

## Review Article

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## Sundry of PGPR as a Potential Source of Plant Growth Promotion in Arid and Semi-Arid Regions

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### ABSTRACT

Arid and semiarid regions are illustrious for stressed atmosphere primarily attributable to erratic precipitation, low fertility of soil, leading to low crop productivity with high uncertainty within the field conditions. In arid and semiarid areas all stresses preponderantly drought limits the expansion and yield of crops significantly inflicting the foremost fatal economic losses in agriculture. This form of abiotic stress, have an effect on the plant water relation at cellular and whole plant level, decrease N and C metabolism that result in modulate plant physiology and chemical process activity. The adaptation difference mechanism of plant drought tolerance might involve promotion of root extension, permitting associate economical water uptake. PGPR can serve as successful eco-friendly tools (Biofertilizers) to implement sustainable agricultural practices in all parts of the planet. PGPR assist host plant to cope with stresses and build changes in root morphology. Drought acceptance to the plants are typically elicited by PGPR inoculations that unit of measurement customized to water restricted soil conditions. Drought tolerance to the plants is induced by PGPR inoculations that are custom-made to water restricted soil conditions. PGPR utilizes induced system tolerance (IST) to induce physical and chemical changes that lead to increased tolerance of plants to abiotic stress. *Azospirillum* spp., isolated from arid areas will develop tolerance level in crop plants below water deficit condition. PGPR considerably promote seedling emergence, vigor and yield by competency with different rhizobacteria through production of antibiotics, lytic catalyst, chemical compound siderophore and bacteriocin. The treatment of soil by biofertilizers not only enhances soil fertility but also enriches soil microorganism life. A number of the foremost established PGPR strains belong to the bacteria genus, *Bacillus*, *Azospirillum*, *Azotobacter*, *Streptomyces*, *Klebsiella*, *Enterobacter*, *Alcaligenes*, *Arthrobacter*, *Flavobacterium*, *Burkholderia*, *Bradyrhizobium*, *Mesorhizobium*, *Rhodococcus* and genus *Serratia*.

#### Keywords

Biodiversity, PGPR, Biofertilizers, Drought

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### Introduction

Dry lands cover 6150 million ha, that is, 47.2% of land area. Amongst hyper-arid zones cover 7.5%, arid zones cover 12.1% of land area, while semiarid zones are more extensive,

occur in all continents, and cover 17.7% of land surface. 9.9% of land area covers by the dry sub-humid environment. In India almost 53.4% land area comprises arid and semi-arid regions. Arid and semi-arid regions area unit characterized by a climate with no or

insufficient rainfall, low fertility of the soil, resulting in low crop productivity with high uncertainty in the field conditions. In these regions the rains are erratic and often come in a few heavy storms of short period leading to high runoff, rather than replenishing the bottom water. Protective vegetation cover is distributed and there's little moisture for the most parts of the year. Cultivation in these regions is confined to limited productive land, while a large animal population depends on native vegetation. Chemicals used as fertilizers for crop improvement in arid and dry regions have also worsened the condition of soil by creating them more saline and barren. Continuous use of chemicals destabilize the soil ecology, disrupt the surroundings, degrade soil fertility, and consequently shows destructive effects on human health together with contaminating water and therefore making environmental hazards. Therefore, there is emerging need to develop ecologically and environmentally sound technology for crop plant growth in arid and semi-arid regions.

The rhizosphere of plants is colonized by complicated and dynamic communities of microorganisms. The bacterium lodging around the plant roots (rhizobacteria) area unit additional resourceful in reworking, mobilizing, solubilizing the nutrients as compared to those from bulk soils (Ali *et al.*, 2010). Therefore, the rhizobacteria area unit the dominant etymologizing forces in usage the soil nutrients and consequently, they're crucial for soil fertility (Glick, 2012). Soil-plant-rhizobacteria interactions area complicated and there are several within which the end result will influence the plant health and productivity.

Soil microorganism species mushrooming in plant rhizosphere which raise in, on, or around plant tissues stimulate plant growth by a superfluity of mechanisms are collectively

known as PGPR (plant growth promoting rhizobacteria) (Vessey, 2003). PGPR enhance plant growth with mechanisms such as phosphate solubilization, 1-aminocyclopropane-1-carboxylate (ACC) deaminase production, siderophore production, quorum sensing signal obstruction, biological nitrogen fixation, rhizosphere engineering, inhibition of biofilm formation, antifungal activity, phytohormone production, etc (Figure 1). In addition, a number of the PGPR produce volatile organic compounds, induced systemic resistance, promote useful plant-microbe symbioses, and also interfere with toxin production by pathogenic microbes. The importance of PGPR in sustainable agriculture has steady magnified attributable due to the possibility that PGPR might replace the utilization of chemical fertilizers, pesticides and different supplements. These rhizosphere microorganisms produce the growth promoting substances in huge quantities by that influence the general morphology of the plants indirectly.

