Optimum sowing window to maximise canola yield in Western Australia

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Abstract

In the last decade there has been a trend towards earlier sowing of canola by Western Australian farmers. Time of sowing trials were conducted in 3 locations in 2018 to obtain canola yields for very early sowings and to validate the Agricultural Production Systems Simulation (APSIM)-Canola model for very early sowings. A simulation study using the APISM-Canola model determined the optimum sowing window to maximise canola yield for 24 locations and 3 canola cultivars in Western Australia (WA). As a rule of thumb, in WA, in low and medium rainfall locations, the optimum sowing period for a medium maturity cultivar is April; and in the high rainfall locations the optimum sowing window is from early-April to mid or late-May.

Key Words

APSIM, crop modelling, sowing date, simulation

Introduction

In the last decade sowing canola from mid-April has become standard practice in the north of the Western Australia (WA) cropping zone (Fletcher *et al*. 2016). Several studies have reported yield declines with sowing date (5% to 12% per week delay in sowing) (Farre *et al*., 2002). In those studies sowing dates were mainly in May and June However, there is a lack of experimental data on very early sowings before mid-April. Harries and Seymour (2016) found significant yield increases when sowing mid-April compared to end-April in 2015 at Buntine and a small yield increase when sowing end-March compared to mid-April in 2016 at Wongan Hills. The aims of this study were : 1) to conduct time of sowing trials in 2018 to obtain canola yields for very early sowing and to validate the APSIM-Canola model for very early sowing in WA; 2) to perform a long-term simulation study to establish the optimum sowing window to maximise grain yield for different locations in WA.

Methods

Field trials and model validation

Three field trials were conducted in 2018 with a range of sowing dates, including very early sowings. Trials were conducted at Dale, Wongan Hills and Mullewa. Treatments included 11 varieties and four or five times of sowing (TOS) (15 March, 5 April, 26 April, 17 May and 20 June). The varieties were all Triazine Tolerant and included both open pollinated (OP) and hybrid plant types of a wide range of season lengths. OP varieties were: CB Telfer (V.Early), ATR Stingray (Early), ATR Bonito (Early/Mid), ATR Wahoo (Late); Hybrids varieties were: Hyola 350TT (V.early), Bayer InVigor 4510 (Early), Pioneer 44TO2 (Early), Hyola 559TT (Mid), SF Ignite (Mid/late), DG 670TT (Late), Hyola 725RT (Late). Irrigation was applied prior to sowing to assist crop establishment.

The crop simulation model APSIM-Canola (v.7.9) (Farre *et al*. 2002; Keating *et al*. 2003) was run with 2018 climate data for the three locations in order to validate the model. Generic phenology parameters for early, mid and late maturity cultivars were used in the simulations.

Simulation study

APSIM-Canola was used to perform a long-term simulation study for the period 1976-2018 (43 years) at 24 locations (Table 1) in the Wheatbelt of Western Australia, with eight times of sowing from mid-March to end-June at 15 day intervals, three canola cultivars and three soil types (sand, duplex, clay). The locations were chosen to represent low (L), medium (M) and high (H) rainfall zones in the Wheatbelt of WA. The canola cultivars were generic early, mid and late maturity cultivars, equivalent to series 3, 4 and 6 respectively. The three generic soil types, differing mainly in the plant available water content (PAWC), were a sand (PAWC = 57 mm), duplex (PAWC = 90 mm) and clay soil (PAWC = 135 mm). For each simulation, 10 mm irrigation was applied at sowing to ensure that the crop was successfully established. Crop management was simulated to reproduce best management practices in each rainfall zone.

A yield reduction to account for frost and heat damage was calculated for minimum air temperatures below 2 °C and maximum temperatures above 30 °C during a period of approximately 6 weeks around flowering and early grain filling, using the method of Lilley *et al*. (2015).

Results

Field trials and model simulation

Unfortunately, no reliable yield data was obtained for the very early sowings from the 2018 field trials due to bird damage at Wongan Hills and Dale or difficulty in establishing the canola crop in very hot conditions at Mullewa. Yield was obtained for the later sowing dates. APSIM-Canola model assumed that canola established in hot weather conditions with supplementary irrigation but in the Mullewa trial canola failed to establish in hot conditions, despite the irrigation applied. The trial was useful to compare observed crop development to model simulation and to validate the model for phenology. Despite the lack of yield data from the 2018 trials, the APSIM-model can be used for yield response to sowing date studies because the model had previously been validated for WA conditions by Farre *et al*. (2002).

APSIM-Canola model simulated the flowering dates for 3 generic cultivars (early, mid and late season length types), 4 times of sowing and 3 locations with a Root Mean Square Error (RMSE) of 6.5 days (Figure 1). The generic early cultivar in APSIM had the best fit in flowering time to cultivar ATR Stingray at Dale and Mullewa and to CB Telfer at Wongan Hills. The mid maturity cultivar in APSIM had flowering dates that matched best Hyola 559TT, SF Ignite and ATR Bonito. The APSIM late maturity cultivar phenology had the best match with Hyola725RT.

