Managing clethodim resistant ryegrass in canola with crop competition and pre-emergent herbicides

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Key findings

- Two seasons of trials have demonstrated there are differences in crop vigour / biomass production within open pollinated varieties ATR Stingray (less competitive) and ATR Bonito (more competitive) relative to a competitive hybrid variety Hyola559TT.
- In 2017, at Hart and Roseworthy both OP and hybrid varieties provided similar crop competition for ryegrass control.
- A combination of effective pre-emergent herbicides with competitive canola varieties combines two tactics to reduce ryegrass seed set.

Why do the trial?

Clethodim (Select®) has been a major herbicide used for the control of annual ryegrass in canola and pulse crops. However, resistance to clethodim in ryegrass has been increasing in the southern region, which makes it more difficult for the growers to control this weed. Some growers have responded by using increased rates of Clethodim, but weed control achieved can still be disappointing. As canola is more sensitive to clethodim than pulse crops, increasing clethodim dose can cause crop damage. Even though there are currently two different types of herbicide tolerant canola available in SA (TT, triazine tolerance; CLF, imidazolinone tolerance), each of these types has weaknesses for weed management and all have relied on clethodim to manage annual ryegrass.

Crop competition has long been known to be a useful tool in weed management. Practices such as decreasing row spacing, increasing seed rates, and growing more competitive varieties have all been demonstrated to reduce weed numbers. With an increasing number of canola varieties introduced to the market each season there is limited understanding of their ability to compete with weeds.

Here we report results from field trials undertaken at Hart and Roseworthy to demonstrate that crop competition afforded by a hybrid canola in combination with pre-emergent herbicides can reduce ryegrass seed set.

Materials and Methods

Field trials were established at Hart and Roseworthy in 2017 to investigate the effect of crop competition and different pre-emergent herbicides and their mixtures on annual ryegrass control in canola. The trials were established in a split-plot design to compare a triazine (TT) open-pollinated (OP) variety (ATR Bonito) with a TT-Hybrid (Hyola559TT) under eight pre-emergent herbicide strategies (Table 1).

Table 1. Pre-emergent herbicide strategies used in canola competition trial at Hart & Roseworthy in 2017.

Herbicide treatment	Herbicides applied
1	Nil
2	Propyzamide (1.0 L/ha) pre
3	Butisan® (1.5 L/ha) pre
4	Altiplano® (3 kg/ha) pre
5	Atrazine (1.1 L/ha) pre + atrazine (1.1 L/ha) post
6	Propyzamide® (1 L/ha) pre + atrazine (1.1 kg/ha) post
7	Butisan® (1.5 L/ha) pre + atrazine (1.1 kg/ha) post
8	Altiplano® (3 kg/ha) pre + atrazine (1.1 kg/ha) post

Seeding rate was adjusted according to seed viability and size to obtain a target density of 35 plants/m^2, with ATR Bonito (equivalent to 2.3 kg seed/ha) and Hyola559TT (equivalent to 2.9 kg seed/ha) sown on the 3rd of May at Hart. Because of the adverse sowing conditions at Roseworthy higher seed rates for ATR Bonito (2.8 kg seed/ha) and Hyola559TT (3.4 kg seed/ha) were sown on the 12th of May. The replicated trials were sown using a standard knife-point press wheel system on 22.5 cm (9") row spacing. Fertiliser rates were applied as per district practice, with glyphosate applied for pre-sowing weed control. Pre-emergent herbicides were applied with a 2 m pressurised handboom within a few hours of sowing. Atrazine was applied post-emergent (treatments 5, 6, 7 & 8) to ryegrass at the 1-3 leaf growth stage.

Assessments included ryegrass control (reduction in plant and seed set), crop establishment, and grain yield. Data was transformed by a square root if required to stabilise variances. Data from the competition trials was analysed by 2-way ANOVA with variety and herbicide treatment as factors. Where the result of the ANOVA was significant, means were separated by Fisher's protected LSD test ($P \leq 0.05$).

Results

There was no effect of herbicide treatment on canola establishment at Roseworthy (~50 plants/m^2). However higher establishment was observed for ATR Bonito (28 plants/m) compared to Hyola559TT (24 plants m^{-2}) at Hart, respectively (data not presented). Higher crop establishment at Roseworthy relative to Hart resulted from the higher seed rate used at Roseworthy to compensate for the adverse sowing conditions.

