Beer is better than bread and porridge; evaluating wheat, barley and oats for early sowing in frost-prone landscapes in Lake Grace-Kulin, Western Australia in 2017-2018

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Key messages

- With a mid-April sowing, Bannister oats achieved a higher grain yield and gross income than wheat and barley in 2017 and was the highest yielding and gross income treatment of all sowing windows in 2018.
- With a late-May sowing, Bass barley achieved a higher grain yield and produced the highest gross income in frost-prone landscapes in 2017 and 2018.
- Sowing short-season wheat and barley varieties in April and early May resulted in grain being either downgraded to feed in and general-purpose milling in 2017 or having no commercial value at all in 2018.
- Wheat was not suitable for sowing in frost-prone landscapes relative to oats or barley but, of the wheat varieties evaluated, Cutlass sown in late-May and Scepter in early-June generated the highest gross incomes and met premium grain delivery specifications.

Aims

To compare the relative suitability of wheat, barley and oats when sown in mid-April, early-May and late-May in a frost-prone landscape.

Method

The trials reported here examined the relative suitability of long-, mid- and short-season wheat, barley and oat cultivars to early sowing in frost-prone landscapes in Western Australia at sites between Lake Grace and Kulin in 2017 and 2018. Each season (2017 and 2018) comprised three sowing windows (‘early’, ‘mid’ and ‘late’) each with six wheat varieties, three barley varieties and three oat varieties of differing maturities. The varieties were chosen based on their agronomic fit in Western Australia, but as maturity types were not replicated with multiple varieties, inferences about maturity groups within each crop type are confounded by the performance of that particular variety. The three sowing windows were established in mid-April, early-May and late-May in 2017 and in mid-April, late-May and early-June in 2018.

Each sowing window was treated as a different trial. Crop types were blocked and crop varieties randomised within replicates in a spilt-plot trial design with crop type as the main plot and crop variety as the sub-plot. The trials were sown in a frost-prone valley floor on a frost-prone soil type (non wetting sandy duplex) with even elevation and no cross slope across the trial area. To ensure consistent frost across the trial, wheat buffer plots were sown around the exterior of the trial to minimise soil heat bank accumulation and limit cold air drainage off the plots. To minimise neighbour effects of crop types and manage spray drift from post-emergent herbicide treatments, internal buffers were sown between each crop type. Plots were also sown close together to minimise the ‘same effect’ common with an inter-plot gap.

To monitor the impact of crop canopy on frost severity and duration, unshielded air temperature was measured at canopy height (600mm). Temperature was logged every 15 minutes between early stem elongation (Z31) and crop maturity (Z87) in La Trobe barley, Scepter wheat and Bannister oats across three replicates in each sowing window. Tiny Tag Plus 2 (TGP-4017) loggers with internal temperature probes were used.

Seedling establishment counts were done 10-14 days after sowing. Zadok scores were assessed weekly from ~Z45 to Z70 to estimate flowering date of barley and oats (Z49), heading date (Z55) all crops and flowering date of wheat (Z65). Frost damage was estimated via floret sterility samples taken at Z80-83.

Harvest maturity cuts were taken at Z90. Floret sterility was assessed within 30 heads using the outside florets only and excluding the terminal and basal spikelets and supernumerary spikelets. Floret sterility was defined as the proportion (%) of total florets assessed showing up as frost-induced sterile florets. Maturity cuts were processed to obtain maturity biomass, number of viable heads, grain yield and harvest index. Grain was threshed and assessed for screenings, grain size (1000-grain weight). Each individual plot was trimmed at maturity to 8m by 1.8m and harvested with a small-plot research header. Grain harvested from each plot was weighed and a 1kg grain sample retained for grain quality analysis to estimate delivery grades.

Table 1 Cultivar list for the sowing window by crop-type trial at Lake Grace 2017 and Kulin 2018, Western Australia.

