Beer is better than bread and porridge; evaluating wheat, barley and oats for early sowing in frost -prone landscapes at Wickepin, 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 the highest yield and gross income 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 late-April resulted in grain being either downgraded to feed 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, Forrest sown in mid-April in the high rainfall 2017 season (370mm GSR and early break) was competitive with barley and oats.
- Frost is not the only threat with early sowing, foliar disease pressure is also higher and contributed to yield decline along with frost particularly in Bass barley (leaf rust) and Durack oats (oat stripe blight) with mid- and late-April sowings in 2017.

Aims

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

Method

This trial examined the relative suitability of a single long-, mid- and short-season wheat, barley and oat variety to early sowing in frost-prone landscapes at Wickepin, WA in 2017 and 2018. The trial comprised 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 experiment had three sowing windows that were established in mid-April, late-April and late-May in 2017; and in mid-April, late-May and early-June in 2018.

Each sowing window was treated as a separate trial. Crop types were blocked within sowing date and varieties were randomised within crop types in a spilt-plot trial design with crop type as the main plot and crop variety as the subplot. 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 time of sowing. 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) 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, and grain size. 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 Wickepin 2017 and 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 management information for the sowing window by crop-type trial at Wickepin in 2017 and 2018, Western Australia.

Year		2017			2018		
		Mid-April sowing	Late-April sowing	Late-May sowing	Mid-April sowing	Late-April to early-May* sowing	Late-May
Date sown		11/4/2017	27/4/2017	19/05/2017	11/4/2018 (wet sown)	29/04/2018 (marginal)	28/5/2018
Germination date		11/4/2017	27/4/2017	19/05/2017	11/4/2018	29/04/2018-7/5/2018	28/5/2018
Variety		As per treatment list (see Table 1)					
Target plant density		150 plants/m^2					
Row spacing		25.4cm					
Nutrition	**At seeding**	100kg/ha Gusto Gold (N:10, P:12.5, K:12 units) 100kg/ha urea (N:42 units)			100kg/ha Gusto Gold (N:10, P:12.5, K:12 units) 100kg/ha urea (N:42 units)		
	In season	70L/ha UAN (N:29 units) 30L/ha UAN (N:13 units)			70L/ha UAN (N:29 units) 30L/ha UAN (N:13 units)		
Herbicide	**Pre-seeding**	1.0L/ha Glysophate 500 1.0L/ha trifluralin (480g/L trifluralin) 500ml/ha Dual Gold (960g/L S-Metolachlor) 200g/ha diuron (900g/kg diuron)			1.0L/ha Glysophate 500 1.0L/ha trifluralin (480g/L trifluralin) 500ml/ha Dual Gold (960g/L S-Metolachlor) 200g/ha diuron (900g/kg diuron)		
	In-season	1L/ha Precept			1L/ha Precept		
Insecticide	**Pre-seeding**	1000ml/ha chlorpyrifos 200mL/ha Bifenthrin Gaucho (240ml/kg seed treatment)			1000ml/ha chlorpyrifos 200mL/ha Bifenthrin Gaucho (240ml/kg seed treatment)		
	In-season	50g/ha Transform			50g/ha Transform 60g/ha Transform		
Fungicide	**Pre-seeding**	300ml/ha Uniform (on fertiliser) Vibrance (360ml/kg seed treatment)			300ml/ha Uniform (on fertiliser) Vibrance (360ml/kg seed treatment)		
	Post-seeding (August; whole trial)	200ml/ha Prosaro (250g/L propiconazole)			400mL/ha Aviator Xpro		

***originally planted as a Late-April sowing window but germination was staggered into early May.**

Results

The 2017 season at Wickepin had an early break and wet July and August (130mm) and an above-average growing season rainfall (GSR) of 370mm. Several moderate frosts occurred in late September and early October (Figure 1). All 2017 sowing dates established well without irrigation, however establishment was slightly lower in the earlier sowing windows (140 and 160 plants/m^2) than the latest sowing date (180 plants/m^2). In contrast, the 2018 season received below-average rainfall (total GSR 264mm) and had a late break on about 20-22 May. Two major and damaging frosts occurred on 15-16 September. The mid-April sowing window germinated well (140 plants/m^2), but early growth was hindered by wind damage and erosion, which resulted in furrow infill at the 1-2 leaf stage. In 2018 the late-April sowing window was deep sown into a drying soil profile and germination was staggered over the first week of May, consequently it was also slightly lower at ~100 plants/m^2. The last sowing window for 2018 was planted in late May into wet soil and established well (130 plants/m^2).

