7.4 Crop management to improve WUE of barley - Cambridge, Tas

Location:
"UTAS Cambridge Farm", Cambridge, Tasmania

Funding: GRDC

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Rainfall:
Avg. Annual: 496 mm
Avg. G.S.R.: 277 mm (Jul to Dec)
2010 Total: 411 mm
2010 G.S.R.: 291 mm (Jul to Dec) + 69 mm irrigation

Summary of findings:

- This trial assessed the effect of N, irrigation and crop sequence on growth, WUE and/or grain yield of barley.
- High rates of applied N increased plant height and leaf area. Multispectral imaging using an unmanned aerial vehicle clearly showed thermal, infrared and NVDI differences between N treatments.
- Grain yield of barley following perennial ryegrass increased with applied N, most likely as N was tied up in stubbles at the start of the season and unavailable for plant growth.
- WUE estimated by computer modelling was high (~ 20 kg/ha.mm) and similar to the potential for wheat grown in Tasmania. However, grain yield and WUE of barley following forage rape was unresponsive to applied N.

Background/Aim:
Potential water-use efficiency (WUE) of wheat has been benchmarked for Tasmania using computer modelling of historical data and ranges from 8 to 22 kg/ha.mm (Figure 1). This approach accounts for drainage and runoff, which can be large in the high rainfall zone, and is based on unlimited crop N-supply. The wide range of values reflects differences in climate and soil type. The benchmarking activity showed that WUE fell short of potential in many environments as N-supply was limiting crop growth (Botwright Acuna *et al.* 2010). However, improved grain yields and WUE may not be realised with higher rates of applied N if soil moisture becomes limiting. This is supported by computer modelling, which showed that grain yield, WUE and economic returns were improved in most years by increasing both N supply and irrigation, rather than either input separately (Botwright Acuna *et al.* 2010).

Field trials are needed to validate that N-supply is limiting WUE in Tasmania, and whether changing the management of applied N and irrigation can improve grain yield and WUE. Benchmark WUE data for Tasmania is also required for grain crops other than wheat. The aim of this trial was to evaluate the effect of irrigation and quantity of applied N on grain yield and WUE of barley grown in southern Tasmania following forage rape or a perennial ryegrass pasture.

Variety: Gairdner barley

Sowing date: 22 August 2010

Plant density:
151 and 135 plants/m² for the forage rape and pasture sequences, respectively.

Fertiliser:
Base rate of 125 kg N/ha (total) - 39 kg N/ha at sowing, topdressings of 60 and 25 kg N/ha on 16 Oct and 4 Nov.

Plot size: 9m x 2m x 4 reps.

Paddock History:
2008: 50: 50 barley and perennial ryegrass pasture
2009: 50: 50 processing peas/forage rape (winter/summer) and perennial ryegrass pasture

Soil Type: sandy loam over clay

Soil test:
Before sowing (18 July), forage rape sequence: Surface soil (0 – 10 cm) had 7.5% soil moisture, 25 mg/kg nitrate-N, 3 mg/kg ammonium-N, 2.25% organic carbon, EC 0.17 dS/m and pH 5.8.

Irrigation:
Base rate of 69 mm - 25 mm at sowing, 24 and 20 mm on 21 Oct and 7 Nov

Tillage type:
Chisel ploughed, harrowed then drilled

Ground cover:
Perennial ryegrass pasture sprayed out close to sowing

Treatments:
The trial was undertaken in a growers paddock under a centre pivot irrigator. To test whether yield and WUE were N-limited, three N treatments were applied (base 'grower' rate, double the first topdressing and double both topdressings i.e. 125, 185 and 245 kg N/ha). Irrigation treatments were applied by ceasing irrigation during booting (GS55) vs. base irrigation. There were two previous crop sequences (forage rape and perennial ryegrass pasture).

