

23-24 Oct 2021

Enhancing Plant Resilience in Challenging Environments: A New vista

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Abstract

Plants are continuously exposed to environmental stresses such as drought, salinity, extreme temperatures, flooding, nutrient deficiency, and heavy metal toxicity, which can adversely affect their growth, productivity, and survival. With increasing climate variability and pressure on agricultural resources, enhancing plant resilience to challenging environments has become an important area of research. This paper provides an overview of emerging approaches for improving plant resilience through physiological, biochemical, molecular, and biotechnological strategies. Plants possess complex adaptive mechanisms that enable them to perceive environmental stress and activate protective responses, including antioxidant defence, osmotic adjustment, changes in root architecture, regulation of stomatal activity, and accumulation of stress-responsive metabolites. Recent advances in plant biotechnology, genomics, transcriptomics, and gene-editing technologies have provided new opportunities to understand and enhance these natural defence mechanisms. Beneficial microorganisms, including plant growth-promoting rhizobacteria and mycorrhizal fungi, also play an important role in improving nutrient uptake, stress tolerance, and overall plant health. The integration of conventional breeding with molecular approaches may facilitate the development of crop varieties capable of maintaining productivity under adverse environmental conditions. Sustainable agronomic practices, efficient water management, and the use of biofertilizers and bio stimulants can further complement these strategies. The paper highlights the importance of combining multidisciplinary approaches to develop resilient agricultural systems. Strengthening plant resilience can contribute to sustainable crop production, improved food security, and better adaptation to changing environmental conditions. Continued research is required to translate laboratory-based findings into effective and economically viable field applications.

Keywords: Plant Resilience, Abiotic Stress, Climate Change, Drought Tolerance, Salinity Stress, Plant Biotechnology, Stress Physiology, Plant-Microbe Interaction, Sustainable Agriculture, Crop Improvement