Long term row spacing trials and stubble retention, and implications for future development of varieties

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Key messages

Retaining stubble over burning stubble has increased wheat yield by an average of 5.7% (120 kg/ha or $36/ha at $300/t) in 15 crops on a red sandy clay loam at Merredin.

Wheat yield decreased by an average of 0.4% for every centimetre (1% per inch) row spacing increased from 180 mm (7”). Canola yields were severely depressed by wide row spacing, while pulse yields were largely unaffected.

A wheat line that produces less tillers was lower yielding in this year, but may be useful in the future in a dry environment where tiller density and non-productive tillers can be controlled by plant genetics and not seed rate or fertiliser.

Aims

(a) To examine the long term effect of stubble retention and row spacing on crop yield, and (b) to compare a low tillering line to a standard variety with different row spacings.

In low rainfall environments crop plants can run out of water post anthesis with effects on grain filling and yield. Options to conserve water to the post anthesis period typically include lower seeding rate, and/or wider row spacing, stubble retention and lower nitrogen fertiliser. Each tactic should theoretically provide a more consistent yield under dry conditions during grain fill, but will not necessarily optimise yields in good seasonal finishes.

Genetic material with reduced tillering (and fewer non-productive tillers) is now available which can be used to test the concept of lower leaf area contributing to water saving for the post anthesis period. Mitchell et al (2012) have shown that incorporation of tiller inhibition genes (*tin*) can reduce screenings in wheat subject to post anthesis drought stress, and that grain size is increased by about 10%.

(A) Methods - Long term row spacing X stubble experiment 2013

This work reports on a continuing experiment at the Merredin Research Station that was initiated in 1987 by Steve Porritt to investigate stubble and row spacing interactions in wheat (87M71). Each year the same treatment is applied to the same plot. Treatments are burnt or stubble retained, with row spacings of 90, 180, 270 and 360 mm, six replications and a plot centre width of five metres. The soil is a red-brown sandy clay loam (salmon gum, gimlet). Stubble was cut to 20 cm long at harvest each year to allow ease of stubble handling at seeding. The experiment is sown with a raised box combine that can deliver seed or fertiliser to each of six ranks of JD 753 tines. All seed points were Primary Sales Australia 40 mm wide with Janke 110 mm wide chamfered “V” press wheels set at 4 kg/cm width for cereals and 2 kg/cm width for pulses and canola and a 150 mm inside diameter 16 mm ring harrow was attached. All non-sowing tines were removed from 1995 onwards.

The centre of each plot was harvested for grain yield (1.62 m for 90, 180 and 270 mm and 1.8 m for 360 mm) and the remaining crop was harvested at the same height for stubble handling. Also Percy Riethmuller design crop lifters were used to improve ryegrass seed capture into the plot harvester. The straw going through the KEW plot harvester concentrates towards the centre so immediately after harvest the straw was evened out by a hand rake.

Stubble burnt:	Not possible due to poor chickpea growth in 2012
Sowing date:	28 May 2013 (270 mm on 29 May after 4.4 mm rain)
Row orientation:	21 degrees west of north
Seed Rate:	97.4 kg/ha Mace wheat (pickled with Raxil, 25 g/L tebuconazole 4 g/L triflumuron) seed weight 39.4 g/1000, lab germination 97%
Viable seed sown:	240 seeds/m^2
Fertiliser:	None as soil P was 43 ppm and N should be high from previous chickpeas and summer rain
Sprays:	13/5/13 2.0 L/ha Roundup Attack 28/5/13 2.0 L/ha Spray.Seed + 118 g/ha Sakura
Harvest date:	26 Nov 2013

2013 Rainfall

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
59.8	2.0	52.4	11.2	42.6	9.4	34.0	43.8	46.0	17.4	6.2	1.0	325.8

Results 2013 - Long term row spacing X stubble experiment

The soil was just moist at sowing but probably not enough to germinate. The depth of the seed was similar for all spacings but averaged 17 mm deeper on the stubble retained plots (Table 1). This is consistent with previous years where the more friable soil adds to the depth since the seeder wheels run on the very hard and flat inter-plot gap.

In mid June there was no ryegrass plants present but in November the ryegrass head density was higher in the 270 and 360 mm spacings with stubble retained, i.e. an interaction of stubble with spacing (Table 1). The low density of ryegrass was not expected to impact grain yield.

Windmill grass has slowly been creeping into the experiment and there were more plants present in the stubble retained but no effect of spacing.

Wireweed also has been more evident, but mainly on the end of rep 6 and showed no effect of stubble or row spacing. Perhaps the lack of trifluralin use since 2010 has allowed the wireweed to increase (Boxer Gold® in 2011 wheat and simazine in 2012 chickpeas).

The wheat plant density was highest on the 180 mm averaging 199/m^2 and lowest on the 270 mm rows averaging 159/m^2 (Table 1.) The low count in the 270 mm spacing may have been due to being sown late the following day as there was 4.4 mm of rain overnight and we had to wait for the surface to dry enough for sowing. This rain would have benefited the other spacings. The 360 mm rows averaged 15% less plants than the 180 mm, which is likely to be due to inter-plant competition. The burnt treatments averaged 76% field emergence while the stubble retained was only 72%, which may have been due to the deeper seed depth of the stubble retained plots.

