NexAvens Scientific Library

OPEN ACCESS

NL Journal of Agriculture and Biotechnology

(ISSN: 3048-9679)

Volume 2 Issue 1 February 2025

Editorial

Amelioration of Soil Salinity Through Plant Growth-Promoting Bacteria: A Sustainable Solution

Salma Mukhtar

Corresponding Author: Salma Mukhtar, Department of Plant Biology, Rutgers University, New Jersey, USA

DOI: 10.71168/NAB.02.01.101

Received Date: January 16- 2025 **Publication Date:** January 31- 2025

Soil salinity is a growing agricultural challenge affecting millions of hectares of arable land globally. Excessive salt accumulation in the soil disrupts plant growth by limiting water uptake, causing ion toxicity, and reducing soil fertility. Traditional methods to address soil salinity, such as chemical amendments and physical leaching, are often costly, time-consuming, and environmentally taxing. An emerging and sustainable alternative is the use of plant growth-promoting bacteria (PGPB) to improve plant salt tolerance.

Understanding Soil Salinity

Soil salinity has emerged as a formidable challenge to sustainable agriculture worldwide. The accumulation of soluble salts in the soil profile adversely affects soil structure, nutrient availability, and plant growth, ultimately reducing agricultural productivity. Soil salinity arises from both natural and anthropogenic factors [1-3]. Naturally, saline soils develop in arid and semi-arid regions where evaporation exceeds precipitation, leaving salts to accumulate near the surface. Salinity negatively affects plant metabolism, leading to stunted growth, reduced yield, and, in severe cases, complete crop failure [4-7]. Addressing this issue is critical given the increasing demand for food security and sustainable agriculture.

Role of Plant Growth-Promoting Bacteria to Improve Plant Salt Tolerance

Plant growth-promoting bacteria are naturally occurring microorganisms that enhance plant growth by various mechanisms [8-11]. PGPB can thrive in saline environments and offer a sustainable approach to mitigate soil salinity as shown in Figure 1. Key benefits of PGPB include:

1. **Salt Tolerance Induction:** PGPB produce metabolites like exopolysaccharides (EPS) that help plants maintain ionic balance and reduce salt stress.
2. **Nutrient Bioavailability:** These bacteria solubilize essential nutrients like phosphorus and potassium, making them more accessible to plants.
3. **Phytohormone Production:** PGPB synthesize hormones such as auxins, gibberellins, and cytokinins, which promote root growth and enhance plant resilience.
4. **ACC Deaminase Activity:** By breaking down the stress hormone ethylene precursor (1-aminocyclopropane-1-carboxylic acid), PGPB alleviate plant stress and promote growth under saline conditions.

Mechanisms of Soil Salinity Amelioration

PGPB contribute to soil improvement in several ways:

- **Soil Structure Stabilization:** Exopolysaccharides secreted by PGPB bind soil particles, improving soil structure and water retention capacity.

- **Reduction of Salt Toxicity:** Certain PGPB strains sequester toxic ions like Na+ and Cl−, reducing their availability to plants.
- **Bioremediation:** PGPB metabolize organic pollutants and enhance the degradation of harmful compounds in saline soils.

Practical Applications

Incorporating PGPB into agricultural practices can be achieved through:

1. **Biofertilizers:** Formulating biofertilizers with salt-tolerant PGPB strains to enhance soil and plant health.
2. **Seed Inoculation:** Coating seeds with PGPB to promote germination and early-stage growth under saline conditions.
3. **Soil Amendment:** Introducing PGPB directly into saline soils to improve microbial diversity and soil quality.

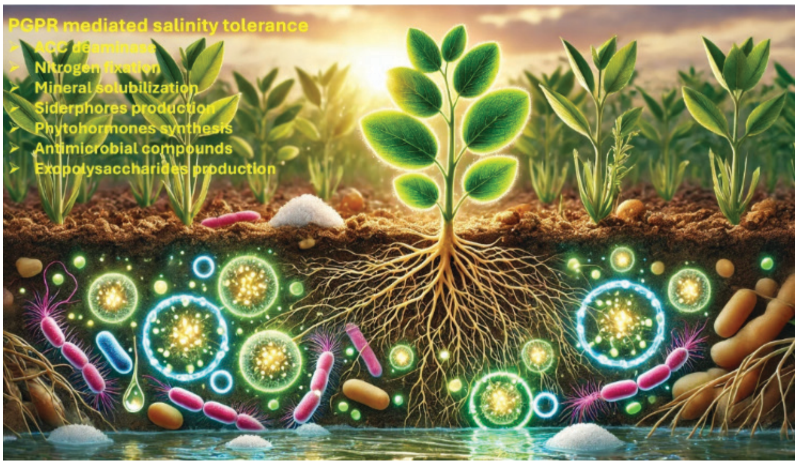

Figure 1: Halotolerant and halophilic plant growth promoting bacteria mediate direct or indirect mechanisms to improve plant salt tolerance

Challenges and Future Directions

Despite their potential, the application of PGPB faces challenges such as variability in bacterial efficacy across different soil types and crops, limited awareness among farmers, and difficulties in large-scale production and distribution. Future research should focus on:

- Identifying and engineering highly effective PGPB strains.
- Understanding the interactions between PGPB, plants, and the soil microbiome under saline conditions.
- Developing cost-effective and scalable delivery systems.

