Plant growth promoting Rhizobacteria (PGPR): as an eco-friendly agricultural practice

[Article ID: SIMM0318]

Baishnab Charan Muduli[1,2] and Rhea Samantaray[1,3]

[1]Ph.D. Research Scholar ICAR-National Rice Research Institute, Cuttack, Odisha, India
[2] Ph.D. Scholar Utkal University, PG Dept. Of Botany, Vani Vihar, BBSR
[3] Ph.D. Scholar Ravenshaw University, Cuttack

In the 21st century, global agricultural systems are facing other challenges, such as decreasing productivity and decreasing agricultural sustainability. World population growth has a negative impact on agriculture and food systems across the planet. Sustainable food production is becoming increasingly difficult. According to FAO (2009), the demand for food will increase by 70% by 2050 to meet the needs of the growing population. Sustainable agricultural practices are essential for people to meet the world's future food needs.

PGPRs, such as biofertilizers, plant stimulants, cleaners, and biopesticides, help plants use nutrients more efficiently and become healthier. They can change the way we view plant-microbe relationships and play a crucial role in ensuring agricultural sustainability by supporting agricultural activities.

What is plant growth promoting rhizobacteria

Rhizobia, root-associated microorganisms, can have harmful, adverse, or beneficial effects on plant growth. Originating from the Greek word "rhiza," they compete with microorganisms in the root zone, affecting plant growth in various ways.

Action of PGPR for plant growth:

In order to improve plant growth, PGPR work in two ways by direct mechanism and also indirect mechanism affecting their environment.

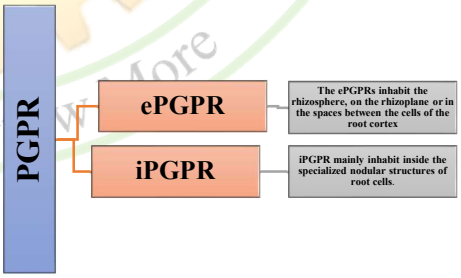
Table-1 Direct and indirect mechanism effects of PGPR on agricultural sustainability

PGPRs		
	Direct mechanism	Root colonization
		Nitrogen Fixation
		Phosphate solubilization
		Potassium Solubilization
		Phytohormone Production
	Indirect mechanism	Antibiotic production
		HCN
		Siderophore production
		Enzyme

1.Direct mechanism

Fixation, Mobilization and Uptake of Nutrients:

Nitrogen is crucial for plant growth and survival, making up the fourth most important component of plant dry matter.



PGPR, a plant growth promoter, uses dinitrogenase reductase to fix atmospheric nitrogen, converting N2 to NH3. Nitrogen can also be acquired by roots, contributing to crop nitrogen balance. The first large-scale experiment used N2-fixing bacteria to increase crop productivity.

Phosphate, potassium Solubilization, Phyto hormone production by PGPRs:

Phosphorus is crucial for plant growth and metabolism, and is abundant in soil in insoluble compounds. It is converted into a soluble form by PGPR. Potassium, found in minerals like microcline, muscovite, biotite, and feldspar, is essential for plant growth. At low concentrations, phytohormones, classified into auxins, cytokinin, gibberellins, abscisic acid, and ethylene, influence physiological processes and plant behaviour.

Table-2 Mechanism action of PGPRs strains

Mechanism Action	PGPRs Strains	References
Nitrogen Fixation	*Aneurinibacillus aneurinilyticus CKMV1, Burkholderia sp.*	Chauhan et al. (2017)
Phosphate Solubilization	*Pseudomonas fluorescence, Rhizospheric strain Arthrobacter, Bacillus, Beijerinckia,*	Ramyasmruthi et al. (2012)
Potassium Solubilization	*Acidothiobacillus sp., Bacillus edaphicus, Ferrooxidans sp., Bacillus mucilaginosus, Pseudomonas sp.,*	Liu et al. 2012
Phytohormone		
IAA	*Agrobacterium sp., Azotobacter spp., Pseudomonas denitrificans*	Barazani and Friedman, 1999,
Gibberellin	*Acetobacter, Azospirillum, Herbaspirillum, Bacillus, and Pseudomonas*	Maheshwari et al., 2015
Cytokinin	*Bacillus, Escherichia, Agrobacterium, Methylobacterium,* and *Klebsiell*	Maheshwari et al., 2015

2.Indirect Mechanism

Various mechanisms adopted by PGPR that indirectly supports plant growth promotion in agriculture development are table-3.

Table-3 Indirect mechanism actions of PGPRs

Mechanism Action	PGPRs Strains	References
Antibiotic Production	*Botrytis cinerea, Rhizoctonia solani,* and *Verticillium dahliae.*	Raaijmakers et al., 2002
Siderophore production	*Pseudomonas* sp.	Beneduzi et al., 2012
Volatile organic compound & Lytic acid production	B. subtilis GB03, B. amyloliquefaciens IN937a, and E. cloacae JM22 and *Fusarium oxysporium* and *R. solani*	Ryu et al., 2004

Roles of PGPR in Ecofriendly agriculture:

PGPR is beneficial for crop growth and yield, impacting legumes, cereals, non-cereals, and other ecologically important plant species. It has significant effects on various agricultural products, and its potential applications and benefits in improving plant performance are discussed.

