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Biostimulants in Crops

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Abstract

Agricultural or plant biostimulants are biological or biologically derived fertilizer additives and similar products that are used in crop production to supplement and enhance existing agricultural practices and crop inputs. It is intended to provide a broad overview of known effects of biostimulants and their ability to improve tolerance to abiotic stresses. Inoculation or application of extracts from algae or other plants have beneficial effects on growth and stress adaptation. Algal extracts, protein hydrolysates, humic and fulvic acids, and other compounded mixtures have properties beyond basic nutrition, often enhancing growth and stress tolerance. Non-pathogenic bacteria capable of colonizing roots and the rhizosphere also have a number of positive effects. These effects include higher yield, enhanced nutrient uptake and utilization, increased photosynthetic activity, and resistance to both biotic and abiotic stresses.

Introduction

Diverse approaches in plant disease management have been very much influenced by the recent advances in the field of molecular biology. Many biotechnical tools have been developed by using different plant pathogens as experimental materials. The increased reflection on environmental concern over pesticide use has resulted in a large upsurge of use of biocontrol methods in India. According to the Directorate of Plant Protection, Quarantine and storage, a total of 361 biocontrol laboratories and units are working in India and there are 970 bio-pesticides registered with the Central Insecticide Board and Registration Committee Data suggests that in India the use biocontrol has increased in the last few decades from 7,190 MT in 2016-17 to 8,645 MT in 2020-21.

A promising and environmental-friendly innovation would be the use of natural plant biostimulants (PBs) that enhance flowering, plant growth, fruit set, crop productivity, and nutrient use efficiency (NUE), and are able also to improve the tolerance against a wide range of abiotic stressors (Colla and Rouphael, 2015).

Biostimulants

Plant biostimulants are substances and materials, with the exception of nutrients and pesticides, which, when applied to plant, seeds or growing substrates in specific formulations, have the capacity to modify physiological processes of plants in a way that provides potential benefits to growth, development and/or stress responses.

The Curious Role of Biostimulants

Biostimulants can include a wide variety of ingredients, which can be placed in the following four categories:

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• Microorganisms (*e.g.*, fungi and bacteria).

• Extracts from plants or Botanical extracts.

• Organic (*i.e.*, carbon-containing) molecules including various components of soil organic matter.

• Inorganic (*i.e.*, not carbon-containing) elements or molecules.

Biostimulants can enhance plant health in multiple ways. Like biopesticides, a biostimulant may have more than one of the following modes of action:

• Improve soil quality by impacting soil characteristics like water holding capacity, structure, or aeration.

• Improve plant access to nutrients already present in the soil.

• Stimulate plant defences or otherwise increase the plant's tolerance to stress (from biological or non-biological sources).

• Improve root growth of the plant (so that the plant can take up nutrients better).

• Improve the quality of something produced from or by the plant (*e.g.*, improved flavour or nutrition of fruit).

While biostimulants focus on judicious and reduced use of fertilizers, biological control aims to reduce application of pesticides. Biological control is a method of restricting the effects of harmful animals, pathogens and plants using other useful organisms, *e.g.*, microorganisms, insects and plants that inhibit the harmful organisms. Predation, parasitism, pathogenicity, and competition are all examples of basic ecological interactions between species that the approach makes use of. Biological control is now predominantly employed in agricultural agriculture to combat pests.

Microbial Plant Biostimulants

Microbial biostimulants, especially bacterial plant biostimulants (BPBs), to improve crop growth and productivity. The BPBs that are based on PGPR (plant growth-promoting rhizobacteria) play plausible roles to promote/stimulate crop plant growth through several mechanisms that include-

• nutrient acquisition by nitrogen (N_2) fixation and solubilization of insoluble minerals (P, K, Zn), organic acids and siderophores;

• antimicrobial metabolites and various lytic enzymes;

• the action of growth regulators and stress-responsive/induced phytohormones;

• ameliorating abiotic stress such as drought, high soil salinity, extreme temperatures, oxidative stress, and heavy metals by using different modes of action; and

• plant defense induction modes.

Bacterial plant biostimulants (BPBs) comprise a major category of plant biostimulants. Plant growth-promoting rhizobacteria (PGPR) that colonize the plant rhizosphere are the most prominent group in this category (Du Jardin, 2015). These PGPR improve plant growth, control plant pathogens, improve nutrient and mineral uptake in plants, and increase plants' resistance to various types of biotic stresses and tolerance towards abiotic stresses.

The representative beneficial groups of PGPR-based BPBs include nitrogen-fixing *Rhizobium* spp., *Azotobacter* spp., *Azospirillum* spp., *Pseudomonas* spp., and *Bacillus* spp. (Lugtenberg, 2015; Rouphael and Colla, 2020).

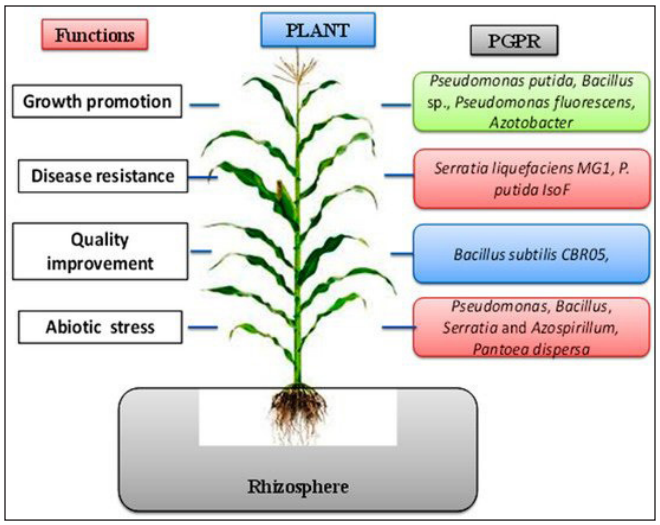

Figure 1: Beneficial influence of PGPR on crop plants

Non-Microbial Biostimulants

Protein hydrolysates (PHs) which contain mainly signaling peptides and free amino acids have gained prominence as non-microbial PBs because of their potential to enhance germination, seedling growth, plant growth, fruits, and vegetables quality as well as crop productivity especially under environmental stress conditions (Colla *et al.*, 2015). Seaweed extracts (SWE) represent another important category of organic non-microbial PBs; however red, green, and brown microalgae are the most common SWE used in agriculture and horticulture with several commercial products present on the market.

Microalgae, impacts critical agricultural needs such as biological nitrogen fixation, soil phosphorus cycling, effects on soil microorganisms, plant growth promotion either by soil nutrient cycling and/or phytohormones or root associations, biocontrol, and soil stabilization.

Microalgae improve soil fertility and contribute to plant growth and protection and offer an alternative to reduce our dependence on chemical fertilizers and pesticides. Microalgae also fix carbon dioxide through photosynthesis for carbon capture and some produce exopolysaccharides that improve soil structure.

Conclusion

The work to be focused on developing biostimulant and biological products rooted in biology and biochemistry, with the goal of further improving the performance of plant nutrition programs and providing growers with the tools they need to increase productivity and sustainability.

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