LOW SEEDING RATE AND VERY WIDE ROWS FOR WHEAT ON SHALLOW SOIL IN A LOW RAINFALL ZONE WITH WINTER DROUGHT

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AIM

To provide better guidelines on safer methods of sowing wheat on shallow soil in the low rainfall zone; especially in terms of row spacing seeding rate, variety, depth of soil and soil type.

BACKGROUND

Wheat yields and profitability are often challenged in the low rainfall areas with soils less than about 800mm depth. Periods of drought and warm weather conditions are common in the winter. These can rapidly exhaust limited soil moisture supply from shallow soils and causes severe, yield limiting, drought stress. It is important to gain more understanding and better management advice on how such problems can be minimized economically.

TRIAL DETAILS

	Site 1; Deeper Red	Site 2; Shallower grey	Site 3; Shallower red
Property	Marlingu Farms, Pindar M&D Kerkmans.		
Soil type	Shallow red sandy clay loam	Stony soil; sandy clay loam	Shallow red sandy loam
Depth to gravelly loam, mm	-	250	310
Depth to rock, mm	480	380	430
Available P, K, OM and pH ($CaCl_2$)	av. P 50ppm, av.K 255ppm, 1.4% OM, pH 4.2.	av. P 30ppm, av. K 170ppm, 1.3% OM, pH 4.8.	av. P 40ppm, av. K 200ppm, 1.4% OM, pH 4.2.
Sowing date	7th May	7th May	1st June
Seeding rate	30 or 60 kg/ha graded to 2.5mm sieve (farm equivalent of 35 and 70 kg/ha)		
Fertiliser (kg/ha)	55 kg/ha of MultiMAPS; deep banded with a DBS opener; always applied on 300mm rows (50% of fertiliser deep banded on the inter-row of the 600mm plant row spacing)		
Paddock rotation	2004 Pasture, ploughed after a September rain.		
Herbicides	Knockdowns with total of 1L/ha glyphosate and 3 g/ha 'Ally' Broadleaf control with 750 mL/ha of 'Jaguar' on 24th May (site 1) and 300 mL/ha of 'Riddler' 8th June (sites 2 and 3). 300mL of 'Tilt' applied 28th June as insurance.		
Growing Season Rainfall	May to October 190mm (total 255); 80mm added in July and August by Ttape irrigation to 'Arrino+'. March 52, April 11, May 57, June 46, July 7, August 53, September 23, October 6		

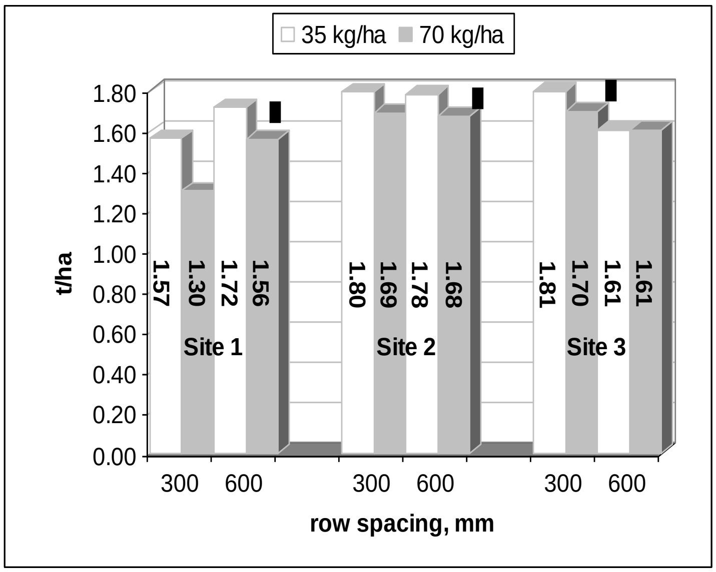
Trial design; A randomised split plot layout with repeated check treatments to reduce site variation effects (covariate analysis). *Measurements*: establishment, canopy temperature, soil moisture, tillers, heads, biomass, grain yield, quality and yield components.

