GOA Trial Site Report

Improving annual ryegrass (*Lolium rigidum*) knockdown- assessment of various glyphosate formulations, rates and adjuvant combinations - Alectown 2017

Trial Code:	GOWE05317-4
Season/Year:	Autumn, 2017
Location:	'Wandeen', Alectown
Trial Partners:	Roger Armstrong and Matt Shephard

Keywords

Annual ryegrass, *Lolium rigidum*, resistance, knockdown, glyphosate, paraquat, adjuvants, wetter, surfactants, GOWE05317-4, Alectown

Take home messages

- To ensure adequate ryegrass control with glyphosate use robust rates
- Adding wetter or using glyphosate products with built-in surfactants can improve control at lower rates, however, a more reliable alternative maybe to increase the glyphosate rate.
- In this trial where control by the first pass (low rate of glyphosate) was poor a paraquat double knock did not improve level of control to acceptable standards.
- Knowing the resistance status of ryegrass populations allows for choosing more appropriate management options.

Background

Annual ryegrass (ARG) is expressing increasing levels of resistance to various herbicides across the Orana Region[1]. One of the most concerning is developing resistance to glyphosate, rendering it useless for fallow or pre-sowing knockdown control. The remaining effectiveness of glyphosate needs to be protected as much as possible to prolong its useful life.

Growers have numerous options to maintain and maximise effectiveness of glyphosate. For example, choosing glyphosate products which contain different surfactant packages; the form and concentration of active ingredient; adding additional surfactants; and rate of glyphosate applied.

Control of glyphosate resistant ARG is commonly rate responsive- that is increasing application rate will increase control level. Increasing glyphosate rates may also contribute to more effective control by "counteracting poor application, improving control of older plants, stressed plants or overcoming reduced efficacy caused by using poor quality water or treating plants covered by dust. Higher label rates can also improve glyphosate activity of plants exposed to higher temperatures that can arise in early autumn or late spring"[2].

Active glyphosate generally is poorly absorbed by plants. Many commercial glyphosate formulations have surfactants or adjuvants included to bolster performance by aiding droplet retention on target weeds and adding to absorption into weeds. Despite inclusion of surfactants, additional adding of

[1] See GOA report: http://www.grainorana.com.au/documents?download=29
[2]https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/02/optimising-the-impact-of-glyphosate

them to glyphosate products is common. Wetter TX is most commonly recommended for adding to various glyphosate product via labels suggesting improvement in ARG control under specific circumstances (i.e. Roundup Ultra®Max recommendation to add in late winter and spring). However, there are a range of alternate surfactants also available.

Glyphosate also comes in a range of salt forms and concentrations. Some of these products are often considered premium ones and are often promoted as likely to result in better spray outcomes

Aim

This trial aimed to investigate the effectiveness of commonly available glyphosate choices growers have available to them and their effectiveness in the control on ARG suspected of glyphosate resistance-

- The formulation/ brand of glyphosate
- A range of alternate additional surfactants
- The rate of product applied
- The use of a double knock using paraquat

Methods

A high population of ARG with over 200 plants per m2 measured in the untreated control (UTC) was selected for the trial. Both the grower and their advisor suspected that ARG population had significant resistance to glyphosate because of poor past control. However, commercial testing did not detect any ARG resistance in this population to glyphosate (detailed in the appendix).

A small plot randomised complete block strip design with three replicates was the trial format. It was established in growers' paddock with visible ARG population.

Herbicide treatments were applied using an ATV mounted boom. A double knock treatment of 2 l/ha paraquat was applied to half of each plot (split design).

Results were analysed by ANOVA and results compared by using LSD method with a 95% confidence interval. Any references to differences between treatments should be assumed to be statistically different unless otherwise stated.

Table 1. Trial site details

Trial Establishment Date	Autumn, 2017
Soil Type	Gravelly colluvium
Previous Crop	Wheat
ARG resistance status	Detailed in appendix- suspected resistance to glyphosate

Table 2. Alectown site treatment list. All treatments received a double knock on half the plot consisting of 2 L/ha paraquat.

