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Original Research Paper

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A SYSTEMATIC REVIEW ON THE IMPORTANCE OF PLANT GROWTH PROMOTING RHIZOBACTERIA

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ABSTRACT Soil microorganisms (PGPR) and Rhizosphere are important in sustaining crop and soil health through various mechanisms like nutrient cycling and uptake, suppression of plant pathogens, induction of resistance in plant host, direct stimulation of plant growth. PGPR are associated with plant roots and enhance plant productivity and immunity; however, recent work by several groups shows that PGPR also provoke increase nutrient uptake from soils, thus reducing the need for fertilizers and preventing the accumulation of nitrates and phosphates in agricultural soils. Scientific researches involve multidisciplinary approaches to understand adaptation of PGPR, effects on plant physiology and growth, induced systemic resistance, biocontrol of plant pathogens, bio fertilization, and potential green alternative for plant productivity, viability of co inoculating, plant microorganism interactions, and mechanisms of root colonization. Plant growth promoting rhizobacteria (PGPR) are commonly used as inoculants for improving the growth and yield of agricultural crops, however screening for the selection of effective PGPR strains is very critical. This study focuses on the effectiveness of PGPR strains on the basis of their potential for metabolite production and plant growth promoting activity. In India the use of Bio inoculants for crop production is in research stages only and thus this review paper provides a thorough understanding and status of alternative bio fertilizers (agro chemicals) and their usage in agriculture and highlights their positive impact on crop production.

KEYWORDS : Plant growth promoting rhizobacteria; Rhizosphere; Plant Growth; Bio inoculants

INTRODUCTION

Rhizosphere

The rhizosphere is the slender region of soil that is directly influenced by root secretion and associated with soil microorganisms known as the root microbiome. Plant root exudes entice microbes and feed them and, in return, the plants often benefit from the microbes. This symbiosis leads to more complex interactions, influencing plant growth and competition for resources. Much of the nutrient cycling and disease suppression by antibiotics required by plants, occurs immediately adjacent to roots due to root exudates and metabolic products of symbiotic and pathogenic communities of microorganisms. (Elaine et.al.,2006)

Nutrient Procurement by Plant Growth Promoting Rhizobacteria

Soil microorganisms play a dynamic role in soil processes which have direct bearing on productivity of crop plants. The direct use of microorganisms to promote plant growth and to control plant pests continues to be an area of rapidly expanding research. Rhizosphere colonization is one of the major and initial stage in the pathogenesis of soil borne microorganisms. It is also vital for the microbial inoculants to be used as biofertilizers, biocontrol agents, bio-remediators and Phyto stimulators. The independent bacterium found within the rhizosphere of plants, called Plant Growth Promoting Rhizobacteria (PGPR), are extremely economical within the promotion of plant growth through direct and indirect mechanisms (Hassan et al., 2015). Direct effects are associated with the synthesis of phytohormones, like auxins, gibberellins and cytokinin, that facilitate the absorption of nutrients within the plants and supply protection against varied assortments of environmental strain (Glick, 2012; García-Fraile et al., 2015).

Furthermore, the synthesis of enzymes, like 1-aminocy clopropane-1-carboxylic acid (ACC deaminase), enzyme activity, modulate the event of plants by increasing plan growth and chlorophyl activity, moreover because the total biomass of crops (Glick, 2012). The indirect mechanisms embrace the inhibition of harmful microorganisms, like root pathogens, and biological management of plant diseases through the assembly of antibiotics and siderophores (Widnyana and Javandira, 2016). Therefore, PGPR increase crop yields, soil fertility and have the potential to contribute to agriculture as a result of which they increase the general tolerance to fret (García-Fraile et al., 2015).

