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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(6): 246-250

www.thepharmajournal.com
Received: 05-03-2022
Accepted: 16-05-2022

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Bio-stimulants application in agriculture: An update

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Abstract
Biostimulants that are applied to soil have the ability to promote the establishment and proliferation of beneficial soil organisms, which in turn serve as plant growth substrates. In light of the ongoing processes of soil deterioration and air pollution, it is especially necessary to use environmentally friendly natural remedies. Plant growth-promoting biostimulants include, but are not limited to, enzymes, protein hydrolysates, seaweed extracts, humic substances, nitrogen-fixing bacteria, phosphorus-solubilizing bacteria, and rhizobacteria. Even while a biostimulant may not have an immediate effect, there is still a chance that it may improve the health of the soil over time, resulting in higher yields in subsequent years.

Keywords: Bio stimulants, humic substances, soil biota, soil health

1. Introduction

Agriculture relies on synthetic nutrients (fertilisers), pesticides, improved tillage, and adequate irrigation water to meet present food demand. These concerns cause the loss of ecosystem services, pollution, and excessive greenhouse gas emissions [1-7]. Biotechnologies that successfully manage resources, especially water, nutrients, and soil, while increasing crop yields and refining agro-based products are desperately required today and will be vital in the near future if agricultural intensification is to be sustainable [8-11]. Developing innovative technologies and strategies to increase partial factor productivity and resource use efficiency, especially with regard to water and fertilisers, as well as to increase field crop productivity under optimal and suboptimal conditions is of utmost importance to protect food security, while also focusing on preserving the quality and health of the soil and providing ample opportunities for farmers [12]. These fertilisers are often transported off the field in runoff or become unavailable to crops [13-15], causing environmental difficulties and affecting human health. Compost, sludge, and manure help use minerals already present in the Agro-ecosystem and need minimal energy to process. Chemical fertiliser manufacture is energy-intensive and impacts the system's energy [16]. This has increased global CO2 emissions [17]. Organic nutrients are harder for plants to absorb since they aren't water-soluble. The supply isn't synchronised, so the crop isn't given nutrients when it needs them. De Pascale *et al.* Developing plants with stronger root systems and higher nitrogen absorption efficiency may help with this shortfall. This ensures that plants obtain the nutrients they need, even while organic delivery decreases immediate availability. Encourage certain soil microbes to enhance nutrient availability. Leaves, seeds, or soil may be treated with biostimulants to speed up root formation [18-20]. Biostimulants are a competent, sustainable alternative or complement to their synthetic equivalents for enhancing NUE and yield stability of agricultural and horticulture crops under optimum and sub-optimal circumstances. Natural plant stimulants (PBs) may improve crop resilience to abiotic stressors and raise agricultural productivity by boosting flowering, plant growth, fruit development, crop yield, and nutrient utilisation efficiency. This tech is rough (NUE). Several greenhouse and open-field vegetable experiments suggest that biostimulant compounds may improve nutrient absorption and assimilation. Research shows this. Increased soil enzymatic and microbial activity, changed root architecture, and better micronutrient mobility and solubility promote plant nutrient uptake [21-25]. Biostimulant extracts are derived from a variety of organic sources. These sources include animal or vegetable raw material fermentation, industrial residues, humic substances, algal extracts, protein hydrolysates, and plant-growth boosting fungi and rhizobacteria [26-33]. Other synthetic compounds, not derived from organic biological resources, may have stimulating effects, although they are not regarded plant biostimulants at this time [34-36].

Plant bio stimulants are chemicals that encourage crop development. Biofertilizers, plant probiotics, bio stimulators, and metabolic enhancers are labels for these products [37-40]. This review focuses on biostimulants, their characteristics, and their influence on soil health.

