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### An Introduction to Plant Growth Promoting Rhizobacteria, Antifungal Metabolites Biosynthesis using PRPR with reference to Pseudomonas species and It's other characteristics like Antagonistic and Biocontrolling properties

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#### Abstract

Plant Growth Promoting Rhizobacteria (PRGR) are the rhizosphere bacteria that help in the enhancement of plant growth by a variety of mechanisms like phosphate solubilization, siderophore production, biological nitrogen fixation, rhizosphere engineering, production of 1-Aminocyclopropane - 1-carboxylate deaminase (ACC), quorum sensing(QS) signal interference and inhibition of biofilm formation phytohormone production, exhibiting antifungal activity, production of volatile organic compounds (VOCs), induction of systematic resistance, promoting beneficial plant microbe symbiosis, interference with pathogen toxin production etc. It is generally free living, soil borne bacteria. The potentiality of PGPR is continuously increasing as it offers us a good way to replace the chemical fertilizers, pesticides as well as directly or indirectly influence the whole morphology of the plants and play a vital role in crop protection, growth promotion and in the improvement of soil health. Some well known PGPR Strains are Pseudomonas, Bacillus, Azospirillum, Rhizobium and Serratia species. Different strains of PGPR are capable of secreting antifungal metabolites (AFM) like siderophore, chitinase and hydrogen cyanide. For example Pseudomonas fluorescens belonging to PGPR class produce siderophore and control Phythium ultimum and Pseudomonas stutzeri produce chitinase which lyse the cell wall of Fusarium solani. Antifungal metabolites produced by these Rhizobacteria were identified as antibiotics ( iturin, surfactins, fengycin, DAPG, Phenazine etc, ), cell wall degrading enzymes( proteases, chitinases, cellulases), plant growth promoting enzymes and hormones (indole-3-Acetic Acid, ACC-deaminase, phosphatase, nitrogen fixation), N-acylhomoderine lactones and siderophore. Due to synthesis of antifungal metabolites PGPR also used as a biocontrol agent in case of many diseases for instance, it degrades fusaric acid produced by Fusarium sp. That is a causative agent of wilt. They also help plants to be resistant against biotic stresses via direct antagonism to pathogens or by induction of systematic resistance to pathogens. It mostly trigger induced systematic resistance via methyl jasmonate and methyl salicylate in plants.

**Keywords:** PGPR, WILT disease,, Antifungal metabolites, Pseudomonas species

#### 1. Introduction

Growth of plants is highly regulated by both

biological and non-biological entities and is strongly dependent on the usage of the chemical

pesticides, weedicides, fertilizers causing numerous side effects like environmental pollution, health issues, intrusions to the biotic entities which favours crop production. To achieve the process of production of crops increasingly we have to equalize and manage the diseases that are caused due to these chemicals and can be achieved by the use of biological resources like bio-manures. Undoubtedly, PGPR fits here with its higher novelty and is highly influenceable and impactable.

### 1.1 Rhizopore

Tapered belt of soil covering the roots where the stimulation of microbe inhabitants (like algae, fungi, protozoa and bacteria's) is done by the activities triggered by the roots involving physical, biological and chemical characterizations. The presence of bacteria sways the physiology of plants manifestly. Along with their competitiveness in the root colonization, PGPR are considered as free living bacteria's that are soil borne which are considered as a growth promoting bacteria's as they produce growth hormones like cytokines, Auxins, gibberellins. They are helpful in the process of nitrogen fixation, solubilizes the minerals i.e., phosphorous as it produces siderophore which is helpful in the solubilization and sequestering of iron as it produces various growth regulators. Some of the soil borne bacteria's act as biomes which improve the growth restricted conditions by the production of antagonistic substances or by implementing the resistance to the host towards the pathogenic plants. PGPR penetrates directly inside to the root surfaces. The communities of Rhizopore bacteria have well organized systematic structures for the metabolism of organic compounds that are present in the root exudates.

### 1.2 Effects of PGPR

PGPR is strongly effective on the health of plants and the productivity as it smoothly used on the place of chemical fertilizers, weedicides, pesticides and other chemical supplements as it lessens the agro based chemicals uses and promotes the role of biofertilizers.

The associations of PGPR ranges from the bacterial proximity degree to the roots and it intimate an association whose separation is done via extracellular (on the rhizoplane) and intracellular PGPRs (inside the cells of roots with a specialization in their nodular structures).

