Morpho-physiological effects of moisture, heat and combined stresses on Sorghum bicolor [Moench (L.)] and its acclimation mechanisms☆

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Abstract

Increasing incidences of combined drought and heat stress poses a serious threat to production and productivity of crops in sub-Saharan Africa where 95% of crop production is rainfed. In this review we discuss the morphological and physiological effects of drought and heat stresses, with specific emphasis on their combined effects on sorghum, a hardy small grain crop of diverse uses and suitable for marginal areas of the semi-arid tropics. Resistance mechanisms to drought stress were reviewed to enhance understanding amongst crop scientists and botanists. The most important physiological processes in sorghum that is sensitive to drought and heat stresses include cell division, cell metabolism, photosynthesis, biosynthesis of bioactive and secondary metabolites, nutrient uptake and membrane stability. All of which affects germination, growth, reproduction and consequently controls crop yield. Various morphological and physiological traits enable sorghum to tolerate drought and heat stress through escaping, avoiding and tolerating their effects to sustain physiological and metabolic activities. A deep root system, thick leaf cuticle layers and leaf rolling enable drought avoidance, while physiological adjustments include osmotic adjustment and stomatal regulation. Drought tolerance mechanisms are mainly physiological adjustments such as antioxidative capacity, membrane stability, cooler canopies and a stay green trait that achieves photosynthetic capacity and transpiration efficiency. However, there is great genetic variability even within sorghum on the genotypic responses to drought and heat stress. Understanding of morphological and physiological effects of abiotic stresses, especially when combined and tolerance mechanisms of a specified important crop like sorghum, gives us better insight and a more holistic approach in understanding biological systems that affect its productivity that may enhance its management and improvement.

Keywords: Sorghum, Drought tolerance, Drought avoidance, Drought escape