RESULTS

1. Early May sown Westonia and Tammarin Rock on 600mm rows and 35 kg/ha equivalent farm seeding rate gave the best gross margin on about 500mm of fertile red sandy clay loam over granite (Site 1). Arrino yielded best, but missed noodle segregation; see Table 1. The estimated best gross margins from Site 1 were about $170/ha and the best yields were just under 2 t/ha (1.94 t/ha).

2. Early May sown Arrino, Calingiri and Cunderdin on 600 or 300mm row spacing and 35 kg/ha seeding rate gave the best yields and gross margin on 400 of stony grey gravelly loam over granite (Site 2, Table 2). The best gross margins from Site 2 were about $190/ha and the best yields were about 2 t/ha.
3. June sown Westonia on 300mm row spacing and 35 kg/ha gave the best yields and gross margin on about 400mm of gravely sandy loam over granite (Site 3). The best gross margin of Site 3 was about $170/ha, the best yield 1.9 t/ha.
4. Bonnie Rock on the fertile red loam benefited most from modified row spacing and seeding rate; the gross margin was improved by $105/ha. Average improvements to gross margin by reduction of seeding rate and increase to very wide rows ranged from $65/ha on Site 1 through $11 at Site 2 to $6/ha on Site 3.

Varieties Kalannie and Janz flowered very early and very late, compared to the other varieties and often performed differently at the three sites than the other varieties. Figure 1 summarised the mean yield of Arrino, Bonnie Rock, Calingiri, Cunderdin, Drysdale, Wyalkatchem and Westonia at Site 1, Arrino, Bonnie Rock, Calingiri, Cunderdin, Drysdale and Wyalkatchem at Site 2 and Calingiri and Westonia at Site 3. More detail is given for each site in Tables 1-3 below.



Observations:

1. **The more fertile red soil at Site 1 encouraged much early growth and drought stress in the early sown crops; Wide rows and low sowing rates reduced stress and gave 420 kg/ha better yield than narrow rows and higher seed rates.**
2. **The marginally less fertile grey soil at Site 2 resulted in less early growth and drought stress, low seeding rates provided about 100 kg/ha better yield for either row spacings.**
3. The late sowing at Site 3

Figure 1. Average yields of all varieties, excluding Kalannie and Janz at the three sites. The Least Significant Difference (5%) is shown for each site as a vertical bar. Seeding rate in kg/ha is expressed as the equivalent on farm rate.

GENERAL OBSERVATIONS AND THEORY

The balance between setting up yield potential with early vigour (and greater early water use) and saving soil moisture for use during times of drought (normally at the end of the season – though midseason at Pindar in 2005) governs whether yields will increase or decrease with management aimed at controlling that early vigour.

On shallow soils in low rainfall zones, early crop vigour (induced by high seeding rates, narrow row spacing, high fertiliser use or high soil fertility) can use stored soil water early at the expense of later crop growth and both grain yield and quality.

On soils with adequate stored moisture and/or a ‘soft’ finish to the season, better early vigour usually translates into better grain yield. These trials show that on shallow soils and soils with a gravelly subsoil, moisture storage is so low that attempts to reduce early crop vigour simply reduce yield because there is no compensating grain fill associated with significant stored moisture. On slightly deeper soils with a propensity for more stored moisture (Site 1), management to reduce early vigour and conserve water for later growth and grain fill, can pay off in seasons with 6 weeks of winter drought. In 2005, management to reduce early vigour worked because there was a severe mid-season drought where more vigorous treatments lost heads and spikelets and consequent grain yield.