Treatment	Product	Rate		Adjuvant	rate %
		mL/ha	g ai/ha		
13	Generic 450 g/L glyphosate	750	337	Nil	N/A
14	Generic 450 g/L glyphosate	1500	675		
15	Generic 450 g/L glyphosate	3000	1350		
1	Roundup CT®	750	337		
2	Roundup CT®	1500	675		
3	Roundup CT®	3000	1350		
4	Roundup CT®	750	337	Wetter TX	0.25%
5	Roundup CT®	1500	675		
6	Roundup CT®	3000	1350		
7	Roundup CT®	750	337	Activator	0.13%
8	Roundup CT®	1500	675		
9	Roundup CT®	3000	1350		
17	Roundup CT®	3000	1350	Consume#	0.20%
19	Roundup CT®	750	337		
18	Roundup CT®	6000	2700	Nil	N/A
10	Roundup Ultra®Max	592	337		
11	Roundup Ultra®Max	1184	675		
12	Roundup Ultra®Max	2368	1350		
16	Untreated control	-	-	-	-

Consume- 1020g/L Polyether Modified Polysiloxane

Table 3. Application records

First application	**Date Applied**	12/04/2017	**Temp (°C)**	**Wind (km/hr)**	**Wind Dir.**	**Humidity (%)**
	Start time	14:05	27.5	4-7	E	43.0%
	Finish Time	15:00	**Δt**	9	**% Cloud**	60%
	Water rate (L/ha)	100	**Nozzle**	DG015	**Pressure**	3
	Equipment	ATV	**Speed km/h**	8		
Double knock	**Date Applied**	17/04/2017	**Temp (°C)**	**Wind (km/hr)**	**Wind Dir.**	**Humidity (%)**
	Start time	9:00	21.1	5-13	E	53.6%
	Finish Time	9:10	**Δt**	6	**% Cloud**	10%
	Water rate (L/ha)	100	**Nozzle**	AIXR	**Pressure**	2.5
	Equipment	ATV	**Speed km/h**	6-7		

Results

Full results table is in the appendix at the end of the document.

Impact of product rate: Compared to untreated control (UTC) the lowest rate (337 g ai/ha glyphosate) of Roundup CT® did not provide any statistically better control of ARG. At this glyphosate rate, changing product or adding an adjuvant did not improve control.

At 675 g ai/ha (glyphosate) control was better than the UTC, however, at around 58% is was not 'commercially acceptable'. At higher rates, 1350 and 2700 g ai/ha, excellent control (>98%) was achieved. (**Figure 1**).

