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Bacterial Endophytic Microorganism in Plant Disease and Suppression

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Abstract: -

Microbial endophytes are beneficial microorganisms that live inside plant tissues without causing harm. They are one of the least explored groups of microbes, yet they play an important role in improving plant health and productivity. In modern agriculture, crop yield and quality are often reduced due to biotic and abiotic stresses such as diseases, pests and environmental changes. While chemical fertilizers and pesticides are widely used to manage these problems, they can pose serious risks to human and animal health. A safer and eco-friendly alternative is the use of endophytic bacteria, which naturally support plant growth. These bacteria, commonly found in soil, leaves, and seeds, help plants by fixing nitrogen, solubilizing phosphorus, producing growth hormones, improving stress tolerance, and protecting against diseases. The use of endophytic bacteria is therefore gaining importance as a sustainable approach to enhance crop productivity under changing environmental conditions.

Keywords: Endophytic bacteria, Colonization, Mode of action, Plant microbe interaction.

1. Introduction:

Bacterial endophytes are beneficial microorganisms that reside within the internal tissues of plants, including roots, stems, leaves, and seeds, without causing any visible harm to their host. These bacteria form symbiotic associations with plants, where both partners benefit through enhanced growth, improved nutrient uptake, and increased resistance to stress. They are now recognized as vital components of the plant microbiome,

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playing a key role in maintaining plant health and supporting sustainable agriculture. Bacterial endophytes promote plant growth through several mechanisms. They fix atmospheric nitrogen, solubilize phosphorus and potassium, and produce plant growth-promoting hormones such as auxins, gibberellins, and cytokinin's. These activities improve nutrient availability and stimulate overall plant development. Additionally, bacterial endophytes can produce secondary metabolites like antibiotics, siderophores, and lytic enzymes, which suppress harmful plant pathogens and reduce disease incidence. Through these actions, they act as effective biocontrol agents, minimizing the need for chemical fertilizers and pesticides that can harm the environment and human health.

Prominent genera of bacterial endophytes include *Pseudomonas*, *Rhizobium*, *Bacillus*, and *Azospirillum*, which are widely studied for their plant growth-promoting abilities. Beyond growth promotion, they also help plants tolerate various abiotic stresses such as drought, salinity, and temperature fluctuations by inducing systemic resistance and enhancing stress-related physiological responses. Advancements in genetics, molecular biology, and biotechnology, the role of bacterial endophytes is being increasingly explored in modern agriculture. Their potential applications extend beyond crop improvement to environmental sustainability and bioremediation. By reducing chemical dependency, enhancing soil fertility, and improving plant resilience, bacterial endophytes offer a promising, eco-friendly approach for achieving sustainable crop production under changing climatic conditions.

2. Nature and Occurrence

Endophytic bacteria inhabit all plant tissues, primarily in intercellular and intracellular spaces, playing key roles in plant physiology and ecosystem function. Early studies, based on isolates from rhizosphere and phyllo sphere regions, revealed a wide diversity of endophytes, with genera like *Bacillus* and *Pseudomonas* commonly found in crops. Their presence varies with plant species, tissue type, season, and environmental conditions. Most endophytes belong to Proteobacteria (especially α-, β-, and γ-subgroups), with γ-proteobacteria being the most diverse. Gram-negative endophytes often serve as biocontrol agents, while Gram-positive ones are dominated by *Bacillus* species. Culture-based methods identify only about half of the community, prompting the use of metagenomics to uncover unculturable species. These studies show root tissues harbor the highest diversity, with dominant groups varying by plant e.g., γ-proteobacteria in rice, α-proteobacteria in sugar beet, and various pathogens in sorghum.

3. Applications of Bacterial Endophytic Microbes :

1. Sustainable Agriculture:

- Act as **biofertilizers, biopesticides and biostimulants**, reducing chemical input and enhancing crop productivity.
- **Nitrogen-fixing and phosphorus-solubilizing bacteria** (e.g., *Rhizobium*, *Azospirillum*, *Bacillus*, *Pseudomonas*) improve soil fertility and plant nutrition.
- Function as **biocontrol agents**, suppressing plant pathogens and promoting healthy growth.

2. Bioremediation:

- Bacterial endophytes assist in **phytoremediation** by **detoxifying heavy metals** and **degrading organic pollutants**, enabling plant survival in contaminated areas.

3. Pharmaceuticals:

- Produce **bioactive metabolites** such as **antibiotics, anticancer compounds, and antioxidants**, useful in drug development.

4. Climate Resilience:

- Improve **plant stress tolerance** to drought, salinity, and temperature extremes through hormone modulation and antioxidant activity.

