Performance of second wheat under no-till full stubble retention (NTSR) using in-crop nitrogen, plant population and row spacing at Yarrawonga

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Key points

- Wheat on wheat (cv Gregory) sown 15 May 2013 yielded between 3.35–4.70t/ha depending on row spacing, plant population and nitrogen (N) application.
- The narrow row spacing (22.5cm) produced the same yield and water use efficiency (WUE) as the wider row spacing (37.5cm).
- There was no difference in dry matter (DM) at harvest and grain yield due to plant population, though the lower plant population produced grain with significantly higher protein levels.
- Wider-row-spaced crops produced significantly higher protein than narrow-row crops, though there was no difference in grain yield.
- Wide row spacing significantly reduced DM compared with narrow row spacing at all assessments from tillering onwards until harvest when the difference was not statistically significant.
- This result is in contrast to first wheat after canola, where the wider row spacing (37.5cm) yielded less and had a lower WUE compared with the narrower rows.

Location: Yarrawonga, Victoria
Rainfall:
Annual: 378mm
GSR: 222mm (April – October)
Stored moisture: 32mm (estimated at 35% fallow efficiency)
Soil:
Type: Loamy clay
Sowing information:
Variety: Gregory
Sowing date: 15 May 2013
Sowing equipment: Janke tine with Janke presswheel
Treatments: Row spacing x nitrogen application x plant population
Row spacing: 22.5cm and 37.5cm
Paddock history:
2012 — wheat
2011 — canola
2010 — wheat
2005–09 — pasture
Plot size: 16m x 2m
Replicates: 4

Overall goal

Improved water use efficiency (WUE) in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains.

Aim

The aim of this trial was to evaluate the performance of in-crop nitrogen (N), plant population and row spacing interaction in a no-till full-stubble-retention (NTSR) scenario.

Method

A replicated experiment was established to test the effect of four nitrogen timing strategies across four combinations of: two row spacings (22.5cm and 37.5cm) and target plant population (100 and 200 plants/m^2).

The four nitrogen timing treatments were based on: 50kg N/ha applied at sowing in the seedbed, at early stem elongation (pseudo stem erect to first node — GS30–31), a 50% split of 25kg N/ha between both timings and nil nitrogen fertiliser. Nitrogen application in these treatments was based on prilled urea fertiliser (46% nitrogen by weight).

A further four nitrogen strategies (25kg N/ha in the seedbed, 25kg N/ha at GS30–31, 100kg N/ha in the seedbed and 100kg N/ha at GS31) were applied to additional plots established on a 22.5cm row spacing with a plant density target of 200 plants/m². The trial was sown in fully-retained wheat stubbles approximately 30cm in length.

Statistical analysis was carried out using Statistix (version 9.0). The trial was analysed as two trials: row spacing, plant population and nitrogen timing was analysed as a factorial design and nitrogen rate by timing (22.5cm row spacing and 200 plants/m² population target) was analysed separately as a factorial and a randomised complete block.

Reference to significant differences in the text denotes a p value equal to or <0.05.

Results

Crop establishment

The plant density (plants/m²) was greater than expected for both target plant populations with the narrow row spacing. Row spacing generated significant differences in establishment: the 22.5cm spacing produced more plants per square metre than the 37.5cm spacing at both high and low target populations.

There was a significant interaction between row spacing and target plant population, indicating that as the sowing rate increased the plant establishment decreased in the wide row spacing relative to the narrow spacing (see Table 1).

There was some evidence (at higher target plant populations) that nitrogen at sowing increased plant establishment relative to crops that did not receive nitrogen fertiliser, however differences were not significant (see Figure 1).

Dry matter production

i) Plant population

This second wheat trial followed the same trend as the first wheat trial in that the higher target plant populations produced significantly larger canopies throughout the season until harvest, by which time the lower target population had compensated, resulting in equivalent dry matter (DM) production (see Figure 2).

