Can current commercial wheat cultivars be exploited for early sowing in Western Australia?

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Abstract
Advances in seeding techniques, increased farm sizes and the concern with penalties for delayed sowing have meant that growers are sowing progressively earlier than May, the current practice. However, there is a lack of data on how currently available wheat cultivars respond to April sowings in Western Australia. The grain yield response of long season cultivars (including winter wheats) were compared to mid-long season commercial cultivars and the commonly grown short-mid cultivar Mace sown in mid-April, early May and late May. Cultivars were sown at three sites in 2015 and four sites in 2016 in the wheat belt of Western Australia. The cultivars grown showed a wide spread of flowering dates with a difference between the long maturing winter wheats Wylah or Whistler, spring wheat Forrest, and the mid-long maturing cultivar Cutlass. The winter wheats were not as competitive in yield with the mid-long maturing cultivars when sown in mid-April, except at Katanning in the Great Southern. Forrest was found to be more adaptable to WA conditions than the winter wheats assessed (based on its yield response across a range of sites and early sowing). The research found that there are commercial mid-long maturing cultivars currently available in WA for early sowing which can yield higher than the available winter wheats or Mace, however all of these cultivars are at risk of frost and grain quality problems associated with early sowing. There is still the need for a cultivar which is better suited for April sowing opportunities in WA.

Keywords
Flowering, yield.

Introduction
As the size of the cropping programs increase in Western Australia, growers need to take advantage of seeding opportunities in April. It is well documented that a delay in sowing beyond a critical date can substantially reduce the grain yield of a wheat crop (Sharma et al. 2008). However, when crops are sown early their rate of development needs to be adjusted so the crop does not flower too early leading to reduced biomass accumulation or become exposed to a greater frost risk. Slower developing cultivars sown early have been shown to produce similar or higher grain yields than faster or shorter developing cultivars sown later and flower at the same time (Hunt et al. 2015). However the unavailability of slower developing commercial cultivars is preventing growers from utilising early sowing opportunities. Australian wheat breeders have generally focused on breeding cultivars which have a rapid development suited to later times of sowing, and main season variety testing in Western Australia favours short- mid season cultivars. This study aimed to test and compare the performance of currently available commercial cultivars sown early, to winter and long spring lines grown in the National Variety Testing programs around Australia.

Methods
A total of 7 experiments were established in Western Australia, 3 in 2015 and 4 in 2016. The experiments examined 12 wheat cultivars (including potential lines) at three sowing dates, nominally mid-April, early May and late May. Details are included in Table 1. The results of five cultivars are presented in this paper, representing the range of maturities used. Mace (short-mid season), Magenta and Cutlass (mid-long), Forrest (long) and Wylah or Whistler (winter). Experiments were sown as a randomised block design with sowing times as whole blocks and cultivars randomised in two directions. Treatments were replicated three times. All experiments had optimal nutrient levels applied and weeds, diseases and insects were controlled by recommended pesticides so yields were not limited. Zadok scores were recorded two to three times a week. Anthesis date was recorded as the date where 50% of the ears in the plots had yellow anthers extruded. Grain yields were based on machine harvest (8 m x 1.54 m). In 2016, yield components were determined on a subset of four cultivars (Mace, Magenta, Forrest and Wylah) from quadrant cuts of 2 x 0.44 m² in each plot.

Biomass, yield, ear number and grain weights were recorded and grain number was calculated from quadrant yield and grain weight. Grain quality analyses were conducted as per Cooperative Bulk Handling guidelines.

Table 1. Year, site, soil group, pre-season and growing season rainfall (April – October) and sowing times in the 7 experiments in Western Australia.