Late sowing (Site 3) and poorer soil fertility (Site 2) reduced early vigour and a kind seasonal finish meant treatments with less heads/m^2 suffered yield depressions. An added complication at Site 1 comes from the interaction of the duration of the mid-season drought with the different development stages of the various wheat cultivars. Early maturing cultivars (Kalannie and Westonia) got through to ear emergence before the cumulated effects of the drought were too extreme. Later maturing varieties had ears caught in the boot and suffered spikelet and tiller deaths which caused yield reductions on the early vigour (close spaced, high seeding rate) treatments.

These trial results and associated measurements support the basic idea (hypothesis) that the best management of shallow soil for wheat production in zones prone to winter drought is strongly influenced by soil fertility, soil depth, depth of drying by evaporation and soil water holding capacity.

1. Very shallow soil (<250mm) is very prone to drying by evaporation; thus very wide rows are a penalty and low seeding rates at normal row spacings allow better use of what rain does arrive.
2. Deeper soil (up to at least 500mm) provides a better soil water storage on the inter-row, especially if the soil is very fertile and encourages early plant growth, thus early water use. Here very wide rows can be a large benefit, especially if combined with lower seeding rates.
3. If the deeper layers are very gravelly, this inter-row moisture is quickly exhausted to minimise drought stress and very wide rows can be a penalty.
4. Lower fertility is a benefit on these soils, because it does not encourage excessive early growth and water use.
5. Late sown crops on shallow soil can get little benefit from wide rows and a yield penalty if spring rains rapidly evaporate from the wide inter-rows. Previous drier springs at Pindar have shown benefits to very wide rows for grain fill.
6. The low seeding rate and wider rows worked in this case because of their effect on water conservation through a very long mid-season drought. If this had not occurred, we would more likely have seen effects similar to the later sown trial on that deeper red soil. This would be in keeping with past years results where the water conservation associated with poor early crop vigour on the wide row spacings, allowed yields to be maintained through a higher harvest index and quality to marginally improve because of better water relations for the more common end of season drought.
7. The detailed data show marked interactions of the crop variety development rating with the various drought stresses imposed by the different treatments.
8. Most importantly, the results are VERY site and season specific and should not be directly applied to other situations.

Table 1: Yield, quality and economics of wheat sown on 7th May Site1. Farm gate returns delivered to Morawa. Grain from all treatments of the same variety analysed as the same grade.

Variety & grade	Seed rate	Row spacing	Yield (t/ha)	Protein (%)	Scrnings (%)	Weight (kg/hl)	Price $/t	Gross Income $/ha	Gross Margin $/ha
Arrino	30	300	1.49	13.5	0.09	83.02	$142.41	$212	$80
ASW	30	600	1.94	12.5	0.14	84.60	$142.41	$276	$144
	60	300	1.50	14.2	0.31	82.20	$142.41	$214	$75
	60	600	1.82	13.1	0.14	84.35	$142.41	$259	$121
Calingiri	30	300	1.50	12.7	0.81	82.98	$142.41	$214	$81
ASW	30	600	1.42	13.1	1.12	84.45	$139.94	$199	$66
	60	300	1.28	13.4	0.88	81.86	$142.41	$182	$44
	60	600	1.50	13.1	0.48	83.32	$142.41	$214	$75
Kalannie	30	300	1.56	13.2	1.99	81.68	$157.26	$245	$113
AHard	30	600	1.62	12.9	2.24	82.42	$152.81	$248	$115
	60	300	1.55	13.4	2.81	81.04	$154.79	$240	$102
	60	600	1.58	13.2	2.27	83.08	$154.79	$245	$106
Bonnie Rock	30	300	1.48	13.7	2.00	82.43	$168.15	$249	$116
AHard	30	600	1.68	13.0	1.15	83.19	$164.19	$276	$143

