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

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Key findings

- Ryegrass seed production was reduced by more than 50% for the hybrid cultivar compared to open-pollinated.
- Pre-simazine or pre-propyzamide/simazine with post-atrazine, were more effective than herbicide strategies that relied just on pre-emergent herbicides.
- Combination of effective pre-emergent herbicides with competitive canola cultivars of canola can significantly reduce ryegrass seed set.

Background

Clethodim (i.e. 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 steadily in the southern region, which makes it more difficult for growers to control. Some growers have responded by using increased rates of the herbicide 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 three different types of herbicide tolerant canola available (TT, triazine tolerance; CLF, imidazolinone tolerance; RR, glyphosate tolerance), each of these types has weaknesses for weed management and all have relied on clethodim to manage annual ryegrass.

Here we report results from a field trial undertaken to demonstrate that crop competition offered by a hybrid canola in combination with pre-emergent herbicides can greatly reduce ryegrass seed set. Competition, therefore, could provide an easy and simple to use tool for integrated management of grass weeds in canola.

What's been undertaken?

A field trial was established at Roseworthy in 2016 to investigate the effect of crop competition and different pre-emergent herbicides and their mixtures on annual ryegrass control in canola. The trial was established in a split-plot design to compare a triazine (TT) open-pollinated (OP) cultivar (ATR-Stingray) with a TT-Hybrid (Hyola559TT) under six pre-emergent herbicide strategies (Table 1).

Table 1. Pre-emergent herbicide strategies used in canola competition trial at Roseworthy in 2016.

Herbicide treatment	Herbicides applied
1	Nil
2	Propyzamide 500 g/L (1 L/ha) pre
3	Propyzamide 500 g/L (1 L/ha) + tri-allate 500 g/L (2 L/ha) pre
4	Simazine (1.1 kg/ha) pre + atrazine (1.1 kg/ha) post
5	Propyzamide 500 g/L (1 L/ha) + simazine (1.1 kg/ha) pre
6	Propyzamide 500 g/L (1 L/ha) + simazine (1.1 kg/ha) pre + atrazine (1.1 kg/ha) post

Seeding rate was adjusted according to germination and size to obtain a target density of 35 plants/m^2. This resulted in ATR-Stingray sown at 1.6 kg ha^{-1} and Hyola559TT at 2.4 kg/ha^{-1} on May 14th. The replicated trial was sown into a faba bean stubble using a standard knife-point press wheel system on 22.5 cm (9") row spacing. Fertiliser rates were applied as per district practice with 100 kg ha^{-1} DAP banded below the seed at sowing, and 50 kg/ha urea top dressed when the crop was at the six true-leaf growth stage. Pre-sowing weed control was glyphosate (2.5 L/ha) + oxyfluorfen (90 mL/ha). Lontrel Advance® (150 mL/ha clopyralid) was applied early post-sowing on June 14th to provide broad-leaf weed control. Insecticide chlorpyrifos (Lorsban) was applied on May 24th at 900 mL/ha. Pre-emergent herbicides were applied with a 2 m pressurised handboom on May 12th. Atrazine was applied post-emergent (treatments 4 & 6) on June 25th to ryegrass at the 1-3 leaf growth stage. Assessments included ryegrass control (reduction in plant and seed set), crop establishment and grain yield.

Results and discussion

There was no significant effect of herbicide treatment on canola establishment, averaging 37 and 41 plants for ATR-Stingray and Hyola559TT, respectively (data not presented).

There was a significant effect of herbicide treatment on ryegrass present in the crop at six and 12 weeks after sowing (WAS), but no effect of cultivar (Table 2 & 3). Despite the high ryegrass pressure, all herbicide treatments significantly reduced the size of the ryegrass population (~60-80%). Herbicide treatments four and six, which combined either pre-simazine or pre-propyzamide/simazine with post-atrazine were the most effective and provided 78% control relative to the nil at 12 WAS (722 plants/m^2; Table 3). Relative to just pre-propyzamide/simazine (treatment five), addition of post-atrazine to treatment six provided a 27% improvement in control. This result highlights the importance of extended residual control that post-applied residual herbicides can provide, particularly in the absence of effective grass selective herbicides (i.e. loss of clethodim to resistance).

