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The effect of sowing date, soil moisture and nitrogen rate on flowering and grain yield of hybrid and open-pollinated canola

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Key findings

- Hybrid canola varieties Archer, Nuseed Diamond and Clearfield (CL) Pioneer® 44Y90 (CL) out-yielded open-pollinated (OP) triazine tolerant (TT) varieties ATR Stingray$^{\Phi}$ and ATR Bonito$^{\Phi}$ across all sowing dates. Hybrids generally had more growth and better recovery from frost damage.
- ATR Wahoo$^{\Phi}$ was competitive with hybrid varieties as its slower phenology helped avoid frost damage.
- The highest yield resulted from planting early–mid developing (Pioneer® 44Y90 (CL)) and slow-developing (Archer) varieties on either sowing date, and fast-developing (Nuseed Diamond) on a later sowing date.
- Full irrigation led to an earlier flowering date and average yield increases of 109% over partial irrigation.

Introduction

Recent experiments in the 'Optimised canola profitability' (OCP) project have emphasised the importance of matching sowing date with phenology in order to reduce crop exposure to stress during critical growth periods (Brill et al. 2017). This experiment was designed to further evaluate previous findings in the context of different seasonal conditions and altering water availability to change yield potential. Six varieties with diverse phenology and breeding (hybrid or OP) were sown on two sowing dates with two nitrogen (N) rates across full and partial irrigation. A partial irrigation treatment was required due to the low, decile one, rainfall conditions throughout the season.

This experiment formed part of a larger network of national canola experiments evaluating varietal response to sowing times in a range of climatic zones. Experiments were sown from South Australia's Eyre Peninsula to southern Queensland.

Site details

Location	Condobolin Agricultural Research and Advisory Station
Soil type	Red–brown chromosol, pH_{Ca} 4.7 (0–10 cm)
Previous crops	Wheat 2014, wheat 2015, field peas 2016, wheat 2017
Fertiliser	70 kg/ha mono-ammonium phosphate (MAP) at sowing + Jubilee (flutriafol 500 g/L) at 580 mL/100 kg MAP (fungicide on fertiliser)
Soil available N	95.2 kg/ha (0–120 cm) soil test conducted in February 2018
Growing season rainfall	86.8 mm (1 April–30 September 2018)
Fallow rainfall	159.4 mm (1 November 2017–31 March 2018)
Harvest	Harvested by hand as varieties reached maturity

Treatments

Canola varieties	Nuseed Diamond	Fast, hybrid, conventional
	ATR Stingray$^{\Phi}$	Fast, open-pollinated triazine tolerant (OP TT)
	Pioneer® 44Y90 (CL)	Mid–fast, hybrid, Clearfield (CL)
	ATR Bonito$^{\Phi}$	Mid–fast, OP TT
	ATR Wahoo$^{\Phi}$	Slow, OP TT
	Archer	Slow, hybrid, CL
Sowing date (SD)	SD1: 5 April	
	SD2: 26 April	
Supplementary watering	Full: 234 mm (applied regularly with an overhead lateral irrigator)	
	Partial: 93 mm (applied intermittently with an overhead lateral irrigator)	
Nitrogen rate	Decile 3 yield target: no additional fertiliser	
	Decile 9 yield target: 75 kg N/ha (pre-sowing) + 75 kg N/ha at the 6 to 8-leaf growth stage	

Seasonal conditions

Growing season and pre-season fallow rainfall were both below average for the region, with 86.8 mm of rain falling from 1 April to 31 October. The long-term average (LTA) growing season rainfall is 227.5 mm. Rainfall was below the LTA in all growing season months. There were 30.6 mm in June and 31.8 mm in October, while the remaining five months received a combined 27.2 mm.

Monthly minimum temperatures were lower than average, with 28 days below 0 °C. There were seven major frosts during the growing season (≤–3.0 °C); –3.3 °C (26 June), –4.3 °C (14 July), –4.5 °C (15 July), –4.1 °C (16 July), –3.3 °C (22 July), –3.7 °C (23 July) and –4.0 °C (29 August).

