

Management of annual ryegrass in genetically modified canola options

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Key findings

- It remains key for growers to monitor the survival of ARG populations in paddocks and resistance test where required to implement appropriate management strategies.
- Seasonal conditions at Hill River in 2022 were wet with 506 mm growing season rainfall (GSR). This favoured conditions for multiple germinations of annual ryegrass (ARG) to occur throughout the growing season.
- Weed control benefits were observed in glyphosate tolerant canola when compared to traditional Triazine Tolerant (TT) and Clearfield® (CL) options. This resulted from their extended application window (> crop stage 6-leaf) in addition to herbicide susceptibility to glyphosate.
- Herbicide treatments for dual tolerance technologies Liberty® + TruFlex® (LR) and Liberty® + Triazine Tolerant (LT) performed well, providing ≥ 79% in-crop weed control. However, Liberty® + LT spray regimes were not able to provide similar suppression of ARG heads when compared to glyphosate and other dual tolerant glyphosate options in a high production year.

Introduction

In 2021, the genetically modified (GM) moratorium in South Australia lifted, providing mainland growers the opportunity to grow GM canola for the first time.

Current canola technologies include Triazine Tolerant and Clearfield® (imidazolinone tolerant) options, however, the development of metabolic resistance to these chemistries, including Group 1 (previously Group A) herbicides in weeds such as annual ryegrass (ARG) has become a growing concern. Current resistance levels of annual ryegrass in South Australia, tested within the past 5 years, show that approximately 49% of paddocks have confirmed resistance to imidazolinone herbicides and > 10% to clethodim (Boutsalis et al. 2021). New GM technology options including Roundup Ready® (RR), TruFlex® and LibertyLink®, alongside various mixed tolerance options will provide additional weed management tools on-farm, assisting growers to manage weeds with glyphosate or glufosinate.

Trials conducted across the medium rainfall zone of the Mid-North aim to demonstrate a best-use approach for in-crop management of annual ryegrass (ARG) in GM canola through the use of on-label glyphosate and some glufosinate options. The trials will also compare new technologies to current TT and CL options as an industry benchmark.

Methodology

A field trial was conducted at Hill River, SA in 2022 (Table 1). The trial was a randomised block design with 22 treatments, including various canola technologies, herbicide regimes and application timings. Variety inclusions were Pioneer 44Y94 (CL), HyTTec Trophy (TT), Pioneer 44Y27 (RR), Nuseed Raptor TF (TruFlex®) and Hyola Garrison XC (stacked Clearfield® and TruFlex® tolerance). The trial was managed with the use of pesticides to ensure an insect and disease-free canopy.

The site had a high background population of ARG with 1287 plants/m² when assessed post seeding. It was lightly burnt in April prior to seeding to remove significant ground cover affecting herbicide efficacy and seeding operations. The trial was sown on May 7, after IBS treatments were applied using a standard knife-point press wheel system on 22.5 cm (9") spacings. Follow up herbicide applications were applied, including a post sowing pre-emergent (PSPE) for the Liberty[®] + TT treatment (Table 2).

Various in-crop applications of glyphosate and glufosinate with mixing partners were applied when canola was at two-leaf (2L), four-leaf (4L) and 8-leaf (8L) (Table 2). These in-crop application timings were applied early due to high ryegrass populations emerging post-seeding. Late applications of glyphosate were also applied to some treatments at first flower to evaluate a three-spray regime, however due to a spray error at final application, this data could not be analysed. Selected treatments were trialed again at Hill River in 2023 to investigate efficacy of late applications of glyphosate, however low rainfall conditions contributed to a low ryegrass population.

All plots in 2022 and 2023 were assessed for crop establishment (%), ARG weed control (%) and ARG head suppression (heads/m²) at maturity to assess potential seed set in consecutive years. Spray regimes (\$/ha) were also calculated to estimate herbicide costs (Table 3).

All 2022 and 2023 data was analysed using a REML spatial model (Regular Grid) in Genstat.

