Role of Endophytic Bacteria in Plant Growth Promotion

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Plants benefit extensively from endophytic bacteria, which live in host plant tissues exerting no harmful effects. Bacterial endophytes promote the growth of host plants and enhance their resistance toward various pathogens and environmental stresses. They can also regulate the synthesis of secondary metabolites with significant medicinal properties and produce various biological effects. Their distribution and population structure are affected by their host plant's genetic characteristics and health and by the ecology of the surrounding environment. Understanding bacterial endophytes can help us use them more effectively and apply them to medicinal plants to improve yield and quality. Endophytes are well known for their potential to improve plant growth by direct and indirect mechanisms. Direct mechanisms involve the microbial synthesis of phytohormones like IAA, ethylene etc. In addition, have the ability of nitrogen fixation. On the other hand, indirect mechanisms include assisting plants in acquiring nutrients *via* phosphate solubilisation, nitrogen fixation and siderophore production. Therefore, characterization of endophytic bacteria with various properties will have much applications to improve plant growth promotion.

Indole Acetic Acid production

Indole acetic acid is the main auxin in plants controlling many important physiological processes including cell enlargement, cell division, tissue differentiation and responses to light. IAA Stimulates over production of root hairs, lateral roots in plants and release of saccharides from plant cell walls during the elongation. Hassan, S. E. (2017) reported that IAA produced by bacteria increase root surface area and length and thereby provides the plant greater access to soil nutrients and water uptake. IAA Stimulates over production of root hairs, lateral roots in plants and release of saccharides from plant cell walls during the elongation.

Phosphate Solubilization

Phosphorus is one of the major essential macronutrients for biological growth and development. *Pseudomonas, Bacillus, Rhizobium, Burkholderia, Achromobacter, Agrobacterium, Micrococcus, Aerobacter, Flavobacterium* and *Erwinia* are the bacterial species having the ability to solubilize insoluble inorganic phosphate compounds such as tricalcium phosphate, dicalcium phosphate, hydroxyapatite and rock phosphate. The use of phosphate solubilizing bacteria as inoculants simultaneously increases phosphorus uptake by the plant and crop yield. The principal mechanism for mineral phosphate solubilisation is the production of organic acids and acid phosphatases which play a major role in the mineralization of organic phosphorous in soil.

Kim *et al*. (1997) explained that phosphate solubilization by PSB strains is associated with the release of low molecular weight organic acids mainly gluconic and ketogluconic which through their hydroxyl and carboxyl groups chelate the cations bound to phosphate, therefore converting it into soluble forms. Endophytic bacterial isolates that displayed a high degree of phosphorus solubilization also exhibited acid and alkaline phosphatase activities, extracellular protease and hydrogen cyanide production, the last two traits being recognized for biocontrol of pathogenic microbes.

Ammonia Production

Cultivated rice (*Oryza sativa*) is the most important staple crop and nitrogen is the main input required for rice production. For sustainable rice cultivation, identification of the diazotrophic bacteria along with plant growth promotion and antagonistic traits.

Ammonia can be produced by several processes such as Nitrite ammonification, decarboxylation of amino acids to produce biogenic amines as well as ammonia, deamination and the urease mediated hydrolyze degradation of urea. The Ammonia so produced cannot be assimilated by plants but will be available through biological nitrogen fixation processes that only prokaryotic cells have developed including some *Eubacteria*, *Cyanobacteria* and *Actinomycetes*. Mostly these are freely living soil organisms (*Azotobacter*) but some of them have developed symbiotic relation with plant for nutrients in return fixing nitrogen which can be used by plant for growth, for example *Gluconacetobacter, Herbaspirillum, Azospirillum, Bacillus, Enterobacter, Klebsiella, Pseudomonas* and *Burkholderia*. Therefore, production of ammonia by endophytes is a desirable trait for plant growth promotion and soil fertility Karkaria et al (2021).

Cell wall Degrading Enzymes:

Endophytic bacteria are proposed to enter plants through pre-existing openings such as emergence sites of lateral roots or wounds to external plant tissues. Alternatively, it is also possible that bacterial endophytes may create openings by hydrolyzing major plant cell wall components such as cellulose, hemi cellulose or pectin. The ability of bacterial endophytes to evade plant defences is thought to involve in the production of enzymes that degrade elicitors of plant immune responses. As a result, these enzymes also have the function to suppress plant pathogen activities directly.

Bacteria are important alkaline protease producers and *Bacillus* is most prominent producer with ability to produce large amount of extra cellular protease with significant proteolytic activity. Several *Bacillus* species involved in protease production are *Bacillus cereus, Bacillus sterothermophilus*, *Bacillus mojavensis, Bacillus megatarium* and *Bacillus subtilis*

Hydrogen Cyanide (HCN) Production

The ability to produce HCN is most among *Pseudomonads.* The rate of cyanide production in batch cultures differed widely among the different isolates tested (Bakker and Schippers, 1987). Several environmental factors influence rate of production of HCN by *Pseudomonas* sp. Production depends highly on the amino composition of the substrate. HCN production inhibits the proper functioning of enzymes and natural receptors by reversible mechanism of inhibition. Glycine has shown to be the direct precursor of microbial cyanide production and exerts the strongest effect of the aminoacids production.

The rate of microbial HCN production of different crops possibly varies widely due to differences in the amino acid composition of their root exudates and proline is the precursor of microbial HCN production, as glycine and proline found in the root exudates.

Siderophore Production

Endophytic bacteria produce iron chelating agents called siderophores that can bind to insoluble ferric ions. Plants can acquire iron from these bound siderophores either through root based chelate degradation or ligand exchange and play a major role in providing iron to plants under iron limitation.

References

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