Irrigation

Irrigation was applied at regular intervals within the fully irrigated treatment to target a high yield potential, while intermittent applications were made within the partially irrigated treatment area. Dry conditions throughout the season allowed for a large difference in water treatments. Intermittent irrigation was applied to partially irrigated plots to ensure crops remained alive throughout the season. Fully irrigated plots received enough water to minimise soil moisture limitations.

There was a 40 mm irrigation applied to the partially irrigated blocks in the month preceding SD1, while the fully irrigated blocks received 70 mm over this period. An additional 18 mm was applied to the partially irrigated blocks between SD1 and SD2, while the fully irrigated blocks received 36 mm over the same period. Table 1 shows the irrigation dates and water quantity applied from SD1.

Table 1. Water applied across the partial and fully irrigated treatments at Condobolin, 2018.

Date	7 Mar	19 Mar	20 Mar	21 Apr	22 Apr	22 May	24 May	7 Jun	25 Jul	8 Aug	24 Aug	Total
Full irrigation (mm)	20	30	20	18	18	15	15	20	38	20	20	234
Partial irrigation (mm)	20	–	20	18	–	15	–	–	–	20	–	93

Results

Flowering

From SD1, the fast-developing variety Nuseed Diamond started flowering in late June and early July (Figure 1). ATR Stingray$^{\Phi}$ flowered one week later in early July where moisture was not limiting and up to eight days earlier in partially irrigated plots where moisture stress was evident (Figure 1). The slowest two varieties, Archer and ATR Wahoo$^{\Phi}$, started flowering in early–mid August, up to six weeks later than Nuseed Diamond.

From SD2, ATR Stingray$^{\Phi}$ flowered in mid July where fully irrigated, and up to three weeks later in early August where partially irrigated. Nuseed Diamond began flowering two weeks later

than ATR Stingray$^{\Phi}$, on 28 July in fully irrigated plots. There was little difference in flowering date between Nuseed Diamond and ATR Stingray$^{\Phi}$ where plots were partially irrigated. ATR Bonito$^{\Phi}$, Pioneer® 44Y90 (CL) and ATR Wahoo$^{\Phi}$ all flowered between 10 August and 16 August regardless of irrigation. The slow-developing variety Archer flowered in late August, with fully irrigated plots flowering eight days earlier (21 August) than those partially irrigated (29 August).

