

Plant stimulants and horticultural production

Abstract

Plant stimulants is an organic substance and micro-organisms, used by small quantities, Biostimulants categorize according to their nature, modes of action, and types of effects on crops, there are main groups of plant stimulants include Protein hydrolysates, Humate substances, Seaweed extracts, Biopolymers (Chitosan and other polymers), and Microbial biostimulants like mycorrhizal, non-mycorrhizal fungi, Rhizobium, and Trichoderma.

Horticulture crop production facing several challenges particularly abiotic stresses and malnutrition resulting in yield loss and affects negatively fruit quality. The main effects of plant stimulants due to its working as the auxin-like effect, enhancing Nitrogen uptake, and stimulate plant growth. There is various stimulation effects on horticulture crops including promote plant growth, increase plant tolerance for biotic and abiotic stresses. Applying plant stimulants to plants or the rhizosphere stimulating plant metabolic processes, increase the efficiency of the nutrients, and increase plant tolerance to abiotic stress, consequently, improving plant growth increases yield, and enhancing fruit quality.

Keywords: horticulture crops, humate substances, plant stimulants, protein hydrolysates, seaweed extracts

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Introduction

Under global warming conditions, there are different challenges facing horticulture production, and it is expected to get worse shortly. Therefore, focusing on improving horticulture crop productivity considered the main target for many researchers to achieved food security.¹ Climate changes have affected the rain precipitation and reduce the growth and productivity of various crops,² the water shortage is one of the severe problems in horticulture production, it affects various metabolisms, impaired photosynthetic activity, reduce vegetative growth, decrease total yield, and produce poor fruits, the water shortage is one of the severe problems in horticulture resulting in yield loss and affects negatively fruit quality.³

In recent decades, due to the rapid increase in the world population, there is a more growing demand for food worldwide, it is necessary to increase crop yield, even under stressful conditions, like water deficit, salinity, and rising temperature. Currently, there is more attention to understanding tree behavior under this condition to sustain crop productivity. Researchers looking for new ingredients to sustain the production systems for horticultural crops and reducing the negative effects of abiotic stress particularly drought and salinity, application of biostimulants is more efficient in promoting the recovery of different crops after subjecting to water shortage stress.⁴

Biostimulants play important role in controlling the adverse effects of abiotic stresses like water deficit and have an anti-stress role on plant metabolism,³ consequently improve the growth and productivity of different horticulture crops, also, plant stimulants that contain seaweed and fulvic acid had antioxidant effects and protect plant through reducing produce free radical.⁵ Plant stimulants are used to increase agricultural production under serious challenges facing humanity, which represented by feeding a growing population worldwide and reducing the impact of agricultural agrochemicals on human health and the environment,⁶ Many biostimulants improve plant nutrition, for instance, biofertilizers as a subcategory of biostimulants, improve nutrient use efficiency, and increase nutrients acquisition uptake by plants.⁵

This work discusses the role of plant stimulants in the horticultural sector, their effects on nutrient absorption, both primary and secondary metabolisms.

Materials and methods

This review was explaining the importance of plant stimulants and their role in improving horticulture crop productivity, also classification of plant stimulants, and the mechanism of different biostimulants like Protein hydrolysates (PHS), Humate substances, Seaweed extracts, and chitosan. A systematic literature review was conducted, searching the platforms Research Gate, Academia and Egyptian Knowledge Bank, Web of Science, Google Scholar, AGRIS, for a combination of the following keywords: “Plant stimulants”, “horticulture crops”, “Protein hydrolysates”, “Humate Substances” and “Seaweed extracts”. The most recent papers dealing with plant stimulants were selected for this review.