2. What are Biostimulants

Professor V.P. Filatov introduced the "biogenic stimulant" argument for the first time in 1933. According to Filatov's stress-exposed species hypothesis, organisms, including plants, produce biological components that affect the flow of energy and metabolic activity in other creatures, including humans and animals [41, 42]. Herve argued that the creation of biostimulants, which he termed "Bio-rational products," should be based on a sequential technique that employs chemical synthesis, biochemistry, and biotechnology on real plants, taking into account the physiological, agricultural, and ecological constraints. He argues that these products should be used in modest dosages, be environmentally friendly, and maybe boost the yield of agricultural plants [43, 44]. Yakhin was a pioneer in beginning a systematic discourse on biostimulants, which paved the way for biostimulant research [45]. Due to the fact that the use of biostimulants in field crops increases crop yields and the nutritional content of the crop, these biostimulants are frequently used in agricultural management practises to reduce the amount of chemical inputs, improve productivity, and restore the natural balance of agroecosystems [46].

Some individuals have the misperception that biostimulants and nutrition providers are the same thing; nevertheless, biostimulants do help plants absorb nutrients from the rhizosphere, which boosts growth and increases resilience to biotic and abiotic stresses [47, 48]. Examples of plant biostimulants include natural components, manufactured or naturally produced chemicals, macro and micro-algal extracts, silicon, arbuscular mycorrhizal fungus (AMF), and plant growth-promoting rhizobacteria (PGPR) belonging to the genus Azotoba (Rouphael *et al*., 2020). With a compound annual growth rate (CAGR) of 10.65 percent from 2015 to 2019, the biostimulants industry will be the fastest-growing sector of the agricultural industry. The market for 60 times more value inorganic fertiliser is increasing at a pace of 1.3–1.8 percent each year [49, 50]. The word "bio"-stimulant is unclear since not all of the listed ingredients or components are "biological." Bio refers to the intrinsic characteristics of living organisms. Non-organic components may have a synergistic impact on biological factors. Relationships between physiology, metabolic rate, morphology, and agroecosystems [51, 53].

3. Types of Biostimulants

In agriculture, biostimulants are catalogued consistently. Biostimulants might be classified by their mode of action and the place of origin of their active components [54]. The design of biostimulants should be one of the least significant indices used to describe them; instead, the categorization should be based on the impact biostimulants have on plants or the physiological responses of plants to such actions [55]. Any description or categorization of biostimulants should emphasise their agricultural functions above their components or methods of action [56]. The following categorisation is popular:

3.1 Microorganisms produce plant biostimulants

Microorganisms such as fungi, bacteria, and arbuscular mycorrhizal fungi may assist generate plant biostimulants [57]. Rhizosphere engineering combines microbial inoculants for a cumulative impact. This helps revive functioning and beneficial bacteria communities associated to soil fertility and restore the natural microbiome depleted by crop domestication. Rhizosphere engineering imitates soils' biological networks [58]. Microbial inoculants are predominantly endophytic fungus and plant growth boosting rhizobacteria (PGPR). AMF and *Trichoderma spp*. are microbial inoculants [59, 60]. In recent years, industrial manufacture of enzymes using microbial fermentation has industrialised the purification and manufacturing of enzymes for use in farming systems through soil application. Industrializing enzyme manufacturing has made this feasible [61].

3.2 Plant-based biostimulants

Using this information and plant extracts, further biostimulants are being produced. This is done by looking for species with natural defences and antioxidants [62]. Protein hydrolysates (PHs) derived from plant extracts include oligopeptides, polypeptides, and free amino acids. Chemical, enzymatic, or chemical-enzymatic hydrolysis of plant leftovers produced these hydrolysates. Plant extract biostimulants promote plant growth [63]. Sugars and proline are key osmoprotectants in plant-based biostimulants. Osmoprotectants assist agricultural plants cope with biotic and abiotic stressors [64, 65]. Plant-based biostimulants include free amino acids and polypeptides obtained by extraction and/or enzymatic hydrolysis [66]. Plant biostimulants, especially protein hydrolysates and natural plant-based extracts from tropical locations, have boosted crop productivity and nutritional efficiency in recent years [67].

