SIDEROPHORE

Producing Rhizobacteria as a Plant Growth Promoter

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ABSTRACT

Iron deficiency in crops causes iron chlorosis, which depletes micronutrients and leaves plants vulnerable to microbial diseases. There are around 60 phytopathogens that cause various plant diseases. Plant growth promoting rhizobacteria (PGPR) found near plant roots and also on the surface, play an important role in providing iron nutrition to crops, promoting plant health/growth and suppressing major phytopathogens, and have been viewed as a sustainable and environmentally friendly alternative to chemical fertilizers and pesticides. The most important biotechnological application of siderophores that produce PGPR in the plant's rhizosphere region, where they offer iron nourishment, act as a first line of defense against root parasites, and aid in the removal of hazardous metals from polluted soil. Siderophore-producing PGPRs act as BCAs by denying the pathogen of iron, leading in improved crop yields.

Keywords: Iron chelator, Microbial diversity and Plant growth promoter

Introduction

Agriculture accounts for a large portion of capital earnings in both developing and developed countries, and it helps to create jobs and provide food security. Sustainable agriculture is incredibly important in today's changing world since it has the potential to satisfy future agricultural needs. To achieve the target of 321 million tonnes of food grain production by 2020, the nutrient demand will be 28.8 million tonnes, with only 21.6 million tonnes available, resulting in a 7.2 million-tonne deficit. To meet this demand, agricultural areas are sprayed with a large amount of artificial fertilisers to restore soil nitrogen and phosphorus. The Green Revolution-I began in the 1960s with the goal of using chemical fertilizers such as insecticides, herbicides, and weedicides. Excessive use of these chemical fertilizers, on the other hand, has negative consequences for soil fertility, soil microbial diversity, surface and ground water, and so on. These chemical fertilizers tend to harm beneficial bacteria in the soil because they contain acids, such as sulfuric and hydrochloric acids, and when they are overused.

Chemical fertilizers and pesticides accumulated in the environment, resulting in pollution, bio-accumulation and bio-magnification, as well as the spread of illness. Furthermore, fertilizer application can be damaging not only to soil health but also to the proliferation of soil-borne diseases. The primary focus of contemporary agricultural developments in India is the quest for alternatives to artificial fertilizers and pesticides. Organic farming with bio-fertilizer application has arisen globally in the era of sustainable agriculture, addressing the surge in demand for safe and healthful food as well as long-term sustainability. It contributes to soil biodiversity while also ensuring food safety (Megali et al., 2014). The main benefit of using biofertilizers is that they have a longer shelf life and have no negative effects on the ecosystem. Compost, biofertilizers, biopesticides, and other organic farming techniques may not be a total substitution, but they can be an effective supplement to reduce the use of agrochemicals. The typical microbial flora of the soil, which includes all sorts of eubacteria, archae bacteria, and eukarya (fungi), including arbuscular mycorrhiza fungi (AMF) and plant growth boosting rhizobacteria, is essential for organic farming (PGPR) (Sahoo et al., 2014).

Biofertilizers have recently received a lot of attention in the agricultural area since they are a significant alternative source of plant nutrition. Biofertilizers are live formulations or latent cells of efficient microorganisms, such as bacteria, algae, or fungi that can be applied directly to seed, soil, or composting regions. As a result, an increasing number of these organisms speed up the digestion of complicated nutrients and convert them into a form that plants can directly absorb. They are biologically active products that provide plants with critical nutrients and can be nitrogen fixers, phosphate solubilizers, sulfuroxidizers, or decomposers. Simply put, they are bio-inoculants, which boost the yield of crop plants when applied.

Soil Microbial Diversity

Soil quality is defined as a soil's ability to function within ecosystem boundaries, supporting plant and animal growth and productivity while also enhancing air and water quality and supporting human health. Soil organisms are directly responsible for soil ecosystem processes such as soil organic matter decomposition and antibiotic compound synthesis, as well as nutrient cycling. As a result, soil (micro) biological characteristics could be used as sensitive markers of soil ecological problems. Soil microflora is employed as a potential biochemical or ecological indicator of soil quality in the case of soil enzyme activity and exopolysaccharides. The total microbial biomass of soil samples from different management regimes can be used to estimate soil quality. It has already been demonstrated that 1 gm of soil can contain ten billion microorganisms, which can shelter thousands of different species and 10% of the microorganisms visible under the microscope that can be cultured and classified.

Plants typically emit a carbon-rich substance that feeds microorganisms and in reaction to environmental variables, plants also release a variety of compounds. Soil bacteria can detect these chemo-signals and release compounds that help plants activate complicated plant defences. Some of these bacteria are classified as Agriculturally Vital Microorganisms because they play an important function in agriculture crops (AIMs). AIMs have a wide range of uses in agriculture and associated sciences, and they interact with soil and plants to provide unexpectedly beneficial results. Plant growth promoters such as *Azotobacter chroococcum*, *Azospirillum basilensis*, *Bacillus weihenstephanensis*, *Bradyrhizobium* sp., *Paenibacillus* sp., *Pseudomonas corrugate*, *Rhizobium* sp., and others have been identified. As biotic elicitors, soil-dwelling microorganisms safeguard crops by boosting plant resistance capacity and protecting against various biotic and environmental stressors.

