

Management of annual ryegrass in genetically modified canola options

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Key findings

- 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.
- Herbicide treatments for dual tolerance technologies LibertyLink® + TruFlex™ and LibertyLink + Triazine Tolerant (TT) performed well, providing $\geq 79\%$ in-crop weed control. However, Liberty Link + TT spray regimes were not able to provide similar suppression of ARG heads when compared to glyphosate and other dual tolerant glyphosate options.
- Weed control benefits were observed for LibertyLink and glyphosate tolerant technologies when compared to TT and Clearfield® (CL), resulting from the extended application windows these technologies offer ($>$ crop stage 6-leaf).
- Liberty herbicide applied in-crop at 2-leaf, followed by a second application 14 days later, performed similarly to glyphosate when applied twice in-crop at Hill River.
- Trials will be conducted in 2023 to further evaluate in-crop applications of glyphosate as a two and three-spray regime option.

Introduction

In 2021, the genetically modified (GM) moratorium in South Australia (SA) 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 for SA growers include Roundup Ready® (RR), TruFlex and LibertyLink, alongside various mixed tolerance options will provide additional weed management tools on-farm, assisting weed management through the use of 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 in 2022 at Hill River in the Mid-North of South Australia. The trial was a randomised block design with 22 treatments, including various canola technologies, herbicide regimes and application timings (Table 1). The varieties trialed were Pioneer 44Y94 (CL), HyTTec Trophy (TT), Pioneer 44Y27 (RR), Nuseed Raptor TF (TruFlex) and Hyola Garrison XC (Clearfield and TruFlex dual tolerance). The trial was managed with the use of pesticides to ensure an insect and disease-free canopy. Treatments were analysed using a spatial model in Genstat 22nd edition.

The site had a high initial 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 for the LibertyLink + TT treatment. 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 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.

All plots 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).

A resistance test (quick test) was conducted to determine resistance levels to clethodim (Group 1), Intervix (Group 2), atrazine (Group 5) and glyphosate (Group 9). At this site, 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.

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Plot size	2.0 m x 10.0 m	Water rate	100 L/ha
Seeding date	May 7, 2022	Nozzle application	Coarse
Location	Hart, SA		
Harvest date	November 9, 2022		
Previous crop	Scepter wheat		

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.

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 favoured annual ryegrass populations, providing an environment for consecutive germinations of ARG to occur throughout the growing season.

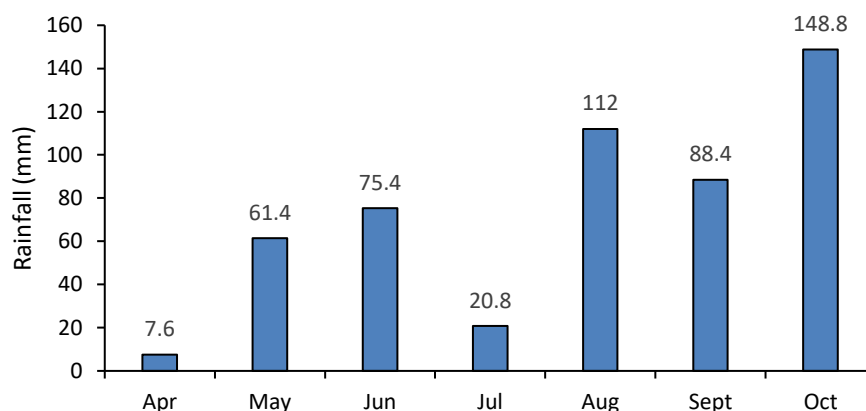


Figure 1. Monthly growing season rainfall near Hill River in 2022. Rainfall data sourced from the Clare Mesonet station (2022).

Pre-emergent herbicides

Background ARG populations at Hill River 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. This was a result of early ARG germination at seeding time in wet conditions, influencing herbicide efficacy.

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. This increased control was due to the persistence of propyzamide in the soil 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).

In-crop 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 the Hill River ARG population having 100% susceptibility to glyphosate. 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 low rates of 1.15 L/ha further reduced control when compared to the highest on-label rate of 1.67 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 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 2021). This gives growers confidence that lower rates may be applied to susceptible ARG populations, still achieving effective weed control while reducing input costs. However, however 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.

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 at this site due to susceptibility of ARG 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 resistant 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.

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.

Liberty herbicide applied in-crop at 2-leaf, followed by a second application within 14 days (as per label recommendations), performed similarly to glyphosate options applied as a two-spray regime at Hill River in 2022. This was observed in 2021 trials at Hart, with in-crop applications of glufosinate providing equal control to glyphosate options (Figure 2).

Similar trends were observed for weed control (%) and ARG head suppression (Table 1 and Figure 2). In addition to the LibertyLink + TruFlex treatment, all glyphosate treatments with two in-crop applications (+/- mixing partners) significantly reduced ARG head numbers by 79 – 100% (Table 1).

Table 1. 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

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	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	1 L + 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										
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%										
11	LibertyLink + TruFlex	Propyzamide	1 L			Liberty + Roundup PL + Uptake	2 L + 1.67 L + 0.5%										
12	TruFlex	-				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										
16	TruFlex	Propyzamide	1 L			Roundup PL	1.67 L										
17	TruFlex	Propyzamide	1 L			Roundup PL	1.67 L										
18	TruFlex	Propyzamide	1 L			Roundup PL	1.67 L										
19	TruFlex	Propyzamide	1 L			Roundup PL + Clethodim 360 + Hasten	1.15 L + 330 mL + 1%										
20	TruFlex	Overwatch	1.25 L			Roundup PL + Clethodim 360 + Hasten	1.15 L + 330 mL + 1%										
21	TruFlex	Overwatch	1.25 L			Crucial	1.5L										
22	TruFlex + CL	Propyzamide	1 L			Roundup PL + Intervix + Hasten	1.67 L + 600 ml + 1%										

Table 3. Herbicide costs (\$/ha) for various spray regimes trialed at Hill River in 2022. Costs include IBS, PSPE and in-crop applications and should be used as a guide only.

Technology	Spray regime	Rates/ hectare	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
Roundup Ready / TruFlex	IBS: Propyzamide Post-emergent: Roundup Ready PL (1 application)	1 L 1.67 L	\$70.05
Roundup Ready / TruFlex	IBS: Propyzamide Post-emergent: Roundup Ready PL (2 applications)	1 L 1.67 L	\$95.10
Roundup Ready / TruFlex	IBS: Propyzamide Post-emergent: Roundup Ready PL (2 applications)	1 L 1.15 L	\$79.50
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	\$118.40

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.

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 the herbicides trialed. Hart would also like to kindly acknowledge the support from growers who hosted these trials from 2021 – 2022.

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