ISSN 2277 – 8322

Bacterial Endophytes & their roles as Ameliorators for Abiotic & Biotic Stress

Dr. Suman Kacholia
Associate Professor
Department of Botany
B.B.D. Govt. College,
Chimanpura, Shahpura,
Jaipur, Rajasthan, India

Dr. Manisha Chauhan
Associate Professor
Department of Botany
S.K. Govt. College Sikar,
Jaipur, Rajasthan, India

Dr. Ram Pal Ahrodia
Assistant Professor
Department of Botany
Govt NM College
Hanumangarh,
Rajasthan, India

Abstract: A sustainable and environmentally acceptable solution to the problems caused by diverse environmental stressors is the use of bacterial endophytes in stress management in crops. Bacterial endophytes have demonstrated amazing promise in improving crop resilience and reducing the negative impacts of abiotic and biotic stressors since they live within plant tissues without appearing to do any harm. An overview of the function of bacterial endophytes in reducing stress in agricultural crops is given in this review. It explores the complex ways by which these advantageous microbes provide their host plants the ability to withstand stress. This includes the synthesis of stress-related hormones like cytokinins and abscisic acid (ABA), which control how plants react to drought, salt, and temperature changes.

The potential of bacterial endophytes to stimulate antioxidant enzymes and reactive oxygen species (ROS) scavengers is also explored, illuminating their function in minimising oxidative damage brought on by stress conditions. Under challenging circumstances, its antioxidant activity helps to maintain cellular integrity and general plant health. Additionally, the paper looks at how bacterial endophytes may improve nutrient absorption and assimilation, particularly under nutrient-deficient stress situations. As a result of their capacity to solubilize and mobilise vital nutrients from the soil, the host plant's access to nutrients is enhanced, reducing nutritional stress. Additionally, the relationship between bacterial endophytes and the plant's immune system is investigated, as well as their part in causing systemic acquired resistance (SAR) to infections. This feature emphasises how endophytes provide plants the ability to withstand stress while also enhancing their resistance to disease. The paper also emphasises how bacterial endophytes might reduce environmental stresses such drought, salt, heavy metals, and significant temperature changes. Their activation of genes that respond to stress and creation of stress-protective substances reduce plant stress, eventually boosting crop resilience in difficult circumstances.

Keywords: Bacterial endophytes, Endophytic bacteria, Ameliorators, Biotic stress, Abiotic stress, Plant growth promotion, Nutrient cycling, Stress

tolerance, Environmental stress, Drought tolerance, Salinity tolerance

Introduction:

The use of microbial symbionts in environmental management and agriculture has gathered substantial traction in recent years as a sustainable solution to the myriad problems that face plants. Bacterial endophytes have become important actors among these helpful microbes, living inside plant tissues without appearing to cause any harm. Numerous intriguing functions that they play in encouraging plant development, improving stress tolerance, and lessening the effects of both biotic and abiotic stressors have been revealed through considerable study on their interactions with host plants.

Crop productivity and environmental sustainability are seriously threatened by biotic stressors including pathogen infections and insect infestations as well as abiotic stresses like drought, salt, severe temperatures, and nutrient deficits. The heavy use of chemicals in traditional techniques of stress management can have a negative impact on the environment and people's health. The potential of naturally existing microorganisms to enhance crop resilience and lessen dependency on agrochemicals is therefore becoming a topic of increasing study.

Numerous plant species, from cultivated crops to natural vegetation, have been discovered to have a symbiotic relationship with bacteria called bacterial endophytes. These bacteria and plants have a deep and intimate relationship that gives them the ability to impact numerous physiological and biochemical processes, which has a variety of positive benefits on the host's general health and performance.

The search for environmentally friendly and sustainable solutions to problems that stress plants and the environment is more important than ever in the fields of agriculture and environmental management. Bacterial endophytes have distinguished themselves among the many microbes that make up the plant kingdom as important agents for enhancing plant resilience and reducing the negative impacts of biotic and abiotic stresses. As scientists and researchers investigate their many functions as stress reducers, their capacity to exist safely within the tissues of plants has inspired a great deal of curiosity.

Bacterial Endophytes - Their Presence and Diversity in Agricultural Crops:

Numerous endophytic bacteria are essential to the physiology of plants and ecosystems. All plant compartments, often the intercellular and intracellular areas of inner tissues, are colonised by these bacteria. The majority of the initial research on the variety of endophytic bacteria was based on the analysis of endophytic isolates that were taken from the plant following surface disinfection. Early research on the make-up of endophytic communities showed that various plant hosts contain similar bacterial endophyte populations. The presence of various endophytic species is primarily influenced by bacterial and plant genotypes, as well as biotic and abiotic environmental variables. The breadth of the endophytic population may depend on the tissue type of the plant or the season of isolation whereas a single host plant species might include a variety of genera and species of endophytes.