Plant stimulants

Plant stimulants are defined according to European Biostimulant Industry Council (www.biostimulants.eu), as follow: plant biostimulants contain substance (s) and/or micro-organisms whose function when applied to plants or the rhizosphere is to stimulate natural processes to increase the utilization of nutrients, increase their efficiency, and raising the plants’ tolerance to abiotic stress, and to enhancing fruit quality.⁷ Furthermore, plant biostimulants including any materials or microorganisms used to improve nutrition efficiency, enhance tolerance of abiotic stress, and improve crop quality.⁴

Classification of plant stimulants

Biostimulants categorize according to their nature, modes of action, and types of effects on crops. There are different classifications of plant biostimulants, for example, Kauffman et al.⁸ divided biostimulants into three basic groups according to their source and their content of organic ingredients as follows:

- a. Humate substances,

- b. Seaweed extracts,
- c. Amino acids containing products.

The amino acid group includes both free amino acids and polypeptides produced by hydrolysis of agro-business by-products from different sources such as animal, plant origins, and biomass crops.⁹

Benefits of plant stimulants

Plant stimulants play various roles in a plant cell that include hormone-like activity, nitrogen uptake, and growth stimulation, it's work as an enhancer for various metabolic activities in the plant cell, provide higher rates of photosynthesis, increases the activity of antioxidant enzymes and affords the efficiency of mechanisms to get rid of excess energy, so, there are various beneficial effects of biostimulants of different crops include enhancing growth, yield, and improve fruit quality (e.g., corn, banana, papaya, strawberry, red grape, Mango),^{10,11} biostimulants could apply by different techniques such as soil and foliar applications, also, it could use through irrigation system depending on the purpose of the application.¹²

- i. Improve crop quality.
- ii. Enhancing nutrient efficiency.
- iii. Increasing tolerance of environmental stress.

Main categories of plant biostimulants

- a) Protein hydrolysates (PHs) and other N-containing compounds.
- b) Humate substances.
- c) Seaweed extracts.
- d) Biopolymers (Chitosan and other polymers).
- e) Microbial biostimulants include mycorrhizal and non-mycorrhizal fungi, Rhizobium, *Trichoderma*, and Plant Growth-Promoting Rhizobacteria.

Various biostimulants increase nutrients uptake and assimilation, they do so regardless of their nutrients contents, for instance, Biofertilizers, which are considered a subcategory of biostimulants, enhance nutrient use efficiency and increase nutrients in plant acquisition. There are various microbial biostimulants like mycorrhizal and non-mycorrhizal fungi, bacterial endosymbionts, and Plant Growth-Promoting Rhizobacteria (PGPR), so, application of biostimulants (microorganisms) in the field provide a duple function as a biocontrol agent and biostimulant.¹³

Protein hydrolysates (PHs)

Protein hydrolysates (PHs) considered one of the important plant stimulants, consist of a mixture of peptides and amino acids produced from animal or plant-derived raw materials,¹⁴ currently there more attention to (PHs) as an important tool for sustainable plant production, PHs have to promote effects as plant biostimulants on plant growth, it can increase yield and product quality of various plants particularly horticultural crops like fruit trees, vegetables, flower, and ornamentals plants.¹⁵

The PHs are classified according to the source of proteins and the method of protein hydrolysis, PHs enhancing plant enzymatic and non-enzymatic antioxidants, affects plant metabolism both primary and secondary through various biochemical and physiological

processes like increased nitrate reductase and glutamine synthetase activities, and Fe (III)-chelate reductase activity, also, due to the presence of peptides in PHs,¹⁶ there is numerous work indicating a strong gibberellin-like activity of PHs on plant growth Cola et al.¹⁷ on dwarf Peas (*Pisum sativum* L.); Ertani et al.¹⁸ on lettuce (*Lactuca sativa*); the most regular benefit to the use of biostimulant are the alleviate negative impacts of the abiotic stress on plant growth and productivity, abiotic stresses are the main reason for losing 60–70% of the yield in various crops. PHs play an important role in alleviating abiotic stresses, for instance reducing chloride effect on persimmon (*Diospyros kaki* L. f.).^{12,19,20}

The main actions of biostimulants are

- A. Working as the auxin-like effect.
- B. Enhancing Nitrogen uptake.
- C. Stimulate plant growth.

