Editorial: Portraying the phytomicrobiome studies during abiotic stresses: Revisiting the past and exploring the future outcomes

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KEYWORDS
phytomicrobiome, rhizosphere, signaling, symbiosis, molecular studies, phytohormones, crosstalk, omics

Plants are exposed to a plethora of climatic conditions that adversely affect their growth and development. Many different abiotic stresses can impair plants' metabolic, biochemical, and physicochemical functions, including heavy metals, salinity, flooding, freezing, excessive heat, drought, and nutrient deprivation. These conditions degrade the agro-ecosystem, ultimately ruining yields, productivity, and food supplies (Khan et al., 2021). Under these conditions, plants become disintegrated, reflecting the disrupted metabolic networks, morphological impairments, and productivity losses. Therefore, it is crucial to develop new strategies that can counteract these abiotic stresses and decode the resistance mechanisms associated with them (Kumar and Verma, 2018). This Research Topic features insights into microbe communities during periods of stress tolerance in plants. The mechanisms unraveling plant-microbe interactions and the symbiotic associations between microbes and plants under stress are given special focus.

Plants are surrounded by different zones: namely, the phyllosphere above ground and the rhizosphere below ground. The microbial communities residing within these zones communicate with plants through an array of signaling molecules and compounds forming an effective symbiosis. Moreover, they are able to affect nutrient acquisition, and they respond well to environmental adversity (Khan et al., 2021). However, fluctuating environmental conditions can affect the resident microflora and their activities, thereby affecting plant responses. Unlocking the microbial responses toward stressful conditions will provide us with an asset for stimulating the stress resistance mechanisms in plants.
Schematic representation of the microbial dynamics within soil during stresses. Microbes play an essential role in plant growth and development during adverse conditions through inducing defense signaling and stress-responsive processes in plants.
They also target the acquired systemic resistance mechanisms in plants and induce them to employ specific defensive strategies to overcome the adverse condition. Mulk et al. *Bacillus* spp., a highly significant bacterial species with antagonistic activity against four root pathogens targeting wheat plants: *Fusarium oxysporum*, *F. moniliforme*, *Rhizoctonia solani*, and *Macrophomina phaseolina*. Wheat plants inoculated with *Bacillus* strains also showed lowered electrolyte leakage and increased relative water content in comparison to control plants, thus supporting the potential of *Bacillus* spp. as a biocontrol agent.

The most significant classical example of phytomicrobiome signaling in plants is the association of the rhizobia-legume symbiotic association and mycorrhizal interaction with the roots of plants (Shah et al., 2021). Moreover, many plant-growth-promoting bacteria (PGPR) also reside in free form within the rhizosphere-plant proximity. They also enhance the microbial niche with their secretions, which activate chemical signaling cascades for plant growth and stress mitigation. The findings of other types of -omics investigations (i.e., metabolomics, proteomics, transcriptomics, secretomics, phenomics, interactomics, glycomics), along with examinations of phytohormonal signaling processes and hormonal crosstalk, form a roadmap for phytomicrobiome studies (Liu et al., 2020). These studies have paved new paths for exploring the investigations and discoveries within plant microbiomes and their external and internal communications.

The role of microbial populations as biocontrol agents against different pathogenic organisms and as biofertilizers has been well-depicted (Trivedi, 2021). Shoaib et al. investigated the roles of zinc and green manure in controlling the incidence of *Macrophomina phaseolina* infection, which causes charcoal rot disease in mug bean. Both of these substances induced plant resistance and improved growth, photosynthesis, total proteins, physiology, biomass, harvest index, and yield, while reducing disease incidence. Moreover, the production of antioxidants was also triggered, as seen in the levels of polyphenol oxidase, superoxide dismutase, catalase, and peroxidase. Ultimately, these interventions alleviated disease and increased profits by improving the harvest index and cost-benefit ratio.

Therefore, we have focused on the importance of microbes for sustainable agriculture and their applicability in the field through commercialization. Additionally, different gene and cellular responses, including transcript levels, proteins, metabolic profiles, and signaling pathways in this network, are also modulated in phytomicrobiomes experiencing stress. The series of primary and secondary effects, as explored in these studies of the phytomicrobiome under harsh conditions, are a most crucial step for further investigation.

### Author contributions

KK drafted the editorial text. SK and AS revised the draft. KK and RB finalized the editorial text and approved the final version. All authors contributed to the article and approved the submitted version.

### Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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