Myth busting the frost tolerance of oats.

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KEY MESSAGES

- Oats are not tolerant to frost – they will get frosted, albeit less than wheat or barley.
- Stem frost, pre-flowering frost, flowering frost, and grain filling frost damage were observed in this study corresponding to 47 days below 0°C.
- Species selection is more critical than variety selection when seizing an early sowing opportunity in a frost risk area with oats providing more frost tolerance than barley then wheat

Background

Oat production in Western Australia has increased rapidly in recent years. As the area sown to oats has expanded into inland areas the frequency of observed frost effects on oats has increased. In 2016, multiple frost events provided an opportunity to assess the effects of frost on cereal species including oats from an existing trial at Muresk. This trial initially aimed to evaluate which cereal– wheat, barley or oats, is a better option for seizing early sowing opportunities (Malik et al 2017).

Aim

The aim of this study was to evaluate frost sensitivity of barley, wheat and oat varieties in relation to sowing date.

Method

In 2016, one study at Muresk evaluated six wheat varieties, six barley varieties and six oat varieties that were sown in mid-April, early-May and late-May (Table 1). The varieties were selected on the basis of their maturity. The trial design was blocked by seeding date (TOS) and species, with variety randomised within each block. Wheat and barley were randomised within each seeding date (TOS) while the oats were separated for ease of crop management. The trial was sown in six banks, with two banks per replicate, three replicates per treatment.

Table 1. Varieties included in the study and their maturity.

Barley	Oat	Wheat
Compass (mid)	Bannister (mid to mid-long)	Cutlass (mid to long)
La Trobe (mid)	Carrolup (mid)	Mace (short to mid)
Flinders (long)	Durack (short)	Magenta (mid to long)
Granger (long)	Kojonup (mid to mid-long)	Trojan (mid)
Rosalind (mid)	Yallara (mid)	Wylah (Winter)
Urambie (very long)	Williams (mid)	Yitpi (mid to long)

All plots were given the same nutrition of basal fertiliser at seeding; 100kg/ha Summit GUSTO treated with Uniform (40ml/L) banded below the seed, and 250kg/ha of NPK Blue Special, supplying a total of 40kg N/ha, 25kg P/ha and 49kg K/ha. Additional nitrogen (N) was applied as 48L/ha of Flexi-N at 6WAS. Seed was sown into canola stubble and direct-drilled with a small plot air-seeder with on-row packing press wheels.

A growth stage that could be accurately determined was selected for each species (Z49-awn peep for barley, Z65-flowering for wheat and Z71-watery ripe for oat), and the date at which each plot reached that stage was recorded (data not presented in this paper). Tiny tag temperature loggers (TGP4017) were installed to record ambient canopy temperature within each species at each time of sowing.

Sterility was assessed by sampling 30 spikes per plot at random at maturity. Samples were frozen and later assessed by measuring yield potential per head; this was done by counting the number of florets that would have produced a grain if unaffected by frost. The percentage of sterility was determined by counting the number of florets that produced viable grain, and subtracting this from the yield potential. For oats, frost damage could be isolated into either a) pre-flowering (see photo), or b) flowering sterility, by visual inspection of the physical differences in florets. The ability of a species or variety to re-tiller and compensate for yield loss as a result of severe frost damage was not measured in this study. Evidence of compensation was observed but could not be accurately accounted for.

Stem frost damage was also observed in all three crop types but not assessed in these trials.

Grain yields (t/ha) were recorded at harvest and cleaned samples (sample >1.5 mm) were used to assess grain quality based on receival specifications. Only the grain yield is presented in this paper.

Data was analysed using ANOVA within Genstat (VSN International 2013) with a block structure of (rep+block)/colrep and a treatment structure of sowing date*species/variety for wheat and barley, and sowing date*variety for oats.

Due to the trial management requirement for the oat plots to be separated from the wheat and barley, grain yield of wheat and barley cannot be statistically compared to the oats. For this reason the results below have been split into 1) wheat and barley grain yield, 2) oat grain yield. In contrast, the sterility % of the three species can be statistically compared (Van Burgel pers. com.).

Site

The trial site was located at Muresk (Table 2), on a low-lying paddock alongside the Avon River. The trial was sown into sufficient moisture for germination at each of the three seeding dates; 15th April, 4th May and 30th May 2016. Temperatures were mild until early May when it cooled suddenly, and this was reflected in the observed time to emergence and early growth rate of the second and third sown treatments.

Table 2. Location, soil type, growing season rainfall (May-Oct), and soil test (0-10 cm) data.

Location	Seeding dates	May-Oct rainfall (mm)	Organic C (%)	pH_{Ca} (0-10cm)	Soil type
Muresk	15/4/16 4/5/16 30/5/16	284	0.70	5.5	Grey brown sandy duplex

Results

Barley and Wheat grain yield

Barley and wheat differed in their grain yield, barley out-yielded wheat at all seeding dates producing 3.3t/ha and 1.4t/ha respectively. This low wheat grain yield can be attributed to the effect of frost, with all treatments affected by multiple frost events during the growing season (Figure 1). When sown on 15th April, barley out-yielded wheat by 2.3t/ha, this yield advantage reduced as seeding date was delayed, with barley out-yielding wheat by 1.6t/ha when sown on 30th May.

