Genetic and physiological dissection of transpiration efficiency in wheat

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Crops reliant on rainfall for growth commonly experience water deficits that reduce grain yield and quality. Selection for genotypic adaptation to water-limited environments is challenging and progress is slow. Many factors contribute to slow breeding progress in dry, rainfed environments: (1) strict requirements for improved grain quality and disease resistance reduce genetic variance for performance under drought; (2) drought is a dynamic entity changing in timing and severity from one year/site to another; and (3) both the above contribute to large genotype × environment interaction to reduce repeatability of genotype performance and confidence in selection. The opportunity exists to compliment existing selection for yield with selection for novel trait variation to improve performance.

Water-use efficiency (WUE as biomass ÷ water used) is genetically correlated with improved biomass and yield under drought. Transpiration efficiency (TE), the ratio of net photosynthesis to water transpired, is an important component of WUE in environments where stored soil water accounts for a major portion of crop water use. Carbon isotope discrimination (Δ), through its negative relationship with transpiration efficiency and ease of measurement, has been used in selection of higher wheat yields in breeding for dry, rainfed environments. Mapping studies have shown Δ to be genetically complex. In wheat, chromosomal regions for Δ collocate across populations, while some regions (e.g. 2BS, 3BS, 4AS and 7AS) have been retained in phenotypic selection for Δ from the donor cultivar Quarrion, indicating high breeding value. Detailed studies aimed at physiological dissection of Δ indicate some Δ genomic regions are associated with changes in leaf conductance and/or canopy temperature, and others with regions varying for possible surrogates (e.g. leaf thickness and N content) of photosynthetic capacity. This information is leading toward development of quick, less-expensive protocols for screening breeding populations in early generations for improved performance under water-limited conditions without compromising performance in the absence of water deficit.