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Research Article

PLANT GROWTH PROMOTING RHIZOBACTERIAFUNCTION IN COMBATING CLIMATIC VARIATIONS FOR THE MAINTENANCE OF CROPS GROWTH

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ABSTRACT

Plant growth promoting rhizobia (PGPR) belongs to the various families of Phyllobacteriaceae, Rhizobiaceae and Bradyrhizobiaceae. The nutrition and inhabitation of PGPR is sustained by the niche known as Rhizosphere. PGPRs inculcate numerous benefits specifically for mechanisms including defence mechanism against pests and diseases through activation of defence pathways and development of wide range spectrum resistance to overcome extreme abiotic or combinatorial stress conditions such as over dosage of pesticides, fertilizers, salinity, drought, temperature, heavy metal contamination and pH on a variety of commercially important agricultural crops. PGPRs microbes offer enhanced plant growth and yield with nutrient enrichment of soil using their remarkable property of nitrogen fixation, siderophore production, phosphate solubilisation influencing soil fertility and cellulase, protease, lipase enzyme production to enhance plant defence mechanism. Our review summarizes the importance of efficacy of screening, selection and commercialization to agricultural production sustainability.

INTRODUCTION

The sustainability of agriculture and it's practices completely depends on soil. The soil which is a supporting medium for plant growth must be fertile, productive and nutritionally rich but fluctuation in climatic change caused by the human activities land desertification and degradation are causing major threat to agriculture (FAO, 2011) data reported 24 billion tons fertile soil degradation and the vigour of this degradation had been reported to 25%. The previous studies explain the requirement of food energy and water which is expected to get intensified by 2030 with population explosion (IFPRI, 2012).
All the above problems can be unscrambled throw perpetuation of quality and more productivity of fertile soil this necessitate maintenance of nitrogen properties of soil, regulation of insect pace attack along with disease combating abiotic stress such as extreme temperature salinity, soil acidity, toxic metal pollution, pesticide pollution. The nutritional enrichment of effected soil needs to be supplemented through production of phytohormones, phosphate solubilizers,siderophoreformation process and production of metabolites with bio control properties, antibiotic production of enzymes and induction of resistance in plants in plants from pest attack through activation by plant defence mechanism. These all deficits eventually contribute in degradation of soil fertility and so the sustainability of agricultural production.

Introduction to Plant growth promoting rhizobacteria PGPR's

PGPR's belonged to the group of microbes directly and indirectly bestows and soil health and promotes plant growth. Thus, they are called plant growth promoting rhizobia. PGPR's contributes directly and indirectly in promoting growth of plants as explained in Table1.

Table 1 Contributions of PGPR's directly and indirectly in promoting growth of plants

Contribution of PGPR	Functions
Direct contribution	• Nitrogen fixation • Phosphate solubilisation • Iron chelation • Production of phytohormones
Indirect contribution	• Plant pathogens • Suppression • Development of plant resistance • Combating abiotic stress

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Types of PGPR groups

There are two groups of PGPR. They are grouped as Intracellular PGPR (iPGPR) and extracellular PGPR (ePGPR). Their functions and examples are described in Table 2.

Table 2 Types of PGPR's directly and indirectly in promoting growth of plants

Type of PGPR	Examples	Location	References
ePGPR (Extracellular)	Rhizobium, Bradyrhizobium, Azorhizobium, Mesorhizobium and Sino Rhizobium	• Live in soil near roots (rhizosphere) • Colonize root surface (rhizoplane) • Lives in root tissue (Endophytes)	Bhattacharyya PN, Jha DK (2012) and Johri BN, Sharma A, Virdi JS (2003)
iPGPR (Intracellular)	Bacillus, Pseudomonas Erwinia, Serratia, Caulobacter, Flavobacterium	• Live inside root structure, nodules such as woody tissue or nodules	Bhattacharyya PN, Jha DK (2012) and Johri BN, Sharma A, Virdi JS (2003)

PGPR's Function in Maintenance of Nitrogen Cycling and Nutrition

PGPRs have remarkable role in soil fertility through N, P and Iron recycling and the details are isexplained in Table 3.

