# MICROBIOLOGY COURSE MATERIAL
## Semester - V

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**DSE-A1: UNIT 1: PART B: PLANT GROWTH PROMOTING RHIZOBACTERIA**

# B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
# SEMESTER – V
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# PLANT GROWTH PROMOTING RHIZOBACTERIA

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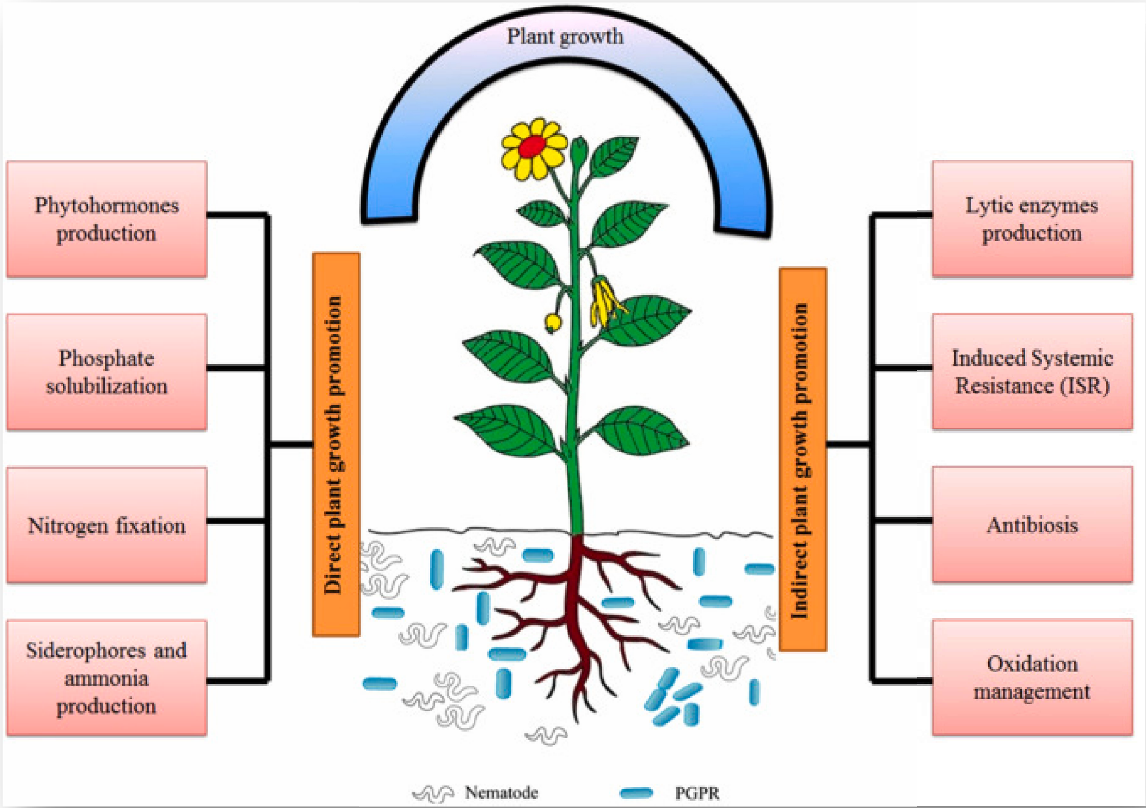
## ❖ PGPR

Plant Growth Promoting Rhizobacteria (PGPR) is a group of bacteria that enhances plant growth and yield via various plant growth promoting substances as well as biofertilizers. Given the negative environmental impact of artificial fertilizers and their increasing costs, the use of beneficial soil microorganisms such as PGPR for sustainable and safe agriculture has increased globally during the last couple of decades. PGPR as biofertilizers are well recognized as efficient soil microbes for sustainable agriculture and holds great promise in the improvement of agricultural yields.

Agriculture contributes to a major share of national income and export earnings in many developing countries, while ensuring food security and employment. Sustainable agriculture is vitally important in today's world because it offers the potential to meet our future agricultural needs, something that conventional agriculture will not be able to do. Recently there has been a great interest in eco-friendly and sustainable agriculture. PGPR are known to improve plant growth in many ways when compared to synthetic fertilizers, insecticides and pesticides. They enhance crop growth and can help in sustainability of safe environment and crop productivity. The rhizospheric soil contains diverse types of PGPR communities, which exhibit beneficial effects on crop productivity. Several research investigations are conducted on the understanding of the diversity, dynamics and importance of soil PGPR communities and their beneficial and cooperative roles in agricultural productivity. Some common examples of PGPR genera exhibiting plant growth promoting activity are *Pseudomonas, Azospirillum, Azotobacter, Bacillus, Burkholdaria, Enterobacter, Rhizobium, Erwinia, Mycobacterium, Mesorhizobium, Flavobacterium,* etc.




