Phenotypic analysis of abiotic stress tolerance in Australian oat

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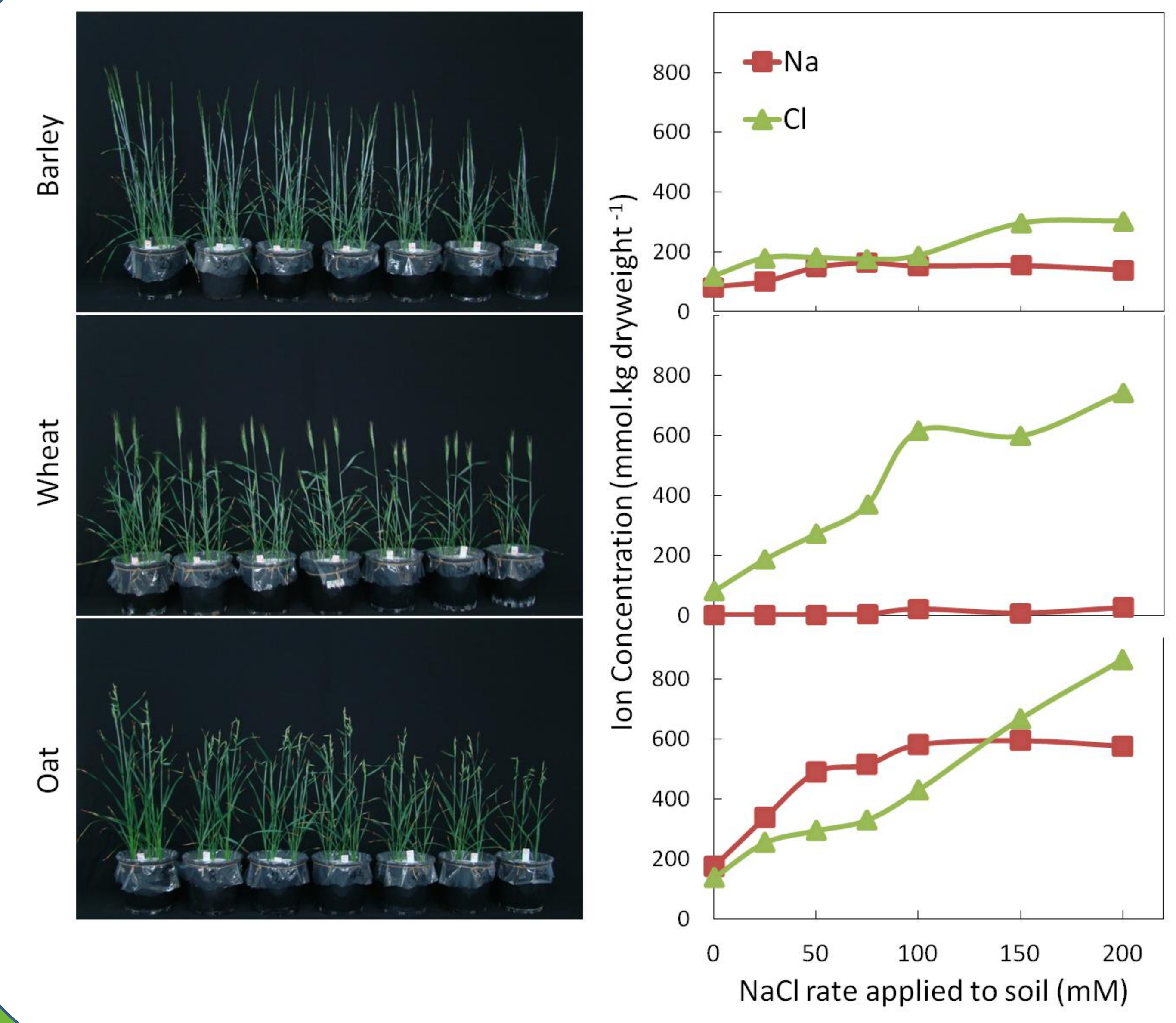
Introduction

Boron toxicity affects about 50% of the neutral-alkaline soils of the South Australian and Victorian grain belt and dryland salinity affects 67% of all cropping areas in Australia. These sub-soil constraints are known to impose yield penalties in wheat and barley under conditions of water deficit that are prevalent in the Australian cropping environment. In this project our aims were to benchmark boron and salinity tolerance of oat against wheat and barley to reveal if potential genetic improvements in boron and salinity tolerance may result in yield improvements.

Benchmarking salinity tolerance in oat

Measurements of salinity tolerance revealed that barley, wheat, and oat may achieve tolerance through different mechanisms. Barley is considered to be the most salt tolerant of all cereal species and maintained both Na^+ and Cl^- exclusion in the present study. There may be limited gains in barley through further Cl^- and Na^+ exclusion. By comparison, bread wheat is known to exclude Na^+, as confirmed in this study, and further improvement may be possible by improving Cl^- exclusion. In contrast, both Na^+ and Cl^- ions were relatively high in oat and there appears to be scope for improved salinity tolerance through identification and selection for exclusion mechanisms.