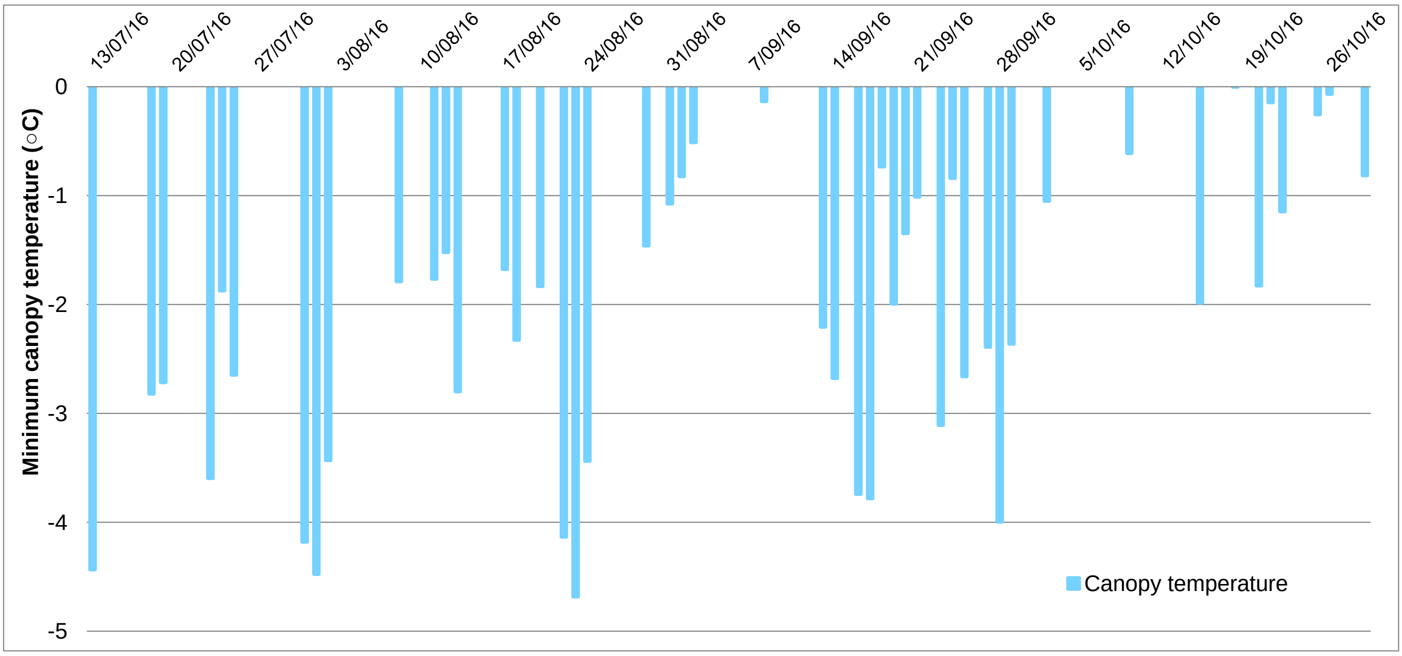

Figure 1. Muresk WA, 2016. Events when ambient temperature was below 0°C (unshielded T-type thermocouple at canopy height).

Oat grain yield

Mean oat grain yield in this study was 3.5t/ha. Mean grain yield ranged from 3.3t/ha when sown in mid-April to 3.7t/ha when sown in late-May. Variety selection had a greater impact on grain yield when sown early, than it did when sowing was delayed (Figure 2). Bannister, Kojonup and Williams out-yielded Carrolup Yallara and Durack when sown mid-April and early-May. Varieties differed in their grain yield, and their ranking was affected by seeding date.

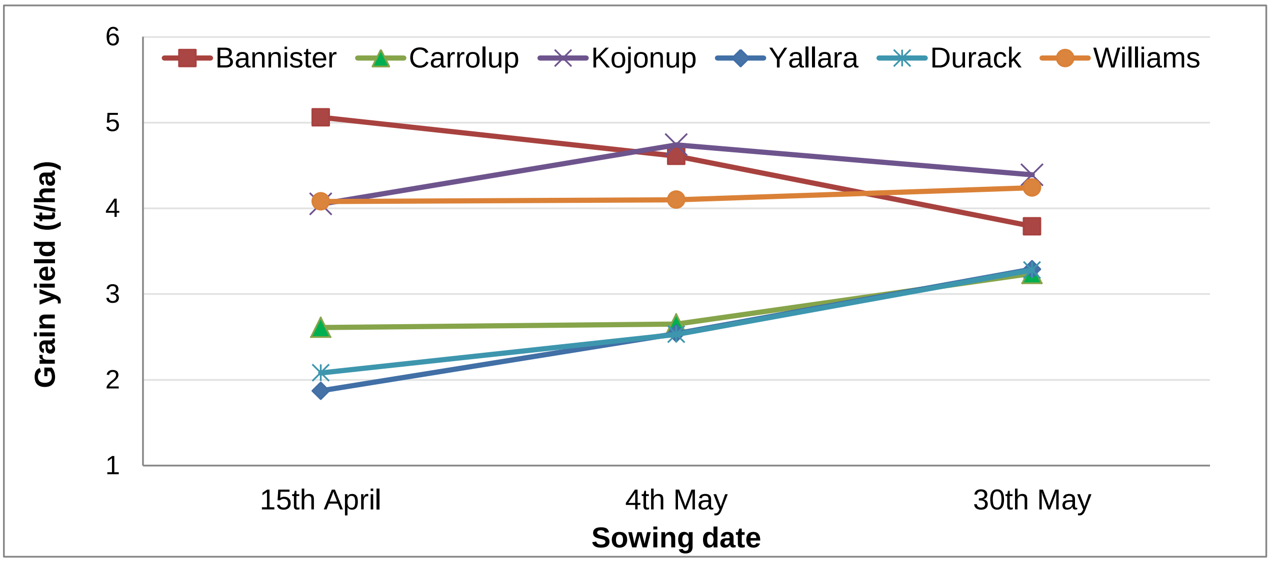

Figure 2. Mean grain yield of six oat varieties at three sowing dates; 15th April, 4th May, and 30th May 2016. Lsd (P = 0.05) = 0.55 t/ha when comparing means with the same seeding date.

