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Bio stimulants use in horticulture - A review

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SUMMARY

Biostimulants are among the natural preparations that improve the general health, vitality, and growth of plants and also protect them against infections. It can be successfully used in both agri and horticultural crops. The main active substances used in such preparations are humic and fulvic acids, protein hydrolysates, salicylic acid, compounds containing nitrogen, seaweed extracts, chitosan, beneficial fungi, and bacteria. Biostimulant formulations may be single- or multi-component. Their physiological effects depend on their composition as they contain various organic and mineral compounds which plants can use as metabolites, growth regulators, and nutrients; however, biostimulants cannot be considered biofertilizers. Biostimulants applied in plant production have been widely considered as an environment- friendly agricultural practice and so are now among tools used in sustainable agriculture.

INTRODUCTION

Biostimulants can be treated as an additive to fertilizers and helps in uptake of nutrients, promote plant growth, and increase the tolerance to abiotic stress. A biostimulant may be any substance or mixture of substances of natural origin or microorganism which improves the condition of crops without causing adverse side effects. Enzymes, proteins, amino acids, micronutrients, and other compounds may be used as biostimulants. Natural stimulants are often included under the term biostimulants, including phenols, salicylic acid, humic and fulvic acids, or protein hydrolases. An important group of plant biostimulants are organisms including fungi and bacteria that change the species composition of organisms found in the soil or plants. Their presence may accelerate the rate of degradation processes or limit the number of specific fungal and bacterial groups. Popular fungi used as biostimulants include *Glomus intraradices*, *Trichoderma atroviride*, *Trichoderma reesei*, and *Heteroconium chaetospira*. Useful bacteria include *Arthrobacter* spp., *Enterobacter* spp., Acinetobacter spp., *Pseudomonas* spp., *Ochrobactrum* spp., *Bacillus* spp., and *Rhodococcus* spp. Biostimulants cannot be defined as fertilizers because they do not provide nutrients directly to plants. Biostimulants may facilitate the acquisition of nutrients by supporting metabolic processes in the soil and plants. An example of such an activity is the facilitation of the development of arbuscular mycorrhizal fungi that transport nutrients to the host plant. The effects of the stimulators may be multifaceted. The effects of their activities vary depending on the type of biostimulant used and the plant variety. However, it should be noted that most of them have a beneficial effect on crops.

Table 1: The main functional components of the particular commercial biostimulants

Biostimulant	Active ingredients
Radifarm	Amino acids, glycosides, saponins, betaines, polysaccharides, organic acids, vitamins, microelements
Megafol	Amino acids (glycin, glutamic acid), betaines, proteins, vitamins (B5, PP, B1, B6), auxin, gibberellin, cytokine
Viva	Folic acid, vitamins (B6 and PP), polysaccharides, humic acids, proteins, peptides, amino acids
Benefit	Amino acids, nucleotides, free enzymatic proteins, vitamins S- 92
Kendal	Urea, oligosaccharides, glutathione, protein hydrolysate, saponins
Bio- algeen	Seaweed Ascophyllum nodosum (L.) Le Jolis extract
Ruter	AA Free amino acids, macro- and microelements
Ergonfill	Animal protein hydrolysates, cysteine, folic acid, keratin derivatives
Grow- plex	SP Liquid humate Bio Rhizotonic Algae extract, vitamins
Roots 2	A mixture of seaweed, humic acid and vitamins
Root & Shoot Builder	Seaweed extract (Ascophyllum nodosum), micronutrients, amino acids, natural chelating agents

Tytanit	Titanium ascorbate
Slavol	Nitrogen- fixing and phosphate- mineralizing bacteria, auxins
Root Juice	Seaweed extract, humic and fulvic acids
Bio Root	Plant and mineral- derived organic acids and humates, alfalfa and soybean meal, brewers yeast, K- sulfate, rock phosphate, sea kelp

Banana (Musa Spp.)

A plant biostimulant prepared by the degradation of chicken feathers, rich in peptides, amino acids and minerals, was sprayed on the leaves at 5% or applied on banana roots at 20% via fertigation. The applications were made 15 days after seedlings transplanting and led to an increase in the content of proteins, amino acids, reducing sugars, phenolics and flavonoids in the ripe fruits. Root application was more effective than foliar spray to induce these changes as well as to induce higher productivity.

