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Trehalose -mediated drought tolerance in bread wheat: integrating biochemical and physiological insights for resilience in arid environments

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Abstract

Drought stress remains one of the most critical constraints to wheat productivity in arid and semi-arid regions such as Oman, where limited water resources and high temperatures significantly threaten crop sustainability and food security. This study investigates the role of trehalose, a protective non-reducing disaccharide, in enhancing drought tolerance among 20 bread wheat (*Triticum aestivum* L.) genotypes. Plants were subjected to three soil moisture regimes—80 %, 60 %, and 40 % of field capacity—representing mild, moderate, and severe drought stress conditions. A comprehensive evaluation of physiological, biochemical, and growth-related parameters was conducted at the flowering stage, a phase particularly sensitive to water deficit and critical for yield determination.

The results revealed pronounced genotypic variation in response to drought stress. Genotypes with higher endogenous trehalose accumulation exhibited superior adaptive responses, including enhanced leaf relative water content, improved chlorophyll retention, and better membrane stability. These traits were associated with reduced oxidative damage, as indicated by lower levels of lipid peroxidation. Furthermore, elevated activities of key antioxidant enzymes—superoxide dismutase (SOD), catalase (CAT), and peroxidase (POD)—were observed in these genotypes, suggesting an efficient reactive oxygen species (ROS) scavenging system that contributes to cellular protection under stress conditions.

In addition to physiological resilience, high-trehalose genotypes maintained greater shoot biomass, leaf area, and overall plant vigour under moderate and severe drought conditions. These findings underscore the functional significance of trehalose in osmoprotection, stress signaling, and metabolic stability. Overall, this study identifies trehalose as a promising biochemical marker and potential target for improving drought tolerance in wheat. The insights gained provide a valuable foundation for breeding programmes aimed at developing climate-resilient wheat cultivars tailored to the harsh environmental conditions of Oman and similar arid regions.

Keywords: Adaptation, arid soils, crop improvement, desiccation, enzymatic defense, metabolic regulation, osmoprotection, resilience, stress biomarkers, water deficit

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