Update on GRDC Project UA00159: Improving wheat yields on sodic soils

Rhiannon Schilling

Key messages

- Multiple subsoil constraints are limiting crops from achieving their yield potential in sodic sites
- Field and greenhouse trials are identifying plant traits linked to higher grain yields in sodic soils
- Wheat diversity lines are being screened to identify novel tolerance to subsoil constraints
- A crossing program is underway to pyramid traits of interest into elite wheat varieties

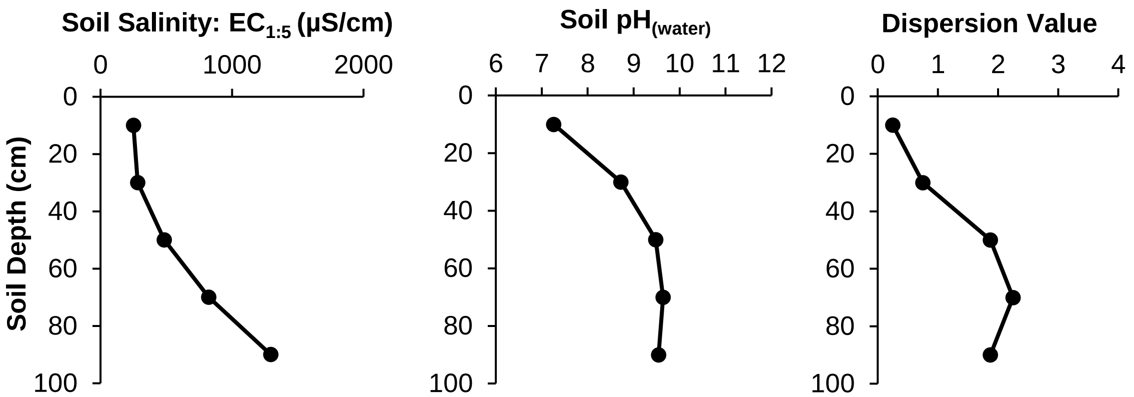
Sodic soils contain multiple subsoil constraints including high pH (pH > 9), high salinity, high aluminium, high boron, waterlogging and high soil strength. These soil constraints can restrict the ability of plant roots to uptake water and nutrients from the subsoil limiting crops from achieving their grain yield potential. A current GRDC-funded project (UA00159) is aiming to improve wheat yields by pyramiding tolerance to multiple subsoil constraints into elite wheat varieties. Two approaches are underway including:

(1) Screening current wheat varieties to identify plant traits linked to higher grain yield in sodic soils and pyramiding these traits in elite wheat varieties using marker assisted selection; and

(2) Identifying landrace wheat with novel sources of tolerance to one or more subsoil constraints and incorporating this tolerance into current elite varieties using conventional crossing methods.

Field trials at 12 sodic and non-sodic sites around Australia (WA, SA, Vic, NSW and Qld) are being conducted to test a core set of 52 bread and durum wheats including varieties with known tolerance to one or more subsoil constraints, local check varieties, advanced breeding lines and landraces. Various soil measurements are collected at each trial including EM38 mapping throughout the year and deep soil core analysis for electrical conductivity ($EC_{1:5}$), pH, soluble cations, clay dispersion levels and soil water contents. Figure 1 shows soil salinity, alkaline pH (>9) and clay dispersion increasing with soil depth at Mallala, South Australia this year and indicates that multiple soil constraints are occurring from 60 to 100 cm in the soil profile.

Figure 1: The electrical conductivity ($EC_{1:5}$), soil $pH_{(water)}$ and clay dispersion value (0 to 1 = none, 1-2 = low, 2-3 = moderate and 3-4 = high dispersion) at 0-20, 20-40, 40-60, 60-80 and 80-100 cm in the soil profile at Mallala, SA.



Other field trial measurements recorded include plant establishment counts, leaf ion analysis, flowering time, drone aerial imaging for plant growth rates and multispectral values, 1000 grain weights and grain yield. A destructive trial of 12 varieties is included for biomass measurements at stem elongation and anthesis, evaluation of crop water use in the subsoil and measurements of root length in the soil profile (to 1 m) using soil DNA methods. Figure 2 shows the average soil water content shortly after anthesis in three plots of Mace, Bremer, Corack and Saintly compared to the bare soil with no plant growth at Mallala this year. The results indicate that the varieties are extracting water in the soil profile to around 80-100cm. The amount of water used by Mace at 20 to 60 cm in the soil profile is less than other varieties suggesting Mace may be conserving soil water up to anthesis.