Sterility

Wheat had a higher percentage (%) of sterile florets per head than barley or oat (Figure 3). Sterility of wheat and barley consistently reduced as sowing was delayed from mid-April to late-May (mean sterility ranged from 92% to 30% in wheat, and 44% to 7% in barley). Sterility of oats was more stable than wheat and barley, with mean sterility ranging from 17% when sown in mid-April to 13% when sown in late-May.

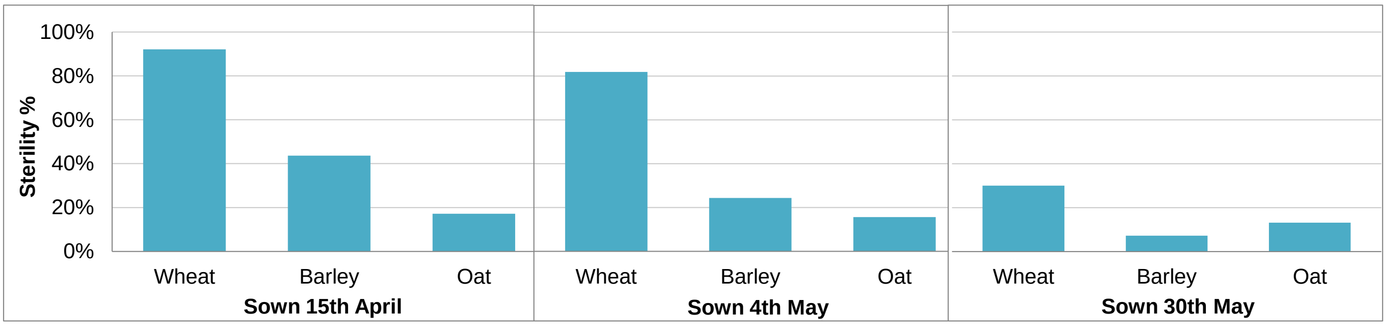

Figure 3. Total sterility (% sterile florets per head) of wheat, barley, and oats.

Oat varieties differed in their sterility, and the ranking of varieties was affected by sowing date (Figure 4). Mid-season variety Yallara had significantly higher sterility than the other varieties evaluated when sown in mid-April, with greater flowering frost damage driving this overall sterility increase. The sterility ranking of varieties does not correlate with their maturity, with multiple frost events attributing to the sterility recorded in this study. New short-season variety Durack had mid-range levels of sterility when compared to the other oat varieties in this study.

Delaying sowing of oats from 15th April until 4th May did not reduce flowering sterility, however delaying sowing until 30th May did reduce flowering sterility. This delay in sowing date reduced the variation in grain yield between varieties, and overall had no negative effect on mean oat grain yield.

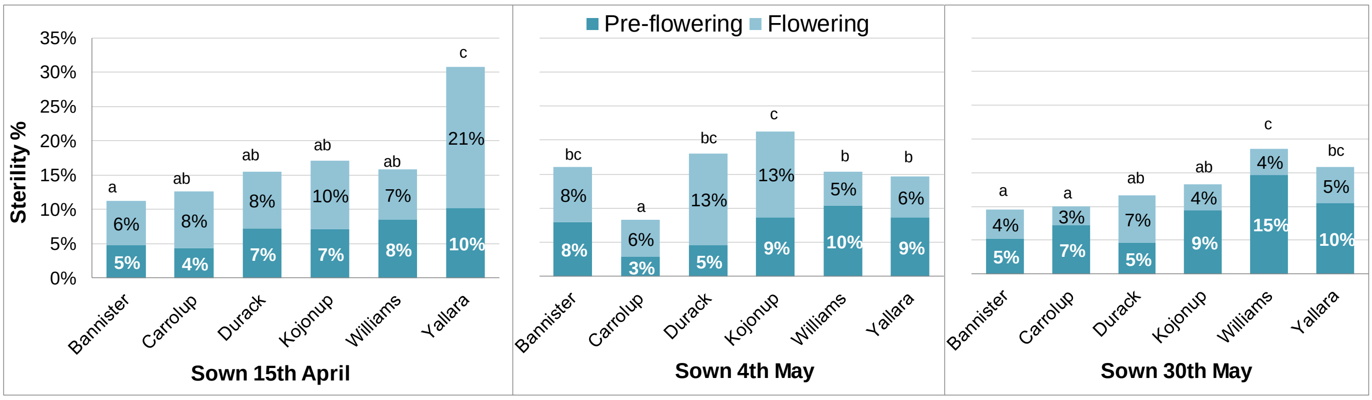

Figure 4. Total sterility (% sterile florets per head), pre-flowering sterility (%) and flowering sterility (%) of six oat varieties. Letters denote significance (P = 0.05).

Relationship between sterility and grain yield

A regression analysis to determine if a relationship existed between grain yield and sterility of each of the species identified that there was a) no relationship between oat grain yield and sterility (R^2 = 0.17), b) there was a slight relationship between barley grain yield and sterility (R^2 = 0.44), and c) there was a relationship between wheat grain yield and sterility (R^2 = 0.94).

The polynomial relationship that exists between the grain yield and sterility of wheat suggests that the plant is capable of compensating for gain yield loss from sterility due to frost events until this sterility exceeds 75%, once this threshold is exceeded the ability of the plant to compensate is compromised (Figure 5). This relationship was evident when grain yield from all sowing dates was interpreted, and will differ when sowing dates are considered individually.