Maturity type	**Wheat***	**Barley***	**Oats***
Early	Emu Rock	La Trobe	Durack
Mid	Scepter		Kowari
Mid-long	LRPB Trojan	Bass	Bannister
Long (mild Photoperiod	Cutlass		
Long (strong Photoperiod)	Forrest		
Winter	Kittyhawk in 2017 EGA Wedgetail in 2018	Urambie	

***All cultivars used are covered by Plant Breeders Rights**

Crop and sowing details

Table 2 Agronomic information for the sowing window by crop-type trial at Lake Grace 2017 and Kulin 2018, Western Australia.

Year		**2017**			**2018**		
		Mid-April	Early-May	Late-May	Mid-April	Late-May	Early-June
Date sown		13/04/2017	04/05/2017	24/05/2017	16/4/2018 (irrigated~20 mm)	7/5/2018 (dry sown)	6/6/2018
Germination date		13/04/2017	4/05/2017	24/05/2017	16/4/2018	22/5/2018	6/6/2018
Variety		As per treatment list (see Table 1)					
Target plant density		120 plants/m^2					
Row spacing		22cm					
Nutrition	**Pre-seeding**	50kg/ha MOP and 80kg/ha Urea top-dressed and incorporated by sowing 80kg/ha DAP Star Extra (N:19, P:13, S:9.5, Cu:0.1, Zn:0.19)			80kg/ha Urea top-dressed and incorporated by sowing 80kg/ha K-Till Plus Mn (N:10.3, P:13.6, K:8.2, S:5.7, Cu:0.08, Zn:0.17, Mn:0.8)		
Herbicide	**Knockdown (whole site)**	1.5L/ha glyphosate			1.5L/ha glyphosate		
	Pre-seeding	1L/ha trifluralin (480g/L trifluralin) 500ml/ha Dual Gold (960g/L S-Metolachlor) 500g/ha diuron (900g/kg diuron)			1L/ha trifluralin (480g/L trifluralin) 500ml/ha Dual Gold (960g/L S-Metolachlor) 500g/ha diuron (900g/kg diuron)		
Insecticide	**Pre-seeding**	200ml/ha chlorpyrifos 200ml/ha alpha-cypermethrin 100			200ml/ha chlorpyrifos 200ml/ha alpha-cypermethrin 100		
Seed treatment		Gaucho (240ml/kg seed) Vibrance (360ml/kg seed)			Gaucho (240ml/kg seed) Vibrance (360ml/kg seed)		
Fungicide	**Pre-seeding**	200ml/ha flutriafol 500 (on fertiliser)					
	Post-seeding (23/8/17 – whole trial)	500ml/ha Opera (85g/L pyraclostrobin + 62.5g/L epoxiconazole) 250ml/ha Tilt (250g/L propiconazole)			Not required due to low disease pressure		

Results

Seasonal conditions

Situated between Kulin and Lake Grace, the trial site in 2017 was very wet with an early break and wet spring (July-Oct 170mm) and a total growing season rainfall (GSR) of 360mm. Several moderate frosts occurred in late September and early October. In 2017 all sowing dates established well without irrigation, however early sowing dates had slightly lower establishment numbers than the mid- and late-sowing dates (100 vs 120 and 120 plants/m^2). In comparison, the 2018 season delivered below average rainfall (total GSR 270-290mm) and a false break. The mid-April sowing was irrigated with ~20mm pre-sowing and established

well (100 plants/m2). In 2018 the Late-May sowing window was dry-sown in early May but did not establish until rain fell in late-May (120 plants/m^2) (Table 2). As a result there was no early May sowing window in 2018. The final 2018 sowing was planted in early-June and established well (120 plants/m^2).