4. Identification of Endophytes

Biochemical Tests (Bacterial endophytes)

Bacterial endophytes can be identified using classical biochemical assays such as:

- **Gram staining** (to classify bacteria as Gram-positive or Gram-negative)
- **Catalase test, oxidase test,** and other enzymatic assays
- **Carbohydrate utilization tests** (e.g., API strips)

5. Plant Colonization with Endophytes

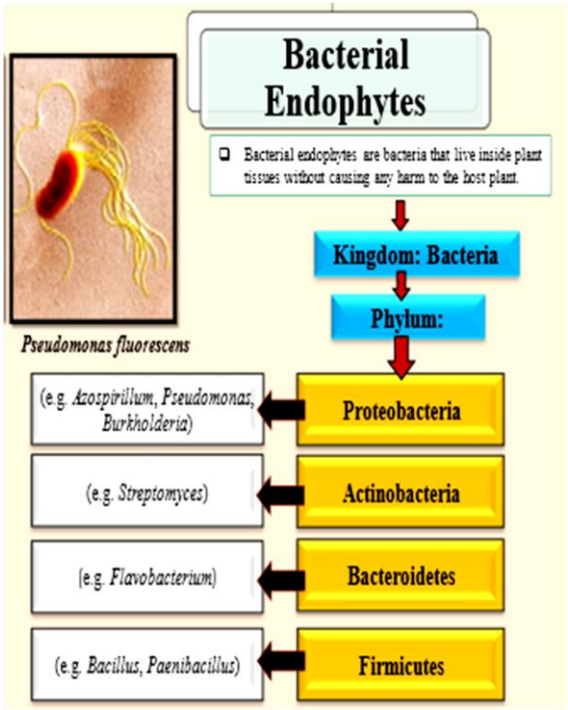
Bacterial endophytes colonize plants primarily through the roots, where specific regions provide suitable entry points. The apical root zone, including the elongation and root hair regions, allows active penetration as bacteria attach to thin-walled root cells, while the basal root zone, with small cracks formed during the emergence of lateral roots, facilitates passive penetration. To enter plant tissues, bacterial endophytes produce cellulolytic enzymes that break down cell walls, enabling successful colonization. Their population is generally higher in the rhizosphere and rhizoplane than in bulk soil, as these areas are enriched with nutrients secreted by plant roots. During seed germination, the release of carbon and nitrogen compounds attracts various microorganisms, and the composition of root exudates specific to each plant species determines which bacterial genera colonize the roots. Once established, bacterial endophytes act as natural plant growth promoters and biocontrol agents by

enhancing nutrient uptake, producing growth hormones, and suppressing pathogens, thereby contributing to improved plant health, stress tolerance, and sustainable crop productivity.

6. List of endophytic bacteria isolated from major agricultural crops

Bacterial Endophytes

Crop	Endophytes	Activity	References
Turmeric (*Curcumac longa* L.)	*Bacillus cerecus, Bacillus thuringiensis, Pseudomonas putida*	Nitrogen fixation, production of IAA, Siderophores, Antagonistic to pathogen	**Kumar *et al.* (2016)**
Chilies (*Capsicum annuum* L.)	*P. Fluoresecens*	Antibiosis against *Pythum aphanidematum*	**Muthukumar *et al.* (2010)**
	Bacillus tequilensis, Burkholderiacepica	Antagonistic activity against *Botrytis cinerq Colletotrichum acutatum*	**Paul *et al.* (2013)**
Rice (*Oryza sativa* L.)	*Pseudomonas, bacillus, Enterobacter*	PGP activity	**Mbai *et al.* (2013)**
	*Burkholderia*spp.	Siderophores	**Souza *et al.* (2013)**
Corn (*Zea mays* L.)	*Bacillus*spp.	Nitrogen fixation , production of IAA, Siderophores, Antagonistic to the pathogen *Fusarium vertcillioides Colletotrichum graminicola Bipolaris Maydis*	**Zecchin *et al.* (2014)**



7. Bacterial Endophytes: Role and Function in Crop Health

- Increase plant growth and development.
- Reduce oxidative stress of hosts.
- Protect plants from disease.
- Suppress growth of competitor plant species.
- Defend plants from pathogens and insects.
- Modulate plant development

8. Bioprospecting Of Bacterial Endophytes in Plant Disease

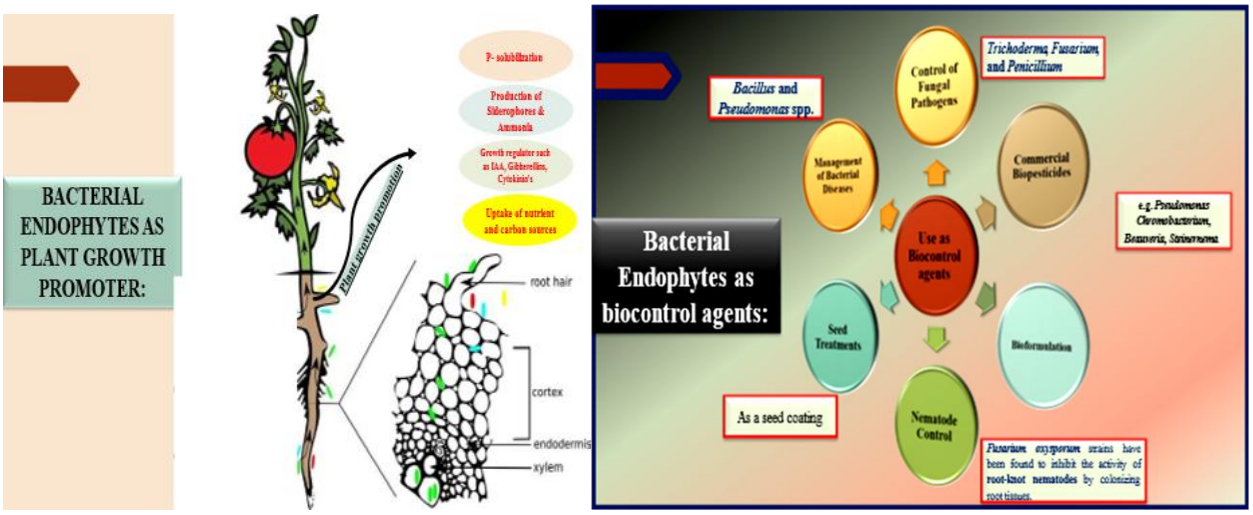
Prospecting of endophytes in plant disease involves the discovery and utilization of endophytic microorganisms (both bacteria and fungi) that reside within plants and possess the potential to control plant diseases. Endophytes offer a natural and eco-friendly

