Yield performance of open-pollinated and hybrid TT, RR, and IT canola in the low and high rainfall areas of WA

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Key messages

- RR canola produced the highest yield at both the low (Cunderdin) and high (Kojonup) rainfall areas.
- The mid flowering TT, RR and Clearfield/conventional canola produced higher yield than the early flowering ones in the high rainfall area (Kojonup) while the difference in yield between the early and mid flowering varieties was minimum in the low rainfall area (Cunderdin).
- Open-pollinated TT canola produced similar yields to hybrid TT canola in both the low and high rainfall areas. Open-pollinated RR canola yielded less than hybrid RR canola in the high rainfall area while no yield difference was observed between them in the low rainfall area.
- The response of canola to N is highly dependent on the initial soil N. Yield did not respond to N application at Cunderdin with a high initial soil mineral N but was increased by 63-83% by applying 150 kg N/ha at Kojonup with a low initial soil N and high rainfall condition.

Aims

Determine yield formation of open pollinated and hybrid canola with four herbicide tolerance (HT) groups (Triazine tolerant (TT), imidazole-tolerant (IT) (Clearfield), conventional, and roundup ready (RR)) under different environments and identify physiological traits associated with high and stable yield across the rainfall zones of WA through contrasting phenology, early vigour and yield potential.

Method

Two field experiments involving a number of open-pollinated (OP) and hybrid TT, CL/C and RR canola were conducted at the low (Cunderdin) and high (Kojonup) rainfall areas of WA in 2013. The experimental design at each site include 21 canola varieties with contrasting phenology (early and mid flowering), early vigour (low and high), and yield potential (low and high). They are grouped as TT, IT (Clearfield) (CL), conventional, and RR canola. Since Clearfield and conventional canola perform similarly in terms of growth and yield, we classified these two HT groups into one group named as CL/C. Two N rates (0, 100-150 kg N/ha) was imposed to investigate the genotypic differences in N uptake and use efficiency. A split-plot experimental design was used with the HT groups being the whole plot and variety subplot. The treatments were replicated 3 times at each site. The plot size was 20m by 1.54 m at Cunderdin and 30 m by 1.54 m at Kojonup. Seeding rates was set to achieve 40 plant m^{-2} based on the seed weight measured prior to seeding and the crop was sown at a row space of 22 cm. The crop was sown on 8 May 2013 at Cunderdin and on 9 May 2013 at Kojonup. The N applications were split as 20% at seeding, 40% at six weeks after seeding, and 40% at flowering. Weeds were controlled with corresponding herbicides in each HT group. Oil content, protein and moisture content were measured using a grain analyser (FOSS Infratec 1241). Seed yield was calculated based on the seed weight from the whole

plot harvested by a plot harvester. Seed yield were standardized and reported at 8% of moisture and 42% of oil content for all varieties. The previous crop was clover-based pasture at Cunderdin and its initial soil mineral N at sowing was 216 kg N/ha. The previous crop was wheat at Kojonup and its initial soil mineral N was 86 kg N/ha. The growing seasonal rainfall was 244 mm from May to October at Cunderdin and 429 mm at Kojonup.

Table 1 Seed yield (t/ha) of four herbicide tolerant (HT) canola (Clearfield: CL; Conventional: C; Roundup Ready: RR, and triazine tolerant: TT) at Cunderdin and Kojonup in 2013. Seed yield was adjusted at a 8% moisture content and 42% of oil content.

HT	Cultivars	Flowering	Pollination	Cunderdin			Kojonup		
				0 kg N/ha	150 kg N/ha	Mean	0 kg N/ha	150 kg N/ha	Mean
C	AV Garnet	Mid	OP	1.82	1.65	1.73	2.26	3.26	2.76
C	AV Zicorn	Mid	OP	1.55	1.40	1.48	1.51	2.87	2.19
C	Hyola 50	Mid	Hybrid	1.73	1.74	1.74	2.44	3.50	2.97
CL	H 575CL	Mid	Hybrid	1.70	1.54	1.62	2.10	3.04	2.57
CL	Pioneer 43C80	Early	OP	1.45	1.24	1.35	1.40	2.58	1.99
CL	Pioneer 43Y85	Early	Hybrid	1.69	1.58	1.63	1.65	3.18	2.42
CL	Pioneer 45Y86	Mid	Hybrid	2.01	1.97	1.99	2.23	3.70	2.97
	Mean			1.71	1.59	1.65	1.94	3.16	2.55
RR	CB Status RR	Mid	OP	1.88	2.04	1.96	1.63	2.93	2.28
RR	GT Cobra	Mid	OP	1.89	1.81	1.85	1.60	3.38	2.49
RR	Hyola 404RR	Early	Hybrid	2.11	2.23	2.17	2.44	3.78	3.11
RR	Hyola 505RR	Mid	Hybrid	2.03	1.95	1.99	2.26	3.81	3.04
RR	Pioneer 43Y23RR	Early	Hybrid	2.07	2.03	2.05	2.33	3.83	3.08
RR	Pioneer 45Y22RR	Mid	Hybrid	1.95	2.02	1.98	2.28	3.87	3.07
	Mean			1.99	2.01	2.00	2.09	3.60	2.84
TT	ATR Gem	Mid	OP	1.39	1.30	1.35	1.96	3.41	2.68
TT	ATR Stingray	Early	OP	1.52	1.54	1.53	1.48	2.68	2.08
TT	CB Atomic	Mid	OP	1.66	1.64	1.65	2.11	3.12	2.61
TT	CB Telfer	Early	OP	1.10	1.14	1.12	0.84	2.22	1.53
TT	Crusher TT	Mid	OP	1.69	1.62	1.65	1.77	3.47	2.62
TT	Hyola 450TT	Early	Hybrid	1.63	1.44	1.53	1.87	3.60	2.73
TT	Hyola 555TT	Mid	Hybrid	1.50	1.43	1.47	1.80	3.43	2.61
TT	Hyola 559TT	Mid	Hybrid	1.72	1.70	1.71	2.03	3.69	2.86
	Mean			1.53	1.48	1.50	1.73	3.20	2.47
	Grand mean			1.72	1.67		1.90	3.38	
l.s.d. (P = 0.05) for HT						0.27			0.43
l.s.d. (p = 0.05) for cultivars under the same HT						0.26			0.38
l.s.d. (P = 0.05) for N					0.03			0.13	
l.s.d. (P = 0.05) for N under the sa,e HT					0.27			0.23	