Mid-April sowing 2017 and 2018

Over both years the crop with the highest grain yield and associated gross incomes in the mid-April sowing window was Bannister oats at $598/ha in 2017 and $1065/ha in 2018 followed by La Trobe barley at $520/ha in 2017 and Kowari oats at $849/ha in 2018. La Trobe performed poorly in 2018 due to severe grain-frost damage (data not shown). In 2017 the barley and oats suffered less frost damage than wheat with <30% floret sterility compared to >40% for the wheat varieties (data not shown). All wheat varieties from short- through to long- and winter-varieties suffered frost damage and high floret sterility from widespread frosts throughout the flowering and grain-fill windows in both seasons (Figure 1a and 2a). This frost damage translated into low gross incomes due to low grain yields of poor quality (Table 4). The frost damage was so severe in 2018 that Emu Rock, LRPB Trojan, Scepter and Cutlass did not produce grain of export value due to very low hectolitre weights (<40kg/hL; Table 3). In the mid-April sowing window Forrest achieved the highest gross income of the wheats in 2017 of $284/ha and $297 in 2018, but this was still less than half the highest gross income generated by the oats and barley (Figure 1a and 2a). In 2017 and 2018 a mid-April sowing of the longer-season Bannister oats achieved the highest gross income. In contrast, the short-season barley and even the long-season and winter wheats were not suited to a mid-April sowing relative to oats and barley.

Early-May sowing 2017

The early-May sowing in 2017 saw the short- and mid-season barley varieties achieve the highest gross incomes with La Trobe generating $629/ha and Bass $624/ha (Figure 1b). Despite sustaining 20-30% floret sterility in this sowing window, spring rains enabled good grain-fill which resulted in La Trobe and Bass achieving reasonable yield, quality and gross income (Table 4). The least profitable treatment within the early-May window was Scepter wheat with a gross income of $214/ha. This was a direct result of head and flowering frost damage as Scepter was at mid-flowering (Z65) when frosted and suffered head frost of ~1/5 affected spikes and floret sterility of 20% (data not shown). Forrest wheat was the best performing wheat in this sowing window with a gross income of $512/ha, but this was still ~$50-100/ha behind the gross incomes of Bannister oats and the barley varieties. There was no sowing window establish in early May in 2018 as it was too dry to germinate.

Late-May sowing 2017 and 2018

In both seasons, the most profitable treatment was Bass barley in the late-May sowing window with a gross income of $971 (2017) and 813/ha (2018) (Figure 1c and 2c). While Bass yielded similar to La Trobe in both years it achieved MALT1 classification, while La Trobe received a feed classification due to low protein and hectolitre weight and a lower gross income. In 2017, the late-May sowing window generated gross incomes competitive across most treatments, with Cutlass the best wheat at $713/ha and $521/ha in 2018 (Table 4). In 2018, however, the late-May sowing window experienced low grain yields in all wheat varieties. This was primarily due to poor weed control due to the dry sowing in early-May and low effectiveness of both the pre-emergent herbicides when the crop finally germinated in late-May and the lack of post-emergent herbicide options after the break of the season on 20-22 May. Poor weed control is a well-known risk associated with dry sowing and affected the wheat more than the barley and oats, presumably due to greater early vigour and better weed competitiveness compared to wheat.

Early-June sowing 2018

In 2018, the early-June sowing of La Trobe barley yielded the most and achieved Malt1 and the highest gross income of $782/ha, followed by Bass barley ($710/ha) and Bannister oats ($637/ha; Figure 2c). Of all the wheat varieties, Scepter wheat delivered the highest yield and gross income of $604/ha in this sowing window (Figure 2c).