So, it could act as plant growth regulators, therefore, using PHs in corn and tomato cultivation increased nutrient absorption mainly nitrogen and iron Planques, et al.,²¹ and Ertani, et al.,¹⁸ also, it could work as a chelating agent,²² PHs play important role in enhancing salinity tolerance in corn plants.²³

There are the different role of PHs in plant metabolism includes:

- i. Better nitrogen metabolism.
- ii. Higher K/Na ratio.
- iii. Proline accumulation in leaves.
- iv. Enhancing salinity tolerance.

The stimulant IAA-like activity of PHs may be due to their higher content of tryptophan which is the main precursor for IAA biosynthesis in plants, in addition to the biological effect of peptides, which hydrolysate plant-derived protein, various peptides signals contribute to various aspects of plant growth regulation like callus growth, meristem organization, and defense mechanism.²⁴ Both secretory and non-secretory peptides signals have an important role in regulating plant enzymes as they contribute to the regulation of plant defense responses, plant growth, in addition to stimulating root growth.²⁵ There are different direct effects of PHs in plant metabolic processes like inducing carbon and nitrogen metabolism, stimulating hormonal activities; moreover, indirect impacts of PHs include increase nutrient absorption, and enhancing use efficiency of uptake of minerals.²⁶ Further studies are required to explain the mechanisms of action of PHs, which conferring the beneficial effects of the PHs, as well as increasing positive impacts, also, proper application methods that increase their effectiveness under various agricultural and environmental conditions.

Humate substances

Humate substances play an important role in plant metabolism, it is widely used in sustainable agriculture, the intensification of agriculture production facing critical situations in providing enough food for a growing world population, in addition to the negative impacts of climate change on the agriculture productivity worldwide, therefore, plant biostimulants based on humic substances represent a potential solution to induce sustainable intensification for agricultural products, it stimulates plant growth, increases plant tolerating for stress conditions, modifies whole-plant growth, as well as promoting plant health.²⁷

Role of humate substances in plant growth

The inducing influence of humate substances are related to nutrient absorption and the physiological changes in root system and structure, there is a positive relationship between the humate matter and its bioactivity as stimulators for growth of lateral roots, also, it promotes uptake and supply of various nutrients, also, it can induce shifts in plant metabolism under abiotic stress, stimulate plant growth,²⁸ as well as increase plant tolerating for stress conditions and modify whole-plant growth as well as promoting plant health, also, the exogenous application of humic substances used to improve the development of agricultural systems and sustain intensify.²⁹

The main effects of humate substances

There are numerous benefits of humate substances application in the horticultural sector (Figure 1), include:

- Improve root growth and structure
- Enhancing nutrient uptake and efficiency.
- Increase yield
- Stimulate fruit quality.
- Increase plant tolerance to abiotic stresses.