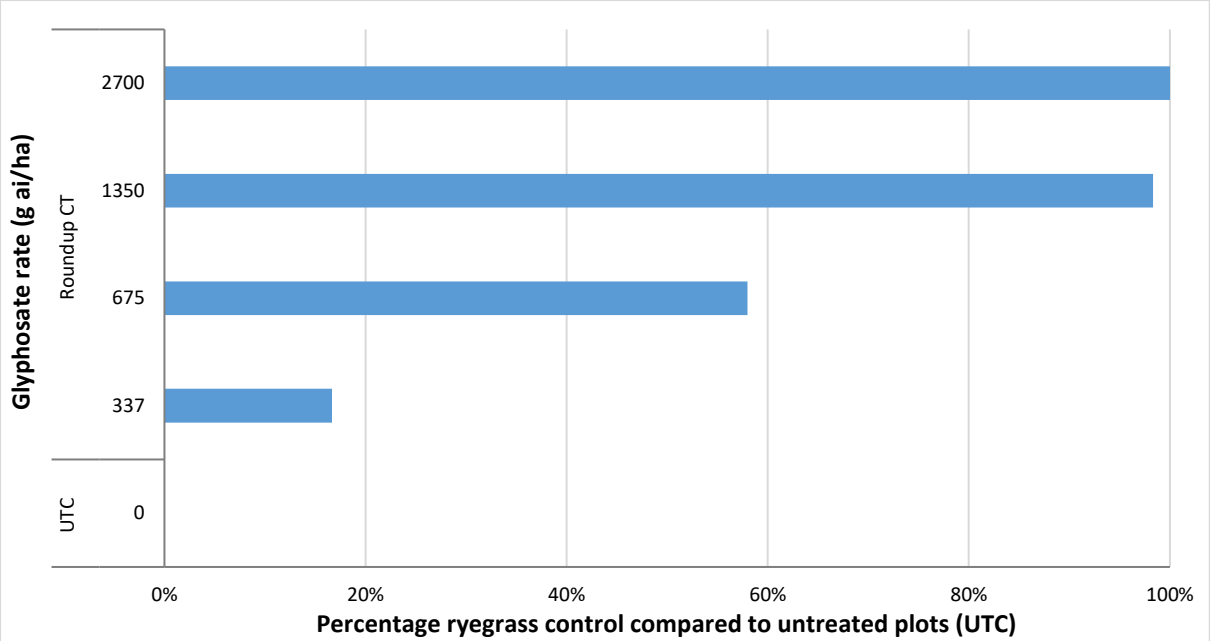

Figure 1. Percentage control (compared to the UTC) for four rates of Roundup CT® 52 days after initial application (DAA1)

Impact of additional surfactants: At 337 g ai/ha and 1350 g ai/ha glyphosate rates the addition of surfactants to Roundup CT® did not significantly improve control. Control at the lowest glyphosate rates, +/- surfactant, were all poor (<51%). While control at the 1350 g ai/ha glyphosate rate +/- surfactant were both high with little room for improvement (>92%).

However, surfactants significantly improved the control at the 675 g ai/ha glyphosate rate. Addition of Wetter TX or Activator to Roundup CT® improved control to greater than 95% (**Figure 2**).

Similarly, Roundup Ultra®Max at 675 g ai/ha, a product with a higher loading of surfactant, also yielded high control (95%). Roundup CT® (at 675 g ai/ha), a product with a lower surfactant loading only achieved 58% ARG control.

Consume, a penetrant, was tested as an alternate surfactant with rates of glyphosate at 337 and 1350 g ai/ha. At the lower rate the glyphosate, the addition of Consume was the only treatment to provide improvement control compared to Roundup CT® by itself (see Appendix)
but it was still poor at 51%.

Impact of different formulation/product choice: Generic 450 g/l glyphosate performed similarly to Roundup CT® (at 675 g ai/ha) with ARG control between 50 and 60%. Roundup CT at 675 g ai/ha with added Wetter TX or Activator improved control to over 90% (**Figure 2**). Roundup Ultra® Max (at 675 g ai/ha with an inbuilt wetter) also gave better than 90% control.

