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Editorial: Biotechnology for agricultural sustainability

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Editorial on the Research Topic
Biotechnology for agricultural sustainability

The focus of sustainable agriculture is to meet increasing global food requirements without adversely affecting the environment. Agricultural sustainability is a major challenge due to the rising human population, global climate change, and significant environmental degradation. Further, various biotic and abiotic stresses aggravate the challenges posed by global climate change. Achieving sustainability goals requires control over the use of harmful chemicals, the quantity and quality of water, the type of seed source, the surrounding abiotic parameters, and the biome. Bioengineering can potentially help in achieving agricultural sustainability by creating crops that are more tolerant to stress and changing environmental conditions. Biotechnological interventions can further generate information beforehand to predict emerging agricultural challenges and generate sustainable crop types.

Emerging climate change has adversely affected crop productivity in Southeast Asian countries (Abubakar et al., 2021). Every 1°C rise in temperature beyond 25°C has reduced crop yield by more than 10% (Chakraborty et al., 2000), and raised CO_2 levels have further enhanced the severity of plant diseases, thus affecting plant growth and productivity. Biotechnological techniques have improved the identification of stress-responsive traits to facilitate tolerance in plants. Urdbean Leaf Crinkle Virus (ULCV) infection reduces black gram yield by more than 80% (Gautam et al., 2016). Black gram is highly susceptible to ULCV and can be infected at any time during the life cycle. A comparative physiochemical and transcriptional account of resistant and susceptible black gram responses upon ULCV interaction/infection helped improve understanding of the tolerance mechanism. The accumulation of sugar, protein, phenol, hydrogen peroxide, malondialdehyde, and antioxidant enzymes was significantly affected upon ULCV infection. The genes in the salicylic acid, jasmonic acid, and ethylene pathways were altered, indicating their role in tolerance to ULCV. Plant secondary metabolites thus maintain a balance between the plant antioxidant system and reactive oxygen species, helping to alleviate biotic stress (Díaz-Vivancos et al., 2008; Hančević et al., 2018). Additionally, the interaction of pathogens with plants instigates various molecular crosstalk, leading to changes in the metabolite profile of plants that are responsible for the sensitivity/resistance of crops to the pathogen.

Genetic engineering along with breeding is widely employed to develop stress-tolerant plants. However, strategies such as seed priming or plant exposure to different agrochemicals can offer an efficient method for improving crop traits and yield. Plant growth regulators induce and regulate tissue regeneration and growth in plant tissue cultures. However, their potential for crop growth and yield improvement remains unknown. Cytokinin-based compound, 6-benzyl adenine (6-BAP) has also been widely tested for conferring resistance against temperature and salinity stress in grain crops, such as maize, rice, and wheat. In plants, 6-BAP regulates the expression of genes encoding antioxidant enzymes and the accumulation of photosynthetic pigments to induce stress tolerance (Giehl et al., 2013). During drought stress, 6-BAP regulates the signals perceived and transmitted by the plant in response to altered water uptake and nutrients, modulating the shoot-root architecture, vasculature development, and time of senescence (Hu et al., 2020). Likewise, exogenous exposure to jasmonic acid on the green callus of neem was found to increase flavonoid biosynthesis. Jasmonic acid triggered the production of polyphenols and photosynthetic pigments, thereby inducing the antioxidant potential of neem. Therefore, knowledge of the physiological and molecular regulation of plants upon exposure to plant growth hormones, such as 6-BAP and jasmonic acid, can be employed for developing stress-resistant plant varieties.

Legumes are of keen interest because of their protein-rich nature. Therefore, it is important to identify stress-resistant legume varieties to help meet food requirements. Drought is the most common abiotic stress that severely affects legume productivity, including soybean. Repeated drought stress with intermittent rehydration at the seedling stage is the common strategy for identifying stress-tolerant soybean. It is already known that first-time exposure to drought stress induces stress memory in the form of physiological and molecular events in plants. Stress memory generates faster stress-avoiding responses in future stress episodes in the same plant, similar to the immune response of animals (Longenberger et al., 2006; Xie et al., 2021). However, rehydration cannot be used as a cure to alleviate the stress, as the damage caused by the second drought is significantly higher. Further, rehydration can potentially vary the expression of stress-responsive genes, thus adversely affecting the stress memory, which leads to heavier stress damage upon subsequent drought exposure.

The plant microbiome, essentially the belowground microbiome, significantly regulates the development and environmental responses of plants. The belowground microbiome constitutes the complex soil microbial community or rhizosphere. The microbes can directly or indirectly benefit plant health thus affecting yield (Xiong et al., 2020). Various microorganisms can act as potential biocontrol agents to regulate plant diseases. Only 1% of such microorganisms are currently available as commercial biopesticides. DNA sequencing has explored microbial genomes for target activity-related genes that segregate the best possible microbial isolates among populations (Glare et al., 2016; Samaras et al., 2021). The molecular and biological interaction of plants with rhizospheric bacteria can significantly regulate the parameters associated with plant growth. Microbes may improve environmental conditions and soil bio-chemicals and thus improve plant tolerance to environmental challenges. Hence, supplemented with biotechnological interventions, functionally complementary microbial strains could be a promising plant management approach for regulating pathogenesis.

Agriculture around the globe is facing serious productivity concerns due to pollution, drought, global climate change, and ubiquitous pathogenesis. Biotechnology can improve our understanding of the network of physiological, biochemical, and molecular plant responses to all possible interacting factors to target stress mitigation and agricultural sustainability.

Author contributions

PG and VK: writing—review and editing. BM: editing. 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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