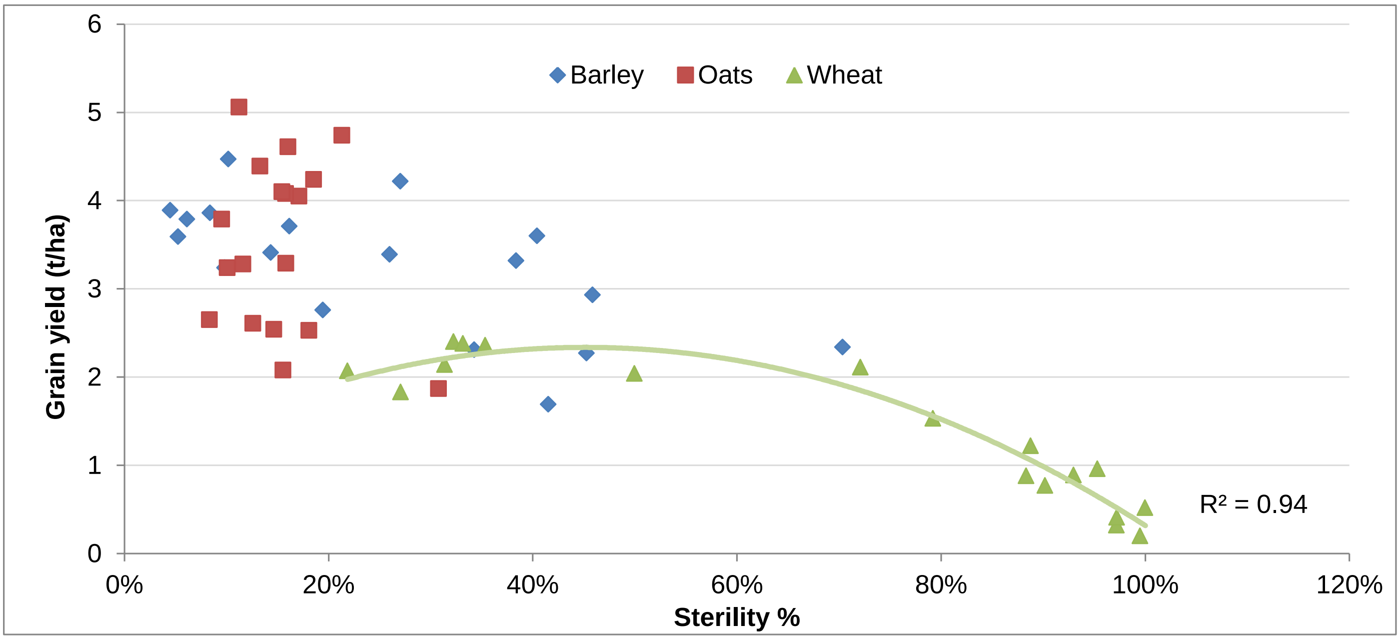

Figure 5. Relationship between total sterility (%) and grain yield (t/ha) of oat, wheat and barley.

Conclusion

The study determined that oats are susceptible to frost damage, albeit to a lesser extent than barley or wheat. Wheat is significantly more frost sensitive than barley (Biddulph et al. 2013). Species selection was more critical than variety selection when preparing to seize an early sowing opportunity in a high frost risk environment. Grain yield differences between the highest and lowest yielding varieties of wheat, barley and oats were greater when sown early than when sowing was delayed.

The high sterility (up to 100%) of some wheat varieties when sown early was attributed to the sensitivity of wheat during its flowering stage (Z65) compared to barley and oats. Consistent varietal differences in frost sensitivity of wheat and barley have been found in WA (Biddulph et al. 2013) supporting the observations in this trial. Sterility was not consistently related to grain yield in all species, this may be attributed to their differing ability to compensate for frost damage.

Evaluating sterility in oats required the development of an assessment protocol to determine the sterility percentage that occurred at pre-flowering, or flowering. Mid-season oat variety Yallara had significantly higher sterility than other varieties evaluated when sown mid-April, and its grain yield was lower than expected, this may be attributed to the variety's inability to compensate for the greater reduction in grain number by frost. This observation will require validation from further research to confirm the observations made in 2016.

Key words

Oat, wheat, barley, frost, sterility, grain yield.

References

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Variety specific agronomy requirements of recently released oat varieties; Durack, Bannister and Williams

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KEY MESSAGES

- Varieties differ in their yield, quality and response to changes in plant density.
- Bannister was the best performing variety in 2016 as it out-yielded the other varieties evaluated and met Oat1 quality standards at all sites. However, Bannister should be sown to achieve a higher plant density than Carrolup.
- Grain quality of newly released, short season variety Durack was not consistent with previous studies.
- Choosing to grow more than one variety will maximise the strengths, and mitigate the weaknesses of oat varieties.

Background

In 2016, the milling oat production in Western Australia increased by 81% from 2015 tonnages (GIWA February Crop Report), this increase in production was also coupled with a decline in the market price for milling grain, and a greater price differential between Oat1 and Oat2. Variety specific agronomy requirements and variability in market price for milling grain, emphasises the importance of research that supports growers to select the right variety and apply the right agronomy, in order to: build confidence, meet milling specifications, capture forward contract opportunities, and be a price maker rather than a price taker at harvest.

Strong uptake of high yielding varieties Williams and Bannister by growers, coupled with fluctuations in grain quality during recent seasons, and new research which identified that these varieties had an increased sensitivity to crop management has reduced grower confidence in their ability to meet milling oat market requirements (Troup et al 2015, and 2016). For example, Bannister appears to respond more to increased plant density than other varieties whilst Williams has been shown more likely to lodge under high N inputs, be more sensitive to dry Springs, and more likely to have higher screenings than other varieties. Clearly oat varieties differ in their sensitivity to management inputs and this directly influences their probability of being received as Oat1 or Oat2 in the bulk handling system. Subject to pricing, this sensitivity then affects their likely adoption. Durack, a new short season variety which will undergo commercial milling evaluation early in 2017, is expected to increase the likelihood of growers meeting milling specification due to its significantly higher hectolitre weight and lower screenings (Troup et al 2015 and 2016). Its performance in this trial series in 2016 provides a new perspective in comparison to previous trials, including the National Variety Trial program.