A resistance test (quick test) was conducted at each site in 2022 and 2023 to determine resistance levels to clethodim (Group 1), Intervix (Group 2), atrazine (Group 5) and glyphosate (Group 9). At these sites, ARG was shown to have low-level but detectable resistance to clethodim at 500 ml/ha and medium-level resistance to Intervix. No resistance to Group 5 or 9 herbicides was present.

Table 1. Details for glyphosate trials at Hart and Hill River, SA (2021 – 2023).

2022	Plot size	2.0 m x 10.0 m	Water rate	100 L/ha
	Seeding date	June 3, 2022	Nozzle	Coarse
	Location	Hill River, SA		
	Harvest date	December 15, 2022		
	Previous crop	Scepter wheat		
2023	Plot size	2.0 m x 10.0 m	Water rate	100 L/ha
	Seeding date	June 16, 2023	Nozzle	Coarse
	Location	Hill River, SA		
	Harvest date	November 22, 2023		
	Previous crop	Oaten hay		

Two trials were also conducted across the Mid-North region in 2021 at Hart and Spalding. These trials investigated in-crop herbicide regimes focusing on a 2-spray approach, targeting medium rainfall environments. All in-crop applications of glyphosate were applied to young ARG plants prior to tillering.

Table 2. Herbicide treatments and canola technologies trialed at Hill River in 2022. Roundup Ready PL= abbreviated to Roundup PL.

	Technology	Pre-emergent (1)		PSPE (2)		Crop stage 2L (3)		Crop stage 4L (4)		Crop stage 8L (5)		1st Flower (6)	
		Product	Rate (L)	Product	Rate	Treatment	Rate	Treatment	Rate	Treatment	Rate	Treatment	Rate
1	CL												
2	CL	Propyzamide	1 L										
3	CL	Overwatch	1.25 L										
4	CL	Propyzamide	1L			Clethodim 360 + Intervix + Hasten	330 ml + 600 ml + 1%						
5	CL	Overwatch	1.25 L			Clethodim 360 + Intervix + Hasten	330 ml + 600 ml + 1%						
6	TT	Propyzamide + Simazine	1L + 1 kg			Clethodim 360 + Atrazine + Hasten	330 ml + 1kg + 1%						
7	TT	Overwatch	1.25 L			Clethodim 360 + Atrazine + Hasten	330 ml + 1kg + 1%						
8	RR	Propyzamide	1 L			Roundup PL	1.67 L			Roundup PL	1.67 L		
9	RR	Propyzamide	1 L			Roundup PL	1.67 L						
10	LibertyLink + TT	Propyzamide	1 L	Atrazine	1 kg	Liberty + Clethodim 360 + Uptake	2 L + 330 ml + 0.5%	Liberty + uptake	2 L + 0.5%				
11	LibertyLink + TruFlex	Propyzamide	1 L			Liberty + Roundup PL + Uptake	2 L + 1.67 L + 0.5%	Liberty + uptake	2 L + 0.5%				
12	TruFlex	-				Roundup PL	1.15 L	Roundup PL	1.15 L				
13	TruFlex	Propyzamide	1 L			Roundup PL	1.15 L	-	-				
14	TruFlex	Propyzamide	1 L			Roundup PL	1.67 L	-	-				
15	TruFlex	Propyzamide	1 L			Roundup PL	1.15 L	Roundup PL	1.15 L			Roundup PL	1.15 L
16	TruFlex	Propyzamide	1 L			Roundup PL	1.67 L	Roundup PL	1.67 L				
17	TruFlex	Propyzamide	1 L			Roundup PL	1.67 L	Roundup PL	1.67 L			Roundup PL	1.67 L
18	TruFlex	Propyzamide	1 L			Roundup PL	1.67 L	Roundup PL	1.67 L			Roundup PL	1.67 L
19	TruFlex	Propyzamide	1 L			Roundup PL + Clethodim 360 + Hasten	1.15 L + 330 mL + 1%	Roundup PL	1.15 L				
20	TruFlex	Overwatch	1.25 L			Roundup PL + Clethodim 360 + Hasten	1.15 L + 330 mL + 1%	-	-			Roundup PL	1.15 L
21	TruFlex	Overwatch	1.25 L			Crucial	1.5L	Crucial	1.5 L				
22	TruFlex + CL	Propyzamide	1 L			Roundup PL + Intervix + Hasten	1.67 L + 600 ml + 1%	Roundup PL	1.67 L				

Results and discussion

Seasonal conditions

Following a dry April, seasonal conditions at Hill River in 2022 were wet (Figure 1), with the site receiving approximately 506 mm growing season rainfall (GSR). This provided an environment for consecutive germinations of ARG to occur throughout the growing season.

