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Plant Growth Promoting Rhizobacterial as Biocontrol Agent Against Soil Borne Diseases

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Summary

Soil-borne diseases are responsible for major crop losses worldwide. Diseases caused by plant pathogens adversely affect global crop productivity and account for 20-40 per cent yield losses annually in various cereal and legume crops. In India, 57,000 metric tonnes of synthetic pesticides were used during the 2016-17 to control the plant pathogens and insect pests, whereas the amount of biopesticide consumption was only 6340 metric tonnes. The development of resistance due to continuous use of pesticides in modern farming and increased availability of pesticide residues in vegetables, cereals and grains has generated many problems. Moreover, the unregulated and indiscriminate use of chemical pesticides causes pollution of soil, water and air along with decrease in the soil microflora and fauna. Huge amounts of money are being spent on application of synthetic pesticides to control soil borne diseases worldwide. Alternatives to the use of synthetic chemicals for disease control are increasingly being sought due to among other reasons, the detrimental effects of these compounds on the environment.

Solution to the Problem

Beneficial rhizosphere microorganisms could be exploited to provide sustainable solutions in reducing the application of pesticides for agricultural crop production. Biopesticides offer several advantages including complete biodegradability and water solubility over traditional chemical/ synthesised pesticides. Thus, microorganisms and plant-based biochemicals provide a safe alternative option for plant disease suppression in agriculture system.

Plant growth-promoting rhizobacteria (PGPR) are free-living bacteria able to colonize roots and soil around them that have a positive effect on plant growth, development, and health. One of the mechanisms by which PGPR exert a beneficial effect involves the capacity to control growth of deleterious organisms diminishing or preventing their negative effects on plant health and growth. Pathogen biocontrol implicates diverse features of bacteria; one of them is the antagonism that excludes pathogen due to the ability of some bacteria to colonize faster and more effectively a niche, reducing nutrient availability for the deleterious organism.

Also, some bacteria produce antibiotics, organic compounds that are lethal in low concentration for growth and metabolic activities of other microorganisms. Finally, the ability of bacteria to elicit a defence response in plant, called induced systemic resistance (IRS), involves the induction of synthesis of defence metabolites, but without causing a disease itself, enhancing the plant's defensive capacity. This chapter analysed and discussed PGPR as biocontrol agent and the possibility to use them as ecological alternative to the use of agrochemicals, since they have been proved in different plant species in order to diminish the damage of pathogen and to reduce losses in crops.

What are PGPRs?

We define PGPR as a group of free-living rhizospheres occupying bacteria that enhances plant growth and can also be classified as biocontrol agents, biofertilizers, or biopesticides, depending on their activities/abilities. PGPR as biocontrol agents have certain advantages over conventional chemical control compounds. Firstly, PGPR are beneficial, naturally occurring microorganisms, which are environmentally friendly and nontoxic. Secondly, from an ecological perspective, their application is sustainable (long term). Another advantage of PGPR is the fact that they possess a diverse range of modes of action including antibiosis, production of siderophores, cell wall degrading enzymes, bio-surfactants and volatiles, and also induces systemic resistance in plants. The fact that some PGPR by definition directly enhances the growth of plants is an additional advantage. PGPR as biocontrol agents have certain advantages over conventional chemical control compounds.

Advantages of PGPRs

1. Firstly, PGPR are beneficial, naturally occurring microorganisms, which are environmentally friendly and nontoxic. Secondly, from an ecological perspective, their application is sustainable (long term).

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3. The fact that some PGPR by definition directly enhances the growth of plants is an additional advantage. PGPR as biocontrol agents have certain advantages over conventional chemical control compounds.

Mechanisms Involved in Disease Control

1. Root colonization: The pathogens are known to enter in the plant system through their roots, but when PGPRs colonize the roots, they do not allow the pathogens to enter in the system and thus protect the plant from the harmful effect of pathogens.

2. Competition: The PGPRs also compete with pathogenic for nutrition and water supply available in soil and due to the abundance PGPR get selective advantage which reduce the population of pathogens and hence the chance of infection to plants is also reduced. Some PGPRs secrete siderophores, which is a good chelator of iron. These siderophores reduces the availability of iron, which is crucial factor for the growth of pathogens, and hence controls the growth of such pathogens.

3. Suppression through the production of secondary metabolites: The plant growth promoting microorganisms also secrete certain secondary metabolites (such as antibiotics), which act as toxic agent for the pathogens. The secondary metabolite kills or reduces the population of pathogenic elements. Some PGPRs also secrete cell wall degrading enzymes (chitinase, cellulose, protease etc.) which kill the pathogen through their cell wall disintegration.

4. Induced systemic resistance or systemic acquire resistance: Induced systemic resistance (ISR) is the state of defensive capacity developed by the plant when stimulated by diverse agents including rhizobacteria. Once resistance is induced in plants, it will result in nonspecific protection against pathogenic fungi, bacteria, and viruses. PGPR elicit ISR in plants by increasing the physical and mechanical strength of the cell wall as well as changing the physiological and biochemical reactions of the host. This results in the synthesis of defense chemicals such as chitinase, peroxidase, and pathogenesis-related protein.

Example of Some Common Biocontrol Agents are

1. *Pseudomonas fluorescence*
2. *Acenetobacter*
3. *Staphylococcus*
4. *Bacillus*
5. *Enterobacter*
6. *B. subtilis*
7. *B cereus*
8. *Pseudomonas chlororaphis*
9. *Bacillus stearothermophilus*
10. *B. licheniformis*
11. *B. circulans,*
12. *Chromobacterium violaceum*
13. *Brevibacterium laterosporus*
14. *Serratia marcescens*
15. *P. frederiksbergensis* 202

The Outcome (i.e., Success) of a Biocontrol Agent (BCA) Treatment Depends on the Following

1. The method of inoculation/application.
2. The physiological state of the BCA.
3. The concentration and dosage of the BCA.
4. The presence or absence of nutrients.
5. The presence or absence of adjuvants such as adhering or protective agents.
6. The media used for BCA production.
7. The volume of treatment.
8. The plant type and cultivar. Both plant and cultivar specificity has been observed for some BCAs.

Conclusion

In conclusion, as there are numerous examples of effective biocontrol candidates, the future challenge is not to prove that biocontrol is possible, but to improve efficacy and durability of biocontrol in the field. This will only be achieved through a better understanding of the biocontrol mechanisms, plant–microbe interactions and processes as well as microbial ecology in the soil and rhizosphere. The necessary molecular tools for studying these processes and interactions are already Plant Growth Promoting Rhizobacteria as Biocontrol Agents 225available. If this is achieved, the efficacy of biocontrol could conceivably be improved through application of this knowledge to develop improved screening protocols, formulation, and application procedures as well as new innovative integrated disease management practices.