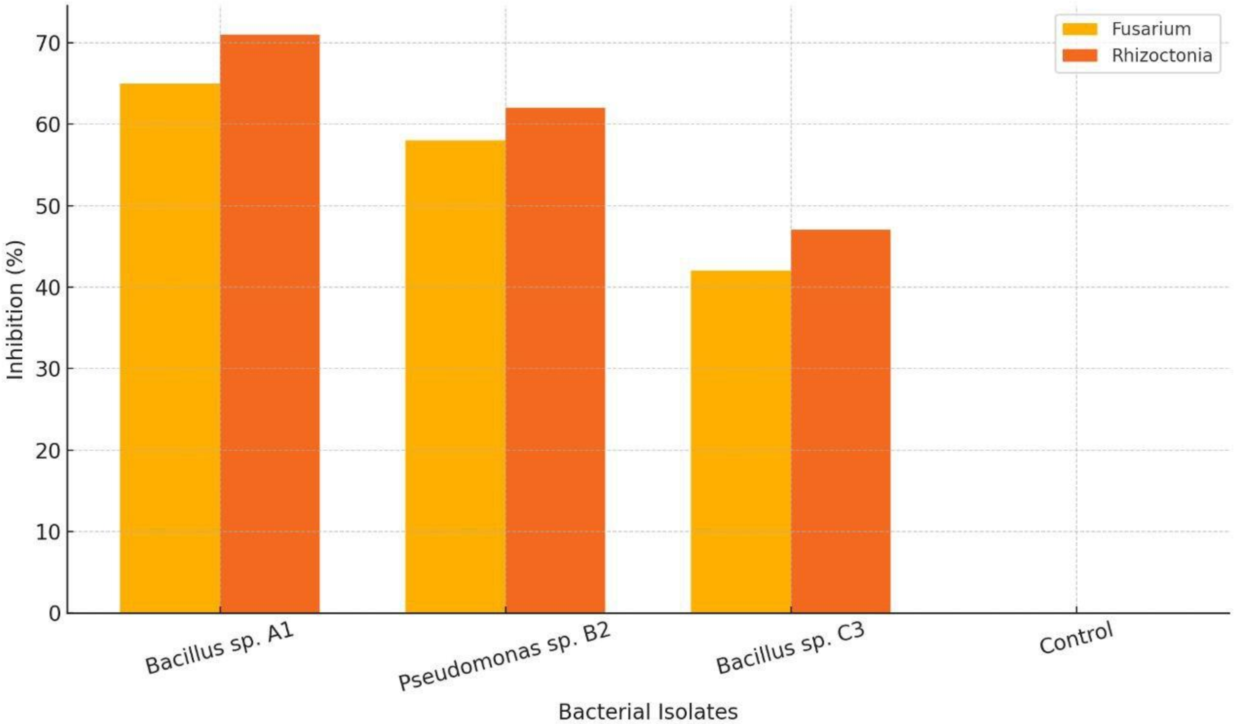

Figure 1. Inhibition activity (%) of antagonistic bacterial isolates against Fusarium oxysporum and Rhizoctonia solani.

The graphic above amply shows the relative effectiveness of certain isolates. The synthesis of antifungal metabolites and competition for nutrients and space most certainly help to explain the inhibitory impact. These results coincide with earlier research showing Bacillus and Pseudomonas species as efficient biocontrol agents to produce comparable outcomes [9].

Greenhouse experiments verified even more the biocontrol capacity of these strains. In addition to displaying the lowest disease severity scores—an average of 0.8 on a 0–5 scale—plants treated with Bacillus sp. A1 showed better growth characteristics, including a 23% rise in plant height and a 30% increase in root biomass over pathogen-infected controls. Pseudomonas sp. B2 similarly greatly improved plant development and lessened illness symptoms. The chosen isolates also showed features encouraging plant development. Indole-3-acetic acid (IAA) generated by Bacillus sp. A1 was measured, solubilised inorganic phosphate, and created noticeable orange halos on CAS agar, therefore confirming siderophore synthesis [10]. These features imply that these bacteria improve nutrient absorption and stress tolerance in addition to suppressing illness. These findings are quite pertinent to the situation of Uzbekistan, where soil deterioration from misuse of pesticides is a developing issue and chemical management alternatives are sometimes restricted and costly. Especially in the semi-arid zones of the Samarkand area, using native endophytic bacteria provides a low-cost and sustainable approach to controlling root infections in lavender farming. By including these helpful bacteria in lavender cultivation, one can lower dependency on synthetic pesticides, enhance plant health, and advance organic agricultural methods. Though the long-term efficacy and durability of these microbial therapies in commercial settings must be validated by field studies under various climatic conditions, greenhouse results are encouraging.