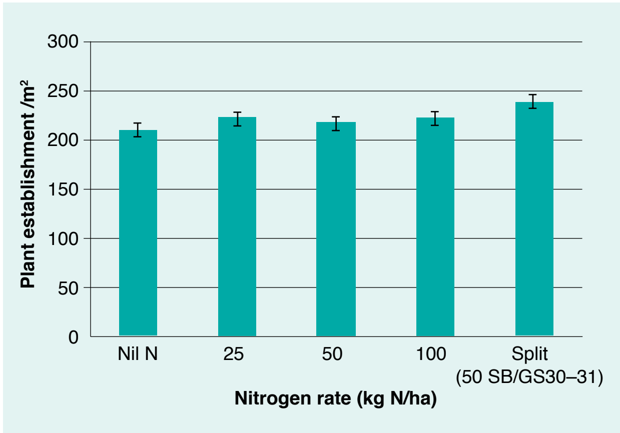

FIGURE 1 Influence of nitrogen application at sowing on plant establishment at a targeted plant population of 200 plants/m² sown on 22.5cm row spacings*

* Error bars presented as LSD value

TABLE 1 Plant establishment at three-leaves-unfolded stage (GS13), 37 days after sowing*

Nitrogen treatment	Plant establishment (plants/m²)					
	Target 100 plants/m²			Target 200 plants/m²		
Row spacing (cm)	22.5	37.5	Mean	22.5	37.5	Mean
Nil nitrogen	129	103	**116**	216	167	**191**
50kg N/ha seedbed	136	106	**121**	255	166	**211**
50kg N/ha GS30–31	128	104	**116**	209	166	**188**
50:50 seedbed:GS30–31 split	129	95	**112**	229	180	**205**
Mean	**131**	**102**		**227**	**170**	
LSD [plant population]	10					
LSD [row spacing]	10					
LSD [nitrogen treatment]	13					
LSD [pop^n x row spacing]	13					
LSD [pop^n x nitrogen treatment]	19					
LSD [pop^n x row x nitrogen treatment]	27					
Interaction — plant population x row spacing p value <0.001						

* At the time of the GS13 assessment the GS31 nitrogen application had not been applied.
Pop^n — plant population

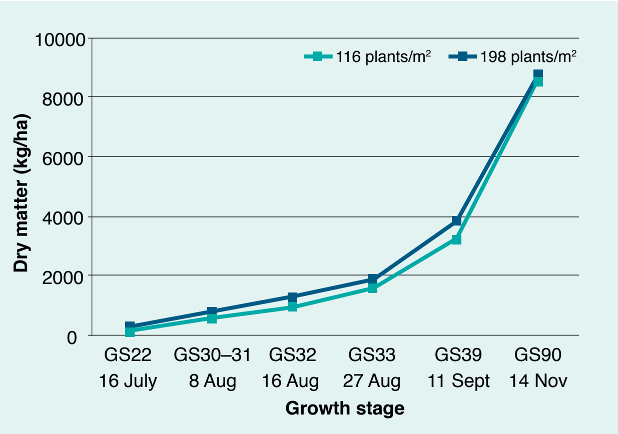

FIGURE 2 Influence of plant population on dry matter production*

LSD (5%): GS22; 29, GS30–31; 64, GS32; 120, GS33; 153, GS39; 250, GS90; 705kg DM/ha

* Mean of two row spacings and two nitrogen strategies (16 July – 27 August 2013), mean of two row spacings and four nitrogen strategies (11 September – 14 November 2013)

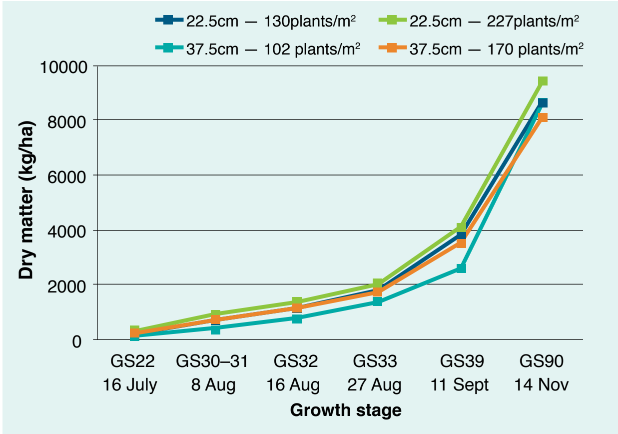

FIGURE 4 Influence of plant population and row spacing on dry matter production*

LSD (5%): GS22; 41, GS30–31; 91, GS32; 169, GS33; 217, GS39; 354, GS90; 998kg DM/ha

* Mean of two nitrogen strategies (16 July – 27 August 2013), mean of four nitrogen strategies (11 September – 14 November 2013)

ii) Row spacing

The narrower row spacing produced significantly more DM/ha throughout the growing season. However, by harvest the difference was no longer significant (see Figure 3).

iii) Plant population and row spacing

Significant differences in DM production were only evident at the flag-leaf-fully-emerged stage (GS39) when DM in the wider row spacing combined with the lower target plant population was less than the other three treatments (see Figure 4). This is partly due to fewer plants/m², since the higher target plant population on wider rows did not show a significant DM disadvantage.