Aims

The aims of this study are to:

(1) compare the responses of four milling oat varieties to changes in nitrogen and seeding rates

(2) determine if there are significant variety x nitrogen x seeding rate interactions between oat varieties

(3) develop variety specific management guidelines for growers and industry on new oat varieties.

Method

In 2016, six sites were established to compare the performance of four milling oat varieties x four plant densities x three nitrogen rates. At the higher rainfall sites (Kojonup West, Pingelly and Muresk), varieties Bannister, Carrolup, Kojonup and Williams were sown. At the lower rainfall sites (Grass Patch, Varley and Merredin), varieties Bannister, Carrolup, Durack (previously tested as WA02Q302-9), and Yallara were sown. The seed rate (kg/ha) to establish the four target plant densities of 80, 160, 240 and 320 plants/m^2 varied for each variety and was adjusted based on their grain weight and germination percentage. A seed rate of 80 plants/m^2 = 27 to 36kg/ha, 160 plants/m^2 = 57 to 76kg/ha, 240 plants/m^2 = 98 to 129kg/ha, 320 plants/m^2= 130 to 173kg/ha was used. Plant establishment was determined at 4 weeks after seeding (WAS) by counting the number of plants in 2 rows x 1m x 2 locations per plot. The three nitrogen (N) rates differed based on rainfall zone: in the lower rainfall environment 10, 30 and 60kg N/ha was applied; while in the higher rainfall environment 30, 60 and 90kg N/ha was applied.

Trials were sown as a split plot cyclic design with variety and nitrogen as whole plots and density randomised as subplots within a variety + nitrogen combination. Seed was sown into canola stubble and direct-drilled with a small plot air-seeder with on-row packing press wheels. Basal fertiliser comprised of Summit GUSTO compound fertiliser which was treated with Uniform (40ml/L) and banded below the seed at 100kg/ha, supplying a total of 10kg N/ha, 12kg P/ha and 14kg K/ha.

Grain yields (t/ha) were recorded at harvest and cleaned samples (sample >1.5 mm) were used to assess grain quality based on GIWA Oat receival specifications. Only the grain yield, hectolitre weight and screenings data are presented in this paper. Data was analysed within Genstat (VSN International 2013) with a block structure of (rep+colrep)/(Nitrogen applied + Variety and a treatment structure of nitrogen applied x variety x plant density).

Results

Site and variety

Growing season rainfall (May-October) ranged from 421mm at Kojonup West) to 172mm at Varley (Table 1). The site mean grain yield ranged from 3.03t/ha (Grass Patch) to 4.27t/ha (Kojonup West). Grain quality was generally within the Oat1 limits (hectolitre weight ≥51kg/hL and screenings ≤10%) with a few exceptions. At Pingelly and Kojonup West, group B resistant ryegrass was uniformly distributed across the trial area.

Table 1. Location, soil attributes, growing season rainfall, seeding dates and site mean yields for the six trials.

Site No.	Location	Organic C (%)	SYN* (kg N/ha)	pH $CaCl_2$ (0-10cm)	Soil type	May-Oct rainfall (mm)	Seeding date	Site mean yield (t/ha)
16ES24	Grass Patch	0.83	54	5.8	Brown-grey loam	229	17-May-16	3.03
16KA07	Kojonup West	4.2	205	5.3	Brown deep sandy duplex	421	16-May-16	4.27
16ME09	Merredin	0.86	56	5.0	Brown sandy duplex	225	4-May-16	4.09
16NO04	Muresk	0.67	44	5.5	Grey brown sandy duplex	284	28-April-16	4.09
16NO05	Pingelly	2.21	132	5.3	Grey brown sandy duplex	283	6-May-16	4.23
16KA06	Varley	1.16	74	4.7	Dark yellow loamy gravel	172	27-April-16	3.11

*SYN – estimate of N available in the paddock

Table 2. Analysis of variance for main effects (variety, density and seeding date) and their interactions at six trial sites. Significance: *** = p<0.001, ** = p<0.01, * = p<0.05 and n.s. = not significant.

	Grain yield					
	Muresk	Pingelly	Kojonup West	Varley	Grass Patch	Merredin
Variety (V)	***	n.s.	***	***	***	***
Plant density (D)	***	n.s.	***	***	***	**
Applied N (N)	*	n.s.	n.s.	***	***	***
V x D	n.s.	*	***	***	***	n.s.
V x N	n.s.	n.s.	n.s.	***	n.s.	n.s.
N x D	n.s.	n.s.	*	n.s.	n.s.	n.s.
V x N x D	n.s.	n.s.	**	n.s.	*	n.s.

	Hectolitre weight (kg/hL)						Screenings (% < 2.0 mm)					
	Muresk	Pingelly	Kojonup West	Varley	Grass Patch	Merredin	Muresk	Pingelly	Kojonup West	Varley	Grass Patch	Merredin
V	***	***	***	***	***	***	***	***	***	***	**	***
D	***	**	n.s.	n.s.	**	n.s.	***	***	***	n.s.	***	n.s.
N	***	***	n.s.	n.s.	n.s.	***	***	**	n.s.	n.s.	n.s.	**
V x D	n.s.	n.s.	n.s.	*	***	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.	n.s.	n.s.	n.s.	n.s.	n.s.	*
N x D	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.	**	n.s.
V x N x D	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Grain yield

Bannister was the highest yielding variety overall, out-yielding Carrolup by 1.1t/ha averaged across six sites and out-yielding Williams by 0.23t/ha where they were sown together at the higher rainfall sites. For the three high rainfall sites (Kojonup West, Muresk and Pingelly), average yields relative to the site mean were: Bannister +0.44t/ha, Carrolup -0.60t/ha, Kojonup -0.06t/ha, and Williams +0.21t/ha (Figure 1a). For the three lower rainfall sites (Grass Patch, Varley and Merredin), average yields relative to the site mean were: Bannister +0.95t/ha, Carrolup -0.14t/ha, Durack -0.68t/ha, and Yallara -0.12t/ha (Figure 1b).