	60	300	1.09	14.1	6.07	80.89	$157.26	$171	$33
	60	600	1.48	13.7	1.53	82.86	$168.15	$249	$111
Wyalkatchem	30	300	1.42	13.8	0.19	82.88	$159.74	$227	$94
APW	30	600	1.75	13.5	0.11	84.38	$159.74	$280	$147
	60	300	1.25	13.9	1.10	81.25	$157.26	$197	$58
	60	600	1.58	13.7	0.11	83.58	$159.74	$252	$114
Cunderdin	30	300	1.42	12.4	2.02	83.40	$152.81	$217	$85
APW	30	600	1.45	12.7	0.50	84.01	$157.76	$229	$96
	60	300	0.99	13.0	4.36	81.83	$149.84	$148	$10
	60	600	1.51	12.9	1.12	83.66	$155.28	$234	$96
Drysdale	30	300	1.74	13.2	0.78	84.72	$142.41	$248	$115
ASW	30	600	1.82	13.6	0.59	83.36	$142.41	$259	$127
	60	300	1.41	13.1	3.55	84.51	$133.75	$189	$50
	60	600	1.37	13.6	2.55	84.14	$137.46	$188	$50
T. Rock	30	300	1.74	13.1	0.74	82.58	$169.14	$294	$162
AHard	30	600	1.82	12.8	0.94	82.87	$166.67	$303	$171
	60	300	1.41	13.0	0.80	81.83	$169.14	$238	$100
	60	600	1.37	13.4	1.15	82.64	$165.67	$227	$89
Westonia	30	300	1.72	13.4	0.34	82.92	$159.74	$275	$142
APW	30	600	1.89	13.1	0.60	83.39	$159.74	$302	$169
	60	300	1.40	14.0	0.64	83.06	$159.74	$224	$85
	60	600	1.54	13.7	0.89	83.74	$159.74	$246	$108
Janz	30	300	1.03	13.5	1.70	83.13	$168.15	$173	$41
AHard	30	600	1.05	13.8	2.87	83.77	$165.68	$174	$42
	60	300	0.65	13.9	9.31	81.17	$148.35	$96	-$42
	60	600	0.89	13.3	2.13	83.72	$164.19	$146	$8
LSD (5%) between any variety & treatment			*0.32*	1.1	2.94				

NB - The variable costs to calculate the Gross Margins come from the operations outlined in the Trial Details and the method of the 2004 "Farm Budget Guide" for the Eastern Wheatbelt. Estimated variable costs were $138/ha for the higher seeding rate and $132.4/ha for the lower seeding rate; it is encouraging that some of the treatments saved costs, rather than increased them!

Site 1 Observations

1. Arrino, Tamarin Rock and Westonia were the best average performers on this soil. (Unfortunately, 6mm of October rain resulted in a falling numbers test below 300 in this harvest).
2. Very wide row spacing and lower seeding rate provided most yield benefit.
3. Hectalitre weight was best at higher yields and lower drought stress; screenings were all low due to the soft finish.
4. Yield loss came from drought stress during July and early August. Lower seeding rates and very wide rows reduced yield loss from about 2.5 t/ha to about 2 t/ha (compared with irrigated and fungicide treated Arrino which yielded 3.8 t/ha). About 270mm of rain and no drought periods from May to October could have resulted in a 4 t/ha yield!
5. Higher leaf temperature was caused by exhaustion of water supply in the 300mm row spacing and 60 kg/ha sowing rate, due to too higher early growth. High plant temperatures caused leaf damage and head damage.
6. The drought stress caused some extra tiller loss and poor grain set and fill, especially in the later flowering varieties.
7. Despite two, zero degree nights, there was no significant flower damage by frost. Almost all canopy and head damage symptoms came from drought stress. No crown rot could be detected.
8. The drought stress was reduced by the inter-row moisture between 20 and 45cm depth in the very wide rows.