Phenology, grain yield and gross income

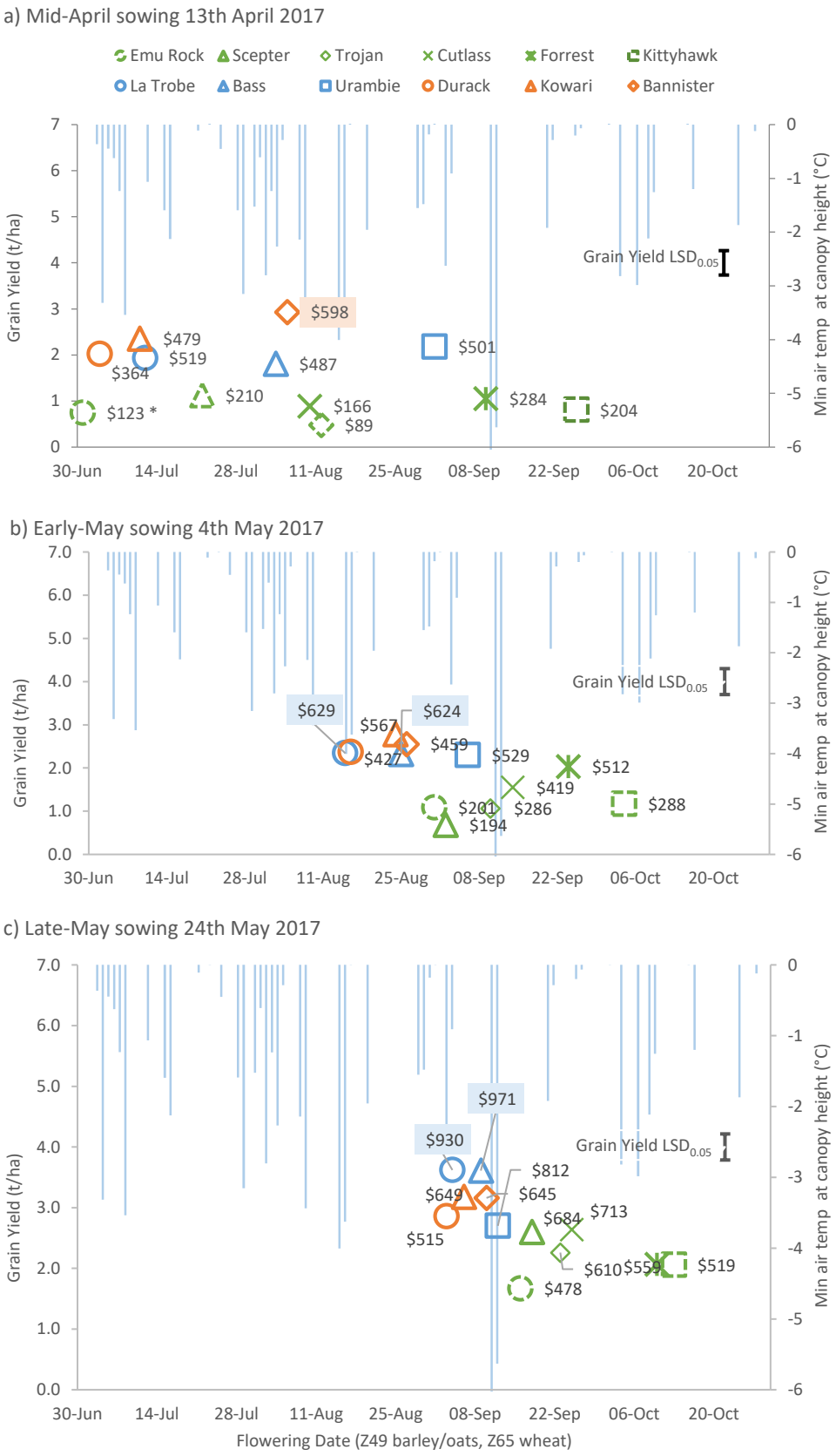
