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# Assessing waterlogging tolerance in wheat varieties

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## Key findings

- Measuring redox potential and soil water potential helps to explain crop responses to waterlogging in different soils.
- Current varieties vary in their response to irrigation and waterlogging on heavy, sodic clays. As these soils occupy 40–60% of some irrigation districts, variety experiments on them are needed so lines better suited to irrigation on heavy, sodic clays can be selected.

## Introduction

Heavy, sodic clays are the predominant soil type in 40–60% of some irrigation districts. There is evidence of varietal differences in waterlogging tolerance. Local variety experiments on waterlogging-prone soils are recommended as the best way to identify tolerant varieties (Setter & Waters 2003). However, not all soils become anoxic when waterlogged, so it is important to select experiment sites where waterlogging treatments will lead to anoxia. Combined measurement of soil redox (reduction-oxidation) potential and water potential can provide an objective measure of the timing, duration and intensity of waterlogging (North 2012).

The aim of this experiment was to determine:

- an experimental methodology for assessing the waterlogging tolerance of irrigated wheat varieties
- whether there is sufficient variability in the tolerance of current wheat varieties to justify further experiments to identify lines best suited to irrigation on waterlogging-prone soils.

## Site

The experiment was conducted on two sites in contour basin layouts on soils with low final infiltration rates:

1. non-self-mulching clay (NSMC) 20 km west of Jerilderie, NSW
2. transitional red–brown earth (TRBE) 20 km west of Moulamein, NSW.

## Methodology

It was intended to subject the plots to multiple ponding events to coincide with scheduled spring irrigations, thereby creating waterlogged conditions. The control plots were to be drained after 12 hours, the waterlogged plots were to be drained after 40–50 hours to simulate the effect of slow-draining irrigation layouts. However, the winter–spring period in 2016 was exceptionally wet and the first irrigation planned for September was not possible. Instead plots to be waterlogged were subjected to a single prolonged period of waterlogging (14 days) to coincide with flowering.

Control plots were irrigated (water applied and drained within 12 hours) at the start of the waterlogging treatment and again when the waterlogged plots were drained. This ensured both the waterlogged and control plots started grain filling with full moisture profiles.

Soil water potential and redox potentials were measured at 5 cm, 15 cm and 30 cm depths from two weeks before waterlogging started through to physiological maturity.

### Varieties

Condo$^{\phi}$ and LongReach Dart (early season); Corack$^{\phi}$, LongReach Cobra$^{\phi}$ and Scepter$^{\phi}$ (early–mid season); Chara$^{\phi}$, Suntop$^{\phi}$ and Elmore CL PLUS$^{\phi}$ (mid season); EGA Gregory$^{\phi}$ and LongReach Trojan$^{\phi}$ (mid–late season).

### Sowing and fertiliser management

Plots were sown on 18 May 2016 at Moulamein and 20 May 2016 at Jerilderie at a seeding rate for each variety to achieve a 175 plants/m$^2$ with 70% establishment target plant density (90–115 kg/ha depending on seed weight). DAP (di-ammonium phosphate) at 125 kg/ha was drilled with the seed. Both experiments were top-dressed with 250 kg/ha urea in split applications, with the first on 20 July at Jerilderie and 23 July at Moulamein.

## Results

### Grain yield

Average header yields from the two sites (Figure 1) demonstrated:

- In the control plots, yields at Jerilderie were lower than those at Moulamein, indicating an effect caused by soil type. This effect was greatest in Condo⟃, which fell from the third highest yield in the control plot at Moulamein to the lowest yield in the control plot at Jerilderie.
- At Moulamein there was no significant difference in yields between control and waterlogged plots for all varieties except Scepter⟃. The two highest yielding varieties from the control plots were LongReach Trojan⟃ and Scepter⟃.
- Waterlogging had a significant effect on most varieties at Jerilderie, with higher proportionate losses in the better-yielding varieties. LongReach Cobra⟃, Suntop⟃ and LongReach Dart⟃ were least affected by the waterlogging treatment, while Chara⟃, Scepter⟃ and EGA Gregory⟃ were the most affected.

### Soil redox potentials

Although both sites were subjected to the same irrigation and waterlogging events, the results from each experiment site varied significantly. This indicates a difference in the two soils susceptibility to become anaerobic when saturated.

#### Control

Redox potential measurements showed that in the control plots, the soil at Moulamein remained aerobic throughout the treatment period, but not at Jerilderie. The researchers concluded this effect was caused by rainfall in October at Jerilderie and the sodic nature of the soil at that site.

#### Experiment

The waterlogged plots at Jerilderie were anaerobic for longer than the control and had a slower recovery to aerobic conditions compared with the Moulamein site.

## Conclusion

The differences in yield responses between Moulamein and Jerilderie are due to differences in the soil redox potential at the two sites. The longer duration of anoxic conditions at the Jerilderie site, in both the control and waterlogged plots, is attributed to sodicity-induced dispersion and blocked soil pores. The more stable soil at Moulamein ensured higher levels of soil oxygen, even with prolonged waterlogging, so no treatment effect was observed. This result highlights the importance of, firstly, selecting sites that become anoxic when waterlogged, and secondly, obtaining an objective measure of the timing, duration and intensity of waterlogging.

