Farm level considerations of sowing date for canola and wheat

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Abstract
Sowing date is critical in determining the yield potential and production risk (frost and heat shock) of an individual paddock. Multiple paddocks are sown in sequence each year with sowing date decisions made at the paddock level, but also within the context of a whole farm. Sequential sowing dates were demonstrated in this trial to raise awareness about the different sowing programs that might be employed on a farm. The trial was established (2014) at Cunderdin at the site which hosted the WANTFA Spring Field Day. Wheat (Mace @ 60kg/ha) and canola (IH30RR @ 3kg/ha) crops were sown at approximately 3 day intervals beginning on 29 April and finishing on 1 July (total 24 sowing dates). The trial, visited in spring by farmers and industry professionals, was a backdrop to discuss the risks and benefits of early sowing on yield and flowering date of a cropping program. The maximum canola yield of 1.21 t/ha decreased by 0.17 t/ha for each 10 day sowing delay. However, wheat yield was constant (2.9 t/ha) between 29 April and 1 June, decreasing thereafter by 0.56 t/ha for each 10 day sowing delay. These results demonstrate the importance of early sowing particularly for Canola. The flowering date for each time of sowing was also monitored, with the data used to discuss the spread of flowering across a cropping program, and the implications for frost and heat damage.

Key words
Flowering date, frost, time of sowing, yield

Introduction
In a Mediterranean environment, such as the WA wheatbelt, timeliness of sowing is one of the most important aspects of crop agronomy (Sharma et al. 2008, Turner 2011). There has been a multitude of research examining the effect of sowing date on crop yield and the optimum crop phenology to match this (e.g. Shackley and Anderson 1995, Sharma et al. 2008). There is widespread agreement that the sowing date needs to be managed so there is sufficient time for the crop to complete grain filling before the onset of terminal drought and high temperatures (Turner and Asseng 2005). However, if crops are sown too early then they may be exposed to damaging frosts around anthesis and they may complete grain filling before all of the available soil moisture is utilized, thus yield is less than potential. Whilst the agronomic understanding is well advanced, the reality is that farmers managing a sowing program over many hectares cannot sow all of their crops at the optimum time.

As cropping farms have increased in size and the time taken to complete sowing has increased it has become important for farmers to take a more holistic view. At a farm level sowing time will ultimately be a compromise between some crops being sown early and some sown after the optimum sowing date. For example, Fletcher et al. (2015) showed that early seeding (achieved through dry seeding) gave yield benefits up to 0.5 t/ha across a whole farm but this depended on the number of days taken to sow the cropping program and the growing season rainfall. The objectives of this paper are to establish the farm level yield benefits that accrue from early sowing and investigate the frost and heat stress risks that are associated with sowing time at the farm level.

Materials and methods
In 2014, an unreplicated trial with 24 discrete sowing dates was established at the WANTFA spring field day site near Cunderdin in WA (31.59°S, 117.24°E). Sowings were made at approximately 3 day intervals from 29 April to 1 July 2014. On each date a plot of wheat (cv 'Mace') was sown at 60 kg seed/ha and a plot of Canola (cv 'IH30RR) was sown at 3 kg seed/ha. Fertiliser of 100 kg/ha of Agras (16% N, 9%P, 14% S) was applied at sowing and weeds were controlled by pre-emergent applications of glyphosate. The canola plots received two post-emergent treatments of glyphosate. The ultimate objective of this trial was to provide a backdrop for a field day discussion about farm level sowing dates.

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Plots were machine harvested on 18 December and the yields were analysed using regression analysis. Due to the trial being unreplicated, a statistically different yield between any two sowing dates was unable to be established. However, because the trial had multiple sowing dates it was possible to establish, with some certainty, the shape of the yield response with respect to sowing date using a regression analysis. The yield response functions were used to calculate the implications at a farm level of various start dates for a sowing program.

Wheat flowering was monitored on five occasions using digital photography. On each date high resolution digital photos were taken of each plot. From these we identified the plot that had just anthesed. Thus, there were five sowing dates where the anthesis date was known.

Results and discussion

The break of the season occurred on 27 April (49mm) and there was continuing rainfall throughout May (65 mm) and June (27 mm) which ensured that all sowings were made into moist soil and germinated immediately. The overall growing season rainfall (Apr-Oct) was 320 mm. The yield response to sowing date differed markedly between wheat and canola (Figure 1). Wheat yield remained stable at 2.9 t/ha for sowing dates between 29 Apr and 1 June, possibly due to limiting soil N. Thereafter yield declined by 0.56 t/ha for each 10 day delay in sowing (R^2 = 0.85). In contrast Canola yield decreased by 0.17 t/ha (R^2 = 0.55) for each 10 day delay in sowing from a maximum of 1.21 t/ha at the first sowing date (29 Apr). Canola yields were lower than expected from the early sowings due to shattering losses before harvest.

