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Plant Growth Promoting Rhizobacteria (PGPR): A Review

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A B S T R A C T

The growth of plant is reaction between interplay of roots and shoots with the environment. Planting media i.e. soil supply support to plants and growth to microorganisms. The interactions between roots and microbes is beneficial and if enhanced then results in increased plant growth and yield. Plant growth promoting rhizobacteria are certain aggressive root colonizing bacteria that benefits plants. They also play an important role in multiple functioning like increase supply of nutrients, produce plant hormone, boost other beneficial bacteria, control pathogenic disease and insect pest. This review highlights the features of growth promotion by PGPR.

Introduction

PGPR is sustainable way of promoting growth and sideways protecting it also. Rhizosphere is a soil layer which is surrounding plant roots, and is a dynamic environment of acute microorganisms interactions stimulated by root activity. A pool of microbes such as fungi, bacteria, protozoa, algae exist side by side but bacteria is amongst most abundant ones, they influence physiology of plant the most mainly considering competition in roots for colonization. The preference of plant for bacteria is only which puts up the strength and health of plant by releasing exudates of organic compound producing a particular environment where diversity is low. Rhizobacteria habits in plant root and the way they interact with roots produces a positive effect not only as biofertilizers but also as biopesticide in both direct and indirect mechanisms.

Direct Mechanism

Nitrogen Fixation

Nitrogen element can't be consumed by plants as such from atmosphere.BNF (Biological Nitrogen Fixation) are the N- fixing bacteria which makes nitrogen usable for plants from nitrogen to ammonia, by a complex enzyme

system and this process is called as nitrogenase. PGPR have ability to do this by 2 mechanisms which are – symbiotic and non symbiotic.

Symbiotic N-fixing is a process of relationship between microorganism and plant of mutualism, plant give habitat which is colonization in root where they end up fixing N for plants. Example – *Rhizobium.*

Non-Symbiotic N-fixing is carried out by free living microbes or Diazotrophs. Examples – *Azotobacter*. Drawback this process faces is the availability of carbon and other energy sources for energy exhausted in N-fixation process. This can be compensated by moving near to diazotroph present on rhizosphere like *rhizobia* and *Frankia* (in symbiosis). This N-fixing not only influence the biomass production and yield but also is an indirect approach to disease management because the gene involved in N-fixing is nif gene consist structural gene which is further involved in activation of Fe Protein, electron donation, regulatory gene required for synthesis of enzyme.

Phosphate Solubilization

Phosphate is in insoluble, immobilized and precipitated form with cations (because of reactivity) and is vital on the nutrient of plant because plays main key in the metabolic process ex photosynthesis, respiration, energy transfer, etc. The only for in which plants can absorb phosphate is monobasic (H_2PO_3) and Dibasic (HPO_4^{2-}) ions. PGPR uses multiple strategy for solubilization. The mechanisms are by releasing – i) of mineral dissolving or complexing compounds which are organic acids anions, protons, CO_2. ii)of extracellular enzymes i.e biochemical phosphate mineralization and iii) biological phosphate mineralization i.e. phosphate during substrate degradation. Also, some PGPR Solubilize through acidification, chelation, or enzymatically.

Ex -*Bacillus*, Gluconacetobacter diazotrophicus used in sugarcane and uses the property of acidification.

Potassium Solubilization

Potassium exists in soil as silicate mineral and insoluble rock. PGPR solubilize potassium rock by secretion of organic acids. Ex- *Pseudomonas* and *Bacillus*.

Siderophores

Sequestration of Fe (Iron) Is done by production of siderophores. Iron is present in the form of ferric ion which is meagerly soluble. Because of this Fe-limiting condition, PGPR builds low-molecular weight compounds to scavenge ferric ion that is later taken up by mechanism of active transport. Siderophores are small, highly reactive ion chelating compounds and strongest binders.