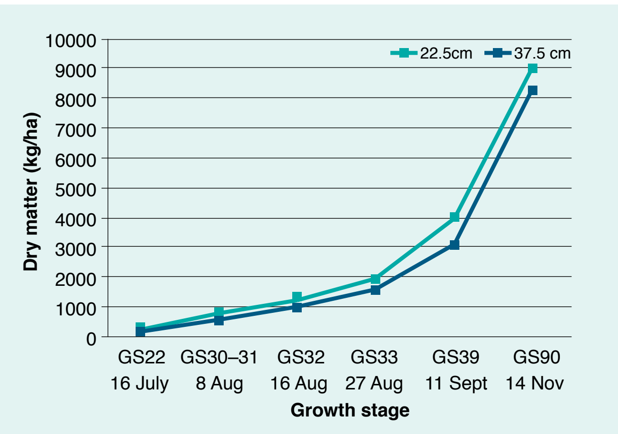

FIGURE 3 Influence of row spacing on dry matter production*

LSD (5%): GS22; 29, GS30–31; 64, GS32; 120, GS33; 153, GS39; 250, GS90; 705kg DM/ha

* Mean of two plant populations and two nitrogen strategies (16 July – 27 August), mean of two plant populations and four nitrogen strategies (11 September – 14 November 2013)

However, the trend in data would still indicate that a wider row spacing does not fully compensate in terms of DM per unit area compared with a narrower row spacing.

At harvest, although the narrow row spacing and higher target plant population produced the highest DM, the differences were less pronounced than in the first wheat trial (see page 6).

iv) Nitrogen application: timing and rate

From GS30–31 through to harvest there was significantly more DM produced when 50kg N/ha was applied at sowing. At GS39 there was no significant difference in DM production between applying all the nitrogen at sowing or splitting the application 50:50 between sowing and GS30–31.

At harvest the seedbed application of 50kg N/ha had produced the largest amount of DM (see Figure 5), with all three nitrogen treatments significantly increasing DM production compared with the untreated crop.

The nitrogen rate applied had a significant impact on DM production at harvest. When averaged across two nitrogen application timings — seedbed and GS30–31 — assessments showed no significant advantage of applying 25kg N/ha over the untreated crop, however there was an advantage in applying 50–100kg N/ha compared with the untreated crop (see Figure 6).

v) Nitrogen uptake

From the second assessment (8 August 2013) at GS30–31, there was greater nitrogen uptake in the larger crop canopies where nitrogen was applied at sowing. From GS39 through to harvest, the untreated crop had

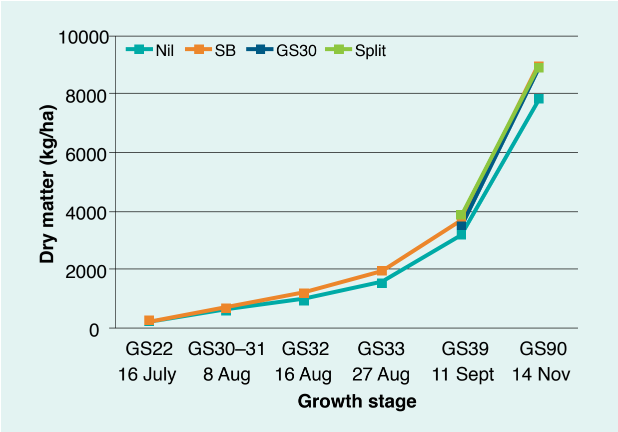

FIGURE 5 Influence of 50kg N/ha applied in the seedbed at GS30–31 and 50:50 split between seedbed and GS30–31 on dry matter production*.

