

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

Trial Code:	GOWE05317-1
Season/Year:	Autumn, 2017
Location:	Narromine
Trial Partners:	Billy Browning and Campbell Muldoon

Keywords

Annual ryegrass, *Lolium rigidum*, resistance, knockdown, glyphosate, paraquat, wetter, surfactants, GOWE05317-1, Narromine.

Take home messages

- To ensure adequate ryegrass control with glyphosate use robust rates (675 g ai/ha or higher)
- 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 low rate of glyphosate (337 g ai/ha) was poor, control improved significantly by double knock (DK) with paraquat (2 L/ha product), but not quite to the level of higher glyphosate rate (675 g ai/ha) either alone or with DK.
- Knowing the resistance status of ryegrass populations helps choose appropriate control management options.

Background

Annual ryegrass (ARG) is expressing increasing levels of resistance to various herbicides across the Orana Region¹. One of the most concerning is the developing resistance to glyphosate, rendering it useless for fallow or pre-sowing knockdown control. Retaining glyphosate's remaining effectiveness needs to be protected as much as possible to prolong its useful life.

Growers have numerous available options to maintain and maximise glyphosate effectiveness. For example; choosing glyphosate products with different surfactant packages; form and concentration of the active ingredient; choice of added additional surfactants; and rate applied.

Control of glyphosate resistant ARG is commonly rate responsive, Weeds with weak glyphosate resistance mechanisms can often be killed with higher label rates². 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".

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>

Active glyphosate generally is poorly absorbed by plants; therefore, many commercially available glyphosate formulations have surfactants or adjuvants included to bolster performance by aiding in droplet retention on the target and absorption by the plant. Despite the inclusion of these surfactants commercially, additional surfactants use is common. Wetter TX is most commonly recommended on various glyphosate product 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 also a range of alternate surfactants available.

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

Aim

This trial investigates the main agronomic choices growers have available and the resultant control on populations of ARG suspected of glyphosate resistance-

- Formulation/ brand of glyphosate
- A range of alternate additional surfactants
- Rate of product applied
- Use of a double knock using paraquat

Methods

The trial site was selected as it had suspected annual ryegrass (ARG) resistance to glyphosate, which was confirmed by a commercial resistance test. The population was shown to have low level resistance with 10% survival.

A small plot randomised complete block strip design trial with three replicates was established in the 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	Red Clay Loam
Previous Crop	Wheat
ARG resistance status	Detailed in appendix- Suspected resistance

Table 2. Narromine 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 glyphosate	750	337	Nil	N/A
14	Generic glyphosate	1500	675		
15	Generic glyphosate	3000	1350		
1	Roundup CT®	750	337		
2	Roundup CT®	1500	675		
3	Roundup CT®	3000	1350	Wetter TX	0.25%
4	Roundup CT®	750	337		
5	Roundup CT®	1500	675		
6	Roundup CT®	3000	1350	Activator	0.13%
7	Roundup CT®	750	337		
8	Roundup CT®	1500	675		
9	Roundup CT®	3000	1350	Nil	N/A
18	Roundup CT®	6000	2700		
10	Roundup Ultra®Max	592	337		
11	Roundup Ultra®Max	1184	675		
12	Roundup Ultra®Max	2368	1350		
17	Roundup Ultra®Max	4736	2700		

Table 3. Application records

First application	Date Applied	7/04/2017	Temp (°C)	Wind (km/h)	Wind Dir.	Humidity (%)
	Start time	1:45 pm	25	2-5	NNW	44%
	Finish Time	2:45 pm	Δt	8.1	% Cloud	5%
	Water rate (L/ha)	100	Nozzle	DG015	Pressure	3
	Equipment	ATV	Speed	8 km/hr		
Double knock	Date Applied	13/04/2017	Temp (°C)	Wind (km/h)	Wind Dir.	Humidity (%)
	Start time	12:40 pm	25.1	6	S	37.1%
	Finish Time	12:45 pm	Δt	10.1	% Cloud	30%
	Water rate (L/ha)	100	Nozzle	DG015	Pressure	2.5
	Equipment	ATV	Speed	6-7 km/h		

Results

Full results are detailed in the table in the appendix at the end of the document.

