Drivers of high-yielding irrigated wheat production

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Abstract
Irrigated wheat has the potential to consistently yield over 10 t/ha with optimum management. Growers however are often achieving much lower yields. Yields of 1520 t/ha have been obtained in ideal conditions overseas but Australia's climate significantly reduces yield potential. Barriers to consistent 10 t/ha yields for irrigated wheat were identified in trials conducted throughout south-eastern Australia. The trials investigated the effects of variety, plant population and nitrogen management on irrigated wheat grain yield. Preliminary results are presented from the first of three years' trials as part of the 'Southern Irrigated Cereal and Canola Varieties Achieving Target Yields' project. Data show the significant effect that variety selection and management can have on productivity. Variety had a significant effect on grain yield at both Murrumbidgee trial locations. At Leeton six of the 12 varieties included in the trial achieved over 10 t/ha with Suntop and Chara both yielding 10.32 t/ha followed by Kiora, Merinda and Corack, and Lancer. At Coleambally, Suntop (7.33 t/ha) was again the highest yielding variety followed by Lancer and Chara. EGA Gregory yielded lowest at Leeton (8.84 t/ha) followed by Mace (9.05 t/ha) and Dart (9.53 t/ha). The three lowest yielding varieties at Coleambally were Dart, Bolac and EGA Gregory, with 5.86 t/ha, 6.60 t/ha and 6.72 t/ha, respectively. A plant population of 140 plants/m^2 yielded significantly higher than 210 plants/m^2 at Leeton but there was no effect of plant population at Coleambally. Applying the bulk of nitrogen at booting stage significantly increased yield at Leeton compared to applying the bulk of nitrogen at sowing. At Coleambally, there was no difference in yield between applying most nitrogen at the first node stage and most nitrogen at booting. Delaying nitrogen application significantly increased grain protein.

Key words
Irrigated, wheat, variety, agronomy, high yielding, winter cropping

Introduction
Recent research identified significant potential for increased production and profitability of irrigated cereals (Milgate 2007). The importance of correct varietal selection for dryland crops is well documented; however, the best performing varieties in dryland systems may not be equally successful in irrigated systems. Identifying the best wheat varieties, and agronomic management, for irrigated systems is essential to consistently achieve high potential yields.

Methods
The trial was conducted at two locations – Leeton and Coleambally. It evaluated the effect of variety, plant population and nitrogen management on grain yield and grain quality (Tables 1 and 2). Varieties are shown in Figure 1. Plant populations included low (140 plants/m^2) and high (210 plants/m^2) treatments. Coleambally and Leeton trials were both a 3 replicate randomised block design. Data were analysed spatially with Genstat 17th edition.

Table 1. Nitrogen treatments at the Leeton and Coleambally trial sites.

Nitrogen treatments:		Nitrogen applied (kg N/ha)		
Site	*Treatment*	*At sowing*	*1st node*	*Booting*
Leeton	Early N	90	50	30
	Late N	30	50	90
Coleambally	Early N	90	60	20
	Late N	90	20	60

Table 2. Soil, paddock history, fertiliser, sowing and cultural details at the Leeton and Coleambally trial sites.

Detail	Leeton	Coleambally
Soil type	Self-mulching medium clay	Grey lightmedium clay
Previous crop	Barley (2013)	Barley (2013)
Soil starting N	55 kg N/ha	65 kg N/ha
Pre-sowing fertiliser	150 kg/ha of MAP (15 kg N/ha)	150 kg/ha of MAP (15 kg N/ha)
N treatments	370 kg/ha of urea (170 kg N/ha)	370 kg/ha of urea (170 kg N/ha)
Soil N mineralised	45 kg N/ha	45 kg N/ha
(estimation)	*Total N budget – 285 kg N/ha*	*Total N budget – 295 kg N/ha*
Sowing date	7 May 2014	14 May 2014
Row spacing	260 mm	260 mm
Irrigation	Autumn pre-watering – 2.2 ML/ha	Autumn watering-up – 1.2 ML/ha
	Three spring irrigations – 1.1 ML/ha x 3	Two spring irrigations – 1.3 ML/ha x 2
	Total – 5.5 ML/ha	Total – 3.8 ML/ha
Fungicides	Tilt® at 250 mL/ha (by boom)	Orius® at 150 mL/ha (by aircraft)
	Orius® at 150 mL/ha (by boom)	
Herbicides	Achieve™ at 400 mL/ha	MCPA at 1.25 L/ha (by boom)
	MCPA at 1.25 L/ha (by boom)	Lontrel™ at 70 mL/ha (by boom)
	Lontrel™ at 70 mL/ha (by boom)	
Harvest date	9 December 2014	10 December 2014