Strains with PGPR activity, particularly that happens to be the genera of eubacteria sp. and bacteria genus sp., are significantly vital within the soil-plant relationship (Widnyana and Javandira, 2016). Both genera play key roles within the biogenesis of phytohormones, like the indole carboxylic acid (IAA), that promotes cellular division and root elongation whose activity will increase throughout the life cycle of plants (Widnyana and Javandira, 2016). On the opposite hand, olefin could be a plant hormone that plays a very important role within the senescence and abscission of leaves, germination and within the development of the seeds (Jha et al., 2012). Olefin created endogenously by the majority plants could be a phytohormone, however it may cause negative effects on the event of plants, like water stress, once synthesized by excess because of the repressing result of the enlargement and root elongation (Jha et al., 2012). Previous studies have indicated that a number of the PGPR strains, the genera of eubacteria sp. and bacteria genus sp. are capable to supply the accelerator ACC deaminase, that is beneficial in reducing the amount of olefin by the conversion of ACC to NH4 and α-ketobutyrate in plants, promoting growth and increasing stress tolerance (Glick et al., 2007).

Thus, microorganisms are essential to extend the exploration potential of roots, and improve nutrient and water uptake, and as physiological parameters that alter plants to tolerate adverse environmental stresses, improve quality and upsurge crop yields (Lim and Kim, 2013). In this sense, the immunization with PGPR to attain enhanced stress tolerance are often a decent tool to reinforce production in water-deficit regions (Lim and Kim, 2013). Plant growth-promoting rhizobacteria are independent soil bacterium that sharply colonize the rhizosphere/plant roots, and enhance the expansion, and yield of plants once applied to seed or crops (Kumar et al., 2014).

Interest within the useful rhizobacteria related to cereals has

enhanced recently and several other studies clearly state the positive and useful effects of PGPR on growth and yield |of various crops particularly wheat at different surroundings underneath variable ecological conditions (Ozturk et al., 2003; Marques et al., 2010; Mehnaz et al., 2010; Zhang et al., 2012). Immunization with bacteria genus fluorescens showed a big increase in root weight 19–43%, variety of tillers per plant 10–21%, grain yield 15–43%, and straw yield 22–39% of wheat compared to un-inoculated plants (Shaharoona et al., 2008). Moreover, immunization with PGPR strain Azotobacter saved 25–30kilogram chemical plant food (Narula et al., 2005). Kumar et al. (2014) conducted experiments on wheat underneath pot and field condition to look at the result of PGPRs on the expansion and yield of wheat and located that triple combination of strains B. megaterium, A. chlorophen olicus, and Enterobacter considerably enhanced 79.5, 79.8, 78.6, and 26.7% plant height, grain yield, straw yield, and check weight underneath pot condition and conjointly 29.4, 27.5, 29.5, and 17.6% underneath field condition, severally.

Knowledge of the native microorganism population, their characterization, and identification is needed for understa nding the distribution and variety of autochthonal bacterium within the rhizosphere of specific crops (Keating et al., 1995; Chahboune et al., 2011). With increasing awareness concerning the-chemical-fertilizers-based agricultural practices, it's vital to go looking for region-specific microorganism strains which might be used as a growth promoting/enhancing matter to attain desired crop production (Deepa et al., 2010). Earlier, the microorganism diversity within the forest soil of Kashmir, Republic of India was investigated and rumoured (Ahmad et al., 2009) however no knowledge is offered relating to the rhizosphere microbiome of wheat native to the current space. Wheat being a staple food has special importance within the economy of the country.

During the last number of decades, the utilization of PGPR for property agriculture has enhanced enormously in varied components of the globe. The increase in growth and yield of agronomically vital crops in response to immunization with PGPR are rumoured (Chen et al.1994; Amara and Dahdoh 1997; Biswas et al. 2000a, b; Hilali et al. 2001; Asghar et al. 2002). Studies have conjointly shown that the growth-promoting ability of some bacterium is also extremely specific to sure plant species and genotypes (Nowak 1998). Dish and Kabi (1979) rumoured that immunization with Azotobacter strains isolated from the rhizosphere soils of Cucurbita maxima, wheat and jute improved the grain yields but the strains were crop specific. Like alternative phytohormones, auxins are synthesized endogenously by plants, however, their secretion effects are elucidated by their exogenous applications. There is conjointly ample proof that various soil micro-organisms are actively concerned within the synthesis of auxins in pure culture and in soil (Arshad and Frankenberger 1998; Barazani and economic expert 1999; Biswas et al. 2000a, b). Generally, micro-organisms isolated from the rhizosphere and rhizoplane of varied crops have discovered additional potential of growth regulator production than those from the basis free soil (Sarwar and Kremer 1995a, b; Arshad and Frankenberger 1998). L-tryptophan (L-TRP), associate degree organic compound, is a physiological precursor for biogenesis of auxins in plants and in microbes (Frankenberger and Arshad 1995). Root exudates are natural supply of TRP for rhizosphere microflora, which may enhance growth regulator biogenesis within the rhizosphere (Kravchenko et al. 1991; Martens and Frankenberger1994). It is possible that auxins of microorganism origin within the neck of the woods of plant roots might evoke a physiological response within the host plant.

