Breeding Durum Wheat for South Australia

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Abstract

Durum wheat (*Triticum turgidum* L. var. *durum*) is a relatively new crop to South Australia, with commercial production commencing in 1991, based on the variety Yallaroi from New South Wales. Although the South Australian climate is characterized as Mediterranean, the environment for crop growing is highly variable. Early introductions were poorly adapted to this environment. Production is currently limited to the high rainfall zones of the state and for production to increase the crop needs to expand into more marginal areas. Much of the cereal belt in these areas is affected by high levels of soil boron (B), which has been identified as a major environmental factor limiting yield in hexaploid wheat (*T. aestivum*) and barley (*Hordeum vulgare*). Tolerance to B will therefore be a pre-requisite for improved adaptation of durum in South Australia. Success of the durum industry depends on continuity of supply, maintaining quality equivalents to premium grain from Canada, and improving quality attributes to have an advantage on the world market. This thesis examined: (i) genotype x environment (GxE) interaction to improve adaptation, (ii) breeding to increase B tolerance, and (iii) enhancing quality by improving dough strength.

Field studies showed a major factor influencing the grain yield of durum wheat in South Australia was seasonal rainfall. Durum wheat had a lower grain yield per unit of rainfall compared with the bread wheat variety Spear, which suggested durum had a lower water use efficiency. This is likely to be a reflection of edaphic variation (eg. intolerance to B toxicity and sodicity) in the root zone resulting in lower water and nutrient uptake, and therefore breeding should be for stress tolerance, not yield potential *per se*. GxE interaction accounted for most of the observed variation, and most was associated with the locations x years (LxY) component, indicating that testing over a number of locations and years is necessary. Genotype x locations (GxL) and genotype x years (GxY) components were relatively small, which suggests some consistency in the ranking of genotypes over locations and years, and a need for greater genetic diversity. Durum yielded poorly under unfavourable conditions. Yallaroi had the lowest overall rank for yield performance and was specifically adapted to
favourable environments, while the advanced breeder's line RH972025 had the highest rank and was well adapted to all environments. Yallaroi and RH972025 existed in two distinct and dissimilar genotypic domains on a Principal Component biplot, which will provide reference points from which stability and adaptation of new genotypes can be assessed in the future. Widely adapted lines are likely to be selected from within the domain of RH972025. Spatial Analysis classified four distinct groups of sites, one of which could be attributed to drought and another to toxic locations.

To improve the B tolerance of Australian durum varieties, F2-derived progeny from a cross with moderately B tolerant genotype AUS 1401b and sensitive Australian germplasm were selected at a high concentration of B, screened in a filter paper assay and evaluated under a range of B conditions in the field. The seedling root length of F4 progeny showed significant differences in response when grown in toxic level of B in a filter paper assay. Families with long roots in the filter paper bioassay had a grain yield advantage (11-19% over families with shorter roots) when grown under high B conditions (eg. when grain B concentrations > 3.0 mg kg⁻¹) in the field. This yield advantage did not occur at all locations, and other factors are likely to have contributed to yield differences among genotypes at these sites. In contrast to previous work with bread wheat, the concentration of B in whole shoots and in grain was not significantly correlated with root length at high B in the filter paper assay, or with grain yield at sites with a B effect. The concentrations of other elements in the grain were also determined, and these differed significantly among families. The concentrations of sodium (Na) indicated the levels for durum were generally higher than those reported for bread wheat, and above the value considered toxic for bread wheat.

To secure and maintain international markets, varieties with strong dough strength are necessary. To enhance quality of Australian durum, the association of alternative HMW glutenin subunits at the Glu-I loci (including Glu-D1) with physical dough properties and cooked pasta in a Yallaroi background was evaluated. The SDS-sedimentation (SDSS) test, which evaluates gluten strength, showed durum progeny lines had lower mean SDSS values
than the hexaploid controls. However, progeny lines with the substitution of chromosome 1D
(with subunits 5+10) for chromosome 1A were associated with higher sedimentation volumes
comparable to a hexaploid wheat with subunits 2+12. Significant differences occurred
between the durum controls for mixograph rheological parameters mix time (MT), peak
height (PR), time to peak bandwidth (TPBW) and peak bandwidth (PBW). In the progeny
populations, subunits 2* or 13+16 increased MT, and the allele Glu-AIV produced higher PR.
The introgression of desirable subunits 17+18 from hexaploid wheat into Yallaroo,
unexpectedly, did not improve the quality parameters assessed. Cooked pasta firmness was
highly significant and positively correlated with grain protein concentration and mixograph
PR. No differences in firmness between the HMW glutenins occurred when protein
concentration was used as a co-variante. Pasta resilience was independent of rheological
parameters, but nevertheless varied with subunits 1, 2* or 13+16. Stickiness was negatively
correlated to firmness, and influenced by protein concentration and subunit 2*.

In conclusion, the outcome of the yield evaluation trials conducted in this study was the
identification of the high yielding and widely adapted line, RH912025, which was
consequently released as the variety Tamaroi. Development of B tolerant lines, with a grain
yield advantage when grown under high B conditions in the field, means durum production
will be able to expand into marginal areas where B toxicity occurs. Furthermore, by
pyramiding genes for B tolerance and dough strength (ie. subunit 2*) into Tamaroi, the result
should be widely grown germplasm, with premium quality for the international market,
providing farmers with a financial reward.