Canola yield and heat stress in the Northern Agricultural Region

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Key messages

- Yield was highest from earlier sown plants; mid-May sown plants yielded only 18% of those sown in mid-April.
- This occurred despite warm autumn conditions which caused higher pod abortion on the main stems of mid-April sown plants.
- Irrigation in spring reduced pod abortion by 15%; this highlights the advantage in using agronomic methods such as stubble retention and canopy management to conserve moisture through to the podding stage.

Aims

To quantify the impact of high temperature and water stress at flowering on canola yield.

Background

Canola is most sensitive to heat stress from a week before flowers open until a week after. The critical temperatures range from 27 to 30°C (Kirkegaard et al 2017, Morrison and Stewart 2002). Many canola crops in the Northern Agricultural Region flower when temperatures are high enough to limit yield and there is concern that this will become more frequent and severe if spring temperatures increase, as predicted by climate change models.

There are two ways to mitigate this risk include: 1) encourage early flowering, before temperatures are too high, by sowing early and using a short season variety; and 2) reducing heat stress experienced by the crop by managing soil moisture so plants can transpire during flowering and podding to keep cool.

This trial was designed to look at both of these mechanisms by sowing at different dates and implementing +/- irrigation treatments to manipulate temperatures at flowering and plant water stress.

Methods

Canola (cv. Pioneer 43Y23 RR) was sown in 1.0 m rows at Geraldton on 4 dates (April 18, April 28, May 8 and May 18). At each TOS there were +/- irrigation treatments, hence there were 8 treatments; each replicated 5 times. Plant growth stage and volumetric soil moisture at 0-10 cm was monitored twice weekly. From early August moisture was measured to 1.0 m using a Sentek 2000 Diviner. Temperature and humidity were data logged hourly.

At the commencement of flowering of the earliest sowing time a rainout shelter was placed above unirrigated plots and left in place through to harvest. Irrigated plots had 10mm irrigation treatments applied twice weekly from the end of August through to the third week in September. Stem sap flow was measured on the largest stems of two plants each in the irrigated and unirrigated plots of TOS4 from 12 September to 17 October using SF-3 sap flow sensors (Edaphic Scientific, Australia) logged with a Campbell Scientific CR10X datalogger at 30 minute intervals. Plants were hand harvested as they reached maturity, from the September 22 to October 2.

Results

Seasonal conditions

Rainfall was 315mm for the year to Nov (Table 1). This compares to a long term average for Geraldton of 445mm. Monthly rainfalls for March April and May were lower than long term average and irrigation was used to sow the trial. May and June were also warmer than average. Recording of temperature from the Bureau of Meteorology Geraldton town site ceased in 1953 and the Geraldton Airport site temperature is only available from 2011 to 2017. As such Mullewa temperature data is included in Table 1. This indicates 2017 April, May and June maximum temperatures were 2-3°C > long term.

Table 1. 2017 monthly rainfall (mm) from BOM Geraldton Airport station (8315). Monthly maximum temperature averages from BOM Mullewa station (8095).

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Geraldton Rainfall	33	18	6	0	31	41	49	80	50	7	-	-	315
Mullewa max	37.6	35.2	33.9	30.9	25.4	23.1	19.8	20.4	23.4	28.2	33.4	34.9	

temp 2017													
Mullewa max temp 1925-2017	36.8	36.5	33.7	28.8	23.7	20.0	18.8	20.2	23.5	27.3	31.2	34.5	

Plant development

Flowering on the main stem commenced as early as June 6 and as late as July 31, depending on sowing date, and finished as early as June 26 and as late as August 21. April 18 sown plants had the shortest main stem flowering period of 20 days, the rapid plant development corresponding to the higher temperatures. Main stem flowers were recorded on plants sown on April 28 for 31 days, May 5 32-38 days (-/+ irrigation) and 18 May 21 to 25 days (-/+ irrigation). The very early flowering of April 18 sown plants meant they were exposed to more hours of high temperature during main stem flowering than later sowing times but fewer hours or high temperature over the total flowering period (Table 2).

Table 2. Average temperatures from data logger (hourly intervals) and total hours above specified temperatures during the main stem flowering period and total flowering period for plants sown on different dates at Geraldton in 2017.

	Main stem flowering period				Total flowering period			
	TOS1: 18/04/2017	**TOS2: 28/04**	**TOS3: 8/05**	**TOS4: 18/05**	**TOS1: 18/04**	**TOS2: 28/04**	**TOS3: 8/05**	**TOS4: 18/05**
Average temp°C	18.3	16.0	16.2	15.8	16.7	16.0	16.3	17.0
Hours > 27°C	45	3	3	0	48	3	17	64
Hours > 28°C	34	1	1	0	35	1	10	38
Hours > 29°C	17	0	1	0	17	1	6	28
Hours > 30°C	9	0	1	0	9	1	5	20

Soil moisture

There were clear differences in soil moisture between irrigated and unirrigated treatments during August and September with irrigation increasing water down to a depth of 60 to 70 cm. Between 13 and 22 September the diurnal pattern of sap flow and sap velocity was almost identical in irrigated and unirrigated plants, suggesting soil water had not been sufficiently depleted to retard transpiration. Between 7 and 16 October sap flow was significantly reduced in unirrigated plants (data not presented).