Total annual rainfall received at Hill River in 2023 was 388 mm with 312 mm of growing season rainfall (GSR). Early rainfall from April – July promoted germination of ARG, however seasonal conditions from July through to spring were below average (Figure 1) suppressing conditions for further ryegrass populations to emerge.

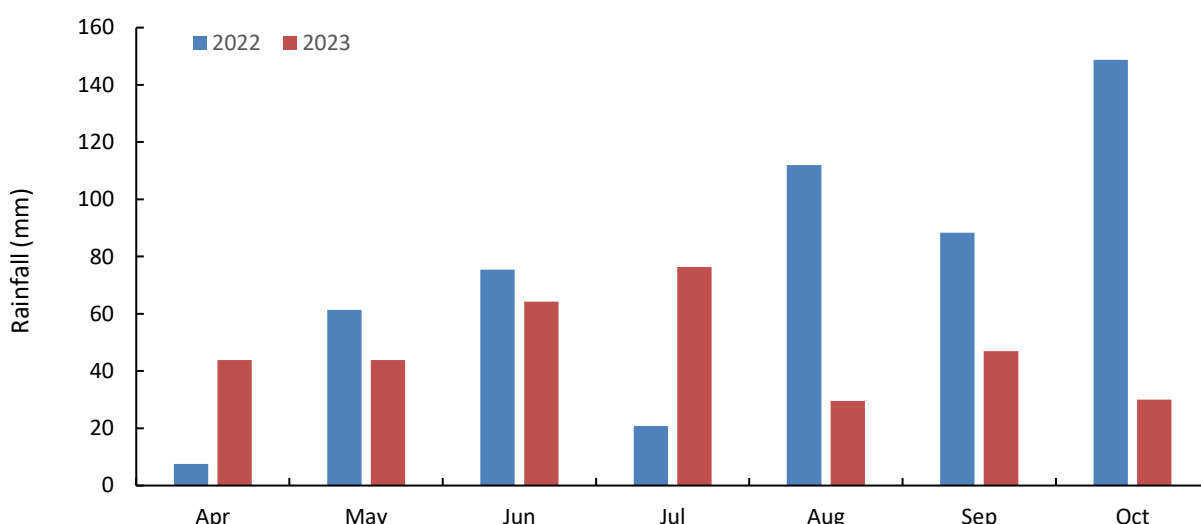


Figure 1. Monthly growing season rainfall near Hill River (2022 – 2023). Rainfall data sourced from the Mid North Mesonet, Clare station.

Pre-emergent herbicides

Background ARG populations at Hill River in 2022 were high (1287 plants/m²) with pre-emergent herbicides Overwatch and propyzamide providing similar control. Pre-emergent herbicides alone did not provide any benefits over the nil (no herbicide applied) treatment, likely a result of the knockdown herbicide not effectively controlling newly germinated annual ryegrass seedlings prior to the application of pre-emergent herbicides.

This was in contrast to trials conducted in 2021, with propyzamide at 1 L/ha providing increased weed control when compared to Overwatch at 1.25 L/ha (data not shown). This was due to the increased persistence of propyzamide in soils after a significant opening rain event in May (23 mm) following dry conditions, controlling ARG for a longer period of time. After in-crop applications were applied at crop stage 6 – 8 leaf, no differences in weed control were observed between treatments with either propyzamide or Overwatch applied (Allen R., 2021).

Weed control

Annual ryegrass control was improved when a two-spray herbicide regime was implemented in-crop at Hill River in 2022 (Figure 2).

Two in-crop applications of glyphosate as Roundup® Ready PL at 1.67 L/ha, performed similarly when compared to two in-crop applications at lower rates, of either Roundup Ready PL at 1.15 L or Crucial at 1.5 L/ha. This was a result of ARG populations testing 100% susceptible to glyphosate at Hill River.

