

# Unveiling the Potential of Bio-Stimulants for Seed Treatment: A Sustainable Approach to Boost Crop Performance

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In the quest for sustainable solutions to global agricultural challenges, bio-stimulants emerge as powerful allies in enhancing crop productivity, resilience, and resource efficiency. As both academia and the seed industry intensify their efforts in bio-stimulant research and development, the potential for transformative impact across the agricultural value chain is immense. By harnessing the untapped potential of bio-stimulants as seed treatment agents, we pave the way towards a greener, more resilient, and sustainable future for agriculture (Masondo *et al.*, 2018). These innovative formulations, derived from natural sources, offer a promising solution to enhance crop productivity. They are considered safe for the environment and possess a broad spectrum of biological activities (Bulgari *et al.*, 2019). Let's delve into the burgeoning field of bio-stimulants and explore their role in shaping the future of agriculture. Modern biostimulants may be complex mixtures derived from raw materials of highly diverse origin, including waste from food and paper industries.

## What is Bio-Stimulants?

In the scientific literature, the word bio-stimulant was first defined by Kauffman *et al.* (2007) in a peer-reviewed paper, with modifications: bio-stimulants are materials, other than fertilisers, that promote plant growth when applied in low quantities.

Bio-stimulants encompass a diverse range of organic substances, including plant hormones, seaweed extracts, beneficial microbes, amino acids, and humic acids. Unlike synthetic chemicals, bio-stimulants work in harmony with nature, enhancing plant growth and resilience through various mechanisms such as improving nutrient uptake, stimulating root development, and enhancing stress tolerance.

## The Rise of Bio-Stimulants:

Traditional seed treatments often rely on synthetic chemicals to protect seeds from diseases and pests or to promote germination and early seedling growth. However, concerns about the ecological footprint of these chemicals, along with their potential adverse effects on human health and the environment,

have spurred the quest for safer and more sustainable alternatives. Enter bio-stimulants – a diverse array of biological substances that stimulate plant growth, improve nutrient uptake, and enhance stress tolerance. Seed treatment with biostimulants is a technology to counteract environmental stress at the time of sowing, and improving yield, all starting from seed germination (Rady *et al.*, 2019).

## Bio-Stimulants for Seed Treatment:

1. **Humic Substances:** These are organic compounds derived from humus or decaying organic matter. They improve soil structure, nutrient uptake, and seedling vigor.
2. **Seaweed Extracts:** Extracts from seaweed contain growth-promoting compounds such as cytokinins, auxins, and betaines. They enhance seed germination, root development, and stress tolerance.
3. **Microbial Inoculants:** Beneficial microorganisms like rhizobacteria (e.g., *Bacillus* spp., *Pseudomonas* spp.) and mycorrhizal fungi form symbiotic relationships with plant roots, improving nutrient availability and plant health.
4. **Plant Growth-Promoting Rhizobacteria (PGPR):** These bacteria colonize the rhizosphere and produce growth-promoting substances like phytohormones, siderophores, and enzymes that enhance seedling vigor and nutrient uptake.
5. **Biological Extracts:** Extracts from various plants or microbes that contain natural growth promoters, antioxidants, and other beneficial compounds can improve seed germination and seedling establishment.
6. **Chitosan:** Derived from chitin, a natural polymer found in crustacean shells, chitosan enhances seed germination, root growth, and protects against pathogens.
7. **Amino Acids:** Amino acids are essential for plant growth and development. Their application as seed treatments can enhance

protein synthesis, stress tolerance, and overall plant vigor.

8. **Enzymes:** Enzymatic treatments can break down seed coat dormancy, facilitate nutrient release, and improve seedling emergence.

These bio-stimulants are often used in combination or integrated into seed coating technologies to maximize their beneficial effects on seedling establishment and crop productivity.

#### Benefits of Bio-Stimulants for Seed Treatment

1. **Improved Germination and Seedling Establishment:** Bio-stimulants promote quicker and more uniform germination, leading to robust seedlings with enhanced vigor. By providing essential nutrients and hormones, they create an optimal environment for seedling growth, even under challenging conditions.
2. **Enhanced Nutrient Uptake:** Bio-stimulants stimulate the activity of beneficial microbes in the soil, improving nutrient availability and uptake by the developing seedlings. This results in healthier plants with better nutrient utilization efficiency, ultimately contributing to higher yields.
3. **Boosted Stress Tolerance:** Bio-stimulants bolster the plant's natural defense mechanisms, increasing its resilience to environmental stresses such as drought, heat, and disease. By strengthening the plant's immune system and root structure, they enable crops to withstand adverse conditions and maintain productivity.
4. **Reduced Environmental Impact:** Unlike chemical seed treatments, which may have negative repercussions on soil health and biodiversity, bio-stimulants offer a sustainable and environmentally friendly approach to crop protection. They degrade naturally in the environment, minimizing the risk of pollution and adverse effects on non-target organisms.
5. **Promoting Sustainable Agriculture:** One of the key advantages of bio-stimulants lies in their compatibility with sustainable farming practices. By fostering natural processes within the plant and soil microbiome, these products help reduce the reliance on synthetic

fertilizers and pesticides, thus mitigating the environmental footprint of agricultural activities. Moreover, bio-stimulant-treated seeds often exhibit enhanced tolerance to abiotic stresses such as drought, salinity, and temperature extremes, enabling farmers to cultivate crops more resilient to the challenges posed by climate change.

#### Application Methods and Considerations:

Bio-stimulants can be applied to seeds through various methods, including seed coating, seed soaking, or seed priming. The choice of application method depends on factors such as crop type, seed size, and desired outcomes. It's essential to follow recommended dosage rates and application techniques to ensure optimal results without wastage or phytotoxicity.

#### Future Outlook and Challenges

As awareness of the benefits of bio-stimulants continues to grow, their adoption in agriculture is expected to increase. However, challenges such as regulatory barriers, standardization of products, and market acceptance remain to be addressed. Collaborative efforts involving researchers, industry stakeholders, and policymakers are essential to overcome these obstacles and unlock the full potential of bio-stimulants for seed treatment.

#### Conclusion

Bio-stimulants represent a paradigm shift in seed treatment, offering a sustainable and effective alternative to conventional chemical inputs. By harnessing the power of nature's own mechanisms, bio-stimulants hold the key to enhancing crop productivity, resilience, and environmental stewardship. As farmers seek innovative solutions to meet the demands of a changing world, bio-stimulants are poised to play a pivotal role in shaping the future of agriculture.

#### References

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