In this study, application timing for post-atrazine was ideal, with much of the treated ryegrass no more advanced than 3-leaf growth stage. Furthermore, rainfall during early Winter was well above average and would have provided ideal soil moisture conditions for incorporation and uptake of this moderately soluble herbicide.

Table 2. Influence of canola cultivar and herbicide strategy on ryegrass density six weeks after sowing at Roseworthy in 2016.

Herbicide treatment	**T1**	**T2**	**T3**	***T4**	**T5**	***T6**	**Average**
	Ryegrass density (plants m^{-2})						
Cultivar							
ATR-Stingray	559	210	176	214	235	167	260
Hyola559TT	568	253	185	194	240	227	278
Average	564	231	181	204	237	197	
Herbicide × cultivar	ns						
Herbicide	<0.001						
Cultivar	ns						

*Post atrazine not yet applied.

Table 3. Influence of canola cultivar and herbicide strategy on ryegrass density 12 weeks after sowing at Roseworthy in 2016.

Herbicide treatment	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**Average**
	Ryegrass density (plants m^{-2})						
Cultivar							
ATR-Stingray	773	437	325	179	386	127	371
Hyola559TT	671	417	299	140	321	182	338
Average	722	427	312	160	353	155	
Herbicide × cultivar	ns						
Herbicide	<0.001						
Cultivar	ns						

There were significant effects of both herbicide treatment and cultivar on the number of ryegrass heads produced (Table 4). For herbicide treatments four and six, which provided greatest reduction in ryegrass plants, there were ~50% fewer heads found compared to the nil treatment (967 heads/m^2). These treatments of either pre-simazine or pre-propyzamide/simazine with post-atrazine, were far more effective than herbicide strategies that relied just on pre-emergent herbicides. In fact ryegrass seed set was similar to the untreated nil (967 heads/m^2) for pre-propyzamide (897 heads/m^2), and pre-propyzamide + tri-allate (915 heads/m^2). High seed set under these treatments would have resulted in a considerable blow-out in the seedbank, making management of this population difficult for years to come.

Table 4. Influence of canola cultivar and herbicide strategy on ryegrass head density at Roseworthy in 2016.

Herbicide treatment	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**Average**
	Ryegrass heads (heads m^{-2})						
Cultivar							
ATR-Stingray	1186	1062	1135	498	753	610	874
Hyola559TT	748	733	694	212	510	367	544
Average	967	897	915	355	631	489	
Herbicide × cultivar	ns						
Herbicide	<0.001						
Cultivar	<0.001						

Between the two cultivars, there were significantly more heads in ATR-Stingray (874 heads/m^2) compared to the hybrid Hyola559TT (544 heads/m^2). This is despite there being no difference in the number of ryegrass plants present between the two cultivars. The relationship between average plant and average head density of ryegrass for the two canola cultivars (Figure 1) clearly shows that seed set per plant was approx. 2-fold higher for ATR-Stingray compared to Hyola559TT. This result supports previous research that showed hybrids are more competitive against ryegrass than standard OP cultivars (Lemerle et al. 2014).

The increased competitiveness of the hybrid over the OP most likely relates to the superior vigour and early growth of the hybrid compared to the OP. NDVI, a measure of green vegetative growth showed higher NDVI values (approx. 2-fold) recorded from crop emergence through to flowering for Hyola559TT relative to ATR-Stingray (Figure 2).

Previous research (Lemerle *et al*. 2014) has also shown that hybrids were generally more competitive than OP cultivars, and concluded that suppression of weed growth was negatively correlated with crop biomass. The authors also speculated that traits such as: rapid early growth, height, early flowering; sufficient large, thin leaves to effectively shade weeds, combined with a vast root system to compete for nutrients and water, would be of importance to the competitiveness of canola. Traits which appear more strongly aligned to the growth displayed by hybrids.