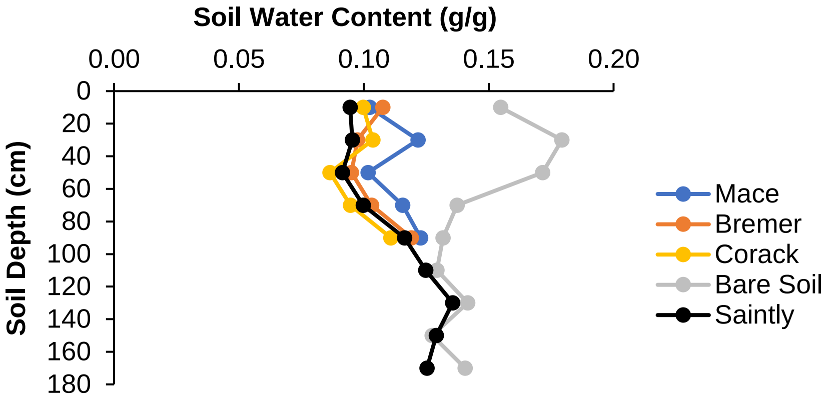
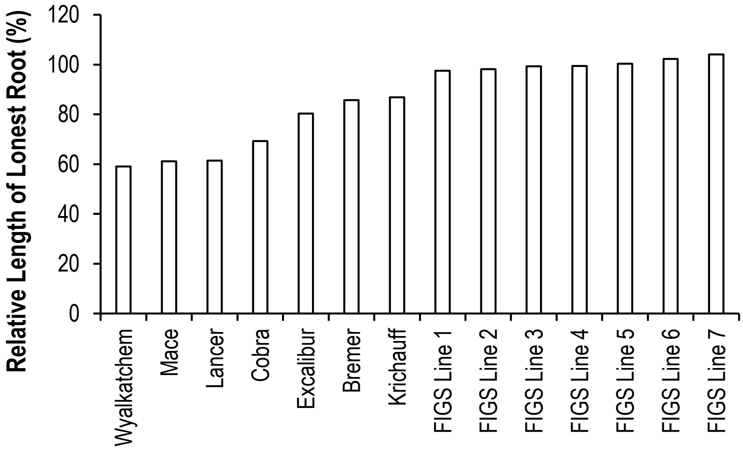


Figure 2: Soil water content (g/g) in plots of Mace, Bremer, Corack and Saintly shortly after anthesis at 0-20, 20-40, 40-60, 60-80, 80-100, 100-120, 120-140, 140-160, 160-180 cm in the soil profile at Mallala 2017. Crop water use is the difference in soil water content for each variety compared to the bare soil.

Controlled greenhouse trials ranking the core set of 52 varieties for tolerance to waterlogging at seed imbibition, high boron, high pH, high pH with high aluminium and root growth through hard soil have been conducted. Krichauff was identified as the most tolerant variety to high pH (>9) out of the core set of 52 varieties screened in this project. Two wheat diversity sets, including 330 lines from a Focused Identification of Germplasm Strategy (FIGS) with landraces from 28 countries, have also been screened for tolerance to subsoil constraints including maintenance of root growth under high pH (>9). We have now identified FIGS lines with greater tolerance to high pH conditions than Krichauff including FIGS lines that show no reduction in root growth under high pH relative to their root growth under adequate pH conditions (Figure 3).

Figure 3: The relative length of the longest root (%) at pH 9.2 versus pH 7.8 (%) of Wyalkatchem, Mace, Lancer, Cobra, Excalibur, Bremer and Krichauff and 7 FIGS landrace wheat lines. The solid line indicates the current level of tolerance to high pH conditions with Krichauff being the benchmark variety identified from a screen of 52 bread and durum wheat varieties.



Genetic markers linked to high boron, salinity and aluminium tolerance, as well as important phenology and grain quality genes have been tested on all varieties and landraces. A conventional crossing program is underway to pyramid tolerance to these multiple constraints into current elite varieties and future crossing will use any landraces identified with novel tolerance to subsoil constraints.