At Hart there were differences between herbicide treatments, variety and their interaction on ryegrass control early in the season (Table 2). Only herbicide treatment was significant at Roseworthy (Table 3). Despite the low ryegrass infestation at Hart (<90 plants/ m^2), nearly 2-fold more ryegrass was present in plots sown to ATR Bonito compared to Hyola559TT, whereas equal densities (83 plants/m^2) were observed between varieties at Roseworthy. At both sites herbicides propyzamide, Butisan® and Altiplano® provided similar effective control (>74%) irrespective of variety. In comparison weed control in ATR Bonito with atrazine was <50%. Atrazine requires adequate soil moisture for activation, and rainfall deficits in May and June at both field sites may have compromised the herbicides activity.

*Table 2. Influence of canola variety and herbicide strategy on ryegrass density 6 weeks after sowing at Hart in 2017. *Post atrazine not yet applied.*

Herbicide treatment	T1	T2	T3	T4	*T5	*T6	*T7	*T8	Average
	Ryegrass density (plants m^2)								
Variety									
ATR Bonito	88	12	20	11	38	25	14	17	28
Hyola559TT	40	11	11	17	15	15	17	15	18
Average	64	12	16	14	26	20	16	16	
Interaction	<0.01								
Herbicide treatment	<0.001								
Variety	<0.01								

*Table 3. Influence of canola variety and herbicide strategy on ryegrass density 6 weeks after sowing at Roseworthy in 2017. *Post atrazine not yet applied.*

Herbicide treatment	T1	T2	T3	T4	*T5	*T6	*T7	*T8	Average
	Ryegrass density (plants/m^2)								
Variety									
ATR Bonito	210	40	51	38	128	43	71	82	83
Hyola559TT	227	58	63	57	93	44	72	45	83
Average	219	49	57	47	111	44	72	64	
Interaction	NS								
Herbicide treatment	<0.001								
Variety	NS								

At Roseworthy herbicide treatments propyzamide and propyzamide + POST atrazine were the most effective options providing >82% control relative to the nil 12 WAS (405 plants/m^2; Table 4). Propyzamide is known for its moderate persistence and the benefit of its extended residual control was obvious during this season on the larger ryegrass population at Roseworthy.

Table 4. Influence of canola variety and herbicide strategy on ryegrass density 12 weeks after sowing at Roseworthy in 2017.

Herbicide treatment	T1	T2	T3	T4	T5	T6	T7	T8	Average
	Ryegrass density (plants/m^2)								
Variety									
ATR Bonito	420	70	166	96	96	53	121	45	134
Hyola559TT	390	72	103	91	191	56	89	57	131
Average	405	71	135	94	144	54	105	51	
Interaction	NS								
Herbicide treatment	<0.001								
Variety	NS								

At both Hart and Roseworthy herbicide treatment, but not variety, impacted the number of ryegrass heads present at the end of the season (Table 5 and 6). However, herbicide responses were somewhat different between sites, with atrazine + POST atrazine providing the greatest reduction in seed production at Hart (95%), whereas propyzamide + POST atrazine (82% reduction) and Altiplano® + POST atrazine (83% reduction) were the most effective treatments at Roseworthy. Differences in weed pressure were obvious between sites, and the more robust herbicide treatments (i.e. propyzamide or Altiplano® + POST atrazine) prevailed at Roseworthy were ryegrass was present in large numbers. In contrast atrazine + POST atrazine was only effective on the smaller weed population at Hart, where rainfall conditions improved later in the season.

Table 5. Influence of canola variety and herbicide strategy on ryegrass head density at Hart in 2017. Values in average column with different letters are significantly different (P = 0.05).

Herbicide treatment	T1	T2	T3	T4	T5	T6	T7	T8	Average
	Ryegrass seed heads (heads/m^2)								
Variety									
ATR Bonito	92	14	13	17	5	15	12	4	22
Hyola559TT	78	11	8	17	3	15	10	8	19
Average	85a	13bc	11bc	17b	4d	15b	11bc	6cd	
Interaction	NS								
Herbicide treatment	<0.001								
Variety	NS								

There was no effect of variety on ryegrass seed production at either Hart or Roseworthy. This is in stark contrast to previous studies where seed set was often reduced by as much as 40-50% with the more competitive hybrid versus OP variety. For example, at Roseworthy in 2016 (Kleemann et al 2016), Hyola559TT reduced seed set by 50% compared to ATR Stingray (OP). In these studies ATR Bonito, whilst an OP variety, appeared to show more comparable early vigour and growth to hybrid Hyola559TT. This was evident from the similar NDVI values (measure of green vegetative growth) recorded from crop emergence through to flowering for both varieties (Figure 1 and 2).