LSD (5%): GS22; 29, GS30–31; 64, GS32; 120, GS33; 153, GS39; 354, GS90; 998kg DM/ha

* Mean of two row spacings and two plant populations (16 July – 14 November)

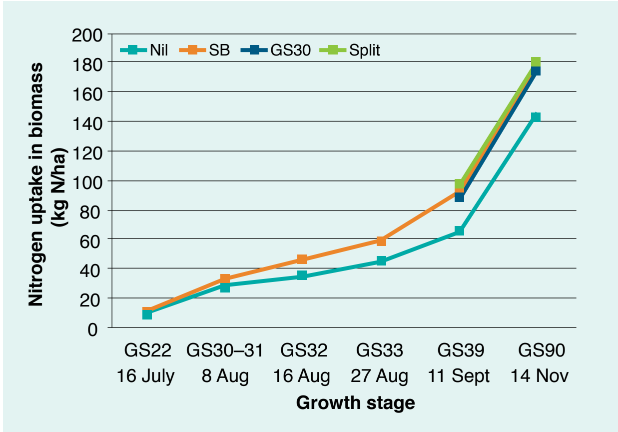

FIGURE 7 Influence of 50kg N/ha applied in the seedbed at: GS30–31 and 50:50 split between seedbed and GS30–31 on nitrogen uptake*

LSD (5%): GS22; 1.5, GS30–31; 2.9, GS32; 4.2, GS33; 5.3, GS39; 9.9, GS90; 19.8kg DM/ha

* Mean of two row spacings and two target plant populations (16 July – 14 November)

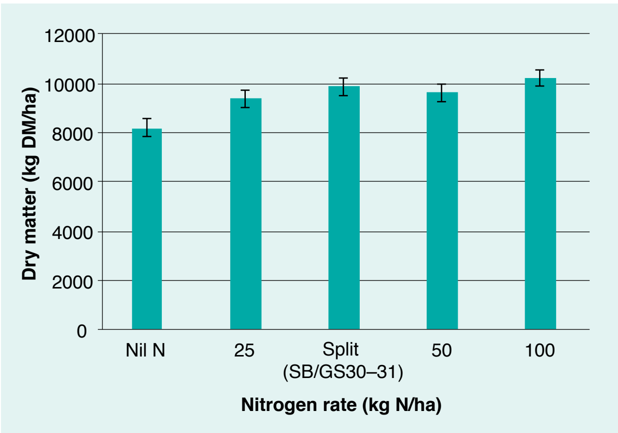

FIGURE 6 Influence of nitrogen rates applied on dry matter production at harvest (14 November 2013) when sown at 22.5cm row spacings at a target plant population of 200 plants/m²*

* Mean of two application timings — seedbed and GS30–31

Error bars presented as LSD value

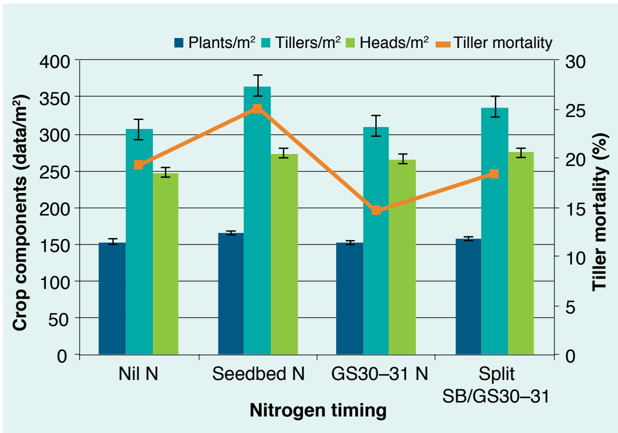

FIGURE 8 Influence of timing of nitrogen application (50kg N/ha) on crop structure *

* Mean of two row spacings and two plant populations (plants 24 June, tillers 14 August, heads 14 November)

Error bars presented as LSD value

significantly less nitrogen in the above-ground biomass than where 50kg N/ha had been applied. There were no differences in nitrogen uptake as a result of nitrogen timing from GS39 onwards (see Figure 7).

Crop structure

The 50kg N/ha applied to the seedbed at sowing produced the greatest number of tillers per unit area, which was significantly higher than when 25kg N/ha was applied (as part of a split application of 50kg N/ha), which in turn was significantly higher than the untreated crop.

At harvest, when head counts were made, all nitrogen treatments resulted in more heads per metre square than the untreated crop, but there were no differences between the various nitrogen strategies (see Figure 8).

This second wheat trial had a mean yield of 4.02t/ha. Grain yield was unaffected by target plant population or row spacing (see Table 2).