When glyphosate was applied as a single application early in-crop, weed control was reduced. It was also noted that single applications of Roundup Ready PL at high rates of 1.67 L/ha increased control when compared to the lowest on-label rate of 1.15 L/ha. This suggests that when high populations of

ARG are present, higher rates of glyphosate may be required for sufficient control. A trial at Spalding (data not shown) in 2021 showed that Roundup Ready PL at 1.15 L/ha performed similarly to rates of 1.67 L/ha under low ARG populations (Allen R 2021). This gives growers confidence that lower rates may be applied to susceptible ARG populations, still achieving effective weed control while reducing input costs. When ARG is present in high numbers, higher rates may be required in-crop, but only when a maximum of two glyphosate applications will be applied.

Single applications of glyphosate provided similar control to CL and TT treatments (Figure 2), however when more than one in-crop application of glyphosate was applied to TruFlex varieties and dual tolerance varieties, control was improved. This shows that new herbicide technologies with extended application windows will provide additional control when compared to traditional options. Weed control data collected from trials conducted at Hart in 2021 also show that TT and CL options can provide similar levels of ARG control to glyphosate options in lower rainfall years (reduction in subsequent ARG germinations), and where susceptible populations are present.

Due to below average rainfall at Hill River in 2023, single applications of Roundup Ready PL (1.15 or 1.67 L/ha) were sufficient to control annual ryegrass. Follow-up applications 14 days later (crop stage 6-8 leaf) through to first flower were not economical. Reduced control was observed for Clearfield treatments (in crop application of 330 mL Clethodim 360 + 600 mL Intervix + 1% Hasten), due to ARG resistance of Group 1 and 2 herbicides. Triazine Tolerant treatment (in crop application of 330 mL Clethodim 360 + 1 kg atrazine + 1% Hasten) performed similarly to single applications of Roundup Ready.

Liberty® herbicide

Liberty herbicide applied with either glyphosate or clethodim at 2-leaf canola stage, followed by a second application of Liberty within 14 days performed similarly to glyphosate standalone when applied as a two-spray regime at Hill River in 2022 (Figure 2). Similar trends were observed for weed control (%) and ARG head suppression (Table 1 and Figure 2). All glyphosate treatments with two in-crop applications (+/- mixing partners) significantly reduced ARG head numbers by 79 – 100% (Table 1). The stacked Liberty + TT treatment was not able to provide similar suppression of ARG heads when compared to glyphosate and other dual glyphosate tolerant options in a two-spray regime.

Tank mixing

The presence of clethodim tank mixed with glyphosate at early in-crop timings was effective but did not improve ARG control where low-level resistance to Group 1 herbicides was identified. This result is due to the effectiveness of glyphosate on susceptible ARG populations to Group 9 herbicides. Incorporating additional modes of action into a spray program is important and can reduce the potential development of metabolic resistance to herbicides and continue to provide effective weed control.

Previous research conducted by Plant Science Consulting has shown that some populations of ryegrass are resistant to clethodim, glyphosate or both herbicides. Pot studies conducted in 2020 show that tank mixes of 1.15 L/Roundup Ready PL and 500 ml/ha Clethodim 240 had effective control across most populations tested, with control of ARG averaging 95%, compared to 73% for standalone glyphosate and 79% for standalone clethodim (Boutsalis et al. 2021). It will be important for growers to resistance test to implement appropriate in-crop spray regimes.

Table 3. Annual ryegrass head counts (plants/m²) for treatments at Hill River. Treatments with the same letter are not significantly different. Shading indicates highest level of ARG head suppression.

Treatment	ARG head counts (heads/m ²)	ARG head counts (% control)
1	1884 ⁱ	0
2	1353 ^h	28
3	1123 ^{gh}	40
4	642 ^{def}	66
5	824 ^{efg}	56
6	996 ^{fgh}	47
7	1382 ^h	27
8	1 ^a	100
9	406 ^{bcd}	78
10	449 ^{bcd}	76
11	195 ^{ab}	90
12	392 ^{a-d}	79
13	612 ^{cde}	68
14	487 ^{b-e}	74
16	0 ^a	100
19	397 ^{a-d}	79
21	168 ^{ab}	91
22	232 ^{abc}	88



Photo: The Hill River trial site, 2023.