Impact of glyphosate rate: The lowest application rate of 337 g ai/ha of glyphosate (as Roundup CT®) provided the lowest level of control at 47% compared to the untreated control (UTC). All higher application rates (675 g ai/ha or higher) resulted in close to 100% control. (Figure 1,) significantly better than the lowest rate. There were no differences between any of the higher rates.

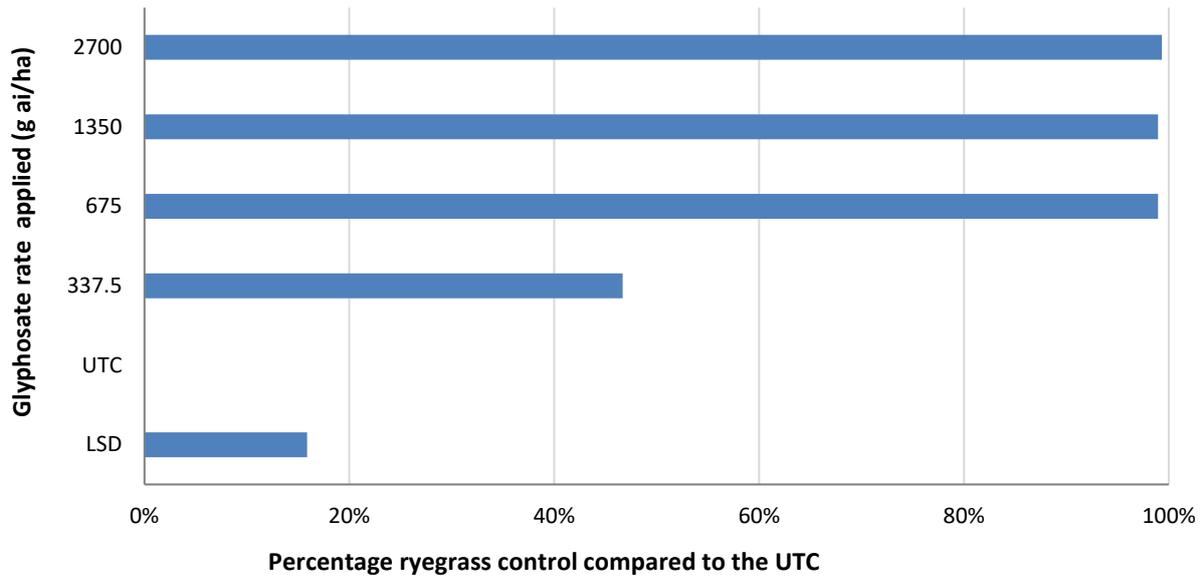


Figure 1. Percentage control (compared to the untreated) for four rates of Roundup CT[®] assessed 35 days after initial application (DAA1)

Impact of additional surfactants: Where Roundup CT[®] was applied at 675 g ai/ha (1.5 L/ha product) and higher, the addition of wetter did not significantly improve levels of control. The addition of Activator to the lower rate of Roundup CT[®] (337.5 g ai/ha) significantly improved control to above 90% from 47%. But the addition of Wetter TX did not improve control to anywhere near commercially acceptable levels when added to the lowest rate of Roundup CT[®].