The yield from the stubble retained treatments averaged 0.37 t/ha more than the burnt stubble. This is more than other years – perhaps the more friable soil of the stubble retained plots allowed more of the higher than average January and March rain to infiltrate the soil profile. This fits with the observation on 5 August that the stubble retained plots appeared to have much better growth than the burnt plots.

The yield was relatively constant with spacing this season with the exception of the 270 mm spacing, which averaged 9% higher than the 180 mm spacing (Table 1). Perhaps the higher than normal late season rain allowed all the spacings to make use of soil water where in other normal years the wider rows, which were sometimes greener longer, allow more soil water evaporation and therefore loss for production.

The 270 mm spacing yield is interesting. One thought is since it had around 11% less plants than the other treatments, it may have been an advantage in the early part of dry season. Another thought is that there may have been greater water harvesting of the late season rainfall. Most years it has been observed that there is a higher hump of soil between the 270 mm rows than any other spacing. The 360 mm actually had a hollow between the rows, which might have diverted water away from the rows (photo 1).

Photo 1 Soil hump between 270 mm rows (left) and hollow between 360 mm rows (right) taken on 5 August 2013.

Table 1 Wheat seed depth, density, yield and ryegrass head number with treatment.

Treatments	Wheat depth 17-6-13 (mm)*	Wheat density 17-6-13 (pl/m^2)	Ryegrass head density 11-11-13 (heads/m^2)	Harvest yield 26-11-13 (t/ha)	Wheat protein 13-1-14 (%)
Stubble Burnt					
1. 90 mm rows	25.5	188	0.00	1.96	10.5
2. 180 mm rows	28.7	199	0.50	1.82	10.2
3. 270 mm rows	35.3	168	0.00	1.95	11.2
4. 360 mm rows	34.2	177	0.00	1.86	11.1
burnt mean	30.9	183	0.12	1.90	10.7
Stubble Retained					
5. 90 mm rows	47.5	172	0.17	2.21	10.1
6. 180 mm rows	49.0	199	0.17	2.23	10.5
7. 270 mm rows	43.2	150	4.83	2.44	10.7
8. 360 mm rows	50.2	169	7.67	2.21	10.9
stubble mean	47.5	173	3.21	2.27	10.6
Lsd (5%)Stubble	4.97	10.2	1.94	0.083	n.s.
F pr	<0.001	0.045	0.003	<0.001	0.072
Lsd (5%) Spacing	n.s.	14.4	2.74	0.118	0.28
F pr	0.419	<0.001	0.025	0.019	<0.001
Lsd (5%) Stub x Spac	n.s.	n.s.	3.87	n.s.	0.40
F pr	0.182	0.600	0.014	0.203	0.030
C. of V. (%)	14.5	9.7	198.1	6.8	3.2

* reps 1, 2 and 3 only

Interestingly in the other experiment using no fertiliser and two varieties on a similar soil nearby in 2013, Mace wheat at 250 mm row spacing yielded similar to 500 mm rows (1.96 vs 1.93 t/ha). The unusual late season rainfall and some stored water from autumn may have contributed to this.

B. Methods - Row spacing by variety with different tillering

Previous crop: Poor yielding field peas
Sowing date: 23 May 2013
Row orientation: 21 degrees west of north

Seed Rate:	70.1 kg/ha Mace wheat (pickled with Raxil, 25 g/L tebuconazole 4 g/L triflumuron), 78.5 kg/ha DBW10 (unpickled)
Seed weight:	Mace 39.4 g/1000, lab germination 97% DBW10 45.4 g/1000, lab germination unknown
Viable seed sown:	Mace 173 seeds/m^2, DBW10 unknown
Fertiliser:	None as soil P was high and N was high from previous field peas and summer rain
Sprays:	22 May, 2.0 L/ha Roundup Attack + 30 mL/ha Nail + 120 g/ha Sakura 4 July 670 mL/ha Velocity + Plantocrop 1% at 5 leaf stage, 14°C air temperature
Harvester:	KEW 1.75 m wide (7 rows at 250 mm and 4 rows at 500 mm) with Riethmuller crop lifters at 9" spacing.
Harvest date:	27 Nov 2013
Rainfall:	As per the Merredin site A

Results - **Row spacing by variety with different tillering**

The plant density was counted on 13 June (Table 2). The aim was to establish 100 plants/m^2, which was almost achieved The DBW10 averaged 20% less plants than Mace after allowing for the seed size difference so its germination must have been poorer. The Mace averaged 73% field emergence, which is a little higher than expected so perhaps the rain following sowing helped. The 500 mm rows averaged 11% less plants than the 250 mm rows, which is common due to inter-plant competition.

Table 2 Wheat plant density with treatment.

