Response of Bannister and Williams oat varieties to sowing date and nitrogen

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Key messages

- Time of sowing had a greater influence on oat grain and hay yield, and oat grain quality than variety selection or level of applied nitrogen in 2015.
- High screenings limited the ability of grain to meet Oat1 quality standards, this was due to the detrimental impact of delayed seeding and/or applied nitrogen in excess of that required in lower rainfall environments.
- Applying more than 20 kg N/ha did not improve the return per hectare ($/ha); rather, applying 80 kg N/ha consistently reduced return per hectare ($/ha).
- Screening of Williams and Carrolup were more sensitive to applied nitrogen than WA02Q302-9, Bannister and Yallara.
- WA02Q302-9 appears a suitable replacement for Yallara and Carrolup, and should achieve a better hectolitre weight than Bannister at similar or lower yields.

Aims

Growers in medium to low rainfall regions are keen to grow oats as a break crop, either for hay or as a profitable grain crop; however, there is a need to identify management inputs and varieties that consistently meet quality specifications. Currently there is considerable interest in the high yielding milling oat varieties Bannister and Williams but they have not been adequately evaluated in lower rainfall environments in WA. Oat agronomy trials conducted in 2014 suggested that the grain quality of Banister and Williams was more sensitive to nitrogen inputs than established varieties like Carrolup in lower rainfall regions (Troup *et al*. 2015) but these trials were only sown in late May at the end of the 'modern oat grower' sowing window for milling oats.

The aims of this study are to:

1. quantify the impact of delayed seeding and N inputs on the yield and quality of hay and grain production,
2. evaluate the responsiveness of Bannister and Williams oat varieties to applied nitrogen,
3. determine if Bannister and Williams are suitable milling oat varieties for lower rainfall regions.

Method

This study was undertaken in 2015 at three medium to low rainfall sites (Cunderdin, Holt Rock and Merredin) to compare the performance of six milling oat varieties/lines (Bannister, Carrolup, WA02Q302-9, Williams and Yallara, and 05096-32) when sown on two seeding dates (May and June, 4 weeks apart) and fertilised at four different nitrogen rates (0, 20, 40, and 80 kg N/ha). Oat seed was direct-drilled (2 to 3 cm depth) into canola stubble using a small plot air-seeder with trailing on-row press wheels; CSBP Super CZM was banded below the seed at 120 kg/ha. Urea was top dresses across select plots, 6 to 7 weeks after sowing (WAS), at 20 or 60 kg N/ha to fully implement N treatments. Soil samples were taken just before seeding and analysed for soil physical and chemical properties. Based on soil parameters, rotation and expected rates of mineralisation, we used the Select Your Nitrogen (SYN) tool to calculate total available nitrogen at each site.

Variety seeding rate was between 117 - 130 kg/ha and was adjusted (based on grain weight and germination percentage) to achieve a target density of 240 plants/m^2. Plant establishment was assessed 4 weeks after seeding by counting the number of seedlings along adjacent 1 m long rows at two locations per plot.

The trials were sown in split plot design with variety and time of sowing (TOS) as whole plots and nitrogen rate randomised as subplots within a variety + TOS combination. Yield and quality data were analysed with GenStat version 17 and statistical comparisons between treatments were made with Least Significant Difference (LSD). Data for 05096-32 is not presented in this paper as this line is still to be progressed to the final stage of field evaluation.

Hay yield and quality was assessed using protocols approved by the Australian Fodder Industry Association (AFIA). Each variety was cut by hand, 15cm above the ground (sample size 0.88m^2), when it reached watery ripe stage (Z71). Samples were oven dried at 60 °C to determine hay yield, and then measured for stem diameter. Grain yields were assessed at harvest and clean grain samples were used to assess hectolitre weight, screenings and grain protein (i.e.

key oat receival standards), plus thousand kernel weight, groat per cent, grain colour and oil per cent. Only the grain yield, hectolitre weight and screenings data are presented in this paper. Site details and soil chemical properties are given in Table 1.

Table 1. Trial site location, seeding dates, growing season rainfall (May-Oct), soil type, select chemical properties and soil mineral nitrogen (0-10 cm) of oats trials conducted in 2015 .