## ❖ PGPR as Biofertilizers

Free-living PGPR have shown promise as biofertilizers. Many studies and reviews have reported plant growth promotion, increased yield, solubilization of P (phosphorus) or K (potassium), uptake of N (nitrogen) and some other elements through inoculation with PGPR. In addition, studies have shown that inoculation with PGPR enhances root growth, leading to a root system with large surface area and increased number of root hairs. A huge amount of artificial fertilizers are used to replenish soil N and P, resulting in high costs and increased environmental pollution.

Most of P in insoluble compounds is unavailable to plants. $N_2$-fixing and P-solubilizing bacteria may be important for plant nutrition by increasing N and P uptake by the crop plants, and playing a crucial role in biofertilization. $N_2$-fixation and P-solubilization, production of antibiotics, and other plant growth promoting substances are the principal contribution of the PGPR in the agro-ecosystems. More recent research findings indicate that the treatment of agricultural soils with PGPR inoculation significantly increases agronomic yields as compared to uninoculated soils. Several mechanisms of Plant Growth Promotion by PGPR have been suggested by which can promote plant growth; some important ones are as follows (Table 1):

**Table 1: PGPR and their effect on growth parameters/ yields of crop/fruit plants**

| PGPR | Crop parameters |
|---|---|
| *Rhizobiumleguminosarum* | Direct growth promotion of canola and lettuce |
| *Pseudomonas putida* | Early developments of canola seedlings, growth stimulation of tomato plant |
| *Azospirillum brasilense* and *A. irakense* | Growth of wheat and maize plants |
| *P. flurescens* | Growth of pearl millet, increase in growth, leaf nutrient contents and yield of banana (*Musa*) |
| *Azotobacter* and *Azospirillum* spp. | Growth and productivity of canola |
| *P. alcaligenes*, *Bacillus polymyxa*, and *Mycobacterium phlei* | Enhances uptake of N, P and K by maize crop |
| *Pseudomonas*, *Azotobacter* and *Azospirillum* spp. | Stimulates growth and yield of chick pea (*Cicer arietinum*) |
| *R. leguminismarum* and *Pseudomonas* spp. | Improves the yield and phosphorus uptake in wheat |
| *P. putida*, *P. flurescens*, *A. brasilense* and *A. lipoferum* | Improves seed germination, seedling growth and yield of maize |
| *P. putida*, *P. fluorescens*, *P. fluorescens*, | Improves seed germination, growth parameters of |
| *P. putida*, *A. lipoferum*, *A. brasilense* | maize seedling in greenhouse and also grain yield of field grown maize |

**Plant Growth Promoting Rhizobacteria (PGPR):** PGPR (rhizo-biofertilizers) are a group of bacteria that actively colonize plant roots and enhance plant growth and yield.

**Biofertilizer:** Composition of living microorganisms which, when applied to surface of plant, seed, or soil, colonize the plant rhizosphere or inside the plant body (as endophyte) and promotes plant growth through enhancing the supply or availability of fundamental nutrients to crop plants.

**Sustainable Agriculture:** Sustainable agriculture involves the successful management of agricultural resources to satisfy human needs while maintaining or enhancing environmental quality without exploiting the natural resources of future generations.

## ❖ Phytohormone Production

The enhancement in various agronomic yields due to PGPR has been reported because of the production of growth stimulating phytohormones (Table 2) such as indole-3-acetic acid (IAA), gibberellic acid (GA3), zeatin, ethylene and abscisic acid (ABA).

**Table 2:** Examples of different phytohormone producing PGPR

| Phytohormones | PGPR |
|---|---|
| **Indole-3-acetic acid (IAA)** | *Acetobacter diazotrophicus* and *Herbaspirillum seropedicae* |
| **Zeatin and Ethylene** | *Azospirillum sp.* |
| **Gibberellic acid ($GA_3$)** | *Azospirillum lipoferum* |
| **Abscisic acid (ABA)** | *Azospirillum brasilense* |

Recent studies confirm that the treatment of seeds or cuttings with non-pathogenic bacteria, such as *Agrobacterium, Bacillus, Streptomyces, Pseudomonas, Alcaligenes,* etc. induce root formation in some plants because of natural plant growth promoting substances produced by the bacteria. Although the mechanisms are not completely understood, root induction by PGPR is the accepted result of phytohormones such as auxins, growth inhibiting ethylene and mineralization. Environment friendly applications in agriculture have gained more importance particularly in horticulture and nursery production. The use of PGPR for nursery material multiplication may be important for obtaining organic nursery material because the use of all formulations of synthetic plant growth regulators, such as indole-3-butyric acid (IBA), is prohibited in organic agriculture throughout the world.

## ❖ Phosphate Solubilization

*Rhizobium* and phosphorus (P) solubilizing bacteria are important to plant nutrition. These microbes also play a significant role as PGPR in the biofertilization of crops. These bacteria secrete different types of organic acids (e.g., carboxylic acid) thus lowering the pH in the rhizosphere and consequently release the bound forms of phosphate like $Ca_3(PO4)_2$ in the calcareous soils. Utilization of these microorganisms as environment friendly biofertilizer helps to reduce the use of expensive phosphatic fertilizers. Phosphorus biofertilizers could help increase the availability of accumulated phosphate (by solubilization), increase the efficiency of biological nitrogen fixation and render availability of Fe, Zn, etc., through production of plant growth promoting substances.