PGPR and control to Diseases:

Strains of PGPR like Bacillus, Acetobacter, Azospirillum, Rhizobium and most commonly species of Serratia and Pseudomonas species plays a crucial role in plants by protecting the crops, promoting the plant growth and improved quality of soil which includes the biosynthesis of antibiotics which majorly 3 cins in their prefixes i.e. Panto, zwittermy-A, oomy and most commonly phenazine-1-carboxylic acid. They are responsible for the biosynthesis of antibiotics and are highly conservative in nature. They directly show their anti pathogenecity effects and act as determinants as the triggers induces resistance which is systematic in nature of the plant body system. Due to production of these antibiotics they serves as a contributor to the management of diseases. [1-6]

### 1.3 Potent ability of PGPR with regards to species of Pseudomonas and B. subtilis:

In the agricultural soil the growth of plants is highly influenceable by the two type of stresses i.e. biotic as well as abiotic ones. Pseudomonades have varying characteristic features like it is a gram negative species, ubiquitous and aerobic in nature. It possess Rhizobacteria due to its rapidly growing characteristic it can be produced on a mass scale in a large quantity and gave us a broadcast production of metabolites that are bioactive in nature majorly the antibiotics. PGPR are somehow live in a non- symbiosis association and due to their free living characteristic they have an influencing capacity towards the growth hormone indole acetic acid.

### 1.4 Antifungal Activities of PGPR:

PGPR contains phytopathogenic bacteria's who isolation has been taken place from the crops of potato, wheat, rice, sunflower and soybean whose analysis has been done via LCMS which are identified as antibiotics i.e. DAPG, fengycin etc. They have enzymes like chitinase, cellulases and proteases for the degradation of cell wall. They also have the growth hormones for the growth of experimental plants they must have validation potential towards agents of both biopesticides and biofertilizers.

*P. fluorescens* Pf-5 is helpful in the protection of cucumber from premerging damping off which is caused by *Phythium ultimum* and produces a vast spectral number antifungal metabolites in the

culture media which involves fluorescent siderophore i.e., cyanide, pyoluteroin, pyrrolnitrin as well as an uncategorizable compound called as antibiotic 3. [7-10]

## **2 PGPRs boon for improving the production of crops:**

There are some crops that are highly adapted towards high saline conditions and mostly present near to lakes that are hyper saline due to this they are hypersaline and hypertolerant in nature as they are halophilic or salt loving in nature.

Antagonistic and biocontrolling feature of PGPR:

PGPR have an ability to form a bulk of the rooting in plants and promoted growth of plant. They PGPR, their occurrence has been take place to pathogens that are soil borne through the passage of antagonistic effects via antibiotics and siderophore. They induces systemic resistance which is helpful in the resemblance of Pathogen Induced Systematic Acquired Resistance. Species of *Pseudomonas* and *Bacillus* are best known and most predominant ones for the triggering of Induced Systematic Resistance and is helpful in the formulation of new inoculants with their different actions and mechanisms they have more efficacy towards the strategies that play their major role in bio control for the improvement in systems of cropping.

Classification of PAB i.e. it must be deleterious, have neutral groups based on the growth of plants and it must be beneficial free living soil bacteria which must be independent for the promotion of vegetatal growth of the plants most probably for the roots.

The effect of PGPR is done via both in direct and indirect ways to the parts of the plants.

The direct means of influencing is done via the supplementation of phytohormones, or it is done via facilitating them certain micro and macro nutrients for the growth from the environment. It includes Nitrogen fixation, Phosphate solubilization, Potassium Solubilization, siderophore production and Phytohormone production.

The indirect means of promoting growth of plants occurs when there is a minimization or prevention of PGPR take place deleteriously by the organisms that are phytopathogenic in nature. It involves Antibiotics Production, Hydrolytic enzyme production, Siderophore production, Induced

Systematic resistance and Exo polysaccharides Production.

As this happens due to the production of substances that have antagonistic properties as they have induced resistance towards the pathogens. Not only these two ways, PGPR affects the promotion of plant growth via other factorial mechanisms also and also plays a major role in bring the best out of the sustainable agriculture crops that includes potatoes, canola, peas, Wheat, Barley and Maize for commercial purposes. [11-15]

### **2.1 Microbial Antagonicity:**

There is a reduction in severd diseases of plants due to those agents that are bio controllable in nature as they have antagonistic property and those who exert these properties are known as antagonists as they are the agents for physiological antagonism.

Antagonists have the property for the biosynthesis of enzymes like glucanases and many more as they are hydrolytic in nature and lyses fungal cells that are pathogenic in nature.

### **Antagonistic Activities of the following three mechanisms**

Siderophores as they are chelating compounds for iron, Bacteriocins, and the Antibiotic Production:

#### **Mechanism of Siderophores:**

Siderophores, the chelating compounds for iron and for the satisfaction and fulfillment of micro and macro nutritional requirements, there is an involvement of microorganisms in that pathways that are highly specific in nature as the employed lower molecular weight chelators for iron and hence termed as Siderophores. They are the secretions which is helpful in the solubilization of iron from the neighbouring environmental conditions, and finally forms a ferric siderophore complex whose movement take place via the process diffusion and its returning to the surface of cell. It also moves via the Active Transport System i.e., the membrane whose beginning take place by the ferric siderophore recognition with the help of receptors that are specific to membrane of both the bacteria's (Gram positive and Gram negative). They act as a chelating agents with a high affinity to the ferric ions, and allows their solubilization and extraction from the complexes as they are the minor molecules of peptides possessing functional groups and the side chains

that are helpful in providing them a set of ligands with high affinity for the coordination of ferric ions.

