Genetics and Agronomy of Transient Salinity In *Triticum durum* and *T. aestivum*

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ABSTRACT

Transient salinity in soils is characterised by high concentrations of salts in the subsoil, which vary with depth and change throughout the season in response to rainfall, surface evaporation and water usage by vegetation. Soils affected by this form of salinity comprise at least 50% of the area cropped to cereals in South Australia and have a large impact on grain production, particularly in years receiving below average spring rainfall. Durum wheat (*Triticum turgidum* L. Var *durum*) is less tolerant of transient salinity than locally developed bread wheat (*Triticum aestivum*) varieties, and this results in reliable durum production being restricted to relatively unaffected soils.

Field trials were conducted to assess the relative impact of transient salinity, boron toxicity and bicarbonate on crop production. Despite more than half of the sites being located on subsoils with salinity levels in excess of 4dS/m ECe, there was only one transient saline site, at Roseworthy, where EC was the dominant soil co-variate affecting yield. Boron toxicity was the dominant covariate at another Roseworthy site, while high pH was the dominant factor at half of the locations investigated. At many of the sites, more than one constraint was present at levels expected to restrict crop growth, yet one dominant factor explained most of the variation in yield. This highlighted the importance of combining tolerance to all three subsoil constraints into varieties intended for widespread adoption.

A Na exclusion trait was backcrossed into the background of the boron tolerant variety Kalka three times (BC_3), and a population of 196 F_2 derived lines selected. The trait segregated in ratios indicative of control by a single dominant gene at all stages of the backcross process, and full recovery of the Na excluding ability of the donor parent was

achieved. Na exclusion reduced the Na concentration in grain and it was found that grain analysis can be used as an accurate selection method.

The population was sown at three field sites with subsoil salinity levels in excess of 10dS/m ECe. A significant yield difference between Na excluding and non-excluding lines was detected at one of these sites; however, one site suffered from a severe infection of crown rot (*Fusarium pseudograminearum*), while the other has been shown to be dominated by high pH. In the latter site, the sensitivity of the recurrent parent Kalka to high pH restricted root growth to the upper soil layer, above that affected by transient salinity.

Na^+ exclusion was expected to increase the concentration of K^+ in plant tissue, but it was found that other ions were also affected. The cations Ca^{2+} and Mg^{2+} increased in concentration, while the concentration of the anions Cl^- and SO_4^{2-} decreased, suggesting that the exclusion of Na^+ ions was to some degree balanced by changes in concentration of other ions. The specific ions affected and the relative change in each varied depending on the soil. The increase in concentration of the low Na accumulating genotypes was large enough to be the difference between deficient and adequate nutrition of K, Mg and Ca at some field sites.

Bread wheat is able to exclude Na, so whole plant concentrations are commonly 5-10 fold lower than that of durum; however the variety Krichauff was shown to exclude more Na than its sister variety, Worrakatta. A population of F_5 derived lines developed from the cross between these two varieties, was yield tested at four sites affected by transient salinity. The population was sampled at the Redhill site, and assessed for Na concentration in the whole tiller by inductively couped plasma (ICP) spectrometry. Significant correlations were detected between the Na concentration at Redhill and grain yield at Buckleboo, and screenings (%) at Port Pirie, indicating that the Na exclusion of Krichauff can have a beneficial effect on transient salinity tolerance.

Bulked segregant analysis revealed that the Na exclusion trait of Krichauff was controlled by a QTL on the long arm of chromosome 4B, which was linked to the microsatellite marker *gwm149*. This marker explained 61% of the variation in Na concentration among the lines included in the bulks.

A synthetic hexaploid (*Triticum aestivum*), which was identified as having the ability to tolerate high internal concentrations of Na, was able to maintain a significantly higher green leaf area than either Kharchia 65 or Krichauff when irrigated with saline nutrient solution. A significant salinity x genotype interaction occurred, which resulted in the synthetic line having higher fresh shoot weight in 75mmol/L NaCl. ICP analysis revealed that there was no significant difference in Na concentration, suggesting that an internal tissue tolerance mechanism, rather than exclusion was responsible for the observed tolerance.

This work has been incorporated into local breeding programs and has illuminated agronomic work on toxic subsoils and nutrient deficiencies.