PGPR functions as elicitors of tolerance to varied stresses found in arid and semi-arid regions like drought, salt and nutrient deficiency. Here, we tend to review PGPR-induced physical and chemical changes in plants that end in increased tolerance to varied stresses found in arid and dry regions, and recently published work associated with this subject.

### **PGPR effects on drought stress**

PGPR effects on drought stress are recognized as a complex constraint limiting the potential yields of crops. Moisture stress throughout the crop cycle, accounts for about 30 to 70 % loss in productivity. In India, as in many other parts of semi-arid regions of the world, 78% of the area under rain-fed cultivation and is inescapably linked to the uneven rainfall

distribution. Out of the overall gross cultivated space of the country, 56m HA is subjected to inadequate and extremely variable rainfall. In Bharat 337 districts as drought prone declared by National Commission on agriculture.

In arid and semi-arid regions drought stress limits the expansion and productivity of crops (4). So that PGPR can be used as a better alternative. Early studies on IST to drought (Timmusk and Wagner, 1999), according that immunisation with the PGPR *Paenibacillus polymyxa* increased the drought tolerance of *Arabidopsis thaliana*. RNA differential show on parallel ribonucleic acid preparations from *P. polymyxa* treated and untreated plants unconcealed that template RNA transcriptions of a drought-response cistron, Early Responsive to Dehydration (ERD15), were conjointly increased. Another PGPR strain, *Achromobacter piechaudii* ARV8, that produces 1-aminocyclopropane-1-carboxylate (ACC) deaminase, bestowed IST to drought stress in pepper (*Capsicum annuum* L.) and tomato (*Solanum genus Lycopersicon* L.) plants (Mayak, *et al.*, 2004).

The co-inoculation of bean (*Phaseolus vulgaris* L.) with bacteria genus tropici and 2 strains of *P. polymyxa* was subjected to drought stress conditions resulting in an increase in the shoot dry weight, nodule range, and plant height (Figueiredo, *et al.*, 2008). Investigations into however drought stress affects phytohormone balance unconcealed a rise in abscisic acid (ABA) content within the leaves, indicating that the reduction of endogenous plant hormone levels magnifies ABA content, eliciting stomata closure (Figueiredo *et al.*, 2008 and Cowan *et al.*, 1999). The cytokinin ABA antagonism can be the results of metabolic interactions as a result of they share a standard synthesis origin (Cowan *et al.*, 1999). The cytokinin produced by *P. polymyxa* might have a determinable effect on the ABA signaling of plants or

rhizobia-elicited nodulation (Timmusk and Wagner, 1999 and Figueiredo, *et al.*, 2008).

*Arbuscular mycorrhizal* fungi (*Glomus intraradices* or *G. mosseae*) and PGPR *Pseudomonas mendocinawere* co-inoculated in lettuce (*Lactuca sativa* L.) and increased AN inhibitor enzyme underneath severe drought conditions, suggesting that they will be employed in inoculants to alleviate the oxidative harm evoked by drought (Kohler, *et al.*, 2008).

The effects of inoculation of ACC-deaminase containing PGPR (*Pseudomonas fluorescence* 169 and *Pseudomonas putida* 108) on the yield and some agronomic traits of maize underneath water shortage stress within the Mahvelat region of Iran has considerably increased stem, tassel dry weights, cob weight and grain yield (Ghanbari, *et al.*, 2013). Seed bacterization of maize with exopolysaccharide (EPS) improve soil wetness content, plant biomass, shoot and root length and leaf area by using these bacterial strain *Proteus penneri* (Pp1), *Pseudomonas aeruginosa* (Pa2), and *Alcaligenes faecalis* (AF3). Plants showed increase in relative water content protein sugar though proline content and activities of antioxidants enzymes were decreased under drought stress. Consortia of inocula and their individual EPS showed bigger potential to drought tolerance compare to PGPR inocula used alone (Hafsa, *et al.*, 2014).