Carboxylates, pyoverdine, catecholates and hydroxamates are the four major classifications of Siderophores on the basis of their coordination towards the iron functional groups, types of ligands and the structural features.

Siderophore activity of production tremendously plays a role in the determination of the capability of improving development of plants for different microorganisms. The Siderophores that are microbial in nature are helpful in the enhancement of iron uptake of iron via the plants which are capable for the recognition of complex which is a combo of bacteria and the ferric siderophore as they also uptake iron in the presence of other metallic compounds like cadmium as well as nickel.

#### **Advantages:**

- Helpful in the colonization of roots
- Helpful in the excludation of microorganism that are outside from the ecological cranny.
- Helpful in the determination of outcomes of competition that is done for the different carbon sources that are the outcomes of excudation of roots. This all is a result of capability of acquired iron via siderophores.
- Pseudomonas species especially Pseudomonas fluorescents have high afficacy towards the ferric ions.

### **3. Molecules that act as a Defensive System towards Microbes- Bacteriocins**

They are known for killing microorganisms on a narrow scale means they only show toxicity towards those bacterial species that produces the strains that are closely related towards them. There is always a recombination carried out between the prior existing bacteriocins and the isolated one bacteriocins and are the important ones as the provide a broad spectra for inhibition of the pathogenic creatures. The protein colicins, which is obtained by the staining of E.coli are the widely represented bacteriocins molecule of that bacteria which is gram negative in nature. Same for the molecule pyogenes as it is derived from the strains of P.pyogenes etc.

### **3.1 The capability of Plant Growth Promoting Rhizobacteria having Antagonistic Activity - Antibiotics:**

Act against phytopathogenic microorganisms. They are antibiosis in nature whose activity of biocontrolling is based on those molecules secretion which are helpful in directly killing or reducing the growth of the targeted pathogen.

#### **3.2 Characteristics of Antibiotics:**

Heterogeneous in nature as made up of different types of compounds

Have low molecular weight

Example of Antibiotics that are helpful in the biocontrolling of diseases in roots:

- ❖ Pyrrolnitrin- P.fluoresens
- ❖ Phenazines- Pseudomonads
- ❖ Phloroglucinols
- ❖ Pyoluteorin
- ❖ Polymyxin-Bacillus ssp.
- Lipopeptides Biosurfactant have its major implications in biocontrolling due to its positive potentiabile effect on the interactions that are competitive in nature with the organisms although it also includes plants, nematodes as well as fungi and bacteria.
- The isolated antibiotics diverse in their mechanism of actions of inhibiting the synthesis of pathogenic cell walls as their isolation has been done from different strains of bacteria and fungi.
- They have high influence on the structures of cell membranes and it inhibits the forming of initiation complexes on the smaller subunits of ribosome.

### **3.3 Agents used to Biocontrol are- Induced Systematic Resistance and Systematic Acquired Resistance**

Induced Systematic Resistance as the name suggests to induce or to suppress.

These biocontrol agents the Rhizobacteria that are non-pathogenic in nature with a capability of suppressing a disease by the induction of a resistant mechanism inside the plants.

It is also defined as enhanced defensive capability which is developed by the plants when their stimulation is appropriate. It was first described in the caranation plants whose protection is done systematically by the strain of Pseudomonas

fluorescens.

### 3.4 Systematic Acquired Resistance

It is called as a resistance to a whole plant whose responses occurs after an earlier exposure to a pathogen. It is somehow analogous to innate immune system as found in animals. It uses receptors that are patterns recognized for the recognition of microbial signatures that are conserved in nature. It is helpful in the triggering of immune response which recognizes variable number of pathogenic effectors.

### 4. Future Aspects :

From this review paper we can conclude that Plant Growth Promoting Rhizobacteria have a bright and promising future towards the sustainable agriculture which will lead to improved and increased production of crops for ones better health and as well as for the development of the their use towards the agricultural industry. As it uses growth hormones so we can imagine that using these hormones there is a reduction in the time for the growth and ripening of crops and this leads them towards and increased status at commercialization level for the nation as well as for other nations or we can say that it will reach at the peak of its development at commercial scale globally.

### Conclusion:

From this review paper we can conclude that PGPR have numerous effects on the crops production that using PGPR increases the yield and productivity of crops , growth of plants with a balanced nutrient content that is supplied to them in both direct and indirect ways, reduces the adverse effects of hyposalinity, stresses that are caused due to osmotic pressure, production of phytohormone for the development of sustainable agriculture, production of siderophores and most importantly they have a potentiability to act as antagonistic and biocontrol agents

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