

GROWING GREEN

Path To Sustainability

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Abstract

The current challenges posed by increasing global population, decreasing arable land and unfavorable environmental conditions are threatening the development of sustainable and environmental friendly systems. Increasing global population, decreasing arable land and unfavorable environmental conditions that are prevailing today are posing serious threats to the development of sustainable and environmental friendly systems. For achieving higher yield along with quality production, various types of products derived from biological origin have gained importance in the past few years. Among the natural products, biostimulants have shown immense potential in reducing the reliance on chemical fertilizers, pesticides and herbicides. Biostimulants are substance or mixture of substances of natural origin or microorganisms which improve the condition of crops without causing adverse side effects. Important categories of plant biostimulants include humate substances, protein hydrolysates, seaweed extract, biopolymers and microbial inoculants. Fruits

crops are subjected to various kinds of abiotic (extreme in temperature, salinity, heavy-metals drought, etc.) and biotic stresses (insects, nematodes, fungi or bacteria) which limit their quality production and yield. Biostimulants are reported to improve plant development subjected to various types of stresses. Application of biostimulants help to promote physiological actions like photosynthesis, nutrients metabolism, enzymatic activities, chlorophyll, protein and carbohydrate contents and thereby help in mitigating biotic and abiotic stresses. The use of biostimulants can make agriculture more sustainable and resilient as they play important role in protecting the plants from various stresses. The potential benefits of biostimulants are expected to challenge the dominance of the chemical industry and help in overcoming the global problem of food security. However, selection of an appropriate biostimulant as per need is critical as their effects may vary in different species.

Introduction

It is estimated that global population will increase to 9.1 billion in the next 3 decades which will be 34 per cent more than today's population (FAO, 2018). Decreasing arable land and unfavourable environmental conditions are other factors which are posing serious threats to the development of sustainable and environmental friendly systems. For achieving higher yield along with quality production, various types of products derived from biological origin have gained importance in the past few years. These natural products not only have positive influence on natural environments but also known to enhance health of the plants.

Among the natural products used, biostimulants are considered to be important products having immense potential to reduce the dependency on chemical fertilizers and pesticides.

Types of biostimulants

Five major categories of plant biostimulants are humate substances, protein hydrolysates, seaweed extract, biopolymers and microbial inoculants.

1. Humate substances are natural constituents of the soil organic matter, resulting not only from the decomposition of plant, animal and microbial residues but also from the metabolic activity of soil microbes using these substrates. Humate substances makes the soils more friable and breaks up hard pan, increases water holding capacity and aeration of soil, reduces soil erosion, greater absorption of solar energy providing warmer sub soil temperature.

2. Protein hydrolysates are mixture of peptides and amino acids, mainly produced by enzymatic or chemical

According to Du Jardin (2015), biostimulants are defined as "Any substance or mixture of substances of natural origin or microorganisms which improve the condition of crops without causing adverse side effects". Horticultural crops are subjected to various kinds of abiotic (extreme in temperature, salinity, heavy-metals drought, etc.) and biotic stresses (insects, nematodes, fungi or bacteria) which limit their quality production and yield. Biostimulants are reported as highly effective in improving plant development subjected to various types of stresses (Colla *et al.*, 2015). Application of biostimulants help to promote physiological actions like photosynthesis, nutrients metabolism, enzymatic activities, chlorophyll, protein and carbohydrate contents and thereby help in mitigating biotic and abiotic stresses.

hydrolysis of proteins from animal or plant derived raw materials or agro industrial by products. Several benefits of protein hydrolysates include: increase in microbial biomass, enhancement in roots growth and improvement in soil respiration, fertility, nutrients etc.

3. Seaweed extracts are brown, red and green marine macro algae. The biological activity of these extracts depends on the raw material and extraction process like alkali extraction, acid extraction or any other technology. Major components are polysaccharides (30-40%) of the dry weight and include alginates and laminarins. Polysaccharides possess plant growth promoting activities and are known to trigger defense responses.

4. Chitosan is a biopolymer in nature that arises from natural component i.e., cell walls of fungi, exoskeletons of insect and crustacean shells etc. The physiological activity is to bind plasma membrane, cell wall elements and specific receptors. The physiological effects of chitosan are oligomers in plants i.e. it results in binding of this polycationic compound to a wide range of cellular components, including DNA, plasma membrane and cell wall constituents and also helps to bind the specific receptors involved in defence gene activation.