Mid-April 2017 and 2018

The long-season variety Bannister oats achieved the highest yield (Figure 1a and 2a) and gross income (Table 3 and 4) in the mid-April sowing at Wickepin in both the wet, early start of 2017 and the late dry season of 2018. Bannister's gross income for 2017 was $1,022/ha and $1,197/ha in 2018. The next highest incomes from this early-sowing window were achieved by Forrest wheat ($1010/ha in 2017) and Urambie barley ($961/ha in 2018). The barleys La Trobe ($955/ha) and Urambie ($915/ha) were not far behind in 2017 (Table 3). All these crops achieved high grain yields with minimal frost damage. However, in 2017 Bass barley suffered significant foliar disease (barley leaf rust and scald) and Durack and Kowari oats suffered oat strip blight. In 2018 early-sown Bass and La Trobe barley suffered significant early grain-fill damage from

frost (data not shown). As expected, the shorter-season wheats of Emu Rock, Scepter, LRPB Trojan and Cutlass suffered significant flower, head and grain frost and high floret sterility and low harvest index (data not shown) and were either unable to meet delivery standards or achieved only feed and general-purpose milling grades (Table 4).

Late-April 2017 and late-April to early-May 2018

In the 2017 late-April sowing, Forrest wheat ($1,328/ha), La Trobe barley ($1,247/ha) and Bannister oats ($1,128/ha) achieved the highest gross incomes (Figure 1a and Table 3). The short-season wheats were significantly frosted in the late-April sowing with high floret sterility and low harvest index (data not shown). Bass barley again became severely infected with foliar diseases and Durack oats with oat stripe blight and, as a result, both crops suffered reduced yields and low harvest indexes (data not shown). This increased disease pressure associated with earlier sowing highlights that frost is not the only risk to be managed with early sowing.

In 2018 the late April sowing was into marginal soil moisture and had staggered germination over the first week of May. This sowing window generated a different yield ranking compared to 2017. Bannister oats ($1,482), Bass barley ($1,422/ha) and the winter barley Urambie ($1,326/ha) were the three highest-yielding varieties (Figure 2b) and achieved among the highest gross incomes of the three sowing windows (Table 4).

The short-season wheats and La Trobe barley wheat were severely damaged by the frost events of September 15-16 as Emu Rock, Scepter, LRPB Trojan and Cutlass were just at or past head emergence at this time and La Trobe was at early grain-fill. The dry September (6.6mm) penalised the grain yield of the longer-season wheat varieties Forrest and EGA Wedgetail. While Forest avoided the frosts and still achieved the highest grain yield and gross income of all the wheats ($786/ha; Table 4), this was only just over half the income generated by the longer-season barley and oats.

Late-May 2017 and 2018

Sowing La Trobe barley ($1,472) in late-May in 2017 generated the highest yield (Figure 1c) and gross income (Table 3) of all sowing windows. However, many crop varieties yielded well in 2017 with Emu Rock ($1,298/ha), Bass barley ($1,178/ha) Bannister oats ($1,167/ha) and Scepter, LRPB Trojan and Cutlass wheats (~$1,137/ha) all achieving high gross incomes (Table 3). Durack oats was again impacted by oat stripe blight and the longer-season Forrest and Kittyhawk flowered too late to yield well (Figure 1c).