Both row spacing and plant population affected the protein content of the harvested grain: the narrow spacing and higher target plant population had significantly lower protein contents than crops established in wide rows or at low target plant populations (see Figure 9). Nitrogen application increased yield over the untreated crop although there was no difference in yield due to nitrogen timing (see Figure 10). In terms of timing, where nitrogen was applied at GS30, grain protein was higher than the other two nitrogen treatments (at sowing and the split application approach), which in turn were higher than the untreated crop (see Figure 10). Grain protein levels were

TABLE 2 Yield at harvest (9 December 2013)

Nitrogen treatment	Yield (t/ha) Target 100 plants/m²			Yield (t/ha) Target 200 plants/m²		
Actual plant population (m²)	**131**	**102**		**227**	**170**	
Row spacing (cm)	**22.5**	**37.5**	**Mean**	**22.5**	**37.5**	**Mean**
Nil nitrogen	3.57	3.29	**3.43**	3.45	3.41	**3.43**
50kg N/ha seedbed	4.14	4.02	**4.08**	4.18	4.16	**4.17**
50kg N/ha GS30–31	4.31	4.12	**4.21**	4.23	4.28	**4.25**
50:50 seedbed:GS30–31 split	4.25	4.27	**4.26**	4.39	4.28	**4.33**
Mean	**4.07**	**3.92**		**4.06**	**4.03**	
LSD [plant population]	0.10					
LSD [row spacing]	0.10					
LSD [nitrogen treatment]	0.14					
LSD [pop^n x row spacing]	0.14					
LSD [pop^n x nitrogen treatment]	0.20					
LSD [pop^n x row x nitrogen treatment]	0.29					
Interaction – plant population x row spacing			ns			

Pop^n —plant population

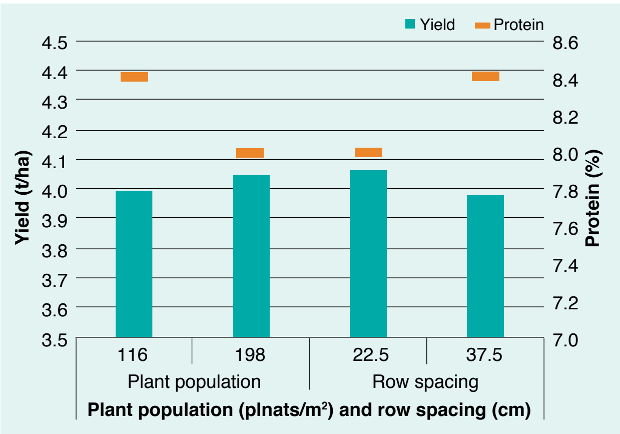

FIGURE 9 Influence of target plant population* and row spacing^ on yield and protein

* Plant population is the mean of two row spacing and four nitrogen timings
^ Row spacing data is the mean of two plant populations and four nitrogen timings
LSD (5%): compare yield 0.10t/ha, protein 0.18%, plant population and row spacing separately

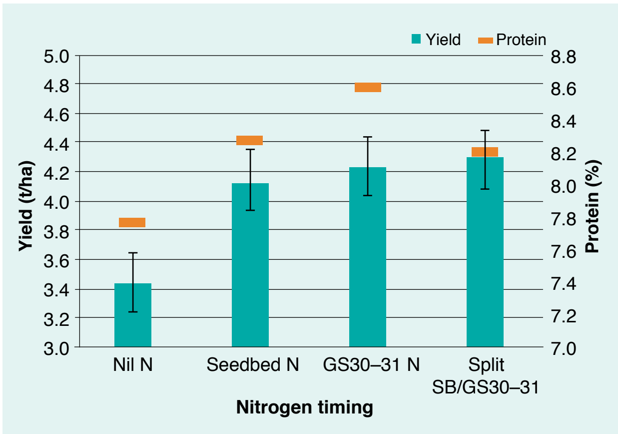

FIGURE 10 Influence of timing of nitrogen application (50kg N/ha) on yield and protein content*

* Mean of two row spacings and two plant populations
Error bars presented are LSD

low indicating that yield would not have been optimised, even with an application of 50kg N/ha (see Figure 11).

Nitrogen rate had a significant influence on grain yield (tested at high plant population and the 22.5cm row spacing). The higher the rate of nitrogen applied, the greater the yield response and grain protein obtained (see Figure 11).

