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Plant Bio-Stimulants: Smart Approach towards Sustainable Agriculture

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SUMMARY

These are the natural preparations that improve the general health, vitalityand growth of plants and protect them against contagions.In recent years; farmers are remarkably using bio-stimulants because of their significant advantages. In early period, its use is very much confined for specific crops only but now a days it is being used for wide range of crops including fruits, vegetables, flowers and other crops. Thesenatural chemicalsare used in very small quantity and they affect the expression of biological responses in plant tissues; which result in enhancing productivity of plant as well as quality of produce.Since few years, various agricultural research institutes are engaged in highlighting the advantage of bio-stimulants in mitigating biotic and abiotic stresses.

INTRODUCTION

"Bio-stimulants are materials other than fertilizers, which can promote plant growth when applied in small amounts" (Kauffman *et al*. 2007). In other words, bio-stimulants are the formulations consisting one or more active substances and/or microorganisms which are supposed to improve the nutrient uptake capacity of plant, tolerance to abiotic and biotic stress as well as improve the quality of crops (Calvo *et al*. 2014). They mainly trigger numerous physiological processes, which has a positive effect on plant yield and crop quality (Nardi *et al*. 2016).

Common features of bio-stimulants

- Improve plant tolerance to abiotic and biotic stresses
- Enhance uptake and efficient use of nutrients
- Improve soil health
- Enhance crop quality
- Increase harvestable yields

Types of bio-stimulants

- Humic substances
- Seaweed extract
- Chitosan
- Protein hydrolysates and other N-containing compounds
- Silicon
- Beneficial fungi
- Beneficial bacteria

Humic substances

Humus is a collection of relatively low molecular weight natural components of soil organic matter produced by the decomposition of plants, animals and soil microorganisms. It can be divided into three categories: Humic acid (HA), Fulvic acid(FA) and Humas used in gardening most of the sources of humas are non- renewable, including naturalhumidifying organic matter, such as peat and organic soil and mineral deposits. The most sustainable renewable source is humus from compost and earthworm compost.

Benefits of Humic substances

Chemical Benefits

- Humus acts as a buffer, neutralizing excessive acidity and alkalinity of the soil.

- They induce high cation exchange capacity (CEC) and ensure that the roots retain nutrients for subsequent assimilation in the plant.
- Improve the absorption and retention of important nutrients.

Physical Benefits

- Make soils more friableor crumby - breaks up hard pan (dense layer of soil).
- Increases water holding capacity (up to 4 times).
- Increases aeration of soil.
- Reduces soil erosion.
- The darker color imparted leads to greater absorption of solar energy providing warmer sub soil temperature.

Biological benefits

- Increases germination of seed.
- Stimulates root development.
- Various growth regulators, vitamins, amino acids, auxins and gibberellins are formed as organic matter decays and enhance growth.
- Feed's microorganismsthat recycle nutrients and produce antibiotics.

Seaweed extracts

Seaweeds are brown, red and green marine macro algae. The most commonly used algae in horticulture is brown algae, including the genus Algae, Fucus and laminaria. The biological activity of these extracts largely depends on the raw materials and the extraction process, which can be alkaline extraction, acid extraction or any other extraction method technology.

Chitosan

Chitosan is a deacetylated foam of chitin, a natural component of fungal cell walls, nematode egg shells and insect and crustacean exoskeletons. A wide range of cellular components, including DNA, plasma membrane and cell wall components, also help to bind to specific receptors involved in the activation of defence genes.

Chitosan as bio stimulant helps in

- Protection against fungus, bacteria and virus
- Tolerance to abiotic stress (drought, salinity and cold stress)
- Enhancement of quality traits related to primary and secondary metabolisms

Application

- Seed-coating agents, foliar treatments and postharvest coatings of fruits to prevent postharvest decay and increase the shelf life.

Modes of action

- Affects cell membranes, alters DNA and activates defence genes
- In mango irradiated crab shell chitosan type is use and coated on fruit which help to extend the shelf life and maintain eating quality up to four weeks (Abbasi *et al*., 2009).

Protein Hydrolysates and other N-containing compounds

Protein hydrolysate (PH) is a group of important plant bio stimulants. It is a mixture of peptides and amino acids. It is mainly produced by enzymatic or chemical hydrolysis of proteins from raw materials of animal or plant origin or by products of agricultural industry.

PHs are known to

- Tolerant to abiotic stress.
- Soil respiration and soil fertility.
- Increase microbial biomass and activity.
- Nutrient's availability and acquisition by roots (chelating and complexing activities of specific AAs and peptides).

Silicon

Silicon is a kind of bio stimulant in inorganic products. It is an important beneficial element in the soil solution, silicon exists in the form of non-ionic silicic acid. It is easily absorbed by the roots of plants and moves throughout the plant. There are two types; solid and liquid from. It is mainly deposited in the form of hydrated amorphous silicon dioxide on the cell wall, cell cavity and interstitial space. The end points of sweat flow are higher and usually exist around the stomata.