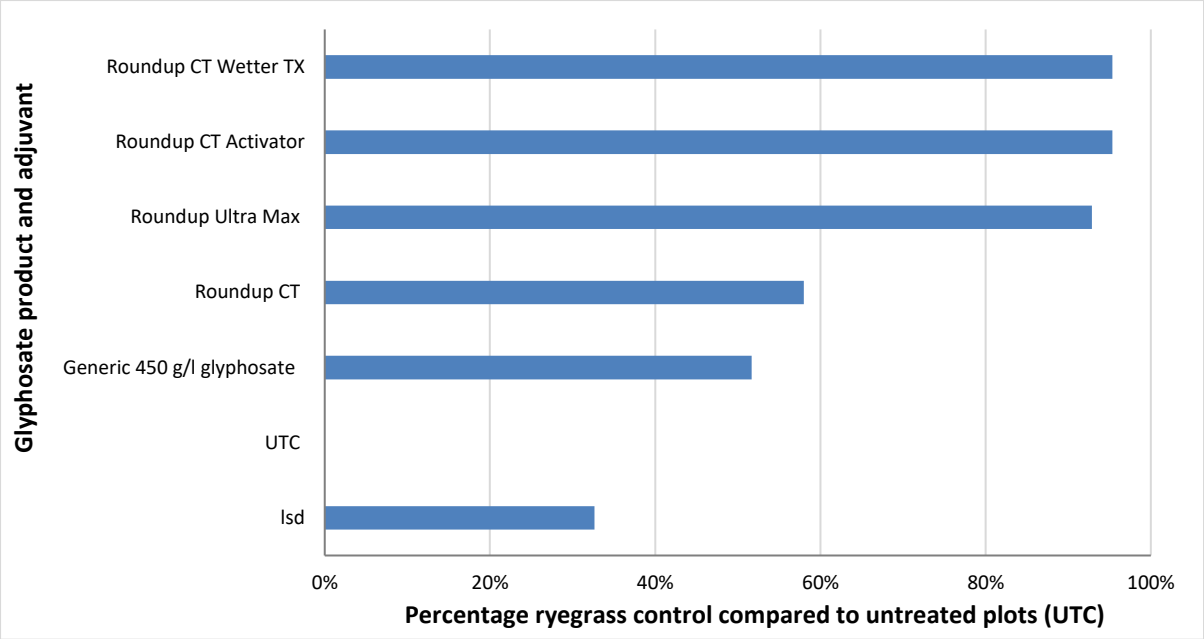

Figure 2. Percentage control (compared to the UTC) for Roundup CT (675 g ai/ha) with selected adjuvant packages. Assessed at 52DAA1.

Impact of a double knock: Seven days after the initial application of the glyphosate treatments, 2 L/ha of paraquat was applied to one half of each plot.

Where paraquat was applied as a standalone treatment (at the double knock timing), control was not significantly better than the UTC. At the lowest Roundup CT® rate (337 g ai/ha), double knock with paraquat improve control (from ~17% to over 50%), still below acceptable levels. Because ARG control was high at higher glyphosate rates (1350 and 2700 g ai/ha) added control from double knock paraquat was not significant (**Figure 3**).

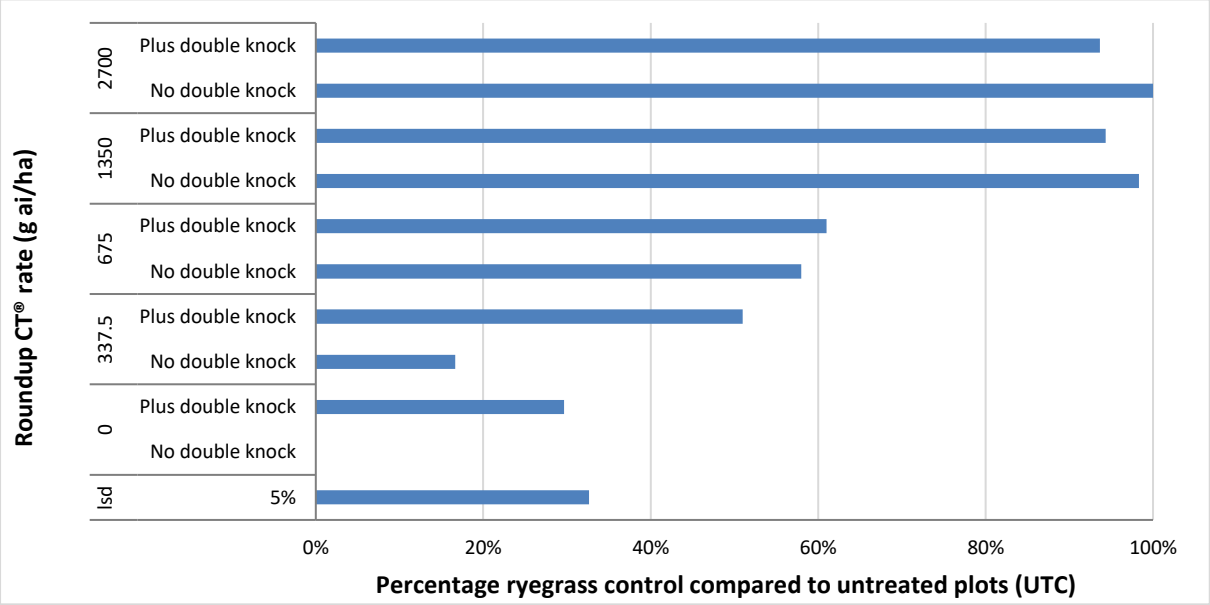

Figure 3. Percentage control (compared to the untreated) of the single pass application of Roundup CT and the double knock application (at 7 days with 2 L/ha paraquat), 52 days after initial application (52DAA1)