Conclusion

Using plant growth-promoting bacteria represents a promising avenue for sustainably ameliorating soil salinity. By enhancing soil health, increasing crop resilience, and reducing dependency on chemical inputs, PGPB offers a viable solution to one of agriculture's most pressing problems. To fully realize their potential, collaborative efforts among scientists, policymakers, and farmers are essential, ensuring that this innovative approach benefits both the environment and global food security.

References

1. Mukhtar, S., Malik, K.A. and Mehnaz, S., (2020a). Osmoadaptation in halophilic bacteria and archaea. Res. J. Biotechnol. 15 (5): 154-161.

2. Mishra, A.K., Das, R., George, K.R., Biswal, B., Sinha, T., Sharma, S., Arora, P. and Kumar, M. (2023). Promising management strategies to improve crop sustainability and to amend soil salinity. Front. Environ. Sci. 10: 962581. doi: 10.3389/fenvs.2022.962581

3. Mukhtar, S., Mehnaz, S., Malik, K.A. (2019). Microbiome of halophyte: diversity and importance for plant health and productivity. Microbiol. Biotechnol. Lett. 47(1): 1-10.

4. Peng, M., Jiang, Z., Zhou, F. and Wang, Z. (2023). From salty to thriving: plant growth promoting bacteria as nature's allies in overcoming salinity stress in plants. Front. Microbiol. 14: 1169809. doi: 10.3389/fmicb.2023.1169809

5. Saberi, R.R., Ebrahimi-Zarandi, M., Tamanadar, E., Moradi Pour, M., and Thakur, V.K. (2021). Salinity Stress: Toward Sustainable Plant Strategies and Using Plant Growth-Promoting Rhizobacteria Encapsulation for Reducing It. Sustainability 13(22): 12758. https://doi.org/10.3390/su132212758

6. Sapre, S., Gontia-Mishra, I., and Tiwari, S. (2022). Plant growth-promoting Rhizobacteria ameliorates salinity stress in pea (Pisum sativum). J. Plant Growth Regul. 41: 647–656. doi: 10.1007/s00344-021-10329-y

7. Haroon, U., Khizar, M., Liaquat, F., Ali, M., Akbar, M., Tahir, K., et al. (2021). Halotolerant plant growth-promoting rhizobacteria induce salinity tolerance in wheat by enhancing the expression of SOS genes. J. Plant Growth Regul. 41: 1–14. doi: 10.1007/s00344-021-10457-5

8. Trivedi, P., Batista, B.D., Bazany, K. E., and Singh, B.K. (2022). Plant–microbiome interactions under a changing world: responses, consequences and perspectives. New Phytol. 234: 1951–1959. doi: 10.1111/nph.18016

9. Mousavi, S.S., Karami, A., Saharkhiz, M.J., Etemadi, M., and Ravanbakhsh, M. (2022). Microbial amelioration of salinity stress in endangered accessions of Iranian licorice (Glycyrrhiza glabra L.). BMC Plant Biol. 22: 1–17. doi: 10.1186/s12870-022-03703-9

10. Prittesh, P., Avnika, P., Kinjal, P., Jinal, H.N., Sakthivel, K., and Amaresan, N. (2020). Amelioration effect of salt-tolerant plant growth-promoting bacteria on growth and physiological properties of rice (Oryza sativa) under salt-stressed conditions. Arch. Microbiol. 202: 2419–2428. doi: 10.1007/s00203-020-01962-4

11. Mukhtar, S., Hirsch, A.M., Khan, N., Malik, K.A., Humm, E.A., et al. (2020b). Impact of soil salinity on the cowpea nodule-microbiome and the isolation of halotolerant PGPR strains to promote plant growth under salinity stress. Phytobiome J. 4: 364-374.

Citation: Salma Mukhtar. "Amelioration of Soil Salinity Through Plant Growth-Promoting Bacteria: A Sustainable Solution". NL Journal of Agriculture and Biotechnology 2.1 (2025): 01-03.