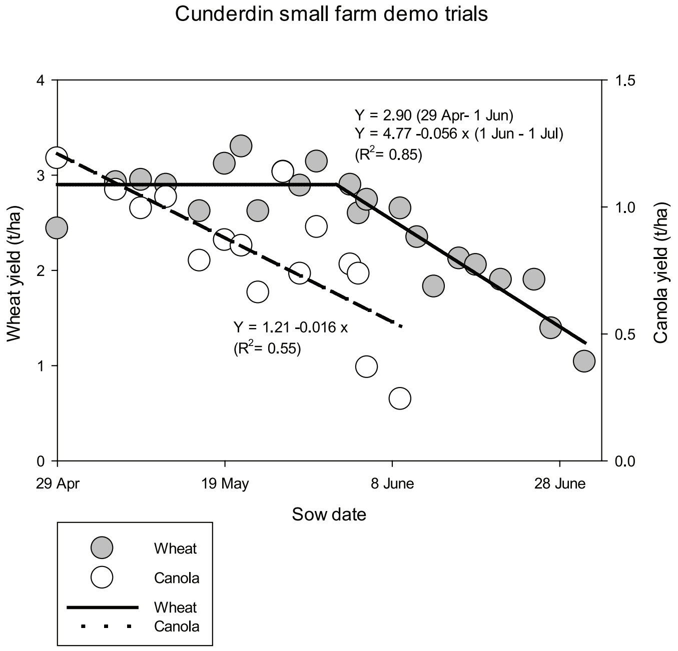

Figure 1. Yield response of wheat and canola to sowing date on at Cunderdin in 2014.

From these responses it would seem that canola should be sown as early as possible and wheat should be sown sometime before the end of June. This would be the case if sowing only took a few days. Using the yield response regressions we were able to calculate the implications at a farm level of various start dates for a sowing program. We use the example of a sowing program consisting of 20% canola and 80% wheat (Table 1). For a short sowing program (20 days) the commencement of sowing can be delayed until 20 May with no major loss in wheat yield and only a small decrease in canola yield. In contrast in a longer program (40 days) any delay of sowing after 30 April resulted in a major decrease in average wheat yield. Thus, the optimum starting date will depend on the amount of sowing that needs to be done and the capacity of machinery available to complete it.

Table 1. Calculated average canola and wheat yields for sowing programs of different duration beginning on different dates.

	20 days			30 days			40 days		
Start date	Canola (t/ha)	Wheat (t/ha)	End date	Canola (t/ha)	Wheat (t/ha)	End date	Canola (t/ha)	Wheat (t/ha)	End date
30 Apr	1.17	2.90	20 May	1.15	2.90	30 May	1.14	2.86	9 Jun
10 May	1.01	2.90	30 May	0.99	2.84	9 Jun	0.98	2.64	19 Jun
20 May	0.85	2.81	9 Jun	0.83	2.56	19 Jun	0.82	2.26	29 Jun
30 May	0.69	2.39	19 Jun	0.67	2.05	29 Jun	0.66	1.72	9 Jul
9 Jun	0.53	1.83	29 Jun	0.51	1.49	9 Jul	0.50	1.16	19 Jul

As expected, where the sowing date of wheat was delayed the anthesis date was also delayed (Figure 1). For every 10 day delay in sowing wheat anthesis was delayed by 8.8 days ($R^2 = 0.97$). The observed flowering dates were well simulated by the Flower Power statistical model (Sharma and D'Antuono 2011). The approximate optimum flowering window is between 25 Aug and 15 Sep in this location (Shackley 2000). This is the window that optimises yield but also balances the risk of frost and heat stress events. Crops flowering before this are considered to be at risk of a frost and crops flowering after this are considered to be at risk of heat stress and terminal drought. In this experiment in order to flower within this window this variety needed to be sown between 14 May and 17 June (Figure 2).

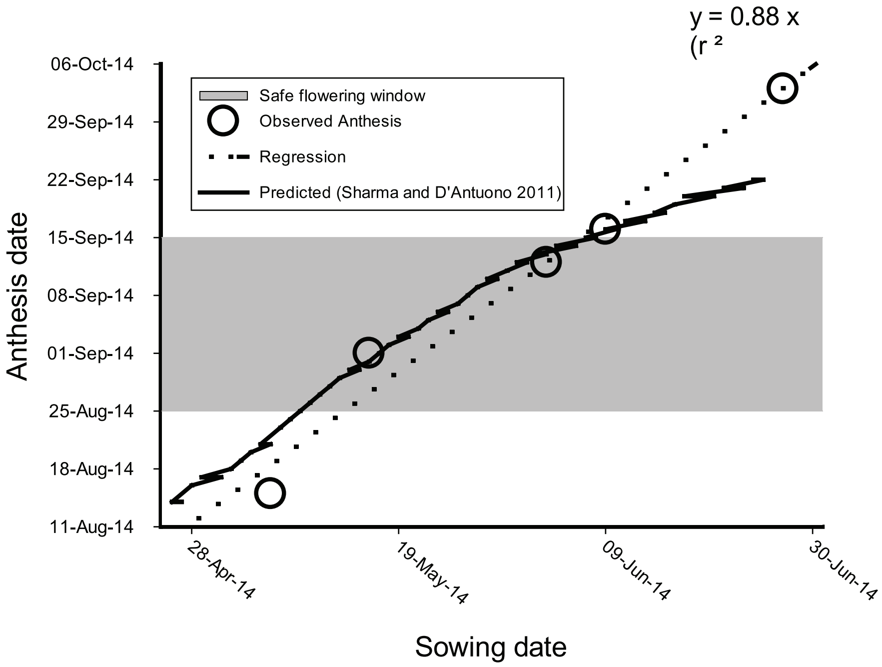

Figure 2. Effect of wheat sowing date on observed anthesis date. The grey area represents the optimum flowering window for Cunderdin (25 Aug to 15 Sep). The dotted line is the regression and the solid line is the predicted flowering dates (Sharma and D'Antuono 2011).

