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CAPABILITY OF MULTIPLE SELECTION CRITERIA TO EVALUATE CONTRASTING SPRING WHEAT GERMPLASMS UNDER ARID CONDITIONS

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Abstract

Selection criteria that would evaluate a large number of germplasm in a rapid and non-destructive manner would be considered advantageous in plant breeding programs. Trade-off between traditional and non-destructive screening criteria in evaluating 90 wheat accessions under water shortage was tested using multivariate statistical techniques. Only three irrigations during the growing cycle of germplasm were applied with the amount of water totalling 2550 m^3 ha^{-1}. Sequential path analysis identified one traditional trait (grain weight per plant) and two non-destructive traits (leaf area index and stomatal conductance) as important first-order traits that influenced final grain yield. The three traits, taken together, explained 96.8% of the total variation in grain yield. Total dry weight per plant, green leaf area per plant, harvest index, grain number per plant, leaf water content and canopy temperature were identified as important second-order traits that influenced grain yield. Although canopy temperature was ranked as a second-order trait, it explained 64.4% of the total variation in stomatal conductance. Approximately 78.0% of the total variation in grain weight or leaf area index was explained by the leaf water content (66.2%) and total dry weight (11.5%). The 90 examined spring wheat germplasms were grouped into five clusters based on all agro-physiological traits using the centroid linkage method. The tested wheat germplasm that produce high grain yield under water shortage were characterised by good performance of certain rapid, easy and non-destructive physiological traits such as high leaf area index, high stomatal conductance and low canopy temperature. Therefore, these three traits could be used in combination as quick and easy screening criteria to select suitable genotypes for water-limiting conditions.

Key words: Canopy temperature; Leaf area index; Phenomics; Sequential path analysis; Stomatal conductance.

Introduction

Water shortage has plagued every country in arid and semiarid areas. It is fundamental factor determining the distribution and productivity of many staple food crops in these areas. It is imperative to identify new germplasm adapted to these conditions in such situation. Evaluation of a large number of germplasm using different phenotypic traits at regular time intervals throughout the whole life cycle of plants is the first step to identify high yielding germplasm adapted to water-limiting conditions. In recent years, physiologists are looking for new indirect traits rather than grain yield as screening tools to select superior germplasm. These new indirect traits must be characterised by several features such as being easy, inexpensive, non-destructive and fast to observe or measure. Additionally, responding rapidly and sustainably to the environmental conditions. Moreover, showing a wide range of variability within the germplasm, being genetically associated with grain yield and stable over the measurement period (Araus *et al*., 2008; Winterhalter *et al*., 2011; Monneveux *et al*., 2012). Therefore, any trait that meets the above mentioned features would be a strong possibility as a screening tool in breeding programs for evaluating a large number of germplasm.

Many physiological processes respond rapidly and sustainably to different environment conditions, which, can be used as indirect and reliable indicators for some important direct traits that confer adaptation to water shortage (i.e., final grain yield, biomass accumulation, leaf area and water use efficiency, etc.), but measuring these direct traits are difficult, time-consuming and destructive. For example, canopy temperature (CT) has been considered a reliable predictor of final grain yield of wheat under water shortage (Feng *et al*., 2009; Li *et al*., 2012). Measurements of stomatal conductance (SC) and CT both provide indirect indicators for the water status of plants and agronomic water use efficiency under water stress as well as the capacity of roots to access available soil water (El-Hendawy *et al*., 2005; Pask & Reynolds, 2013; Marenco *et al*., 2014). Measurements of SC also provide important information about the main limitations of photosynthesis and growth under water stress (Munns *et al*., 2010; Khakwani *et al*., 2013). The leaf area index (LAI), which is the ratio of the leaf green area to the area of ground on which the crop is growing, can be used as a reliable indicator for leaf area expansion of a cereal crop, relative water content and dry matter production under water stress (Royo *et al*., 2005). Fortunately, the availability of different devices for high-throughput phenotyping allows measurement of some indirect traits such as CT, SC and LAI in a fast and non-destructive manner.