Site	Location	Seeding dates	May-Oct rainfall (mm)	Organic C (%)	pHCa (0-10cm)	Ammonium Nitrogen (mg/Kg)	Nitrate Nitrogen (mg/Kg)	SYN Nitrogen (Kg/ha)	Previous crop	Soil type
15NO30	Cunderdin	5-May-15 4-Jun-15	167	0.87	5.8	1	17	63	Canola	Red loamy earth
15ME22	Merredin	8-May-15 8-Jun-15	211	1.35	5.2	6	23	91	Canola	Red sandy earth
15KA22	Holt Rock	1-May-15 2-Jun-15	140	1.06	5.5	5	27	65	Canola	Shallow sand over clay

Table 2. Analysis of variance for main effects (time of sowing, variety and nitrogen rate) and their interaction at Cunderdin, Merredin and Holt Rock oats trials conducted in 2015. Significance: *** = p<0.001, ** = p<0.01, * = p<0.05 and n.s. = not significant.

	Grain yield (t/ha)			Hectolitre weight (kg/hL)			Screenings (% < 2.0 mm)		
	Cunderdin	Merredin	Holt Rock	Cunderdin	Merredin	Holt Rock	Cunderdin	Merredin	Holt Rock
Seeding date (TOS)	*	***	***	*	**	n.s.	***	**	**
Variety (V)	n.s.	***	**	***	***	***	***	***	***
TOS x V	n.s.	***	n.s.	**	n.s.	*	***	**	*
Nitrogen applied (N)	**	***	n.s.	***	***	***	***	***	***
TOS x N	***	**	n.s.	***	n.s.	n.s.	***	**	n.s.
V x N	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	**	*	n.s.
TOS x V x N	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	*	n.s.

	Hay yield (t/ha)			Stem thickness (mm)		
	Cunderdin	Merredin	Holt Rock	Cunderdin	Merredin	Holt Rock
Seeding date (TOS)	***	***	***	**	***	n.s.
Variety (V)	*	*	*	n.s.	n.s.	**
TOS x V	*	*	**	n.s.	***	*
Nitrogen applied (N)	***	***	**	n.s.	n.s.	n.s.
TOS x N	*	n.s.	n.s.	n.s.	n.s.	n.s.
V x N	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
TOS x V x N	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Results

Crop establishment

The trials were sown into sufficient moisture for germination, and established well with follow-up rain 10-17 days after sowing. Growing season rainfall was above average at Merredin, but below average at Cunderdin and Holt Rock. Plant density was consistent across all treatments and averaged 205 plants/m^2. Weed control was good but there was a prolonged dry period between mid-May and mid-June, and the season shutoff at the end of August.

What effect did crop management have on grain yield?

Grain yield decreased with delayed seeding at all three sites (Figure 1), and was influenced by nitrogen rate at Cunderdin and Merredin (Figure 2). Delayed sowing resulted in a grain yield penalty of 28% at Cunderdin, 36% at Merredin and 26% at Holt Rock. The response to applied N differed between sites. At Cunderdin, for the early May seeding date, grain yield increased in response to applied nitrogen up until 40 kg N/ha but decreased thereafter, and for the early June seeding date grain yield decreased when applied N was greater than 40 kg N/ha. At Merredin, all applications of N decreased yield for both sowing dates. While at Holt Rock there was no response to nitrogen at either time of sowing.