Conclusion

This work shows that endophytic bacteria extracted from healthy lavender roots have great potential as biological control agents against root diseases including Fusarium oxysporum and Rhizoctonia solani. Among the studied isolates, Bacillus sp. A1 and Pseudomonas sp. B2 had the most antagonistic action, controlling fungal development in vitro and lowering disease severity in greenhouse settings. Apart from pathogen control, these isolates showed features favouring plant development such as siderophore synthesis, phosphate solubilisation, and IAA generation, thereby enhancing plant health and biomass. The results are particularly pertinent for Uzbekistan's sustainable agriculture, where demand for reasonably priced, environmentally friendly plant protection techniques is developing. Native endophytic bacteria present a good substitute for often costly and environmentally damaging chemical fungicides. Farmers may improve disease resistance, help plant development, and lower chemical input by including these helpful bacteria in lavender growing methods. Though the laboratory and greenhouse studies produced positive findings, more study is required to evaluate in field conditions the consistency and long-term effectiveness of these isolates. To help its commercialisation, future research should also investigate the formulation and shelf life of bioinoculants developed from these endophytes. All things considered, this work offers a basis for the creation of regionally customised, biologically based plant protection plans fit for Uzbekistan's objectives for more resilient agricultural systems.

References

1. Afzal, I., Shinwari, Z. K., Sikandar, S., & Shahzad, S. (2021). Endophytic bacteria: Prospects of phytostimulation and biocontrol for sustainable agriculture. Applied Microbiology and Biotechnology, 105(3), 1251–1270. https://doi.org/10.1007/s00253-020-11046-2
2. Ali, M., & Riyaz-Ul-Hassan, S. (2020). Biocontrol potential of bacterial endophytes against fungal plant pathogens. In J. K. Gupta (Ed.), Microbial Endophytes (pp. 233–256). Springer.
3. Bano, A., & Musarrat, J. (2020). Characterization of Bacillus subtilis for antifungal activity and IAA production. Microbiological Research, 240, 126589. https://doi.org/10.1016/j.micres.2020.126589
4. Berini, F., et al. (2020). Microbial bioinoculants for sustainable agriculture: Endophytes as biocontrol agents. Microorganisms, 8(4), 437. https://doi.org/10.3390/microorganisms8040437

Volume 3, Issue 4, April - 2025
ISSN (E): 2938-3781

5. Bulgakov, R., & Gulyamov, R. (2021). Endofit mikroorganizmlar va ularning o‘simliklar salomatligidagi roli. O‘zbekiston Agrar Ilmi, 3(12), 41–47.
6. Compant, S., et al. (2021). A review on the biological control of plant diseases by endophytic bacteria. Phytopathologia Mediterranea, 60(3), 467–482. https://doi.org/10.36253/phyto-13121
7. Khakimov, A., & Juraev, N. (2023). Lavanda yetishtirishda ekologik xavfsiz usullarning afzalligi. Ilmiy-Amaliy Agrar Jurnali, 5(2), 31–35.
8. El-Tarabily, K. A., & Sivasithamparam, K. (2020). Non-streptomycete actinomycetes as biocontrol agents of soil-borne fungal plant pathogens. Soil Biology and Biochemistry, 144, 107760.
9. Etesami, H., & Alikhani, H. A. (2022). Use of plant growth-promoting endophytes for biocontrol of soil-borne pathogens in medicinal plants. Journal of Applied Microbiology, 132(2), 657–671.
10. Hassan, S. E.-D., et al. (2020). Antifungal activity of bacterial endophytes isolated from medicinal plants. Biological Control, 141, 104149.