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Use of Plant-Based Biostimulants in Organic Horticulture

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SUMMARY

Plant-based biostimulants are emerging as a promising tool in organic horticulture, offering an eco-friendly alternative to synthetic agrochemicals. These substances, derived from botanical extracts, seaweeds, compost teas, and other natural sources, enhance plant growth, nutrient uptake, stress resistance, and overall productivity. This article reviews the types, mechanisms, and applications of plant-based biostimulants in fruit, vegetable, and ornamental crops, highlighting their potential to improve soil health, crop quality, and sustainability in organic systems.

INTRODUCTION

The demand for organic horticultural produce has surged globally due to increasing consumer awareness of food safety, environmental sustainability, and health. However, organic farming often faces constraints such as limited nutrient availability, lower yields, and higher susceptibility to biotic and abiotic stresses. In this context, plant-based biostimulants offer a sustainable solution by enhancing crop performance without violating organic standards. Biostimulants are defined as substances or microorganisms that stimulate natural processes to improve nutrient uptake, efficiency, tolerance to abiotic stress, and crop quality, independent of their nutrient content. Among them, plant-based biostimulants are particularly valued in organic systems due to their renewable origin, biodegradability, and compatibility with organic certification norms.

Types of Plant-Based Biostimulants

Plant-based biostimulants encompass a diverse group of naturally derived substances known for their ability to stimulate physiological processes in plants. These inputs not only support plant growth and development but also enhance stress resilience and soil health. The following are the major categories:

Seaweed Extracts: Derived primarily from brown marine algae such as *Ascophyllum nodosum*, seaweed extracts are among the most widely used plant-based biostimulants in horticulture. These extracts are a rich source of bioactive compounds including plant hormones like auxins, cytokinins, and gibberellins, as well as trace elements, polysaccharides (alginates, laminarins), amino acids, and antioxidants. Their mode of action includes stimulation of root initiation and elongation, enhanced chlorophyll production, increased flowering and fruit set, and improved tolerance to environmental stresses such as drought, salinity, and heat. In organic systems, seaweed extracts are valued for their ability to improve plant vigor and postharvest quality without harmful residues.

Botanical Extracts: These include aqueous or ethanolic extracts from a variety of plant sources such as neem (*Azadirachta indica*), moringa (*Moringa oleifera*), garlic (*Allium sativum*), aloe vera (*Aloe barbadensis*), and fenugreek (*Trigonella foenum-graecum*). Each of these botanicals contains a unique spectrum of secondary metabolites such as flavonoids, terpenoids, alkaloids, and essential oils. Neem, for instance, is known for its bioactive compound azadirachtin which acts as both a growth stimulant and a natural insect repellent. Moringa leaf extract is highly effective due to its content of zeatin (a cytokinin), vitamin C, calcium, and antioxidants, which collectively improve photosynthesis, flower retention, and yield in crops like tomato and okra. Aloe vera extract enhances root development and resistance to fungal pathogens through its saponins and enzymes.

Compost Tea and Vermiwash: Compost tea is a water-based extract of decomposed organic matter that contains soluble nutrients, enzymes, and a consortium of beneficial microorganisms such as nitrogen-fixing bacteria, phosphate-solubilizing bacteria, and actinomycetes. Vermiwash, a liquid leachate obtained from earthworm beds, is rich in plant growth regulators (auxins, gibberellins), micronutrients, amino acids, and microbial metabolites. These bio-inputs improve soil microbiology, suppress foliar and soil-borne pathogens, and stimulate plant immune responses. Regular foliar and soil application has been associated with improved plant vigor, flowering, and yield in organically grown vegetables and flowers.

Humic and Fulvic Acids: While these are technically formed from the decomposition of plant and microbial biomass rather than directly extracted from plants, humic and fulvic acids are often included in plant-based biostimulant formulations due to their origin in compost and organic matter. Humic acids improve soil structure, increase water holding capacity, and enhance root biomass. Fulvic acids, being of lower molecular weight and higher solubility, facilitate the chelation and transport of micronutrients into plant tissues. Their combined application is known to enhance seed germination, chlorophyll content, and stress resilience, especially in nutrient-poor soils commonly encountered in organic farming.

Mechanisms of Action Plant-based biostimulants function through multiple biochemical and physiological pathways:

Enhancing Nutrient Uptake: By stimulating root growth and microbial colonization, they improve nutrient absorption and translocation.

Hormonal Modulation: Seaweed extracts and moringa leaf extract contain phytohormones that regulate growth and flowering.

Stress Alleviation: Certain biostimulants enhance antioxidant enzyme activity, reducing oxidative damage under drought, heat, or salinity stress.

Microbial Stimulation: Compost teas enhance rhizospheric microbial diversity, improving nutrient cycling and disease suppression.

Applications in Organic Horticultural Crops

Fruits: In mango, guava, and banana, foliar application of moringa and seaweed extracts has shown increased fruit set, size, and shelf-life.

Vegetables: Tomato, chili, and cucumber show enhanced vegetative growth, flowering, and yield with biostimulant use.

Ornamentals: Floricultural crops like marigold, gerbera, and rose benefit from improved bloom quality and stem strength.

Advantages in Organic Systems

- Complies with organic certification standards (e.g., NPOP, EU Organic Regulation).
- Reduces reliance on chemical fertilizers and synthetic plant growth regulators.
- Enhances soil microbial activity and promotes regenerative soil health.
- Increases resilience to climate-induced stresses.

Challenges and Limitations

- Lack of standardization in formulation and quality control.
- Variable efficacy depending on crop, dose, and application method.
- Limited availability of commercial products in rural markets.
- Regulatory ambiguities in classification and labelling.

Future Perspectives

- Research is needed to elucidate precise mechanisms using molecular tools.
- Development of crop- and stage-specific biostimulant formulations.
- Integration with other organic inputs for holistic nutrient and pest management.
- Strengthening policy and certification frameworks to include novel plant-based products.

CONCLUSION

Plant-based biostimulants represent a sustainable frontier in organic horticulture. By enhancing nutrient efficiency, plant vigor, and resilience to stress, they hold the potential to bridge the productivity gap in organic systems while maintaining ecological integrity. With ongoing research, farmer training, and regulatory support, these biostimulants can become a cornerstone of sustainable horticultural practices.

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