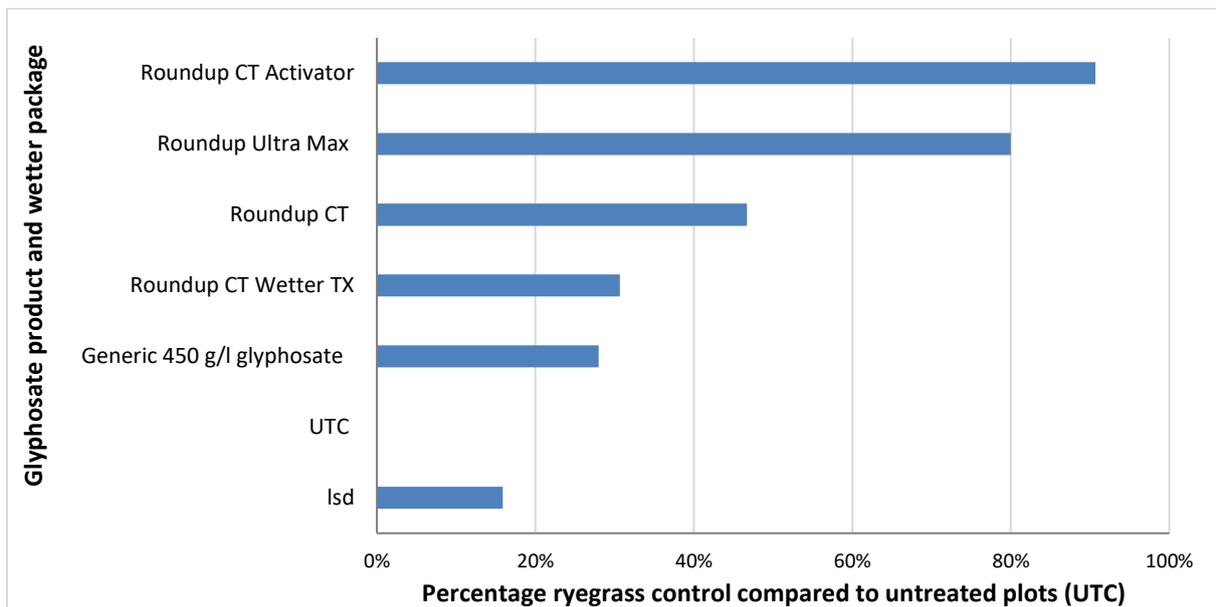


Figure 2. Roundup Ultra[®]Max at the equivalent rate of active was better than Roundup CT[®] achieving 80% control but was not significantly different to Activator + Roundup CT[®] at 91%.

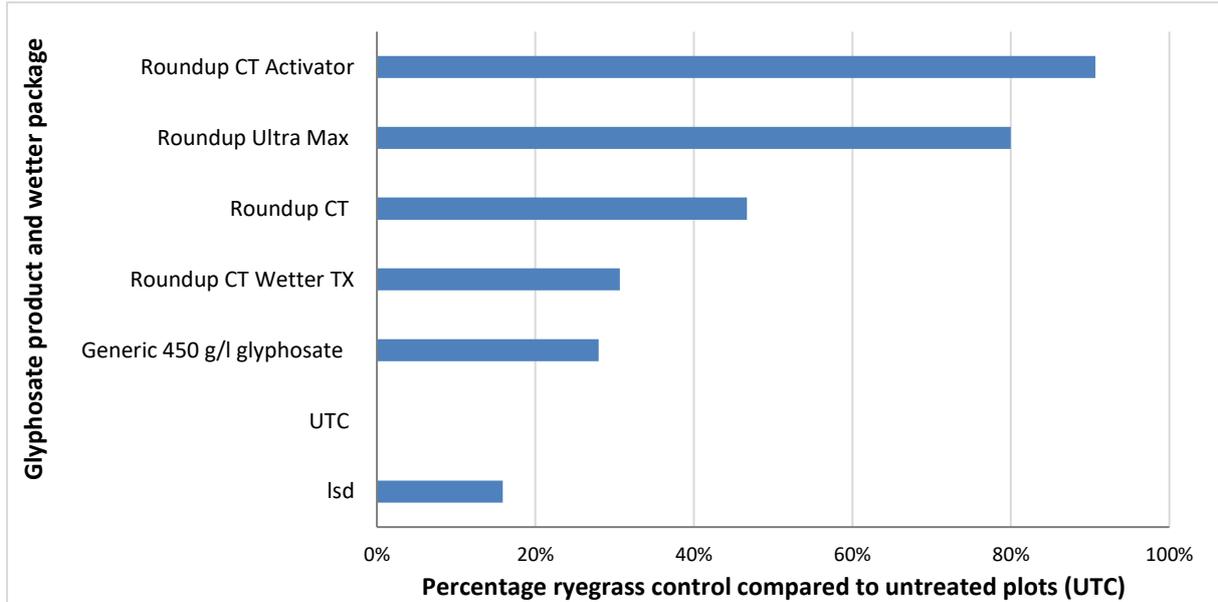


Figure 2. Percentage control (compared to the untreated) for different glyphosate products and wetter packages where the equivalent of 337.5 g ai/ha was applied. Assessed 35DAA1