Plant growth

Earlier sown plants produced more dry matter ($P < 0.001$, Table 3) and there was a trend for irrigation to increase total biomass, especially in early sowing times, although this was not statistically significant.

Plant podding

Averaged across irrigation treatments TOS1 plants initiated almost twice as many pods (fertile plus aborted) as TOS4 plants (Table 3). Irrigation increased pod initiation by 6% compared to unirrigated but this was not significant. The proportion of total initiated pods that aborted (aborted %) was not affected by sowing date but was reduced by irrigation ($P < 0.001$). Averaged across all sowing times irrigation reduced pod abortion by around 15%.

Yield

Irrigated early sown plants produced highest yield (Figure 1). Yield declined with each delay in sowing date and TOS4 produced only 18% as much yield as TOS1 (mean of irrigation treatments). The proportion of total yield carried on the main stem was very low at 1.9% for the mid-April sowing and 5% for the mid-May sowing date. Hence whilst temperatures during main stem flowering of mid-April sown plants were higher and pod abortion rates were higher (Table 4) compensating seed production from later flowering branches resulted in higher yield potential and harvest index ($P < 0.001$) (Table 3).

There was a clear trend for irrigation to increase yield, particularly on earlier sown plants, but the variability in single plant yield meant this was not statistically significant (Figure 1, Table 3). Because irrigation main effect was not significant the TOS irrigation interaction was also considered not significant despite a low P value.

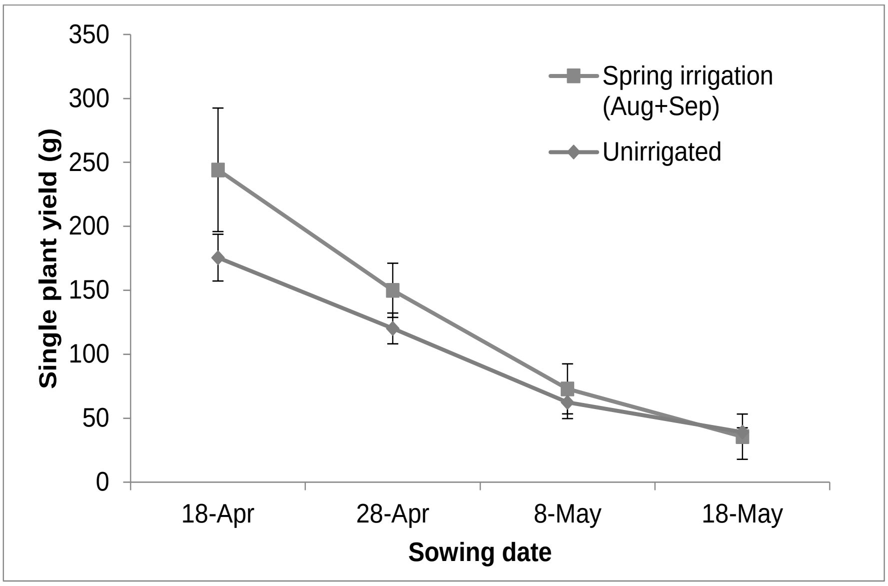

Figure 1. Plant yield (g/plant) as affected by sowing date and irrigation at Geraldton in 2017.

Table 3. Final plant dry weight (g/plant), number of pods per plant and seed yield (g/plant) of canola sown at four times of sowing x +/- irrigation at Geraldton in 2017.

Sow date	Dry matter (g/plant)	Fertile pods /plant	Aborted pods/ plant	Total pods initiated/ plant	Aborted pods (% of total)	Yield (g)
18-Apr	677	3422	2261	5682	41	207
28-Apr	453	3211	2278	5488	42	132
8-May	267	1893	1528	3421	45	64
18-May	217	1660	1343	3003	44	35
Irrigated	434	2976	1544	4520	35	123
Unirrigated	373	2116	2161	4277	51	96
Overall	403	2546	1852	4398	43	109
P value sow date	<0.001	<0.001	<0.05	0.002	NS	<0.001
Lsd sow date	143	957	769	1584		43.4
P value irrigation	NS	<0.05	<0.05	NS	<.001	NS
Lsd irrigation		676	544		6	30.7

None of the interactions of sow date and irrigation were significant

Conclusions

Yield was highest from early sowing despite heat stress reducing main stem pod set of mid-April sown plants due to pod set occurring on branches at a later date. Hence, it was best to sow early even though autumn conditions were unusually warm.

It is challenging to separate the effects of heat stress (the effect of short term temperature spikes) and terminal drought on yield as in practice the two usually occur together. However, we showed that maintaining high soil moisture levels with irrigation reduced pod abortion by an average of 15%. This suggests that any practice that can conserve soil water until the reproductive stage, such as conservation tillage, stubble retention and altering row spacing and plant density combinations may reduce pod abortion.

The results from this trial reinforce the idea that in the Northern Agricultural Region heat stress across the total flowering period is most likely to be avoided by sowing in April and by using short season varieties. Conserving soil moisture using agronomy to manage the crop canopy such as wide row spacing and low plant density is also likely to improve the plants ability to tolerate high temperatures.

Key words

Canola, heat stress, irrigation, sowing time

Acknowledgments

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