Genetic Studies of Salinity Tolerance in Wheat

By

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Abstract

Salinity is an important issue in arid and semi-arid regions of the world, both in irrigated and dryland agriculture. Increasing salinity tolerance of crops is a feasible approach to tackling salinity. Focusing on the physiological traits associated with salinity tolerance such as Na^+ exclusion and osmotic stress tolerance simplifies the strategies for improving tolerance.

The first aim of the study described in this thesis was the development of a high throughput technique for the measurement of osmotic stress tolerance in bread wheat. This technique was then applied to 162 recombinant inbred lines derived from crossing two Australian bread wheat cultivars (Gladius and Drysdale), to identify the loci associated with osmotic stress tolerance and 4^{th} leaf Na^+ accumulation. This population was grown under two growth conditions – a pot-soil set-up with non-destructive imaging system (LemnaTec Scanalyzer 3D technology) for the estimation of osmotic stress tolerance using high through-put system (conveyor belt system) and a supported hydroponics set-up for 4^{th} leaf Na^+ and 4^{th} leaf K^+ accumulation measurements. In the soil based study, QTL analyses revealed two major QTL on the distal regions of the short arms of chromosomes 2B and 1B, where the salinity tolerance index (shoot biomass in saline conditions relative to shoot biomass in control conditions) and osmotic stress tolerance overlapped. Another significant QTL for osmotic stress tolerance was mapped onto the distal region of the long arm of chromosome 5D. In the hydroponics study, two QTL associated with 4^{th} leaf Na^+ accumulation were mapped to the distal regions of the long arms of chromosomes 1D and 3B. Loci containing a vernalisation gene (*VRN-A1*), on the long arm of chromosome 5A, and a photoperiod gene (*Ppd-D1*), on the short arm of chromosome 2D, had an impact on tiller number, shoot biomass and shoot water content in salt and control conditions.

The second aim of the research program was to study the genetics of Na^+ exclusion in two Afghani durum wheat landraces, which accumulated half the amount of 3rd leaf Na^+ compared to Australian commercial durum wheat cultivars. These landraces were crossed with an Australian durum wheat (cv Jandaroi) and F_2 populations were developed. The parents and F_2 population were grown in a supported hydroponics system at 100 mM NaCl, and the Na^+ and K^+ concentrations in the third leaf was measured after ten days growth in salt. Selective genotyping analysis using DArT markers and bulked segregant analysis (BSA) using SNP markers were carried out to detect the putative genomic regions responsible for salinity tolerance. Both analyses revealed a locus on the distal region of the long arm of chromosome 4B associated with Na^+ and K^+ accumulation and the ratio of K^+/Na^+ in the third leaf; the favourable allele derived from the Afghani landraces. BSA identified another locus on the distal region of the long arm of chromosome 3B, associated only with 3rd leaf Na^+ accumulation and the favourable allele was inherited from Jandaroi. These loci on chromosomes 3B and 4B were validated in the entire F_2 population and marker regression analysis showed that both have a significant association with 3rd leaf Na^+ accumulation.

The putative genomic loci identified in this thesis can be validated further and these would lead to the identification of genes and the development of markers to facilitate the breeding of salt tolerant wheat cultivars.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, 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 in my name, 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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