Impact of different formulation/product choice: At the lowest rate of active ingredient (337.5 g ai/ha) both Roundup CT® and the Generic glyphosate resulted in poor control at 47% & 28% respectively. At the same rate of active, Roundup Ultra® Max achieved 80% control.

At all the higher rates of active there was no significant difference between any of the three products.

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

Where no glyphosate was applied in the initial application, paraquat provided 96% control (**Figure 3**).

At the lowest rate of glyphosate (337.5 g ai/ha) the addition of a paraquat (DK) increased control from 55% to 97%. At the higher rates of glyphosate (675 g ai/ha and above) there was no significant improvement in control.

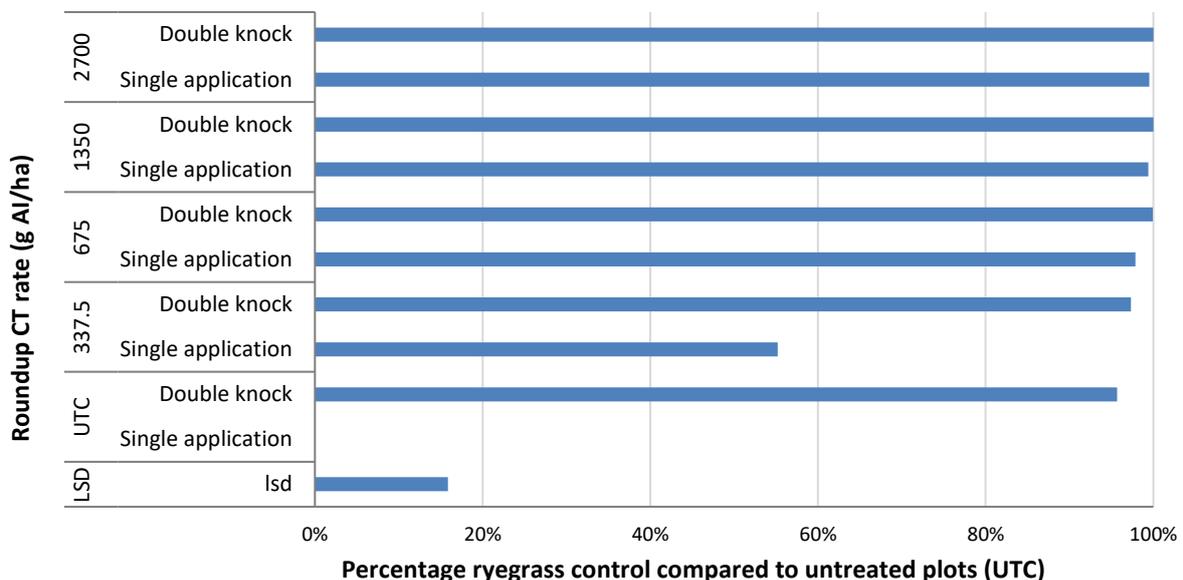


Figure 3. Percentage control (compared to the untreated) of the single pass application of Roundup CT® and the double knock application (at 7 days with 2 L/ha paraquat), assessed 35DAA1

Discussion

Prior to the establishment of the trial, significant rainfall events in March (approximately 90 mm) ensured an ample weed germination. At the time of the initial application, there was a moderately high population of ARG with close to 100 plants/m² in the untreated control. Plants were from 3-6 leaf and not visibly stressed, however the conditions at the time were hot and dry.