Increasing the nitrogen rate also increased grain yield irrespective of whether the nitrogen was applied at sowing or GS30–31 (see Figure 12). The application of 100kg N/ha resulted in significantly higher grain protein, regardless of the timing of application (see Figure 13).

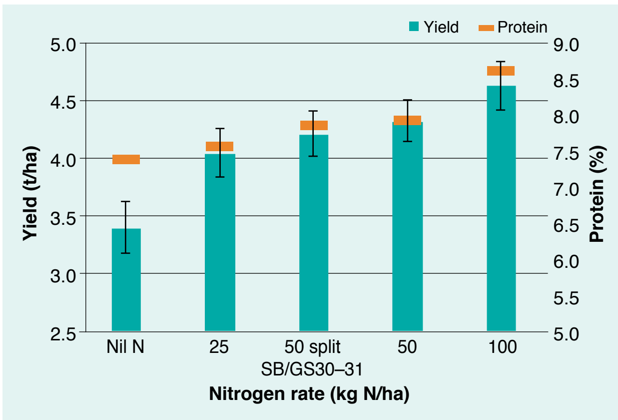

FIGURE 11 Influence of nitrogen rates applied on yield and protein content when sown at 22.5cm row spacings at a target plant population of 200 plants/m²*

* Mean of two application timings
Error bars presented as LSD value



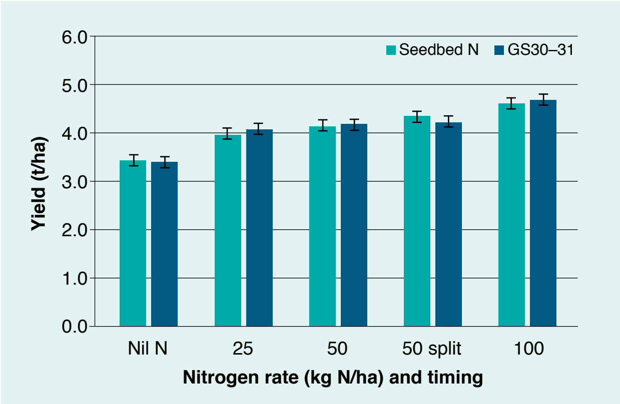

FIGURE 12 Influence of nitrogen rate and timing on yield when sown at 22.5cm row spacing and 200 plants/m^2*

* Error bars presented as LSD value

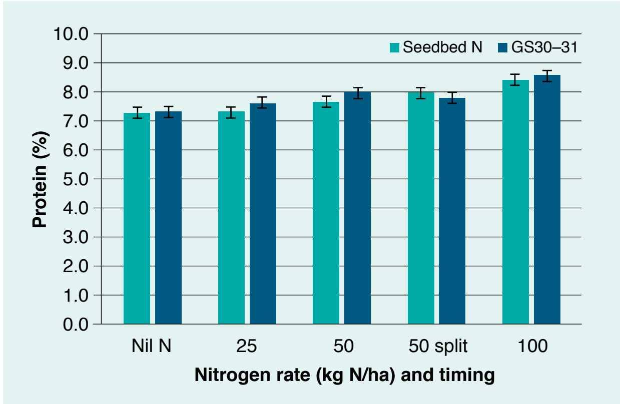

FIGURE 13 Influence of nitrogen rate and timing on protein when sown at 22.5cm row spacing and 200 plants/m^2*

* Error bars presented as LSD value

Harvest index and water use efficiency

The narrow row spacing produced more biomass than the wider row spacing but partitioned proportionally (non-significantly) less into grain yield giving a lower harvest index (HI) — % of final crop biomass that was grain. The overall result was no difference in grain yield between the 22.5cm and 37.5cm row spacings.

The split application of nitrogen along with wide row spacing produced the highest HI. The split nitrogen application also generated the greatest WUE at 14.8kg/mm, although it was only significantly different to the nil-nitrogen crop treatment (see Table 3). The untreated crop had the lowest WUE at 11.8kg/mm, with the greatest estimated soil evaporation.