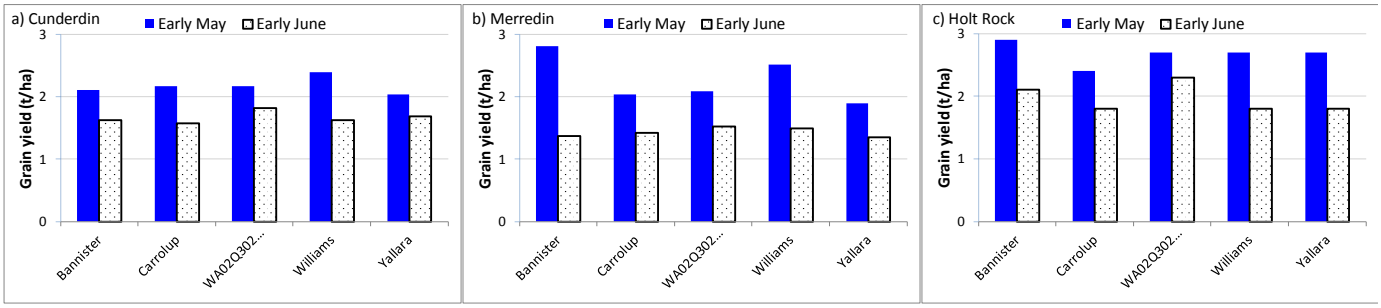

Figure 1. The effect of time of sowing on grain yield of five oat varieties at a) Cunderdin, LSD (P = 0.05) = 0.3, b) Merredin, LSD (P = 0.05) = 0.2 and c) Holt Rock, LSD (P = 0.05) = 0.3.

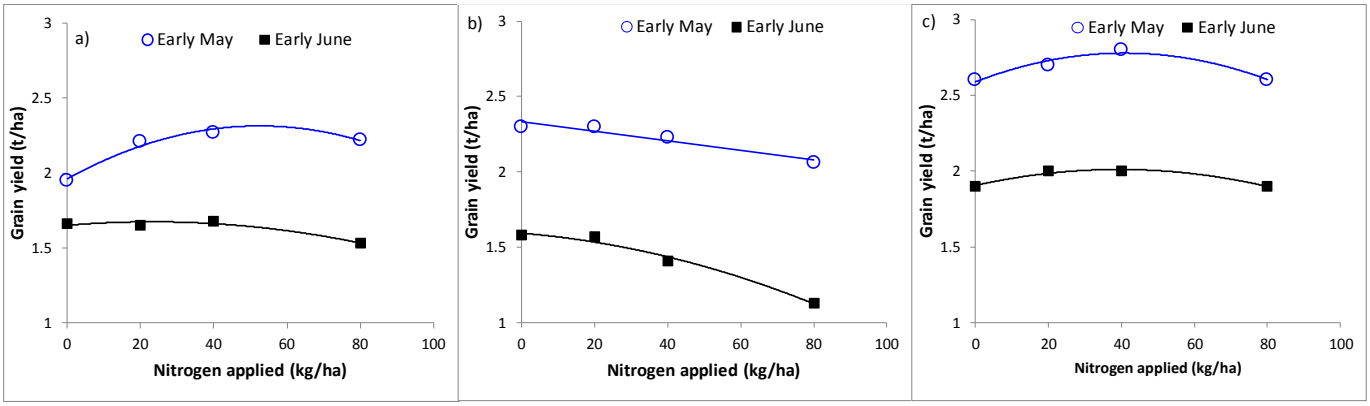

Figure 2. Average grain yield response of five oat varieties to increasing nitrogen inputs at a) Cunderdin, LSD (P = 0.05) = 0.1, b) Merredin, LSD (P = 0.05) = 0.1 and c) Holt Rock, LSD (P = 0.05) = 0.1.

What influenced grain quality the most?

Grain quality was influenced by time of sowing, variety selection and applied nitrogen all three sites with one exception, there was no significant difference in hectolitre weight between seeding dates at Holt Rock (Table 2). Variety selection and applied nitrogen had a greater impact on hectolitre weight and screening levels than time of sowing (Table 2).

All varieties exceeded the Oat1 minimum hectolitre weight receival limit of 51 kg/hL regardless of time of sowing and applied nitrogen; nevertheless, crop management influenced hectolitre weight and the ability of some varieties to meet the Oat1 maximum screenings receival limit of 10% (Oat2 has no limit on screenings). Hectolitre weight decreased as N applied increased at all three sites (Figure 5 & 6). WA02Q302-9 had the highest hectolitre weight, Carrolup, Bannister and Yallara produced similar hectolitre weights, while Williams had the lowest hectolitre weight, nearly 3 kg/hL less than Carrolup.

Time of sowing had a greater impact on screenings than applied nitrogen. Delayed sowing reduced hectolitre weight and the probability of meeting the Oat1 screenings limit of 10%. Williams and Carrolup produced more screenings than Bannister, Yallara and WA02Q302-9 at all three locations and only met the Oat1 screenings limit at Cunderdin and Holt Rock when sown in early May. The ranking of varieties was influenced by time of sowing at all sites and by the application of nitrogen at Cunderdin and Merredin (Figure 3 and 4). When averaged across all sites and seeding dates, screenings increased by 5% when applied N increased from 0 to 80 kg N/ha.