Results

At Cunderdin, RR canola produced higher ($P < 0.05$) yield than CL/C and TT canola while CL/C and TT canola produced similar yield (Table 1). There was no significant difference in yield between the three HT types at Kojonup. More importantly, there were significant ($P < 0.001$) differences in yield between the varieties within the same HT group. For example, Crusher TT, CB Atomic HT, Hyola 559TT yielded higher yield than other TT varieties at Cunderdin while ATR Stingray and CB Telfer yielded lower than the rest of TT canola at Kojonup. The yield in Pioneer 45Y86 and Hyola 50 was higher than Pioneer 43Y85, Pioneer 43C80, Hyola 575CL and AV Zicorn at Cunderdin and Kojonup. Similarly, CB Status RR and GT Cobra produced lower yield than the rest of the RR canola at Kojonup. The difference in yield between the varieties within the same HT type is caused by phenological difference and the growth difference from the pollination types and is discussed in detail below.

Comparing the pollination groups of OP vs hybrid system, the hybrid canola produced 24% higher yield than the OP ones in Kojonup and 11% higher yield at Cunderdin (Table 2). This indicates that the potential of hybrid canola in the high rainfall area may be greater than in the low rainfall area, but this must be balanced against the performance of individual cultivars. However, there exist individual OP varieties that match hybrid yield within TT and CL and conventional technologies. For example, OP TT canola (Crusher TT and CB Atomic) produced a similar yield as hybrid TT canola and OP conventional canola (AV Garnet) yielded as much as hybrid CL canola. OP RR canola (CB Status RR and GT Cobra) tended to have lower yields than the hybrid canola in Kojonup and similar yields to the hybrid ones at Cunderdin.

Overall, the mid-flowering varieties yielded significantly higher than the early flowering at both locations. The longer-season mid flowering varieties yielded 13% more than the early flowering ones in Kojonup (Table 2). However, although statistically significant at Cunderdin, the advantage of mid-flowering was minor. Considering the fact of the above the long term averages spring rainfall and a relatively mild seed filling period in 2013, this minor advantage could disappear or even become negative if the seasonal rainfall is at and below the average. We are conducting these trials over years, and will continue to pay close attention to the relationship between phenology and seasonal rainfall in future. It is worthwhile to notice that two of early flowering RR canola (Hyola 404RR and Pioneer 43Y23RR) and one early flowering hybrid TT canola (Hyola450TT) produced similar yields to the mid flowering RR canola at both locations. The early flowering canola (Pioneer 43C80, CB Telfer and ATR Stingray) yielded significantly lower yield than the mid-flowering ones in their respective HT groups in the high rainfall area because they were unable to fully utilize the longer growing season and available water.

Table 2 The effect of flowering time and pollination type on yield of canola (t/ha) at the low (Cunderdin) and high (Kojonup) rainfall area in 2013.

Phenology	Kojonup	Cunderdin	Pollination	Kojonup	Cunderdin
Early flowering	2.42	1.63	Open-pollinated	2.32	1.59
Mid flowering	2.73	1.73	Hybrid	2.88	1.77
lsd ($P = 0.05$)	0.09	0.06	lsd ($P = 0.05$)	0.08	0.04

There was contrasting responses of canola to N between Kojonup and Cunderdin. At the Cunderdin site with the high initial soil mineral N at sowing, all 3 types of canola did not respond to the N application. In contrast, all 3 types of canola responded significantly to N application of 150 kg N/ha, with a yield increase of 63-83% compared with the nil N treatment.

Conclusion

While it is essential to confirm these results over a range of locations and seasonal rainfalls, our preliminary data has highlighting some important principles. OP and hybrid TT, IT, RR canola provide growers with a range of choices to select for different rainfall conditions and growing season lengths. TT and RR canola is probably more suitable for the low rainfall areas because of its low cost in TT canola and the high yield potential of hybrid RR canola. In the high rainfall area, the longer-season mid flowering canola has high yield potential and hybrid CL/C and hybrid RR canola can produce higher yield than OP canola. There was no significant yield advantage of CL/C canola compare to TT canola in lower rainfall area and therefore it is unlikely to be adopted as a result of high costs associated with seed and weed management. The effect of crop growth pattern and yield components on yield formation is currently under study. With these additional data, we expect to further dissect yield formation and identify the traits associated yield variation between the HT groups and between the varieties within the same HT group.

Key words

Canola, phenology, pollination, yield, herbicide tolerance

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