Mechanism of PGPR

Net result of plant–microbe interactions on plant growth may be either positive, neutral or negative. All those bacteria inhabiting plant roots and influencing the plant growth completely by any mechanism are named as Plant Growth-Promoting Rhizobacteria (PGPR) (Kloepper et al. 1986; Frankenberger and Arshad 1995; Arshad and Frankenberger 1998). These bacteria considerably have an effect on plant growth by increasing nutrient absortion, suppressing pathogens by manufacturing antibiotics and siderophores or microorganism and flora antagonistic substances and/or by producing biologically active substances like auxins and alternative plant hormones. a various array of bacterium together with species of bacteria genus, Azospirillum, Azotobacter, Bacillus, Klebsiella, Enterobacter, Xanthomonas and Serratia are shown to push plant growth.

The Plant Growth Promoting (PGP) ability of the PGPR is usually elucidated by the discharge of metabolites directly stimulating growth. Many mechanisms are postulated to clarify however PGPR profit the host plant. These include: (a) the power to supply plant growth regulators or phytohormones like indole carboxylic acid (IAA), cytokinins, and gibberellins (Glick, 1995; Marques et al., 2010); (b) enhancing asymbiotic N2 fixation (Sahin et al., 2004; Khan, 2005); (c) solubilizing phosphate and mineralization of organic phosphate and/ or alternative nutrients (Glick, 1995; Jeon et al., 2003); (d) antagonistic result against phytopathogenic microorganisms by production of siderophores, the synthesis of antibiotics, enzymes, and/or antifungal compounds, and competition with prejudicious microorganisms (Dey et al., 2004; Lucy et al., 2004).

Growth promotion and disease control by rhizobacteria are complex interconnected processes which involve direct and indirect mechanisms.

The mechanisms comprise of: -

- Synthesis of some metabolites (auxin, cytokinin and gibberellins)
- Induction of 1-aminocyclopropane-1-carboxylate (ACC) deaminase
- Production of siderophore, antibiotics, hydrogen cyanide hydrogen cyanide (HCN) and volatile compounds
- Mineral solubilization competition, and
- Induction of systemic resistance.

Various microbes which are mainly studied and increasingly marketed as the biocontrol agents include Bacillus, Streptomyces, Pseudomonas, Burkholderia and Agrobacterium spp. They control plant disease through induction of systemic resistance, and production of siderophores or antibiotics. Exposure to the PGPR triggers a defense reaction by the crop as if attacked by plant pathogens. Siderophores produced by some PGPR scavenge 3 heavy metal micronutrients in the rhizosphere (e.g., iron) and make plant pathogens starve for micronutrients.

Rock phosphate is source of phosphorus but its availability to plants is restricted under most conditions. Phosphate solubilizing bacteria help in making this phosphorus available to the plants. PGPR produce phytochromes such as indole-acetic acid, cytokinin's, gibberellins and inhibitors of ethylene production.