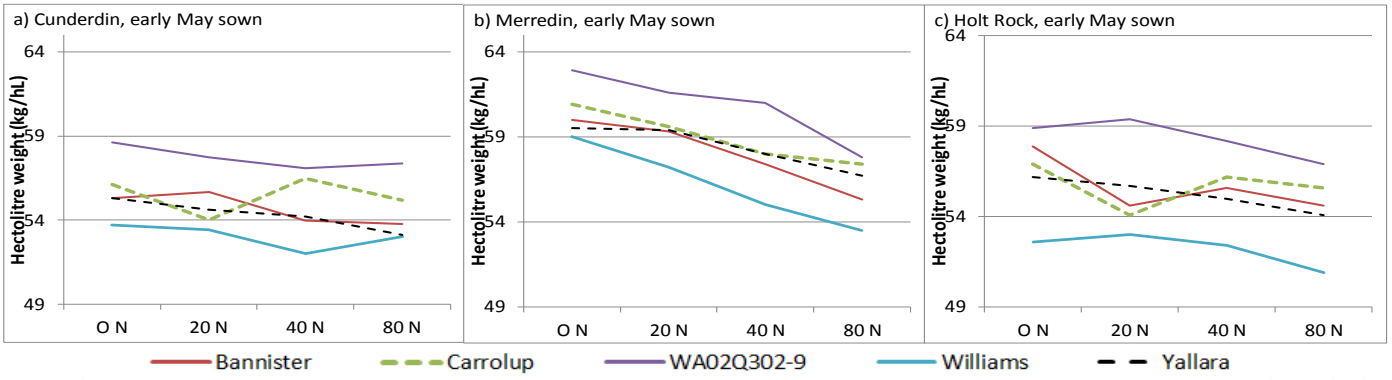

Figure 3. The effect of applied nitrogen on hectolitre weight of five oat varieties when sown in early May at a) Cunderdin, b) Merredin, and c) Holt Rock, LSD (P = 0.05) = 2.0 kg/hL.

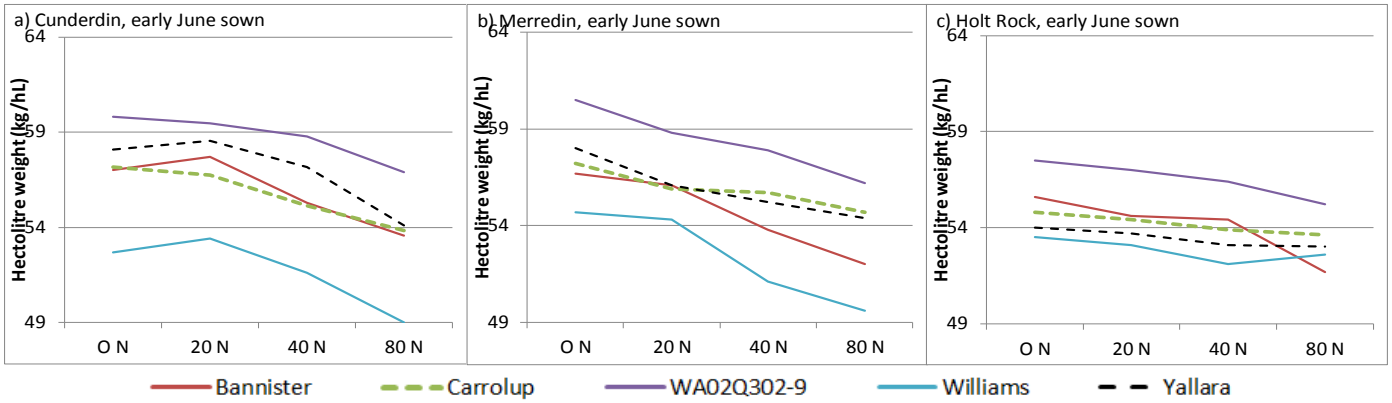

Figure 4. The effect of applied nitrogen on hectolitre weight of five oat varieties when sown in early June at a) Cunderdin, b) Merredin, and c) Holt Rock, LSD (P = 0.05) = 2.0 kg/hL.

