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Conceptual

Bacillus: Potential Antimicrobial Agents

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Bacilli are spore forming, aerobic bacteria which are gram positive and non-pathogenic in most cases. These bacteria are widely distributed in the environment with soil as the primary habitat. Bacilli are widely distributed in decaying organic matter, vegetable and water. Most of the species of genus *Bacillus* have significant microbiological uses due to production of numerous antibiotics, enzymes, and other metabolites having potential applications in pharmacy, agriculture, medical and other industries. Important enzymes produced by these bacteria include protease, amylase, phospholipase, lecithinase, hemolysin, collagenase and urease. Some of the antibiotics produced by *Bacillus* include polymyxin by *B. polymyxa*, bacitracin by *B. subtilis*, and *B. licheniformis* and gramicidin by *B. brevis*. These bacteria have been widely studied and well documented as potential biological control agents due to their ability to produce antibiotics.

Bacillus species have the ability to suppress growth of other phytopathogens during competition for colonization in the rhizosphere of several crops like tomato, sweet corn, banana and wheat. These tiny microorganisms own biocontrol activities that linked to the production of lipopeptides. *Bacillus* species perform their activities well by producing biofilm which provide favorable environment to cells while protecting it from unfavorable conditions. Surfactin is one of the most important antibiotics involved in biofilm formation in rhizosphere of crop plants.

Biocontrol substances produced by *Bacillus* species are of great importance because these have proved to tackle several plant pathogens. They compete for space and nutrients with other pathogens. The *Bacillus* species can also improve plant growth through induced systematic resistance due to production of large number of antimicrobial substances such as lipopeptides, antibiotics and enzymes.

Other antibiotics produced by *bacillus* species against pathogens are effective amphiphilic and surfactant lipopeptides which includes iturins, bacillomycins, mycosubtilin and fengycins or plip statin. The non-ribosomally-encoded lipopeptides are antibiotic compounds that have negative impacts on phytopathogens. The lipopeptides produced by *Bacillus* species are of great importance in agriculture and pharmacy because these have specific antifungal properties in plants. There are almost 261 peptides which have been isolated and identified from bacteria. The peptides obstruct and disrupt the cellular and intercellular structures of fungi and finally result in death of fungi.

The *Bacillus* species enhance seedling growth, leaf area and, shoot and root growth of plants by producing plant growth promoting hormones and antioxidant defense inducing enzymes such as peroxidase (PO), polyphenol oxidase (PPO) and superoxide dismutase. By the production of these enzymes, plants can activate resistance against pathogenic organisms. *Bacillus* species also enhanced the level of major nutrient content and chlorophyll content in plants and defense inducing gene PR1 in plant tissues so that plant can combat against diseases. Chitinase is an enzyme that can break chitin, which is structural component of pathogens cell wall especially that of fungi, component of outer shell of insect body and a component of other arthropods and crustaceans. Chitinase can be used as biocontrol agent due to its ability to break chitin of phytopathogenic fungi, as well as an insecticide against insect pests. Chitinase production from *Bacillus* species can be usable in the field of agriculture, for plant protection from phytopathogens. There are other such substances produced by *Bacillus* spp. like chitosanase, protease, cellulase, glucanase and hydrogen cyanide that trigger negative effect on several pathogens such as pathogenic bacteria, fungi, nematodes, viruses and pests and improve crop productivity.

Siderophores are also produced by *Bacillus* species which chelate iron and provide iron to root zone and at the same time compete with pathogens to prevent iron availability to other pathogens. In this way, they suppress the growth of pathogens and play role in disease control. The siderophores also aid in root colonization of *Bacillus*. These metabolites disturb the respiration mechanism of pathogens, compete with them for nutrients and break their cell wall structures. These metabolites also increase resistance in plants against pathogen by changing plant physiology. Due to production of these antimicrobial agents, *Bacillus* has been termed as important genus of bacteria in human and plant health.

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