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Integrating rapid phenotyping and speed breeding to improve stay-green and root adaptation of wheat in changing, water-limited, Australian environments.

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Abstract

Temperatures have increased and in-crop rainfall decreased over recent decades in many parts of the Australian wheat cropping region. With these trends set to continue or intensify, improving crop adaptation in the face of climate change is particularly urgent in this, already drought-prone, cropping region. Importantly, improved performance under water-limitation must be achieved while retaining yield potential during more favourable seasons.

A multi-trait-based approach to improve wheat yield and yield stability in the face of water-limitation and heat has been instigated in northern Australia using novel phenotyping techniques and a nested association mapping (NAM) approach. An innovative laboratory technique allows rapid root trait screening of hundreds of lines. Using soil grown seedlings, the method offers significant advantages over many other lab-based techniques. Another recently developed method allows novel stay-green traits to be quantified objectively for hundreds of genotypes in standard field trial plots. Field trials in multiple locations and seasons allow evaluation of targeted trait values and identification of superior germplasm. Traits, including yield and yield components are measured for hundreds of NAM lines in rain fed environments under various levels of water-limitation. To rapidly generate lines of interest, the University of Queensland "speed breeding" method is being employed, allowing up to 7 plant generations per annum. A NAM population of over 1000 wheat recombinant inbred lines has been progressed to the F5 generation within 18 months. Genotyping the NAM lines with the genome-wide DArTseq molecular marker system provides

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up to 40,000 markers. They are now being used for association mapping to validate QTL previously identified in bi-parental populations and to identify novel QTL for stay-green and root traits.

We believe that combining the latest techniques in physiology, phenotyping, genetics and breeding will increase genetic progress toward improved adaptation to water-limited environments.

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Keywords: root architecture; wheat; drought adaptation