The biggest discrepancies between observed and simulated flowering dates were for very early and very late sowings at Dale, the coolest location. At Dale, for the very early sowing (mid-March), the varieties reached flowering faster than the model simulated (about 12 days earlier). In Dale, for late sowings (mid-May), it was observed that delaying sowing caused flowering dates of the varieties to converge more (observed range 84 to 96 DAS) than was simulated by APSIM (simulated range 80 to 101 DAS). This discrepancy in flowering dates for later sowing dates is due to the way that the model calculates vernalisation, using a daily average temperature. If a 3 hourly temperature was used to calculate vernal time in APSIM, there would be more vernal time accumulated in locations with warm days and cool mornings, and this may improve the simulation of flowering date (Whish *et al* 2018). The response to photoperiod played a minor role compared with the response to vernalisation. In the range of locations and dates of the trials the range of daylength was minimal.

Flowering dates were satisfactorily simulated for the two April sowings in Dale and for all treatments in Wongan Hills and Mullewa (Figure 1).

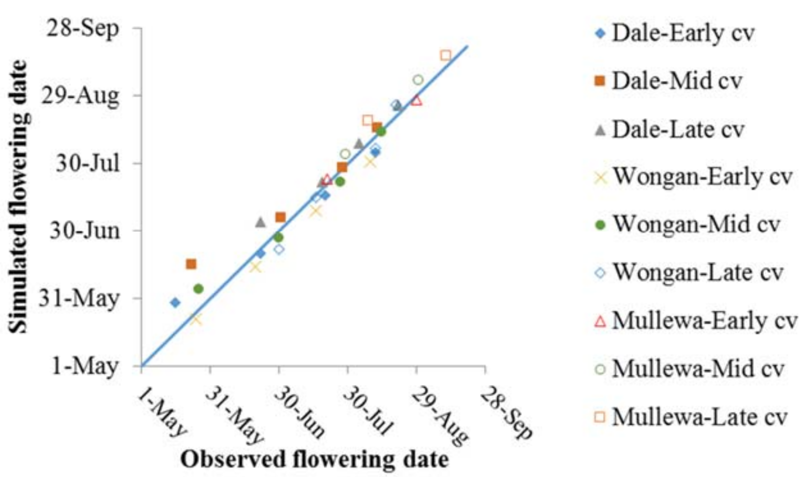


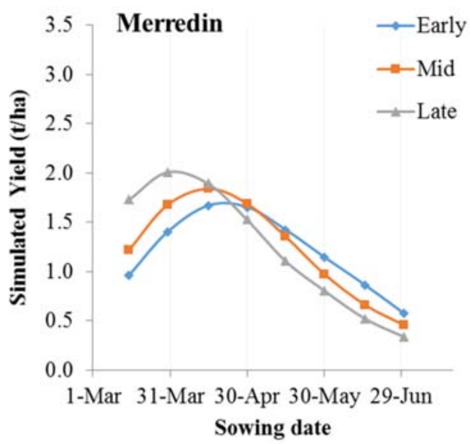
Figure 1. Observed versus APSIM simulated flowering dates for 3 canola cultivars (Early, Mid and Late maturity type), 3 locations (Dale, Wongan Hills and Mullewa) and 4 or 5 sowing dates (15 March, 5 April, 26 April, 17 May and 20 June). Solid line is 1:1 line. Root Mean Square Error for all data is 6.5 days.

Simulation study

Simulated average yields increased from very early sowing up to a peak or maximum yield at the optimum sowing window and decreased with later sowing (Figure 1). Yields were higher for high rainfall locations. Peak simulated yields for a mid maturity cultivar (i.e. ATR Bonito) at Merredin (L) and Kojonup (H) were 1.8 and 2.9 t/ha, respectively (Figure 2).

Once passed the optimum sowing window (peak yield) there is a marked yield decline with sowing date. For example, in Merredin, delayed sowing of ATR Bonito from mid-May to mid-June would incur an average yield penalty of 23 kg/ha/day (163 kg/ha/week) (Figure 2).

Different maturity varieties have slightly different optimum sowing times. The biggest difference in cultivar performance is for early sowing times, where long maturity cultivars out-yielded short and mid maturity cultivars (Figure 2). With late sowings, yield differences between cultivars decreased and short maturity cultivars out-yielded the other cultivars in general.



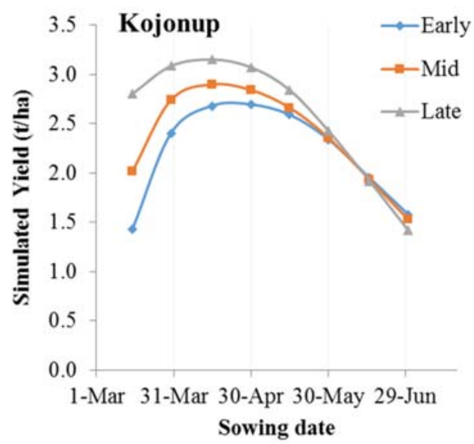


Figure 2. Simulated yield response to sowing date for Merredin (L) and Kojonup (H), for an early, mid and late maturity cultivar. Average simulated yields for the last 43 years of climate data.