Phytohormone Production

Hormones are the organic chemical messengers that is responsible for the ability of plant reacting/responding to environment. They interact only with particular target tissue for the response and are synthesized only in one part and further transported to required location. Major groups of these hormones are auxins, gibberellins, ethylene, cytokinin and abscisic acid.

IAA (indole-3-acetic-acid)

IAA (indole-3-acetic-acid) is auxin, has role in cellular response and works as signal molecule. It influences in processes like division & expansion of cell, expression of gene, formation of pigment, seed germination, development of root, photosynthesis and

resistance from stress of plant. Root formation and lengthening are also effected by IAA. The amount of nutrients released by root and released excreta from roots influence sideways the increased production of biomass of PGPR and nodulation in rhizosphere.

Ethylene Production

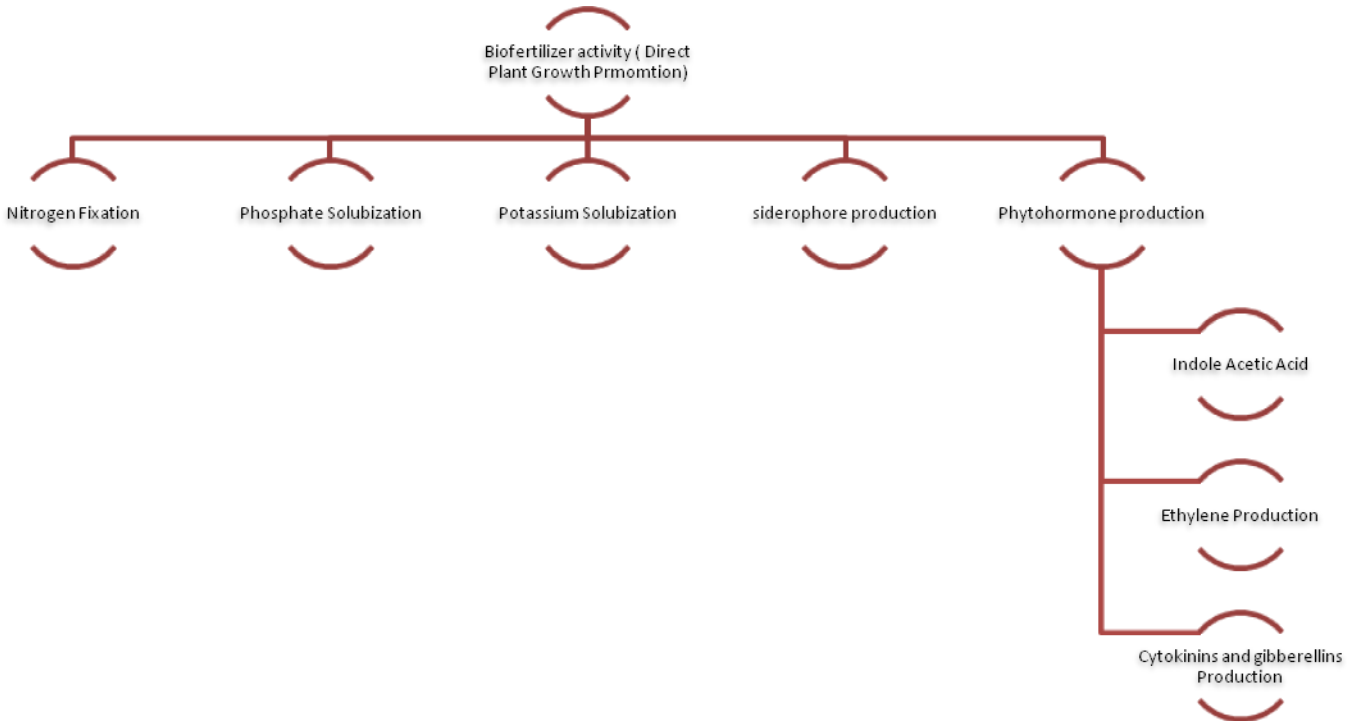
Ethylene Production leads to fruit ripening, inhibiting long root elongation, promoting over toot growth, activating other phytohormones. The high concentration of ethylene can lead to reduced plant performance. This hormone can be synthesized even in biotic and abiotic stress conditions faced by plant.