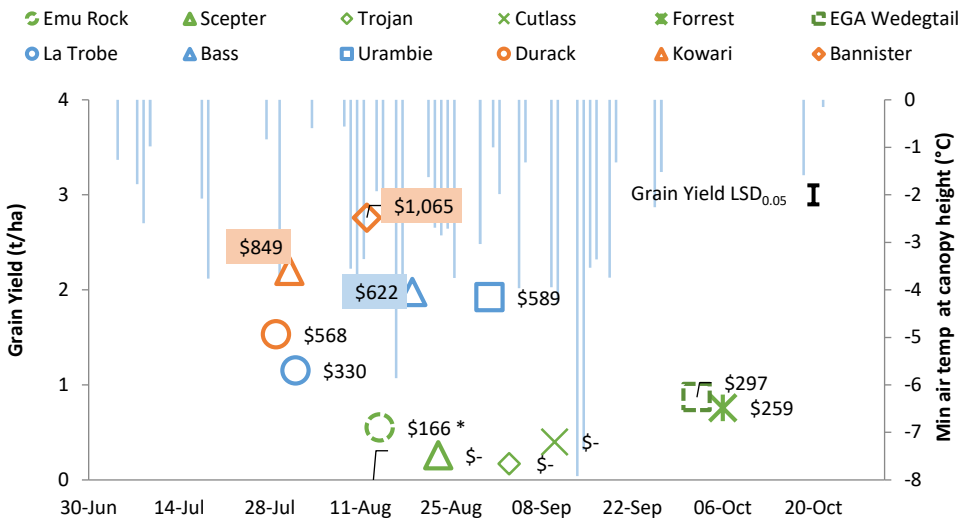
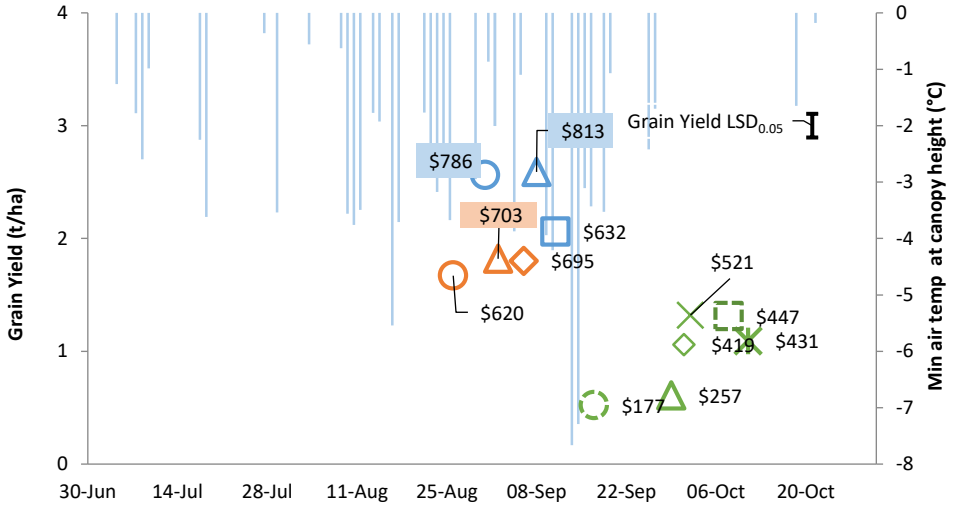


