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Increases in yield potential achieved by breeding in durum wheat and barley for Mediterranean environments

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In Mediterranean environments, water regime and temperature explain a mayor proportion of the yield variation of cereals. The region is particularly sensitive to drought and potentially very vulnerable to future climate changes. Even if rainfall does not change, increased risks for drought will result from an increased atmospheric evaporative demand in a warmer future climate. As a consequence, soils will dry out faster and prolonged summer droughts might become more frequent.

Breeding for drought resistance is therefore required for both mild and severe stress conditions. This implies a need for a better characterization of the biodiversity available for drought and a deeper comprehension of the physiological mechanisms, which are crucial to assure yield when drought occurs.

Thus, traits related to drought resistance and to high yield potential should be alternatively favored in cereal breeding programs, based on the ideotype for a target area and a specific type of stress.

In the present work, we evaluated the diversity for yield performance under rainfed conditions and with supplementary irrigation in a set of barley and durum wheat cultivars in a Mediterranean environment subjected to mild drought. In this environment, more severe drought events may occasionally occur, especially during grain filling, when a gradual rise in temperature is associated with a severe depletion of soil water resources. We assumed, therefore, that the ideotype for these environments should have minimal GE interaction, so that genotypes with both high yield potential and stable yield would be selected.

Here we propose to use the integrated growing season WSI (water stress index) as a parameter to quantify the stress level experienced by a crop in different trials and the yield vs. WSI regression as a tool for simultaneous comparison of the performance of the genotypes across water-stressed and nonstressed environments.

Under the conditions of our trials, the higher sensitivity to decreasing water availability in high-yielding genotypes was associated with the absence of a significant GE interaction. This suggests that in high-yielding genotypes, physiological mechanisms operate in a way that confers the ability to perform well under water limitation. In this study, this ability was associated with a higher slope of the yield vs. WSI regression. Genotypes with high intercept and more negative slope may therefore be regarded as highly responsive to water availability, possibly because of their higher WUE or a greater ability to take up water.

Notably, some the genotypes selected in environments very different with respect to the site analyzed here, have shown wide adaptability, performing even better than the local checks included in the experiment. This indicates that selection under favorable environments allows for the identification of genotypes well adapted to moderate Mediterranean water stress levels. The alternate use of optimum and stress conditions during of after selection, however, may be even better for identifying genotypes with high yield potential with low of high yield stability under more stressed conditions.

The genotypes identified here are endowed with genes for a wide range of adaptability under favorable and stress environments. These genotypes can be used to understand better which metabolic processes and morphophysiological traits are crucial to assure high yield performance under different environments.