Plant density influenced grain yield at all sites except Pingelly where group B resistant ryegrass was uniformly distributed across the trial area. The relationship between grain yield and plant density at Grass Patch, Kojonup West, Merredin and Varley supports the current recommended plant density of 160 plants/m² for the lower rainfall area and 240 plants/m² for the higher rainfall area (Figure 2a). However, the grain yield of Bannister was maximised at a higher density than for Carrolup, Durack, and Yallara at Grass Patch and Varley with a similar trend observed at Kojonup West (Figure 2b). This supports previous research (Troup et al 2016) suggesting Bannister should be sown to achieve a higher target density than those varieties. At Muresk, grain yield was optimised between 80 and 160 plants/m², lower than the current recommended target density of 240 plants/m² (Figure 2a).

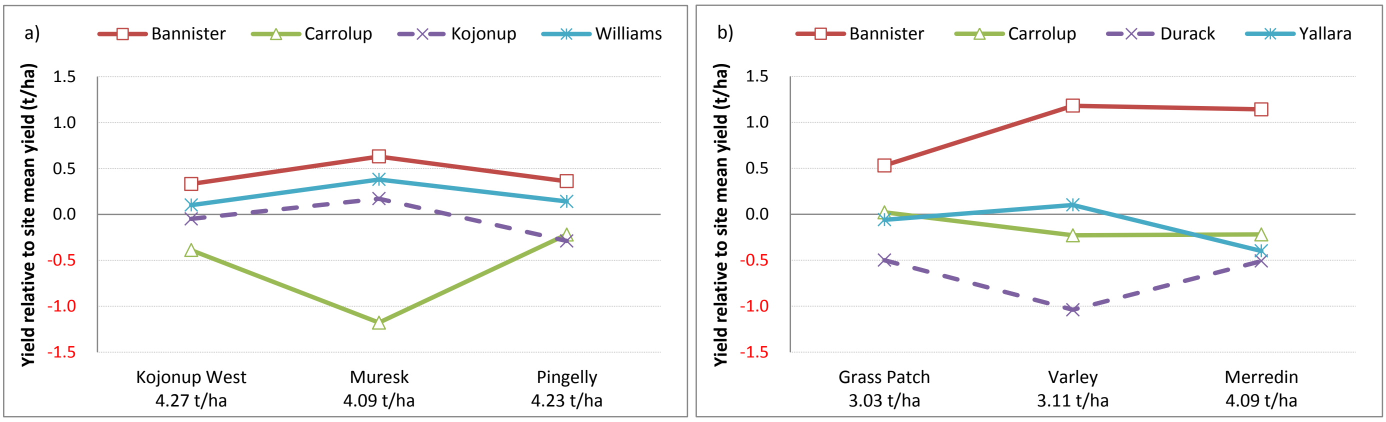

Figure 1. Yield of four oat varieties at six sites relative to the site mean yield. a) at the three high rainfall sites Kojonup West, Muresk and Pingelly b) at the three lower rainfall sites Grass Patch, Varley and Merredin.

Applied nitrogen (N) fertiliser influenced grain yield at all sites except Pingelly and Kojonup West, both of which had high background levels of nitrogen in the soil (Table 1). Grain yield responded similarly to increasing applied N at Merredin, Varley and Grass Patch, increasing grain yield by 20% when applied N increased from 10 to 60kg N/ha. Grain yield decreased when N increased from 60 to 90kg N/ha at Muresk. At most sites there was no interaction between variety and N; however, at Varley, Durack was not responsive to increasing applied N, whereas the grain yield of Bannister, Carrolup and Yallara increased out to 60kg N/ha.

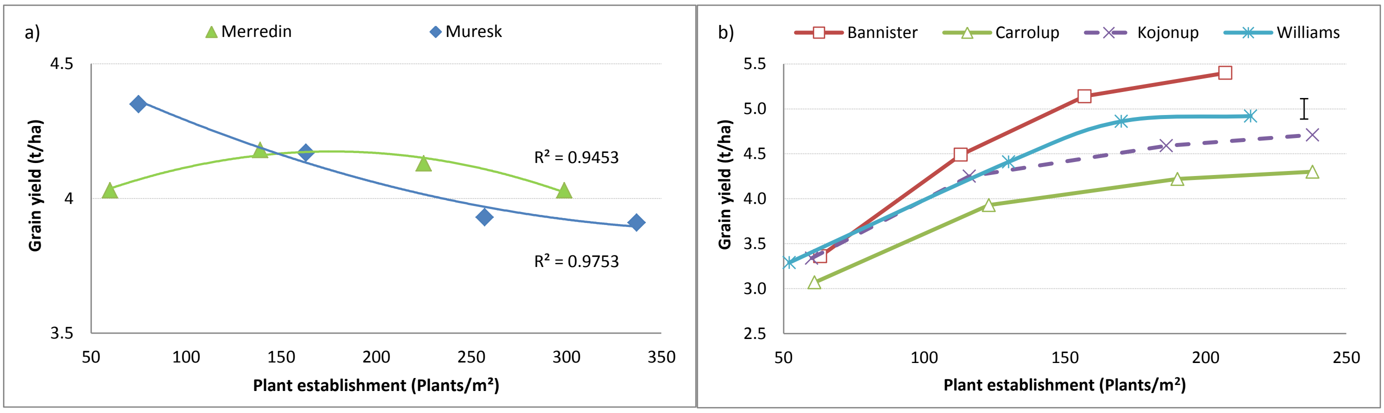

Figure 2. a) Mean grain yield (t/ha) response to changes in plant density (plants/m²) at Merredin, Lsd (P = 0.05) = 0.09t/ha, and Muresk, Lsd (P = 0.05) = 0.24t/ha, and b) Mean grain yield (t/ha) response of four oat varieties to changes in plant density (plants/m²) at Kojonup West in 2016. Vertical bar indicates Lsd at P = 0.05.