Table 4. Herbicide costs (\$/ha) for various spray regimes trialed at Hill River in 2022. Herbicide costs should be used as a guide only.

Technology	Spray regime	Rates /ha	Herbicide costs (\$/ha)
Clearfield	IBS: Propyzamide Post-emergent: Clethodim 360 + Intervix + Hasten	1 L 330 mL + 600 mL + 1%	\$78.55
TT	IBS: Propyzamide + Simazine Post emergent: Clethodim 360 + Atrazine + Hasten	1 L + 1 kg 330 mL + 1 kg + 1%	\$82.68
RR / TruFlex	IBS: Propyzamide Post-emergent: Roundup Ready PL (1 application)	1 L 1.67 L	\$70.05
RR / TruFlex	IBS: Propyzamide Post-emergent: Roundup Ready PL (2 applications)	1 L 1.67 L	\$95.10
RR / TruFlex	IBS: Propyzamide Post-emergent: Roundup Ready PL (2 applications)	1 L 1.15 L	\$79.5
LibertyLink + TT	IBS: Propyzamide PSPE: Atrazine Post-emergent 1: Liberty + Clethodim 360 + Uptake Post-emergent 2: Liberty + Uptake	1 L 1 kg 2 L + 330 mL + 0.5% 2 L + 0.5%	\$130.45
LibertyLink + TruFlex	IBS: Propyzamide Post-emergent 1: Liberty + Roundup Ready PL + Uptake Post-emergent 2: Liberty + Uptake	1 L 2 L + 1.67 L + 0.5% 2 L + 0.5%	\$136.25
TruFlex	IBS: Propyzamide Post-emergent: Roundup Ready PL (3 applications)	1 L 1.15 L	\$96.75
	IBS: Propyzamide Post-emergent: Crucial (2 applications)	1 L 1.5 L + 1.5 L	\$90.00
	IBS: Propyzamide Post-emergent 1: Roundup Ready PL + Clethodim 360 Post-emergent 2: Roundup Ready PL	1 L 1.15 L + 330 mL 1.15 L	\$89.75
TruFlex + CL	IBS: Propyzamide Post-emergent 1: Roundup Ready PL + Intervix + Hasten Post-emergent 2: Roundup Ready PL	1 L 1.67 L + 600 mL + 1% 1.67 L	\$118.4

Estimated costs per litre or gram: propyzamide \$45.00, clethodim \$20.50, Intervix \$31.00, Hasten \$4.70, simazine \$7.53, Uptake \$6.20, atrazine \$15.20, glyphosate and glufosinate \$15.00. Values sourced from: Farm Gross Margin and Enterprise Planning Guide, 2022.

Summary

Genetically modified canola options including Roundup Ready and TruFlex will be useful to growers for controlling ARG, particularly where Group 1 and 2 herbicide resistance is present. Through various trials from 2021 - 2023, applications of glyphosate have shown to be equally or more effective when compared to traditional Clearfield or TT herbicide options. This has been dependent on both seasonal conditions and herbicide resistance levels present in the field. In years where conditions are favourable for germinations of ARG throughout the growing season, an extended application window of TruFlex variety options will provide additional weed control. It is important that growers monitor and test for herbicide resistance on farm to appropriate select varieties and spray regimes. Further research investigating glufosinate through SAGIT project HAR 00523 - Improving efficacy of glufosinate for annual ryegrass control in canola, will provide further data to inform management decisions (data to be released in 2024).

Acknowledgements

The Hart Field-Site Group would like to acknowledge SAGIT for funding this project.

We would also like to thank BASF, Nuseed, Pioneer® Seeds and Pacific Seeds for providing seed, and Nufarm, Bayer and BASF for providing herbicides trialed.

Hart would also like to kindly acknowledge the support from growers who hosted these trials from 2021 – 2022 at Spalding and Hill River.



References

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Photo: Third year ag science students from the University of Adelaide inspect the trial at Hart in September 2023.