Discussion

This trial with high populations (over 200 plants per m2) of non-glyphosate resistant ARG, was selected by the grower and their agronomist as previously experiencing poor control via glyphosate, thus indicating to them suspect ARG resistance to glyphosate. However, as has occurred in other trials, these results are extremely valuable providing updated control strategies for still common non glyphosate resistant ARG populations.

A clear issue from this and other trials is why is poor ARG control from glyphosate occurring? This data provides guidelines for best rates and use of surfactants. Also important is the investigation of factors such as application set up, water quality for spraying or timing to name a few.

Prior to the trial's establishment local BOM data indicated significant rainfall in March (approximately 170mm) ensuring ample ARG germination. A further ~35mm fell in April and a further 45mm in May. At the time of the initial herbicide application, plants were 3-6 leaf and not visibly stressed. However, the conditions at the time were hot and dry.

At this site control of ARG improved as glyphosate rates increased (rate responsive). However, because resistance tests did not detected ARG resistance) the trial was unable to show that increasing application rate can improve control of glyphosate resistant ARG.

There were some subtle differences in the performance of various glyphosate formulations which could be either a response to the differing salt forms of the glyphosate or the different surfactants included in the formulations. However, the addition of added surfactants did improve control at rates where control was marginal. At higher rates of glyphosate, addition of surfactants made no difference.

Benefits from DK of paraquat was not significant at higher glyphosate rates, and although improved control at the lower glyphosate rate, it was still not satisfactory.

This outcome contrasts with some other trials, where poor glyphosate control was significantly improved by double knocking glyphosate resistant ARG[3]. A possible explanation may be that the use of a coarse spray quality for the double knock application (AIXR02 nozzles @ 2.5 Bar) may have been less than ideal, however higher water rates of 100L/ha should have counteracted any decrease in droplet number.

However, where control from the glyphosate pass was good (higher rates) improved ARG control from DK was marginal at best. There could be longer term advantages of applying a DK in controlling any resistant ARG individuals preventing seed set and proliferation of a resistant population.

Conclusion

This trial has shown that increasing the glyphosate rate (regardless of formulation) improves the level of ARG control. Adding a surfactant or using glyphosate products with a higher surfactant loading can also improve control but most likely only where marginal rates of glyphosate are used.

The use of DK in this trial has not shown any clear benefits but the longer terms benefits in managing developing resistance in a population cannot be underestimated. When DK (with paraquat) ensure

[3]https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0ahUKEwjhvu22r-TUAhUMh7wKHQ_LD1QQFgg8MAI&url=http%3A%2F%2Fahri.uwa.edu.au%2Fwp-content%2Fuploads%2F2015%2F04%2FNSW-doubleknock-trial-2.pdf&usg=AFQjCNFfFKtRa18QDF7FjmSeV3r7BkXlqw

glyphosate rates used for the first application are robust enough to maximise control of ARG and ensure adequate spray coverage when DK.

There are implications for confirming suspected ARG resistance. Where resistance is not found the reasons for past poor results require investigation. Confirmation of suspected resistance will avoid exclusion of potentially effective control options that may otherwise be overlooked.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC. The authors would like to thank them for their continued support. Special thanks go out to Roger Armstrong at Alectown and Matt Shephard who hosted this trial.

DISCLAIMER — TECHNICAL

This report has been prepared in good faith on the basis of information available at the date of publication without any independent verification. The Grains Research and Development Corporation, and Grain Orana Alliance do not guarantee or warrant the accuracy, reliability, completeness of currency of the information in this publication nor its usefulness in achieving any purpose.

Readers are responsible for assessing the relevance and accuracy of the content of this publication. The Grains Research and Development Corporation and Gran Orana Alliance will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this publication.