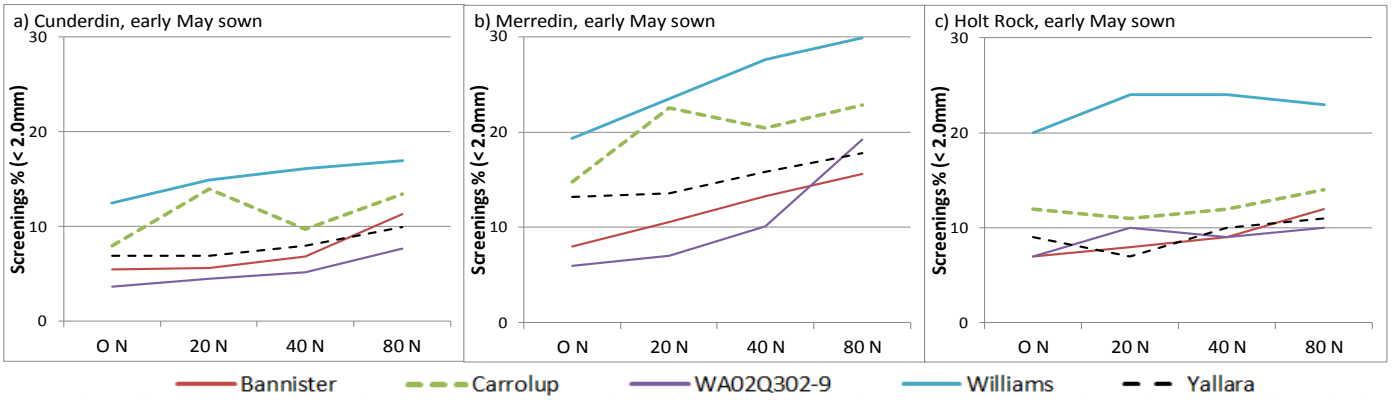

Figure 5. The effect of applied nitrogen on screenings of five oat varieties when sown in early May at a) Cunderdin, LSD (P = 0.05) = 2.8%, b) Merredin, LSD (P = 0.05) = 3.7%, and c) Holt Rock, LSD (P = 0.05) = 5.0%.

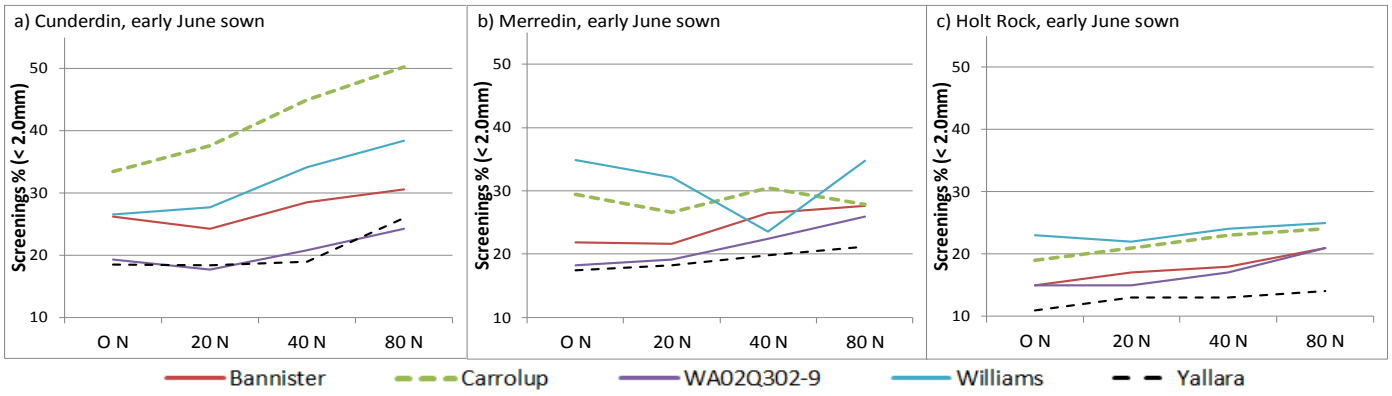

Figure 6. The effect of applied nitrogen on screenings of five oat varieties when sown in early June at a) Cunderdin, LSD (P = 0.05) = 2.8%, b) Merredin, LSD (P = 0.05) = 3.7%, and c) Holt Rock, LSD (P = 0.05) = 5.0%.

