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EDITORIAL
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Editorial: Biostimulants as an Avenue of Abiotic Stress Tolerance Improvement in Crops

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Editorial on the Research Topic

Biostimulants as an Avenue of Abiotic Stress Tolerance Improvement in Crops

Plants are continuously exposed to changing climatic conditions. To provide food security for the increasing global population, agricultural production must double by 2050. Increases agricultural productivity have been provided using chemical fertilizers. However, such gains in productivity using this non-sustainable, synthetic chemistry have been shown repeatedly to pose threats to the ecosystem and human health. Additionally, the prices of these inputs continuously increase as their sources are non-renewable. Thus, there is an immediate need for the development of more sustainable agricultural production systems (Castiglione et al., 2021). A sustainable approach to improve productivity is to use biostimulants which economically and reliably improve the innate stress tolerance and growth metabolism of treated plants. Biostimulants are a class of agricultural inputs derived from natural resources, which when applied to the plant, as foliar, or as a root drench, induce innate, natural abilities to cope with stresses and enhance water management and nutrient uptake, efficiencies (Shukla et al., 2019). Rai et al. reviewed the role of microbial and non-microbial biostimulants to improve the plant growth and yield, flowering, nutrient-use-efficiency, nutrient translocation and stress tolerance. This review comprehensively presents responses to several classes of biostimulants and presents a comparative analysis of modes of actions. Hexanoic acid, a natural priming agent, induces the expression of defense-responsive genes in *Coffea arabica* and can be applied successfully as an elicitor for disease management (Budzinski et al.). An essential oil from *Zanthoxylum armatum* was found to control tomato fruit rot by inducing anti-oxidative defense mechanism pathways and can be used as post-harvest management of *Alternaria* rot in tomatoes (Slathia et al.). These two publications in this current issue address the sustainable strategy for disease management using naturally-derived products.

Seaweed-extract-based biostimulants are some of the most researched of the entire category and are known to improve plant growth stress tolerance and both water- and nutrient-use-efficiency (Shukla et al., 2019, 2021). Several studies showed that foliar sprays of an extract of the red seaweed, *Kappaphycus alvarezii* improved plant growth and nutrient content of treated maize and wheat grown by regulating stress-responsive, physiological and biochemical processes (Patel et al., 2018; Trivedi et al., 2018; Kumar et al., 2020). *K. alvarezii* extract mitigates drought stress in maize by inducing the expression of genes involved in metabolic, as well as, regulatory processes (Trivedi et al.). This study helps to provide understanding of the molecular mode of action of a *Kappaphycus* extract in conferring drought tolerance in maize.

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Plant interactions with beneficial microbes produce a wide array of secondary metabolites, as counter a strategy which help to mitigate abiotic stress tolerance (Ganugi et al., 2021). This interaction led to the development of several microbial-based plant biostimulants, which are known to improve plant growth and stress tolerance by regulating physiological processes, antioxidative mechanisms, water-use and nutrient-use efficiencies (Castiglione et al., 2021; Rai et al.). The metabolites present in the cell-free supernatant of salt tolerant *Bacillus amyloliquefaciens* was seen to improve the percentage germination and radicle length of both corn and soybean under salinity stress (Naamala et al.). Msimbira et al. reported the effects of changing pH on the growth of *B. subtilis* and *Lactobacillus helveticus* and production of secondary metabolites. The cell-free extract of both *B. subtilis* and *L. helveticus*, produced in an acidic condition, improved seedling growth of corn and tomato (Msimbira et al.). These results provide the basis for the development of next-generation microbial biostimulants.

This Research Topic presents six articles covering different aspects of both microbial and non-microbial biostimulants. Contributors provide deep insight into understanding the molecular modes of actions of biostimulants in mitigating various types of stress, as well as up-regulating defense responses of treated plants. The results presented in this special issue not only provide insights about the mechanisms of existing products but also promotes new perspectives for the development of next generation plant biostimulants.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of Interest: PS is employed by Sea6 Energy Pvt. Ltd.

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