Knowledge of Bacterial Endophytes:

Bacterial endophytes are, as their name implies, bacteria that live in symbiotic relationships with their hosts by colonising the interior tissues of plants. They have direct access to plant nutrients thanks to their special niche, which also presents chances to affect many physiological and biochemical processes in the plant. Researchers are looking at the many different functions that these microorganisms perform, particularly in the face of environmental stress, as a result of their unique coexistence.

Interactions Among Bacterial Endophytes in Population:

Hydrolytic enzymes and a large range of secondary metabolites are known to be produced by endophytic bacteria. The study of new endophytic metabolites and how they relate to plant metabolism is an active area of study. Many of the substances produced by endophytes have antibacterial or antifungal properties. The influence of endophytes on pathogenic bacteria and fungi has been the primary focus of study to far on the antibacterial activity of endophytes. Although it is challenging to mimic in in vitro studies, the possibility of a multidimensional network of antagonistic and symbiotic interactions in the plant endosphere is suggested by the quantity of endophytic bacteria and the capacity for metabolic signalling. Therefore, it is still completely unknown how endophytic bacteria interact with one another and how this affects endophytic fungus& it will remains a challenge for future research.

Agriculture Practises' Impact on Communities of Endophytic Bacteria:

Agricultural land management significantly modifies the physical, chemical, and biological qualities of soil. Due to mechanical damage, soil compaction, reduced pore volume, desiccation, and interruption of access to food supplies, soil tillage may result in a decrease in the variety of soil microbes. The structure and operation of soil microbial communities might alter significantly as a result of excessive pesticide usage. Pesticides may have a direct negative influence on the development and metabolism of microorganisms, and changes in the variety of microbes may result from general changes in the structure of agricultural ecosystems. Through adjustments to nutrients and inputs, agricultural management modifies the amount, quality, and geographical distribution of plant wastes that reach the soil.

The majority of bacteria in the plant endosphere are thought to live a "facultative endophyte" existence and go through a phase of their life cycle where they are not present in the host plants. These endophytes frequently come from the soil and infect the host plant's roots before colonising the apoplast. Consequently, it may be assumed that the endophytic community is a specific subset of the larger microbial population of the rhizosphere and that it would reflect variations brought about by agronomic practises that are typical of the soil microbial community. However, there have only been a few investigations on the impact of agricultural practises on endophyte population dynamics.

Plant Growth and Nutrient Cycling Improvement:

Promoting plant development and improving nutrient cycling are two of the main ways that bacterial endophytes help to reduce stress. These bacteria may create compounds that aid in growth, including phytohormones like auxins, gibberellins, and cytokinins. They promote the growth of the plant's roots and shoots, which improves nutrient absorption and promotes greater vigour and growth.

Additionally, bacterial endophytes are critical for nutrient cycling because they solubilize and mobilise vital nutrients in the soil, enhancing their accessibility to plants. The host plant gains from this nutrient-improving activity, which also enhances agricultural systems' overall soil fertility and sustainability.

Endophytes' role in agricultural crops' adaptation to biotic and abiotic environmental stress:

It has been demonstrated that endophytic bacteria have a number of advantageous impacts on their host plant. Improved nutrient uptake, especially nitrogen fixation, encourages plant development. The endophytic bacteria's control of plant metabolism and phytohormone signalling improves tolerance to environmental stress that may be biotic or abiotic, in addition to improving growth characteristics. Since endophytic bacteria have the benefit of being largely sheltered from the harsh soil environment during drought, excessive salt, or other stress conditions, they have a specific interest for improving crop tolerance to stress.

Mitigating Abiotic Stress:

Plant development and agricultural output are severely hampered by abiotic stress factors such as nutrient deficiency, salt, drought, and excessive temperatures. It has been shown that bacterial endophytes play a crucial role in assisting plants to survive these challenging circumstances. They promote the expression of genes that respond to stress and produce molecules that defend against it, enabling the plant to better survive and recover from challenging environmental circumstances.

For example, endophytes can improve the plant's water-use effectiveness and osmotic adjustment during dry spells, minimising water loss and preserving turgor pressure. Similar to this, in saline environments, bacterial endophytes help maintain ion homeostasis, limiting the buildup of harmful ions and lowering salt stress on the plant.

Protection Against Biotic Stress:

Bacterial endophytes are essential for decreasing biotic stressors like infections and pests in addition to their contributions to the control of abiotic stress. They cause induced systemic resistance (ISR), a state of increased defence against pathogenic invaders, by inducing the plant's innate immune responses. This boosted immune system aids the plant in fending off disease and lessens the need for chemical pesticides, encouraging the use of ecologically benign pest control methods.

Additionally, certain endophytic bacteria have direct antagonistic effects on plant diseases, competing with them for nutrients or generating antimicrobial substances that stop pathogen development. Because of their dual functions, bacterial endophytes are effective biocontrol agents in agriculture.