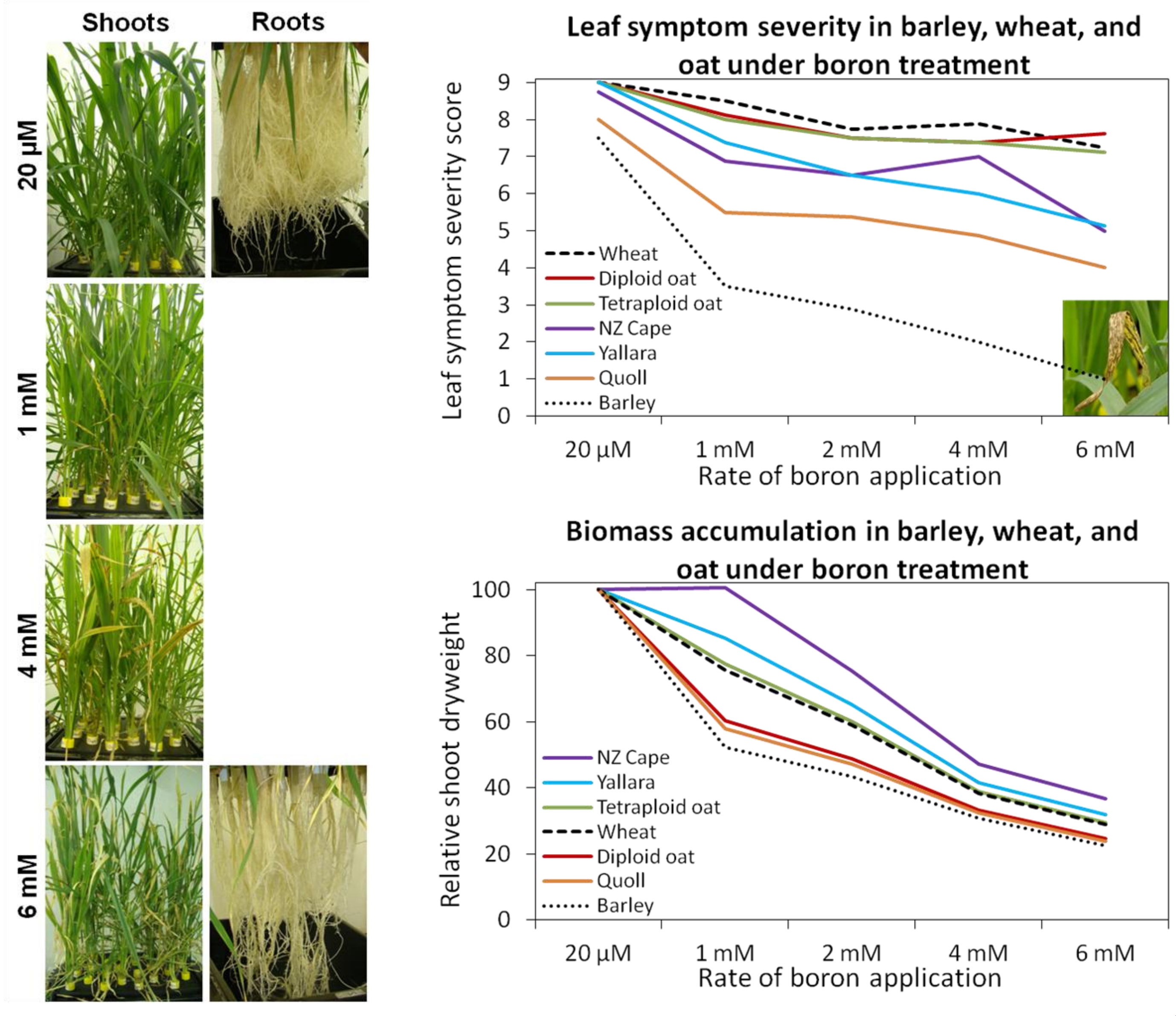
The effects of varying levels of salinity stress
Barley, wheat, and oat grown in potting mix was exposed to salt application in the range 0, 25, 50, 75, 100, 150 and 200 mM (left to right in photos). Plants were harvested at 6 weeks and the Na^+ and Cl^- ion content determined by Inductively Coupled Plasma Optical Emission Spectrometry (ICPOES).



Benchmarking boron tolerance in oat

After exposure to increasing rates of boron it became clear that oat were significantly more tolerant to B than the susceptible barley cultivar used. In most cases the tested oat cultivars also showed tolerance to B stress comparable to or greater than wheat. In the case of oat cv. NZ Cape 1 mM B had no quantifiable negative effect on biomass production. Only cv. Quoll responded with a strong reduction in dry matter production, similar to the intolerant barley. The necrotic lesions typically associated with B toxicity as seen in the intolerant barley were not pronounced in this intolerant oat cultivar. This observation may mean that it is also difficult to detect B stress in oat under field conditions. The tetraploid and diploid oat species tested showed little B toxicity lesions. However, the diploid oat species showed reduced dry matter accumulation whereas the tetraploid oat was comparable with wheat across the entire range of B levels.

The impact of boron stress
An intolerant barley cultivar, tolerant wheat, and oat grown in a hydroponics system were treated with boron in the range of 1mM, 2mM, 4mM, and 6mM to induce stress. 20 µM boron was used as a non-toxic control. Photos depict overall impact of boron rate on shoot and root growth in a hydoponics unit. Symptoms of boron stress were assessed as necrotic lesions (scored by eye) and biomass accumulation (shoot dryweight) relative to 20µM control.



Conclusion

The impact that the findings in this project will have on the development of better adapted oat varieties can best be extrapolated from findings made in wheat. In a comprehensive study on wheat, analysis was made of yield in 52 wheat varieties from 233 field trials over 12 years to quantify the importance of subsoil constraints such as Boron and salinity to yield in wheat (McDonald *et al*. 2012). The authors stated that "*In WA, SA and Victoria, the traits with the greatest influence on yield were B toxicity (14–16% yield improvement) and soil salinity (based on Na+ exclusion data; 13–17% yield improvement)*".

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