At this site ARG control increased dramatically with glyphosate application rates above 337 g ai/ha. However, because resistance tests showed only low levels of ARG resistance, the trial is not conclusive in demonstrating that increasing application rate can improve control of glyphosate resistant ARG.

At this site with relatively low level ARG resistance to glyphosate, control via glyphosate was rate responsive and clearly showed the effectiveness of the higher rates (675 g ai/ha, or higher) compared to the lower rate (337 g ai/ha). There were some subtle differences in performance between the various glyphosate formulations, though this likely to be mainly due to product wetter packages.

The results from this trial would tend to suggest that some wetters work better on ARG than others, especially at lower rates of glyphosate. For example; Activator significantly improved glyphosate performance (at the lowest rate) while Wetter TX provided no improvement. Roundup Ultra[®]Max (with built in surfactants) at the lowest glyphosate rate provided improved performance compared to Roundup CT[®] (at the equivalent rate), however, at 80% control may not be considered commercially acceptable.

At this the site the application of paraquat proved to be effective as a standalone knockdown, and improved levels of control when applied as a DK. This is supported by other work that has also found very high levels of control by DK where glyphosate resistant ARG occurs³.

Results of the trial suggest that determining resistance status of the ARG population would allow for fine tuning glyphosate use and the ongoing management of resistance toward it.

In very heavy ryegrass populations with suspected resistance using higher rates of glyphosate followed by a double knock of paraquat is advisable.

Conclusion

Know the glyphosate resistance status of ryegrass populations to determine rate requirements for better control.

Adding wetter or using glyphosate products with built-in surfactants can improve control, however, an alternative is to increase the glyphosate rate.

DK can be an effective strategy for reducing weed escapes. When DK (with paraquat) ensure adequate coverage.

Where possible apply herbicides to younger vigorously growing plants for better control.

³https://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=AFQjCNFFkRa18QDF7FjmSeV3r7BkXlqw

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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 Narromine	
		Survival	Rating
Select 250ml/ha + 1% Hasten	Group A - Dims	85	RR
Select 500ml/ha + 1% Hasten	Group A - Dims	10	RR
Verdict 300ml/ha + 1% Hasten	Group A - Fops	90	RR
Paraquat 2L/ha + 0.2% BS1000	Group L	0	S
Glyphosate 450@ 0.75L/ha	Group M	10	R
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
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Ryegrass control 30 days after the application of various glyphosate treatments.

Single or Double knock	Glyphosate active rate (g/ha)	Product rate (ml/ha)	Treatment	Control (%)	Groups	
Single application	UTC		UTC	0%	E	
	337.5	750	Roundup CT	47%	C	
			Generic 450 g/l glyphosate	28%	D	
			Roundup CT Wetter TX	31%	D	
			Roundup CT Activator	91%	AB	
	675	1500	Roundup Ultra Max	80%	B	
			Roundup CT	99%	A	
			Generic 450 g/l glyphosate	94%	A	
			Roundup CT Wetter TX	99%	A	
		1350	1184	Roundup CT Activator	99%	A
	Roundup Ultra Max			99%	A	
	Roundup CT			99%	A	
	2700		3000	Roundup CT Wetter TX	100%	A
				Roundup CT Activator	98%	A
			4736	Roundup Ultra Max	100%	A
		Generic 450 g/l glyphosate		100%	A	
	Double knock			Double knock only	96%	A
337.5		750	Roundup CT	98%	A	
			Generic 450 g/l glyphosate	99%	A	
			Roundup CT Wetter TX	90%	AB	
			Roundup CT Activator	99%	A	
675		592	Roundup Ultra Max	100%	A	
			Roundup CT	100%	A	
			Generic 450 g/l glyphosate	100%	A	
			Roundup CT Wetter TX	100%	A	
		1350	1184	Roundup CT Activator	100%	A
Roundup Ultra Max				100%	A	
Roundup CT				100%	A	
2700			3000	Roundup CT Wetter TX	100%	A
				Roundup CT Activator	100%	A
			4736	Roundup Ultra Max	100%	A
		Generic 450 g/l glyphosate		100%	A	
Isd		LSD	(blank)	Isd	16%	