Environmental Restoration and Phytoremediation:

Bacterial endophytes show potential for environmental restoration and remediation outside of their roles in agriculture. They can increase plant resistance to heavy metals and organic toxins and detoxify pollutants. This characteristic makes them excellent candidates for phytoremediation, a method that uses plants to remove or breakdown contaminants from the environment. By collecting these metals within their cells or by converting them into less hazardous forms, endophytic bacteria can aid in the removal of heavy metals from polluted soils and water. Their participation in phytoremediation offers up new doors for sanitising contaminated places and repairing damaged ecosystems.

Challenges and Future Perspectives:

Although bacterial endophytes have the potential to reduce stress, there are obstacles in the way of their actual use. Further study and improvement are needed in the areas of choosing the best endophytes for certain plants and environmental circumstances, optimising inoculation procedures, and guaranteeing long-term stability in different agroecosystems.

Additionally, the incorporation of these microbial agents into common agricultural and environmental management practises is significantly influenced by regulatory concerns and public acceptance. To overcome these obstacles and utilise the full potential of bacterial endophytes, collaboration between researchers, decision-makers, and stakeholders is crucial.

Conclusion:

Endophytic bacteria have been recovered from a wide variety of agricultural plants, and this diversity shows that the bacteria are crucial to maintaining the balance of plant physiology and the operation of agroecosystems. The advent of metagenomic research tools over the past ten years has revealed fresh data on the variety of inhospitable endophytic bacteria and opened up significant opportunities for investigating intricate interactions between the microbial population and the plant host. Numerous studies show that endophytic bacteria have positive impacts on plant development and resilience to biotic or abiotic stressors.In order to improve plant performance and implement the integrated plant disease management systems necessary for sustainable agricultural production, it is important to understand the makeup and function of the microbial communities that are associated with plants as well as how to control the structure of endophytic bacterial populations.

In the fight against abiotic and biotic stresses in agriculture and environmental management, bacterial endophytes are emerging as crucial partners. They provide a variety of functions that are advantageous in the search for ecologically friendly and sustainable solutions, including boosting nutrient cycling, reducing biotic and abiotic stress, and assisting in phytoremediation.

The incorporation of bacterial endophytes into agricultural practises and environmental restoration initiatives holds the potential of a greener and more resilient future as research in this area develops.

References:

1. Akhtyamova N. 2013. Human pathogens-the plant and useful endophytes. Journal of Medical Microbiology and Diagnosis, 2: e121 http://dx.doi.org/10.4172/2161-0703.1000e121
2. Bacon C. W., Hinton D. M. 2007. Bacterial endophytes: the endophytic niche, its occupants, and its utility. Plant-associated bacteria, p. 155–194.
3. Compant S, Clement C, Sessitsch A. Plant growth-promoting bacteria in the rhizo- and endosphere of plants: Their role, colonization, mechanisms involved and prospects for utilization. Soil Biol Biochem 42: 669–678. (2010).
4. Kandel SL, Joubert PM, Doty LS. Bacterial endophyte colonization and distribution within plants. Microorganisms 5: 77; Accepteddoi:10.3390/microorganisms5040077. (2017).
5. Miliute, Inga & Buzaite, Odeta & Baniulis, Danas & Stanys, Vidmantas. (2015). Bacterial endophytes in agricultural crops and their role in stress tolerance: A review. Zemdirbyste-Agriculture.

102. 465-478. 10.13080/z-a.2015.102.060.

6. Bell C. R., Dickie G. A., Harvey W. L. G., Chan J. W. Y. F. 1995. Endophytic bacteria in grapevine. Canadian Journal of Microbiology, 41: 46–53http://dx.doi.org/10.1139/m95-006.
7. Brader G., Compant S., Mitter B., Trognitz F., Sessitsch A. 2014. Metabolic potential of endophytic bacteria. Current Opinion in Biotechnology, 27: 30–37 http://dx.doi.org/10.1016/j.copbio.2013.09.012.
8. Christina A., Christapher V., Bhore S. J. 2013. Endophytic bacteria as a source of novel antibiotics: an overview. Pharmacognosy Reviews, 7 (13): 11–16.
9. Weller D. M., Raaijmakers J. M., Gardener B. B., Thomashow L. S. 2002. Microbial populations responsible for specific soil suppressiveness to plant pathogens. Annual Review of Phytopathology, 40: 309–348 http://dx.doi.org/10.1146/annurev.phyto.40.030402.110010
10. Endophytic microbes: biodiversity, plant growth-promoting mechanisms and potential applications for agricultural sustainability. Rana KL, Kour D, Kaur T, Devi R, Yadav AN, Yadav N, Dhaliwal HS, Saxena AK. Antonie Van Leeuwenhoek. 2020 Aug;113(8):1075-1107.