Manufacturing effective biofertilizer:

Soil contains beneficial microorganisms called biofertilizers, which aid plants in obtaining nutrients and making the soil healthier. Three types of organisms are arbuscular mycorrhizal organisms (AMF), plant growth promoting rhizobacteria (PGPR), and nitrogen fixing rhizobia. Synthetic fertilizers, such as PGPR, are used to replenish soil nutrients, but they increase costs and environmental pollution. PGPR promotes sustainable agriculture by providing environmentally friendly chemical fertilizers and pesticides.

Biopesticides:

Plant pathogenic microorganisms are a major and chronic threat to sustainable agriculture and ecosystem stability. The regular use of chemical pesticides and fungicides creates environmental problems and even causes resistance to pathogens, necessitating the continuous development of new drugs (Fernando et al., 2006).

Table-4 Some PGPR species as biocontrol agents against various plant diseases

PGPRs	Disease	Reference
Bacillus species, Azospirillum	Rice blast	J.S. Singh.,2013
Pseudmonas fluorescens	Sheath blight disease and leaf folder insect in rice (Oryza sativa),	
Pseudomonas fluorescens	Banana bunchy top virus	Kavino et al., 2010

Bioremediatory:

PGPR enhances plant growth and removes pollutants from soil, particularly in polluted areas. Rhizobacteria like Pseudomonas aeruginosa and genetically modified Pseudomonas fluorescein can promote phytoremediation. However, more research is needed to remove large-scale pollutants like heavy metals from soil and water sources. PGPR can also be used as a bioremediation agent for synthesis of siderophores, phytohormones, enzymes, antibiotics, and nutrient fixation.

Stress management

Stress, a factor that inhibits plant development, is a significant constraint for sustainable agricultural production. PGPRs, such as Penicilliums polymyxa strains B2, B3, B4, Bacillus amyloliquefaciens strain HYD-B17, B. licheniformis strain HYTAPB18, B. thuringiensis strain HYDGRFB19, and R. B. strains B3, B3, 44, can help solve these problems by protecting plants from drought, salt, and heavy metal stress.

Conclusion:

Globalization has significantly impacted agricultural practices, necessitating adaptation to environmental degradation. PGPR, which uses natural materials like biofertilizers, biopesticides, plant hormones, and bioremediation, enhances plant growth and sustainability. Advances in technology have made it easier for businesses to sell natural fertilizers and pest control products, impacting human welfare and agriculture. Strengthening its capacity is crucial.

Reference

Barazani OZ, Friedman J. Is IAA the major root growth factor secreted from plant-growth-mediating bacteria? Journal of Chemical Ecology. 1999 Oct; 25:2397-406.

Belimov AA, Dietz KJ. Effect of associative bacteria on element composition of barley seedlings grown in solution culture at toxic cadmium concentrations. Microbiological research. 2000 Jan 1;155(2):113-21.

Beneduzi A, Ambrosini A, Passaglia LM. Plant growth-promoting rhizobacteria (PGPR): their potential as antagonists and biocontrol agents. Genetics and molecular biology. 2012; 35:1044-51.

Chauhan A, Guleria S, Balgir PP, Walia A, Mahajan R, Mehta P, Shirkot CK. Tricalcium phosphate solubilization

and nitrogen fixation by newly isolated Aneurinibacillus aneurinilyticus CKMV1 from rhizosphere of Valeriana jatamansi and its growth promotional effect. brazilian journal of microbiology. 2017 Apr; 48:294-304.

Kavino M, Harish S, Kumar N, Saravanakumar D, Samiyappan R. Effect of chitinolytic PGPR on growth, yield and physiological attributes of banana (Musa spp.) under field conditions. Applied Soil Ecology. 2010 Jun 1;45(2):71-7.

Liu D, Lian B, Dong H. Isolation of Paenibacillus sp. and assessment of its potential for enhancing mineral weathering. Geomicrobiology Journal. 2012 Jun 1;29(5):413-21.

Maheshwari DK, Dheeman S, Agarwal M. Phytohormone-producing PGPR for sustainable agriculture. Bacterial metabolites in sustainable agroecosystem. 2015:159-82.

Ramyasmruthi S, Pallavi O. Chitinolytic and secondary metabolite producing Pseudomonas fluorescens isolated from Solanaceae rhizosphere effective against broad spectrum fungal phytopathogens. Asian Journal of Plant Science & Research. 2011.

Ryu CM, Farag MA, Hu CH, Reddy MS, Kloepper JW, Paré PW. Bacterial volatiles induce systemic resistance in Arabidopsis. Plant physiology. 2004 Mar 1;134(3):1017-26

Singh JS. Plant growth promoting rhizobacteria: potential microbes for sustainable agriculture. Resonance. 2013 Mar;18(3):275-81.