3.3 Seaweed-derived growth promoters

Seaweed-derived biostimulants are the most popular in the business due to their low production costs and ability to increase plant biomass. The seaweed species, which may be brown, red, or green, temporo-spatial (happening in time and place), origin of the raw material, and techniques involved in obtaining the required biostimulant can all affect the extracts derived from them [68]. The bulk of seaweed PBs originate from Ascophyllum nodosum. Most SWEs are produced via the Alkali Extraction technique, which involves boiling sodium or potassium solutions [69, 70]. Since dried seaweeds disintegrate slowly and produce hazardous sulfhydryl compounds that might persist up to 15 weeks, they must be transformed into liquid extracts or soluble powders [71].

3.4 Protein hydrolysate-derived plant biostimulants

Protein hydrolysates are another well-studied family of PBs that help plants overcome biotic and abiotic stressors. Protein hydrolysates may enhance agricultural yield and quality, particularly in places with limited water [72-75]. These protein hydrolysates are available in liquid, powder, and granular forms. These hydrolysates may be sprayed on the plant or side-dressed near the roots [76]. Protein hydrolysates may be made by acid, alkaline, thermal, and enzymatic hydrolysis. These techniques work on animal and plant biomass [77, 78]. Chemical and enzymatic protein hydrolysis may produce amino-acid and peptide combinations from agro-industrial wastes. Byproducts may be from plants (crop wastes) or animals (collagen, epithelial tissues) [79]. Protein hydrolysates boosted carbon and nitrogen metabolism, nutrient availability and crop absorption, and nutrient use efficiency [80].

3.5 Humic biostimulants

Hydrolysis processes may be used to extract biostimulants from manures, compost, and other carbon-based materials [81]. Humic acid is beneficial to plants because it promotes physiological and structural changes in their roots and shoots, allowing them to more efficiently consume and distribute nutrients [82]. According to outdated interpretations, the ultimate result, humus or humic substances, is constituted of stable chemical components. Soil organic matter is similar (SOM). Recalcitrant molecules make up these humic compounds. Humic chemicals are hard-to-break-down substances [83]. Characterizing humic compounds requires knowing their average molecular mass and mass distribution (calculated via ultracentrifugation, sedimentation velocity, equilibrium sedimentation, and the Archibald technique) [84]. Biostimulants include seaweed extracts, humic and fulvic acids, nitrogen-fixing bacteria, phosphorus-solubilizing microorganisms (PSM), arbuscular mycorrhizal fungi, PGPR, enzymes, and biochar [85-87].

4. Conclusion

In addition to stimulating plant growth and tolerance to water and other abiotic and biotic challenges, biostimulants also reduce the demand for fertilisers. When present in modest concentrations, these compounds are useful because they promote the proper functioning of the plant's vital processes, allowing the plant to produce an abundance of high-quality products. In addition, the application of biostimulants to plants improves the efficiency of plant nutrition, the plant's resistance to abiotic stress, and/or the plant's qualitative traits, independent of the nutritional content of the plant. Numerous studies have been conducted to establish the efficacy of biostimulants in enhancing plant development despite a variety of challenges, including the presence of a salty environment and the growth of seedlings. Several additional kinds of source materials, such as humic acids, hormones, algal extracts, and plant growth-promoting microbes, have also been used to make biostimulant compounds. In this perspective, the purpose of this chapter is to examine the use of biostimulants in plant growth in relation to the raw materials used in their compositions as well as their impact on abiotically challenged plants. The use of biostimulants in plant growth will be analysed per raw material.

In addition to being unusually benign to the environment, the primary distinction between biostimulants and other agricultural inputs is that biostimulants are more capable of eliciting the desired reaction. For example, the use of seaweed extract as a biostimulant during planting may have an effect on the microbial populations in the region where the extract is applied. In contrast, the primary goal of foliar treatments during vegetative development stages is to activate certain signalling pathways in order to reduce the effects of abiotic stress. These biostimulants may be derived from either plant or animal biomass. The science behind the stimulating mechanism of biostimulants is one of the unresolved issues in the field. Furthermore, it is uncertain if biostimulants and synthetic compounds will have synergistic or antagonistic effects. Farmers are sceptical since the results of a single growing season might vary greatly, and a prescription is now necessary for the proper usage of biostimulant on grower fields. In addition, a new strategy will need many seasons of refinement before it can be used efficiently.

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