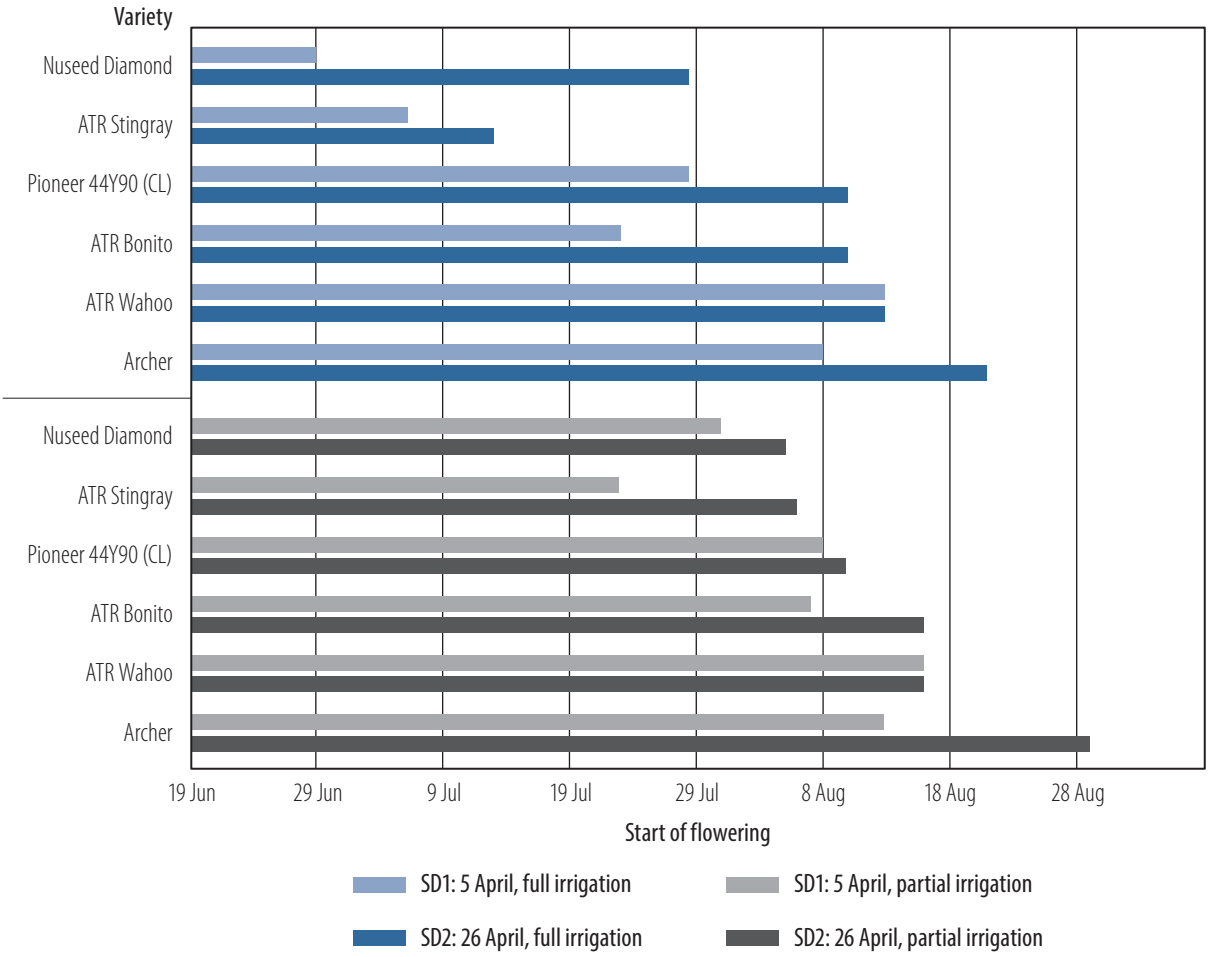

Figure 1. Start of flowering (50% of plants with at least one flower open) for six canola varieties fully irrigated and partially irrigated, sown on two sowing dates at Condobolin, 2018.

Grain yield

There was no significant yield difference recorded on average between SD1 and SD2 across either irrigation treatment. Grain yields within fully irrigated treatments were 109% greater than in partially irrigated treatments, or 1.12 t/ha on average.

Hybrid varieties Archer and Pioneer® 44Y90 (CL) recorded grain yields around 2.5 t/ha across both sowing dates under full irrigation (Figure 2). These treatments flowered in the optimum window with fewer extreme frosts and a mild start to spring, so pods were not exposed to significant periods of environmental stress (Condon 2018).

Sowing date did not significantly affect the ATR Wahoo$^{\Phi}$ grain yield under full irrigation, nor under the limited irrigation treatment.

ATR Bonito$^{\Phi}$, ATR Stingray$^{\Phi}$ and Nuseed Diamond recorded 0.6 t/ha, 0.4 t/ha and 0.3 t/ha yield increases in SD2 compared with SD1 respectively, in the fully irrigated plots. These varieties at SD1 had flowered in mid-winter, increasing exposure to frost during a sensitive development phase, limiting grain yield.

In partially irrigated plots, ATR Stingray$^{\Phi}$ produced a 0.3 t/ha yield increase at SD1 compared with SD2.