What influenced hay yield and quality?

Hay yield was significantly influenced by time of sowing and applied nitrogen ($p<0.001$), and to a lesser extent variety selection ($p<0.05$) at all locations (Table 2). Delayed sowing from early May to early June reduced hay yield by 34% at Cunderdin, 25% at Merredin and 32% at Holt Rock (Figure 8). All varieties responded similarly to increasing nitrogen: at Cunderdin and Merredin yield increased out to 40 kg N/ha, while at Holt Rock yield response plateaued after 20 kg N/ha (Figure 7).

Varieties differed in their hay yield, and the ranking of varieties was influenced by time of sowing at all locations. At Cunderdin, the highest yielding varieties, when averaged over both seeding dates, were WA02Q302-9 (4.1 t/ha), Carrolup and Williams (4.0 t/ha), and the lowest yielding varieties were Bannister (3.5 t/ha) and Yallara (3.8 t/ha). At Holt Rock, Yallara was the highest yielding variety (4.4 t/ha) and Williams the lowest (3.7 t/ha) with the hay yield of Bannister, Carrolup, and WA02Q302-9 being similar to Williams, but below Yallara. At Merredin, Carrolup and Yallara were the highest yielding varieties (4.4 t/ha), the yield of WA02Q302-9 was similar to Williams but significantly less than Carrolup and Yallara (Figure 8).

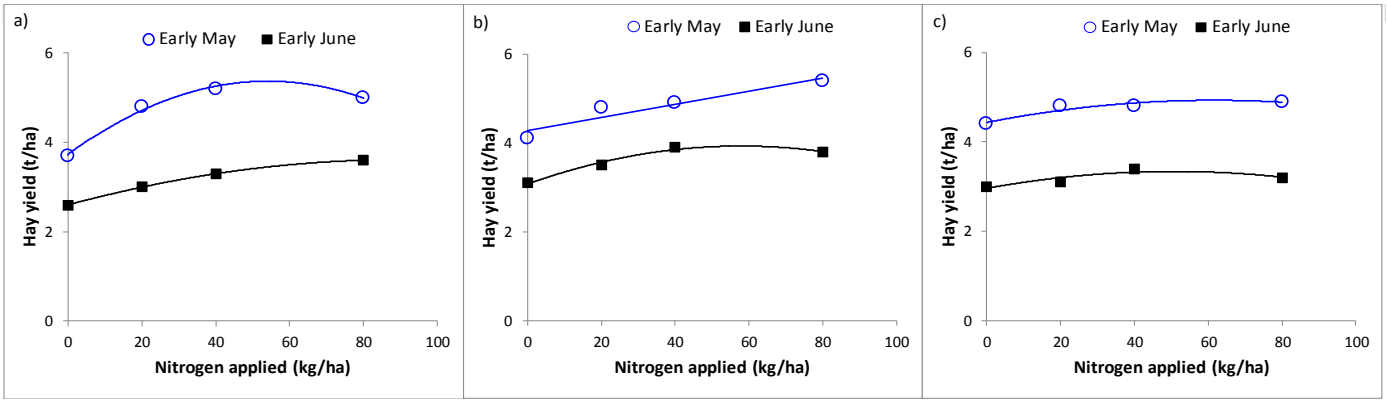

Figure 7. Average Hay yield response of six oat varieties to applied nitrogen at a) Cunderdin, LSD (P = 0.05) = 0.3, b) Merredin, LSD (P = 0.05) = 0.4 and c) Holt Rock, LSD (P = 0.05) = 0.3.