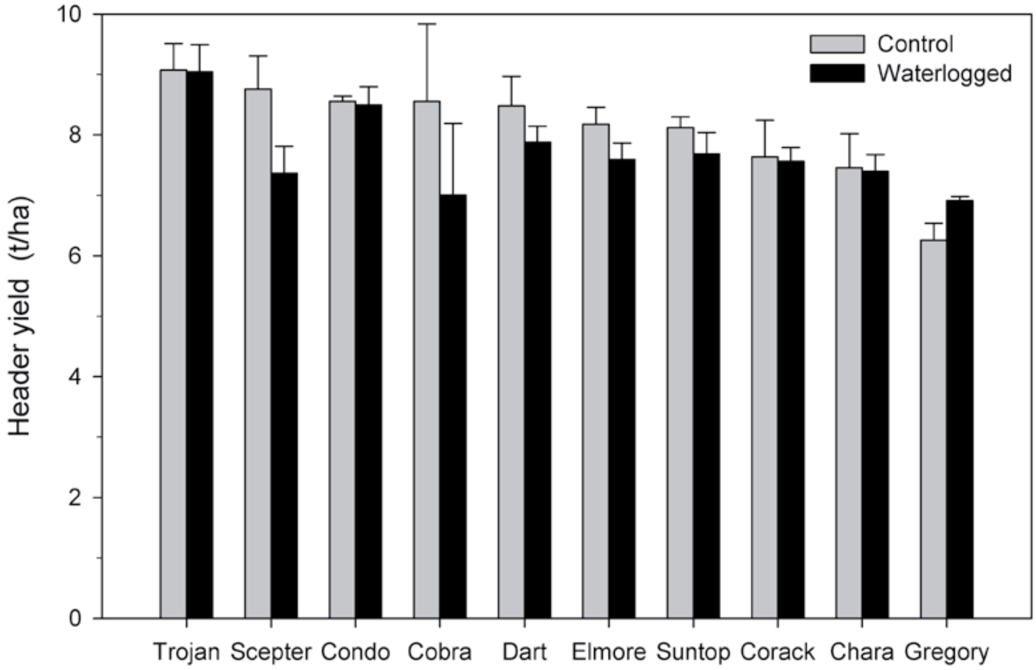
This experiment can only be considered a pilot and no variety inferences should be drawn because of the limited capacity for replication over time. However, the research does provide clear evidence that current varieties differ in their yield response to both irrigation on heavy, sodic clays and to waterlogging. The results also indicate there is a variety × soil type × waterlogging duration interaction. Experiments will be needed on local soils to provide recommendations to irrigators with soils prone to waterlogging.

## References

North, SH 2012, 'Waterlogging, anoxia and wheat growth in surface irrigated soils', in I Yunusa (ed), *Capturing opportunities and overcoming obstacles in Australian agronomy*: Proc 16th Australian Agronomy Conference, Armidale, NSW, 14–18 October 2012, Australian Society of Agronomy Inc.

Setter, TL & Waters, I 2003, 'Review of prospects for germplasm improvement for waterlogging tolerance in wheat, barley and oats', *Plant & Soil*, vol. 253, pp. 1–34.

a)

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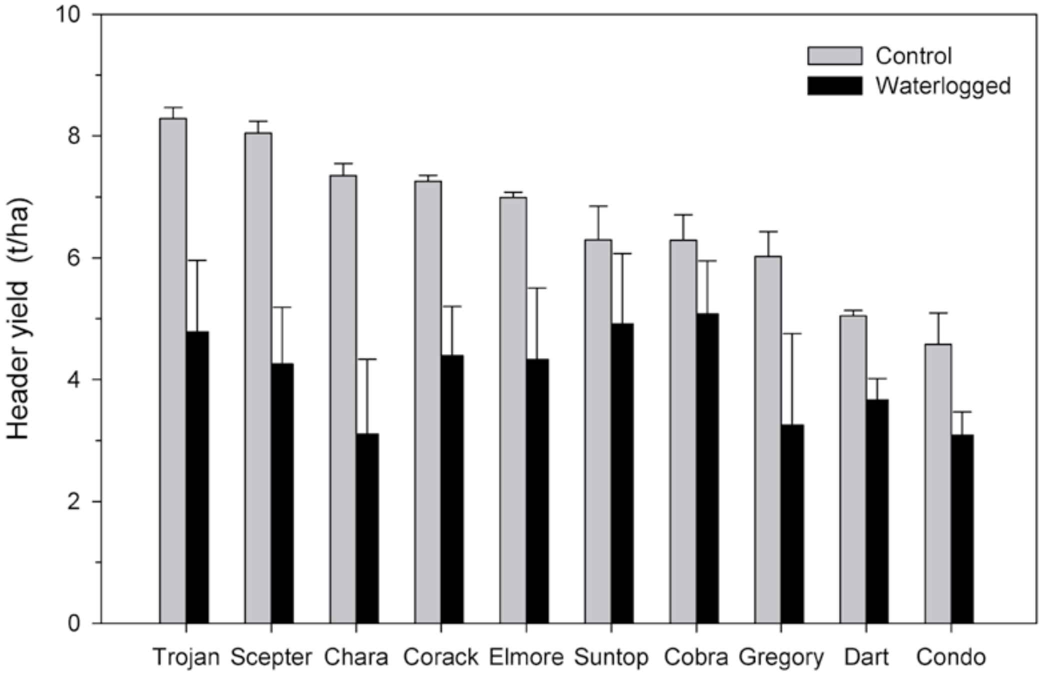


Figure 1. Treatment mean grain yield at 12% moisture for 10 wheat varieties subjected to short duration (12 hour) surface irrigation (control) and prolonged ponding (two weeks) at flowering. Varieties have been ranked in order of highest control yield (left) to lowest (right) at a) Moulamein and b) Jerilderie. Error bars show the standard error (n = 3).


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