9. Lower sowing rates retained more moisture in the soil for grain fill; despite 80mm of rain in August and September there was still a moisture deficit during the spring.
10. High soil fertility also encouraged early growth and extra use of water compared to the shallow stony soil.
11. These red fertile soils formed from the weathering of dolerite dykes and with about 500mm of loam over rock are best cropped with about 600mm row spacing and 35 kg/ha of farm seed with fertiliser on the inter-row.
12. Significant re-growth (water shoots) occurred following the late rains and was more evident in Calingiri and Bonnie Rock which had suffered major head damage from the mid-season drought.
13. Higher seeding rate increased protein by about 0.3%.
14. Low sowing rates and very wide rows had lower protein than the other treatments.
15. Janz and Wyalkatchem had higher protein than Calingiri and Cunderdin.
16. Row spacing had no real effect on average protein.
17. The lower sowing rate reduced screenings and the wider row spacing reduced screenings; both by about 1%.
18. Bonnie rock, Cunderdin and Janz showed high screenings at narrower rows and higher seeding rates, despite the soft finish to the season.
19. Best Gross margin of $169/ha for Westonia at 30 kg/ha on 600mm row spacing; also >$140/ha by Tammarin Rock, Wyalkatchem, Arrino and Bonnie Rock for the same treatments. Improved margins came from grade yield and protein; protein was too high for noodle segregation. (Note Tammarin Rock would have been downgraded).
20. Bonnie Rock showed the best gross margin improvement from the worst treatment ($104/ha); all benefits for all varieties averaged $68/ha.

Table 2: Yield, quality and economics of wheat sown on 7th May Site 2 Farm gate returns delivered to Morawa. Grain from all treatments of the same variety analysed as the same grade.

Variety & grade	Seed rate	Row spacing	Yield (t/ha)	Protein (%)	Screenings (%)	Weight (kg/hl)	Price $/t	Gross Income $/ha	Gross Margin $/ha
Arrino	30	300	1.97	10.0	0.04	84.14	$163.08	$321	$189
ASWN	30	600	1.95	10.3	0.06	84.50	$163.08	$318	$186
	60	300	1.70	10.6	0.12	83.39	$163.08	$277	$139
	60	600	1.68	10.4	0.14	84.54	$163.08	$274	$136
Calingiri	30	300	1.77	11.0	0.08	83.68	$163.20	$289	$156
ASWN	30	600	1.76	11.5	0.35	83.01	$159.49	$281	$148
	60	300	1.65	11.4	1.32	82.55	$158.99	$262	$124
	60	600	1.63	11.2	0.12	83.41	$161.47	$263	$125
Kalannie	30	300	1.66	10.8	0.24	82.73	$166.02	$276	$143
APW	30	600	1.63	10.8	0.30	83.43	$166.02	$271	$138
	60	300	1.69	10.7	0.38	82.67	$166.02	$281	$142
	60	600	1.67	11.2	0.19	82.18	$168.00	$281	$142

Bonnie Rock	30	300	1.72	10.3	0.45	83.34	$151.32	$260	$128
AHard	30	600	1.70	10.7	0.13	83.68	$153.06	$260	$128
APW	60	300	1.59	10.7	0.89	82.92	$153.06	$243	$105
	60	600	1.56	10.8	0.66	83.37	$153.06	$239	$101
Wyalkatchem	30	300	1.72	11.0	0.23	84.24	$154.79	$266	$134
APW	30	600	1.70	10.9	0.18	84.73	$153.06	$260	$128
	60	300	1.65	11.3	0.13	84.72	$154.79	$255	$117
	60	600	1.63	11.7	0.24	84.60	$156.27	$255	$117
Cunderdin	30	300	1.80	11.0	0.21	82.53	$153.06	$275	$143
APW	30	600	1.80	11.7	0.12	82.75	$156.27	$281	$149
	60	300	1.84	11.4	0.22	82.20	$154.79	$285	$147
	60	600	1.85	11.5	0.46	82.42	$154.79	$286	$148
Drysdale	30	300	1.79	10.4	0.07	83.72	$136.48	$244	$112
ASW	30	600	1.79	11.0	0.09	83.90	$137.96	$247	$114
	60	300	1.70	11.1	0.85	54.96	$139.44	$237	$99
	60	600	1.72	11.5	0.21	82.07	$140.93	$242	$104
LSD (5%) between any variety & treatment			0.26	1.1	0.50				

