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Editorial: Biostimulants for climate-smart and sustainable agriculture

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Editorial on the Research Topic
Biostimulants for climate-smart and sustainable agriculture

In the quest for sustainable and climate-resilient agriculture, a diverse array of innovative strategies has emerged to bolster resilience and productivity, from harnessing biostimulants to unraveling the intricate interplay between plants and their microbiome under environmental stresses. The Research Topic "*Biostimulants for climate-smart and sustainable agriculture*" presents a collection of pioneering studies in a wide range of areas, including the beneficial effects of biostimulants, new formulations for sustainable agriculture under different climate change-associated abiotic stresses, and the application of biostimulants for plant growth promotion and protection. The compilation of research weaves together a tapestry of data that illuminate novel pathways toward enhancing crop productivity, resilience, and sustainability in the face of changing climatic conditions. Through a synthesis of diverse approaches and findings, this Editorial aims to contextualize the contributions of the included articles and underscore their collective implications for advancing climate-resilient agriculture.

Several studies within this Research Topic investigate the application of plant growth-promoting rhizobacteria (PGPR) to enhance plant growth, performance, and stress tolerance. Chamkhi et al. and Cheto et al. highlight the efficacy of PGPR consortia in mitigating phosphorus deficiency stress and water deficit, respectively. Chamkhi et al. delve into the realm of PGPR to enhance faba bean growth under P deficiency stress, advocating for a multi-strain consortium approach. Their findings underscore the potential of synergistic bacterial interactions in improving plant growth parameters under challenging conditions. The study by Cheto et al. explores the synergistic effects of rhizobacterial consortia and intercropping on faba bean and wheat plants under water deficit and low P availability stress. Additionally, Lobato-Ureche et al. shed light on the application of PGPR strains to enhance pepper plant productivity, showcasing the potential of specific bacteria in improving plant growth parameters and reducing reliance on chemical fertilizers. These studies underscore the importance of microbial inoculants in improving plant nutrition, health, productivity, and soil fertility, paving the way for sustainable agricultural management practices.

Nazari and Smith's research delves into the impact of Thuricin 17 on canola plants under drought and heat stress conditions, highlighting the compound's potential as a growth regulator to enhance crop resilience in challenging environments. Their findings illuminate the intricate mechanisms by which microbial symbionts enhance plant adaptation, thereby opening new avenues for enhancing plant tolerance to adverse environmental conditions through innovative biostimulants. Similarly, Sati et al. and Ait-El-Mokhtar et al. delve into the interplay between drought stress and the plant microbiome, emphasizing the multifaceted interactions that underpin plant resilience and adaptation strategies. Sati et al. underscore the importance of utilizing drought-tolerant PGPR strains to mitigate drought stress in wheat plants, showcasing the potential of native bacteria in enhancing agricultural sustainability in regions vulnerable to water scarcity. Ait-El-Mokhtar et al.'s review delves into the complex dynamics of plant-microbiome interactions under drought conditions, emphasizing the significance of understanding the molecular mechanisms driving these relationships. Their insights illuminate the potential of harnessing the crop microbiome as a strategy for improving plant resilience and agricultural sustainability amidst changing environmental conditions. Their work underscores the significance of harnessing microbial allies to bolster crop resilience in the face of environmental challenges.

Fite et al. provide a comprehensive review of endophytic fungi, highlighting their diverse roles in pest biocontrol, growth promotion, and climate change resilience. These studies underscore the importance of harnessing natural resources and microbial symbionts to foster sustainable agricultural systems. In a similar vein, Suriani et al. discussed the use of *Brevibacillus agri* and compost to enhance the growth and phytochemical compounds of *Piper caninum* plants. They demonstrated that the dual combination of both biostimulants, with 1% *B. agri* showing the greatest effect, effectively enhanced growth, nutrient uptake, and phytochemical production in these herbal plants. This strain exhibits traits such as auxin production, protease enzyme activity, and nitrogen fixation. Furthermore, Tajdinian et al. concluded that the foliar application of brown alga (*Sargassum angustifolium*) extract can elicit defense responses in strawberry plants challenged by *Macrophomina phaseolina* (Tassi) Goid, leading to improved growth indices and reduced disease severity. Building on this, Sheffield et al. investigated the impact of biochar on plant growth parameters, shedding light on its potential as a soil amendment to enhance crop productivity.

Addressing the challenges and opportunities in sustainable agriculture, the review article by Lumactud et al. underscores the complexities of soil microbiology and plant-microbiome interactions in agricultural ecosystems. They emphasize the need for interdisciplinary research and holistic approaches to harnessing biostimulants for sustainable agriculture. These insights provide a roadmap for future endeavors aimed at optimizing the use of biostimulants to enhance agricultural resilience and mitigate the impacts of climate change.

Collectively, the articles compiled in this Research Topic present a mosaic of innovative approaches and findings that underscore the transformative potential of biostimulants, microbial interactions, and climate resilience in shaping the future of climate-smart and sustainable agriculture. As we navigate the complexities of a changing climate, the insights gleaned from this Research Topic offer valuable guidance for fostering resilience, sustainability, and food security in agricultural systems worldwide. This Research Topic exemplifies interdisciplinary studies that have applied principles from multi-omics, experimental biology, and eco-physiology to demonstrate the role of biostimulants research in alleviating stresses and improving food safety. The articles also provide insights into future challenges and opportunities in the field of biostimulants. They discuss the need for additional strengthening of biostimulant products and specific crop-based research and development under changing climate contexts.

We trust that these innovative contributions will provide insights, address longstanding inquiries (while also sparking new ones), and motivate researchers in vital fields related to plant (a)biotic stress, climate change, and molecular biology. We invite authors to persist in submitting their high-quality research in Crop Biology and Sustainability to Frontiers in sustainable Food Systems.

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