Table 6. Influence of canola variety and herbicide strategy on ryegrass head density at Roseworthy in 2017. Values in average column with different letters are significantly different (P = 0.05).

Herbicide treatment	T1	T2	T3	T4	T5	T6	T7	T8	Average
	Ryegrass seed heads (heads/m^2)								
Variety									
ATR Bonito	591	194	238	278	171	90	184	77	228
Hyola559TT	442	178	162	195	245	97	146	100	196
Average	516a	186b	200b	236b	208b	93c	165bc	88c	
Interaction	NS								
Herbicide treatment	<0.001								
Variety	NS								

Previous research (Lemerle et al. 2014) reported that hybrids were generally more competitive than OP varieties but concluded that there is considerable variation in the competitiveness between varieties in their ability to suppress weed growth.

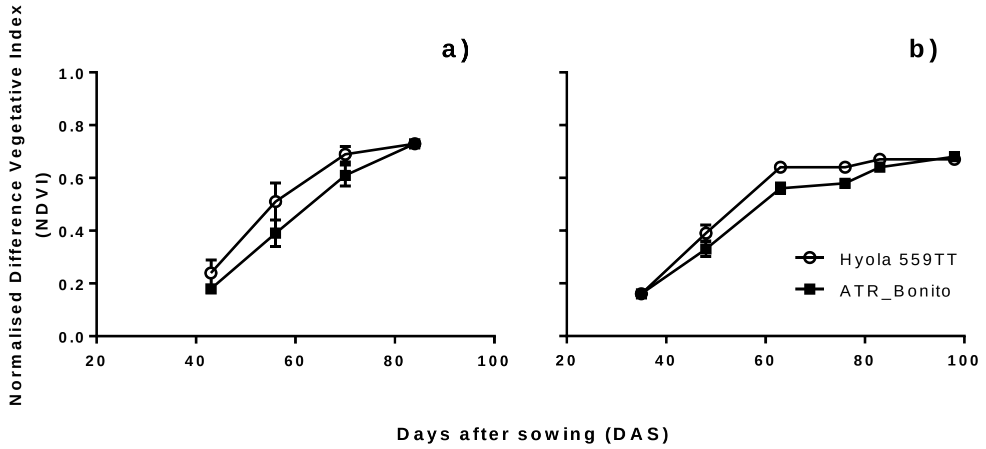

Figure 1. NDVI (Normalised difference vegetative index) of canola varieties, ATR Bonito (■) and Hyola559TT (O) measured during pre-flowering crop development at Hart (a) and Roseworthy (b). To avoid confounding effect of ryegrass on NDVI values only data from herbicide treatment 2, where ryegrass control was greatest, are presented.

Figure 2. Nil treated Bonito TT (left) and Hyola 559TT (right) taken at Hart on 1st July 2017.

Table 7. Influence of canola variety and herbicide strategy on canola yield at Hart in 2017. Values in average column with different letters are significantly different (P = 0.05).

Herbicide treatment	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**Average**
	Canola yield (t/ha)								
Variety									
ATR Bonito	1.55	1.65	1.55	1.63	1.70	1.47	1.82	1.70	1.63a
Hyola559TT	1.41	1.42	1.36	1.36	1.51	1.35	1.50	1.38	1.41b
Average	1.48	1.53	1.43	1.49	1.60	1.41	1.66	1.54	
Interaction	NS								
Herbicide treatment	NS								
Variety	<0.001								

At Hart there was an effect of variety, but not herbicide or its interaction with variety on canola yield (Table 7). This is not entirely surprising given the weed interference at this site would likely have been negligible given the small population present, and that ryegrass on a per plant basis is far less competitive than many of the other grass weeds (i.e. brome and wild oats). Consequently, the small but significant yield difference between varieties (1.63 t/ha vs 1.41 t/ha) is more likely a reflection of the shorter growing season at Hart which would have favoured ATR Bonito which is an earlier flowering type than Hyola559TT. In comparison the impact of weed interference on grain yield was significant at Roseworthy, and there was a significant effect of herbicide (P<0.001) on canola yield (Table 8). Not surprisingly yields were significantly higher for all herbicide treatments relative to nil treatments because of the larger ryegrass population. In response to improved weed control grain yields were highest for both varieties treated with propyzamide + POST atrazine (1.47 t/ha) and Altiplano® + POST atrazine (1.46 t/ha).