Cytokinin and gibberellin production

Both the phytohormone are synthesized by same PGPR while their role are different. Cytokinin influences cell division, increased root growth and root surface area, while gibberellin functions in other plant growth area like flowering, germination, dormancy.

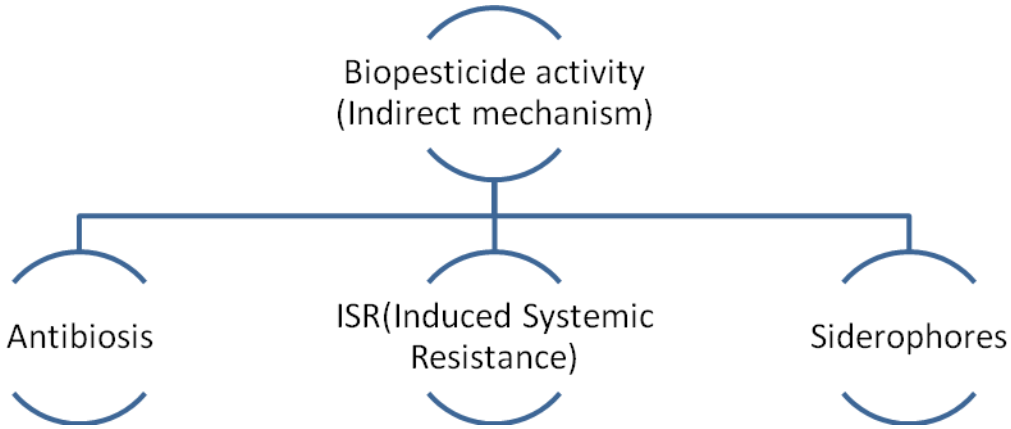
The PGPR producing either one or both phytohormone are *Azotobacter sp., Rhizobium sp., Bacillus subtilis*.

Fig.1



(Gupta *et al.*, J Microb Biochem Technol 2015)

Fig.2



(Gupta *et al.*, J Microb Biochem Technol 2015)

Indirect Mechanism

Antibiosis

It is a biocontrol mechanism to reduce the competition between microbes by releasing these antibiotics, weak organic acids or even lytic enzymes. It also is a tool against pathogen by developing resistance. The antibiotic and enzymes PGPR produces against phytopathogen are chitinase, cellulated, proteases and lipase which destroys the wall of the cell.

Not only this, PGPR has abilities apart from producing antibiotic is another volatile compound HCN hydrogen cyanide which is a biocontrol against many diseases like black root rot of tobacco (Sacherer P, Défago G, Haas D (1994)).

ISR

It is a response of defensive capacity against specific environment stimuli or phytopathogen.

Unlike SAR which needs triggering activation by infection of pathogen, in ISR the trigger is bacteria only that make the plant resistant and it starts from bottom which is root spreading to the top is shoots. This response is generic not pathogen specific.

Siderophores

It action comes under both category of biopesticide and biofertilizer. It is a biocontrol mechanism and has been reported that siderophore picks up other heavy metals from soil like arsenic and likewise prevents plant from toxicity of heavy metals and further can be used as bioremediation of metal toxicity as well (Zaidi A, Khan MS, Ahemad M, Oves M (2009)).

PGPR are diversified group of bacteria which is found in rhizosphere and are reported to enhance plant growth and health infleuncing directly or indirectly.

There is no exact mechaism explained around PGPR working. The results which are obtained in lab conditions can't be seen similar performing under field conditions but there are no disadvantages known till now.

This has the ability to understood and manage the rhizosphere and will definetaly lead to betterment only. Also being a environmental friendly, there is a scope of approaches rather than chemical and artificial ones.

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