Results

Variety

Variety had a significant effect on grain yield at both Leeton and Coleambally. Suntop and Chara (10.32 t/ha) were the highest yielding varieties at Leeton. Grain yield of these varieties was not significantly different to Kiora, Merinda and Corack which all yielded over 10 t/ha at Leeton. EGA Gregory (8.84 t/ha) had the lowest yield, significantly lower than all other varieties except Mace (9.05 t/ha) at Leeton (Figure 1).

Suntop (7.33 t/ha) was the highest yielding variety at Coleambally but not significantly different to Lancer, Chara and Mace. Dart (5.86 t/ha) had the lowest yield. Bolac (6.00 t/ha) was the second lowest in yield, similar to EGA Gregory, Impala and Merinda (Figure 1).

Grain yields at Coleambally were significantly lower than Leeton which was likely due to moisture availability from irrigation scheduling. The Leeton site received 2.2 ML/ha during watering up while Coleambally received only 1.2 ML/ha. Additionally, Leeton received three spring irrigations (total of 5.5 ML/ha for the season) and Coleambally received two spring irrigations (total of 3.8 ML/ha for the season).

Grain protein was affected by variety at both locations. Dart had the highest protein content (12.7%) at Leeton, followed by Wallup (12.4 %) and Lancer (12.2 %). Impala had the lowest grain protein content (10.9%). At Coleambally, Dart and Lancer had the equal highest protein content (12.1%) (Figure 1). EGA Gregory, Mace and Impala protein contents varied greatly between the two locations (Figure 1).

Variety also significantly affected plant establishment, tillering, plant height, number of heads, lodging, normalised difference vegetation index (NDVI), screenings, thousand grain weight (TGW), test weight and harvest index at both trial sites (data not shown).

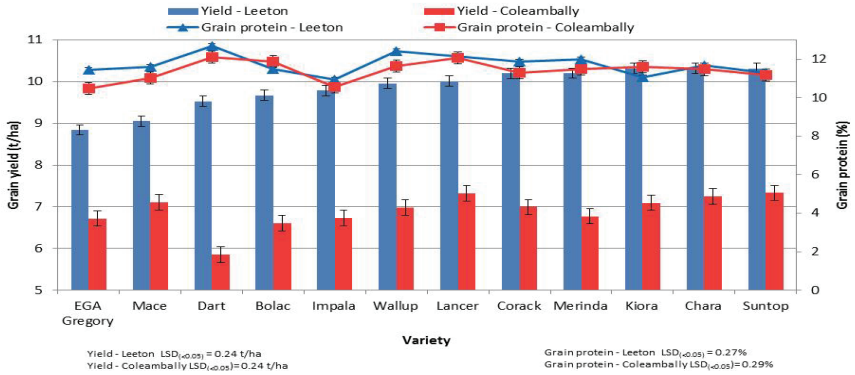

Figure 1. Wheat grain yield and protein content of varieties averaged across all nitrogen and plant density treatments at Leeton and Coleambally 2014.

Nitrogen management

Nitrogen (N) management significantly affected grain yield when averaged over all varieties at Leeton but not at Coleambally. The late N treatment yielded 10.00 t/ha, significantly higher than the early N treatment which yielded 9.70 t/ha. There was also a variety by N interaction effect on grain yield (Figure 2). Mace had the largest response of 0.94 t/ha from early to late N application, followed by Kiora (0.71 t/ha) and Bolac (0.68 t/ha). In addition Lancer, Gregory and Chara also increased grain yield in response to late N applications.

Kiora (10.67 t/ha) was the highest yielding variety for the late nitrogen treatments at Leeton and was statistically similar in grain yield to Chara, Merinda and Suntop. Corack (10.31 t/ha) was the highest yielding variety in the early N treatments at Leeton. This was statistically similar in yield to Suntop, Chara, Merinda and Wallup. Mace (8.58 t/ha) was the lowest yielding variety in the early nitrogen treatments.