Effects of silicon

- Enhance quality of plant products.
- Tolerance to abiotic stress.
- Protection against heavy metals toxicity.
- Increase plant hormone synthesis and signalling.
- Modulate nutrient and water mobility.
- Promote plant growth.
- Other stress alleviating effects of silicon include its ability to immobilize toxic metals in plant tissues and soil and to delay plant senescence processes.

Beneficial fungi

Beneficial fungi with plant bio-stimulating activity exist in a group of symbiotic fungi. Especially arbuscular mycorrhizal fungi (AMF) within the genus corm, which penetrate plant roots and from highly branched roots and hyphae networks as trees, MFA is its sensitivity to different crop management practices, such as soil cultivation fallow periods and high levels of fertilizer.

Fungal based products applied to plants

- Enhance nutrient use efficiency.
- Maintain phytohormone balance.
- Helps in organ growth and morphogenesis
- Improve crop yield and product quality.
- As a biofertilizer.

Beneficial Bacteria

With regard to the horticultural uses of bio stimulants, that promote plant growth, known as **PGPBs** (plant growth-promoting bacteria), includes Free-living bacteria that inhabit the zone around the root (ectorhizosphere), bacteria that colonize the root surface (rhizoplane) and bacteria that live within the roots (endorhizosphere). Bacteria with plant growth promoting activity are found in the genera *Bacillus, Rhizobium, Pseudomonas, Azospirillum, Azotobactor* and many others. One of the best effects of PGPBs on plants is their ability to fix nitrogen, also to produce siderophores, small iron-chelating compounds that reduce the growth of deleterious soil borne pathogens.

Application

- Seed treatment, seedling dip, foliar spray, soil drenching and addition of extracts to hydroponics.

PGPR inoculants are now regarded as plant 'probiotics'

- Supply of nutrients and increase in nutrient use efficiency.
- Induction of disease resistance- Volatile organic compounds (VOCs) such as 2,3-butanediol (2,3-BD)
- Enhancement of abiotic stress tolerance.
- Influence plant growth directly by producing plant hormones such as auxins, cytokinin's and gibberellic acid.

Bio-stimulants and water stress in plants

- Drought is one of the most important and common stress factors for plant in many parts of the word, especially in arid and semi arid areas. Drought stress is a multi dimensional stress, which usually leads to changes in plant physiology, morphology, ecology, biochemistry and molecular properties.
- Bio-stimulants when applied to the early development of seeds or plants, it can stimulate root production and growth.(Lana 2009) Especially in soils with low fertility and low water availability and accelerate seedlings under unfavourable conditions restore.
- In recent years, among plants suffering from water stress, the research and use of products considered to be plant biostimulants have increased to improve agricultural productivity. For e.g. Under water stress applying crop + biostimulant to tomato through the foliar route can provide the highest soluble total acidity and conclusion is that even under water stress, The application of this kind of biostimulant will also increase these indexes in tomato fruit (Peripolli et al., 2018).
- Maize (zea mays) is a species that is sensitive to water shortage and biostimulants are use in management techniques related to the induction of water shortage tolerance in this plant. Almeida *et al*.2017. Concluded that in the initial stages of corn planting, foliar spraying of this biostimulant will result in a higher relative water content in the leaves and the difference between leaf temperature and air temperature under water deficient condition.

Bio stimulants and salt stress in plants

Salt stress is one of the most limiting factors for crop growth and production. The salt in the soil water will reduce the ability of plants to absorb water, there inhibiting plant growth, resulting in slower growth. Under salt stress, many authors divide the effect of different types of biostimulants on plants into direct effect and indirect effect. Indirect effects are related to the improvement of soil physical, chemical and biological properties. While the indirect effects are attributed to the improvement of germination and plant growth. Biostimulants using algae and arbuscular mycorrhizal fungi, fungi and bacteria as raw materials improve the germination rate and growth characteristics. Biological active compounds that are resistant to salt stress. Shoot and roots quality, productivity and plant yield. (Yakhin*et al*., 2017).

Future thrusts

Focus on developing new bio-stimulants, biopreparation and formulations as well as testing their effect in practice. As there is growing demand for the organic foods, greater awareness is needed to create among the farmers for the use of bio-stimulant products.

CONCLUSION

From the forgoing discussion and summary of results it can be concluded that the bio-stimulants can partly substitute the chemical inputs and restore soil fertility particularly by fostering the development of complementary soil microorganisms which facilitate enrichment of nutrients in soil. In plant, it not only enhances the quality traits but also helps in tolerance to biotic and abiotic stress, enhances the nutrient efficiency, increases yield and gives long term benefit in a eco-friendly way.

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