Hectolitre weight

All varieties met the Oat1 minimum hectolitre weight of 51kg/hL when averaged across sites. Nevertheless there were some notable trends. Carrolup and Bannister had higher hectolitre weight than Durack and Yallara when averaged across the three lower rainfall sites. Carrolup had higher hectolitre weight than Bannister, Williams and Kojonup when averaged across the three higher rainfall sites (Table 3).

Applied nitrogen (N) influenced hectolitre weight at Muresk, Merredin and Pingelly, increasing applied N decreased hectolitre weight (Figure 3a). At Kojonup West, Varley and Grass Patch increasing applied N had no significant effect on hectolitre weight. Varieties responded similarly to increasing applied N, and there were no interactions between applied N and plant density.

Plant density influenced hectolitre weight at Muresk, Grass Patch and Pingelly. However, the response to increasing plant density on hectolitre weight was inconsistent. At Muresk, increasing plant density from 160 to 240 plants/m² reduced hectolitre weight by 0.72kg/hL; at Grass Patch, increasing plant density from 80 to 240 plants/m² increased hectolitre weight by 0.5kg/hL; and at Pingelly increasing plant density had a slightly negative effect on hectolitre weight.

Table 3. Varietal differences in hectolitre weight (kg/hL) and screenings (% <2.0mm) averaged across 2016 trial sites.

Variety	Hectolitre weight (kg/hL)	Screenings (%<2.0mm)	Oat receival grade
Averaged across trial sites located at Merredin, Varley and Grass Patch			
Bannister	60.8	1.8	1
Carrolup	61.0	2.0	1
Durack	58.1	2.1	1
Yallara	59.4	2.5	1
Lsd (p=0.05)	*1.16*	*0.3*	
Averaged across trial sites located at Muresk, Pingelly and Kojonup West			
Bannister	57.4	5.4	1
Carrolup	59.1	7.3	1
Kojonup	56.6	3.5	1
Williams	56.9	11.5	2
Lsd (p=0.05)	0.7	1.8	

Varieties differed in their response to plant density at Grass Patch, and Varley (Figure 3b). Hectolitre weight of newly released short season variety Durack plummeted as plant density increased at Varley. Frost damage was observed in this trial, and at the neighbouring barley trial. Durack was exposed to more frost events than other varieties while flowering and during early grain filling. The rapid decrease in hectolitre weight may be due to the effect of increasing plant density on the growth stage of the plot; as plant density increases so does plant growth stage synchronicity resulting in more florets being at a critical growth stage when a frost event occurs (Paynter pers. comm.).

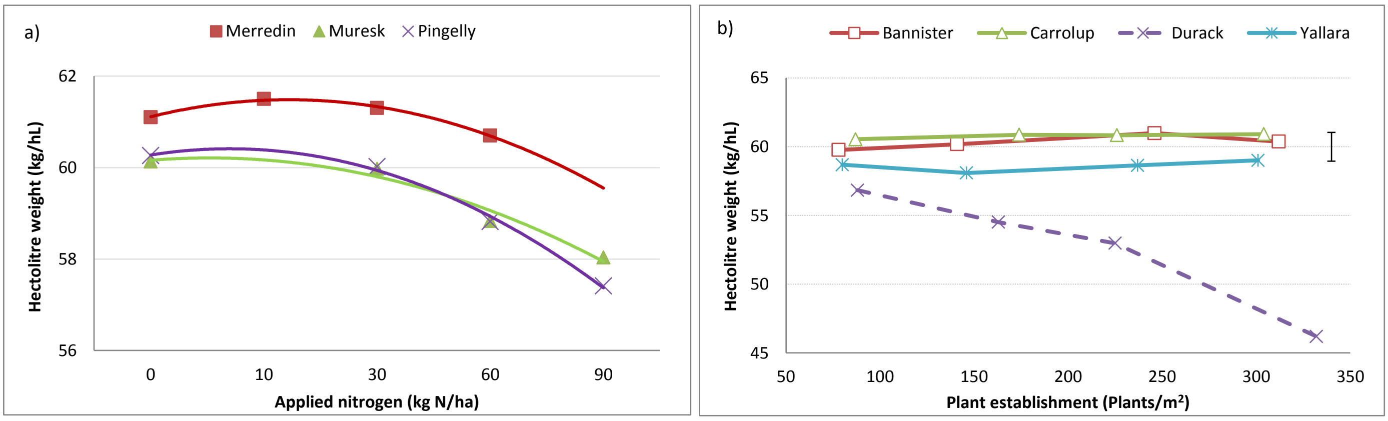

Figure 3. Average hectolitre weight (kg/hL) response a) to applied N at Merredin, Lsd (P = 0.05) = 0.28kg/hL, Muresk, Lsd (P = 0.05) = 0.57kg/hL, and Pingelly, Lsd (P = 0.05) = 0.81kg/hL, and b) of four oat varieties to increasing plant density at Varley. Vertical bar indicates Lsd at P = 0.05.

Screenings

Variety influenced screenings more than plant density or applied nitrogen. Williams had the highest screenings: it was the only variety that exceeded the Oat1 maximum screenings limit of 10% when averaged across sites (Table 3), and at Pingelly it exceeded the limit in all treatments (Figure 4).