Year	Site	Soil group (WA)	Jan – March rainfall (mm)	Apr – Oct rainfall (mm)	Sowing times
2015	Dandaragan	Brown deep sandy duplex	61	350	16 April. 6 & 27 May
2015	Katanning	Brown shallow sandy duplex	22	285	14 April. 6 & 27 May
2015	Gibson	Grey deep sandy duplex	66	352	16 April. 8 & 27 May
2016	Mullewa	Red loamy earth	37	358	14 April. 5 & 26 May
2016	Merredin	Red loamy earth	183	255	15 April. 10 & 27 May
2016	Katanning	Brown shallow sandy duplex	105	303	14 April. 5 & 26 May
2016	Gibson	Grey deep sandy duplex	135	480	14 April. 9 & 26 May

Results

The experiments were rain fed in both years, however a drying top soil at Dandaragan and Katanning in 2015 and Mullewa in 2016 resulted in a reduced plant establishment of approximately 100 plants per m² (compared to the desired 150 plants per m²) for the two early sowing times. Merredin's establishment was also reduced to a similar extent in 2016, possibly due to surface crusting. The overall temperatures throughout the growing season in WA were above average in 2015, but well below average in 2016. Extreme and frequent frost events at the Katanning site in 2016 resulted in almost total yield loss of the mid-April sowing time, and severe yield reduction in the early May sowing. Highlighting that under extreme conditions, all current cultivars are at risk of frost. All other sites received marginal or no frost damage.

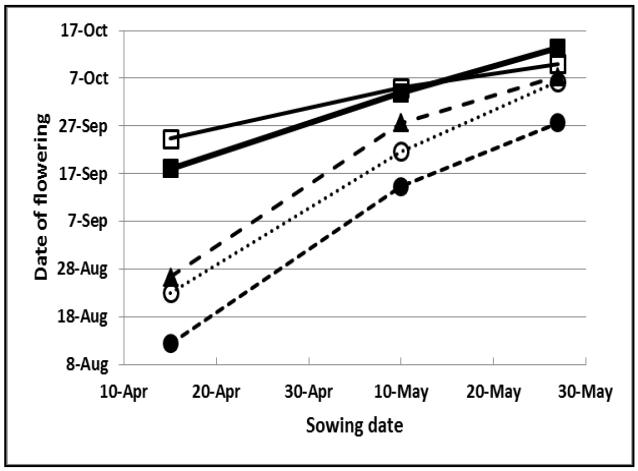

Figure 1. Flowering dates of Wylah (□), Forrest (■), Cutlass (▲), Magenta (○) and Mace (●) when sown 15 April, 10 May and 27 May at Merredin in 2016.

Figure 1 shows the spread of flowering dates representing a range of development times of current cultivars that are available to assist with earlier sowings in Western Australia. There is a clear difference between the long maturing winter wheat Wylah and spring wheat Forrest and the mid to long maturing cultivar which is represented by Cutlass. Actual flowering dates do change from location to location and from year to year, with 2016 generally having later flowering dates than 2015. Despite this difference in seasons, the relative differences between the cultivars are fairly consistent in both seasons.

The average grain yields ranged from over 5.5t/ha for the early May sowings at Dandaragan and Gibson in 2015 to less than 0.5t/ha at Katanning sown mid-April in 2016 (severely frost damaged). Of the longer maturing varieties assessed, only Whistler at Katanning in 2015 and Forrest at Merredin and Gibson in 2016 were competitive with the top-performing mid-long cultivar (Magenta or Cutlass) at the mid-April sowing time (Figure 2). Mace was not competitive with the mid-long cultivars at the mid-April sowing time either, except at Gibson in 2015. All other varieties obtained their highest yields at the early May sowing time, or else their yields were not significantly different between the mid-April and early May sowings.

Mullewa in 2016 (Figure 2b) showed the strong quadratic relationship between grain yield and flowering that the optimal flowering windows have historically been based upon, with the typical yield decline in the earlier (due to frost and inadequate biomass accumulation) and later (due to heat and drought stress) flowering treatments, irrespective of variety (Darshan *et al* 2008). In the warmer environment of Mullewa, Wylah and Forrest were not competitive due to their late flowering time at all times of sowing. Katanning in 2015 and Merredin in 2016 also showed this response to some extent, with a decline in yield with flowering after late September. Forrest (Merredin) and Whistler (Katanning) were more competitive for yield at the mid-April sowing, with a rapid decline in yield with the early and late May sowings. It is to be noted that Mace yields at these two sites appeared to be limited by some other factor than flowering date, possibly frost, despite visible damage observed only at Katanning.