The late-May sowing in 2018 generated a similar yield and gross income ranking to the early-May sowing (Figure 2c and Table 4). Bass ($1,483/ha), La Trobe barley ($1,454/ha) and Bannister oats ($1,295/ha) were the three highest yielding and gross income earners for this sowing window. La Trobe in this sowing window had passed the vulnerable early grain-fill stage and was not impacted by frost. While significantly behind the barley and oats the best-yielding and highest gross-income wheat was Cutlass ($964/ha), and LRPB Trojan ($937/ha). Emu Rock, Forrest and EGA Wedgetail failed to make delivery standards due to low hectolitre and high screenings associated with frost (Emu Rock) and terminal stress (Forrest and EGA Wedgetail; Table 4).

Phenology, grain yield and gross income

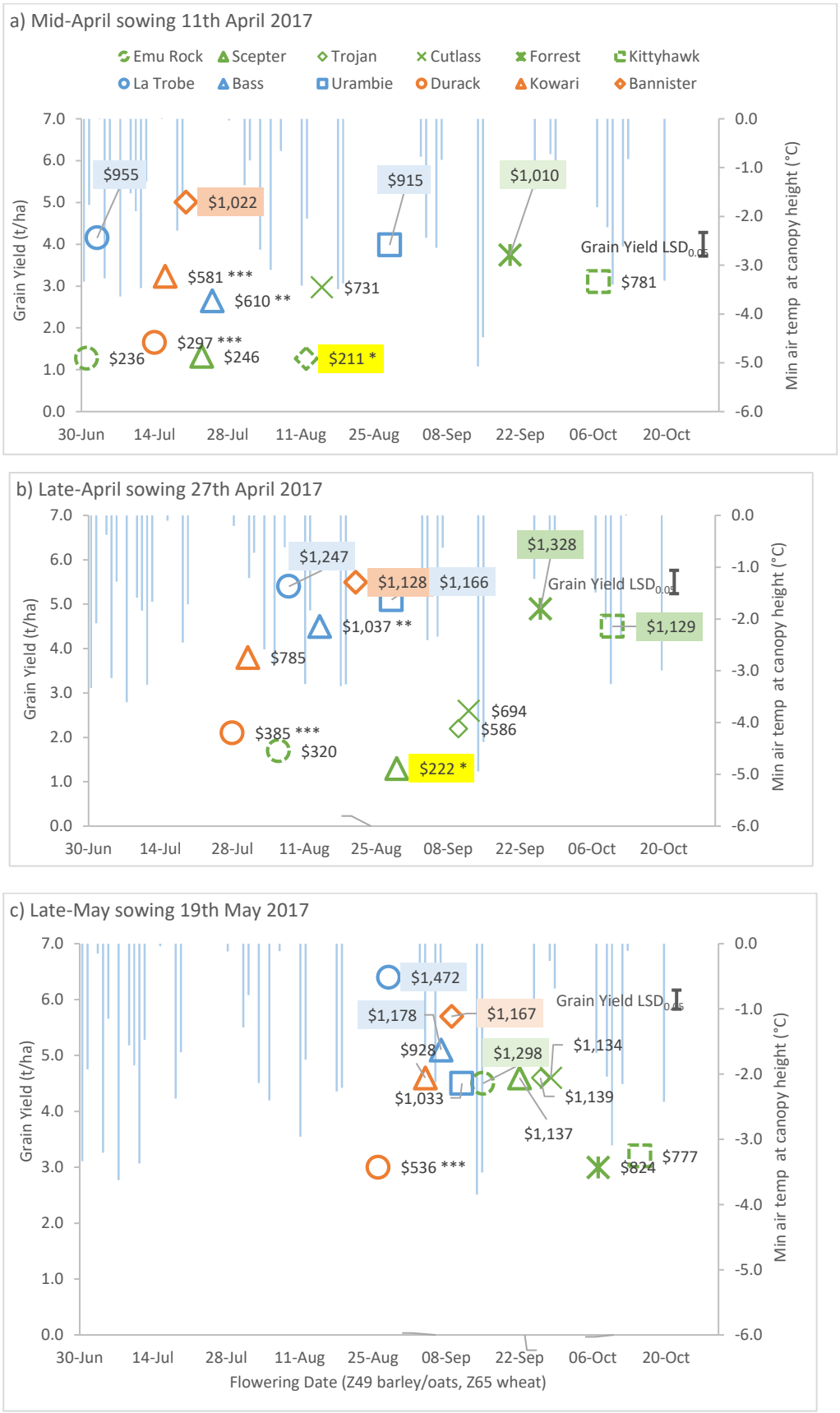

Figure 1 Wickepin 2017: interaction of flowering date, grain yield and gross income of barley, oats and wheat varieties when sown in (a) mid-April, (b) late-April and (c) late-May with June-September frost minimum temperatures (blue bars). Grain yield and flowering dates are the predicted means; n=3. $LSD_{0.05}$ for grain yield comparisons within crop type. For gross income assumptions refer to Table 3. * failed to meet export delivery standards. **barley leaf rust *** oat stripe blight

