Vol. 5 Issue- 1, September 2024 (e-ISSN: 2582-8223)

PGPR: Biocontrol Agents for Plant Diseases

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ARTICLE ID: 37

Introduction:

Plant growth-promoting rhizobacteria (PGP R) are rhizosphere-dwelling bacteria that use root exudates and colonize roots to promote plant growth. Plant roots grow in the rhizosphere, which is a zone of specialized, nutrient-rich soil that is supported by a high level of microbial activity. Root exudates function as essential nutrients, forming a distinct microbial population that is essential to the health and growth of plants. Algae, actinomycetes, bacteria, and protozoa make up the rhizosphere's microbial population, with bacteria being the most common. It is well known that these bacteria encourage plant development. Kloepper and Schroth's term "plant growth promoting rhizobacteria (PGPR)" refers to these helpful microorganisms that are essential to the formulation of biofertilizers. Plant growth promotion via root-level enhancement and phytopathogen management are two of the many ways that PGPR aids agriculture.

Mechanisms of Plant Growth-Promoting Microorganisms (PGPM) as Biocontrol Agents:

- **Antagonism:** PGPR manufactures volatile chemical molecules, lytic enzymes, and antibiotics that directly prevent the growth of infections.
- **Competition:** Pathogen colonization is decreased by PGPM because it competes with pathogens for nutrients and space on plant surfaces and in the rhizosphere.
- **Induced Systemic Resistance (ISR):** Plant defense systems are triggered by PGPM, which equips the plant with signaling molecules and secondary metabolites to fend against pathogen infections.
- **Detoxification:** Certain PGPMs can improve plant health by detoxifying toxic substances in the soil or breaking down poisons created by pathogens.

- **Nutrient Availability:** Through phosphorus solubilization, nitrogen (N2) fixation, and the synthesis of compounds like phytohormones that promote growth, PGPM improve the availability of nutrients to plants.

Bacterial and fungal strains promoting plant growth, employed as biocontrol agents against plant pathogens

1. **Bacterial Plant Growth-Promoting Strains Pseudomonas Spp. Mechanisms:**

Make lytic enzymes, siderophores (compounds that chelate iron), and antibiotics to stop the spread of pathogens. Certain strains also cause plants to develop systemic resistance.

Applications: Effective against a variety of bacterial and fungal diseases, including as Pseudomonas syringae, Phytophthora spp., and Fusarium spp.

2. **Bacillus spp. Mechanisms:**

Generate enzymes (chitinases, proteases) and antibiotics (bacitracin, surfactin, etc.) that break down pathogen cell walls or stop their growth.

Applications: Employed against bacterial infections such as Xanthomonas and Erwinia spp., as well as fungal pathogens such as Fusarium, Rhizoctonia, and Verticillium spp.

3. **Rhizobium spp. Mechanisms:**

Fix atmospheric nitrogen so that it is absorbed by plants, therefore promoting their vigor and growth. Certain strains also generate antibiotics and siderophores.

Applications: advantageous for legume crops because it inhibits root pathogens and encourages nitrogen fixation

4. **Bacillus amyloliquefaciens Mechanisms:**

Generates lipopeptides that show antifungal action and cause plants to become systemically resistant, such as surfactin and iturin.

Applications: Effective against a variety of fungal diseases, such as Alternaria species, Botrytis, and Fusarium species.

5. **Fungal Plant Growth-Promoting Strains Trichoderma spp. Mechanisms:**

Generate lytic enzymes (chitinases, glucanases) and antifungal metabolites (trichodermin, gliotoxin) that break down the fungal cell walls.

Applications:

Utilized to combat soil-borne diseases such Pythium, Rhizoctonia species, and Fusarium. also encourages the solubilization of nutrients, which grows plants.

6. **Beauveria bassiana Mechanisms:**

Entomopathogenic fungus that attacks and destroys insect pests, hence mitigating plant diseases that are transmitted by insects.

Applications:

Effective in preventing plant diseases caused by bacteria and viruses by reducing pests such as aphids, whiteflies, and beetles.

7. **Metarhizium spp. Mechanisms:**

An additional entomopathogenic fungus that affects vectorborne plant diseases by infecting and killing insect pests. Applications: Applied to integrated pest control (IPM) tactics in a manner akin to Beauveria bassiana.

Integration and Challenges Synergistic Effects:

The effectiveness of biocontrol can be increased by combining strains with complementary mechanisms (such induced resistance or antibiosis).

- **Environmental Considerations:** Temperature, moisture content, and soil pH are a few examples of environmental factors that might affect how effective biocontrol agents are.
- **Commercialization:** It's still difficult to increase manufacturing volume and guarantee the stability of biocontrol products for use in the field.
- **Regulatory Approval:** For broad acceptance in agriculture, meeting safety and efficacy regulatory standards is essential.

Future Perspectives Advances in Microbial Ecology:

Further studies in microbial ecology will improve our knowledge of how pathogens, plants, and the environment interact with PGPM.

- **Biotechnological Innovations:** The creation of new PGPM strains via biotechnological methods, like metagenomics and genetic engineering, has the potential to increase the effectiveness of biocontrol.
- **Precision Agriculture:** Biocontrol strategies can be optimized by the use of precision agricultural techniques, such as the customized application of PGPM based on plant health and soil health diagnostics.
- **Climate Change Resilience:** In light of changing environmental conditions, it will be essential to investigate PGPM species and strains that are resistant to the effects of climate change for sustainable agriculture.

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- **Education and Adoption:** A greater understanding of the advantages and appropriate application of PGPM among farmers, scientists, and policymakers will enable its wider acceptance and incorporation into farming methods.

Conclusion:

Microorganisms that stimulate plant growth are a viable biocontrol strategy for plant diseases, providing environmentally acceptable and long-lasting substitutes for chemical pesticides. To fully realize their potential in agriculture, science and technology must address present issues and progress. In conclusion, strains of bacteria and fungi that promote plant growth have a variety of advantages when used as biocontrol agents to prevent the establishment of harmful microorganisms on plants. To maximize their application for integrated pest management methods and sustainable agriculture, more research and technology developments are needed.

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