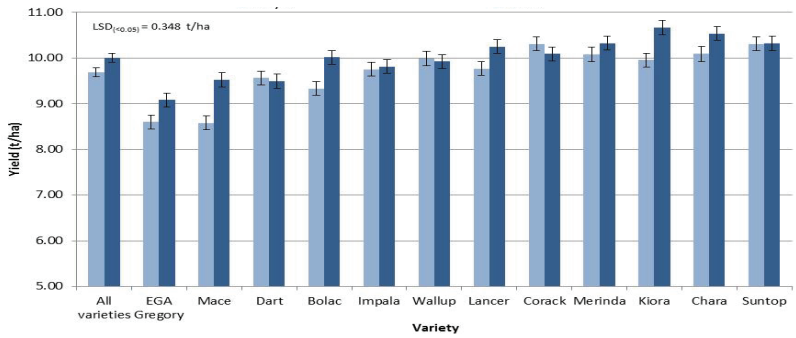

Figure 2. Wheat grain yield of nitrogen treatments averaged across all plant densities at Leeton 2014.

The late N treatment had an average grain protein content of 11.8% which was significantly higher than the early N treatment (11.3%) across all varieties, plant populations and locations. Late N application at Leeton also increased thousand grain weight but reduced tiller number, head number, lodging and NDVI.

Plant population

Plant population and the variety by plant population interaction significantly affected grain yield at Leeton but not Coleambally. At Leeton, the low plant population (140 plants/m2) had a grain yield of 9.90 t/ha which was higher than the high plant population (210 plants/m2) which was 9.80 t/ha (Figure 3).

EGA Gregory had a significant decrease in grain yield (0.62 t/ha) when the plant population increased from 140 plants/m2 to 210 plants/m2. In contrast, Chara had a significant increase in grain yield (0.35 t/ha) when the sowing rate was increased.

Kiora (10.40 t/ha) was the highest yielding variety for the low plant population (140 plants/m2). This was not significantly different to Corack, Merinda, Suntop, Chara and Wallup. Mace was the lowest yielding variety with a grain yield of 8.96 t/ha. Mace and EGA Gregory both had significantly lower grain yield than all other varieties for the low plant population (Figure 3). Chara (10.49 t/ha) was the highest yielding variety in the

high plant population treatment (210 plants/m2). This was not significantly different to Suntop and Kiora. EGA Gregory was the lowest yielding variety (8.53 t/ha) and was significantly lower in yield than all other varieties for the high plant population.

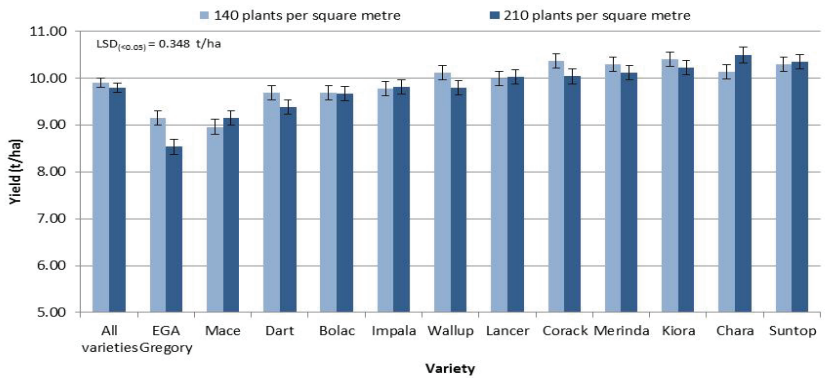

Figure 3. Wheat grain yield of plant population treatments averaged across all N treatments at Leeton 2014.

Conclusion

The wheat trials demonstrated that variety is a major driver of high yields. Suntop and Chara were in the highest yielding bracket at both trial sites. Lancer and Kiora also performed well, both achieving high grain yield at both sites while Mace, Dart and EGA Gregory had the lowest yields at both trial sites.

Timing of nitrogen application had an overall significant effect on grain yield and grain protein. At Leeton, applying most nitrogen (82%) after the first node stage significantly increased grain yield and grain protein compared with applying most nitrogen (53%) pre-sowing. Improved yields through application of late N were driven by increased tillering, increasing head numbers, reduced lodging and increased thousand grain weight. At Coleambally, no difference was observed in grain yield between the different topdressing timing treatments.

A lower wheat plant population (140 plants/m^2) resulted in higher yields across all wheat varieties when compared to a higher plant density (210 plants/m^2) at Leeton. Corack, Dart and Wallup had a yield advantage at the lower plant population whereas Chara and Mace performed better at the higher population. Individual varietal responses to plant population should be considered.

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