Using the regression in Figure 2 wheat flowering date predictions were made for the same hypothetical cropping program described in Table 1 (Table 2). This showed that when using one variety it was difficult to get all wheat crops flowering within this window particularly for the long program (40 days). In this scenario even if the sowing program commenced on 30 Apr the last wheat crops would flower just outside this window. In contrast sowing of the 20 day program could be delayed by 20 days and still have all wheat flowering just within this window. As the size of the cropping program increases the imperative to begin sowing early is greater.

There is the opportunity to manipulate anthesis date using variety maturity in conjunction with sowing date. For example, flowering of early sown crops can be delayed by using longer maturity varieties (Hunt et al. 2012). The objective should be to get a good spread of flowering within this window. Frost and heat stress events can still happen within this window and if flowering is too synchronised this can result in unacceptable risks.

Table 2. Calculated start and end dates of wheat anthesis across a cropping program of different durations starting sowing of different dates.

	20 Days		30 Days		40 Days	
Start date	Start	End	Start	End	Start	End
30 Apr	16 Aug	30 Aug	18 Aug	08 Sep	20 Aug	24 Sep
10 May	25 Aug	08 Sep	27 Aug	17 Sep	29 Aug	03 Oct
20 May	03 Sep	17 Sep	05 Sep	26 Sep	06 Sep	12 Oct
30 May	12 Sep	26 Sep	13 Sep	04 Oct	15 Sep	20 Oct
9 Jun	20 Sep	04 Oct	22 Sep	13 Oct	24 Sep	29 Oct

This trial was visited by approximately 200 farmers and industry professionals on 2 September at the WANTFA spring field day. This was right in the middle of flowering for the experiment. Farmers were able to see crops that had flowered up to a month earlier and those that would flower up to a month later. The trial was a useful backdrop to a discussion on the impacts of sowing date on growth, development and yield across a whole cropping program. Farmers could literally walk through the range of sowing (and flowering dates) that they had across their whole farm in the space of about 50m. This generated lively discussion and ultimately lead to farmers having a greater appreciation of sowing dates across their programs.

Conclusions

Our results are specific to the 2014 season, which was characterised by above average growing season rainfall particularly early in the season (April and May) and there were no major frost events. The yield and flowering date response to sowing date will be different in each season depending on temperature and rainfall. Furthermore, other seasons are likely to have different frost and heat stress patterns. Therefore, this type of research needs to be repeated over multiple sites/seasons with different rainfall and temperature profiles. Nevertheless, this simple experiment has shown the importance of early sowing across a whole cropping program and that as the time taken to sow a cropping program increases the need to start sowing early increases.

Acknowledgements

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References

Fletcher AL, Robertson MJ, Abrecht DG, Sharma DL and Holzworth DP (2015). Dry sowing increases farm level wheat yields but not production risks in a Mediterranean environment. Agricultural Systems 136, 114-124.

Hunt J, Fettell N, Midwood J, Breust P, Peries R, Gill JS and Paridaen A (2012). Optimising flowering time, phase duration, HI and yield of milling wheat in different rainfall zones of southern Australia. 16th Australian Agronomy conference, Armidale, Australia.

Shackley B and Anderson W (1995). Responses of wheat cultivars to time of sowing in the southern wheatbelt of Western Australia. Australian Journal of Experimental Agriculture 35, 579-587.

Shackley BJ (2000). Crop management. The wheat book. Principles and practices. W. K. Anderson and J. R. Garlinge. , Agriculture Western Australia: 131-164.

Sharma DL and D’Antuono MF (2011). Predicting Flowering Dates in Wheat with a New Statistical Phenology Model. Agronomy Journal 103, 221-229.

Sharma DL, D’Antuono MF, Anderson WK, Shackley BJ, Zaicou-Kunesch CM and Amjad M (2008). Variability of optimum sowing time for wheat yield in Western Australia. Australian Journal of Agricultural Research 59, 958-970.

Turner NC (2011). More from Less – Improvements in Precipitation Use Efficiency in Western Australian Wheat Production. Rainfed Farming Systems. P. Tow, I. Cooper, I. Partridge and C. Birch. Netherlands, Springer: 777-790.

Turner NC and Asseng S (2005). Productivity, sustainability, and rainfall-use efficiency in Australian rainfed Mediterranean agricultural systems. Australian Journal of Agricultural Research 56, 1123-1136.