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

By

Haydn Kuchel

Bachelor of Agricultural Science (Honours), University of Adelaide

A thesis submitted for the degree of Doctor of Philosophy in the faculty of Agriculture, Food and Wine at the University of Adelaide

Department of Plant and Pest Science
Waite Campus

November 2007

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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, *QGyld.agt-1B* and *QGyld.agt-4D* were shown to have large and frequent associations with grain yield. *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_1F_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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Haydn Kuchel

November 2007

Acknowledgments

There have been many people who have helped and encouraged me during my PhD studies. To each and everyone one of them, thankyou.

Thankyou to the numerous people at the University of Adelaide who helped me with various field and laboratorial activities. Special thanks to: Ken Chalmers, Penny Henshke, Alison Hay, Matthew Hayden, Dianne Mather, Paul Eckermann, Patricia Warner, Margie Pallotta, Dayton Coffey, Genet Mekuria, Ute Baumann, Klaus Oldach, Glenn McDonald, Colin Jenner, and Rajinder Sharma.

I would like to especially thank Jim Lewis who provided substantial help with my field work in the first two years of my PhD. I learnt a lot during those trips in the truck.

Some of my greatest appreciation must go to Rebecca Fox who not only performed a number of marker assays for these publications, but also helped me 'remember the ropes' when I ventured nervously, on occasion, back into the lab near the end of my studies.

I am very grateful to the SARDI marker lab (Kevin Williams, Kerrie Willsmore, Steve Olson and Judy Cheong) for their contribution to the 'Trident/Molineux' DH map. I enjoyed working with you all. My mapping work would have looked a little thin without the map!

Thankyou to the computer simulation team at the University of Queensland (Gouyou Ye, Ian DeLacy and Alex Pudmensky) for their help with the MAS simulation.

I would also like to thank CAMBIA for hosting me for six weeks and allowing me to work on DArT in wheat. A special thanks to Andrzej Killian for his academic input and to Damian Jaccoud for making me feel so welcome.

To the AGT people with whom I have had the pleasure to work and study; one couldn't ask for a better team to be part of! I would like to thank the AGT quality team (Lee Mosionek, Rob Raymond, Kylie Zakelj and Shylee Alagich) for their help with the end-use quality investigations and the AGT Roseworthy field team (Simeon Hemer, Stuart Milde, Dan Vater, Phil Keatley, Rowan Prior, Colin Warner, Kath Kuchel, Jake Schutz, and Sue Edlington) for their help with the agronomic assessments.

Thankyou to all the breeders at AGT who have provided an ideal forum to thrash out ideas and concepts that have been included in this thesis. I would like to make special mention of Jason Reinheimer, Gil Hollamby and Russell Eastwood who have helped me crystallise many of my conclusions.

Special thanks must be reserved for Howard Eagles who, though by no means obligated, was happy to provide critical feedback for much of my writing. I would also like to thank Howard for being my first 'port of call' for quantitative genetics and all things statistical.

Thankyou Peter for being there to bounce ideas off, critiquing my writing and for the general supervision you have provided. I admire the fine balance you manage to keep between the 'blue sky' and 'applied' research.

Steve. Well, if it wasn't for you, I would probably be finishing a thesis on the eating quality of beef, or the protein content of milk. Thanks for pointing me in the 'right' direction. Wheat breeding has turned out to be my dream job. Thankyou for all the time you gave me, even when you had more important, and probably more interesting things to do!

To my parents: thankyou for always encouraging me to ask 'why' and giving me the confidence to seek the answers. To the rest of my family, thanks for constantly asking "are you finished yet?".

Bianca, if meeting you was the only positive thing to come out of my PhD, it would have been worth it. Thankyou for putting up with the many many hours that I have spent writing, and for doing more than your fare share of chores around the house to provide me the time to complete this thesis. May we enjoy the extra hours that we now have to share.

Lastly, I would like to acknowledge the grand designer and author of life who created this complex puzzle we are attempting to understand.