Site 2 Observations

1. Arrino and Cunderdin were the best average performers on this soil.
2. Lower fertility than Site1 here induced lower early biomass and less early use of available water and drought stress.
3. Low seeding rate benefited average yield most at either row spacing by conserving more moisture to fill grain.
4. There was a minor average yield benefit from 300mm rows. Cunderdin, Drysdale and Kalannie could benefit slightly from very wide rows.
5. The high gravel content in the deep inter-row would result in rapid exhaustion of soil moisture and possibly better interception and conservation of moisture at the narrower row spacing.
6. There were no effects of variety or treatment on grain protein and all levels were relatively lower on this less fertile site.
7. Screenings were generally low due to the soft finish, but there was still a real reduction of screenings by wider rows and lower seeding rates.
8. Best Gross margin of $189/ha for Arrino at 30 kg/ha on 600mm row spacing; also >$140/ha for Calingiri, Kalannie and Cunderdin for the same seeding rate. Improved margins came from grade yield and protein. Protein was within the noodle segregation.

9. Arrino also showed the best gross margin improvement from the worst treatment ($47/ha); all maximum benefits for all varieties averaged $20/ha.

Table 3: Yield, quality and economics of wheat sown on 1st June Site 3. Farm gate returns delivered to Morawa. Grain from all treatments of the same variety analysed as the same grade.

Variety & grade	Seed rate	Row spacing	Yield (t/ha)	Protein (%)	Scrnings (%)	Weight (kg/hl)	Price $/t	Gross Income $/ha	Gross Margin $/ha
Calingiri	30	300	1.69	12.9	3.7	80.93	$133.75	$226	$94
ASW	30	600	1.47	12.7	2.8	81.19	$137.46	$202	$70
	60	300	1.64	12.5	3.5	82.34	$134.99	$221	$83
	60	600	1.52	12.5	3.0	82.41	$137.46	$209	$71
Kalannie	30	300	1.61	12.4	2.8	84.57	$158.63	$255	$123
APW	30	600	1.47	12.6	1.5	84.22	$164.07	$241	$109
	60	300	1.57	12.4	2.5	83.33	$158.63	$249	$111
	60	600	1.48	12.4	3.1	83.55	$156.15	$231	$93
Westonia	30	300	1.92	11.4	3.9	81.01	$148.11	$284	$142
Ahard	30	600	1.74	12.0	4.7	80.49	$152.56	$265	$169
	60	300	1.76	12.4	5.0	81.43	$151.32	$266	$85
	60	600	1.69	12.3	1.7	82.75	$161.22	$272	$108
Janz	30	300	1.55	11.7	4.6	84.89	$149.10	$231	$99
AHard	30	600	1.38	12.2	8.5	83.00	$143.90	$199	$66
	60	300	1.27	12.0	4.8	84.21	$152.56	$194	$56
	60	600	1.29	12.9	8.6	82.92	$146.87	$189	$51
LSD (5%) between any variety & treatment			0.26	1.5	0.50				

Site 3 Observations

1. Westonia was the best performer at this site, at 300mm row spacing and 30 kg/ha sowing rate.
2. When the period of drought occurred the crop was too young to suffer much stress (still at the early tillering stage).
3. Drought had its greatest effect on grain fill.
4. There were no effects of variety or treatment on grain protein at this site.
5. Janz had more screenings than Kalannie and Calingiri.
6. Low seeding rate and narrower rows had no beneficial effect on screenings.
7. Best Gross margin of $169/ha for Westonia at 30 kg/ha on 300mm row spacing; improved margins came from grade, yield and protein; protein was outside the noodle segregation.
8. Janz showed the best gross margin improvement from the worst treatment ($42/ha); all maximum benefits for all varieties averaged $27/ha.

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