Products may be identified by proprietary or trade names to help readers identify particular types of products, but this is not, and is not intended to be, an endorsement or recommendation of any product or manufacturer referred to. Other products may perform as well or better than those specifically referred to.

Following is a report on a scientific experiment. It may contain some herbicide treatments that are not registered for the situation, manner or rate at which they are used in this trial. This document or anything else resulting from, construed or taken from this or by GOA or its representatives should not be taken as a suggestion, recommendation or endorsement for unregistered herbicide use.

Appendix –

Figure 4- Excerpt from herbicide resistance tests performed on ARG population

Table 1: Results as determined by resistance testing 3 weeks after treatment. Data recorded as % survival (% of plants surviving) as compared to untreated plants. 100% refers to all plants surviving and 0% refers to death. Data is the mean of 2 replicate pots per herbicide rate. Included in the test was a susceptible (S) biotype and resistant biotypes. Data for the S and R biotypes is not shown.

Herbicide	**Herbicide Group**	**Paddock Sample** Alectown	
		Survival	Rating
Select 250ml/ha + 1% Hasten	Group A - Dims	30	RR
Select 500ml/ha + 1% Hasten	Group A - Dims	0	S
Verdict 300ml/ha + 1% Hasten	Group A - Fops	75	RRR
Paraquat 2/ha + 0.2% BS1000	Group L	0	S
Glyphosate 450@ 0.75L/ha	Group M	0	S
Glyphosate 450@ 1.5L/ha	Group M	0	S
Glyphosate 450@ 3L/ha	Group M	0	S

Resistance-rating:	RRR- indicates plants tested have strong resistance	RR - indicates medium-level resistance	R-indicates low-level but detectable resistance	S- indicates no detection of resistance

Table 4 Ryegrass control 52 days after the application of various glyphosate treatments.

Single or Double knock	Glyphosate active rate (g/ha)	Product rate (mL/ha)	Treatment	Adjuvant	Control (%)	Groups
Single pass	0	0	UTC		0%	H
	337	750	Roundup CT	Activator	26%	EFG
		750	Roundup CT	Consume	51%	CDE
		750	Roundup CT	Wetter Tx	30%	EFG
		750	Roundup CT		17%	GH
		750	Generic 450 g/L glyphosate		20%	FGH
		592	Roundup Ultra Max		25%	EFG
	675	1500	Roundup CT	Activator	95%	A
		1500	Roundup CT	Wetter Tx	95%	A
		1500	Roundup CT		58%	BCD
		1500	Generic 450 g/l glyphosate		52%	BCDE
		1184	Roundup Ultra Max		93%	A
	1350	3000	Roundup CT	Activator	92%	A
		3000	Roundup CT	Consume	96%	A
		3000	Roundup CT	Wetter Tx	97%	A
		3000	Roundup CT		98%	A
		3000	Generic 450 g/l glyphosate		92%	A
		2368	Roundup Ultra Max		99%	A
	2700	6000	Roundup CT		100%	A
Double knock	0	0	Double knock only		30%	EFG
	337	750	Roundup CT	Activator	42%	DEFG
		750	Roundup CT	Consume	78%	ABC
		750	Roundup CT	Wetter Tx	50%	CDE
		750	Roundup CT		51%	BCDE
		750	Generic 450 g/l glyphosate		22%	FGH
		592	Roundup Ultra Max		44%	DEF
	675	1500	Roundup CT	Activator	92%	A
		1500	Roundup CT	Wetter Tx	94%	A
		1500	Roundup CT		61%	BCD
		1500	Generic 450 g/l glyphosate		79%	AB
		1184	Roundup Ultra Max		80%	AB
	1350	3000	Roundup CT	Activator	95%	A
		3000	Roundup CT	Consume	98%	A
		3000	Roundup CT	Wetter Tx	93%	A
		3000	Roundup CT		94%	A
		3000	Generic 450 g/l glyphosate		95%	A
		2368	Roundup Ultra Max		97%	A
	2700	6000	Roundup CT		94%	A
Lsd (5%)					33%	