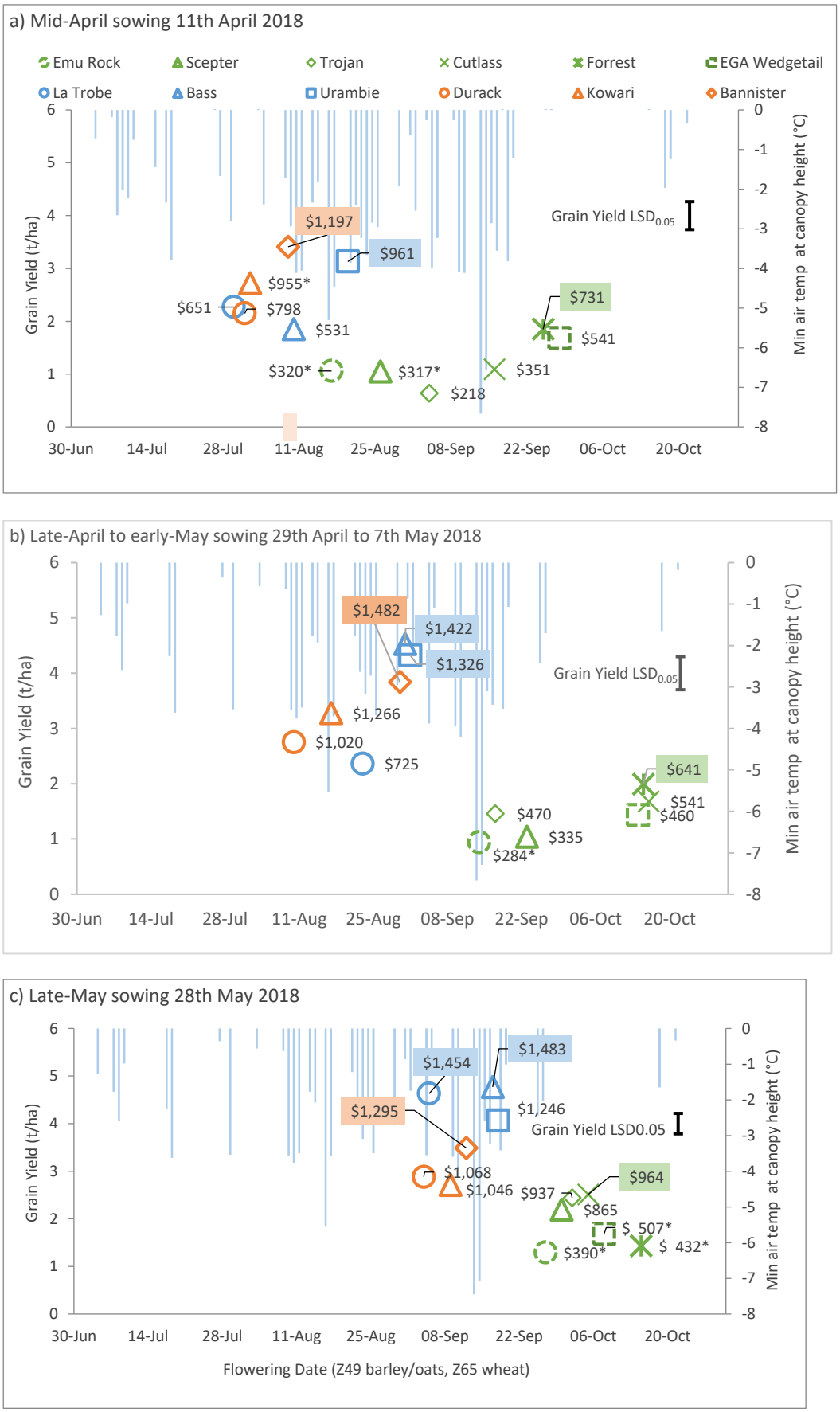

Figure 2 Wickepin 2018: interaction of flowering date, grain yield and gross income of barley, oats and wheat varieties when sown in (a) mid-April, (b) late-April and (c) Late-May with July-October frost minimum temperatures (blue bars). Grain yield and flowering dates are the predicted means; n=3. $LSD_{0.05}$ for grain yield comparisons within crop type. For gross income assumptions refer to Table 4 * failed to meet export delivery standards.

Economic Analysis

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

Mid-April (11 April 2017)		Potential classification	Down-grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	Low hectolitre	FED1	1.27	186	236
	Scepter	AH	Low hectolitre	FED1	1.32	186	246
	LRPB Trojan	APW	Low hectolitre	Seconds*	1.27	166	211
	Cutlass	APW	Low hectolitre	AGP1	2.97	246	731
	Forrest	APW	-	APW1	3.74	270	1010
	Kittyhawk	ASW	-	ASW1	3.1	252	781
Barley	La Trobe	MALT1	Low hectolitre and high protein	BFED1	4.15	230	955
	Bass	MALT1	Low hectolitre and high protein	BFED1	2.65	230	610
	Urambie	BFED1	-	BFED1	3.98	230	915
Oats	Durack	OAT2	-	OAT2	1.65	180	297
	Kowari	OAT1	Low hectolitre	OAT2	3.23	180	581
	Bannister	OAT1	-	OAT1	5.01	204	1022

Late-April (27 April 2017)		Potential classification	Down-grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	Low hectolitre	FED1	1.72	186	320