Treatment	Plants/m^2		
Row spacing	250 mm	500 mm	Average
1. Mace no foliar N	129	119	124
2. Mace + foliar N at 3 leaf stage	135	123	129
3. DBW10 + foliar N at 5 leaf stage	115	97	106
Average	126	113	120
Lsd (p<0.05) treatment, F pr = 0.008	13.7		
Lsd (p<0.05) spacing, F pr = 0.024	11.2		
Lsd (p<0.05) treatment x spacing F pr = 0.77	n.s.		
C. of V. (%)	8.9		

The post seeding rainfall was very low until 12 July and so the planned foliar N treatments were not applied. The plots in rep 1 and 2 appeared to have a soil strength problem at one end which caused very variable crop growth, so it was planned to only harvest the centre 10 m of the plots. However, the crop responded to the late rain which evened out the earlier differences so the whole plot length was harvested.

The DBW10 suffered lodging in the 500 mm spacing and was variable across the site. Only one plot of DBW10 on 500 mm spacing stood up very well, while the others lodged very severely. Hand cuts of six one metre sections of row of the DBW10 averaged 15% less yield than the Mace. The machine harvested yield of Mace was not affected by row spacing but the DBW10 was much lower yielding than the Mace (Table 3). DBW10 had not previously showed lodging, and this was the first time it had been grown with Sakura, which may have affected the development of nodal roots. Sprigg (pers. comm.) found that *tin* lines in his experiments at Merredin also lodged.

The majority of DBW10 plants had one or two ears (results not shown), which would have put the line at a disadvantage with a good seasonal finish. The lower yields of DBW10 would have been largely due to the lower plant numbers established at this site and the lodging.

Table 3 Wheat yield with treatment.

Treatment	Yield (t/ha)		
Row spacing	250 mm	500 mm	Average
1. Mace no foliar N	2.23	2.07	2.15
2. Mace + foliar N at 3 leaf stage (not applied)	2.08	2.32	2.20
3. DBW10 + foliar N at 5 leaf stage (not applied)	1.58	1.38	1.48
Average	1.96	1.93	1.95
Lsd (p<0.05) treatment, F pr = 0.008 Lsd (p<0.05) spacing, F pr = 0.815 Lsd (p<0.05) treatment x spacing F pr = 0.508 C. of V. (%)	0.449 n.s. n.s. 17.9		

Results - 1988-2013 Long term stubble and row spacing (87M71)

Excluding the stubble setup year of 1987, the average wheat yield from 15 crops increased by 5.7% (120 kg/ha or $36/ha at $300/t) by retaining stubble over burning (Table 4). Using the old standard of 180 mm rows, the yield decreased by an average of 0.4% for every centimetre row spacing (1% per inch) increase from 180 mm (Table 4).

The average pulse yield from six crops (2 field pea, 1 faba bean, 1 lentil and 2 chickpeas) showed little effect of stubble or row spacing.

The average canola yield from two crops (Narendra in 1999 and Tanami in 2009) showed little effect of stubble but an average decrease of 1.0% for every centimetre row spacing (2.5% per inch) increase from 180 mm row spacing.

For most crop by stubble situations the 90 mm row spacing increased yields, which leaves open the option of narrowing row spacing for improving yield even in the low rainfall zone.

Table 4 Average yield from 15 wheat seasons, six pulse seasons and two canola seasons with stubble and row spacing.

Treatments	Average wheat yield (t/ha)	Wheat yield loss diff. 180 mm (%)	Average pulse yield (t/ha)	Pulse yield loss diff. 180 mm (%)	Average canola yield (t/ha)	Canola yield loss diff. 180 mm (%)
Stubble Burnt						
1. 90 mm rows	2.24	+4.2	0.973	+2.4	1.020	+11.6
2. 180 mm rows	2.15	0.0	0.950	0.0	0.914	0.0
3. 270 mm rows	2.10	-2.2	0.900	-5.3	0.718	-21.4
4. 360 mm rows	2.00	-6.8	0.896	-5.8	0.779	-14.7
Burnt mean	2.12		0.930		0.857	
Stubble Retained						
5. 90 mm rows	2.32	-0.1	0.950	+4.2	1.047	+6.0
6. 180 mm rows	2.32	0.0	0.911	0.0	0.987	0.0
7. 270 mm rows	2.19	-5.6	0.893	-2.0	0.772	-21.8
8. 360 mm rows	2.14	-7.9	0.900	-1.3	0.817	-17.2
Stubble mean	2.24		0.913		0.906	

Conclusion

Retaining stubble has improved wheat yields on this sandy clay loam soil at Merredin but had little effect on pulse crops or canola yields.

Increasing row spacing has shown decreases in wheat yield on the average of 15 seasons but not in 2013. Canola yield is particularly affected by wider row spacing in this environment, while the pulse yields were largely unaffected.

The line with the tiller inhibition gene (*tin*) line was lower yielding in this experiment consistent with the effect that, under good end of season water relations, higher tillering varieties will result in higher yields.

References

J. H. Mitchell , S. C. Chapman , G. J. Rebetzke , D. G. Bonnett and S. Fukai, (2012). Evaluation of a reduced-tillering (*tin*) gene in wheat lines grown across different production environments, *Crop and Pasture Science* 63(2) 128-141.

Key words

Wheat, stubble, row spacing, pulse, canola, yield, sandy clay loam, tiller inhibition genes

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