Measurements:
Soil analyses for the forage rape sequence before sowing on 18 June; crop DM production and soil N analysis at around flowering on 19 November; multi-spectral imaging using an unmanned aerial vehicle (UAV) at ~3 cm resolution on 30 November; machine harvest for grain yield on 25 January. Computer modelling (APSIM) was used to estimate WUE and/or grain yield. Predicted drainage and runoff were negligible, so WUE was calculated as grain yield / (surface evaporation + transpiration).

Results and discussion:

The season:

June to July rainfall in southern Tasmania was very low (9 mm), in sharp contrast to northern regions. As a result, sowing was delayed and irrigation was required to establish the crop. Spring was relatively wet and delayed the application of N fertiliser until stem elongation. Light rain throughout the second week of January delayed the machine harvest and broke seed dormancy, resulting in grain quality being downgraded from malting to feed.

Crop growth and yield:

Grain yield of barley following the forage was lower than expected at this site (usually ~ 6 t/ha) and unresponsive to applied N. Other factors that may have limited growth were a relatively dry soil profile due to the deep root system of the forage rape and the dry start to the season; delayed application of N fertiliser, which reduced plant tillering (Table 1) and potential yield; and, crop lodging, which affected up to 50% or more of the medium and high-N treatments. While preliminary computer modelling was also unresponsive to high rates of applied N, actual grain yield was over-estimated by up to 2 t/ha. WUE was around the potential maximum for wheat, at 21 to 23 kg/ha.mm. Differences between modelled and actual grain yield could be due to lodging or site-specific soil differences that were not accounted for by the model.

Grain yield of barley following pasture appears to have been limited by the availability of soil N. By flowering, soil nitrate-N (~ 40 mg/kg) in the 125 kg N/ha treatment for barley following pasture was around double that of the forage rape yet the crop was shorter, less green and tended to have smaller leaf area per plant (Table 1) and lower grain yield (Figure 2). These results indicate that soil-N may have been initially tied up in the pasture stubbles and released later during crop growth, when it was too late to contribute to yield formation. Soil-N was very high (~100 mg/kg) in the 285 kg N/ha N treatment at flowering and plants were dark green in colour (higher SPAD reading). Multi-sensor remote sensing was consistent with these results, which showed that the high-N plots were more vigorous, cooler (greater transpiration) and had higher chlorophyll content (Plate 1).

For irrigation, treatments only had a small difference in the total quantity of water applied. Nevertheless, the extra 17 mm of irrigation resulted in an additional 0.5 t/ha of grain yield (data not shown). Computer modelling also showed an increase in WUE for each additional irrigation event (Table 2).

Table 1: Crop growth at flowering for crop sequence and applied N treatments at Cambridge, Tasmania, 2010. SPAD meter measures leaf greenness and was measured at early grain filling.

Treatment	Plant height (cm)	No. tillers	Leaf area (cm^2/plant)	SPAD
Crop sequence				
Forage brassica	87	3.7	140	56.4
Perennial pasture	78	4.7	102	51.9
Lsd (P=0.05)	**4**	**n.s**	**n.s**	**3.1**
N applied (kg N/ha)				
125	82	3.9	94	48.8
185	82	4.2	127	52.1
245	84	4.6	146	54.8
Lsd (P=0.05)	**n.s**	**n.s**	**50**	**2.5**

Table 2: Effect of applied N and irrigation on modelled grain yield, grain protein and WUE (calculated as yield/surface evaporation + transpiration) following the forage rape at Cambridge, Tasmania, 2010-11. Drainage and runoff were negligible.

Applied N (kg N/ha)		Irrigation (mm)		Grain yield (t/ha)	WUE (kg/ha.mm)
22-Jul	16-Oct	26-Jul	21-Oct		
39	0	0	0	3.6	16
39	0	25	0	4	17
39	60	25	0	5.5	21
39	60	25	24	6.5	23
39	120	25	0	5.5	21
39	120	25	24	6.5	23

Figure 1: Benchmark WUE data for wheat in Tasmania. Data are based on 28 current and historical datasets (Botwright Acuna et al. 2010). WUE are calculated using computer modelling as grain yield / (surface evaporation + transpiration + drainage + runoff). Potential WUE is unlimited by N availability.