	Scepter	AH	Low hectolitre	Seconds*	1.34	166	222
	LRPB Trojan	APW	-	APW1	2.17	270	586
	Cutlass	APW	-	APW1	2.57	270	694
	Forrest	APW	-	APW1	4.92	270	1328
	Kittyhawk	ASW	-	ASW1	4.48	252	1129
Barley	La Trobe	MALT1	Low hectolitre and high protein	BFED1	5.42	230	1247
	Bass	MALT1	Low hectolitre and high protein	BFED1	4.51	230	1037
	Urambie	BFED1	-	BFED1	5.07	230	1166
Oats	Durack	OAT2	-	OAT2	2.14	180	385
	Kowari	OAT1	-	OAT1	3.85	204	785
	Bannister	OAT1	-	OAT1	5.53	204	1128

Late-May (19 May 2017)		Potential classification	Down-grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	Low protein	AH2	4.54	286	1298
	Scepter	AH	Low hectolitre and protein	AGP1	4.62	246	1137
	LRPB Trojan	APW	Low hectolitre and protein	AGP1	4.63	246	1139
	Cutlass	APW	Low hectolitre and protein	AGP1	4.61	246	1134
	Forrest	APW	-	APW1	3.05	270	824
	Kittyhawk	ASW	Low hectolitre and protein	AGP1	3.16	246	777
Barley	La Trobe	MALT1	Screenings	BFED1	6.4	230	1472
	Bass	MALT1	Screenings	BFED1	5.12	230	1178
	Urambie	BFED1	-	BFED1	4.49	230	1033
Oats	Durack	OAT2	-	OAT2	2.98	180	536
	Kowari	OAT1	-	OAT1	4.55	204	928
	Bannister	OAT1	-	OAT1	5.72	204	1167

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 the 20 December 2017. *Failed to meet export delivery standards; '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 April to early-May and Late-May sowing windows at Wickepin, Western Australia in 2018.

