Managing clethodim-resistant ryegrass without oaten hay

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Background

An increasing number of paddocks in the Mid-North of South Australia contain clethodim (i.e Select) resistant annual ryegrass. Managing herbicide resistant ryegrass can come at a great expense.

Crop rotation is important to the overall success of long-term ryegrass management. Oaten hay is a popular and profitable option for growers to reduce ryegrass numbers. However, there are a number of crop rotation options available to best suit individual growers in terms of success and profitability. In addition to crop selection, different herbicide strategies can be used to provide successful ryegrass control.

Aim: To conduct a multi-year trial to determine the effects of crop rotation and low, medium and high level herbicide management options to reduce clethodim resistant ryegrass without using hay.

Materials & methods

In year 1 of the study (2013) ryegrass seed with low-medium level resistance to clethodim and Factor® (ai butroxydim) was hand broadcast and lightly incorporated across the site for the purpose of establishing a seedbank. Resistance screening of the Hart population against a known susceptible population (SLR4) confirmed resistance to both clethodim and Factor (Table 2 and Figure 1).

Soil core samples (10 cm diam.) were taken across the trial site in April of last year (2014) to determine the size of ryegrass seedbank established. Soil samples were transferred to shallow trays and germinating ryegrass assessed at regular intervals. Seedbank was determined based on the total number of ryegrass seedlings to germinate, and the total area sampled (i.e. core area (πr^2) x number of cores sampled (n=120)) and converted to a unit area (i.e. seeds/m^2). The starting seedbank was determined to be ~1650 ryegrass seeds/m^2 (±153).

The first cropping phase of two 3-yr rotations (pea/wheat/barley and canola/wheat/barley) of field peas and canola was established in 2014. These breakcrop phases will subsequently be followed by wheat and barley in 2015 and 2016. A standard knife-point press wheel system was used to sow the trials on 22.5 cm (9") row spacings. Sowing and fertiliser rates were undertaken as per district practice (Table 1). Herbicide strategies of low (HS1), medium (HS2) and high (HS3) input included:

Herbicides for Kaspa field peas:

1. Trifluralin (1.6 L/ha) + clethodim (700 mL/ha)
2. Triallate (2.0 L/ha) + propyzamide (1.0 L/ha) + trifluralin (1.6 L/ha) + clethodim (0.7 L/ha) + CT (paraquat)
3. Triallate + propyzamide + trifluralin + clethodim(2×) + Factor (180 g/ha) + CT

Herbicides for ATR-Stingray canola:

1. Trifluralin (1.6 L/ha) + clethodim (500 mL/ha)
2. Triallate (2.0 L/ha) + propyzamide (1.0 L/ha)
3. Propyzamide + clethodim + CT (glyphosate)

The trial design is a split-plot; with crop rotation assigned to main-plots and herbicide strategies to sub-plots with 3 replicates. Pre-emergent herbicides were applied within a few hours of being incorporated by sowing (IBS), while post-emergent (POST) clethodim and Factor were applied when most ryegrass had reached 3-4 leaf growth stage (Table 1). Crop-topping (CT) with paraquat and glyphosate were undertaken as per herbicide label directions. Assessments included ryegrass control (reduction in plant density, seed set and seedbank), crop yield and grain quality.

Table 1. Crop management and herbicide application details for the study site.

Seeding date	Crop/Cultivar	Seeding rate (*kg/ha*)	IBS and POST application date and weed/crop growth stage
15th May	Field pea/ Kaspa	100	15th May (IBS)
	Canola/ ATR-Stingray	5	21st July (POST1) Tillering/12 node & 7-leaf
			23rd October (POST2) Milky to hard-dough/30 & 20% seed colour change

Results and discussion – year 1

The rate of clethodim to cause 50% reduction in survival (LD_{50}) and biomass (GR_{50}) was more than 10 and 6-fold higher for resistant Hart population when compared to the susceptible control (SLR4; Table 2). However, the same population showed much weaker resistance to Factor and was only 1.7 to 1.6-fold more resistant compared to susceptible SLR4 population. The genetic basis for resistance in this population is unknown; however resistance is likely due to one or more target site mutations in the ACCase domain, also see Figure 1.

Table 2. The rate of clethodim and butroxydim required for 50% mortality (LD_{50}) and for 50% biomass reduction (GR_{50}) of resistant (Hart) and susceptible (SLR4) ryegrass. Confidence intervals (95%) are shown in parenthesis. R/S is the ratio of LD_{50} and GR_{50} of resistant and susceptible biotypes.

Herbicide	Biotype	LD_{50} (*g ai/ha*)		R/S	GR_{50} (*g ai/ha*)		R/S
Clethodim	Hart	40.3	(23.9,68.1)	10.1	22.9	(11.7, 44.8)	6.0
	SLR4	4.0	(2.6, 6.4)	-	3.8	(2.9, 5.1)	-
Butroxydim	Hart	7.6	(4.8, 12.1)	1.7	5.9	(3.9, 9.1)	1.6
	SLR4	4.4	(3.4, 5.7)	-	3.6	(2.6, 4.9)	-