Plant Growth Promoter Microorganisms

The rhizosphere is a thin layer of soil that remains in contact with various minerals, vitamins, and amino acids, collectively known as root exudates, and contains a variety of microorganisms as a result. Rhizosphere creates a vibrant habitat in which a variety of microorganisms can thrive. Some bacteria may thrive in both the rhizosphere and the root region, promoting plant growth both directly and indirectly, and are thus classified as Plant Growth Promoting Rhizobacteria (PGPR). Although microorganisms colonise all sections of the plant, the rhizosphere is the primary source of bacteria due to its plant-beneficial activities. The usage of PGPR is viewed as an alternative source that reduces the use of chemical fertilizers in agricultural fields while also preventing the spread of plant diseases through a variety of processes.

PGPR can be divided into two categories: extracellular plant growth promoting rhizobacteria (ePGPR) and intracellular plant growth promoting rhizobacteria (iPGPR) (iPGPR). Extracllular PGPR are found mostly on the outer section of the root surface, known as the rhizoplane or otherwise the space between the cells of the root cortex, while intracellular PGPR are found primarily within the nodular arrangements of root cells. *Agrobacterium*, *Bacillus*, *Burkholderia*, *Azotobacter*, *Azospirillum*, *Arthrobacter*, *Flavobacterium*, *Chromobacterium*, *Caulobacterium*, *Erwinia*, *Micrococcus*, *Pseudomonas*, and *Serratia* are extracellular PGPR Ahemad and Kibret 2014). *Allorhizobium*, *Bradyrhizobium*, *Mesorhizobium*, and *Rhizobium* are members of the *Rhizobiaceae* family, which belongs to intracellular PGPR. Endophytes and Frankia species can fix atmospheric nitrogen in a symbiotic relationship with higher plants.

Through many mechanisms, PGPR promotes direct and indirect plant growth and helps with nutrient consumption, N2 fixation, phosphorus solubilization, siderophore production, IAA, and other growth phytohormones by a direct method (Pahari et al. 2016). Plant pathogenic bacteria, which are a major source of concern for agricultural sustainability and environmental stability, are regulated indirectly through the synthesis of antibiotics, siderophores, and lytic enzymes. The use of PGPR is a viable ecological and green alternative for achieving long-term soil fertility and plant growth.

Iron Chelator: Bacterial Siderophore

Due to the limited availability of Fe^{3+} in the soil, microorganisms have developed explicit absorption strategies such as siderophores. Many bacteria, including *Pseudomonas*, *Azotobacter*, *Bacillus*, *Enterobacter*, *Serratia*, *Azospirillum*, and *Rhizobium* (Pahari and Mishra 2017), manufacture siderophores (Greek: "iron carriers"), which are low molecular weight (500–100 dt), ferric ion specific chelating agents. Siderophore not only forage iron from the environment to make a mineral that is very vital and accessible to microorganisms, but they also build complexes with other metals in the environment, such as Molybdenum, Manganese, Cobalt, and Nickel, to increase availability to microbial cells. Biosynthesis of siderophores takes place at the cellular level, and it is carried out by a series of enzymes that are specific to each siderophore. The relevant genes are found on the bacterial chromosome or Plasmid. Over 500 biomolecules are categorized as siderophores, and their manufacture, transport, and re-import into the cell are all regulated by a variety of genes and regulators.

Many of the siderophores, however, are peptides produced by members of the multi-enzyme family. Microbial peptide antibiotics are also synthesized by the non-ribosomal peptide synthetase (NRPS). The non-ribosomal peptide synthetase (NRPS)-dependent mechanism demonstrates that mRNAs were not involved in the biosynthesis process. Other siderophores, such as numerous hydroxamate-type siderophores, are formed through methods that are not dependent on NRPS.

Plant Growth Promoter : Siderophore

Siderophores are an environmentally safe alternative to dangerous chemical pesticides that can be employed in a variety of agricultural applications. Iron is a necessary micronutrient for a variety of physiological processes in plants, including chlorophyll production and redox reactions. As a result, an iron deficiency affects both the quality and quantity of crop production. However, some researchers have looked into microbe-plant and siderophore-plant interactions in the context of iron deficiency. Different species of *Pseudomonas* have been thought to enhance plant growth by producing pyoverdine siderophores and hydroxymate type of siderophore producing *Pseudomonas* sp. enhanced nodulation and nitrogen fixation of mung bean plant when compared to plant infected with Bradyrhizobium strain alone for decades. Excessive heavy metal accumulation is hazardous to most plants and is responsible for soil contamination, which reduces soil fertility and microbial activity. In this regard, the hydroxamate type of siderophore found in soil plays a significant role in metal immobilisation. Because the generation of microbial siderophores was completely repressed when the plants were cultivated in sterile circumstances, they can be considered an efficient iron source for the plant.

Conclusion

Microbial diversity and soil health have received a lot of attention in recent years because of the emphasis on organic farming. Organic manure applications directly and/or indirectly boosted the soil microbiome, which is important for maintaining soil fertility and productivity. Microbes that invade the rhizosphere of crop plants are known as Plant Growth Promoting Rhizobacteria (PGPR). These organisms boost crop plant growth and, as a result, productivity by their intrinsic ability to act through direct and indirect processes. In the realm of agriculture, siderophore-producing bacteria found in the rhizosphere are extremely important. Siderophore are low molecular weight phenolic compounds that can bind Fe^{3+} irons, decrease them to Fe^{2+}, and then supply the crop plant. Siderophore not only provides iron to the plant, but it also inhibits the growth of soil-borne phytopathogens that are iron-dependent. As a result, it is planned to use siderophore-producing bacteria in crop fields to boost plant growth and productivity.

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