TABLE 3 Biomass at harvest, yield, harvest index (HI), water use efficiency (WUE), transpiration, evaporation/drainage and transpiration efficiency (TE)

	Biomass (kg/ha)	Yield[5] (kg/ha)	HI (%)	WUE[1] (kg/mm)	Transpiration[2] (mm)	Evaporation[3] (mm)	TE[4] (kg/mm)
Plant population (plants/m^2)							
100 (target)	8631	3494	**40**	13.7	157	97	**22.3**
200 (target)	8721	3540	**41**	13.9	159	96	**22.3**
LSD	706	89	**3.8**	0.4	12.8	12.8	**2.1**
P value	0.798	0.312	**0.984**	0.314	0.798	0.798	**0.99**
Row spacing (cm)							
22.5	9010	3555	**39**	14.0	164	90	**21.7**
37.5	8342	3480	**42**	13.7	152	102	**22.9**
LSD	706	89	**3.8**	0.4	12.8	12.8	**2.1**
P value	0.063	0.098	**0.258**	0.090	0.063	0.063	**0.26**
Nitrogen treatments (50kg N/ha)							
Nil nitrogen	7789	3000	**39**	11.8	142	113	**21.2**
Seedbed	9019	3609	**40**	14.2	164	90	**22.0**
GS30–31	8918	3704	**42**	14.6	162	92	**22.8**
50:50 split	8978	3757	**42**	14.8	163	91	**23.0**
LSD	998	126	**5.4**	0.5	18.1	18.1	**3.0**
P value	0.047	0.000	**0.692**	<0.001	0.047	0.047	**0.68**

[1] Based on 222mm of GSR (April – October) + 35% fallow efficiency (32mm) for January – March rainfall (total GSR + stored = 254mm) with no soil evaporation term included and assuming no drainage in periods of excessive rainfall.

[2] Transpiration through the plant based on a maximum 55kg harvest biomass/ha.mm transpired.

[3] Unproductive water (evaporation, drainage and water left unused at harvest) is the difference between transpiration through the plant and GSR (mm) + stored water at sowing.

[4] Transpiration efficiency based on kg/ha grain produced per mm of water transpired through the plant.

[5] Note that yields have been presented expressed 0% moisture content rather than 12.5 moisture as is the case in Table 2.

Observations and comments

The following section examines observations made in the two row spacing trials reported in this year's trial book (first and second wheat). Please note these are observations only, as trials were in separate paddocks and therefore cannot be statistically compared.

The average growth rate between GS39 and harvest (80kg DM/ha per day) was not significantly different as a result of row spacing or plant population in the second wheat trial. In the first wheat trial (94kg DM/day average) the narrow row spacing produced 12kg DM/day more than the wider spacing and the lower plant population had a growth rate of 19kg DM/day more than the higher plant population.

The 50kg N/ha applied to the seedbed at sowing in the first wheat crop generated a greater DM response over the untreated crop than in the second wheat trial (see Figure 14). Although both rotation positions tracked a similar path earlier in the season, when the crop was stem elongating the first wheat generated larger canopies (more DM).

Tiller mortality rates in the second wheat rotation position were almost double the levels (15–25%) observed in the first wheat trial.

This second wheat trial had a mean yield of 4.02t/ha, while the mean yield for the first wheat trial following canola was 4.47t/ha.

The first wheat rotation position showed the 22.5cm row spacing to have a significantly greater WUE. Row spacing did not have a significant effect on WUE in the second wheat position.

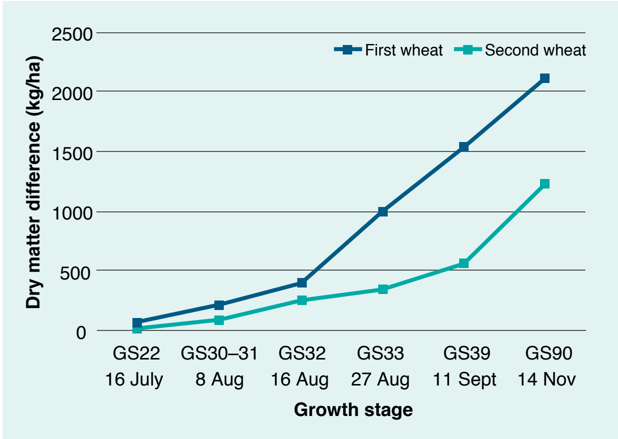

FIGURE 14 Difference in dry matter production between crops treated with 50kg N/ha at sowing and nil-nitrogen crops in a first wheat and second wheat rotation position, established at Yarrawonga (15 May 2013)*

* Mean of two row spacings and two plant populations

Sponsors

This trial was carried out as part of the Riverine Plains Inc GRDC-funded project *Improved WUE in no-till cropping and stubble retention systems in spatially and temporally variable conditions in the Riverine Plains (RP100007)*.

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