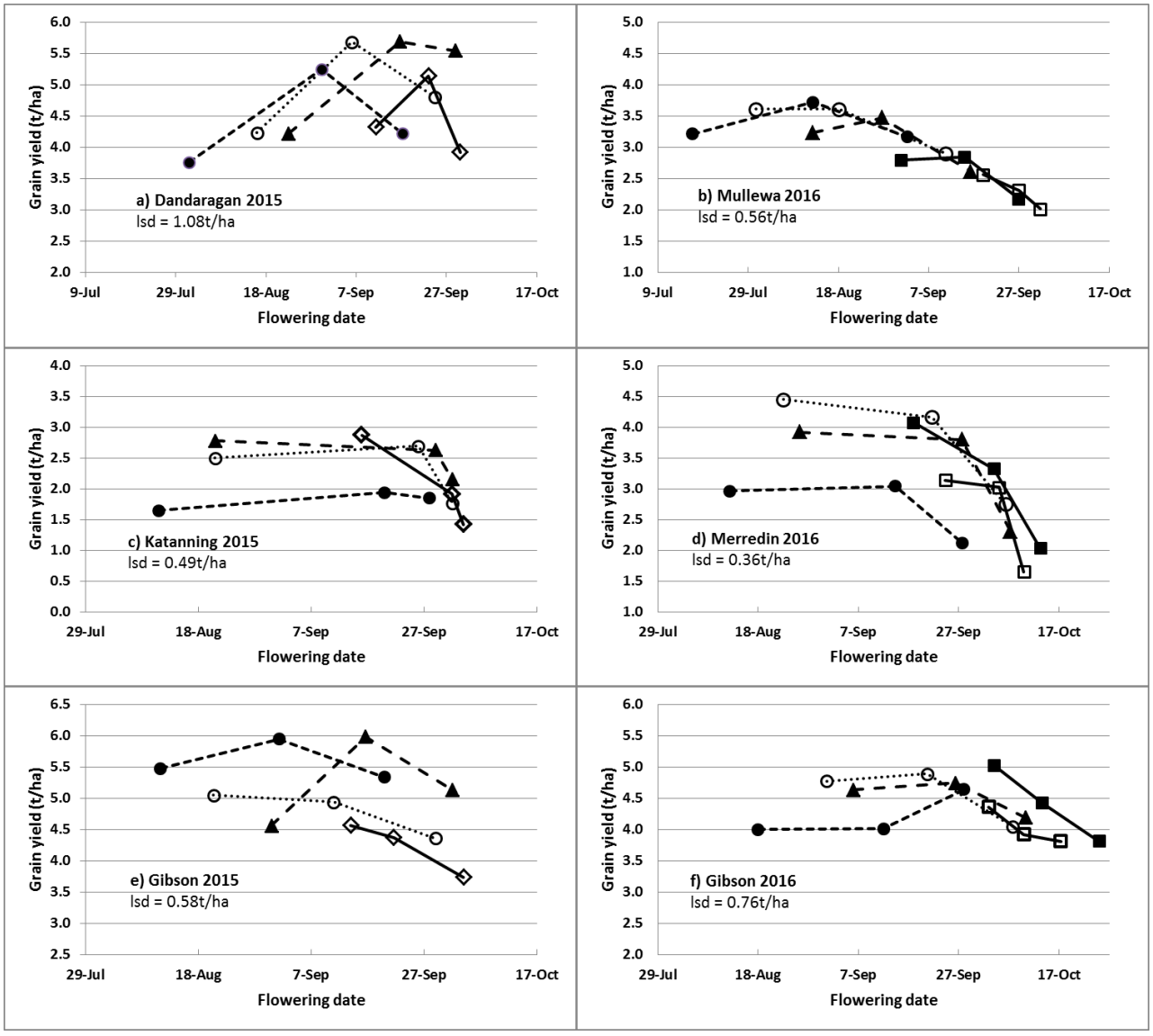

Figure 2. Relationship between grain yield and flowering date for Wylah (□), Whistler (◊), Forrest (■), Cutlass (▲), Magenta (○) and Mace (●) sown mid-April, early May and late May at a) Dandaragan, 2015, b) Mullewa, 2016 , c) Katanning, 2015, d) Merredin, 2016, e) Gibson, 2015 and f) Gibson, 2016.

In the average rainfall (decile 5) year of 2015, Gibson saw no consistent yield response to flowering time, with Mace the highest yielding cultivar. In the extremely wet year (decile 10) of 2016, yield and flowering time were more closely related, with Mace being the lowest yielding cultivar until the late May sowing time, and the longer maturing cultivars' yields declining with later sowing. Whistler or Wylah were not competitive in this environment, but Forrest was more adaptable.