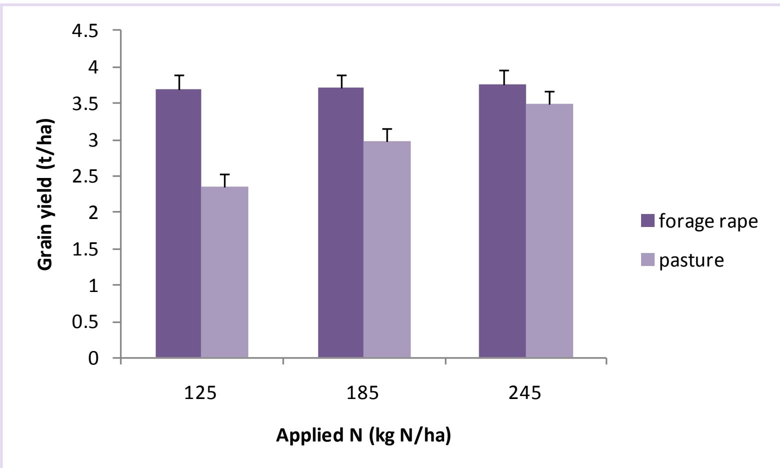
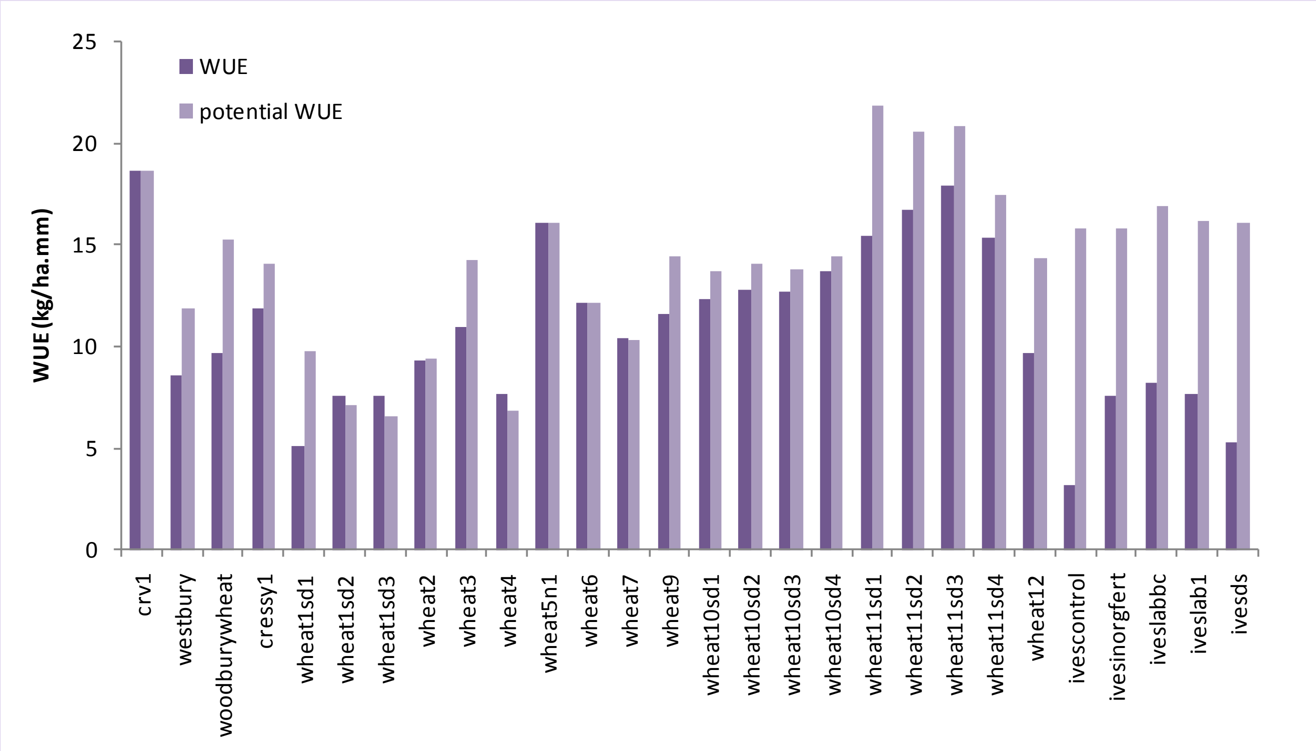