Potential PGPR isolates can be screened in vitro to study their PGP traits that involves estimations of production of indole-3-acetic acid (IAA), ammonia, HCN, phosphate solubilization and siderophore production (Park et al., 2005; Ahmad et al., 2008). PGP traits as phosphate solubilization and ammonia production can directly enhance growth of plants by increasing availability of nutrients while the phytohormone, IAA increases root growth (Bhattacharyya and Jha, 2012; Goswami et al., 2014b)

Applications of PGPR

It is an alternative way to replace agrochemicals i.e., chemical fertilizers, pesticides, and supplements; most of the microbial strains result in a significant increase in plant height, root length, and dry matter production of shoot and root of plants. PGPR help in the disease control in plants. Some PGPR especially when coated on seeds before planting, are able to establish themselves on the crop roots. PGPR as a component in integrated management systems in which reduced cost of agrochemicals and cultural control practices are used as biocontrol agents. Such an integrated system could be used for transplanted vegetables for the production of transplants that would be tolerant to diseases for at least a few weeks after transplanting into the field [Kloepper et al., 2004]. Selected strains of beneficial PGPR trigger a plant-mediated induced systemic resistance (ISR) response that is effective against a variety of plant pathogens.

Challenges, Need and Way forward

Feeding the growing global population is one of the major challenges for agriculture (Rouphael and Colla, 2020). To sustain and guarantee an adequate yield, crop production is getting more and more dependent on chemical fertilisers (Berg, 2009), which has, unfortunately, a very negative impact on the environment (Vejan et al., 2016). Over the last decades, world agriculture experienced high increase in crop yield. This was achieved through high input of inorganic fertilizers and pesticides, and mechanization driven by fossil fuel. To sustain and guarantee an adequate yield, crop production is getting more and more dependent on chemical fertilisers (Berg, 2009), which has, unfortunately, a very negative impact on the environment (Vejan et al., 2016). Over the years this led to serious environmental problems such as depletion of soil quality and health, ocean and ground water pollution, and emergence of resistant pathogens. It is a big challenge to feed the increasing world population on decreasing farmland areas without damaging environment. Thus, the development of eco-friendly alternatives to chemical fertilisers greatly increased importance in recent time.

One effective method is the use of plant biostimulants (PBs), which is gaining interest globally (De Pascale et al., 2017). Indeed, the PB market is constantly increasing with an expected compound annual rate of 10.9 % until 2022 (Sessitsch et al., 2018). The main reasons of this growth are: (i) increasing importance of the organic farming, (ii) more PB use in developed countries and (iii) good acceptance of PBs among consumers (Biostimulant Market, 2014). Plant biostimulants include substances or microorganisms that enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits when applied to plants (du Jardin, 2015). The PGPR have shown promising potential as biofertilizers (Podile and Kishore 2007). Among the various bacteria identified as PGPR, the Bacilli and Pseudomonads are the most common (Podile and Kishore 2007). Rhizobacteria commonly improve plant growth by enhancing photosynthetic efficiency (Xie et al. 2009), synthesizing phytohormone precursors (Ahmad et al. 2008), vitamins, enzymes, antagonistic activity against phytopathogenic microbes by production of siderophore, HCN and antibiotics (Burd et al. 2000; Glick 2001), and by inhibiting ethylene synthesis (Khan et al. 2009).

CONCLUSION

The increasing concern about the natural environment and the usage of chemicals on large scale in the environment needs to come to an end, PGPR offer a striking alternative that contains the possibility of developing more sustainable approaches to agriculture.

Therefore, screening of the rhizobacteria for its in vitro potential of growth regulator production might offer a reliable base for choice of effective PGPR, significantly if this approach is employed together with screening of rhizobacteria for its growth-promoting activity under gnotobiotic conditions. Thus, we have a tendency to use a mixture of two approach including in vitro growth regulator production and growth-promoting activity under gnotobiotic conditions to pick out effective PGPR strains isolated from wheat rhizosphere. The chosen PGPR can be tested for its growth and yield increasing potential under natural soil (non-axenic) conditions by conducting pot and field experiments.

From previous couple of years, the role of rhizobacteria has become terribly attention-grabbing in ecological system as they communicate edges to system. Nearly all organic chemistry cycles in terrestrial ecosystems are driven by Rhizosphere and soil microorganism. They conjointly participate in maintaining health and productivity of soil in agriculturally managed systems. PGPR are thus an excellent model system which can provide the biotechnologist with novel genetic constituents that can be applied to further improve strains that have PGPR qualities in order to create transgenic strains that combine multiple mechanisms of action and create bioactive chemicals having diverse uses in agriculture and environmental sustainability.

Declarations

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