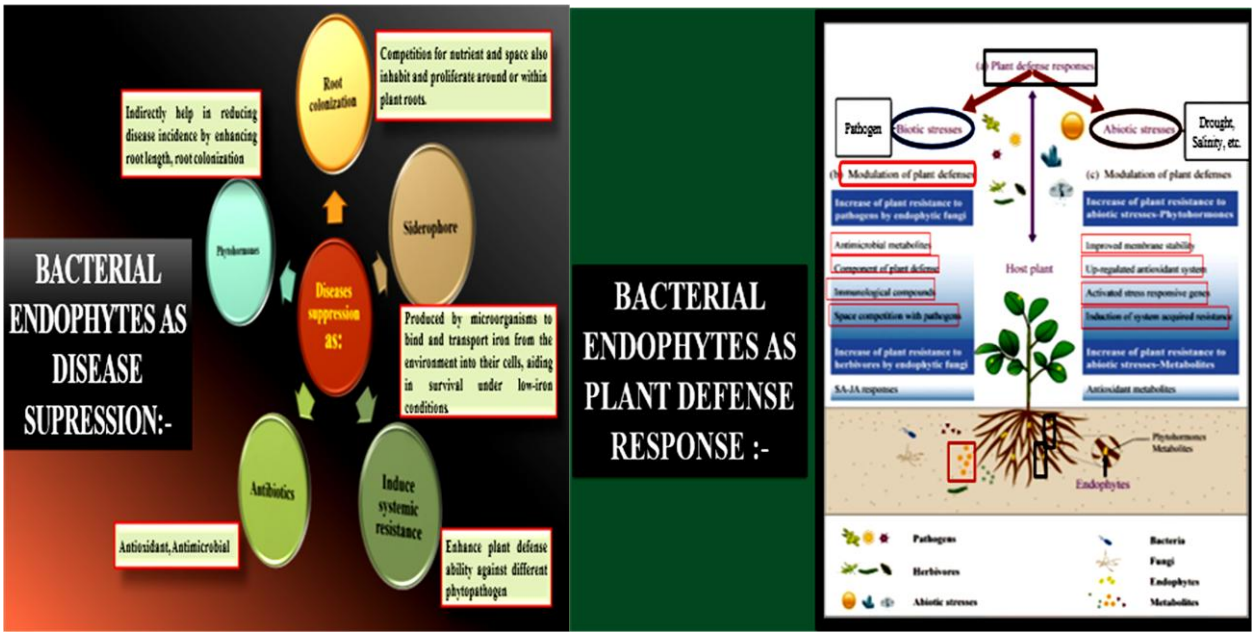
solution to combating pathogens, making them a focus of sustainable agricultural practices. Through bioprospecting, researchers aim to identify endophytes that can be used as biocontrol agents, reducing reliance on chemical pesticides and improving plant health.

- Bacterial Endophytes as plant growth promoters.
- Bacterial Endophytes as biocontrol agents against pathogens.
- Bacterial Endophytes as disease suppression.
- Bacterial Endophytes as plant defense response

9. Conclusion

Plant pathogenic fungi such as *Pythium*, *Phytophthora*, *Sclerospora*, *Rhizoctonia*, *Peronosclerospora*, and *Plasmopara* cause significant crop losses worldwide. Although fungicides are commonly used to control these diseases, they





pose serious drawbacks, including toxicity to humans and animals and the development of pathogen resistance. Bacterial endophytes offer a promising, eco-friendly alternative for managing such plant diseases and reducing dependency on chemical control measures. However, several aspects related to their practical use in agriculture still need to be explored. With proper management and deeper understanding of plant–microbe interactions, bacterial endophytes have great potential to combat current and emerging plant pathogens and mitigate biotic stresses under changing climatic conditions. Future research focusing on plant–microbiome signaling and root exudate manipulation can help develop more effective bioformulations. Enhancing the quality, production efficiency, and shelf life of these bio-control agents will further strengthen their role in sustainable crop protection and productivity.