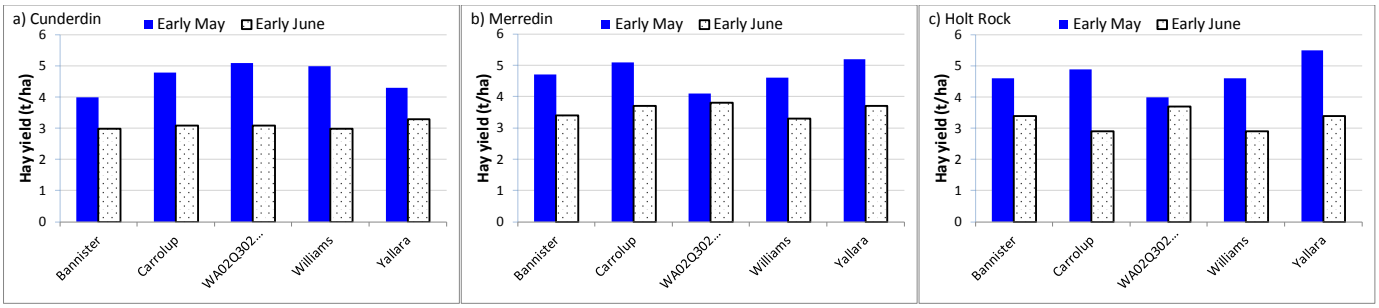

Figure 8. The effect of time of sowing on hay yield of five oat varieties at a) Cunderdin, LSD (P = 0.05) = 0.5, b) Merredin, LSD (P = 0.05) = 0.5 and c) Holt Rock, LSD (P = 0.05) = 0.6.

All varieties met the hay industry Grade 1 standard for stem thickness (6 mm). Interestingly, applied nitrogen had no influence on stem thickness. By contrast, a delay in seeding date decreased stem thickness at Cunderdin and Merredin; the greatest effect was on Williams and Bannister, whose stem thickness reduced by 40 to 47% (Table 4). Within seeding date, varieties had a similar stem thickness at Cunderdin, but differed for both dates at Merredin and for the early seeding date at Holt Rock. Time of sowing also altered the ranking of varieties based on stem thickness.

Table 4. Stem thickness (mm) response to delayed sowing at Cunderdin LSD (p=0.5) = 0.8 mm, Merredin LSD (p=0.5) = 0.5 mm and Holt Rock LSD (p=0.5) = 0.4 mm.

Variety	Cunderdin			Merredin			Holt Rock		
	Early May	Early June	% change	Early May	Early June	% change	Early May	Early June	% change
Bannister	5.3	3.6	-47%	5.6	4.0	-40%	4.1	3.8	-9%
Carrolup	4.7	3.5	-34%	4.9	5.1	4%	3.6	3.5	-3%
WA02Q302-9	4.9	4.3	-14%	4.9	4.2	-17%	3.5	3.8	9%
Williams	5.3	3.6	-47%	5.7	4.0	-43%	4.2	3.7	-13%
Yallara	4.8	3.8	-26%	5.1	4.8	-6%	4.1	3.8	-10%
Site mean	*5.0*	*3.7*	-35%	*5.3*	*4.3*	-23%	*3.9*	*3.6*	-7%

Do Bannister and Williams respond differently to applied N?

Overall, the response of Banister and Williams to applied nitrogen was similar at each site. Grain yield of Williams and Bannister increased when applied nitrogen increased from 0 to 20 kg N/ha at Cunderdin and Holt Rock, but decreased at Merredin when nitrogen was applied; likewise, the hectolitre weight of both varieties decreased (Figure 1 & 2) and hay yield increased as the rate of applied nitrogen increased; but applied nitrogen had no effect on stem thickness. However, Williams was predisposed to having higher screenings than Bannister, Yallara and WA02Q302-9 across all sites and seeding dates.

Economic analysis

An economic analysis calculating return (yield by price minus costs) was done for each variety, nitrogen rate, time of sowing and site using the assumptions in Table 5 and the current GIWA Oat receival standards for Western Australia.

Williams had the lowest proportion of samples meeting the GIWA Oat1 receival specifications, with no samples being suitable for receival as Oat1. The grain quality of Bannister and WA02Q302-9 was suitable for receival as Oat1 at Cunderdin and Holt Rock, but only with early May sowing. At Merredin most varieties with early May sowing failed to achieve GIWA Oat1 specifications.

Time of sowing had the greatest influence on return per hectare. Crops sown in early May had a higher return than the same crop sown in early June, by $216/ha averaged over sites. When sown in early May Bannister had the highest return per hectare, higher than the next best variety Williams by $51/ha. When sowing was delayed until early June the breeding line WA02Q302-9 had the highest return per hectare, higher than the next best variety Bannister by $52/ha (Table 6).