Figure 1 Lake Grace 2017, interaction of flowering date, grain yield and gross income of barley, oats and wheat varieties when sown in (a) mid-April, (b) early-May and (c) late-May with July-October frost minimum temperatures (shown as blue bars; unshielded Tiny-Tag TGP-4017). Grain yield and flowering dates are the predicted means, n=3, $LSD_{0.05}$ for grain yield comparisons within crop type. For gross income assumptions refer to Table 3.

a) Mid-April sowing 16th April 2018



b) Late-May 22nd May 2018



c) Early-June sowing 6th June 2018

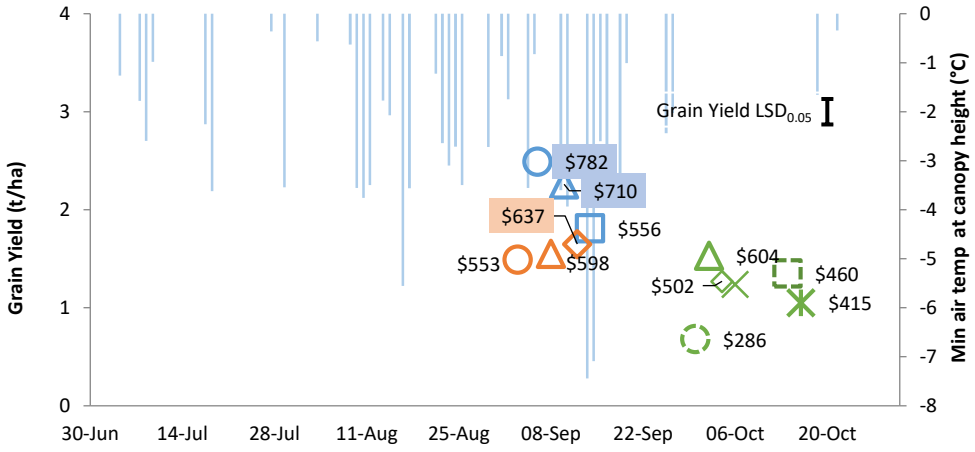


Figure 2 Kulin 2018, interaction of flowering date, grain yield and gross income of barley, oats and wheat varieties when sown in (a) mid-April, (b) late-May and (c) early-June with July-October frost minimum temperatures (shown as blue bars; unshielded Tiny-Tag TGP-4017). Grain yield and flowering dates are the predicted means, n=3, $LSD_{0.05}$ for grain yield comparisons within crop type. For gross income assumptions refer to Table 4.

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Economic Analysis

Table 3 Gross income analysis of mid-April and early- and late-May sowing windows at Lake Grace, Western Australia, 2017.

Mid-April (13 April 2017)		Potential classification	Down grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	Low hectolitre	Seconds*	0.74	166	123
	Scepter	AH	Low hectolitre	FED1	1.13	186	210
	LRPB Trojan	APW	Low hectolitre	FED1	0.48	186	89
	Cutlass	APW	Low hectolitre	FED1	0.89	186	166
	Forrest	APW	-	APW1	1.05	270	284
	Kittyhawk	ASW	-	ASW1	0.81	252	204
Barley	La Trobe	MALT1	-	MALT1	1.93	269	519
	Bass	MALT1	-	MALT1	1.81	269	487
	Urambie	FEED	-	FEED	2.18	230	501
Oats	Durack	OAT2	-	OAT2	2.02	180	364
	Kowari	OAT1	-	OAT1	2.35	204	479
	Bannister	OAT1	-	OAT1	2.93	204	598

Early-May (4 May 2017)		Potential classification	Down grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	Low hectolitre	FED1	1.08	186	201
	Scepter	AH	-	AH1	0.68	286	194
	LRPB Trojan	APW	-	APW1	1.06	270	286
	Cutlass	APW	-	APW1	1.55	270	419
	Forrest	APW	Low protein	ASW1	2.03	252	512
	Kittyhawk	ASW	Low hectolitre	AGP1	1.17	246	288
Barley	La Trobe	MALT1	-	MALT1	2.34	269	629
	Bass	MALT1	-	MALT1	2.32	269	624
	Urambie	FEED	-	FEED	2.30	230	529
Oats	Durack	OAT2	Low hectolitre	OAT2	2.37	180	427
	Kowari	OAT1	-	OAT1	2.78	204	567
	Bannister	OAT1	Low hectolitre	OAT2	2.55	180	459

Late-May (24 May 2017)		Potential classification	Down grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	-	AH1	1.67	286	478
	Scepter	AH	Low protein	APW2	2.60	263	684
	LRPB Trojan	APW	-	APW1	2.26	270	610
	Cutlass	APW	-	APW1	2.64	270	713
	Forrest	APW	-	APW1	2.07	270	559
	Kittyhawk	ASW	-	ASW1	2.06	252	519
Barley	La Trobe	MALT1	Low protein	FEED	3.62	257	930
	Bass	MALT1	-	MALT1	3.61	269	971
	Urambie	FEED	-	FEED	3.16	257	812
Oats	Durack	OAT2	-	OAT2	2.86	180	515
	Kowari	OAT1	-	OAT1	3.18	204	649
	Bannister	OAT1	-	OAT1	3.16	204	645

*Assumptions for economic analysis: potential classifications are based on classifications of each variety as at March 2018. Achieved classification is based on CBH grain quality standards as at December 2017. $ per tonne is calculated from CBH cash price (Kwinana Port) on 20 December 2017 (*Seconds price based on a $20 discount from FED1 or OAT2). Gross Income $/ha is calculated as yield x $ per tonne.

Table 4 Gross income analysis of mid-April, late-May and early-June sowing windows at Kulin, Western Australia 2018.