Figure 2: Effect of applied N and crop sequence on grain yield at Cambridge, Tasmania, 2010-11. Bars represent the standard error.



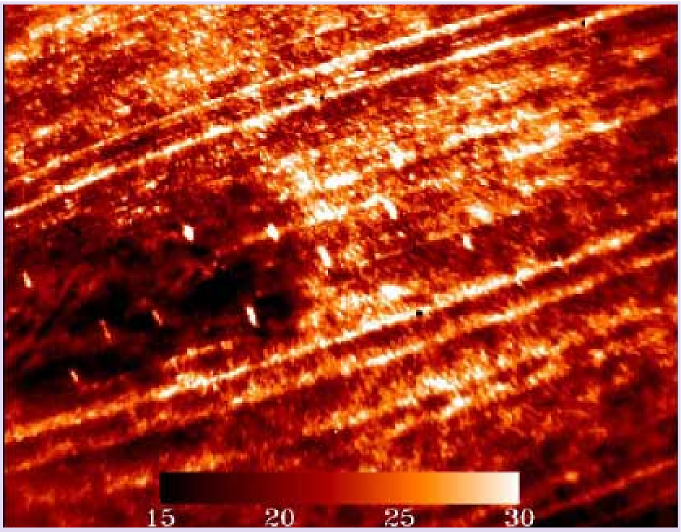


Plate 1: Multi-spectral imaging using an unmanned aerial vehicle (UAV) at ~3 cm resolution for barley following the pasture phase. A) Red, Green, Blue showing location of plots (N, 125 kg N/ha; N+, 185 kg N/ha; and N++ 245 kg N/ha); B) False colour composite image; more vigorous plants in pink; C) Thermal image, darker plants are cooler and moister; D) Normalised Difference Vegetation Index (NDVI) image; greener plants with higher chlorophyll content are red. The small black rectangles are bare ground where the trial had been sampled to measure biomass production.

Reference:

Botwright Acuna T, Lisson S, Dean G (2010) Benchmarking wheat water-use efficiency in Tasmania. In 'Food Security from Sustainable Agriculture: Proceedings of the 15th Agronomy Conference'. 14 - 18 November 2010. Lincoln, New Zealand. (Ed. H Dove) p. 4 pgs

Summary:

N-availability may limit crop growth, yield and WUE of barley depending on the previous crop or pasture and the timing of fertiliser application. Here, growth of the barley crop following the pasture sequence appeared to be limited by the amount of available soil-N, most likely due to tie-up of N in stubbles that was released too late in the season to improve grain yield. These differences were clearly seen in the multispectral images from the UAV, and highlight the detailed information that can be obtained by this technology. In contrast, yield and WUE of barley following the forage rape was unresponsive to increased rates of applied N and were instead constrained by other factors, possibly available soil moisture and lodging. Although the barley following forage rape was overall unlimited by N availability, grain yield and WUE might be improved by changing the timing of applications to better match crop demand. WUE of the barley crop was high and may reflect the shorter growing season compared with wheat and lack losses to drainage and runoff at this site, which has lower average rainfall than elsewhere in Tasmania. Research is continuing on validating the APSIM model for predicting grain yield and WUE of barley in Tasmania.