A genetic dissection of drought and heat tolerance related traits in bread wheat (*Triticum aestivum* L.)

By

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Abstract

This study was conducted with the aim of improving our understanding of the genetic basis of the superior grain yield of an elite bread wheat breeding line, RAC875, under drought and heat stressed Mediterranean-type climates in southern Australia. Here, these abiotic stresses present a significant barrier to production. Kukri is a locally adapted variety which achieves acceptable grain yield under more favourable conditions, but relatively low grain yields under severe stress. A cross between the two lines resulted in an F_1 derived doubled haploid population consisting of 368 individuals.

The population was initially used for the genetic dissection of time to ear emergence and flag leaf glaucousness, with the latter trait hypothesised to explain a significant proportion of RAC875's relative drought and heat tolerance. Whilst parents of the population achieved similar time to ear emergence, segregation for *Ppd-B1* and *Ppd-D1a* created large variation for this trait within the population. Two novel minor loci were detected for time to ear emergence (*Q.Eet.aww-1A* and *Q.Zad.aww-4A*), in addition to another eight known, minor loci. Five novel loci were detected for flag leaf glaucousness (*Q.W.aww-3A, Q.W.aww-3B, Q.W.aww-3D, Q.W.aww-4D* and *Q.W.aww-5B*), with one in particular (*Q.W.aww-3A*) accounting for up to 52 percent of the genetic variance for this trait.

Sixteen field experiments were sown across southern Australia between 2006 and 2010, where average site grain yields ranged from 314 to 5275 kg ha^{-1}. Kernels per square metre was the trait most correlated with grain yield, while spikelet fertility, which had a significant positive correlation with grains per square metre in all experiments and the subsequently derived environment clusters, was also related to grain yield. Nine loci were detected for grain yield independent of time to ear emergence and plant height. Five of these loci co-located with loci for kernels per square metre and only one of these nine loci were associated with any of the loci for flag leaf glaucousness and this genetic effect was opposite (i.e. Kukri allele resulting in large glaucousness value and lower grain yield). The RAC875

allele at QTL on chromosomes 1B and 7A (*Q.Yld.aww-1B* and *Q.Yld.aww-7A-2*) was associated with greater grain yield, kernels per spikelet and kernels per square metre. These two loci were detected in environment clusters where heat stress was a differentiating factor and it was concluded that these may therefore be associated with heat stress tolerance. Another QTL of large effect was consistently detected on chromosome 6A (*Q.Tkw.aww-6A*), with the RAC875 allele positively affecting grain size, flag leaf width and stem water soluble carbohydrate content but resulting in lower kernels per spikelet and therefore kernels per square metre.

Experiments were also sown to assess the performance of the population in north-west Mexico under well watered, high yield potential conditions, as well as drip irrigated drought treatment and late planted but well watered conditions to expose the experiments to heat stress. This resulted in three very distinctive treatments and subsequently detected different genetic regions controlling grain yield. Two distinct QTL were detected for grain yield and canopy temperature on chromosome 3B, under irrigated (Q.Yld.aww-3B-1) and irrigated, drought and heat stressed treatments (Q.Yld.aww-3B-2). The latter QTL accounted for up to 22 percent of the genetic variance for grain yield and 20 percent of the genetic variance for canopy temperature under the heat stress treatment. However, all three treatments failed to detect any major QTL of common effect to southern Australia.

This study highlighted the complex genetic basis of grain yield and physical grain quality in drought and heat stressed conditions, as well as the importance of conducting QTL dissection in the target environment. However, key loci detected offer potential for marker development and deployment of marker assisted selection within wheat breeding programmes targeting southern Australia. In the longer term, this should help improve the rate of genetic gain for grain yield, increasing production by growers in the Mediterranean type climate of southern Australia.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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