The optimum sowing window for each location was defined as the sowing period when average simulated yield was within 95% of the maximum yield (Table 1). The optimum sowing window varied with location and cultivar.

Table 1. Canola optimum sowing window for maximum grain yield for 24 WA locations for a mid-variety (ATR Bonito). Locations grouped according Rainfall zones (Low, Medium, High). Based on APSIM-Canola model and 43 years of climate data.

Low Rainfall Location	Optimal sowing time	Medium Rainfall Location	Optimal sowing time	High Rainfall Location	Optimal sowing time
Mullewa	8 Apr – 3 May	Mingenew	10 Apr – 9 May	Geraldton	14 Apr – 15 May
Dalwallinu	8 May – 1 May	Carnamah	8 Apr – 3 May	Badgingarra	13 Apr – 13 May
Kellerberrin	7 Apr – 27 Apr	Wongan Hills	8 Apr – 6 May	Wandering	6 Apr – 12 May
Merredin	3 Apr – 27 Apr	Cunderdin	5 Apr – 29 Apr	Kojonup	31 Mar – 10 May
Southern Cross	26 Mar – 13 Apr	Northam	8 Apr – 4 May	Frankland	31 Mar – 26 May
Hyden	5 Apr – 27 Apr	Corrigin	7 Apr- 27 Apr	Mount Barker	8 Apr –30 May
Salmon Gums	26 Mar – 25 Apr	Lake Grace	4 Apr- 27 Apr	Gibson	2 Apr – 8 May
		Wagin	2 Apr – 2 May		
		Ongerup	4 Apr – 28 Apr		
		Ravensthorpe	3 Apr – 9 May		

As a rule of thumb, the optimum sowing window for a medium maturity cultivar in low and medium rainfall locations is April, and for high rainfall locations is from early or mid-April to mid-May or late-May. The optimum sowing window began earlier and had shorter duration in low rainfall locations and had longer duration in high rainfall locations (Table 1). For example, the optimal sowing window for ATR Bonito was April 3 to 27 at Merredin (24 days duration) and March 31 to May 10 May at Kojonup (40 days duration) (Table 1).

If the sowing opportunity is late, it is important to assess the probability of achieving a target yield or break-even yield (Figure 3). This information can help growers to make an informed decision regarding when is too late to sow canola. For example, there is only a 9% probability of achieving at least 1.5 t/ha with end-May sowing at Merredin but 93% at Kojonup (Figure 3), based on the last 43 years of climate data.

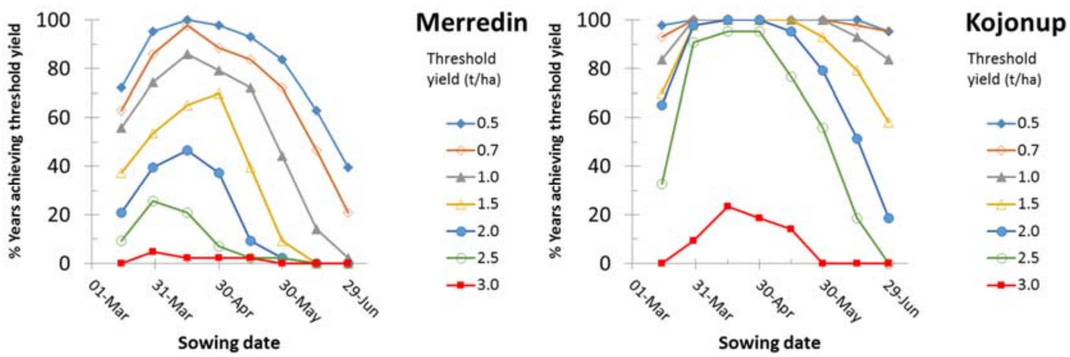


Figure 3. Percentage of years (%) with yield above certain thresholds for different sowing dates, at Merredin (L) and Kojonup (H), sowing a mid-maturity cultivar (i.e. ATR Bonito). Yield thresholds were 0.5, 0.7, 1, 1.5, 2.0, 2.5 and 3.0 t/ha. Based on last 43 years of climate data.

Another assessment of risk is to determine the chances of having a sowing opportunity by certain date. For example, in Merredin there is only 40 % probability of having a sowing opportunity in the optimum sowing window (April). Whereas in Kojonup there is 65% probability of having a sowing opportunity within this location optimum sowing window (early May)

Conclusion

The difficulty establishing canola in hot conditions could limit how early the sowing window can be brought forward in practice. In general, APSIM-Canola can satisfactorily simulate flowering dates across locations and sowing dates. The best model performance for flowering dates occurs in warm locations with little or no vernalisation. More field trials with very early sowings are needed to validate the model for sowing dates outside the traditional sowing window.

Early sowing is the key to maximise canola yield in Western Australia. As a rule of thumb sowing in April will achieve the maximum canola yield in low and medium rainfall locations. For long season environments and/or mild conditions (high rainfall locations) this period extends to mid-May or end-May.

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