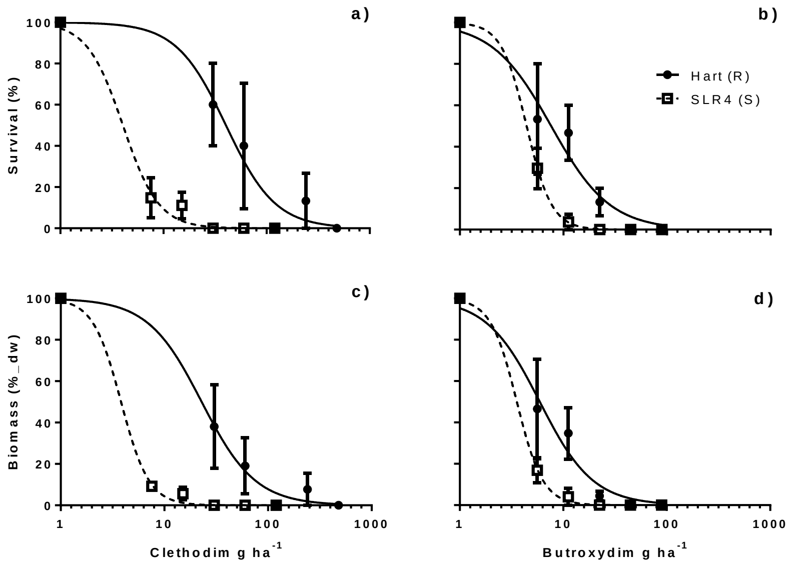

Figure 1. (a, b) Survival and (c, d) biomass (% of nontreated control) of resistant (●, Hart) and susceptible (□, SLR4) ryegrass biotypes to clethodim and butroxydim. Herbicide rates were 0, ½, 1, 2, 4 & 8× field rate of clethodim (250 mL/ha of Select) and 0, ¼, ½, 1, 2 and 4× field rate of butroxydim (180 g/ha of Factor). LD_{50} and GR_{50} values are presented in Table 2.

In both field peas and canola pre-emergent triallate and propyzamide (HS2 & 3) were very effective on ryegrass (Table 3). Excellent post-sowing rainfall appeared to assist the activity of propyzamide extending its residual activity beyond 6 weeks after sowing (WAS). Propyzamide has proven to be a reliable option for ryegrass provided the seedbed is moist and sufficient rain is received after sowing.

Table 3. Impact of cropping phase and herbicide strategy (1, 2 & 3) on grain yield of field peas and canola and reduction in Group A resistant ryegrass at Hart in 2014. The initial ryegrass seedbank was ~1650 ryegrass seeds/m^2.

Crop phase (rotation)	Herbicide strategy (HS)	Ryegrass density (plants/m^2) 6 WAS	12 WAS	17 WAS	Ryegrass (heads/m^2)	Grain yield (t/ha)
Field peas (P/W/B)	1	48	24	5	17	2.18
	2	3	3	0	0	2.24
	3	1	2	0	0	2.11
LSD (P=0.05)		15.5	7.2	2.7	13.2	ns
Canola (C/W/B)	1	55	58	13	34	1.37
	2	24	23	6	23	1.41
	3	12	19	6	23	1.47
LSD (P=0.05)		19.9	20.5	5.1	ns	ns

ns, not significant.

In contrast, ryegrass control in both crops with trifluralin was relatively poor in HS1 with more ryegrass (~50 plants/m^2) requiring follow up control with clethodim. Although the population was not tested, resistance to trifluralin cannot be ruled out as the cause of lower control.

In field peas, above full label rate of clethodim (i.e. 700 mL/ha) in HS1 provided some initial control of ryegrass (50% control at 12 WAS), whereas the lower 500 mL/ha rate used in canola (HS1) provided no control.

Often agronomists and growers comment on improved control of otherwise ACCase-resistant (fop & dim herbicides) ryegrass with high rates of clethodim (>500 mL/ha) in pulses. Previous research from WA (Yu et al. 2007) showed that some clethodim-resistant populations were rate responsive, where increasing the herbicide rate could improve control. However, the research also showed that the response was not always the same between different populations resistant to clethodim and was dependent on several other factors including the mutation(s) endowing resistance and how they were being expressed by the plant. Whilst the exact mechanism (most likely one or more target site mutations) conferring resistance in this population is yet to be determined, it appears to endow low-level resistance at least to the current label rate of clethodim (500 mL/ha).

In the context of cropping phase resistant ryegrass was more prevalent in canola than field peas because of lower initial control from pre-emergent herbicides (Table 3). Of more concern was that under both cropping phases these resistant survivors were able to set viable seed in HS1, where no effective follow up seed set control was undertaken. Whilst some ryegrass was present late in the growing season in HS2 and 3, this ryegrass was either treated with crop-top of paraquat in field peas or over-the-top glyphosate in canola (HS3). Late seed set control tactics (i.e. crop-topping, chaff catching) can play an essential role in preventing resistance multiplication in the field and should be applied at all costs if resistance is suspected.

Although there were clear differences in ryegrass control between herbicide strategies, this had little effect on the grain yield of either canola or field peas (not significant; Table 3). This is not entirely surprising given ryegrass in its own right is a relatively weak competitor, with significant yield loss normally only seen when the weed is present at high infestations (>100 plants/m^2). Given the overall effectiveness of the pre-emergent herbicides to limit the size of the population initially (<50 plants/m^2), the competitive influence of ryegrass would have been negligible.

Conclusion

The 1st year of 3 year field study has been initiated at Hart with the aim of implementing alternate crop and herbicide strategies, other than hay, for effective long-term management of clethodim-resistant ryegrass. Whilst most of the herbicide strategies in field peas and canola were effective against ryegrass, resistant-survivors still were present late in the season. The seed set contribution of these individuals to the seedbank will not be fully realised until seedbank sampling is again undertaken in April of this year. However, it is hoped that were late seed set control tactics were used (HS2 and 3), fewer seeds and greater seedbank depletion has been achieved.

Acknowledgements

The financial assistance of GRDC and the collaboration of Hart Field-Site Group staff are gratefully acknowledged. We also wish to thank Stuart Sherriff (SARDI) and Malinee Thongmee (University of Adelaide) for providing technical assistance.

References

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