Tropentag, September 10-12, 2025, hybrid conference

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Evaluating drought and salinity stress response among tropical sorghum cultivars using high-throughput phenotyping

Elvira Sari Dewi, Issaka Abdulai, Mercy Appiah, Reimund P. Rötter

University of Goettingen, Dept. of Crop Sciences: Tropical Plant Production and Agricultural Systems Modelling (TROPAGS), Germany

Abstract

Climate change threatens agriculture by increasing temperatures and the frequency of drought and extreme heat events, negatively impacting crop productivity and endangering food security. Sorghum, an important staple crop in drought-prone regions, is known for its drought and salinity tolerance. As a C4 plant, it has high photosynthetic efficiency, deep root systems increase water access, and thick leaf cuticles minimise moisture loss. This study aimed to understand better how to enhance sorghum's resilience to drought and salinity, individually and combined, by investigating key physiological traits, including stomatal regulation and stay-green. Using the high-throughput phenotyping platform PlantArray (PlantDiTec), we assessed the response of tropical sorghum cultivars (Kuali, Numbu, and Samurai2) under three phases: a pre-drought (adequate water), drought phase (80 % irrigation transpiration), and recovery (standard treatment restoration), along with two salinity levels (7 dS m^{-1} and 14 dS m^{-1}). Our results indicate significant variations among different cultivars with respect to drought and salinity response. For instance, the cultivar Numbu exhibits a conservative water-use strategy by maintaining stable transpiration, which helps preserve grain production during drought. In contrast, Samurai2 demonstrates significant reductions in transpiration under salinity, indicating effective stomatal regulation, while Kuali shows the most significant decrease in transpiration when faced with combined drought and salinity, suggesting a complex stress response. Traits like stay-green support yield stability in dry conditions, while deep root systems and thick cuticles enhance moisture access and minimise evaporation. While biomass water use efficiency improves under stress, Samurai2 experienced a drop in grain water use efficiency, revealing intricate interactions between water limitation and salinity. All cultivars, especially Samurai2, showed reduced biomass, grain yield, and 100-grain weight under combined stresses. Increased salinity levels exacerbated yield penalties across cultivars, underscoring the importance of understanding these dynamics. Breeding strategies should evaluate drought recovery and utilise genetic markers linked to traits like the stay-green characteristic to enhance resilience. The findings can support efforts to optimise drought response in existing cultivars and inform 'ideotype' breeding for future cultivars tailored to projected climatic scenarios in target regions.

Keywords: Climate change impact, high-throughput phenotyping, sorghum resilience, stay-green traits, stomatal conductance, water use efficiency

Contact Address: Elvira Sari Dewi, University of Goettingen, Dept. of Crop Sciences: Tropical Plant Production and Agricultural Systems Modelling (TROPAGS), Grisebachstraße 6, 37077 Göttingen, Germany, e-mail: elvira@unimal.ac.id