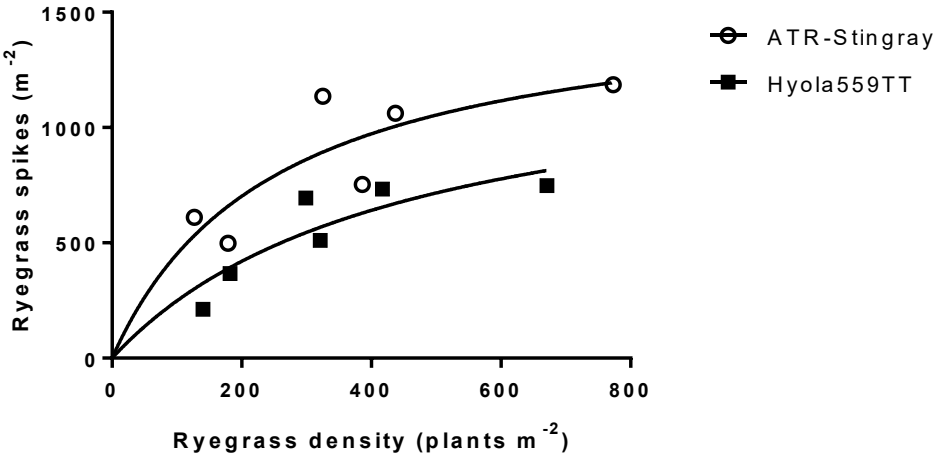

Figure 1. Relationship between average plant density and average head density of ryegrass across all herbicide strategies for canola cultivars ATR-Stingray and Hyola559TT. Each data point represents the average of four replicates.

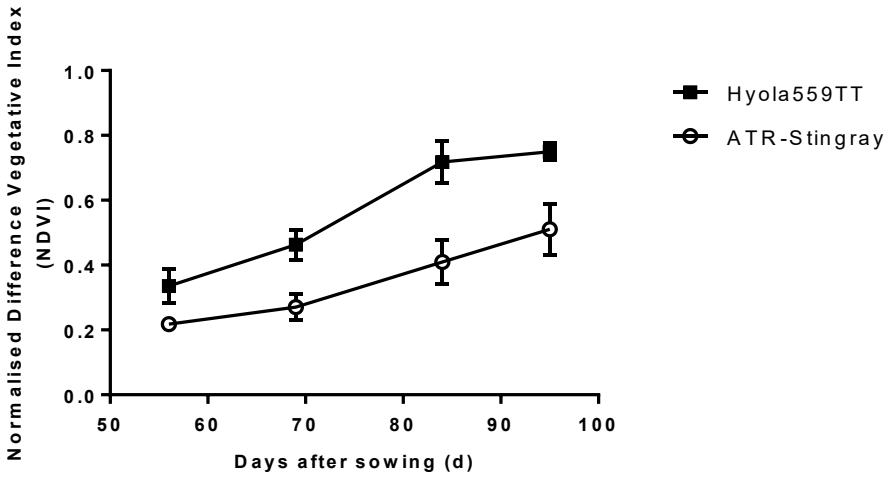

Figure 2. NDVI (Normalised difference vegetative index) of canola cultivars, ATR-Stingray (O) and Hyola559TT (■) measured during pre-flowering crop development. To avoid confounding effect of ryegrass on NDVI values only data from herbicide treatment four where ryegrass control was greatest, are presented.

There were significant effects of both herbicide treatment and cultivar on canola yield (Table 5). Although 2016 received well above average Winter and Spring rainfall, canola yields were generally low and ranged from 0.17 to 1.7 t/ha in response to the high weed pressure. Most herbicide treatments resulted in higher yield outcomes relative the nil, however herbicide treatment four and six, where ryegrass control was greatest produced the highest yields for both ATR-Stingray (0.97 & 0.99 t/ha) and Hyola559TT (1.70 & 1.41 t/ha).