The influence of nitrogen applied on return per hectare ($/ha) was dependent on time of sowing and site. At Cunderdin and Holt Rock return per hectare ($/ha) increased as applied nitrogen increased up to 20 kg N/ha in early May sown oats whilst when sowing was delayed to early June the response to applied nitrogen decreased with increasing amount of applied nitrogen. Averaged over the sites, maximum return was achieved by applying nitrogen between 0 and 20 kg N/ha in early May. The decrease in return beyond 20 kg N/ha was larger when sowing was delayed. The lowest return was achieved when 80 kg N/ha was applied at both seeding dates.

Table 5. Assumptions used in economic analysis.

	Indicative cash price ($/t)			EPR ($/t)	1000 seed weight (g)	Cost of Urea to achieve			
Varieties	Oat1	Oat2	Oat3			0 kg N/ha	20 kg N/ha	40 kg N/ha	80 kg N/ha
Bannister	350	330	120	2.30	35	0	23	46	92
Carrolup	350	330	120	0.00	35	0	23	46	92
WA02Q302-9*	350	330	120	2.30	37.5	0	23	46	92
Williams	350	330	120	2.30	35	0	23	46	92
Yallara	350	330	120	2.00	37.5	0	23	46	92

*estimated EPR

Oat receival + BAMA	$12.50	$/t	
Freight: farm to port	$24.50	$/t	farm to bin + bin to natural port
Seed cost	$400	$/t	
Germination per cent	97	%	
Operating costs	$160	$/ha	low rainfall - fuel, fertiliser, weed control, foliar fungicides
R&D levy	1.02	%	farm gate value

[1]cash price and EPR for WA02Q302-9 assumed to be same as Bannister and Williams

Table 6. The effect of applied nitrogen on return per hectare ($/ha) of five oat varieties when sown in early May and early June, averaged over all sites.

Seeding date	Early May					Early June				
Variety	Units N applied (kg/ha) 0	20	40	80	*Variety average*	Units N applied (kg/ha) 0	20	40	80	*Average*
Bannister	$639	$598	$612	$483	*$583*	$387	$313	$281	$192	*$293*
Carrolup	$504	$449	$468	$371	*$448*	$310	$302	$252	$183	*$262*
WA02Q302-9	$513	$562	$505	$454	*$509*	$387	$359	$350	$286	*$345*
Williams	$566	$563	$542	$456	*$532*	$353	$326	$274	$149	*$275*
Yallara	$467	$520	$452	$399	*$459*	$356	$295	$268	$175	*$274*
Average	*$538*	*$538*	*$516*	*$432*		*$358*	*$319*	*$285*	*$197*	

Conclusion

Screenings limited the ability of the grain to meet Oat1 specifications more than hectolitre weight at our trials in 2015. Screenings increased significantly when sowing was delayed, and when additional nitrogen was applied.

Bannister and Williams responded similarly to applied nitrogen. When grown for hay, applying nitrogen increased hay yield, but decreased its quality because stem thickness increased. When grown for grain, applying nitrogen increased screenings and decreased hectolitre weight. Screenings of Williams and Carrolup were more sensitive to applied nitrogen than WA02Q302-9, Bannister and Yallara.

All varieties exceeded the Oat1 minimum hectolitre weight receival limit of 51 kg/hL regardless of nitrogen rate or seeding date. Overall, the hectolitre weight and screenings of Bannister were better than Williams, making it a more suitable milling oat option than Williams for lower rainfall regions.

In a dry year the effect of applied nitrogen on grain yield is less; this was observed during 2015/16 where only one treatment at Cunderdin had a positive response to increasing nitrogen from 0 to 20 kg N/ha. In contrast, Troup *et al*. (2015) observed that during the 2014/15 season grain yield increased by 19% at Cunderdin and 17% at Holt Rock when nitrogen increased from 0-80 kg N/ha. Troup *et al*. (2015) also observed that applying nitrogen at up to 80 kg N/ha decreased the probability of meeting Oat1 quality standards for hectolitre weight and screenings. A similar observation was found in this study.

In this study return per hectare ($/ha) was maximised when up to 20 kg N/ha was applied on an early May sown crop, return per hectare ($/ha) declined as applied nitrogen increased, whilst in early June sown oats there was no positive response to increasing applied nitrogen on return per hectare ($/ha).

Key words

Oat, variety specific management, grain yield, grain quality, hay yield, hay quality

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