5. Microbial inoculants include arbuscular mycorrhizal fungi, *Rhizobium*, *Trichoderma*, and plant growth-promoting rhizobacteria. PGPBs (plant growth promoting bacteria) includes:

Method of application of Biostimulants:

1. Soil Preparations (Powder or Granules form)
 - Humic and Fulvic Acids

Ectorrhizosphere: bacteria that inhabit the zone around the root, Rhizoplane: bacteria that colonize the root surface and Endorhizosphere: bacteria that live within the roots. One of the best effects of PGPBs on plants is their ability to fix nitrogen and to produce siderophores. Siderophores are low-molecular-weight molecules that chelate iron with a very high and specific affinity. Many bacteria produce and secrete siderophores to scavenge iron from the extracellular environment and to provide soluble iron to plants for its growth. These siderophores are also known to form stable complexes with other metal atoms such as Al, Pb, Cd, Cu, Zn, etc. which consequently increases availability.

2. Foliar Applications
 - Chitosan & its Derivatives
 - Seaweed Extracts and Other Botanicals

Market products

Nowadays, biostimulants products can be easily accessible and already formulated that can be used as per the recommendation. It is been reported MarkNtel Advisors, a leading research, consulting and data analytics firm, that the global biostimulants market was valued at USD 3.13 billion in 2022 and growing

at a Compound Annual Growth Rate of 11.80% from 2022 to 2030. The biostimulants market is predicted to expand in the next few years, driven by rising demand for sustainability in agriculture, increased crop production along with quality enhancement and more environmental friendly approach.

Beneficial effects of biostimulant

- Improve plant growth, productivity
- Act directly on plant physiology and metabolism by improving soil condition
- Alleviate negative effects of plant stresses
- Facilitate nutrient assimilation, translocation and nutrient uptake
- Enhance quality of fruits (nutritional contents, appearance, and shelf-life)
- Enhance water and nutrient use efficiency

Here are some of the case studies

Fruit crop	Biostimulants	Doses	Beneficial effect	References
Grapes	Chitosan	0.5, 1 and 2%	Increases growth of Cuttings	Gornik <i>et al.</i> (2008)
Strawberry	Protein hydrolysate	2.5 g/L	Increased plant biomass, promotes flowering and early production of fruit	Marfà <i>et al.</i> (2008)
Grapevines	PGPB (<i>Burkholderia</i> spp.)	3×10 ⁸ CFU/ml	Production of metabolite which are related to increase resistance against low temperature	Theocharis <i>et al.</i> (2012)
Strawberry	Amino-acids	0.5, 1 and 1.5g per plant	Resistance against low temperature.	Bogunović <i>et al.</i> (2015)
Blueberry	AMF (<i>Glomus mosseae</i>)	-	Increases superoxide dismutase, improves peroxidase activities,	Liu <i>et al.</i> (2017)

Challenges involved in using Biostimulants:

- Lack of Standardization:** There is currently no standardized framework for biostimulants, which can create confusion among farmers, manufacturers and regulators. This lack of standardization also makes it difficult to compare different biostimulants products and assess their effectiveness.
- Limited Scientific Research:** While biostimulants have been shown to have positive effects on plant growth and development, the mechanisms of action are not well understood. Lack of research work tailors the use of biostimulants to some specific crop only.
- Limited Awareness:** While the awareness of biostimulants is increasing, many farmers and research workers are still unfamiliar with their benefits.

Conclusion

Biostimulants helps in promoting physiological actions thereby help in mitigating stresses and have constructive role in enhancing plant growth, yield as well as environmental stability but there are challenges in adoption of sustainable technology. During life cycle of fruit crops, they are often exposed to abiotic and biotic stresses, either alone or in combination, which could dramatically reduce the yield and quality of products. Biostimulants differ from fertilisers and insecticides in that they do not offer nutrients or manage pests and diseases directly. Instead, they

strengthen the plant's ability to absorb nutrients, water, and other necessary components from the soil, as well as its tolerance to abiotic and biotic stressors. Biostimulants could represent an effective and sustainable tool to enhance plant growth and productivity, improving tolerance against abiotic as well as biotic stresses. The potential uses of biostimulants will definitely create a rebellion under chemical industries and will help in overcoming the problem of food security in world.

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