Faculty of Science

Characterization of rhizosphere bacteria and their role in plant growth promotion

By

Karima Ali Sayed Hassan

A thesis submitted in partial fulfillment

Of

The requirements for the degree of

Ph.D. of Science

In

Microbiology

Botany Department

Faculty of Science

Fayoum University

(2025)

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Karima Ali Sayed Hassan

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Supervisions committee:

Prof. Dr/ Ashraf Mohamed Mohamed Essa

Prof. of Microbiology - Botany Department - Faculty of Science - Fayoum University.

Signature……

Dr. Amany Mohamed Reyad

Assistant Prof. of Microbiology - Botany Department-

Faculty of Science - Fayoum University

Signature……

Summary

1. Summary

This study was conducted in the Department of Botany, Faculty of Science, Fayoum University, Egypt, during the period from 2022 to 2024. It aimed to isolate and identify bacteria associated with various plants and agricultural crops, including wheat, cotton, tomato, onion, and garlic. A total of 44 bacterial isolates were obtained. Among them, 18 isolates exhibited phosphate solubilization ability, and 12 demonstrated antifungal activity against *Rhizoctonia solani* and *Alternaria alternata*. The two most promising isolates were selected.

Salinity is one of the most critical global challenges that negatively affect crop productivity. It is estimated that high salinity affects 20% of the total agricultural land worldwide. Salinity stress is a complex phenomenon involving changes in metabolic processes, oxidative stress, osmotic stress, specific ion effects, and nutrient uptake deficiency. Various novel techniques, such as rhizosphere and endophytic bacteria, have been used to enhance plant salt tolerance and mitigate the adverse effects of salinity.

Plant growth and development are influenced by several factors, including the availability of essential nutrients in the soil. Phosphorus (P) is one of the primary macronutrients required by plants for various physiological processes, such as energy transfer, root development, and improved crop productivity. Hence, providing an adequate concentration of P is critical for plant growth.

In their natural environment, plants face various biotic stresses that affect their growth and health. Among these, fungi are a significant threat to plants. *Rhizoctonia solani* is a destructive fungus that infects several agricultural crops, including cotton. This pathogen causes diseases like root rot or damping-off, leading to reduced plant growth and yield by damaging roots and decreasing

nutrient and water uptake, ultimately causing plant weakening and death in severe cases.

To combat such biotic stresses, beneficial bacteria play a crucial role in enhancing plant resistance. These bacteria, known as plant growth-promoting rhizobacteria (PGPR), improve plant health through mechanisms such as phosphate solubilization, production of growth-promoting compounds, and inhibition of pathogenic fungi like *Rhizoctonia solani*.

Based on 16S rRNA gene sequencing analysis:

- The first isolate, obtained from wheat, was identified as *Mammalicoccus lentus*, capable of phosphate solubilization and salt tolerance.
- The second isolate, derived from cotton, was identified as *Bacillus halotolerans*, capable of phosphate solubilization and exhibiting antifungal activity against *Rhizoctonia solani*.

This study evaluated several biochemical and physiological parameters of plants under different stress conditions. IAA levels were measured under salinity stress at increasing concentrations (0, 100, 200, 300mM) to assess the bacterial isolates' effects on auxin levels.

An experiment using *Mammalicoccus lentus* was conducted on wheat plants grown in a Leonard system under stresses such as salinity and insoluble phosphate. The assessments included root and shoot lengths, fresh and dry weights, chlorophyll A content, total phosphorus, proteins, carbohydrates, and key antioxidants such as catalase, ascorbate peroxidase, superoxide dismutase, glutathione reductase, glutathione, and ascorbate.

Results:

1. Under salinity stress and phosphate deficiency, treated wheat grains with *Mammalicoccus lentus* improved significantly germination rate and growth parameters.
2. Also, levels of enzymatic and non-enzymatic antioxidant CAT, SOD, APX, GR, GsH, ASA, total protein, total carbohydrates, and total phosphorus have been enhanced in the bacterial treated seedlings compared with the non-treated ones.

For *Bacillus halotolerans* C3, experiments were conducted on 21-day-old cotton plants infected with *Rhizoctonia solani*, which causes damping-off disease. Similar parameters were assessed, along with total phenolic, to evaluate the plant's response to bacterial inoculation.

Results:

1. In infected soil with *R. solani*, treated cotton seeds with *B. halotolerans* C3 exhibited maximum inhibition of *R. solani* growth. It improved significantly seed emergence and growth parameters
2. Also, levels of enzymatic and non-enzymatic antioxidant CAT, SOD, APX, GR, GsH, ASA, total protein, total carbohydrates, total phosphorus and total phenolic have been enhanced in the bacterial treated seedlings compared with the non-treated ones.
3. Significant improvements in seed emergence, 26, 34, and 40 % increase for seed presoaking, soil drench, and seed coating. Comparing the treated plants to the uninoculated ones.
4. Disease severity was markedly reduced by *B. halotolerans* C3 across all treatment methods. The soil drench method showed the greatest suppression, lowering disease severity to the same level as the uninfected control.

Using GC-MS analysis, several metabolic compounds were identified in the bacterial secretions. For *Mammalicoccus lentus* (TV2), compounds like pentanoic acid, 1,3-dimethylcyclohexane, and pyrrolo[1,2-a]pyrazine-1,4-dione were identified. For *Bacillus halotolerans* (C3), compounds such as heptasiloxane and thymol derivatives with antimicrobial properties were detected.

These results highlight the significant role of phosphate-solubilizing and antifungal bacteria in enhancing plant tolerance to salinity and other stresses, supporting their potential use as eco-friendly biocontrol to improve crop growth and productivity.