## ❖ Siderophore Production

PGPR are reported to secrete some extracellular metabolites called siderophores. Siderophores are commonly referred to as microbial Fe-chelating low molecular weight compounds. The presence of siderophore producing PGPR in rhizosphere increases the rate of $Fe^{3+}$ supply to plants and therefore enhances the plant growth and productivity of crop. Further, this compound after chelating $Fe^{3+}$ makes the soil $Fe^{3+}$ deficient for other soil microbes and consequently inhibits the activity of competitive microbes.

### ❖ PGPR as Biocontrol:

Agents PGPR produce substances that also protect them against various diseases. PGPR may protect plants against pathogens by direct antagonistic interactions between the biocontrol agent and the pathogen, as well as by induction of host resistance. In recent years, the role of siderophore producing PGPR in biocontrol of soil borne plant pathogens has created great interest. Microbiologists have developed techniques for introduction of siderophore producing PGPR in soil system through seed, soil or root system. PGPR that indirectly enhance plant growth via suppression of phytopathogens do so by a variety of mechanisms. These include:

- The ability to produce siderophores (as discussed above) that chelate iron, making it unavailable to pathogens.

- The capacity to synthesize anti-fungal metabolites such as antibiotics, fungal cell wall-lysing enzymes, or hydrogen cyanide, which suppress the growth of fungal pathogens.

- The ability to successfully compete with pathogens for nutrients or specific niches on the root and the ability to induce systemic resistance.

Among the various PGPRs identified, *Pseudomonas fluorescens* is one of the most extensively studied rhizobacteria because of its antagonistic action against several plant pathogens. Banana Bunchy Top Virus (BBTV) is one of the deadly viruses which severely affect the yield of banana (*Musa spp.*) crop in Western Ghats, Tamil Nadu, India. It has been demonstrated that application of *P. fluorescens* strain significantly reduced the BBTV incidence in hill banana under greenhouse and field conditions. Different PGPR species as biocontrol agents against various plant diseases are given in Table 3.

**Table 3: PGPR as biocontrol agents against various plant diseases**

| PGPR | Disease resistance |
|---|---|
| *Bacillus pumilus, Kluyvera cryocrescens, B. amyloliquefaciens* and *B. subtilus* | Cucumber Mosaic Cucumovirus (CMV) of tomato (*Lycopersicon esculentum*) |
| *B. amyloliquefaciens, B. subtilis* and *B. pumilus* | Tomato Mottle Virus |
| *B. pumilus* | Bacterial wilt disease in cucumber (*Cucumis sativus*), Blue mold disease of tobacco (*Nicotiana*) |
| *Pseudomonasfluorescens* | Sheath blight disease and leaf folder insect in rice (*Oryza sativa*), Reduce the Banana Bunchy Top Virus (BBTV) incidence, Saline resistance in groundnut (*Arachis hypogea*) |
| *B . subtilis and B. pumilus* | Downy mildew in pearl millet (*Pennisetum glaucum*) |
| *B. subtilis* | CMV in cucumber |
| *B. cereus* | Foliar diseases of tomato |
| *Bacillus* spp. | Blight of bell pepper (*Capsicum annuum*), Blight of squash |
| *Burkholderia* | Maize (*Zea mays*) rot |
| *B. subtilis* | Soil borne pathogen of cucumber and pepper (*Piper)* |
| *Bacillus* sp. and *Azospirillum* | Rice blast |
| Fluorescent *Pseudomonas* spp. | Rice sheath rot (*Sarocladium oryzae*) |

## ❖ PGPR as Biological Fungicides

*Bacillus subtilis*, *Pseudomonas chlororaphis*, endophytic *P. fluorescens* inhibit the growth of stem blight pathogen *Corynespora casiicola*. The seed treatment and soil application of *P. fluorescens* reduce root rot of black gram caused by *Macrophomina phaseolina*. Seed and foliar application of *P. fluorescens* reduce sheath blight of rice. *B. subtilis* in peat supplemented with chitin or chitin-containing materials show better control of *Aspergillus niger* and *Fusarium udum* in groundnut and pigeon pea, respectively. Strains of *Burkholderia cepacia* have been shown to have biocontrol of *Fusarium* spp.

## ❖ Conclusion

Worldwide, considerable progress has been achieved in the area of PGPR biofertilizer technology. It has been also demonstrated and proved that PGPR can be very effective and are potential microbes for enriching the soil fertility and enhancing the agriculture yield. PGPR are excellent model systems which can provide the biotechnologist with novel genetic constituents and bioactive chemicals having diverse uses in agriculture and environmental sustainability. Current and future progress in our understanding of PGPR diversity, colonization ability, mechanisms of action, formulation, and application could facilitate their development as reliable components in the management of sustainable agricultural systems.