The Genetic Analysis and Manipulation of Economically Important Traits in Bread Wheat

By

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Abstract

The aims of this thesis were to firstly gain an improved understanding of the genetic basis to economically important complex traits in bread wheat, and secondly, to investigate marker assisted selection (MAS) methodologies that may lead to improved rates of genetic gain. An elite Australian breeder's line, 'Stylet', and its parents 'Trident' and 'Molineux' were used as the basis of this study.

A doubled-haploid (DH) population previously produced from a cross between 'Trident' and 'Molineux' (T/M DH) was used to dissect the genetic basis to end-use quality and agronomic performance. The study of end-use quality confirmed the widely published relationship between the glutenin loci and dough rheology. However this study also identified a quantitative trait locus (QTL) on chromosome 2A that was shown to be associated with dough resistance and baking quality, and another QTL on 3A that was associated with baking quality.

QTL were identified in the T/M DH population that were involved in the control of time to ear-emergence through their effects on vernalisation sensitivity, photoperiod sensitivity and earliness per se. In addition to the well characterised Vrn-A1 and Ppd-B1 genes, six other QTL were identified. Three of these, QPpd.agt-1A, QPpd.agt-7A and QPpd.agt-7B are putative new loci involved in the control of photoperiod sensitivity in wheat. QPpd.agt-1A appears homoeologous to the photoperiod response gene Ppd-H2 in barley. QPpd.agt-7A and QPpd.agt-7B are located in homoeologous regions, and may represent a new phenology gene series in wheat.

The T/M DH population was also used to dissect the genetic basis to grain yield and grain yield components, and to examine the influence of QTL-by-environmental covariable interaction on genotype-by-environment interaction. The association of plant height genes, rust resistance genes and phenology...
genes with grain yield were determined. Overall, semi-dwarf rust resistant DH lines, carrying alleles conferring a short time to ear-emergence, showed the highest and most stable grain yield. Nine genetic associations with grain yield, without effects on plant height, time to ear-emergence and rust resistance, were identified. Two QTL, \textit{QGyld.agt-1B} and \textit{QGyld.agt-4D} were shown to have large and frequent associations with grain yield. \textit{QGyld.agt-1B} showed only low levels of interaction with environmental covariables and therefore constitutes a prime candidate for MAS for grain yield.

The second part of this study investigated the potential role of MAS through a practical breeding strategy and by computer simulation. An ‘Anneullo/2*Stylet’ cross aimed at producing a rust resistant ‘Stylet’ derivative with improved end-use quality was used as the model for this analysis. MAS was shown to be highly effective at improving the rate of genetic gain for rust resistance and end-use quality. This was most evident when undertaken on the BC$_1$F$_1$ population, although MAS also improved the efficiency of the breeding programme when performed on fixed lines. Practical implementation of the MAS breeding strategy validated the results from the simulation study and produced elite lines approaching the grain yield level of ‘Stylet’, with resistance to leaf, stem and stripe rust, and with improved end-use quality.

While the results from this study highlight the complex nature of the major economically important traits being manipulated by wheat breeders, this study also concluded that improvements in rate of genetic gain are possible through the application of MAS.
Statement

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. I give consent to this copy of my thesis when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968. The author acknowledges that copyright of published works contained within this thesis (as listed below) resides with the copyright holder(s) of those works.


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NOTE: Statements of authorship appear in the print copy of the thesis held in the University of Adelaide Library.