Eggplant (*Solanum Melongena*)

The application of *A. nodosum*, on eggplant caused different responses according to the cultivar and the year of evaluation. In general, there was a significant increase in the levels of soluble sugars and the total antioxidant activity of the skin and pulp in the two years of experimentation; some cultivars had increased levels of P, Ca, Fe and Zn in the fruit. Anthocyanin increased in the fruit peel, but only in the second year of evaluation. Muhammed Ali *et al*. varied the number of applications (0, 1, 2 or 3 times) of a plant biostimulant prepared from garlic bulb in eggplant before and after the transplanting stages and evaluated the morphological and biochemical characteristics. When the extract was applied only once in the pre-transplant and three times after the transplant, there was an increase in soluble sugars content by 188% and 112%, and the fruit yield was increased by 23.6% and 15.4%, respectively, in comparison with the control.

Capsicum Spp.

Ertani *et al*. observed an improvement in the quality of pepper with the application of alfalfa and grape-based plant biostimulants. The plant biostimulants increased the levels of ascorbic acid, chlorogenic acid, p-hydroxybenzoic acid and p-coumaric acid, and also the antioxidant activity in green pepper fruits, while red fruits had a higher capsaicin content. Unlu and Karakurt reported a higher content of carotenoids in pepper after application of humic acids.

Cherry (*Prunus Avium*)

The application of *A. nodosum*-based AE in two cherry cultivars (Sweetheart and Skeena), grafted on cv. Gisela 6, resulted in a reduction in the cracking index, and an increase in the width, weight, diameter, pH and wax of the fruits, although the nutritional characteristics and fruit yield did not change. To improve the adaptation of cherry trees to adverse climatic conditions, Gonçalves *et al.* tested *A. nodosum*-based AE, salicylic acid and soy betaine, separately, in a commercial orchard of cv. Staccato. There was an increase in total soluble solids, pH, polyphenols, vitamin C and antioxidant compounds, and improvement in the color and size of fruits with all products. The levels of total soluble solids and pH and lower values of acidity were more significantly changed with the application of AE and soy betaine. The color index of fruits, such as the saturation of the color, indicated uniform ripening.

Citrus Spp.

Application of yeast extract with subsequent application of gibberellic acid in combination with cytokinin benzyl aminopurine led to an increase in the content of ascorbic acid, and macro- and micronutrients in oranges of *Citrus sinensis*. In orange orchards, fruit harvest was anticipated in up to seven days with the application of *A. nodosum*, in addition to increasing total soluble solids and reducing titratable acidity. Productivity increased by 15% when the applied rate was 0.30%. *A. nodosum* increased the yield of mandarin orange (*Citrus reticulata* cv. Sunburst and Citrus sinensis cv. Valence) by 11%. In three consecutive years of foliar spraying, the same plant biostimulant increased the productivity of *Citrus sinensis* cv. Washington Navel and *Citrus paradisi* cv. Ruby Red by 10 to 25%, respectively. Although fruit yield increased, their size and weight remained the same, which was considered as positive since a high fruit load reduces fruit size.

Apricot (*Prunus Armeniaca*)

Tarantino *et al*. sprayed cv. Orange rubis with the commercial plant biostimulants composed of polyglucosamine, humic and fulvic acids, and carboxylic acids. Fruit ripening was accelerated, allowing to collect 73% of the fruits in the first harvest, compared with 43% of the control treatment. Still, the antioxidative capacity of the fruits increased in the two years of evaluation and fruits of plants sprayed with Ergostim® were wider than the other plant biostimulants and control plants in one of the two years of evaluation. On the other hand, fruit length, thickness, firmness, color, brightness and weight were not changed by plant biostimulants.