Mid-April (11th April 2018)		Potential classification	Down-grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	low hectolitre	Seconds*	1.06	302	320
	Scepter	AH	low hectolitre	Seconds*	1.05	302	317
	LRPB Trojan	APW	screenings	AGP1	0.64	341	218
	Cutlass	APW	low hectolitre	FED1	1.09	322	351
	Forrest	APW	-	APW1	1.85	395	731
	EGA Wedgetail	ASW	low hectolitre screenings	AUW1	1.68	322	541
Barley	La Trobe	MALT1	low hectolitre	Seconds*	2.27	287	651
	Bass	MALT1	low hectolitre	Seconds*	1.85	287	531
	Urambie	BFED1	-	BFED1	3.13	307	961
Oats	Durack	OAT2	-	OAT2	2.15	371	798
	Kowari	OAT1	low hectolitre	Seconds*	2.72	351	955
	Bannister	OAT1	low hectolitre	Seconds*	3.41	351	1197

Late-April to early-May (29th April to 7th May 2018)		Potential classification	Down-grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	low hectolitre	Seconds*	0.94	302	284
	Scepter	AH	low hectolitre screenings	AUW1	1.04	322	335
	LRPB Trojan	APW	low hectolitre screenings	AUW1	1.46	322	470
	Cutlass	APW	low hectolitre screenings	AUW1	1.68	322	541
	Forrest	APW	low hectolitre screenings	AUW1	1.99	322	641
	EGA Wedgetail	ASW	low hectolitre screenings	FED1	1.43	322	460
Barley	La Trobe	MALT1	low hectolitre	BFED1	2.36	307	725
	Bass	MALT1	-	MALT1	4.53	314	1422
	Urambie	BFED1	-	BFED1	4.32	307	1326
Oats	Durack	OAT2	-	OAT2	2.75	371	1020
	Kowari	OAT1	-	OAT1	3.28	386	1266
	Bannister	OAT1	-	OAT1	3.84	386	1482

Late-May (28th May 2018)		Potential classification	Down-grading parameter	Achieved classification	Yield (t/ha)	$/t	Gross Income $/ha
Wheat	Emu Rock	AH	low hectolitre screenings	Seconds*	1.29	302	390
	Scepter	AH	low protein	H2	2.19	395	865
	LRPB Trojan	APW	low hectolitre screenings	AUH2	2.44	384	937
	Cutlass	APW	low hectolitre screenings	AUH2	2.51	384	964
	Forrest	APW	low hectolitre screenings	Seconds*	1.43	302	432
	EGA Wedgetail	ASW	low hectolitre screenings	Seconds*	1.68	302	507
Barley	La Trobe	MALT1	-	MALT1	4.63	314	1454
	Bass	MALT1	-	MALT2	4.77	311	1483
	Urambie	BFED1	-	BFED1	4.06	307	1246
Oats	Durack	OAT2	-	OAT2	2.88	371	1068
	Kowari	OAT1	-	OAT1	2.71	386	1046
	Bannister	OAT1	low hectolitre	OAT2	3.49	371	1295

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 the 20 December

2017. *Failed to meet export delivery specifications; ‘Seconds’ price based on a $20 discount from FED1 or OAT2. Gross Income $/ha is calculated as yield x $ per tonne.

Conclusion

In conclusion, rather than sowing wheat it is better to sow frost-prone areas in mid-April through to late-April to longer-season oats such as Bannister or in mid-to-late-May to long to mid-season barley varieties with good disease management. The only fit for wheat in frost-prone areas is for longer-season varieties with a strong photoperiod responsive variety such as Forrest sown in late April to early May, but only if subsoil moisture is good and the seasonal outlook is promising. If these conditions are not available or when sowing after this period it is best to sow high yielding mid-long wheat varieties with mild photoperiod requirements such as Cutlass in late-May. This trial has highlighted the value of oats and barley over longer season wheat in maintaining higher gross incomes in frost prone parts of the landscape.

Key words

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

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