### **PGPR effects on salinity stress**

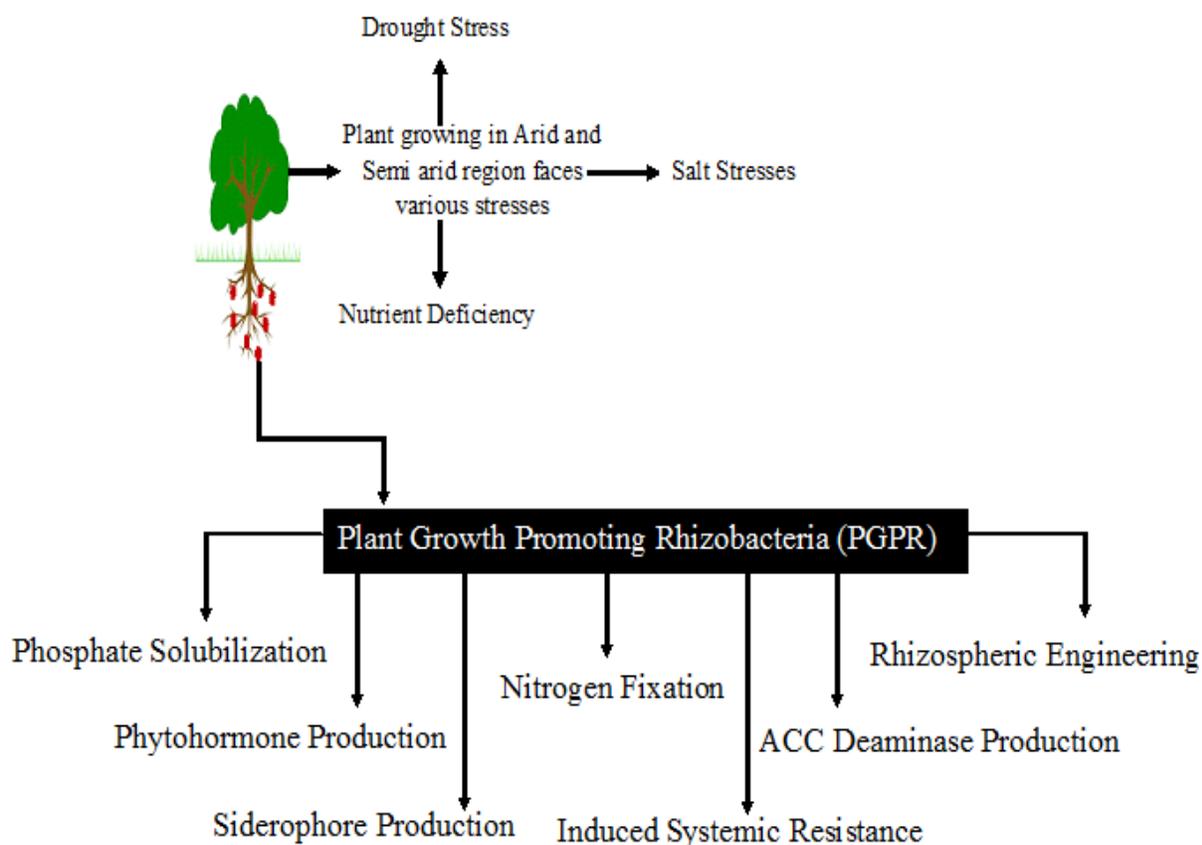
Soil salinity in arid regions is usually a vital limiting reason in cultivating agricultural crops. Though several technologies are involved within the improvement of salt tolerance, solely PGPR-elicited plant tolerance against salt stress has been antecedently studied. In another study (Mayak, *et al.*, 2004), *Achromobacter piechaudii* was used to reduce the the gas content in tomato seedlings

exposed to high salt. Thus, implying that microorganism command deaminase was practical. In the presence of high salt (66%) content the tomato seedling inoculated with *A. piechaudii* that produces ACC which increases growth of tomato seedling.

*Pseudomonas putida* inoculated cotton seedling showed an enhanced germination rate, plant height, fresh weight, dry weight and healthy cotton stand as compared to control (CK) plants. Augmentation in the absorption of the  $Mg^{2+}$ ,  $K^{+}$  and  $Ca^{2+}$  and reduction in the uptake of the  $Na^{+}$  from the soil and improvement in the production of endogenous

IAA content and reduction within the abscisic acid (ABA) content of cotton underneath salt stress was reported (Lixia, *et al.*, 2010).

*Brachy bacterium saurashtrense* (JG-06), *Brevibacterium casei* (JG-08), and *Haererohalobacter* (JG-11) inoculated plants of *A. hypogaea* (100mM NaCl) increased all the physiological parameters like plant length, shoot length, root length, shoot dry weight, root dry weight as compared to uninoculated plants and biochemical (proline and soluble sugar) factors were considerably lower in inoculated plants compared to uninoculated plants (Pushp, *et al.*, 2008).