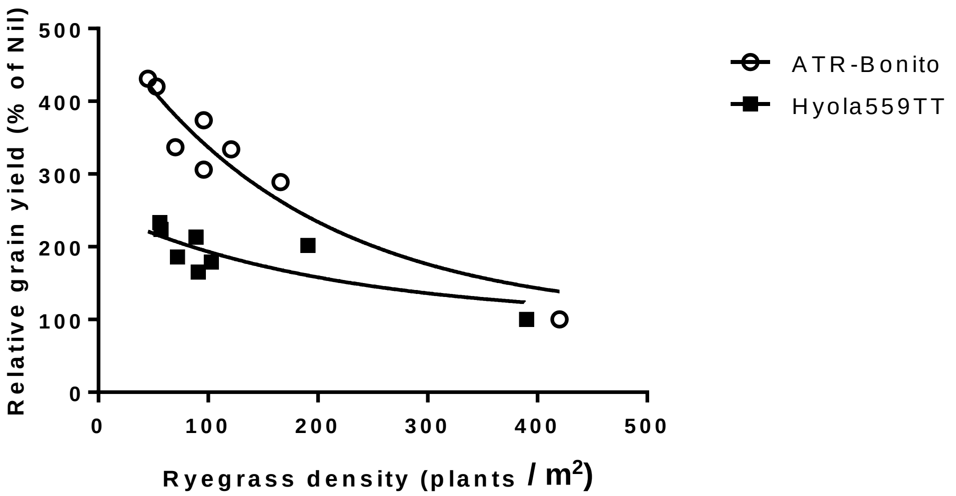

Figure 3. Relationship between average ryegrass density after application of herbicide treatments and relative grain yield of canola varieties ATR Bonito and Hyola559TT at Roseworthy.

Table 8. Influence of canola variety and herbicide strategy on canola yield at Roseworthy in 2017. Values in average column with different letters are significantly different (P ≤ 0.05).

Herbicide treatment	T1	T2	T3	T4	T5	T6	T7	T8	Average
	Canola yield (t/ha)								
Variety									
ATR Bonito	0.35	1.18	1.01	1.07	1.31	1.47	1.17	1.51	1.13
Hyola559TT	0.63	1.17	1.13	1.04	1.27	1.47	1.34	1.41	1.18
Average	0.49a	1.17bcd	1.07bc	1.05b	1.29d	1.47e	1.25cd	1.46e	
Interaction	NS								
Herbicide treatment	<0.001								
Variety	NS								

Furthermore, when the data from Roseworthy was shown as a percentage (relative yield) of the nil an exponential decay relationship between ryegrass density and grain yield was revealed (Figure 3). The yield of ATR Bonito declined more sharply at low to moderate densities of ryegrass compared to Hyola559TT and appeared to reach maximum yield loss at densities above 300 plants/m^2, where interspecific competition of ryegrass would have been high. These results appear consistent with previous studies which also showed that hybrid varieties could better maintain grain yield in the presence of weeds and appear therefore more tolerant of weed competition than the less competitive OP conventional varieties.

Conclusions

At Hart the low ryegrass population resulted in smaller differences between canola varieties and the combined impact of herbicides. Whereas the same trial at Roseworthy, with much larger ryegrass infestation, differences in competitive ability between varieties and their interaction with herbicides were more apparent.

In both studies ATR Bonito was shown to be far more competitive and comparable to the hybrid variety Hyola559TT. Previous studies using the OP variety ATR Stingray showed it is a weaker OP competitor compared to Hyola559TT. In support of previous research, the hybrid appeared to better maintain grain yield in the presence of weeds and was therefore more tolerant of weed competition than ATR Bonito. In addition to other traits, care should be taken when selecting canola varieties for their competitive ability.

Acknowledgements

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