Increasing applied N consistently increasing screenings at all sites. Varieties did not differ in their response to applied N, except at Merredin where Bannister and Yallara were more sensitive to increasing applied N than Carrolup and Durack.

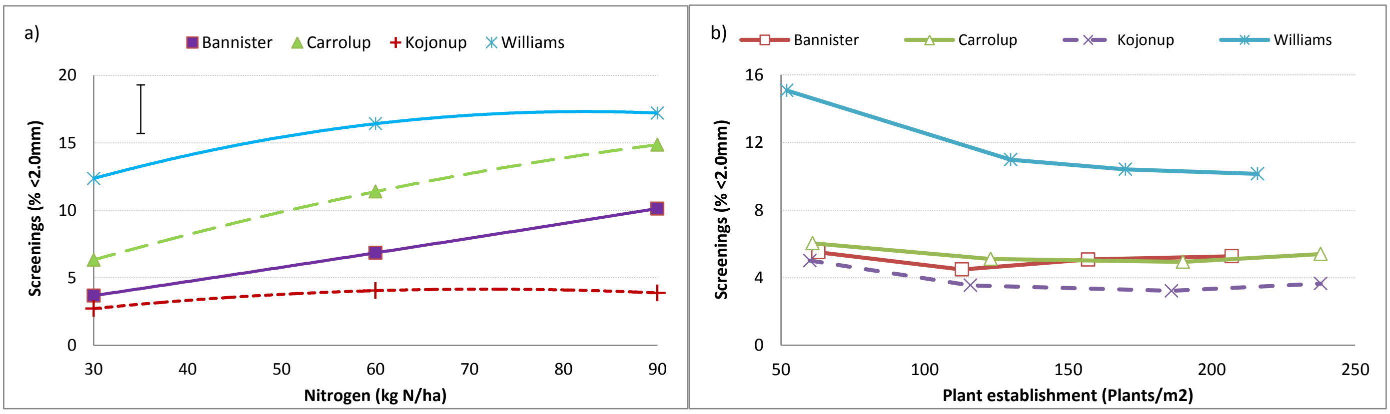

Figure 4. a) Screenings response of four oat varieties to increasing applied nitrogen at Pingelly. Vertical bar indicates Lsd at P = 0.05. b) Screenings response of four oat varieties to increasing plant density at Kojonup West. Lsd (P = 0.05) = 1.11%.

Increasing plant density from 80 to 320 plants/m² increased screenings at Pingelly and Muresk by 1.8% and 1.9% respectively, while at Grass Patch increasing plant density decreased screenings by 0.9%. The ranking of varieties was influenced by plant density at Grass Patch and by the application of nitrogen at Merredin (Table 2).

Varieties differed in their response to plant density at Kojonup West, where screenings of Williams and Kojonup were more sensitive to increasing plant density from 80 to 160 plants/m² than Bannister or Carrolup (Figure 4b).

Conclusion

Bannister was the best performing variety in this study, it consistently out-yielded other varieties evaluated, and met Oat1 quality standards at all sites. Bannister continued to respond to a higher plant density than the current recommended density at 50% of sites, supporting previous research suggesting Bannister should be sown to achieve a higher plant density than Carrolup, Yallara or Durack in these environments (Troup et al 2016). The ability to sow at higher density may assist in alleviating the challenges associated with limited weed control options available in oat crops.

The performance of Bannister in the lower rainfall environment in 2014 and 2015 (Troup et al 2015 and 2016) has led to an increased adoption of this variety in the central and eastern wheatbelt. Its performance in this study supports the increased adoption of Bannister, encroaching on the area sown to previous benchmark variety Carrolup. Bannister has been observed to have issues with grain staining in the higher rainfall environment (Knell pers. comm. 2015) where oat-on-oat rotations are more commonplace increasing the disease pressure on the crop, and where pre-harvest rainfall is more likely. Due to these observations, the increased adoption of Bannister in the higher rainfall environments is to be coupled with a risk mitigation strategy of: a) growing Bannister in low Septoria risk situations and, b) having two oat varieties in the rotation to combat the weaknesses that individual variety can exhibit, with the second variety to have improved disease resistance e.g. Williams.

The grain quality advantages that Durack exhibited in previous seasons was not observed in this study. Durack's short season maturity coupled with an early-May sowing date led to undeliverable grain due to very low hectolitre weight in high applied N and in high density treatments at the frost affected Varley site. Durack's hectolitre weight exhibited greater sensitivity to increasing plant density at Varley than other varieties evaluated (5.5kg/hL lower than the site mean hectolitre weight). This indicates growers should be careful not to sow Durack too early in their sowing program if they are hoping to use it to 'shandy' up other grain for delivery.

Williams tendency to produce narrower grains than other varieties led to it exceeding the Oat1 screenings limit of 10% <2.0mm. This trait of Williams has been consistent during 2014, 2015 and 2016 oat agronomy trials (Troup et al 2015 and 2016). A conservative approach to applied N will improve the probability of meeting the Oat1 grade with Williams as its screenings % will reduce and its hectolitre weight will improve. This response is consistent across all varieties as Williams did not exhibit greater sensitivity to applied N or plant density than the other varieties evaluated.

Carrolup had higher hectolitre weight than Bannister, Williams and Kojonup when averaged across all higher rainfall sites (Muresk, Pingelly, Kojonup West), and it had higher hectolitre weight than Durack and Yallara when averaged across all lower rainfall sites, in contrast to its performance in 2015 (Troup et al 2016) where it was the poorest performing variety in the study. Perhaps this different response between seasons was due to the cool Spring which allowed varieties to express their differences.

Key words

Oat, variety specific management, grain yield, grain quality

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