**Figure 1. Role of PGPR in management of various stresses found in arid and semi arid regions by using various mechanisms to promote plant growth**

### **PGPR increase fertility and nutrient uptake**

Another major issue that affects the plant growth in arid and semi-arid region is insufficient availability of soil nutrients. Although soil fertilization is typically required for agricultural production but over fertilization with chemical is availability of fertilizers that eventually contaminates surface and ground waters because accumulation of nitrate and phosphate components. The environmental impacts of fertilization are attributed, in part, to low uptake potency by crops. For example, phosphorus is very reactive with iron, aluminum and calcium element present in soil which can result in precipitation of up to 90% of the soil phosphorus (Gyaneshwar, *et al.*, 2002), therefore creating it for the most part unavailable to plants. PGPR can rise as promising components in approaches for maintaining adequate plant nutrition and reducing the negative environmental effects of fertilizers. Some PGPR has been related to the solubilization and increase uptake of phosphate which helps in plant growth promotion (Mantelin and Touraine, 2004). PGPR have additionally been according to have an effect on nitrate uptake by plants (Mantelin, Touraine 2004 and Adesemoye, *et al.*, 2008). Additionally to inflicting will increase generally plant growth, some PGPR promote root development (Mantelin and Touraine, 2004) and alter root design by the assembly of phytohormones like indole acetic acid (IAA) (Kloepper, *et al.*, 2007), leading to increased root area and numbers of root tips. Such stimulation of roots will aid plant defense against pathogens and might additionally relate to induced general tolerance (IST). As root tips and root surfaces area unit sites of nutrient uptake, it's possible that one mechanism by that PGPR cause enlarged nutrient uptake is via stimulation of root development.

Due to the various environmental problems and the growing process of fertilizers, there is a thrust amongst farmers worldwide to reduce fertilizer use beneath the recommended levels for paramount yields; however such decline would pose an abiotic stress on plants. Therefore, many studies are being carried out to determine if PGPR can facilitate agricultural plants while maintaining productivity and reducing the rate of fertilizer applications. It was observed in a field study that the yield for wheat (*Triticum aestivum* L.) plants (Shaharoon, *et al.*, 2008) that were given 75% of the suggested amount of N-P-K fertilizer and a PGPR strain was like the yield for plants that were given complete quantity of fertilizer however while not PGPR. Another study performed on tomato (Hernández and Chailloux, 2004) showed that the dry weights of tomato transplants grown in greenhouse were considerably higher with 75% fertilizer and 2 PGPR strains than with the complete quantity of fertilizer and no PGPR; once transplant to the field, yields with some mixtures of PGPR and mycorrhizal fungi at 50% suggested field fertilization were bigger than the yield of the 100% fertilizer management without microbes. In Integrated nutrient management systems of agricultural uses PGPR because they can help to reduce the buildup of nutrients in fertilized soils. A three-year field study on maize (17), was in support of this technique that evaluated PGPR with and while not mycorrhizal fungi, manure and inorganic fertilizer, further like and while not tillage. Noteworthy increase in grain yield from microbial treatments were accompanied by augmented nitrogen content per gram of grain tissue and removal of significantly higher amounts of nitrogen, phosphorus and potassium. Therefore, inside the tested nutrient management system, PGPR contributed considerably to reducing nutrient build up within the soil. Numerous studies are ongoing that will further describe the utility of

PGPR in nutrient management methods aimed at reducing fertilizer application rates and nutrient runoff from agricultural soils.

### **Perspectives**

PGPR will aid the expansion of crops in environmentally unfavorable conditions. Many studies on mechanisms by which PGPR evokes tolerance to specific stress factors show that they improve the utilization of PGPR in agriculture by allowing the microbial mixtures to be optimized for the assembly of specific microorganism determinants (e.g. cytokinin, antioxidants, ACC deaminase, VOCs and IAA).

Improved plant nutrition with PGPR is due to numerous mechanisms used by PGPR as defined here. As an example, if multiplied nutrient content in plants results from increased nutrient uptake, IST is operable as a result of physical or chemical changes within the plant caused by PGPR square measure ultimately accountable, as because once PGPR stimulate root development.

However, PGPR might increase nutrient convenience while not directly moving plants. Though this may additionally end in larger nutrient levels in plants, it might not be explained by IST. Future investigations into every case wherever PGPR have an effect on plant nutrition can elucidate this point. The field of PGPR-elicited ISR should currently concentrate on two directions. First, a lot of studies square measure required to demonstrate that PGPR cause a variety of crops to be tolerant to varied environmental stresses.

Furthermore, the studies included the measures needed for elucidating the signal transduction pathways resulting from the treatment of plants with PGPR below stress conditions. Only then can the complete edges of PGPR be understood.

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