There were significant positive relationships between yield and biomass at maturity, yield and grain number, and yield and grain weight for Wylah, Forrest, Magenta and Mace at Mullewa, Merredin and Esperance in

2016 (data not shown). R^2 values ranged from 0.55 to 0.89 with Wylah and Forrest obtaining the stronger relationships. Sown mid-April, Wylah and Forrest were able to achieve similar grain numbers to the other cultivars examined however both have significantly lower grain weights (Figure 3). A limitation of a later flowering date for Wylah sown mid-April was also a lower biomass at maturity than other cultivars.

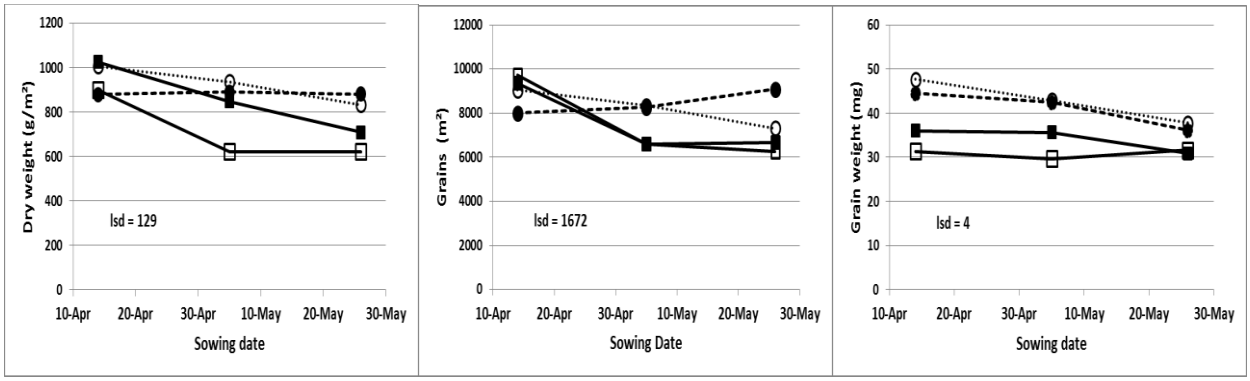

Figure 3. Relationship between sowing date and dry weight at maturity, grains per m² and grain weight for Wylah (□), Forrest (■), Magenta (○) and Mace (●) sown 14 April, 5 May and 26 May at Mullewa, 2016.

Mid-April sowings can expose grain to conditions that are more conducive to pre-harvest sprouting or blackpoint staining, which can readily lead to downgrading. Low falling numbers were not an issue at any of the sites in 2015 or 2016, although some cultivars, in particular Yitpi, were downgraded to General Purpose or Feed grades due to high levels of staining. At Katanning, cultivars were also downgraded due to frost distorted grains.

Conclusion

Traditionally, sowing wheat in Western Australia is not recommended until after Anzac Day, a date based on the yield performance and maturities of commercially available wheat cultivars in the 1990s. This study has shown that mid-long maturing cultivars such as Magenta and Cutlass can be sown in mid-April, however similar or higher yields can be achieved by sowing in early May. Early sown cultivars are at risk of frost damage and grain quality problems. The winter wheats, Whistler (tested in 2015) and Wylah (tested in 2016), didn't typically show a yield advantage in the mid-April sowings at any sites except at Katanning in 2015. Katanning has a cooler growing season than the other sites tested, which may have been an advantage that allowed Whistler to be competitive with the mid-long cultivars. This result is reflected in those obtained by Hunt et al. (2015) and with Wylah in the frost prone sites of Brookton and Dale (Leske et al. 2017) which are similar environments to Katanning. The photoperiod sensitive spring wheat Forrest, however, was found to be more adaptable to a range of WA conditions, as shown in its more competitive response across the sites tested. Despite the range of cultivars and environments tested, no cultivars sown mid-April could consistently match the early May sowing time for yield and quality. This research continues to highlight the need for cultivars which are better suited for early sowing opportunities in WA. Experiments are continuing in 2017 to examine more potential lines as they become available from the breeding companies.

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