Early sowing, mid-April (18th April 2018)		Potential classification	Down grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	low hectolitre	Seconds*	0.55	302	166
	Scepter	AH	hectolitre<40	No value**	0.26		0
	LRPB Trojan	APW	hectolitre<40	No value**	0.17		0
	Cutlass	APW	hectolitre<40	No value**	0.40		0
	Forrest	APW	low hectolitre	AGP1	0.76	341	259
	EGA Wedgetail	ASW	low hectolitre	AGP1	0.87	341	297
Barley	La Trobe	MALT1	low hectolitre	Seconds*	1.15	287	330
	Bass	MALT1	-	MALT1	1.98	314	622
	Urambie	FEED	-	BFED1	1.92	307	589
Oats	Durack	OAT2	-	OAT2	1.53	371	568
	Kowari	OAT1	-	OAT1	2.2	386	849
	Bannister	OAT1	-	OAT1	2.76	386	1065

Late-May (22nd May 2018)		Potential classification	Down grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	low hectolitre	AGP1	0.52	341	177
	Scepter	AH	low protein	H2	0.61	421	257
	LRPB Trojan	APW	-	APW1	1.06	395	419
	Cutlass	APW	-	APW1	1.32	395	521
	Forrest	APW	-	APW1	1.09	395	431
	EGA Wedegtail	ASW	-	ASW1	1.31	341	447
Barley	La Trobe	MALT1	low protein	BFED1	2.56	307	786
	Bass	MALT1	-	MALT1	2.59	314	813
	Urambie	FEED	-	BFED1	2.06	307	632
Oats	Durack	OAT2	-	OAT2	1.67	371	620
	Kowari	OAT1	-	OAT1	1.82	386	703
	Bannister	OAT1	-	OAT1	1.8	386	695

Early June (6th June 2018)		Potential classification	Down grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	-	H1	0.68	421	286
	Scepter	AH	low protein	APW1	1.53	395	604
	LRPB Trojan	APW	-	APW1	1.27	395	502
	Cutlass	APW	-	APW1	1.24	395	490
	Forrest	APW	-	APW1	1.05	395	415
	Kittyhawk	ASW	-	ASW1	1.35	341	460
Barley	La Trobe	MALT1	-	MALT1	2.49	314	782
	Bass	MALT1	-	MALT1	2.26	314	710
	Urambie	FEED	-	BFED1	1.81	307	556
Oats	Durack	OAT2	-	OAT2	1.49	371	553
	Kowari	OAT1	-	OAT1	1.55	386	598
	Bannister	OAT1	-	OAT1	1.65	386	637

*Assumptions for economic analysis: potential classifications are based on classifications of each variety as at March 2018. Achieved classification is based on CBH grain quality standards. $ per tonne is calculated from CBH cash price (Kwinana Port) on 21 December 2018 (*Seconds price based on a $20 discount from FED1 or OAT2). ** no commercial value if hectolitre <40kg/hL. Gross Income $/ha is calculated as yield x $ per tonne.

Conclusion

In frost-prone parts of the landscape sowing time and crop type followed by variety phenology can have a large impact on final yield, quality and gross income. Delaying sowing of Bass barley to late-May generated the highest gross income in a frost-prone landscape between Lake Grace and Kulin in 2017 and 2018. Bannister oats generated the highest grain yield and gross income from an early sowing window of mid-April. The severe frosts in 2017 resulted in the long-season wheat varieties being unable to completely avoid the frost and the dry September in 2018 limited their ability to fill. Despite this, Forrest wheat was the best wheat option for a mid-April and early-May sowing while Cutlass was the best for a late-May sowing and Scepter the best for an early-June sowing. However, all wheats suffered frost damage regardless of sowing window and were unable to compete on grain yield and gross income compared to barley and oats. It is better to sow frost-prone areas in early-May to long-season oats or in mid- to late-May to long- to mid-season barley varieties rather than sowing wheat.

Note:

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Key words

barley, wheat oats, time of sowing, planting date, frost,

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