Table 5. Influence of canola cultivar and herbicide strategy on grain yield at Roseworthy in 2016.

Herbicide treatment	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**Average**
	Grain yield (t ha^{-1})						
Cultivar							
ATR-Stingray	0.17	0.24	0.45	0.97	0.54	0.99	0.56
Hyola559TT	0.96	1.07	0.94	1.70	1.12	1.41	1.20
Average	0.56	0.66	0.70	1.33	0.83	1.20	
Herbicide × cultivar	ns						
Herbicide	<0.001						
Cultivar	<0.001						

Despite there being no difference in ryegrass density between the two cultivars, the grain yield of Hyola559TT averaged across all herbicide treatments was over double that of ATR-Stingray (1.2 t/ha *vs* 0.56 t/ha). Furthermore when the data was shown as a percentage (relative yield) of the nil a negative relationship between ryegrass density and grain yield was revealed (Figure 3). The yield of ATR-Stingray declined more sharply at low to moderate densities of ryegrass compared to Hyola559TT, and appeared to reach maximum yield loss at densities above 500 plants/m, where competition of ryegrass would have been severe. These results appear consistent with the earlier findings of Lemerle et al. (2014) who reported that hybrid cultivars could better maintain grain yield in the presence of weeds, and were therefore more tolerant of weed competition than the less competitive OP conventional varieties. The extended growing season would have also favoured Hyola559TT which is a later flowering type than ATR-Stingray.

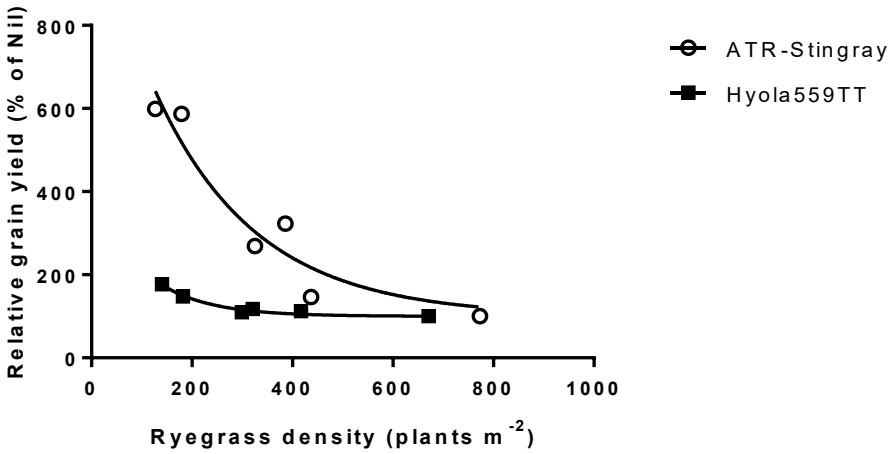

Figure 3. Relationship between average ryegrass density after application of herbicide treatments and relative grain yield for canola cultivars ATR-Stingray and Hyola559TT. Each data point represents the average of four replicates.

Conclusions

The results from this study have clearly demonstrated that where effective herbicides were integrated with more competitive cultivars of canola, ryegrass seed production was reduced by more than 50% for the hybrid cultivar Hyola559TT compared to open-pollinated ATR-Stingray. Furthermore, the hybrid appeared to better maintain grain yield in the presence of weeds, and was therefore more tolerant of weed competition than canola cultivar ATR-Stingray. Combination of effective pre-emergent herbicides with more competitive cultivars of canola can significantly reduce ryegrass seed set, and may play a critical role in the longer-term management of this troublesome weed.

Acknowledgements

We are grateful to GRDC (Grains Research and Development Corporation) for providing project funding (project UCS00020), PacSeeds for supplying seed, and Jerome Martin and Alicia Merriam for providing technical support.

References

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