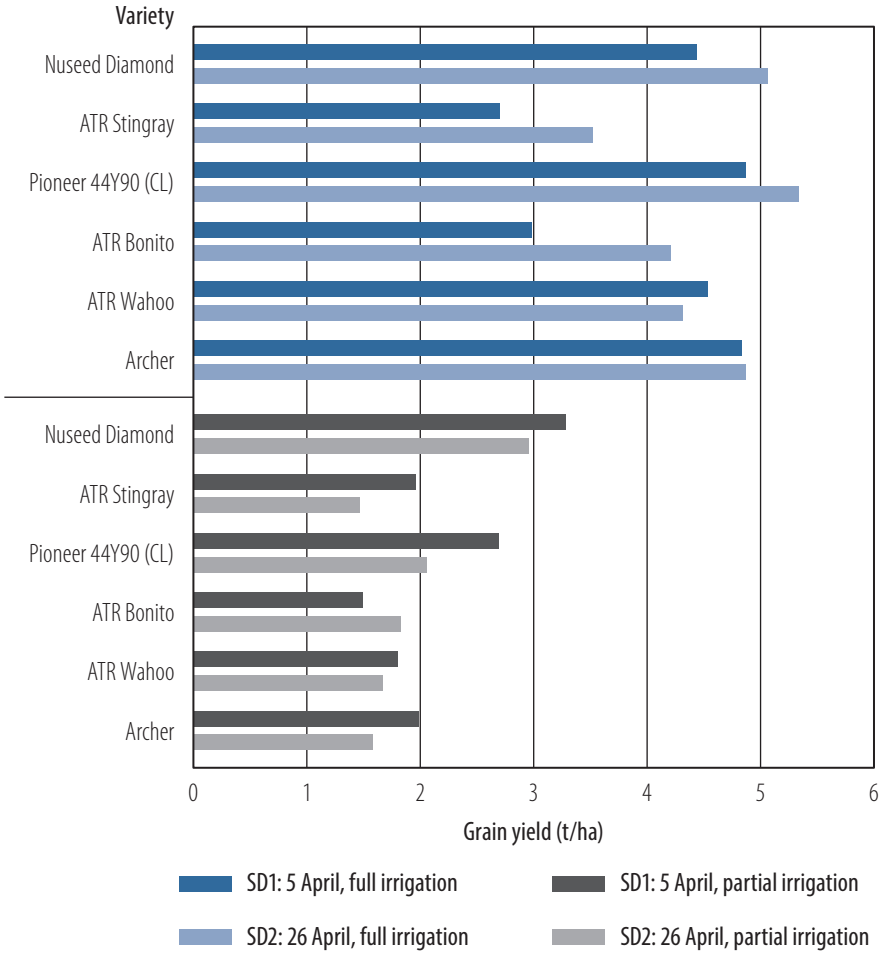

Figure 2. Grain yield of three OP and three hybrid canola varieties sown on two sowing dates (SD1 and SD2) with two irrigation treatments (full and partial) at Condobolin, 2018; l.s.d. (P<0.05) = 0.29 t/ha.

Nitrogen treatment had no significant effect on grain yield within varieties.

All three fully irrigated hybrid varieties recorded significantly higher grain yields than the OP varieties ATR Bonito$^{\Phi}$ and ATR Stingray$^{\Phi}$ regardless of sowing date (Figure 2).

There was no significant difference in grain yield between ATR Wahoo$^{\Phi}$ and the hybrid varieties at SD2 when fully irrigated, while Pioneer® 44Y90 (CL) and Nuseed Diamond both out-yielded ATR Wahoo$^{\Phi}$ at SD1 by 0.5 t/ha and 0.37 t/ha respectively.

Under partial irrigation, the fast-developing hybrid Nuseed Diamond and mid–fast-developing hybrid Pioneer® 44Y90 (CL) recorded significantly higher yields than the remaining four varieties.

Overall, the hybrid varieties under full irrigation recorded an average 0.65 t/ha yield increase in SD1 and an average 0.53 t/ha increase in SD2.

Summary

The outcomes from this experiment support previous research underlining the importance of matching variety phenology with sowing date to limit exposure to environmental stress during key growth stages.

Sowing faster developing varieties early exposed the crop to frost during the sensitive flowering/podding phase. Sowing slower developing varieties early is favourable as the crop remains vegetative at the time when frost risks are high. By implementing sound agronomic practices (variety choice and nitrogen management) in conjunction with matching phenology and sowing date, yields can be significantly improved.

This experiment also underlined the important role plant available water can play in mitigating yield losses related to frost damage, particularly amongst hybrid varieties. Crops affected by frost have the ability to recover and re-establish a profitable yield with increased plant available moisture. While this demonstrates the frost recovery and associated yield benefits observed when water is non-limiting, it also reinforces that current agronomy principles regarding sowing date and phenology are relevant regardless of water availability.

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