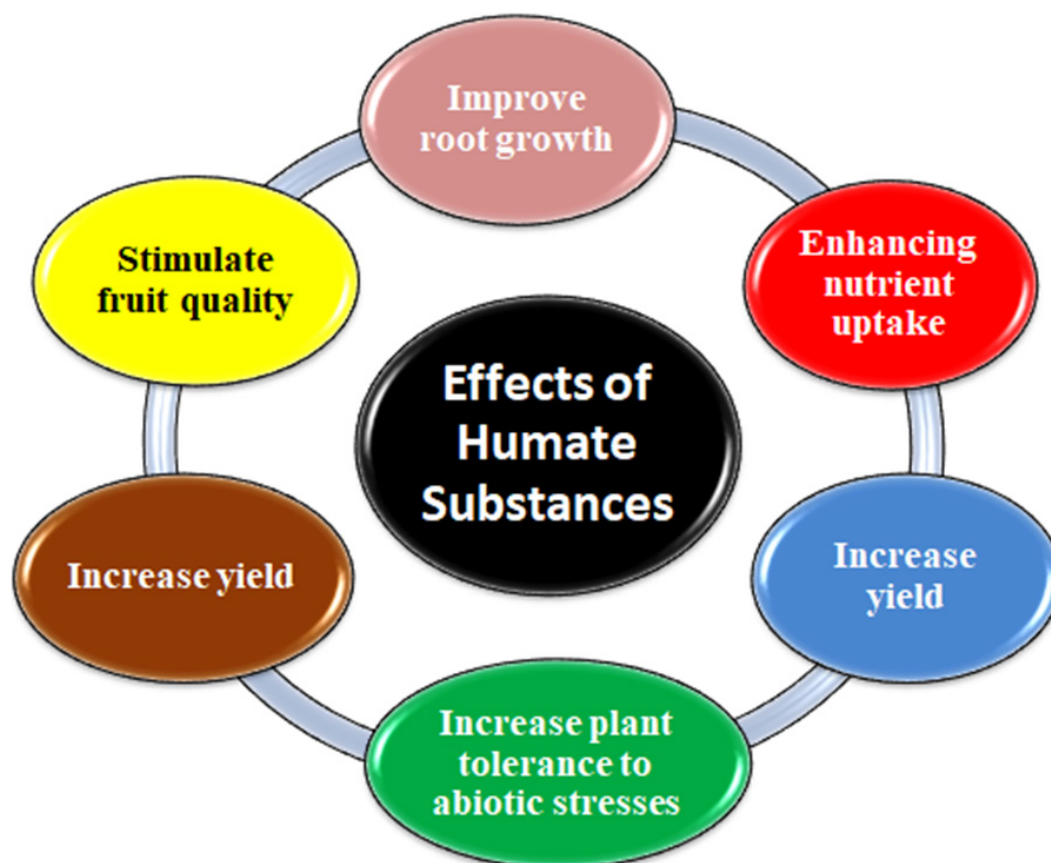


Figure 1 Schematic for main effects of humate substances on horticulture crops.

Seaweed extracts as plant biostimulants in horticulture

Seaweeds have various stimulation effects on horticulture crops including promote plant growth, increase plant tolerance for biotic and abiotic stress like drought,³⁰ salinity, rising temperatures, fungal disease;³¹ herbicides,³² and nutrient deficiency, also, increase yield, and improve fruit quality particularly shelf life,³³ high intensity of Ultra Violet.³⁴

Seaweed extract includes numerous chemical ingredients like complex polysaccharides, Phytohormones, fatty acids, vitamins, and mineral nutrients.³⁵ Currently, there is more attention for using seaweed extract in horticulture production as part of the crop management program, there are different Seaweeds extract used in different crops while, the use of extracts of brown algae are the major one in the horticultural sector.³⁶

Biostimulant activity of chitosan in horticulture

Chitosan-based materials have numerous interesting characters, which make them beneficial substances in agriculture production, Chitosan used as a biostimulant to enhancing plant growth, increase plant tolerance for abiotic stress, and to increase various pathogen resistances, while their stimulating effects considered one of the interesting applications in horticulture crops.³⁷ Chitosan plays an important role in enhancing the defense system in plants against pathogens through stimulating various defensive genes in plants, also, induces several enzymes like peroxidase, superoxide dismutase, and catalase.³⁸

Conclusion

Plant stimulants play an important role in improving horticulture crop productivity particularly under abiotic stress, plant stimulants

applied in small doses in both soil or foliar application, there are different types of plant stimulants such as Protein hydrolysates (PHs), Humate substances, Seaweed extracts, Biopolymers, and Microbial biostimulants. Plant stimulants enhancing Nitrogen absorption, and due to auxin-like effects, they stimulate plant growth, increase yield, and enhancing fruit quality.

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Conflicts of interest

The authors declare there are no conflicts of interest.

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