Table 3 Role of PGPR's in nitrogen fixation and recycling

Specific type	PGPR functions	Reference
Prokaryote and plant interaction plant for nitrogen fixation	• BNF (biological nitrogen fixation) which convert atmospheric nitrogen into plant assimilable nitrogen with enzyme.	Wilson PW, Burris RH *et al*. 1947.
80% of bacteria production IAA in Rhizosphere	• Phytohormone or substances that stimulate the growth of plant in optimized micromolarconcentration of IAA, cytokinin, auxin, gibberlin, abscissic acid. • Induce root and shoot formation • Increase in nodules • Plant cell division • Stem elongation and leaf expansion • Stimulation of shoot growth and induce seed dormancy breakage. • Source of Carbon and nitrogen against stress and defence.	Patten CL and Glick BR. 1996 Frankenberger WTJ and Arshad M.1995) Dobbelaere S *et al*., 2003 Downie A. 1997 Vesely S, Glick BR., 2009 Duhan JS *et al*.,1998 Hafeez FY, *et al*., 2008 Kaneko T, *et al*., 2000
Phosphate solubilising bacteria	• Solubilisation and mineralization of phosphorus and combating abiotic stress	Afzal A, Bano A., 2008 Rodrigues C *et al*., 2006 Tao G *et al*., 2008
Siderophore production and relives stress stress from heavy metals	• Iron as insoluble hydroxides and oxyhydroxides • Sulfur availability as pyrite	Rajkumar M, *et al*., 2010 Bodek I, *et al*., 1988

Important common PGPRs responsible for growth of various leguminous and non-leguminous crops through various mechanisms are mentioned in Table 4.

Table 4 Types of PGPR's directly and indirectly in promoting growth of plants

Sl. No.	Microorganism	Crops	Mechanism
1.	*Azotobacter*	Cucumber, Wheat, oats, rice, maize, tobacco, tea and coffee	Cytokinin synthesis, Nitrogen fixation
2.	*Azospirillum*	Sugarcane	Nitrogen fixation
3.	*Azorhizobium*	Wheat	Nitrogen fixation
4.	*Bacillus*	Potato, cucumber, pepper, peanuts, maize and Alfa alfa.	Plant hormones Auxin, Cytokinin, Gibberlin synthesis, Antibiotic and siderophore production and potassium solubilisation and stress resistance induction.
5.	*Beijerinckia*	Sugarcane	Nitrogen fixation
6.	*Burkholderia*	Rice	Nitrogen fixation
7.	*Cryseobacterium*	Tomato	Siderophore production
8.	*Frankia*	Alnus	Nitrogen fixation
9.	*Gluconacetobacter*	Sugarcane	Nitrogen fixation
10.	*Pseudomonas*	Mung beans, wheat, Pigeon pea, potato, Maize, Cotton.	Chitinase and glucanases production, AA deaminase synthesis, Antibiotic and siderophoreproduction
11.	*Rhizobium*	Rice, Peanuts and legumes	Nitrogen fixation, HCN production andcombating stress via development of rsistance.

Role of PGPR in plant defence mechanism and induction of plant resistance through different approaches. The mechanisms are summarized in Table 5.

Table 5 It summarizes the various strategies through which plant activates their defence function

Sl. No.		Function	References
1	ISR Induced systemic resistance	• Induce host plant defence response • Bacterial or Rhizobial intracellular component produces ISR (such as LPS, flagella, lactose). • Production of bio stimulating agents	Mishra RPN *et al*.2006 Mishra PK *et al*., 2009
2	Temperature	• PGPR (rhizobium) produces HSP (heat stock protein) • Rhizobia tolerant temperature	Eaglesham ARJ *et al*., 1984 Alexandre A and Oliveira S., 2011 Michiels J *et al*., 1994 Chen P., 2011
3	Salinity	• Resistant *Rhizobial*spp. against salt concentrated conditions • Osmoprotectant production	Chen RJ *et al*., 2002 Miller-Williams M, *et al*., 2006

4	Acidity	• Production of extracellular polysaccharides PS & polyamines & glutamate	Muglia CI *et al*., 2007
5	Heavy metal resistance	• EPS & LPS • Plasmid development • Phytoremediation through metallothionineproductiuon • Phytochelatins	Pereira SIA *et al*., 2006a Pereira SIA *et al*., 2006b Kagi JHR., 1991
6	Pesticide tolerance	• Degradative genes	Kumar P., 2012 Kumar S *et al*., 1996

DISCUSSION

PGPRs have beneficial effects for the maintenance of fertility of soil and development of crops as explained previously (Saharan *et al*., 2011). But some studies also explained the negative effects of PGPR on plant growth by (Vacheron *et al.*,2013). It showed the influence of optimized concentration of auxin and in case the auxin levels get higher than the optimized concentration, the root growth may get inhibited and eventually the growth of the crops explained by (Xie, H *et al*., 1996). Some strains of Rhizobium which are responsible for inhibition of ethylene production showed dual effects as an inhibitor as well as toxin causing chlorosis, but these conditions are observed under specific situation.

CONCLUSION

The studies on PGPRs emphasizes on specific selection, isolation, maintenance and field trials of those strains which may support the growth, development and yield of commercially important leguminous and non-leguminous crops.

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