Kiwi (*Actinidia Delicious*)

Donno *et al.* studied the effects of an extract made of agro-industrial residues, rich in peptides, amino acids and hormones (auxins, gibberellins and cytokinins) on two kiwi cultivars (Hayward and Green Light). Weight and ascorbic acid content increased in fruits of both cultivars, but the antioxidant capacity was greater only in the cv. Hayward, indicating that the effect of the plant biostimulant depends on the genotype of the plant.

Apple (*Malus Domestica*)

A. nodosum, vitamin B and alfalfa-based PH applied separately increased the levels of phenolic compounds and the antioxidant potential of the apple cv. Red Jonathan. The improvement in the intensity and homogeneity of the red color was related to increased levels of anthocyanin in the fruit peel. In the same work, the application of a mixture of amino acids (glycine, proline, hydroxyproline, glutamic acid, alanine and arginine) and Zn reduced by more than 50% the incidence of "Jonathan spot", the most common physiological disorder in the apple cv. Red Jonathan. Other quality attributes (average fruit weight, total soluble solids, the acidity and firmness of the pulp) were affected by climatic conditions between the years of evaluation but not by the plant biostimulant.

Strawberry (Fragaria × Ananassa)

Weber *et al*. evaluated the application of *A. nodosum* and silicon in greenhouse organic cultivation of the cv. Clery. Treated fruits harvested at the beginning of the season had the highest levels of anthocyanins. In another strawberry cultivar (cv. Elsanta), Soppelsa *et al.* reported different effects on quality according to the plant biostimulant used. While the application of *A. nodosum* and alfalfa-based PH increased the concentration of phenolic compounds by up to 20%, the application of chitosan increased pulp firmness, which would benefit the shelf life of the fruit.

Tomato (*Solanum Lycopersicum)*

According to Dorais *et al.*, 9 to 20 of the 25 carotenoids found in human blood are found in tomatoes. Since carotenoids have antioxidant properties, an increase in their contents in tomato fruits has been considered a task to improve fruit quality. The application of three plant biostimulants, and seaweed (Kelpak®, Kelp Products (Pty) Ltd., Cape Town, South Africa), in the tomato cv. Sir Elyan improved some components of the fruit quality. PH promoted an increase in the total soluble solids content, an attribute related to sweetness. Fruits of plants treated with this plant biostimulant had the highest levels of lycopene, which might be related to the highest levels of K found, due to the involvement of this nutrient in the biosynthesis of carotenoids. Even though the production costs were higher with the application of plant biostimulants, there were net economic benefits. Rouphael *et al.* observed that the application of the same PH (Trainer®) in two concentrations also increased the antioxidant activity, total soluble solids, K and Mg, and lycopene, thus improving the nutritional quality of the tomato fruits of the cvs. Sir Elyan and Akyra.

Grape (*Vitis Vinifera*)

AE from *A. nodosum* is efficient in increasing the biosynthesis of such compounds in grape. Norrie, Branson and Keathley showed that AE improves the yield and quality of grapes. Frioni *et al.* tested two doses of AE (1.5 and 3.0 kg/ha) and found higher values of phenols in the fruits of treated plants compared with untreated plants. Furthermore, the authors reported increases in the content of anthocyanins, a key component for the appearance and, consequently, the quality of grapes. Another study found an increase in anthocyanins in the cv. Corvina with the application of lupine hydrolysates (*Lupinus albus* L.) and milk casein, which led to a more intense color, besides the reduction in plant water losses by transpiration. In the same work, there was a significant increase in total soluble solids content with the application of soybean and lupine hydrolysates, and casein. Productivity and the total soluble solids were also increased in grapes of the cvs. Feteasca Regala and Riesling Italian with the application of humic acids.

CONCLUSION

The use of plant biostimulants in agriculture has been increasingly adopted by farmers not only for the positive results but also for being a sustainable alternative. These products are produced from organic material and in many cases from rejects/residues from other industries, as it is the case of most PHs available on the market. This has attracted the attention not only of the farmers but also of a demanding consumer, who accepts to pay more for the nutritional benefits associated with sustainable practices. Plant biostimulants can increase the vigor of plants, and increase the efficiency of nutrients and the capacity to tolerate stresses, which ultimately can lead to less chemical fertilizer and pesticides input in crops and better use of water resources.

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