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Morpho-physiological diversity and its implications for improving drought tolerance in grain sorghum at different growth stages

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Abstract

Sorghum grown under rain-fed conditions is usually affected by drought stress at different stages resulting in negative effect on yield. The assessment and quantification of morpho-physiological diversity for the traits contributing towards drought tolerance at these stages is of vital importance. For this purpose, drought stress was imposed on 44 sorghum accessions at seedling stage and natural incidence of water stress at post anthesis stage. The data of 21 different morpho-physiological traits were subjected to different multivariate techniques, including correlation, principal component (PC) and cluster analysis to assess the diversity for drought tolerance in sorghum. The correlation analysis revealed that selection for long roots; higher root/shoot ratio, leaf area and leaf dry matter could be performed simultaneously. There was positive association between relative water contents and cell membrane stability but both of these traits were negatively correlated with residual transpiration and excised leaf weight loss. Principal component (PC) analysis showed first 7 PCs having Eigen value >1 explaining 77.653% of the total variation with head width, head weight, grain yield per plant, fresh and dry shoot weight being the most important characters in PC1. Cluster analysis classified 44 accessions into four divergent groups. The members of first two clusters exhibited adequate degree of drought tolerance on the basis of majority of morpho-physiological traits, whereas, cluster 3 and 4 included genotypes with lower level of drought tolerance. The D^2 statistics revealed the highest distances between 2nd and 3rd clusters, while 3rd and 4th clusters displayed maximum similarity. Scatter plot and tree diagrams demonstrated sufficient diversity among the sorghum accession for various traits and some extent of association between different clusters. The results concluded that morpho-physiological diversity in the studied material is structured by genotypes and this diversity could be utilized for cultivar breeding and germplasm conservation programs aimed at improving drought tolerance in sorghum.

Keywords: Sorghum. Drought tolerance; Diversity; Morpho-physiological traits; Post anthesis

Introduction

The grain sorghum (*Sorghum bicolor* L. Moench) is used as staple food in human diet as well as used in animal feed. It is the fifth leading cereal crop in the world after wheat, maize, rice and barley. Sorghum grain is the staple food of poor and the most food-insecure people, living mainly in the semiarid tropics (Ali et al., 2009a; Bibi et al., 2010). It performs better under adverse soil and weather conditions as compared to other crops (Ejeta and Knoll, 2007). However, sorghum grown in arid and semi-arid regions is influenced by water stress at terminal growth stages like anthesis and post-anthesis which renders the most adverse effect on yield in sorghum (Tuinstra et al., 1997; Prasad et al., 2008). Water stress is a problem in 45 % of the world's geographical area and is a major limitation to the productivity of agricultural systems and food production worldwide (Boyer, 1982). In cereal crops that are major carbohydrate staples for humans, water stress at critical stages like seedling establishment, tillering and reproductive stages may result in significant yield reduction and even lethal to the crops (Westgate et al., 1989; Ludlow and Muchow, 1990). Moreover, moisture deficit at the reproductive stage causes the principal decline in yield as compared to stress happening at any other growth stages. Fluctuations in water balance and soil available water are critical to crop yields because they directly disturb plant physiological processes and responses (Kramer and Boyer, 1995; Miyashita et al., 2005). Water deficits tend to shift the